



Department of Public Works

SCADA Master Plan

November 2015



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City of Snoqualmie Department of Public Works SCADA MASTER PLAN

NOVEMBER 2015

Prepared for:
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City of Snoqualmie Department of Public Works
SCADA Master Plan
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GLOSSARY

BOOTP:	Bootstrap Protocol. A computer networking protocol used to automatically assign an IP address to network devices from a configuration server.
CPU:	Central Processing Unit.
DA Server:	Data Acquisition Server. The HMI server software component that collects data from field devices, including PLCs.
DO:	Dissolved oxygen.
Ethernet:	A computer networking standard that defines a family of protocols, communication media, and device interfaces.
HMI:	Human Machine Interface. A computer that runs graphical interface software for monitoring and supervisory control of a control system.
IO:	Inputs and Outputs. Typically the connection to field instruments and equipment.
IP:	Internet Protocol. Communication protocol standard that enables network communication.
IT:	Information Technology.
LAN:	Local Area Network. Made up of the connection media, networking components, and nearby devices that communicate with each other.
MCC:	Motor Control Center.
MTU:	Master Telemetry Unit. A controller that communicates with multiple RTUs.
OIT:	Operator Interface Terminal.
OPC:	Object Linking and Embedding for Process Control. A standard that enables data exchange between devices made by multiple manufacturers.
ORP:	Oxidation Reduction Potential.
PLC:	Programmable Logic Controller. Typically consists of a CPU, IO modules, and communications hardware.
RDS:	Remote Desktop Services. Windows service that allows remote control of a user session on a remote server.
RTU:	Remote Telemetry Unit. A controller for local equipment that communicates with the MTU.
SCADA:	Supervisory Control and Data Acquisition.
SQL:	Structured Query Language. A database standard that includes a set of common instructions used to extract and present data.
UPS:	Uninterruptible Power Supply. A battery-backed source fed by the utility service during normal operation.
USB:	Universal Serial Bus. A short-distance, high-bandwidth cable communication interface standard.
UV:	Ultraviolet. A technology used for disinfection of treated wastewater.

VFD:	Variable Frequency Drive. A motor control that allows for continuous variations in running speed.
VLAN:	Virtual Local Area Network. A software-configured segmentation of local networks on a common router or managed switch.
VPN:	Virtual Private Network. A secure means of connecting a physically remote host to a LAN, typically via the Internet.
Win 911:	A software application used to annunciate and acknowledge alarms to/from remote users.
Win 411:	A component of Win 911 that enables simple audio reporting of analog values.
Wonderware or Wonderware	
InTouch:	The software application used at the WWTP and WTP to read and write real-time data to and from controllers.
WTP:	Water Treatment Plant.
WWTP:	Wastewater Treatment Plant.

CHAPTER 1. INTRODUCTION

This report summarizes the findings of an investigation of the City of Snoqualmie's water and wastewater SCADA system. It identifies recommended improvements and provides guidance for implementing them.

The technical details of the existing SCADA system and an analysis of deficiencies can be found in Technical Memorandums A and B, attached in the Appendix. Technical Memorandum A focuses on the PLCs, RTUs, telemetry, and instrumentation systems. Technical Memorandum B covers the SCADA head-end servers, HMI software, and process control network.

The body of this SCADA master plan summarizes recommended solutions to the deficiencies identified in the technical memorandums. The recommendations are organized under the following headings:

1. Introduction
2. PLC Standard and Replacement Alternatives
3. Telemetry Improvements
4. Instrumentation and Monitoring Enhancements
5. Networks
6. Servers
7. Uninterruptible Power Supply (UPS)
8. SCADA Alarms
9. Historical Data and Reporting
10. Commissioning Considerations
11. Service and Maintenance Considerations.

In addition to recommended hardware and software solutions, the master plan provides guidance requested by the City on standards and policies related to PLCs, server security and maintenance, and network management.

The recommendations are meant to address the City's immediate needs and account for future needs as the City grows. Where substantial investment in SCADA infrastructure is recommended, unless stated otherwise, the intended result is a system that will last at least 15 years.

The appendix contains material that may be helpful to users of this master plan. For example, Technical Memorandum A includes the City's schematic diagrams of the water and wastewater RTUs. These diagrams provide a clear visual summary of the size and architecture of the existing SCADA system.

This Master Plan has been developed with input from Plant Management, Engineering, IT, and Operations and is intended to be the roadmap for developing and maintaining a system that will meet the water and wastewater system needs with consideration being given to all interested parties concerns. It is recommended that this Master Plan be reviewed periodically, by all interested parties and outside experts in an effort to keep this document up to date with the existing water and wastewater systems as well as existing industry trends.

1.1 STANDARDIZATION

SCADA standards for the City should be seen as a living entity that will result in an effective and predictable means to achieve a reliable infrastructure and operations. This master plan, and associated PLC Standard,

have set forth standard guidelines for various portions of the SCADA system. In short, standards have been developed for:

- PLC
- Programming
- Telemetry (Ethernet Cellular communications)
- Networks
- Servers
- Operator Interface Terminals
- HMI (Wonderware)
- HMI Alarming (Win911)
- Maintenance and Operations

1.2 GOVERNANCE

This master plan sets forth recommendations regarding standards for future design, growth and modifications, security and management policies and guidelines, and recommendations for actions required during anomalies including disaster recovery, backups for all aspects of the system. In general, the management of the water and wastewater SCADA system with respect to modifications will be performed as follows:

1. Need for modification is identified.
2. Proposer informs the Plant Manager of the issue/proposed modification
3. Plant Manager solicits review of the modifications from the appropriate staff
 - SCADA Tech/consultant/integrator
 - IT
 - Engineering
 - Operators
4. Proposer documents anticipated modifications in the form of a memorandum to include:
 - Description of modification
 - Proposed outcome as a result of the modification
 - Potential pitfalls
 - Cost
5. Plant Manager approved modifications for incorporation
6. Design and implement changes
7. Test and commission changes
8. Confirm operations
9. Record modifications in the change management log

1.3 SCADA SYSTEM PERFORMANCE

The SCADA system needs to be provide the City with the appropriate information, accurately and in a timely manner. It needs to be flexible with respect to expandability, future growth, as well as be reliable with minimal errors or down time. However; it should not be overly complex or provide the City with extraneous information or features that are costly, cumbersome and not needed. This master plan lays out

the path for a SCADA system that will provide reliable and accurate information, while being flexible enough to handle future modifications and growth.

The SCADA system modifications shall to be programmed in a manner that is intuitive, easily understandable and provides for the successful operation of the water and wastewater systems. Graphical display of processes shall be developed in conjunction with the Plant Manager, SCADA Tech, Engineering and Operations to ensure that the “look and feel” of the HMI screens works with the operation of both systems. Staff shall be capable of making basic changes (set points) without the need for assistance from the SCADA Tech. Training shall be provided for all impacted staff whenever modifications to the SCADA system are implemented, so that they can understand the changes made, how they impact operations, and how the systems can be adjusted.

1.4 SYSTEM ACCESS

Access to the system should be limited with differing levels of access for staff as follows:

1. SCADA Technician

This position could be City personnel (not currently on staff) or a consultant or integrator, and will be able to:

- Have access to all programs and the ability to modify those programs
- Have access to the network and the ability to modify the network with IT agreement and consent
- Have access to view and modify parameters within the system

This position would also be an asset with respect to instrumentation work for the City.

2. IT

- Access to network with changes being implemented with the buy-in from the Plant Manager

3. Plant Manager

- Full operational access
- View access
- Parameter changes
- Programming changes

4. Operators

- View access
- Limited control of non-essential processes. Staff shall be capable of making basic changes without support from a SCADA Tech.

5. Engineering

- View access

1.5 IMPLEMENTATION PLAN

The current SCADA system is nearing the end its useful life. Components within the system are becoming antiquated and technical support is becoming less available. The City is experiencing an increasing number of system failures and can expect the frequency and severity of failures to dramatically worsen in the

coming years. This Master Plan sets forth recommendations for system improvements that will help to mitigate system malfunctions, improve performance, and improve reliability. The implementation plan for incorporating those recommendations are organized by tasks that may be done concurrently or individually as funding permits. The time frames below are estimated recommendations for completing each task prior to system failure for each item. The tasks are summarized below:

Task 1 – Communication/Telemetry Study and Analysis

Most communications failures are associated with the outdated MOSCAD and this is leading to many current problems for the SCADA systems. A communication/telemetry study should be performed to confirm the reliability of data transfer for all water and wastewater RTUs.

This task should be considered the top priority of this list and should be implemented within 6 months.

- 9 water
- 16 wastewater
- 3 shared

The telemetry study will confirm those sites that should be a priority for upgrades for the City, as well as verify estimated costs for upgrades. In addition to this study, the MOSCAD communications logger software mentioned in the telemetry portion of this Master Plan should be implemented and is included in the costs below.

Cost **\$30,000**

Task 2 – Upgrade Telemetry Communications for Problem Remote Sites

Improve communications to those sites found to have poor reliability and data transfer from the Communication/Telemetry Study to Ethernet cellular. The City could correct all sites at one time or individually as funding permits.

This task should be implemented immediately after Task 1.

Cost per site \$10,000 for 10 sites (estimated). Total Cost **\$100,000**.

Task 3 – Implement Virtual Server (OPC Server)

The OPC server incorporates current technology and will greatly improve data exchange rates, and reliability through self-diagnostic testing and communications rerouting (redundant path auto-failover). Design, install virtual SCADA server, validate, and start the conversion to an OPC server to replace the existing Master Telemetry Unit (MOSCAD) system currently in place.

This task should be implemented within the next 2 years.

Cost **\$210,000**

Task 4 – Upgrade All Telemetry Communications for Remaining Remote Sites

Upgrade all remaining sites to Ethernet cellular communications. The City could correct all sites at one time or individually as funding permits.

This task should be completed as funds become available, but completed within the next 5 years.

Cost per site \$10,000 for 18 sites (estimated). Total Cost **\$180,000**

Task 5 – Upgrade WWTP main PLCs

This should be completed within 3 years, and can be done during the current WWTP upgrade.

Phase 6 – Upgrade PLCs throughout the City’s water and wastewater facilities

This can be done on an as needed basis, when existing PLCs are no longer supported, or with new projects/upgrades come on-line, with all PLCs being replaced within the next 5 years.

Cost for large PLC replacement (2 PLCs). Total Cost **\$170,000**

Cost for small PLC replacement (22 MOSCAD, 6 ACE3600). Total Cost **\$540,000**

CHAPTER 2.

PLC STANDARD AND REPLACEMENT ALTERNATIVES

Development of this master plan was motivated in part by the City's concern that much of its existing PLC and RTU technology has reached or is nearing obsolescence. Identifying a standard for PLC replacement technology that satisfies the City's need for reliability, maintainability and longevity is recommended prior to installing any new or replacement PLCs and RTUs.

2.1 RECOMMENDATIONS FOR DEVELOPING A PLC STANDARD

A proposed PLC standard document is included in the appendix. The recommendations below were used to develop this document and are intended to guide the City's final decisions regarding a PLC standard:

- a. Select a well-supported PLC platform with programming software familiar to maintenance staff and local integrators. Ensure that the PLC platform selected is expected to have a useful service life of at least 15 years.
- b. Identify a specific manufacturer series of PLCs suitable for medium or larger control systems, such as the WWTP's control system. A smaller, more cost-effective model series that runs with the same programming software should be selected for small systems, such as simple water sites and lift stations. Select a PLC platform with a common programming software application and license that runs on the range of PLC models.
- c. Use the contract specification documents for new construction projects to identify the PLC standard and address packaged system requirements. It is common for utilities to specify actual make and model for acceptable PLCs in custom control panels and to require that vendor-packaged panels include controllers with compatible Ethernet protocols for communication with the owner's PLCs and/or the owner's SCADA HMI.
- d. Ensure that the standard PLCs selected have a provision for SD card back-up so that the latest running program is saved in the event of hardware failure and is portable to a spare controller without the need for a computer download.
- e. Include requirements for monitoring PLC health, including communication, scan time, battery status, power supply and UPS status, module status, and minor faults.
- f. Include a requirement for spare PLC components to be supplied for each project that includes a new PLC. Essential components to have in the City's replacement stock include spare CPU modules, spare communication modules, and spare IO modules of each type used.

2.2 RECOMMENDATIONS FOR PLC REPLACEMENT

The following PLC replacement improvements are recommended:

- a. Complete and implement the PLC standard identified above. The maintenance and reliability advantages of PLCs with standard-compliant logic and components should be factored into the decisions about each site.
- b. Replace the Motorola radios at the lift station RTUs with an Ethernet-based VPN solution now implemented at the Hospital Lift Station. The existing communications performance data (see recommendations in the next section) should be used to prioritize the sequence of upgrades. The approximate cost for a typical lift station PLC replacement is shown in Table 1. The lift station RTUs have the following special considerations:

- c. The existing RTUs are a combination of Motorola controllers. The more recent ACE3600 model has an Ethernet port. The MOSCAD model is older and does not have an Ethernet port. For sites selected for upgrade, only an Ethernet compatible RTU/PLC is required. If the site has an existing ACE3600, the Ethernet port is already available and there is no immediate need to replace the RTU. If desired, by leaving the ACE3600 in place, the cost for re-programming and re-commissioning the station can be avoided in the near term. Note, however, that this option does not achieve the benefit of a standard PLC, assuming the ACE3600 is not designated the standard PLC/RTU for remote sites.
- d. At some sites, a PLC was installed in addition to the Motorola RTU to handle equipment control. If the PLC has an Ethernet port and is relatively reliable, it can assume the communication function of the RTU without much additional programming. Otherwise, the PLC and RTU should be replaced with a single, PLC standard-compliant and Ethernet-capable PLC.
- e. For sites that use an existing Motorola MOSCAD RTU, this controller does not have the Ethernet port needed to handle the Motorola radio alternative pathway and should be replaced with a standard-compliant PLC. Replacement of the MOSCAD with ACE3600 is an option, though it does not achieve the benefits of a standard PLC, assuming the ACE3600 is not designated the standard PLC/RTU for remote sites.

