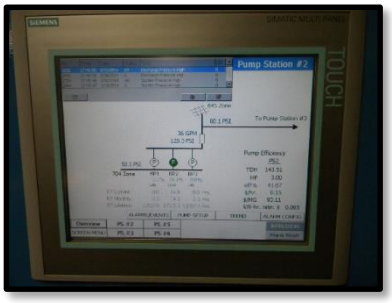
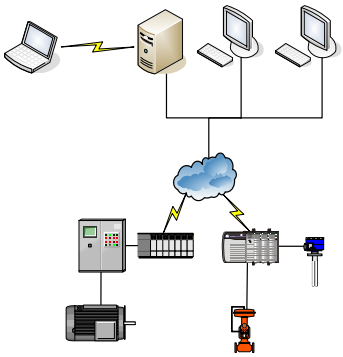
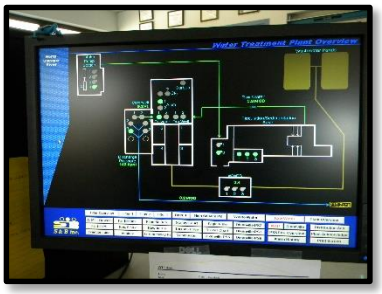
City of Roseburg
Telemetry Study

February 2015







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SCADA Glossary of Acronyms

Broadband – A wide bandwidth data transmission medium with the ability to simultaneously transport multiple digital signals and traffic types.

DSL – Digital subscriber line is a family of technologies that provide Internet access by transmitting digital data over the wires of a local telephone network.

HMI – Human Machine Interface. An HMI is a software application that presents information to an operator or user about the state of a process, and accepts and implements the operators control instructions. Typically, information is displayed in a graphic format (Graphical User Interface or GUI).

Industrial Communication Protocols – High level digital communication standards that are used between control system components. Serial Modbus, Modbus TCP/IP, Serial DF1, Ethernet/IP, and Profinet are common types of communication protocols used in the control industry. These protocols are used to package data into digital packets for transmission over wired or wireless communication systems.

LAN – Local Area Network. Typically consists of an interconnection of networkable devices over a small area such as within a building or a control panel.

OI – Operator Interface. An OI usually consists of a small industrial HMI display. It communicates directly to the control panel PLC and allows operators to directly monitor all facility alarms and status information. An OI usually displays a subset of a full HMI system. Low level facility setpoints are usually entered using the OI instead of the HMI system. These may include instrument calibration setpoints, alarm delays, and miscellaneous setup values.

PLC – A Programmable Logic Controller, PLC, or Programmable Controller is a digital computer used for automatic monitoring and/or control of processes.

POTS – Standard acronym for "Plain Old Telephone System". This is the voice-grade telephone service that is based on analog signal transmission. These systems were used for data communications before the advent of more advanced forms of digital broadband communications.

Profibus – Process Field Bus is a standard for industrial instrument communications in automation technology and was first implemented by Siemens.

SCADA – Supervisory Control and Data Acquisition system. A SCADA system usually consists of the following subsystems.

A human machine interface (HMI) is typically a graphical Windows- based computer or touch screen that presents process data to a human operator, and through this, the human operator monitors and controls the process.

A supervisory (computer) system gathering (acquiring) data on the process and sending commands (control) to the process.

Communication infrastructure connecting the supervisory system to the programmable logic controllers (PLCs) or other data collection devices.

PLCs connected to sensors in the process, converting sensor signals to digital data and sending digital data, to the supervisory system.

Various process and analytical instrumentation.

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TCP/IP – Transport Control Protocol/Internet Protocol. This low level Internet protocol suite is the set of communications protocols used for the Internet and similar networks. TCP/IP is the most popular protocol stack for local and wide area networks. Some industrial communication protocols such as Modbus TCP/IP and Ethernet/IP use TCP/IP as the communication transport. TCP/IP is used by higher level communication protocols to guarantee delivery of data in the correct order between one or many destinations.

WAN – Wide Area Network. Typically consists of an interconnection of LANs over a larger geographic area.

VPN – Virtual Private Network. Extends a private network across a public network, such as the Internet. It enables a computer to send and receive data across shared or public networks as if it were directly connected to the private network, while benefitting from the functionality, security, and management policies of the private network. This is done by establishing a virtual point-to-point connection through the use of dedicated connections, encryption, or a combination of the two.

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1 Telemetry Study Overview

The purpose of this Telemetry Study is to evaluate the existing water SCADA system for the City of Roseburg, Oregon (City). The outcome of this evaluation is to review the existing system and identify a short-term and long-term strategy for upgrading and maintaining the City's SCADA system over the next 5 to 10 years. This evaluation should be reviewed on an annual or semi-annual basis to identify completed projects, new priorities, and revisions to the Telemetry Study.

1.1 Executive Summary

1.1.1 Executive Summary Introduction

The City of Roseburg's drinking water is monitored and controlled with a Supervisory Control and Data Acquisition (SCADA) system. Water SCADA systems typically handle the following functions:

1. Monitoring of system alarm data.
2. Monitoring of control processes such as water treatment, maintaining reservoir storage and water system pressures.
3. Monitoring of facility summary data such as pump run times and flow totals.
4. Movement of control data between remote facilities. An example of this would be the reservoir levels needed by remote booster pump stations for control purposes.
5. Centralized monitoring and control of a water system from one or more locations.
6. Collection of facility data into historical database systems for operational, engineering and planning purposes.
7. Alarm notification system for system operators.

Modern SCADA systems first appeared in the 1970's but used very proprietary hardware and software until about 15-20 years ago. The existing City SCADA system uses a combination of different technologies due to its original installation over 20 years ago and the upgrades that have been added since that time. Some of these technologies are obsolete and some are very modern.

The City of Roseburg's SCADA system consists of five distinctive subsystems (**FIGURE A-1)**. Four of these subsystems use different SCADA technology based on when they were installed. The fifth subsystem currently is not monitored or controlled by the City SCADA system.

Winchester Water Treatment Plant System

The SCADA system at the Water Treatment Plant is specifically designed to handle the water treatment process for the entire city from the North Umpqua River. This SCADA system was installed in the early 1990's and consists of a single Programmable Logic Controller (PLC) that is wired to all the facility instrumentation, control equipment, SCADA computer systems and a large control panel display. The PLC for this facility is also used to monitor and control the Tone Control Facilities.

Tone Control Facilities

At the same time the Water Treatment Plant SCADA system was installed, tone monitoring and control equipment was installed at most of the remote water facilities. Tone systems were originally implemented during the 1960's through the 1990's due to the high costs of installing PLC equipment during that era. Tone equipment basically monitors and controls a remote facility over a dedicated phone line using various analog tone signals. This technology only works for very simple

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control and monitoring systems. This technology has been obsolete for about 20 years due to the substantial drop in PLC equipment costs. The City currently has 10 facilities using Tone technology.

Siemens/Automation Direct PLC Facilities

Four of the City's booster pumps stations have been upgraded in the last 15 years to have their own PLC equipment using Siemens and Automation Direct brand systems. These facilities have more complex pumping control requirements which required an upgrade from the Tone systems used at most of the other City facilities.

Dixonville System

The Dixonville systems is a satellite water system that the City recently assumed. This system was recently upgraded to Siemens PLC equipment and consists of the most modern SCADA equipment within the City.

Isolated Facilities

There are currently six facilities that are not monitored or controlled by the City SCADA system. This is due to the simplicity of facility and low priority for SCADA integration or due to the inability to communicate to the site. Five of the facilities are part of the City water system and have no existing equipment that could be used for integration into the existing SCADA system. The Dixonville #4 facility has a modern control system but is too remote for wireless or landline technologies.

The existing SCADA subsystems consists of four basic technology groups.

Instrumentation

The monitoring instrumentation used around water systems typically consists of equipment used to measure water quality, level, pressure or flow. Control instruments consist of motor control systems for pumping, valves for controlling flow and injection systems for water treatment process control.

Communications

SCADA Communications consists of all the technologies used to move data around the system in real time. This type of communications is critical to the operation of the water system and requires a high level of uptime to prevent water system failures. Typical methods of communications consist of dedicated phone lines, private radio systems, cellular, DSL, and other forms of Broadband. The City is currently using dedicated phone lines and private radio systems for SCADA communications.

Facility Controllers

Programmable Logic Controllers are basically dedicated industrial computers used for monitoring and control of the City water facilities. Each of them has control software specifically written by a SCADA integrator for each facility. The City is currently using Siemens and Automation Direct PLC controllers for the majority of their system. The facilities using Tone are basically a slave to a Siemens PLC running the Water Treatment Plant.

SCADA Computer Systems

SCADA computer systems are used for the following purposes.

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1. Centralized graphical interface to monitor and control the SCADA system. This typically consists of a custom user interface designed by a SCADA integrator and is known as a Human Machine Interface (HMI). This HMI gives the operations staff a visual display of the water system facilities.
2. Password protected security system to limit access to specific parts of the HMI interface depending on staff job titles. All changes to the control system or acknowledgement of alarms is logged based on user names.
3. Historian for storing events, alarms and engineering values for trending and reporting.
4. Alarm notification system over phone, text messaging, email or smartphone app.
5. Remote access for City staff from external computers, laptops, tablets or smartphones.

1.1.2 Executive Summary Recommendations

The following recommendations are based on the findings of this report and discussions with the City staff. This process should be implemented within the next 5-7 years based on yearly funding.