**TABLE 1.
APPROXIMATE LIFT STATION PLC REPLACEMENT COSTS**

Line Item	Description	Approximate Cost	Notes and Assumptions
1	Engineering	\$2,000	
2	New PLC (hardware)	\$4,000	“Small” PLC as defined in PLC standard
3	Wiring and Install	\$1,000	
4	VPN Modem (one at each end)	\$1,500	Includes telecom coordination
5	HMI re-configuration	\$2,000	Database revision
6	PLC re-programming	\$7,000	\$1,500 if ACE3600 left in place
7	PLC re-commissioning	\$5,000	\$1,500 if ACE3600 left in place
	Total (replace MOSCAD)	\$22,500	With Standard “small” PLC
	Total (replace MOSCAD)	\$11,500	With ACE3600 (Items 1, 2, 3, 4, 6, 7)
	Total (keep ACE3600)	\$4,500	(Items 4, 6, 7)

Note: Costs above include contractor overhead and profit. Costs exclude City project management and telecommunication provider fees.

- f. Replace the Quantum PLCs in operation at the WTP and WWTP. These PLCs rely on an obsolete controller, and the software used to program them is obsolete. Replacement of these PLCs is recommended within the next 5 years, or sooner, if significant upgrades are expected to the treatment processes at these facilities. A significant upgrade is planned for the WWTP, and replacement of that Quantum PLC prior to the upgrade is recommended. Details regarding the City’s options for replacing the Quantum at the WWTP are provided in Technical Memorandum A. The cost estimate in Table 2 is based on the recommended option of leaving the existing WWTP control panel and field wiring in place and replacing the PLC with a new standard-compliant PLC. For comparison, Table 3 provides a cost estimate for a less-desirable option that would upgrade the processor and communication modules on these PLCs to enable

them to operate with current programming software. With this option, the remaining PLC hardware would still be nearing the end of its expected life. This option would not achieve the benefit of standardization and would not likely have the longevity of the preferred option.

- g. Based on recent feedback from the City regarding water system communications reliability, replacement of the water RTUs may be a lower priority than the lift stations. The MOSCAD RTUs at many water sites are obsolete and will need to be replaced. If the radio link is reliable, replacement with the ACE3600 should provide the required 15-year longevity and would be less expensive than transitioning the system to the standard PLC adopted for the lift stations. On the other hand, by continuing with the existing platform, the City foregoes the maintenance benefits afforded by implementing the PLC standard across the entire system. If performance of the existing water telemetry communications is acceptable and funding is limited, delaying major changes to the water telemetry system may be the best course of action for now.

**TABLE 2.
APPROXIMATE LARGE PLC REPLACEMENT COST (RECOMMENDED OPTION AT WWTP)**

Description	Approximate Cost	Notes and Assumptions
Engineering	\$18,000	Drawings, Specifications, Oversight
New PLC (hardware)	\$15,000	“Large” PLC as defined in PLC standard
New IO module wiring	\$10,000	Field wiring remains in place
HMI re-configuration	\$2,000	Database revision
PLC re-programming	\$20,000	
PLC re-commissioning	\$16,000	
Total	\$81,000	Each PLC

Note: Costs above include contractor overhead and profit. Costs exclude City project management.

**TABLE 3.
APPROXIMATE LARGE PLC UPGRADE COST (NOT RECOMMENDED)**

Description	Approximate Cost	Notes and Assumptions
Engineering	\$5,000	Drawings, Specifications, Oversight
New Quantum CPU	\$5,000	
PLC Program Overhaul	\$10,000	Field and module wiring remains in place
HMI re-configuration	\$2,000	Database revision
PLC re-commissioning	\$10,000	
Total	\$32,000	Each PLC

Note: Costs above include contractor overhead and profit. Costs exclude City project management.

CHAPTER 3.

TELEMETRY IMPROVEMENTS

The following telemetry improvements are recommended:

- a. Establish a baseline for existing MTU-RTU communication performance. As a basis for performance comparison, recently installed systems of a size similar to that of the City's system operate with polling times consistently under 2 minutes. The following improvements are recommended for evaluating performance of the existing system:
 - Implement MOSCAD-specific communication logger software. This product is available from a vendor for about \$2,000. See Technical Memorandum A for additional information.
 - Implement a poll-time counter on the MTUs and log the data on Wonderware. Each site's cyclic poll time is logged and hourly averages can be calculated.
- b. If baseline data indicates that poor reception is a problem for particular lift stations, plan to migrate these sites first. Transitioning the lift stations to a cellular or other communication option should improve the performance of the wastewater system while also improving the water system's radio network by eliminating traffic and avoiding data collisions associated with the second MTU. As mentioned in the previous section, the obsolete MOSCAD RTUs now in use at many lift stations will need to be replaced with a new PLC in order to implement an Ethernet-based telemetry path.
- c. Eliminate competition between two unsynchronized MTUs relying on a single repeater. Aside from implementing a method for synchronizing MTU clocks and time-slicing the polling, this can be achieved by transitioning the remaining lift stations to a new communication path as described above and removing the wastewater MTU. Water and sewer sites should be on a separate frequency for locations using radio-based communications.
- d. A new OPC server(s) to collect data from multiple PLCs and RTU VPN clients is recommended. The OPC link is more convenient to maintain and may improve communication reliability between progressively more numerous field devices and the Wonderware DA Servers.
- e. The relocation of the water MTU in late 2014 appears to have alleviated the City's concerns about the reliability of the water site communications. The high-elevation siting of many of the water facilities makes them more suited to a radio-based system. If the recommended performance assessment indicates lingering problems with particular sites, transitioning these problem sites to the VPN-cellular solution used for the lift stations is recommended.

CHAPTER 4.

INSTRUMENTATION AND MONITORING ENHANCEMENTS

4.1 RECOMMENDATIONS FOR WATER SYSTEM INSTRUMENTATION

The following water system instrumentation improvements are recommended:

- a. Implement VFD communication capability for new water pumps and consider adding this feature to existing pumps where beneficial. For VFDs installed within the last 10 years, this is a cost-effective method for obtaining real-time monitoring of power, current, and speed data. Power data is useful for accurate pump performance curve and efficiency analysis. Motor current data can be useful for identifying pump problems prior to failure. The approximate cost of a communications adapter is \$600.*
- b. Implement flow pacing for arsenic treatment with ferric chloride. Currently, the feed pump stroke and frequency are adjusted manually.
- c. Install turbidity analyzers for WTP filters.
- d. Add power monitoring for large equipment and at strategic locations on switchgear. These devices are relatively inexpensive, especially when purchased with new switchgear, and come with Ethernet capability. Power data is useful for energy efficiency analysis, monitoring utility service voltage, and evaluating standby generator capacity.*

** Denotes an improvement that may be cost-effective only with new station or equipment installations.*

4.2 RECOMMENDATIONS FOR WASTEWATER SYSTEM INSTRUMENTATION AND MONITORING IMPROVEMENTS

The following wastewater system instrumentation improvements are recommended:

- a. Implement WWTP VFD Ethernet communication upgrades, including on non-potable water pumps, where monitoring of power, current, and speed data would be beneficial. Relying on the communication link for critical control functionality in lieu of the typical hardwired interface, including calling the pump and adjusting the speed command, is not recommended. The communication enhancement is justified where monitoring real-time data, such as pump input power, actual speed, and actual motor current, is useful.
- b. Add aeration basin DO, ORP, and pH analyzers.
- c. Implement automatic clarifier sludge depth monitoring.
- d. Add analog level monitoring for scum well.
- e. Implement transmittance monitoring for UV systems
- f. Implement motor current monitoring for lift station pumps.*
- g. Add outdoor air temperature monitoring at lift stations.*
- h. Implement power monitoring for large equipment and at strategic locations on switchgear where power data is useful, particularly for services backed by a standby generator where load

shedding is used. Power monitoring is also useful for the planning and implementation of alternative energy sources, such as solar photovoltaics.

- i. Remove check valve position from the pump fail alarm logic. Retain status monitoring and designate as a lower priority alarm if desired.
- j. Install discharge flow meters on lift stations for inflow and infiltration records and pump performance monitoring.*
- k. Adjust the time delay for the Hole 9 chlorine residual monitoring or relocate the analyzer.
- l. Connect the existing headworks, centrifuge, and dryer PLCs on the LAN and monitor significant process parameters with the SCADA HMI. These PLCs are Ethernet-compatible as-is. Once the desired process parameters are identified, the implementation should be relatively simple and inexpensive.

** Denotes an improvement that may be cost-effective only with new station or equipment installations.*

CHAPTER 5. NETWORKS

5.1 RECOMMENDATIONS FOR NETWORK IMPROVEMENTS

The following network improvements are recommended:

- a. Communications to be migrated to an OPC network configuration.
- b. Replace the control system VLANs with industrial-grade managed switches dedicated to the control system LAN.
- c. Use redundant media where cost-effective and alternative physical pathways exist between switches, such as at the WWTP.
- d. Monitor redundant media and link health. Incorporate additional network-related alarms to the SCADA alarm database and display status on the HMI. Switch manufacturers have communications features that can be monitored by a PLC over Ethernet if this method is preferable to relying on additional IT infrastructure.
- e. Implement UPS battery health monitoring for the UPS supporting critical communications components. This can be conveniently implemented by wiring UPS dry contacts to nearby PLCs. Include these alarms in the SCADA HMI database.
- f. Ethernet network will utilize a combination of Ethernet cellular, category 6 copper cabling, and multi-mode fiber for in plant communications pathways. Ethernet switches to be industrial hardened type.

5.2 RECOMMENDATIONS FOR A NETWORK MANAGEMENT POLICY

The following network management policies are recommended:

- a. Use static IP addresses for the entire LAN. Maintain a current table of IP addresses and enforce upkeep.
- b. Assign IP addresses to each managed switch and monitor link status for each port. Include the port link fail status alarms in the SCADA HMI database.
- c. Implement port blocking for unused switch ports.
- d. Keep spare switches on-site and ensure that each switch can be replaced quickly, with minimal configuration (such as IP address assignment) to recover service. If necessary, additional security features can be configured as soon as convenient.
- e. Provide for central storage of managed switch configuration files.
- f. Assign IP addresses for laptop use by integrators and maintenance personnel. Designate locations and ports that are enabled for these temporary connections.
- g. Configure the City's firewall to allow for cellular modem data to pass through to the SCADA LAN. Configuration of the cellular modems at the remote ends to "route" to private (City control) network will also be required. Some Ethernet cellular modems have this functionality built in.

CHAPTER 6. SERVERS

The City's existing SCADA servers consist of workstations located in control rooms and the WWTP office. The workstations have a basic level of password protection, but they are not physically secure and therefore are vulnerable to dirt and inadvertent disconnection. Additional concerns include ease-of-maintenance and vulnerability to viruses and malicious intrusion, including access from the Internet. Concerns about reliability, security, functionality and maintenance are addressed with the following recommendations.

6.1 RECOMMENDATIONS FOR SERVER IMPROVEMENTS

The following server improvements are recommended:

- a. Virtualize the SCADA servers as a way to enhance redundancy, simplify maintenance and hardware replacement, improve data collection, and expedite disaster recovery. This implementation assumes that the existing servers would be replaced with rack-mounted, server-class hardware and located in a secure, climate-controlled location. Alarm notification features are integral to the server systems. A preliminary design in drawing format and supporting vendor quotation is attached in the appendix. Due to the rapid pace of computing technology development over the last 30 years, the servers should not be expected to last 15 years. However, the centralized architecture proposed should simplify the inevitable upgrades needed over this time period. The approximate cost for this implementation is presented in Table 4.
- b. Establish a method for notifying Public Works and IT staff when a critical application or device goes down. Implement remote monitoring and alarming for the following hardware and software:
 - Running status of critical applications, such as Win 911, the Historian, and Wonderware IO servers.
 - Operating system status for host and virtual operating systems.
 - Critical hardware components, such as hard drives, power supplies, and modems.
- c. Save a redundant copy of the SCADA, PLC, Historian and associated programming on a server remote from the primary servers. This will provide the City with a back-up in the event that the primary system files are destroyed or compromised. This location should be located at a City facility such as Public Works.
- d. The SCADA system should be continuously monitored through the use of alarm signals on critical equipment, and software monitoring programs in order to confirm proper operation and predict failures/anomalies. The City IT department has developed a Monitoring Dependency Breakdown diagram (pyramid) depicting the overall system with the various items to be monitored, and it is located in the Appendix. This diagram shows the SCADA categories and items monitored within that category. The categories include:
 - Win911 (Alarm Dialer Software)
 - Wonderware (SCADA Software)
 - Core Application
 - Operating System
 - Hardware Monitoring

TABLE 4
APPROXIMATE VIRTUAL SERVER IMPLEMENTATION COSTS

Description	Approximate Cost	Notes and Assumptions
Engineering	\$15,000	Specifications and Oversight
New Host Servers (2)	\$16,000	
Server Room Improvements	\$10,000	HVAC, power circuit, and door lock improvements
UPS (2)	\$3,000	
Network Improvements	\$16,000	
Wonderware Applications and Licensing	\$42,000	Excludes Thin Manager
Thin Manager Licensing	\$10,000	Optional
OPC Servers (2)	\$3,000	
Control System Laptop	\$5,000	
Validate System (data points)	\$70,000	
Configuration and Set-up	\$10,000	
Historian and Reporting Development	\$10,000	
Total	\$210,000	

Note: Costs above include contractor overhead and profit. Costs exclude City project management.

6.2 RECOMMENDATIONS FOR SERVER SECURITY

In addition to locating the servers in a controlled environment as described above, the following security policy elements are recommended:

- a. Restrict access to operating systems to only those users who have the responsibility to install programs, configure network access, modify hardware, and other actions typical of users that need to maintain the servers. Typical operation would be by a user logged in as a non-administrator.
- b. Limit Internet connectivity for normal server operation. Internet connectivity could be enabled on an as-needed basis by an administrator account and disabled when not needed.
- c. Configure authorization levels and activity time-out features for the Wonderware InTouch Viewer application. The access-level feature can be used to limit accessibility to certain functions, such as set-point adjustment or manual on/off control of equipment. Accessibility can be assigned to individual graphic objects or entire screens. No more than three levels of access should be adequate.
- d. In lieu of enabling off-site access to the HMI screens, implement the Win 411 reporting features available on the existing Win 911 software. This extension of Win 911 allows a remote user to dial in and select from a list of pre-configured reports containing process data. Current values for the operator-selected process variables are reported like alarm messages.
- e. Should enabling temporary remote access by vendors or contractors be considered for a major improvement project, define ground rules for the project with final approval from Public Works. Remote access to a network using a secure VPN account is commonly employed. Limitations can be placed on time of day or week that a router supports VPN access. Common practice is to require that outside vendors obtain prior plant permission for each login event.
- f. Implement a change management log to track all changes to any files.