1.1.2.1 SCADA Upgrade Procedure

1. Replacement of the Tone Control Facilities SCADA components in the next two years. This process will require a number of installation stages to create a new SCADA system backbone for the remote facility upgrades. This process will also create the next generation SCADA system that will be the core for all other system upgrades.
    a. A full radio study to obtain 450 MHz frequency from the FCC and to also identify viable radio paths.
    b. Procurement of a new Allen Bradley CompactLogix based master controller at the City Water Treatment Plant.
    c. Procurement of a new SCADA computer system using either Rockwell Automation or Wonderware software.
    d. Procurement of new wireless SCADA network communications backbone. This will be a combination of private UHF wireless radio equipment and broadband wireless systems provided by the City IT staff. This communications system will pay for itself in ~5 years depending on its total costs and the savings from monthly leased dedicated phone lines.
    e. Replacement of the Tone Control facility SCADA equipment. This would be an upgrade to the existing facilities and may include other components such as instrumentation and motor control equipment depending on the facility.

    Due to the total cost of this task of the upgrade, it would most likely be phased in over a number of years as funds become available.
2. Moving Siemens/Automation Direct PLC Facility communications to the next generation SCADA system over the new wireless communications network. This task can be accomplished at any time after task 1 is completed.
3. Replacement of the Winchester Water Treatment Plant control system. This task can only be accomplished after task 1 is completed as the Tone Control facilities use the existing Treatment Plant PLC for monitoring and control.
    a. Installation of new Allen Bradley based control system.
    b. Phased moving of water treatment subsystems from existing Siemens controller to Allen Bradley controller and new SCADA computer system.

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4. Adding isolated water facilities to the next generation SCADA system. This task can be accomplished at any time after task 1 is completed. Dixonville #4 facility will probably not be included in this upgrade due to a lack of communication options at this location.
5. Yearly review and upgrade of SCADA components as they are identified. This method of upgrading SCADA components will keep the system current over time and will greatly reduce large CIP upgrade costs in the future. After the first four tasks are completed, the SCADA upgrade process will be reduced to upgrading individual facilities or components as they reach the end of their lifespan.

1.2 Project Scope

- Data gathering and review – Document as much of the existing system as possible for this study and for future upgrade designs.
- Describe existing system – Provide a summarized and detailed description of the existing SCADA system based on the information collected during the data gathering task.
- Evaluation of existing system – Evaluate the existing SCADA systems components and identify their conditions in relation to current best practices in control system technology.
- SCADA System Best Practices – Identify various SCADA best practices that relate to this project.
- Alternate Approaches for System Upgrading –Identify the various alternative approaches for upgrading the SCADA system.
- Recommendations for System Upgrading — Working with the information collected in this study, identify and document final recommendations for upgrading system based on recommendations from City staff and RH2.

2 Existing Telemetry System

The purpose of this task is to review the City's existing SCADA system as a way of identifying how it evolved into its current state. This task will also discuss the SCADA system's limitations that have been identified by City staff and RH2 Engineering, Inc., (RH2).

The analysis information gathered for this evaluation was obtained from the following sources:

- Discussions with the City's staff; and
- Two day walk through of the City's facilities;
- Review of existing SCADA documentation;
- Discussions with the City's SCADA integrator, Stead and Associates, Bellevue, WA;

The information presented in this Telemetry Study is relevant to the SCADA system as of mid-2014. This plan should be reviewed every year or as changes occur to the SCADA system to identify which parts are still relevant and which require revisions.

2.1 History of Existing SCADA System

As with many water SCADA systems, the City's system has evolved into its current state through various installations and upgrades over the last 30 to 40 years.

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The vast majority of the existing City's SCADA components are based on Siemens Corporation technology. These components consist of legacy equipment from the late 1980's through recent additions to the system using state of the art equipment.

2.2 Existing Control System Integrators

2.2.1 Stead and Associates/S&B

The current SCADA system was integrated by Stead and Associates of Bellevue, Washington. New facilities and the operations and maintenance of the existing SCADA system are still managed by Stead and Associates. This company was originally known as S&B but created a separate design consulting group known as Stead and Associates in 1989. This company is considered a tier one control integration firm for water and wastewater in the Pacific Northwest. Some of the earliest and largest SCADA systems in Washington and Oregon have been implemented by this company starting in the late 1970's. S&B has primarily focused on Siemens control and electrical components for the majority of its existence. They have recently started supporting Allen Bradley equipment due to the popularity of this platform in the Pacific Northwest.