- g. Disaster recovery procedures will involve retrieval of the system program redundant copy to replace any corrupted or lost programming. After replacement, the system should be tested and commissioned to confirm operation.
- h. Establish a policy for remote access to the SCADA system. Policy to include:
 - Allow remote access only for emergency situations
 - Remote access only to the servers or PLCs
 - Access will only by Ethernet connection through the City's firewall
 - Access will only be by trusted integrators, consultants, vendors or engineers. Remote access will only be granted on a case-by-case basis with written consent by the City.

6.3 RECOMMENDATIONS FOR SERVER POLICY GUIDELINES

The following server policy guidelines are recommended:

- a. Inhibit automatic Windows updates on SCADA computers.
- b. Implement periodic review of server hardware. Public Works would be responsible for notifying the IT Department of planned application software updates and identifying particular hardware or operating system prerequisites recommended by the software vendor. The IT Department would be responsible for keeping Public Works informed of hardware and operating system obsolescence.
- c. Coordinate hardware replacement plans between the IT Department and the Public Works Department at least 3 months in advance.
- d. Assign responsibility for SCADA-specific software application maintenance to Public Works. Updates to the HMI and alarming software would be implemented at the discretion of Public Works. An annual review of application software requirements related to operating systems (Windows security patches and service pack updates) is recommended. This information is available from Wonderware and should be reviewed annually by Public Works.
- e. Public Works should be notified at least 30 days in advance of any hardware or IT-provided software changes or updates so that these can be coordinated in advance.
- f. The IT Department should be notified at least 30 days in advance of any software application updates so that if there are potential issues regarding hardware and operating system compatibility, these can be coordinated in advance of the upgrade.
- g. Establish a safe location on the Enterprise server for storing the latest Wonderware and Win 911 applications. These files can be used to restore a server in the event of failure or replacement.
- h. Server back-up procedures should be the same as current IT back-up procedures for other City servers.

CHAPTER 7.

UNINTERRUPTIBLE POWER SUPPLY (UPS)

The City has been experiencing problems with loss of power to equipment, and this is attributed to the current UPS systems being “standby” type. These UPS systems power the loads directly from the AC power source with the charger, batteries, and inverters as a secondary source, which is usually of a lower quality and somewhat prone to more failures. An “online” or “true” UPS system is one in which the charger, batteries and inverter are the main source to the load with the AC bypass as a back-up. The online UPS systems are constructed with more robust chargers, batteries and inverters because these components are being used continuously to supply the load in normal operation and are less prone to failures.

7.1 RECOMMENDATIONS FOR UPS SYSTEMS

The following UPS improvements are recommended for all future upgrades:

- a. Provide only online type UPS systems as back-up power for new installations or where required within this study.

CHAPTER 8.

CONTROL SYSTEM LAPTOP COMPUTER

The City will require a control systems laptop computer for the purpose of making revisions, repairs and troubleshooting of the system in the field. It is important to have current technology and performance for the computer being used for the SCADA system. This laptop should be periodically replaced with newer versions on a timeline similar to that of other City computers and when appropriate to accommodate SCADA system software upgrades.

8.1 RECOMMENDATIONS FOR LAPTOP COMPUTER

The following is the recommended laptop requirements:

- a. Provide a standard office laptop running on a currently supported Windows OS platform no more than five years old. The laptop shall have sufficient memory and performance to successfully operate all software applications required for the SCADA system.

CHAPTER 9. SCADA ALARMS

The existing alarm system and City standard consists of two independent Win 911 applications for water and wastewater. Most alarm signals originate in the field, from the RTUs, treatment PLCs, or other devices being monitored by the Wonderware InTouch HMI. Additional alarms can be configured within the Wonderware InTouch HMI applications themselves. All alarms reach the Win 911 database through the HMI alarm engines. Win 911 integrates well with InTouch, but there are limitations in that Win 911 must run on the computer that has a dedicated modem attached and an active InTouch session. Virtualizing Win 911 on the servers described above is not currently recommended by the manufacturer.

9.1 RECOMMENDATIONS FOR ALARM SYSTEM IMPROVEMENTS

The following alarm system improvements are recommended:

- a. Relocate computers running Win 911 to a secure environment.
 - a. Implement watchdog monitoring for the Wonderware alarm source (InTouch alarm object) for each Win 911 application to indicate this mode of alarm system failure.
 - b. Coordinate with IT to monitor Win 911 service running status on each workstation if not functional for more than a specified number of minutes. Normally the Win 911 service runs continuously. The “System Health” feature of Win 911 provides a heartbeat signal to the workstation or server.
 - c. Coordinate with IT to monitor status of the telephone line and notify Public Works. One option is to implement the “Voice Health” feature of Win 911, which monitors for a failure of the telephone circuit. Note that this feature only works on dialogic type modems connected to PCI, not USB modems. The existing modems connected to the water and wastewater computers are USB and would need to be replaced if this approach is implemented.
 - d. Add alarms to InTouch and Win 911 for server, MTU, and PLC communication status.
 - e. Add alarms for the communication status of each RTU.
 - f. Add an auto callout test status twice a day to provide verification that the system is operating properly

9.2 RECOMMENDATIONS FOR GENERAL ALARM GUIDELINES

The following process-related alarms are recommended for water and wastewater facilities:

- a. High and low levels, pressures, and flows.
- b. High and low analytical instrument measurements.
- c. High equipment temperature (motor bearing, motor windings, pump bearings).
- d. Equipment failure (VFDs, pumps, fans, conveyors, filters, etc.).
- e. Standby generator (low fuel, fuel leak, battery charger, high water temperature, high oil temperature, high alternator temperature, over-torque).
- f. Power failure (utility service, standby service, control power, network power)

- g. UPS battery trouble.
- h. Smoke (in addition to stand-alone fire alarm systems).
- i. Intrusion (door sensors, motion detectors).
- j. Building and vault flood.
- k. Communications loss (network, RTU, PLC, server).
- l. Controller faults (module failure, memory fault).
- m. Standby components of redundant systems (power supplies, communication media, communication components, etc.).

Alarms are categorized based on the risk to people, property and process quality. Decisions about how to prioritize alarms are often best made by the personnel who are responsible for fixing equipment, keeping facilities safe, and keeping treatment processes within quality limits. The best way to ensure that alarms are functioning and set-up correctly is to thoroughly document commissioning activities when facilities are built or modified. After commissioning, periodic checks and preventive maintenance are necessary to counter the effects of equipment failure due to age, instrument drift, and destructive events.

CHAPTER 10.

HISTORICAL DATA AND REPORTING

The City's existing method for historical data storage relies on the integral data logging feature of the InTouch applications. The data collection lacks redundancy, data retrieval must be performed locally at the workstation, and the reporting features have limited flexibility. The following improvements are recommended:

- a. Implement a SQL-based "Historian" server dedicated to collecting and summarizing historical data for the water and wastewater SCADA systems. This server should be rack-mounted and virtualized for increased protection and reliability. A cost estimate is included in the Servers section above.
- b. Implement a "user-friendly" reporting application, such as Dream Reports, to query data directly from the SQL database. This application can be configured to generate minimum, maximum, and average summary data for user-selectable time periods. Reports in PDF, csv, or Excel formats can be automatically generated and saved to a specific location on the network. Reports can be automatically emailed. A reporting option with cost estimate is included in the suggested server implementation.

CHAPTER 11. COMMISSIONING CONSIDERATIONS

Attention to the commissioning phase of a SCADA project is the best way to ensure that the systems are performing as expected. While there may be pressure to take shortcuts, especially toward the end of a project when the major equipment appears to be working, resources invested in a systematic check-out of the system features as described below is the most efficient way to avoid problems after the installers leave the site.

11.1 RECOMMENDATIONS FOR COMMISSIONING ACTIVITIES

The detailed requirements for commissioning water and wastewater facilities should be well-defined in the contract specifications for each new facility or facility upgrade project. The City and contractor/integrator shall hold a pre-commissioning meeting, during construction, to establish the SCADA commissioning schedule, including start and end time and the method of turning over the system to operations. Table 5 summarizes the commissioning activities typically performed on a water or wastewater facility.

TABLE 5. RECOMMENDED COMMISSIONING ACTIVITIES		
Activity	Description	Purpose
MCC and Control Panel Shop Tests	Newly fabricated control equipment testing in a controlled environment.	To verify internal wiring is correct, components are as specified, layout and fabrication satisfy specifications.
Field Instrument Tests	Field instrument functional testing.	To verify instruments are properly configured and calibrated and the display is accurate.
Loop Tests	Signal testing for field instruments, sensors, equipment, and control panels.	To verify signal from field devices are being correctly received at the controller and displayed as required. Signals produce the expected automatic response.
Alarm Tests	Testing for all alarms, alarm displays, notification, and response systems.	To verify proper alarm annunciation, acknowledgment, set point adjustment, and automatic equipment response, where applicable.
System Tests	Multiple equipment, e.g., the lead-lag alternation of a wet well level control system.	To verify systems operate correctly under actual operating conditions.
Cellular Ethernet Radio Tests	Test and confirm RTU Data Transfer	To verify stable and reliable communications
Server/Network Tests	Test and confirm communication and control functionality for all servers and network equipment	To verify server and network wiring and communications are functioning correctly

11.2 RECOMMENDATIONS FOR COMMISSIONING DOCUMENTATION

The documentation associated with commission activities should similarly be well defined in construction specifications. The following documents are typically required:

- a. Schedule for testing/commissioning.

- b. Written procedures for testing/commissioning, including agreed documentation format.
- c. Testing forms, with fields for equipment description, parameter values, results, date, names of attending participants and witnesses, and signatures. Test forms address specific motors, mechanical equipment, cabling, instruments, control loops, HMI displays, historical data recording, communication and network functions, etc.
- d. Parameter settings for microprocessor-controlled process equipment, especially VFDs, soft starts, flow meters, level transmitters, and analytical instruments.
- e. Configuration files in electronic format for VFDs, soft starts, network switches and routers, etc.
- f. Electronic copies, both PDF and native file formats, for all PLCs and RTUs, including all logic comments.
- g. Electronic copies of all OIT and HMI application files.

CHAPTER 12.

SERVICE AND MAINTENANCE CONSIDERATIONS

12.1 RECOMMENDED SPARE PARTS

To mitigate the risk of system down-time, maintaining the following SCADA-related spare parts on-site and ensuring that staff have the necessary training to trouble-shoot and install them is recommended:

- a. One spare PLC or RTU CPU module for each type of processor in use.
- b. One or more spare PLC or RTU IO modules for each type of module in use.
- c. One or more spare PLC communication modules for each type of module in use.
- d. One spare PLC power supply module of each type in use.
- e. Spare modem of each type used.
- f. Spare radio of each type used.
- g. Spare surge protector of each type used.
- h. One or more spare network switch/router of each type in use.
- i. One spare OIT display of each type in use.
- j. 10% spare control relays of each type in use.
- k. One or more spare DC power supplies of each type in use.
- l. One spare UPS of each type in use for non-redundant systems.
- m. Spare limit switches and float switches.
- n. Spare control power fuses.
- o. Spare indicating lights for control panels and MCCs.
- p. Category 6 cable, connectors, and connector installation tool to allow for the making of cables by maintenance.
- q. Fiber optic patch cable with connectors. Length should be adequate to support the longest run in the system for in-plant installation.

12.2 RECOMMENDED MAINTENANCE TECHNICIAN SKILLS AND RESPONSIBILITIES

Maintaining relevant skills in-house is an excellent way to limit process down-time and ensure that contractors deliver satisfying service. Recommended skills and responsibilities for a resident SCADA technician include the following:

- a. Basic computer networking, knowledge of Ethernet switching and routing technology, BOOTP familiarity, basic command line.
- b. PLC programming experience.
- c. HMI programming experience.
- d. Microsoft Windows, Word, and Excel.

- e. Basic knowledge of databases and querying methods.
- f. Experience with if, then, else programming languages.
- g. Relay logic and wiring.
- h. Radio configuration.
- i. Serial communications protocol familiarity.
- j. VFD configuration and applications.
- k. Analog instrumentation design, measurement and trouble-shooting. Signal isolation and grounding.
- l. Low voltage wiring.
- m. Fiber optics.
- n. Voltmeter, ammeter, ohmmeter use.
- o. Electromagnetic flow meter configuration and application.
- p. Ultrasonic level transmitter configuration and application.
- q. Pressure transmitters.
- r. Analyzer transmitter configuration.
- s. A sound understanding of water treatment processes in terms of pressure, temperature, level and flow.

APPENDIX 1.
PLC STANDARD



Department of Public Works

PLC Standard

November 2015



TETRA TECH

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City of Snoqualmie Department of Public Works PLC STANDARD

NOVEMBER 2015

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Project #135-12466-15001

City of Snoqualmie Department of Public Works PLC Standard

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GLOSSARY

CPU: Central Processing Unit.

DA Server or DAS: Data Acquisition Server, the HMI server software component that collects data from field devices including PLCs.

DSL: Digital Subscriber Line. A communication utility-provided link that uses a telephone utility circuit to transmit digital data.

Ethernet: A computer networking standard that defines a family of protocols, communication media, and device interfaces.

Ethernet I/P: A protocol standard that enables Allen Bradley devices to communicate over an Ethernet LAN.

HMI or MMI: Human Machine Interface, a computer that run graphical interface software for monitoring and supervisory control of a control system.

IO: Inputs and Outputs, typically the connection to field instruments and equipment.

IT: Information Technology.

LAN: Local Area Network, made up of the connection media, networking components, and nearby devices that communicate with each other.

Mbps: Mega-bits per second. A unit of measure for communication speed.

MCC: Motor Control Center.

MTU: Master Telemetry Unit, a controller that communicates with multiple RTUs.

NIC: Network Interface Card.

NRTL: Nationally Recognized Testing Laboratory.

OIT: Operator Interface Terminal.

OPC: Object Linking and Embedding (OLE) for Process Control. A standard that enables data exchange between devices made by multiple manufacturers.

P&ID: Process and Instrumentation Diagram. A drawing that identifies process equipment, associated process connections, and equipment interface to PLCs and SCADA.

PLC: Programmable Logic Controller – Typically consists of a CPU, IO modules, and communications hardware.