According to city staff, the City of Roseburg has received excellent service from S&B. Their most recent addition to the SCADA system is the Dixonville system. This is an example of some of the best SCADA technologies available for a system of that size. The City's main concern is with S&B is that they have been installing control system components that are not easily maintained by local vendors in the State of Oregon. The 350 miles between the City and S&B makes any on-site visit expensive and difficult to plan quickly. S&B has mitigated this issue in the past by providing remote access into the SCADA system for software diagnostics and upgrades. In addition, the City currently does not possess any copies of the software for their SCADA system except for the Human Machine Interface computer system. Copies of this software should be obtained from S&B and maintained by the City IT staff. This software will need to be kept in a very secure location and should have some simple versioning control setup to handle software updates. This can be as simple as keeping an Excel spreadsheet that logs updates to software.

Other than the distance to S&B, another issue is their heavy use of Siemens equipment at the City. S&B has historically always been a Siemens vendor even though the vast majority of the SCADA systems have migrated towards Allen Bradley in the Pacific Northwest. Allen Bradley is an American company with a vast network of vendors and support services in the Pacific Northwest for systems such as SCADA and manufacturing. They can supply everything from electrical motor control equipment to SCADA system software. In addition, other companies such as Wonderware supply SCADA system software that is very heavily supported in the area.

Due to the amount of Siemens components in the existing SCADA system, the City will most likely need to work with S&B in the foreseeable future. This is primarily due to the cost of having another integrator work with the existing software may be prohibitive compared to using S&B. It would be in the best interest of the City to open up future SCADA work to other SCADA integrators. S&B has been performing Allen Bradley integration over the last few years but it is still not their core brand.

2.2.2 California Motor Controls

The Dixonville Pump Station #4 is the only Dixonville facility not using S&B integrated equipment. This was a prepackaged control system from California Motor Controls of Benicia, California. This facility was not upgraded using the same standards as the other Dixonville facilities due to budget issues. A pre-packaged

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pump system was purchased that includes a Unitronics controller for maintaining system pressure in a closed water zone above this facility. This equipment is very capable but is not very well supported in the Pacific Northwest. There closest integrator that handles this equipment is near San Francisco. It is recommended that the City specify Allen Bradley control products for any future pre-packaged system that will include a PLC controller.

2.3 Existing SCADA System Documentation

The city currently maintains a book of SCADA electrical documentation for the existing SCADA system. A copy of this book was provide to RH2 along with any addition documents identified to be part of the existing SCADA electrical system. Due to the longevity of SCADA system electrical systems, original electrical documentation does not always identify changes to the system over the life of the facilities. S&B has an excellent reputation for diagramming their systems and updating these diagrams as changes are made. Some of the facilities will be upgraded in such a way that the existing electrical documentation would only be used to identify existing instrumentation wired to the existing SCADA control panel.

Winchester Water Treatment Plant

This facility control system is the oldest among the city SCADA system and the most complex. The Tone Control facilities will be the first section removed from this system but that task does not require any changes to the existing system. Upgrading the water treatment plant control system will require the most up to date documents available. It appears that most of the facility instruments are wired back to the current Siemens control panel system. A review of the existing S&B documentation for this system is missing electrical systems that have changed over the last 15 years. It would be advisable for the City to contact S&B to obtain the latest O&M electrical drawings for the treatment plant. These plans would then need to be confirmed during the design phase of the control system upgrade.

Tone Control Facilities

The existing instrumentation connections to the SCADA system are minimal due to the simplicity of these facility control systems. These facilities will require a full electrical design that will need to identify new and upgraded instrumentation connections. The existing control panel will be completely replaced. The existing documentation may help with moving existing instruments from the current control panel to a future control panel.

Siemens/Automation Direct PLC Facilities

The documentation for these facilities will be used to identify how to update the existing communications system to a wireless system. The existing documentation for these facilities looks up to date at this time.

2.4 Existing SCADA System Equipment Topology

The existing City water facilities include a 20 MGD water treatment plant, 13 Storage Reservoirs, 21 pump stations, 2 PRV control facilities and 22 separate pressure zones. Unlike many potable water SCADA systems, the City of Roseburg system has a minimal number of facilities that require instrument data from other facilities in order to operate automatically. Of the 27 water facilities, only 6 facilities require

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instrument data from other facilities for automatic control. In addition, 6 of the water facilities are not currently connected to the SCADA system at this time.

For the purposes of this study, the existing water SCADA system can be defined as five separate SCADA subsystems (**FIGURE A-1**).

1. Winchester Water Treatment Plant Control System
2. Facility Tone Control System
3. Siemens/Automation Direct PLC Based Control System
4. Dixonville Control System
5. Isolated Control Systems

A complete inventory of the control equipment components is listed in the appendix (**TABLE B-1**).

2.5 Winchester Water Treatment Plant Control System

The Winchester Water Treatment Plant is currently the central location for the City SCADA system monitoring and control. All potable water for the City of Roseburg originates at this facility. Except for the Non-PLC based water facilities, all facility SCADA communications is routed through this facility. This facility consists of the following components.