RAM: Random Access Memory. Memory registers used by a processor to execute a program.

RDS: Remote Desktop Services. Windows service that allows remote control of a user session on a remote server.

RIO: Remote IO – chassis-mounted IO and communications hardware but no local CPU.

RPI: Requested Packet Interval (for Ethernet communication)

RTU: Remote Telemetry Unit, a controller for local equipment that communicates with the MTU.

SCADA: Supervisory Control and Data Acquisition.

SD: Secure Digital data storage medium.

SMS: Short Message Service, or text messaging on mobile devices.

SQL: Structured Query Language. A database standard that includes a set of common instructions used to extract and present data.

TCP/IP: Transmission Control Protocol/Internet Protocol. Communication protocol standards that enable network communications.

UPS: Uninterruptible Power Supply, a battery-backed source fed by the utility service during normal operation.

VFD: Variable Frequency Drive.

VLAN: Virtual Local Area Network, a software configured segmentation of local networks on a common router or managed switch.

VPN: Virtual Private Network, a secure means of connecting a physically remote host to a LAN, typically via the Internet.

VM: Virtual Machine, a software application that allows a host computer or server to run one or more copies of another “virtualized” operating system and any of its associated applications.

Win 911: A software application used to annunciate and acknowledge alarms to/from remote users.

Win 411: A component of Win 911 that enables simple audio reporting of analog values.

Wonderware or Wonderware InTouch: The software application used at the WWTP and WTP to read and write real-time data from/to controllers.

WTP: Water Treatment Plant.

WWTP: Wastewater Treatment Plant.

CHAPTER 1. INTRODUCTION

1.1 PURPOSE OF STANDARD

This document is intended to describe the standards for the PLC controllers and associated software used to monitor and control the water and wastewater processes at the City's public works facilities. It is intended to simplify the planning, design, and implementation of new projects by consolidating the key requirements into a single reference. Though it is not intended to serve as a stand-alone specification for PLCs and PLC software development, it should be used as a guide to such specification development and may be useful to explain the intent behind contract requirements.

It is assumed that the City's needs evolve continuously over time and that multiple users will have differing needs and priorities. For these reasons this Standard should be considered a working document. It should not be interpreted as the final word on a given specific application, and its continued relevance depends on periodic revision as technology and treatment processes improve.

1.2 REFERENCED STANDARDS

This document incorporates by reference the latest revision of the documents listed below.

- IEC 61131 for Programmable Logic Controllers, current (third) edition February 2013.
- ANSI/ISA-5.1 Instrumentation Symbols and Identification

CHAPTER 2. PLCS AND PLC PROGRAMMING

2.1 PLC HARDWARE STANDARD

2.1.1 General PLC Hardware Requirements

Acceptable PLCs must satisfy the following general requirements:

1. Functionally compatible with plant SCADA system, including all interdependent software applications, such as the HMI server, historical database server, alarm annunciation software, and the reporting application.
2. All components are supplied from and supported by the same manufacturer. Model, part number, and revision for any specified component is consistent with the other components.
3. PLC hardware must be compatible with the City's software development license and configured such that any new hardware installed can be readily maintained using the existing software owned by the City. The City shall be notified of any proposed exception to this requirement and any exception must be approved by the City's maintenance staff.

2.1.2 Specific PLC Hardware Requirements

Specific City-approved PLC manufacturers and product line currently include:

1. Allen-Bradley ControlLogix L7 series to match City standard for larger I/O count facilities, including the treatment plants.

2. Allen-Bradley CompactLogix 5370-L3 series for smaller I/O count facilities, including the lift stations and vendor-supplied packaged control systems.
3. MOSCAD ACE3600 for water system RTUs that operate on the radio telemetry system.

2.2 PLC PROGRAMMING STANDARD

2.2.1 PLC Programming Software

Allen Bradley (Rockwell Automation) Logix 5000 Studio is required to develop and edit Allen Bradley PLC programs. The version of this software is coupled to the firmware revision running on the PLC hardware in that older versions of Logix 5000 are not compatible with more recent firmware. Coordinate the version of this software prior to developing any new PLC program to ensure that all controllers at the City's facilities are readily maintainable with the existing City-owned license.

2.2.2 Instruction Format

Ladder logic using the ladder instruction set is required for all PLC code unless otherwise permitted in writing by the City.

Add-On Instructions: Add-On instructions are discouraged for complicated functions because any revision of the instruction requires the PLC to be shut down. Use of Add-On instructions for simple functions, such as those listed below are allowed with prior written approval by the Owner.

1. Totalizers.
2. Runtime and Start Counters.

2.2.3 Program Organization

PLC Routines and Task Organization: Routines are grouped by process, equipment groups, or areas within the Plant. Use folders with appropriate names to hold routines. Use periodic tasks to run closed loop control routines, such as those containing PID instructions.

2.2.4 PLC Variable Data Types

Use REAL (floating point) data types for all process variables. Use DINT (double integers) for variables that do not assume fractional values, such as those for start counter registers, flow totalizer registers, etc.

2.2.5 PLC-to-PLC Communication

Use Produced and Consumed tags to transfer data at fixed intervals between controllers on the same LAN. A Produced Tag is a tag that a controller makes available for access by other controllers. Multiple controllers can simultaneously consume (receive) the data. A Produced Tag sends its data to one or more Consumed Tags (consumers) without the need for instructions in logic. The Produced Tag sends its data at the RPI of the consuming tag. The Consumed Tag is a tag that receives the data of a Produced Tag. The data type of the Consumed Tag must match the data type, including array dimensions, of the Produced Tag. The RPI of the Consumed Tag determines the period at which the data updates. Ensure that all inter-PLC communication features are well commented in logic where these tags are used.

Use of Message instructions to read data from another PLC is appropriate when the Produced/Consumed method of communication is not available or when data exchange is needed only when a specific event occurs. For consistency and to simplify maintenance, use message instructions to read registers in another PLC. Avoid using message instructions to write to registers in another PLC. Ensure all inter-PLC communication instructions are well commented.

For all PLC-to-PLC communication use readily visible comments in the logic of each PLC to clearly identify the purpose and origin of all data being shared between PLCs.

2.2.6 Common Functions

PLC Input Buffering:

Rather than using multiple direct references to a hardwired input or output channels throughout the program, buffer all input channels by assigning each input to a PLC memory tag at a single location in the program. Use of aliases for all hardware inputs and outputs is not allowed in order to avoid processor shutdowns if channels need to be re-assigned. Instead, use simple assignment instructions from hard inputs and outputs to corresponding memory tags with appropriate names. Use the variable description field to identify tags more completely. The description field is easily edited when online with a running processor.

Loss of Equipment Power:

The PLC is powered through a UPS but shall monitor the status of utility power to all equipment it controls. In the event of a utility power outage of at least 10 seconds duration, the run command outputs for all motor driven equipment controlled by a PLC shall revert to the off (or shutdown) state. After a reliable equipment power source has been established, equipment required to run will be enabled to re-start in a controlled sequence. Unless otherwise required, significant motor load start-up events should be staggered to prevent a sudden increase in demand on the power system.

2.2.7 PLC Fault Monitoring

PLC software, firmware and hardware minor faults and status are monitored periodically (at least every 30 seconds) by the PLC. All PLCs self-monitor for the following faults and status conditions, which are displayed on the HMI and OIT:

1. CPU battery status.
2. CPU key switch position.
3. CPU Minor fault.
4. I/O Module Minor Fault status for each module.
5. Status for each communication module.
6. Current scan time.
7. Excessive scan time alarm or watchdog timeout.

2.3 PLC DATA AND PROGRAM DOCUMENTATION

2.3.1 Intent of Program Documentation Requirements

Documentation must be sufficiently thorough to enable reviewers to review and understand all submitted programs without ambiguity, and to enable trained staff of the City to review, understand, maintain, and modify all programs supplied with minimal effort. Thorough PLC program documentation requires that:

- Program tags use an intuitive alpha-numeric naming convention that is consistent with P&ID drawings and equipment field nameplates.
- Tag description fields are populated with unambiguous phrases that describe the instrument or equipment and its operating state.

- Routines, subroutines, and tasks are intuitively named and organized, with comments describing function and purpose.

2.3.2 Tag Names

PLC tag names correspond to the memory addresses in Allen Bradley Logix 5000. Tag names should include the alpha-numeric equipment number followed by an alphabetical character string (suffix) to indicate the function of the control point. Equipment numbers are normally identified on the P&IDs. The underscore character replaces any dashes in the equipment number and an underscore is used to separate the equipment number from the following alphabetical character strings. For example, P101_Running is the tag name for the running status input associated with pump P-101. The table below summarizes many of the tags typically needed for a PLC program. It should be viewed as a guideline. Whatever convention is chosen, consistency of tag naming between process areas and like equipment is the most important goal.

TABLE 1. PLC TAG NAMING CONVENTION		
Tag Name Suffix	Description	Variable Type
Auto	Field HOA switch in Auto	Discrete
Closed	Full Closed Limit Switch	Discrete
Current	Current Scaled	Real
DO	Dissolved Oxygen Scaled	Real
Fail	Transmitter Fault or Open connection	Discrete
Fail_to_Close	Fail to Close	Discrete
Fail_to_Open	Fail to Open	Discrete
Fault	Motor Fault, Common Fault	Discrete
Flow	Flow Scaled	Real
Flow_High	High Flow Alarm	Discrete
Flow_HiHi	High High Flow Alarm	Discrete
Flow_LoLo	Low Low Flow Alarm	Discrete
Flow_Low	Low Flow Alarm	Discrete
High_SP	High Level Alarm Set Point	Real
HiHi_SP	High High Alarm Set Point	Real
Key_On	Field Keyswitch or Disconnect position status	Discrete
Lag	Lag Status in sequence	Discrete
1st_Lag	First Lag Status in Sequence	Discrete
2nd_Lag	Second Lag Status in Sequence	Discrete
3rd_Lag	Third Lag Status in Sequence	Discrete
Lead	Lead Status in Sequence	Discrete
Level_High	High Level Alarm	Discrete
Level_HiHi	High High Level Alarm	Discrete
Level_LoLo	Low Low Level Alarm	Discrete
Level_Low	Low Level Alarm	Discrete
LoLo_SP	Low Low Alarm Set Point	Real
Low_SP	Low Level Alarm Set Point	Real
Manual	Manual HMI Mode Selection	Discrete
Open	Open Limit Switch	Discrete

**TABLE 1.
PLC TAG NAMING CONVENTION**

Tag Name Suffix	Description	Variable Type
PH	pH Scaled	Real
Position	Valve Position	Real
Position_Cmd	Valve Position Command	Real
Press	Pressure Scaled	Real
Press_High	High Pressure Alarm	Discrete
Press_HiHi	High High Pressure Alarm	Discrete
Press_LoLo	Low Low Pressure Alarm	Discrete
Press_Low	Low Pressure Alarm	Discrete
Remote	Field LOR or HOR switch in Remote	Discrete
Reset	Alarm reset	Discrete
Rotation	Position in sequence (1 is lead, 2 is lag, etc.)	Integer
Run_Cmd	Call to Start from PLC	Discrete
Running	Motor Running Status	Discrete
Runtime	Runtime	Real
Speed	Motor Speed	Real
Speed_Cmd	Speed Command to VFD	Real
Standby	Standby Status in Sequence	Discrete
Start_Cmd	Start command from HMI	Discrete
Starts_Count	Starts Counter	Integer
Stop_Cmd	Stop command from HMI	Discrete
Temp	Temperature Scaled	Real
Temp_High	High Temperature Alarm	Discrete
Temp_HiHi	High High Temperature Alarm	Discrete
Temp_LoLo	Low Low Temperature Alarm	Discrete
Temp_Low	Low Temperature Alarm	Discrete
TSS	Total Suspended Solids Scaled	Real

2.3.3 Tag Descriptions

PLC tags shall have a unique description field that contains the full name of the equipment and a phrase clarifying the function of the variable. For example:

**TABLE 2:
TAG DESCRIPTIONS**

Tag Name	Description
P101_Running	Influent Pump 1 Run Status
P101_Lead	Influent Pump 1 Lead Status

2.3.4 Rung and Routine Comments

PLC programs shall be fully documented. Provide comments for all program tasks, subroutines, ladder rungs, and instructions which relate the programming to the control sequence. Provide sufficiently detailed comments to enable reviewers to understand the logic flow and functions of the programs. Provide revision history of programs. PLC program documentation includes:

1. PLC Variable Descriptions: Provide complete descriptions as described above.
2. I/O Slot Names: Provide slot names that reference the type of I/O and the physical location within the rack.
3. Routine and Task Names: Include descriptive names for all routines and tasks.
4. Program Comments: Provide logic comments to clearly indicate the purpose of the routine, task or function. Comments should explain any interdependencies with other tasks or routines. All message instructions should clearly describe the remote device, content of shared data, and purpose for the instruction. Provide similar comments for Produced and Consumed tag communication.

2.4 PLC TIMEKEEPING

Calculations for process variables, such as hourly and daily flow totals, are typically performed by the PLC using the CPU's real-time clock and stored in registers available to the SCADA HMI and historian servers. Reliable data depends on relatively good synchronization (within a minute or two) between the PLC clock and the server computers' clocks. All PLCs should include a routine to periodically synchronize the clock to the servers. Using a script running on the HMI server to set a bit at a specific time of day and using a PLC routine to adjust the PLC clock is a reliable way to accomplish synchronization. The time of synchronization should account for any automatic daylight savings time adjustments in any PLC and ensure that any required adjustments occur early in the day.

2.5 PLC PROGRAM STORAGE

Provide a Secure Digital (SD) card with each PLC processor for nonvolatile memory storage. The SD card must be an industrial rated device suitable for use in the same environment as the controller. The memory card allows multiple files to be stored on the card. The user can manually trigger the controller to save or load from the card and also configure the controller to load from card on power up or when a problem is detected with the data in RAM.

CHAPTER 3. OPERATOR INTERFACE TERMINAL PROGRAMMING

3.1 OIT HARDWARE AND SOFTWARE STANDARD

Acceptable hardware includes Rockwell Automation Panel View Plus 1000 (10.4" display) or 1500 (15" display) color touchscreen terminals with an additional mechanical pushbutton interface. Acceptable software required for configuring these terminals is Rockwell Automation Factory Talk View ME programming software. Software version should be coordinated with the City prior to development to ensure the City's version is compatible.

3.2 OIT PROGRAM DEVELOPMENT

3.2.1 Required Screens

Each OIT monitors and controls equipment associated with the PLC and process area in which it is located. The P&ID drawings indicate the particular PLC associated with a given process area.

To minimize potential confusion, the OIT graphics, monitoring and control features should be similar to the SCADA HMI. Given the relatively limited screen area and resolution of the Plant's OITs, a complete reproduction of the SCADA HMI screen features may not be appropriate. The typical intended purpose of an OIT is to provide Operators and Maintenance staff field access to the most used operating indicators and functions for a nearby process.

3.2.2 OIT Tag Naming

Tag names for OIT registers can most efficiently be imported in groups from the desired PLC(s), or alternatively, browsed directly over the network. It is convenient to use the same tag names as used in the PLC.

3.2.3 OIT Alarms

Each OIT has an alarm log that includes active alarms and alarm history for the alarm tags associate with the OIT's process area(s). Display and alarm acknowledge capabilities are included, though the alarm databases for the OITs are independent of the SCADA alarm database. Acknowledging alarms on the SCADA HMI does not acknowledge those alarms on the OITs. Overall, every HMI alarm derived from a PLC tag has a one-to-one correspondence with the OIT alarm databases.

3.3 OIT TIMEKEEPING AND SYNCHRONIZATION

Display the OIT clock on a status screen, including date and time. Useful alarm logs available on the OIT depend on accuracy of the OIT's real-time clock. Synchronizing the OIT to its partner PLC on a daily basis is recommended to avoid delaying daylight savings time adjustments.

3.4 OIT PROGRAM STORAGE

OIT programs are developed offline and compiled to generate machine code which can then be downloaded to OIT flash memory. Both the development program (.apa file extension for Rockwell Panel View OITs) and the compiled, download-ready program (.mer file extension for Panel View OITs) should be stored in a safe location. The compiled files are necessary to reload the application if the OIT hardware fails and should be easily accessible by maintenance. Use of a flash memory card is a simple way to reload a compiled program without a laptop. Changes to OIT graphics require access to the latest development program.

CHAPTER 4. NETWORKS

The following paragraph discuss the basic features of the control system network.

4.1 NETWORK ARCHITECTURE

The PLCs are connected on a redundant fiber-optic ring architecture using managed switches. This feature provides automatic recovery in the event one of the cable segments between any two PLCs is disconnected or one of the switches fails. In the case of media failure in one of the segments, communication between all

PLCs and servers should remain functional. In the case of switch failure, the PLC connected directly to the switch (along with other devices connected to the switch) will lose connectivity with the rest of the network, but the remaining switches and associated devices should remain connected. Network redundancy will not protect against an outage unless it is monitored for a fault.

For remote sites; the existing MOSCAD should remain in place and operational after upgrading to cellular Ethernet. This will provide a redundant path in the event of a primary path failure.

4.2 NETWORK MONITORING

As discussed in the previous paragraph, effective application of network redundancy depends on continuous fault monitoring. Fault monitoring at the Plant includes the following features:

1. PLCs and/or the HMI alarm server monitors the status of all managed switches on the control system LAN. Switch faults alert maintenance staff so the fault can be corrected.
2. All redundant rings on the network are monitored and any break in the ring shall be indicated on a graphical schematic on the HMI showing the relative location of the open connection. Any alarm indicating the presence an open loop is logged by the SCADA system.
3. Power status to all network components is monitored for on/off status. UPS equipment is monitored for battery status. All redundant back-up power supply systems are monitored for abnormal conditions.
4. The HMI application includes a heartbeat algorithm to monitor the communication status of each PLC on the network. Communication status is available on the designated PLC diagnostic screen of the HMI. A loss of communication lasting longer than 10 seconds is logged as a PLC communication loss alarm on the SCADA system.

CHAPTER 5. HMI ALARMING

5.1 HMI ALARM DATA FLOW AND PROCESSING

HMI Alarms are tags in the HMI (InTouch) tag database that are primarily derived from PLC tags but are also commonly derived from other signals monitored by the SCADA system, including the servers, managed network switches, and 3rd party embedded controllers, such as Ethernet-connected standby generators and power monitors. Scripts can be implemented in the HMI to consolidate several tags into a single alarm tag.

Alarms have assigned priorities and are organized into callout groups within the alarm notification database. Critical alarms are called-out via the City's Win 911 auto-dialer application. The alarm database, including all messages, priority, and grouping details, is normally developed when a PLC is commissioned and requires coordination with City Operations. Testing the complete alarm database is essential. A completed table of the as-built alarms and associated details must be provided with the O&M materials for each PLC.

Alarm notifications should be transmitted to the following:

- Operations to be notified of all alarms including IT related alarms associated with the SCADA equipment.
- SCADA Technician to be notified of all alarms including IT related alarms associated with the SCADA equipment.

- IT to be notified of all IT related alarms associated with the SCADA equipment.

5.2 REQUIRED ALARMS

The following alarms are required:

1. All equipment faults. In many cases a few “common” faults can be used as a proxy for more numerous groups of specific equipment faults. In general, common faults can be appropriate if the more specific faults are annunciated locally at the equipment.
2. Instrument out of range.
3. Instrument process variable low and/or high. Each analog instrument may have one to four or more alarms associated with the appropriate set-point thresholds.
4. Communication link status. This category includes all Ethernet links for all managed switches that have standby links and failover.
5. PLC communication status, often implemented at the IO servers or between PLCs that communicate with each other.
6. PLC faults as described above.
7. Utility and standby power status.
8. UPS status, including line power and battery condition.
9. Server Faults. This includes UPS status, hardware faults, etc.
10. Application Faults. This includes critical applications, such as the Win 911 notification, HMI data acquisition, and the Historian applications.

CHAPTER 6.

OPERATIONS AND MAINTENANCE MATERIALS

6.1 PLC PROGRAMS

All PLC programs (executable project files) shall be archived in a safe location at the Plant, including removable storage (SD card) and server memory, provided it is backed up on a regular basis. Hard drives on computers used to modify PLC programs are not considered a reliable storage medium. Provide a hard copy of all working PLC programs.

6.2 HMI APPLICATION PROGRAMS

Useful backup files for OIT programs include both the development files and the compiled files used for download to the OIT devices. Storage must be as described above for PLC programs and should be located in the same place. Wonderware HMI application and configuration files, Historical database files, alarm database files must be similarly archived. Written, step-by-step procedures for restoring a PLC, OIT, workstation or server in the event of failure should be located in a safe location and reviewed periodically.

6.3 MISCELLANEOUS EQUIPMENT CONFIGURATION DATA

Configuration parameters and settings for all microprocessor based devices must be archived in a secure location and kept current. Such items include:

1. Network switch and router configuration files.

2. IP address list for all equipment.
3. VFD and solid state starter configuration files.
4. Instrument configuration files, including those for all ultrasonic level transmitters, flow transmitters, pressure transmitters, and process analyzers.
5. Miscellaneous microprocessor based devices.
6. Vendor supplied packaged control panel devices.

CHAPTER 7. REFERENCES

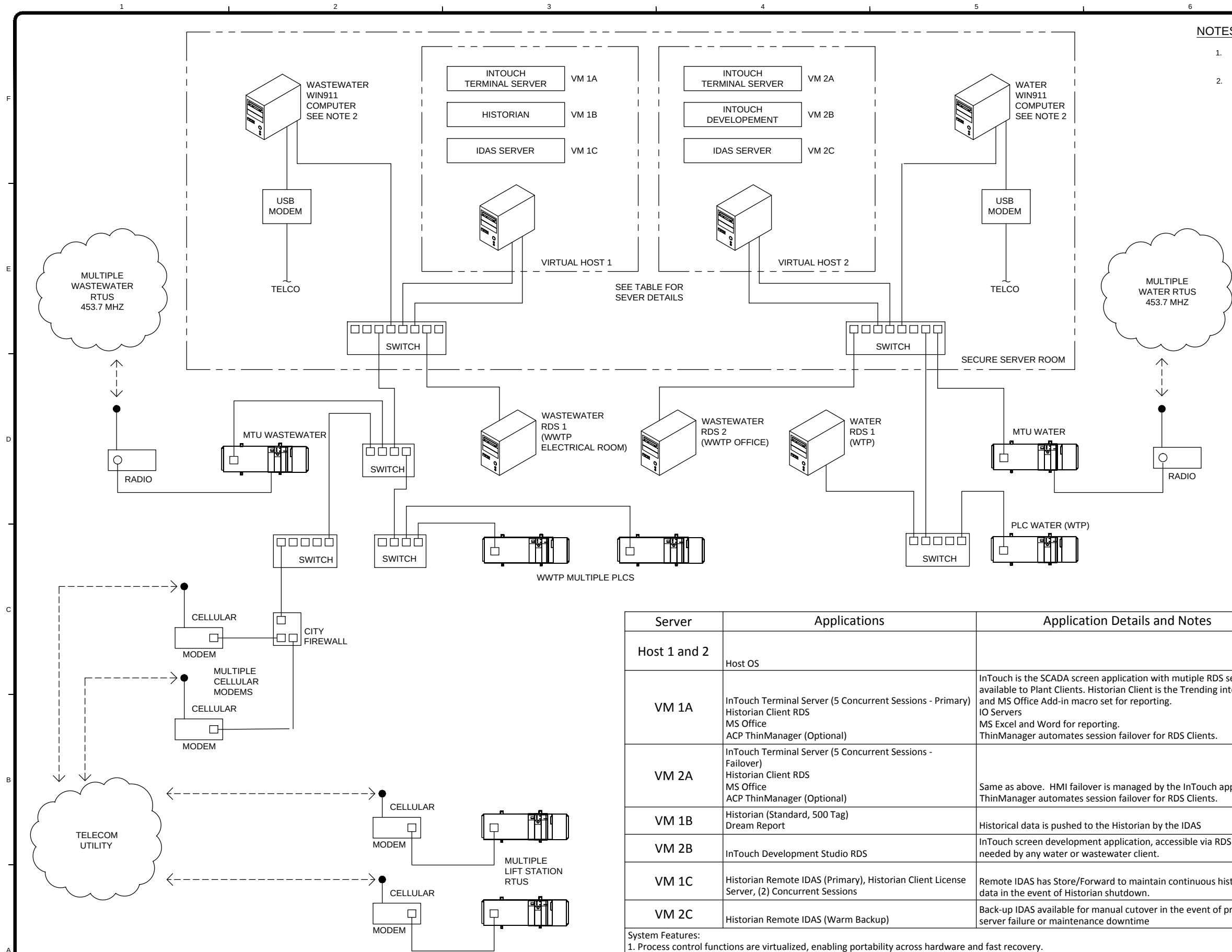
Logix 5000 Controllers Common Procedures Programming Manual, 1756-PM001I-EN-P, January, 2007.

PLC Installation And Programming Guidelines Manual, Rev H.1, Aug 2007, King County Dept. of Natural Resources.

City of Snoqualmie Department of Public Works
SCADA Master Plan

APPENDIX 2.
DRAWING I-001, PROCESS NETWORK DIAGRAM

10/22/2015 9:03:17 AM - P:\12466\135-12466-15001\CAD\SHHEETFILES\I-001.DWG - ENGLISH, SHANNON



NOTES:

1. THIS DRAWING NOT INTENDED TO CONVEY ALL NETWORK COMPONENTS AND MEDIA DETAILS.
2. WONDERWARE RECOMMENDS WIN911 BE ON STAND ALONE COMPUTERS. IN TOUCH RDS LICENSE REQUIRED.

Server	Applications	Application Details and Notes	Minimum Requirements
Host 1 and 2	Host OS		Dedicate one storage drive for the host OS, at least one for each VM, and one general drive for backups
VM 1A	InTouch Terminal Server (5 Concurrent Sessions - Primary) Historian Client RDS MS Office ACP ThinManager (Optional)	InTouch is the SCADA screen application with mutiple RDS sessions available to Plant Clients. Historian Client is the Trending interface and MS Office Add-in macro set for reporting. IO Servers MS Excel and Word for reporting. ThinManager automates session failover for RDS Clients.	4 Cores, 4 GB RAM, 100 GB RAM
VM 2A	InTouch Terminal Server (5 Concurrent Sessions - Failover) Historian Client RDS MS Office ACP ThinManager (Optional)	Same as above. HMI failover is managed by the InTouch application. ThinManager automates session failover for RDS Clients.	4 Cores, 4 GB RAM, 100 GB RAM
VM 1B	Historian (Standard, 500 Tag) Dream Report	Historical data is pushed to the Historian by the IDAS	4 Cores, 4 GB RAM, 500 GB RAM
VM 2B	InTouch Development Studio RDS	InTouch screen development application, accessible via RDS when needed by any water or wastewater client.	2 Cores, 2 GB RAM, 100 GB RAM
VM 1C	Historian Remote IDAS (Primary), Historian Client License Server, (2) Concurrent Sessions	Remote IDAS has Store/Forward to maintain continuous historical data in the event of Historian shutdown.	4 Cores, 4 GB RAM, 100 GB RAM
VM 2C	Historian Remote IDAS (Warm Backup)	Back-up IDAS available for manual cutover in the event of primary server failure or maintenance downtime	4 Cores, 4 GB RAM, 100 GB RAM

System Features:

1. Process control functions are virtualized, enabling portability across hardware and fast recovery.
2. Process control functions run on protected servers.
3. Existing InTouch applications can be used as-is with no re-development.
4. Redundant InTouch applications ensure real-time control availability.
5. Store and forward data acquisition (IDAS) maintains historical data continuity when the Historian is down.
6. Back-up IDAS ensures historical data continuity if primary IDAS is taken down for maintenance.



MARK	DATE	DESCRIPTION	BY

CITY OF SNOQUALMIE
SNOQUALMIE, WA
SNOQUALMIE PUBLIC WORKS
PROCESS NETWORK
DIAGRAM

Project No.: 135-12466-15001
Designed By: RH
Drawn By: RSM
Checked By: SE

I-001

Bar Measures 1 inch



www.tetratech.com
1420 FIFTH AVE, SUITE 600
SEATTLE, WA 98101
MAIN: (206) 883-9300 FAX: (206) 883-9301

Copyright: Tetra Tech

APPENDIX 3.
CITY WW CAMPUS SERVER DIAGRAM

Diagram illustrating a network connection setup between a switch and a rack of servers.