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2.5.1 SCADA Computer System

The SCADA computer system consists of a single HMI server grade computer and a single Data Management System (DMS) computer.

HMI Server Overview:

1. ***Hardware/Software*** – This computer is a Dell PowerEdge 2900 that was purchased around the year 2010. This server is running Windows Server 2008 R2 operating system with Siemens WinCC as the HMI graphical user interface software.
2. ***HMI*** – An HMI is a graphical user interface that displays the water systems in a graphical layout. This is the primary water system user interface to the City staff. Operators can view the current status of the SCADA system, acknowledge alarms, change setpoints and handle other control operations from this centralized location. There is currently no remote access of this computer.
3. ***Alarm Monitoring and Notification*** – Systems alarms are collected and displayed on the GUI. Alarms notification is handled with specific WinCC software for informing operations staff of system alarms.

DMS Computer Overview:

1. ***Hardware/Software*** – This is a very old computer running a version of SCO Unix operating system from either the late 1980's or the early 1990's. This computers main purpose is to act as a historian and report creator for all of the SCADA system data.
2. ***Historical Trending*** – This software was developed by S&B back in the 1980's due to the lack of historical data collection software for SCADA systems at the time. The software stores SCADA system data only when it changes (delta format) rather than collecting data cyclically. This software can also calculate minimums, maximums, averages and can handle totalizing of real time data. This data can be exported directly or through a system report. Most of these systems have no way of directly trending data on a chart as this system has no graphical user interface. The display is text only.
3. ***System Reports*** – Access of historical data is typically through system reports. These are pre-designed reports that can be access on demand or scheduled to print out at various times.
4. ***Historical Data Export*** – This system is designed to be able to export data tags in specific time increments for analysis in software such as Excel.

2.5.2 Simatic 545 Based Control System

(**IMAGES 2-5**) This is the original control system for the water treatment plant and for monitoring and controlling the existing tone control based facilities.

1. ***Hardware*** – The Simatic 545 PLC system was originally developed by Texas Instruments but was sold to Siemens in the late 1980's. Siemens supported this platform until all remaining support was sold to another company about 10 years ago. This PLC system consists of three modular electronic card cages with a single central processing unit (CPU) and various instrumentation and digital communication input and output cards. A hard wired static control panel was originally installed before HMI software became common in the industry. This control panel was

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the original operations staff interface to the SCADA system for the treatment plant and the remote facilities. Some of the features on this control panel have been removed or disabled as facilities have changed and the HMI computer system has been used for more monitoring and control purposes. The City is still using the circular paper charts for tracking historical trends of important system data.

2. ***Water Treatment Plant SCADA*** – The primary purpose of this control system is to monitor and control the city water treatment plant. All of the treatment plant monitoring and control instrumentation is wired back to this control panel.
3. ***Tone Control –*** In addition to the treatment plant, this control system was the original system used to monitor and control the remote water facilities. This system used an early form of communications over dedicated phone lines called Tone Control. In a tone control system, the remote facility sends a specific set of audio tones for events, alarms and analog values. The Simatic 545 can also control certain aspects of remote facilities by sending specific tones to the remote facility. The tone control hardware consists of DAQ tone modules and Tellab phone modules. The DAQ tone modules identify and create communication tones based on inputs and outputs on the Simatic 545 PLC. The Tellab dedicated phone line modules are used to maintain the POTS communications connection.

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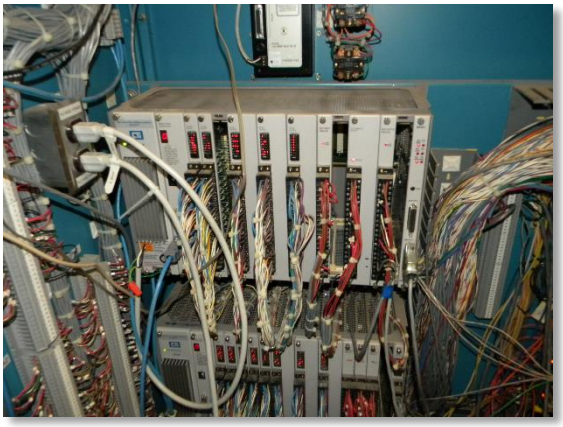
IMAGES 2-5

SIMATIC 545 BASED CONTROL SYSTEM

-

Raw Water Control Panel Example



Siemens 545 PLC Card Cage

DAQ Tone Monitoring/Control Modules

Tellabs Phone Line Bridging Modules

2.6 Facility Tone-Control System

(**IMAGE 2-6**) The tone control system consists of remote water facilities that are monitored and controlled by the water treatment plant Simatic 545 PLC system over dedicated POTS phone lines. The tone control equipment consists of DAQ Tone Monitoring/Control Modules connected to all of the facility monitoring and control equipment. Tone control systems are considered slaves to the Simatic 545 PLC at the water treatment plant. These remote tone control systems are dependent on phone audio signals from the water treatment plant Simatic 545 PLC system. The Simatic 545 system handles the monitoring and control of the treatment plant and these 10 facilities. The SCADA HMI computer system accessed data from these 10 facilities through the Simatic 545 PLC system.