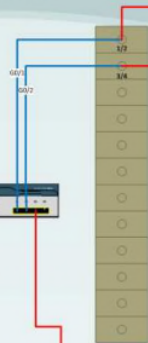
Switch Configuration:

- SW Name: Braeburn
- SW IP (Vlan1): 100.100.100.72
- SW IP (Vlan106): 192.168.10.5
- SW IP (Vlan105): 10.10.50.5.5
- Sec PLC Sw: 192.168.10.22
- Fiber 1-12 <--> PLC Control

Connection Details:

- The switch is connected to a rack of servers via a fiber optic cable (labeled 12/1).
- The rack contains multiple server slots, with the top two slots labeled 1/1 and 1/4.
- The connection is labeled 100/7.

Fiber 1-12 <---> PLC Control



PLC CONTROL BLDG

SW Name: Kinsey
 SW IP (Vlan106): 192.168.10.6
 SW IP (Vlan105): 10.10.50.6

Pri PLC Sv: 192.168.10.20
 PLC Controller: 192.168.10.21

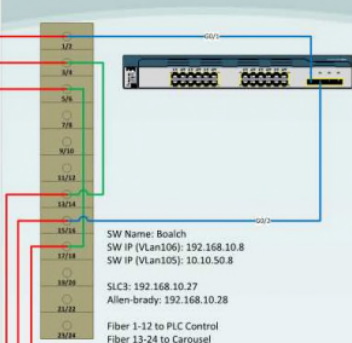
Box 1: Fiber 1-12 to Main
 Box 2: Fiber 1-12 to Solids; Fiber 13-24 to Headworks

HEADWORKS BLDG

The diagram illustrates a network setup for the Headworks Bldg. On the left is a patch panel with ports labeled 1/2, 3/4, 5/6, 7/8, 9/10, 11/12, 13/14, 15/16, 17/18, 19/20, 21/22, and 23/24. On the right is a network switch with two rows of ports. A blue line labeled 'G0/1' connects the switch to the patch panel, and another blue line labeled 'G0/2' connects the switch to the patch panel. Below the patch panel, the following information is listed:

SW Name: Boalch
SW IP (Vlan106): 192.168.10.8
SW IP (Vlan105): 10.10.50.8
SLC3: 192.168.10.27
Allen-brady: 192.168.10.28
Fiber 1-12 to PLC Control
Fiber 13-24 to Carousel

Fiber 1-12 to PLC Control
Fiber 13-24 to Carousel



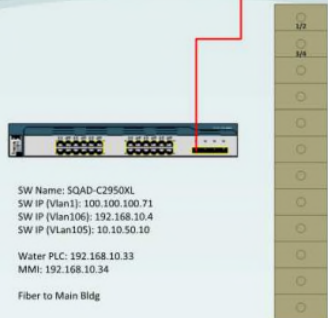
WATER BLDG

SW Name: SQAD-C2950XL
 SW IP (Vlan1): 100.100.100.71
 SW IP (Vlan106): 192.168.10.4
 SW IP (Vlan105): 10.10.50.10

Water PLC: 192.168.10.33
 MM1: 192.168.10.34

Fiber to Main Bldg

Fiber to Main Bldg

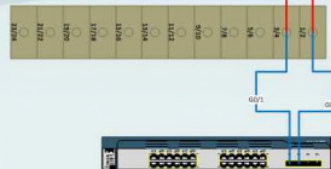


SW Name: Autumn
 SW IP (Vlan106): 192.168.10.7
 SW IP (Vlan105): 10.10.50.7

SLC1: 192.168.10.21, 192.168.10.24
 SLC2: 192.168.10.25, 192.168.10.26

Fiber 1-12 to PLC Control

Fiber 1-12 to PLC Control



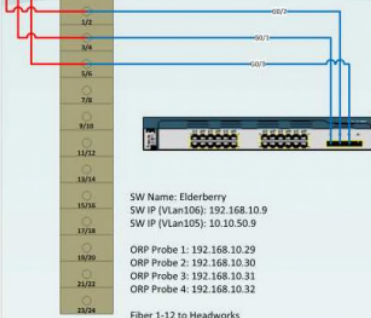
CAROUSEL BLDG

SW Name: Elderberry
SW IP (Vlan106): 192.168.10.9
SW IP (Vlan105): 10.10.50.9

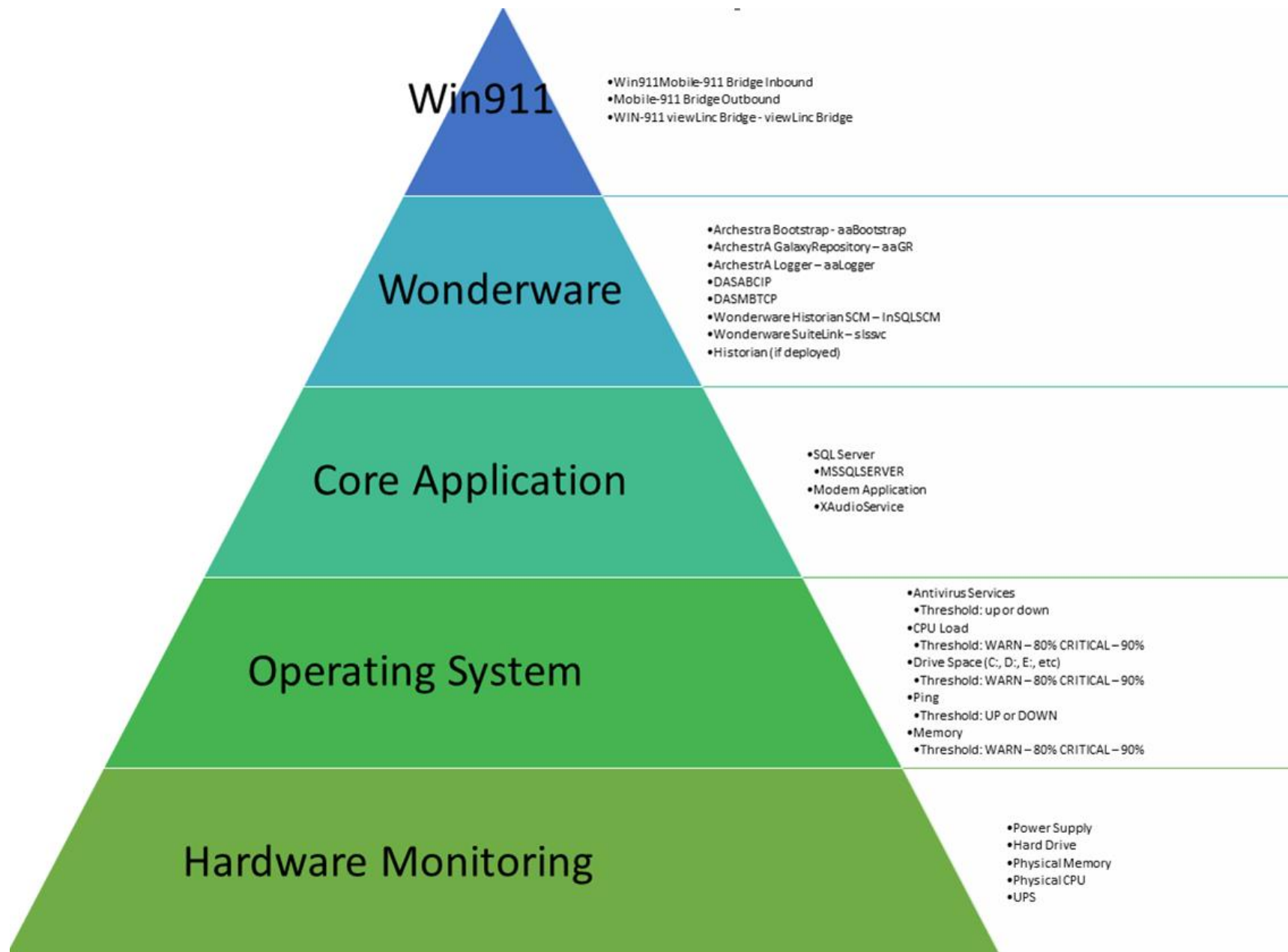
CRP Probe 1: 192.168.10.29
CRP Probe 2: 192.168.10.30
CRP Probe 3: 192.168.10.31
CRP Probe 4: 192.168.10.32

Fiber 1-12 to Headworks

Fiber 1-12 to Headworks



APPENDIX 4.
MONITORING DEPENDENCY BREAKDOWN



City of Snoqualmie Department of Public Works
SCADA Master Plan

APPENDIX 5.
TECHNICAL MEMORANDUM A

City of Snoqualmie SCADA MASTER PLAN

TECHNICAL MEMO A: TELEMETRY, PLCS AND INSTRUMENTATION

Draft: April 3, 2015

Revised: May 29, 2015

1. PURPOSE

This purpose of this memo is to document the existing systems and to identify potential improvements related to the telemetry, PLCs, and instrumentation used to monitor and control the treatment and delivery processes for the water and wastewater systems. The material in this memo is intended to facilitate the City's decisions regarding telemetry, PLC, and instrumentation standards and system improvements. Further refinement of selected items is anticipated and will be addressed in the forthcoming Technical Memo C and the Master Plan Final Report.

2. ABBREVIATIONS AND ACRONYMS

CPU: Central Processing Unit.

DA Server: Data Acquisition Server, the HMI server software component that collects data from field devices including PLCs.

DSL: Digital Subscriber Line. A communication utility-provided link that uses a telephone utility circuit to transmit digital data.

Ethernet: A computer networking standard that defines a family of protocols, communication media, and device interfaces.

HMI or MMI: Human Machine Interface, a computer that run graphical interface software for monitoring and supervisory control of a control system.

IO: Inputs and Outputs, typically the connection to field instruments and equipment.

IT: Information Technology.

LAN: Local Area Network, made up of the connection media, networking components, and nearby devices that communicate with each other.

Mbps: Mega-bits per second. A unit of measure for communication speed.

MTU: Master Telemetry Unit, a controller that communicates with multiple RTUs.

NIC: Network Interface Card.

OIT: Operator Interface Terminal.

OPC: Object Linking and Embedding (OLE) for Process Control. A standard that enables data exchange between devices made by multiple manufacturers.

PLC: Programmable Logic Controller – Typically consists of a CPU, IO modules, and communications hardware.

RDS: Remote Desktop Services. Windows service that allows remote control of a user session on a remote server.

RIO: Remote IO – chassis-mounted IO and communications hardware but no local CPU.
RTU: Remote Telemetry Unit, a controller for local equipment that communicates with the MTU.
SCADA: Supervisory Control and Data Acquisition.
SMS: Short Message Service, or text messaging on mobile devices.
SQL: Structured Query Language. A database standard that includes a set of common instructions used to extract and present data.
TCP/IP: Transmission Control Protocol/Internet Protocol. Communication protocol standards that enable network communications.
UPS: Uninterruptible Power Supply, a battery-backed source fed by the utility service during normal operation.
USB: Universal Serial Bus. A short distance, high bandwidth cable communication interface standard.
VLAN: Virtual Local Area Network, a software configured segmentation of local networks on a common router or managed switch.
VPN: Virtual Private Network, a secure means of connecting a physically remote host to a LAN, typically via the Internet.
VM: Virtual Machine, a software application that allows a host computer or server to run one or more copies of another “virtualized” operating system and any of its associated applications.
Win 911: A software application used to annunciate and acknowledge alarms to/from remote users.
Win 411: A component of Win 911 that enables simple audio reporting of analog values.
Wonderware or Wonderware InTouch: The software application used at the WWTP and WTP to read and write real-time data from/to controllers.
WTP: Water Treatment Plant.
WWTP: Wastewater Treatment Plant.

3. PLC STANDARDS AND REPLACEMENT ALTERNATIVES

3.1. Motivation

The City has requested guidance regarding PLCs standards because the variety of PLCs and RTUs in use has made it difficult to keep an inventory of spare parts, train maintenance staff, maintain PLC programming computers, and to establish common software development criteria. Additionally, critical components, like the CPU and communications modules in the Quantum PLC racks at the WTP and WWTP are obsolete and need to be replaced. The upcoming WWTP expansion project is another motivating factor.

3.2. Existing PLC Inventory

The following PLCs and RTUs are in use at the water facilities. * indicates the RTU serves a site with both water and wastewater facilities:

- Water Treatment Building: Schneider Quantum 140-CPU-013-04
- Reservoir 1040: Schneider Quantum Hot Standby (installed 2005)
- Irrigation PS: Automation Direct Logic Do-05AR
- Water MTU (old Public Works Building): Motorola ACE3600
- Kimball Creek (RTU#4): Motorola MOSCAD*
- 1040 Reservoir (RTU#5): Motorola MOSCAD-L
- Snoqualmie Point (RTU#22): Motorola ACE3600
- River PRV (RTU#25): Motorola ACE3600
- 599 Reservoir (Lift Station Z, RTU#15): Motorola MOSCAD*
- 1040 Pump Station (RTU#1): Motorola MOSCAD
- Well 6/7 (RTU#2): Motorola MOSCAD
- Canyon Springs (RTU#12): Motorola MOSCAD

- Well 8 (RTU#13): Motorola MOSCAD
- SWTP (RTU#17): Motorola MOSCAD
- 384th St Booster (RTU#21) Motorola ACE3600

The following PLCs and RTUs are in use at the wastewater facilities:

- Wastewater Treatment Equipment Building: Schneider Quantum 140-CPU-213-04
- Headworks: Allen Bradley SLC 5/05
- Centrifuge: Allen Bradley SLC 5/05
- Fenton Dryer: Allen Bradley SLC 5/05
- Sand Filters: Modicon Micro PLC and Allen Bradley MicroLogix PLC
- Lift Station E: Automation Direct Logic Do-05AR PLC
- Re-used water chlorine analyzer and 1040 Pump Station: Banner DX-80 900 MHz Wireless Gateway and Node
- Golf Course Chlorine Residual RTU: Motorola ACE3600
- Wastewater MTU: Motorola ACE3600
- Lift Station N6 (RTU#3): Motorola MOSCAD
- Hospital Lift Station (RTU#23): Motorola ACE3600
- Lift Station E (RTU#7): Motorola MOSCAD
- Lift Station K3 (RTU#10): Motorola MOSCAD
- Lift Station 1 (RTU#14): Motorola MOSCAD
- Lift Station K2 (RTU#16): Motorola MOSCAD
- Lift Station 4 (RTU#19): Motorola ACE3600
- Lift Station S12A (RTU#24): Motorola ACE3600
- Lift Station BP (RTU#6): Motorola MOSCAD
- Lift Station F (RTU#9): Motorola MOSCAD
- Lift Station L (RTU#11): Motorola MOSCAD
- Lift Station N (RTU#18): Motorola MOSCAD
- Lift Station Z (RTU#15): Motorola MOSCAD*
- Lift Station 3 (RTU#20): Motorola ACE3600

3.3. Recommendations for a PLC Standard

The following considerations are intended to guide the City's decisions regarding a PLC standard:

- a. The PLC platform selected should be well-supported by the manufacturer and local Integrator community.
- b. The programming software should be easy to use and familiar to maintenance staff.
- c. The existing PLCs at water and wastewater facilities are predominately by two manufacturers: Schneider and Allen Bradley. Both manufacturers are well established and have current models suited to the City's needs (Allen Bradley Controllogix/Compactlogix or Schneider M340). Choosing new PLCs from one of these manufacturers, rather than another alternative manufacturer, is recommended. The choice between the two may come down to owner preference. Considerations that impact this decision include familiarity with the programming software, access to knowledgeable technical support, and availability of experienced programmers.
- d. Packaged equipment often contains a small PLC or embedded controller. Most packaged equipment manufacturers are willing to provide a PLC or network communication protocol to suit the owner's standard.
- e. With the appropriate telemetry communication infrastructure, PLCs can be used in place of RTUs. This approach avoids the hardware, programming, and maintenance cost of installing an RTU at sites that have a PLC. Where integration with the existing MOSCAD MTU is not required, as is

the case for the lift stations because their operation does not depend on remote process signals, use of a standard PLC alone (no MOSCAD RTU) is a good solution.

3.4. Recommendations and Alternatives for PLC Replacement

PLC replacement alternatives for the WWTP:

- a. Replace only the CPU and communication modules in the existing WWTP PLC control panel. If the City chooses to keep these PLCs in operation, the manufacturer advises that these CPU and Ethernet communication modules be replaced with module(s) that are currently supported. The existing input and output (I/O) modules for these PLCs continue to be supported and one-for-one replacements are available. If the CPUs are replaced, the existing Proworx programming application software will need to be upgraded to the manufacturer's current Unity programming application. The existing logic can be readily converted to the Unity format if the CPU modules are replaced. This is a cost-effective option if the existing equipment and processes will remain undisturbed with the new WWTP expansion. Supplier information is attached in the Appendix. If the new expansion will significantly impact the way the existing equipment is controlled, one of the following alternatives may be preferred.

Pros:

- Enables the CPU module to run with currently supported software.
- The existing logic is easily converted into the newer instruction format.
- Cost and operational disruption associated with re-wiring is avoided.

Cons:

- The Quantum platform is not among the recommended new PLC alternatives.
- The O&M staff have indicated that they have received better support from other platform providers.

- b. If the planned WWTP expansion requires that existing logic running in the existing PLC be modified or that the I/O capacity be expanded to control new equipment, it may be cost-effective to replace the PLC with a remote I/O chassis and move the logic processing to a new PLC CPU located in a new control panel. This approach allows for replacing the PLC with the new standard platform and avoids the need to replace the field wiring to the existing field instruments and motor control equipment that will remain in operation. The new PLC panel would contain enough capacity for the new equipment and future growth.

Pros:

- Replaces the obsolete PLC with a new remote I/O platform consistent with the City's chosen PLC standard.
- Extends the system lifecycle by 15 to 20 years.
- Cost and operational disruption associated with field re-wiring is avoided.

Cons:

- If an alternative to Schneider is selected for the PLC platform, the existing logic will need to be re-created and re-commissioned.
- The need to replace the final connections between existing field terminals and the new I/O chassis would require additional labor relative to the previous option.
- The existing equipment will need to be re-commissioned to run on the new PLC platform.

- c. Replace the existing PLC control panel in place with a new control panel containing a new PLC and additional capacity. This option is more disruptive to current operation than the previous alternatives because it requires that existing field wire be disconnected while the enclosure is replaced. If new equipment is being connected, additional raceway may be required. If the new panel is larger than the existing, nearby equipment may need to be relocated.

Pros:

- Replaces the obsolete PLC with a new remote I/O platform consistent with the City's chosen PLC standard.
- Extends the system lifecycle by 15 to 20 years.
- Re-uses the existing enclosure space.

Cons:

- If an alternative to Schneider is selected for the PLC platform, the existing logic will need to be re-created and re-commissioned.
- The need to replace the final connections between existing field terminals and the new I/O chassis would require additional labor relative to the first option.
- Replacement or re-termination of existing field wiring represents additional labor relative to the previous two options.
- The existing equipment will need to be re-commissioned to run on the new PLC platform.

Similar options are available for the existing WTP Building PLC. If no significant modifications to the equipment in this facility are anticipated within the next 5-7 years, simply replacing the CPU and communications modules and re-formatting the program should address the City's immediate concerns about component obsolescence.

4. TELEMETRY IMPROVEMENTS

4.1. Motivation

The City has expressed concerns about the reliability of the existing radio telemetry. Unreliable telemetry causes two main problems for the City. The first is the added time delay between a failure event and the notification of the alarm. The second is the loss of historical data collection during communication outages.

The recent relocation of the water system MTU and its antenna to the Public Works Building appears to have improved communications for the water sites, but communications to wastewater lift stations remains unsatisfactory. Times between successful polls range up to 10 minutes. Wastewater site communication problems are compounded by their siting at typically low elevations relative to surrounding topography. For comparison, modern SCADA systems comparable in size to the City of Snoqualmie and larger have typical polling periods of a minute or less.

The polling success rate and delay between successful transmissions is not currently monitored by the SCADA system. The lack of such diagnostic data has prevented a clear assessment of system performance.

4.2. Existing Telemetry System Overview

The City's existing telemetry system consists of the following major components:

- Water MTU located at the Public Works Building
- Remote Water sites, consisting of 12 RTUs.
- Wastewater MTU located at the WWTP
- Remote wastewater lift stations, consisting of 14 RTUs.
- Radio repeater located at the 1040 Reservoir.

The MTUs are Motorola ACE3600 and communication over radio (UHF 453.7 MHz) with the RTUs. The RTUs are a mix of Motorola MOSCAD, MOSCAD-L, and ACE3600. The MOSCAD and MOSCAD-L are obsolete devices. All but two remote water and wastewater sites (MOSCAD RTUs) rely on the single repeater located at the 1040 reservoir to communicate with the MTUs. Data sheets for the existing MTUs and RTUs are attached in the Appendix.

The polling from both MTUs is not coordinated. Each MTU relies on the same repeater and operates at the same frequency. The repeater does not have store and forward capability, and there is no mechanism to prevent the MTUs from sending overlapping transmissions which may result in data collisions and significantly increased the polling times.

Polling for the water sites uses a “report by exception” algorithm meaning that the RTUs will send a signal to the MTU when one or more process variables changes by a preset threshold or when an event or alarm changes state. If any given water site does not report within an established time period, the Water MTU polls the site. The Wastewater MTU polls the lift stations on a fixed polling period.

4.3. Recommendations and Alternatives for Telemetry

The following recommendations and alternatives are proposed:

- a. Establish a baseline for existing MTU-RTU performance. Two options:
 - Implement MOSCAD-specific communication logger software. This product is available from a vendor for about \$2,000. See Appendix for additional information.
 - Implement a poll-time counter on the MTUs and log the data on Wonderware. Each site’s cyclic poll time is logged and hourly averages can be calculated. This method requires that the MTU be set up for periodic polling (rather than “report-by-exception”).
- b. Relocate the Water MTU to the 1040 Reservoir. If a reliable Ethernet communications path can be established between the 1040 Reservoir and the WWTP campus (DSL, cellular, etc.), the repeater can be eliminated. The relocated MTU could operate as it does now, performing the poll management from the 1040 location, and the primary data path for the SCADA servers would be over the new link. The Wastewater MTU remaining at the WWTP could enable the existing radio to operate as the back-up path if the new primary link fails. A new OPC server would be recommended to manage the failover.
- c. Evaluate alternative pathways for sites that do not have reliable radio reception. Use the baseline performance information obtained per the suggestions above as the basis for comparison. A cellular modem solution has recently been implemented at the new hospital lift station, a site that does not have reliable radio reception to the existing MTU. This new experience will inform the City’s decisions for other sites. A datasheet for an example cellular modem is attached in the Appendix.
- d. Consider bypassing the MTUs for sites where possible. The MTU may be needed to manage data exchange between sites, but for sites that do not depend on data from another site, such as the lift stations, bypassing the MTU eliminates a point of failure. Another advantage of bypassing the MTU is the avoided need for using another Motorola RTU. For example, the new hospital RTU does not rely on the MTU for SCADA data exchange because a “tunnel” has been configured between the LAN and the Ethernet port on the ACE 3600 RTU. Because this path does not depend on the radio and the MTU, this new RTU could have been another manufacturer’s Ethernet-capable PLC.
- e. Transition the wastewater sites away from the radio system. Transitioning the lift stations to a cellular or other communication option should improve the performance of the water system’s radio network by eliminating traffic and avoiding data collisions associated with the second MTU. Note that the obsolete RTUs now in use (MOSCAD) will need to be replaced with a new PLC if a new communication path is implemented to these particular sites.

5. INSTRUMENTATION AND MONITORING ENHANCEMENTS

5.1. Motivation

Given the upcoming investment in SCADA infrastructure, this is an ideal time to reviewing the City's needs and desires regarding instrumentation.

5.2. Water System Instrumentation

The following were identified by the City in the recent workshop:

- a. Implement VFD communication capability for water pumps. For VFDs installed within the last 10 years, this is a cost-effective method for obtaining real-time monitoring of power, current, and speed data. Power data is useful for accurate pump performance curve and efficiency analysis. Motor current data can be useful for identifying pump problems prior to failure.
- b. Implement flow pacing for arsenic treatment with ferric chloride. Currently the feed pump stroke and frequency are adjusted manually.
- c. Install turbidity analyzers for WTP filters.
- d. Add power monitoring for large equipment and at strategic locations on switchgear. These devices are relatively inexpensive, especially when purchased with new switchgear, and come with Ethernet capability. Power data is useful for energy efficiency analysis, monitoring utility service voltage, and evaluating standby generator performance.

5.3. Wastewater System Instrumentation and Monitoring Improvements

The following were identified by the City in the recent workshop:

- a. Implement VFD communication upgrades where practical, including on non-potable water pumps.
- b. Add aeration basin DO, ORP, pH analyzers.
- c. Implement automatic clarifier sludge depth monitoring.
- d. Add analog level monitoring for scum well.
- e. Implement transmittance monitoring for UV systems
- f. Implement motor current monitoring for lift station pumps.
- g. Add outdoor air temperature monitoring at lift stations.
- h. Implement power monitoring for large equipment and at strategic locations on switchgear.
- i. Remove check valve position from the list of lift station alarms. Retain status monitoring only.
- j. Install discharge flow meters on lift stations for flow analysis and pump performance monitoring.
- k. Adjust the time delay for the Hole 9 chlorine residual monitoring (reference Continuous Monitoring Plan) or relocate the analyzer.
- l. Connect the existing Headworks, Centrifuge, and Dryer PLCs on the LAN and monitor significant process parameters with the SCADA HMI. These PLCs are Ethernet-ready. Once the desired process parameters are identified the implementation should be relatively simple and inexpensive.

6. APPENDIX

Attached items include:

- a. Water Control System Communication Block Diagram.
- b. Wastewater Control System Communication Block Diagram.
- c. ACE 3600 data sheet
- d. MOSCAD data sheet
- e. MOSCAD-L data sheet
- f. Quantum CPU pricing (email)
- g. Communication Logger data sheet



- h. Communication Logger pricing (email)
- i. Sierra Raven XE cellular modem data sheet.

City of Snoqualmie Department of Public Works
SCADA Master Plan

APPENDIX 6.
TECHNICAL MEMORANDUM B

City of Snoqualmie SCADA MASTER PLAN

TECHNICAL MEMO B: SCADA HEAD-END

Draft: March 18, 2015

Revised: June 8, 2015

1. PURPOSE

This purpose of this memo is to document the existing systems and to identify potential improvements related to the SCADA network, server equipment, and the software applications used to collect data and perform supervisory control of the water and wastewater systems. The material in this memo is intended to facilitate the City's decisions regarding SCADA standards, policies, and system improvements. Further refinement of selected items is anticipated and will be addressed in the forthcoming Technical Memo C and the Master Plan Final Report.

2. ABBREVIATIONS AND ACRONYMS

CPU: Central Processing Unit

DA Server: Data Acquisition Server, the HMI server software component that collects data from field devices including PLCs.

Ethernet: A computer networking standard that defines a family of protocols, communication media, and device interfaces.

HMI or MMI: Human Machine Interface, a computer that run graphical interface software for monitoring and supervisory control of a control system

IO: Inputs and Outputs, typically the connection to field instruments and equipment.

IT: Information Technology

LAN: Local Area Network, made up of the connection media, networking components, and nearby devices that communicate with each other.

Mbps: Mega-bits per second. A unit of measure for communication speed.

MTU: Master Telemetry Unit, a controller that communicates with multiple RTUs.

NIC: Network Interface Card.

OIT: Operator Interface Terminal.

OPC: Object Linking and Embedding (OLE) for Process Control. A standard that enables data exchange between devices made by multiple manufacturers

PLC: Programmable Logic Controller – Typically consists of a CPU, IO modules, and communications hardware.

RDS: Remote Desktop Services. Windows service that allows remote control of a user session on a remote server.

RIO: Remote IO – chassis-mounted IO and communications hardware but no local CPU.

RTU: Remote Telemetry Unit, a controller for local equipment that communicates with the MTU.

SCADA: Supervisory Control and Data Acquisition.

SMS: Short Message Service, or text messaging on mobile devices.

SQL: Structured Query Language. A database standard that includes a set of common instructions used to extract and present data.

TCP/IP: Transmission Control Protocol/Internet Protocol. Communication protocol standards that enable network communications.

UPS: Uninterruptible Power Supply, a battery-backed source fed by the utility service during normal operation.

USB: Universal Serial Bus. A short distance, high bandwidth cable communication interface standard.

VLAN: Virtual Local Area Network, a software configured segmentation of local networks on a common router or managed switch.