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Unlike PLC based system, tone control systems are incapable of independent action unless they use local relay logic for control. Relay logic is the use of relays to add simplistic control to a facility. Applications typically consist of starting or stopping a pump based on pressure or float switches.

The majority of the remote tone control facilities have very simplistic control and monitoring capabilities. This is due to the limited amount of instrumentation data that can be transmitted over an audio tone system. There are currently 11 tone control facilities still operating at the City (**TABLE 2-6**).

The reason for tone control was originally due to the prohibitively high costs of installing a PLC at every remote facility back in the early 1990's. It wasn't until PLC's started becoming commodity components in the late 1990's that they started to become cost effective to be installed at all facilities.

IMAGE 2-6

TONE CONTROL SYSTEM

-

Facility DAQ Tone Monitoring/Control Module

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TABLE 2-6
Tone Control Facilities

Site Number	Facility Names	Remote Data Connection
1	Broccoli Solenoid Valve	Military Reservoir Level
2	Fairhill Reservoir	
3	Frontier Reservoir and Pump Station	
4	Hawthorn Pump Station	Terrace Reservoir Level
5	Kline Reservoir and Pump Station	Stacie Court Reservoir Level
6	Military Reservoir	
7	Portland Solenoid Valve	
8	Reservoirs 5, 6, 7	
9	Stacie Court Reservoir	
10	Terrace Reservoir and Pump Station	
11	Ventura Pump Station	Frontier Reservoir Level

2.7 Siemens/Automation Direct PLC Based Control Systems

(**IMAGES 2-7**) Remote water facilities that require a higher level of automation have been upgraded over the last dozen years with PLC equipment installed at the remote facilities. There are currently 4 facilities using either Siemens S7-300 PLC's or Automation Direct PLC's for automatic control purposes (**TABLE 2-7**). These facilities were upgraded to have local PLC's to be able to automatically control VFD drives to maintain closed zone pressures. This typically cannot be easily done without the use of PLC equipment. All of these facilities communicate back to a Master Siemens S7-300 PLC at the Winchester Water Treatment Plant over 1200 baud Control Microsystems modems. Instead of using tone signals for remote communications, these facilities use an industrial serial data protocol called Modbus to communicate over dedicated phone lines. Instead of continuous tone signals, these facilities transmit and receive data packets that can contain much more data than a tone system.

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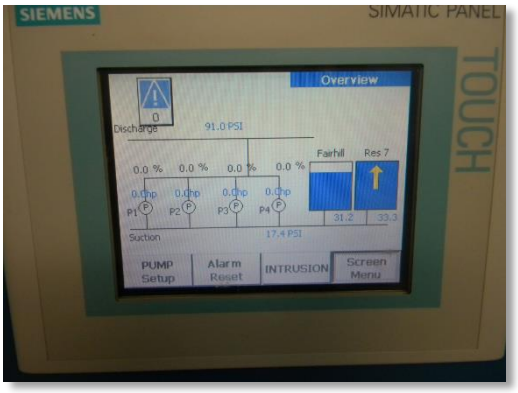
IMAGES 2-7

SIEMENS/AUTOMATION DIRECT PLC BASED CONTROL SYSTEMS

Automation Direct 405 PLC

Direct 1000 Operator Interface

Siemens S7-300 PLC



Siemens Operator Interface

TABLE 2-7

Siemens/Automation Direct PLC Facilities

Site Number	Facility Names	Controller
1	Fairhill Booster Pump Station	Siemens S7-300
2	Garden Valley Booster Pump Station	Automation Direct 405
3	Golden Eagle Booster Pump Station	Siemens S7-300
4	Winchester Booster Pump Station	Siemens S7-300

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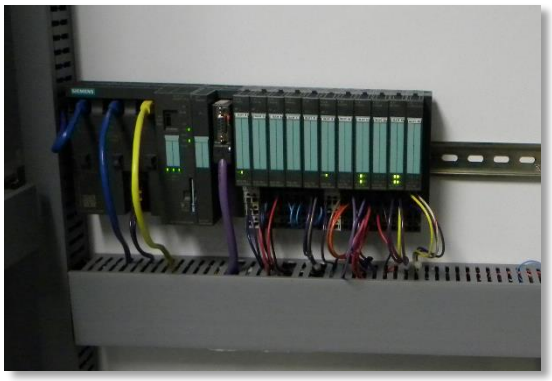
2.8 Dixonville Control System

The Dixonville water system was originally a private water system that purchased wholesale water from the City of Roseburg. The City assumed this system a few years ago and upgraded all of its facilities and SCADA system components. This system currently has the most advanced SCADA and control equipment in the City. There are five facilities that make up the Dixonville system (**TABLE 2-8**). Pump stations 2, 3, 5 and 6 use Siemens S7-300 PLC's for monitoring and control. Pump station 4 has a pre-packaged control system from California Motor Control that uses a Unitronics V570 PLC (**IMAGES 2-8**). All of the Siemens S7-300 equipped facilities use 450 MHz Ethernet radios for SCADA communications. Pump Station 4 does not currently have any communications equipment due to its remote location.