VPN: Virtual Private Network, a secure means of connecting a physically remote host to a LAN, typically via the Internet.

VM: Virtual Machine, a software application that allows a host computer or server to run one or more copies of another “virtualized” operating system and any of its associated applications.

Win 911: A software application used to annunciate and acknowledge alarms to/from remote users.

Win 411: A component of Win 911 that enables simple audio reporting of analog values.

Wonderware or Wonderware InTouch: The software application used at the WWTP and WTP to read and write real-time data from/to controllers.

WTP: Water Treatment Plant

WWTP: Wastewater Treatment Plant

3. EXISTING SCADA SYSTEM OVERVIEW

The City’s existing SCADA system includes dedicated server workstations that monitor and provide supervisory control for the following:

- Water Treatment Facility (WTP)
- Water Telemetry System, consisting of 12 RTUs and one dedicated MTU
- Wastewater Treatment Plant (Water Reclamation Facility or WWTP)
- Wastewater Telemetry System, consisting of 17 RTUs and one dedicated MTU

The servers run Microsoft Windows. One workstation runs the Wonderware and Win 911 applications for the Water Treatment Facility and the Water Telemetry system. Two workstations run another Wonderware application and corresponding Win 911 application for the Wastewater System.

The Wonderware workstations communicate with the PLCs and MTUs over the local control system network (LAN). One MTU (MOSCAD ACE3600), located at the Public Works Building, is dedicated to communication over radio (UHF 453.7 MHz) with reservoirs, booster stations, and wells on the water system. Another MTU, located at the WWTP, polls the sewer lift stations. All but two remote water and wastewater sites (MOSCAD RTUs) rely on a single repeater located at the 1040 reservoir to communicate with the MTUs.

Equipment at the Water Treatment Facility is controlled by a PLC (Schneider Quantum). Equipment at the Wastewater Plant is controlled by another Quantum PLC and other smaller, miscellaneous PLCs associated with packaged equipment and local control panels.

The control system network consists of managed switches (CISCO) and fiber optic cables connecting the Public Works Building, several structures at the WWTP, and the WTP Building. Redundant fiber optic connections at most switches are implemented for fault tolerance. Switch port status is monitored by the City’s IT department. Switches at some locations support both the enterprise and plant control system networks. These switches have separate VLANs configured for enterprise and plant control.

4. SERVER SECURITY

4.1. Existing Operation and Policies

One server workstation for the WWTP is located in main office and the other is located at the Plant's Equipment Building. The WTP workstation is located in the office at the Water Treatment Building. These workstations need to be accessible at all times by Operation staff. A single user is normally logged in to each server and there is no automatic log-out. All user accounts have administrative access to the operating system. Normally the Wonderware HMI and Win911 applications are running continuously on these servers. Wonderware HMIs have operator passwords configured, but these accounts are not automatically logged out. The workstations currently allow access to the Internet, though remote access to the servers by Operators off-site is not allowed. The City has allowed remote access via the Internet in the past, but found that the risks outweighed the benefits. Operations staff have no need to provide remote access to the Wonderware screens at the present time or in the foreseeable future. In addition to critical alarms, however, selected process data may be useful to off-site Operations staff via telephone or the Internet. This data includes the current WWTP levels and flow, reservoir levels, well flow, chlorine residual, etc.

There are no formal, written procedures or policies established regarding levels of access to the server operating systems and the HMI applications.

4.2. Recommendations and Alternatives for Server Security

The following security policy elements are proposed:

- a. Restrict access to operating systems to only those users who have the responsibility to install programs, configure network access, modify hardware, and other actions typical of users that need to maintain the servers. Typical operation would be by a user logged in as a non-administrator.
- b. Limit Internet connectivity for normal server operation. Internet connectivity could be enabled on an as-needed basis by an administrator account and disabled when not needed.
- c. Configure Authorization Levels and the Activity Time-out features for the Wonderware InTouch Viewer application and the Activity Time-out feature. The access level feature can be used to limit accessibility to certain functions, such as set point adjustment or manual on/off control of equipment. Accessibility can be assigned to individual graphic objects or entire screens. No more than three levels of access should be adequate.
- d. In lieu of enabling off-site access to the HMI screens, implement the Win 411 reporting features available on the existing Win 911 software. This extension of Win 911 allows a remote user to dial in and select from a list of pre-configured reports containing process data. Current values for the selected process variables are reported like alarm messages.
- e. Should enabling temporary remote access by vendors or Contractors be considered for a major improvement project, define ground rules for the project with final approval from Operations. Remote access to a network using a secure VPN account is commonly employed. Limitations can be placed on time of day or week that a router supports VPN access. Common practice is to require that outside vendors obtain prior Plant permission for each login event.
- f. Evaluate locating the servers in a secure "server room" and implement Windows Terminal Services (RDS).

5. SERVER MAINTENANCE

5.1. Existing Operation and Policies

The maintenance of the servers has been a joint effort between the IT Department and Operations. In recent years, Operations has relied on IT to supply the hardware and to assist with maintaining the operating systems. The division of responsibility between IT and Operations for server hardware and operating

system maintenance has not been clearly defined, and no formal policy exists for hardware and software to ensure they are systematically maintained. The City has requested guidance on such policies.

5.2. Recommendations and Alternatives for Server Maintenance

Because of the need to monitor remote, unmanned sites around the clock for critical alarms, to ensure effluent quality standards are met, and to maintain a reliable record of historical data, all City departments agree on the need to keep SCADA servers operational on a continuous basis and to prepare in advance for any required planned outages.

In keeping with these constraints, the following maintenance policy elements are proposed:

- a. Inhibit Automatic Windows Updates on SCADA computers.
- b. Consider an annual review of server hardware. Operations would be responsible for notifying the IT Department of planned application software updates and identifying particular hardware or operating system prerequisites recommended by the software vendor. The IT Department would be responsible for keeping Operations informed of hardware and operating system obsolescence.
- c. Coordinate hardware replacement plans between the IT Department and the Operations Department at least 3 months in advance.
- d. Assign responsibility for SCADA-specific software application maintenance to Operations. Updates to the HMI and alarming software would be implemented at the discretion of Operations. An annual review of application software requirements related to operating systems (Windows Security Patches and Service Pack updates) is recommended. This information is available from Wonderware and should be reviewed annually by Operations.
- e. The Public Works Department should be notified at least 30 days in advance of any hardware or IT-provided software changes or updates so that these can be coordinated in advance.
- f. The IT Department should be notified at least 30 days in advance of any software application updates so that if there are potential issues regarding hardware and operating system compatibility, these can be coordinated in advance of the upgrade.
- g. Establish a safe location on the Enterprise server for storing the latest Wonderware and Win 911 applications. These files can be used to restore a server in the event of component failure.
- h. Consider virtualizing SCADA servers as a means to simplify disaster recovery. Wonderware does not currently recommend that data collection component of InTouch (DA Servers) be virtualized, but this could change as the product evolves.
- i. Implement remote monitoring and alarming for:
 - Running status of critical applications, such as Win 911, the Historian, and Wonderware data acquisition.
 - Operating System Status for host and virtual operating systems.
 - Hardware components, such as hard drives, power supplies, and modems.

6. NETWORKS

6.1. Existing Network

The existing control system network is relatively sophisticated and fault-tolerant. A series of fiber optic cables connect the WWTP facilities, the WTP, and the Public Works Building to each other using managed switches. These switches support control system clients (servers, PLCs, MTUs) as well as enterprise network data. VLANs segregate the control system data from enterprise data. Specific RJ45 ports are assigned to the servers and PLCs while others are dedicated to enterprise clients.

Maintenance of the network is currently performed by the IT Department. The IT Department retains password-protected access to the managed switches. As indicated on the diagram attached in the Appendix,

several of the managed switches have more than one fiber optic connection. A second or third fiber connection provides an alternate path for data in the event one connection is broken. This feature is useful in preventing outages, but only if the status of each link is monitored for a break and an alarm is automatically generated. According to the IT Department, these diagnostic functions are configured and working.

Power for each managed switch is supplied by a dedicated UPS plugged into a wall receptacle.

6.2. Network Vulnerabilities

The following concerns have been identified or acknowledged by the City:

- The switches are not industrial grade.
- Because the switches support enterprise traffic and the configuration is under IT jurisdiction, a failed switch cannot be readily replaced by Operations.
- Switch failure is not directly reported to Operations.
- A single data path connects the MTU at the Public Works Building to the SCADA servers.

6.3. Recommendations for Network Improvements

The following recommendations and alternatives are proposed:

- a. Replace the control system VLANs with dedicated, industrial-grade managed switches. These switches are fiber-optic compatible, support redundant media configurations, and have features more suited to industrial environments, such as higher temperature ratings, fan-less passive cooling, and a degree of protection against dust. While the management attributes of these switches need to be configured with software, the Operations department can keep spares on hand and replace failed units without disrupting the enterprise network.
- b. Retain redundant media and link health monitoring. Coordinate continued IT support for switch monitoring and incorporate additional network related alarms to the SCADA database.
- c. Implement UPS monitoring for critical communications components. A warning that the UPS battery is failing may avoid switch failure coincident with the next utility outage.

7. SCADA DATA COLLECTION AND ALARMS

7.1. Existing Real-Time Data Collection

Data is collected from the PLCs and MTUs by the DA Server components of the Wonderware applications running at the SCADA workstations. According to the most recent information provided by the Wonderware support representative, redundant DA Servers are employed at the WWTP but not at the WTP. If configured and functioning as intended, a loss of one or the other SCADA workstations at the WWTP would not inhibit data collection and full screen functionality of the remaining HMI. Since the WTP employs a single workstation, however, its loss or shutdown due to maintenance would result in loss of supervisory control and cause a gap in record data. Loss of the WTP workstation would also prevent offsite alarm notification during the outage.

7.2. Existing Alarm Notification

The existing alarm notification is performed by separate Win 911 applications running on the respective WWTP and WTP workstations. These applications rely on a modem and telephone circuit to call on-duty operators in the event of a critical alarm. There is no monitoring for phone circuit outages that may be the result of utility-initiated activity or natural events.

Based on feedback from City Operations, the alarm database contains the desired process and equipment related alarms. A few additional alarms related to communications, radio, and RTU/PLC status are desired.

7.3. Recommendations for Data Collection and Alarms

The existing Wonderware HMI software satisfies the City's current needs, is readily modified and expanded as the systems grow, and is well-supported locally and nationally. A large installed base ensures that local control system integrators are experienced with maintaining this platform. For these reasons, changing to another HMI platform is not recommended. The Win 911 application integrates well with Wonderware, and replacement of the Win 911 platform is not recommended at this time.

New features continue to be introduced, and some of the features already available with these platforms but not currently implemented may be appealing to the City. Two of these features are included in the following recommendations related to Wonderware and Win 911:

- a. To help ensure continuity of historical data, continuous monitoring for remote sites, and more convenience for server maintenance, implement redundant DA Servers for the Water system. Verify the existing WWTP servers are each functioning as active backups to each other (shutting down one server does not inhibit the functionality of the other).
- b. Implement watchdog monitoring for the Wonderware alarm source on each Win 911 application to indicate DA server failure. See recommendations for server maintenance above.
- c. Coordinate with IT to monitor Win 911 service running status on each workstation if not functional for more than x minutes. Normally the Win 911 service runs continuously.
- d. Coordinate with IT to monitor status of the telephone line and notify Operations.
- e. Add alarms to InTouch and Win 911 for server, MTU, and PLC communication status.

The Win 911 platform offers both email and SMS text messaging as alternative modes to analog telephone for notifying off-site staff. Note that the email option requires that the server running Win 911 have an Internet connection. The SMS text messaging option requires a wireless modem. In all modes of alarm notification, the message descriptions are configured by Win 911. These options can be discussed further at the City's discretion.

Redundancy can be implemented for alarm reporting. A relatively robust and simple solution is to use a hardware auto-dialer connected to an analog telephone circuit. Critical alarms generated by a PLC or MTU are wired as inputs to the auto-dialer. The auto-dialer is configured to call specific telephone number(s) during an alarm event. A more sophisticated option is to implement Win 911 redundancy, wherein two identically configured Win 911 applications and modems are aligned with redundant alarm servers and operate in a duty-standby configuration.

8. HISTORICAL DATA AND REPORTING

8.1. Existing Historical Data Collection

Historical data is currently logged by Wonderware and accessed using the HistData program embedded in InTouch. The routines available in HistData allow a user to filter and export data to comma separated variable (.csv) formatted files which can then be stored and manipulated with Microsoft Excel or other programs. While this method can be a cost-effective solution for reporting data on smaller systems, it can be complicated to configure and not as flexible as other alternatives. The historical data files are currently backed up by the IT Department on a periodic basis. As noted above, a loss of communication between the server and the PLC monitoring the measuring instrument(s) will result in gap in the historical data record.

8.2. Agency Reporting Requirements

The Washington State Department of Ecology requires at least 15 minute averages of specific wastewater treatment process measurements. These instruments are identified in the Continuous Monitoring Plan and include turbidity meters, pH analyzers, dissolved oxygen analyzers, chlorine residual analyzers, and

influent and effluent flow meters. The minimum retention requirement for this data is 3 years for written records; 5 years for electronic.

8.3. Alternatives for Historical Data Management and Reporting

The following are recommended for further consideration by the City:

- a. Implement a SQL-based “Historian” server dedicated to collecting and summarizing historical data for the Water and Wastewater SCADA systems. This server could be rack-mounted and virtualized. It can be configured for automatic failover to a secondary server, if available.
- b. Implement a “user-friendly” reporting application, such as Dream Reports, to query data directly from the SQL database. This application can be configured to generate minimum, maximum, and average summary data for user-selectable time periods. Reports in PDF, .csv, or Excel formats can be automatically generated and saved to a specific location on the network. Reports can be automatically emailed.

9. APPENDIX

Attached items include:

- a. Water Control System Communication Block Diagram (see Technical Memo A Appendix).
- b. Wastewater Control System Communication Block Diagram (see Technical Memo A Appendix).
- c. City of Snoqualmie IT Water/Wastewater Fiber Network.

10. REFERENCES

- a. Win 911 v.7.14 User Manual, Specter Instruments.
- b. InTouch HMI Data Management Guide, Invensys, 2007.
- c. InTouch HMI Application Management and Extension Guide, Invensys, 2007.
- d. Wonderware Historian Concepts Guide, Invensys, 2009.