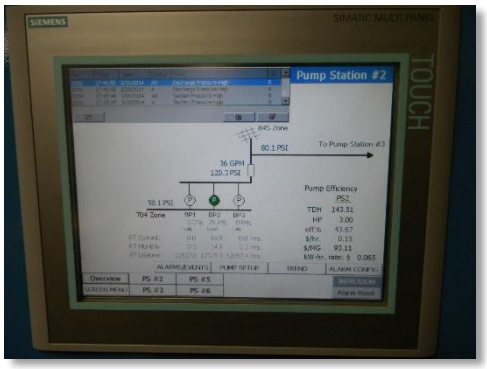
Pump station 2 and 3 are controlling VFD pump systems using Profibus digital communications between the PLC and the VFD controllers. Pump Station 4 is controlling its VFD's using conventional analog outputs.

IMAGES 2-8

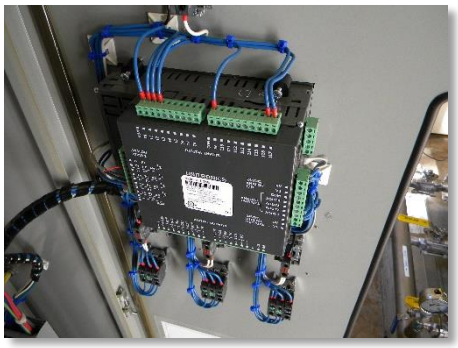
DIXONVILLE CONTROL SYSTEMS



Siemens S7-300 PLC



Siemens Operator Interface



Unitronics V570 PLC

Unitronics Operator Interface

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TABLE 2-8
Dixonville Control System

Site Number	Facility Names	Controller
1	Dixonville Pump Station #2	Siemens S7-300
2	Dixonville Pump Station #3	Siemens S7-300
3	Dixonville Pump Station #4	Unitronics (no SCADA communications)
4	Dixonville Pump Station #5	Siemens S7-300
5	Dixonville Pump Station #6	Siemens S7-300

2.9 Isolated Control Systems

The City currently has 6 facilities that are not connected to the existing SCADA system (**TABLE 2-9**). Sites 2-6 are most likely too small and/or too low a priority to have been connected to the existing SCADA system. Site 1, Dixonville Pump Station #4, is too remote to have been added to the Dixonville radio network. Because Pump Station #4 has an advanced PLC system, it is capable of being connected to the existing SCADA system if a communication method could be identified to reach this facility.

The Military Pump Station has a Siemens S7-1200 PLC but is currently not setup to communicate to the existing SCADA system. The rest of these types of facilities have very simple relay logic control equipment and are not currently capable of SCADA monitoring or control.

TABLE 2-9
Isolated Control Systems

Site Number	Facility Names	Controller
1	Dixonville Pump Station #4	Unitronics V570
2	Dogwood Pump Station	Relay Logic
3	Isabell Pump Station	Relay Logic
4	Joanne Pump Station	Relay Logic
5	Kane Pump Station	Relay Logic
6	Military Pump Station	Siemens S7-1200

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2.10 Existing SCADA System Communications Network

SCADA communications between water system facilities is currently implemented with one of the five methods identified below (**FIGURE A-1**) (**IMAGES 2-10**).

1. Dedicated POTS Land Line Tone Control – All remote Tone Control facilities use dedicated phone lines back to water treatment plant Simatic 545 PLC system using this method of audio communications.
2. Dedicated POTS Land Line Low Speed Modem Modbus Protocol – The remote Siemens/Automation Direct PLC facilities use Control Microsystems low speed modems to communicate back to the S7-300 Master at
3. 450 MHz TCP/IP Radio System – The Dixonville SCADA system uses Calamp Viper SC 450MHz licensed TCP/IP radios to communicate between stations 2, 3, 5 and 6.
4. DSL TCP/IP Broadband – The Dixonville SCADA system is linked to the Winchester Water Treatment Plant though a DSL broadband connection. Data is transmitted from all of the facilities via the 450MHz radio system to Dixonville Pump Station #2. This facility uses a VPN connection to encrypt the data for transmission to the water treatment plant. The HMI computer system can then monitor and control this system. In addition, remote access of the Dixonville Pump Station #2 operator interface can be obtained through the DSL connection from secure City computers.
5. Direct Instrument Connections – A number of remote facilities are monitoring other facilities using direct land line connections. Typically, these connections consists of 4-20ma analog instrument connections from pump stations to closely located reservoirs. Rocky Ridge reservoir level is monitored from the Garden Valley pump station over a buried 4-20ma connection.

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IMAGES 2-10

SCADA COMMUNICATIONS COMPONENTS

DAQ Tone Monitoring/Control Modules

Tellabs Phone Line Modules for Tone System

Siemens/Automation Direct Master at WTP

Dixonville System DSL Connection at WTP

Dixonville Pump Station #2 DSL Connection

Dixonville Calamp Viper 450Mhz TCP/IP Radios

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2.11 Existing SCADA System Instrumentation

The SCADA inventory (**Table A-1**) identifies all of the instrumentation currently connected to the control equipment at each of the remote facilities. The Winchester Water Treatment Plant instrument inventory is not included in this telemetry study.

Discrete Instruments – Discrete instruments are basically switch type input and/or output devices that are connected to discrete input or output cards on a PLC systems. Examples of these instruments include float switches, pressure switches, intrusion switches, pump run/call/fail status contacts, valve status, power monitoring relays, phase failure contacts and HOA switches. These instrument types are located at all of the SCADA connected facilities.

Analog Instruments – Analog instruments are typically 4-20ma loop current sensors that can output a single analog value to a PLC analog input. PLC's also can control a VFD's speed using a 4-20ma analog output card. The 4-20ma loop current is a raw value that is converted to engineering units in the PLC. A 100 ft level sensor would measure 4ma at zero feet and 20ma at 100 feet. Examples of these instruments include water level, suction pressure, discharge pressure, temperature and battery voltage. Most of the SCADA facilities have at least one analog instrument.

Digital Instruments – Digital instrumentation typically consists of devices that have their own user interface and are considered relatively complex. Water quality sensors, electromagnetic flow meters, ultrasonic level sensors, water quality sensors and modern motor control systems with soft starts and VFD's all are considered digital instrumentation. These devices can be configured and tested using some type of user interface display on the instrument. These instruments interface with SCADA PLC devices through discrete switches, 4-20ma loop currents, or digital communications such as Profibus or Ethernet connections. Examples of these types of instruments in the City's SCADA system consists of electromagnetic flow meters, water quality sensors and newer motor control center VFD equipment.

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3 Evaluation of the Existing Telemetry System

This section will review each of the major SCADA system components and identify its current status in relation to current SCADA system lifespans and best practices. SCADA system technology has evolved extensively over the last 25 years. Because the City's SCADA system has been implemented over this period of time, some of its components are obsolete and some are state of the art.

3.1 SCADA System Component Lifespan

The lifespan of SCADA components is based on a number of different considerations.

1. **Component Support** – How long can a specific SCADA component be supported by the original vendor and secondary markets such as EBay? The popularity of some components will extend their lifespan due to the demand for replacement parts. The cost of supporting obsolete equipment can become substantial depending on supply and demand in the market. Spare parts are a great way of extending the life of equipment that is difficult to find. Spare parts should also be purchased for critical systems to prevent long down times when components fail.

2. **Integration Support** – Supporting older technology usually limits your integration support options to those companies that still support the technology. As an example, only S&B still supports tone based control systems in the Pacific Northwest. Most of the other integrators with experience in this technology have retired or moved on to support more modern technology.

3. **Obsolescence** – Even if a SCADA component can be supported, is it in the long term interest of the SCADA system to support obsolete technology. There is usually a tipping point in technology systems where it is no longer cost effective to support obsolete technology.

4. **New Technology –** Modern SCADA technology obviously has many advantages over obsolete technology. These advantages include smarter equipment, better instrumentation, more communications options, and the ability to share SCADA system information with many more stakeholders. These advantages can greatly increase the efficiency of the entire water system if effectively implemented.

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TABLE 3-1

ESTIMATED SCADA COMPONENT LFESPAN ESTIMATES AND COSTS

SCADA Components	Typical Lifespan	Replacement Costs	Annual Maintenance Costs
Computer Systems	5 Years	$2,500 per Server	$1,000 Software License Upgrade Subscription. $5,000 Integrator Support.
Communications Equipment	5-10 Years	$1,500-$3,000 per Facility	$2,000 Vendor Support
PLC Equipment	20 Years if Supported from Vendors and Integrators	>$20,000 Control Panel Upgrade	$5,000 Integrator Support
Instrumentation	10-20 Years if Supported	$1,000-$10,000 depending on instrument	Water quality instruments usually have an annual O&M cost.

3.2 Winchester Water Treatment Plant Evaluation

1. **SCADA Computer System –** The current WinCC based HMI computer system is relatively new as it was constructed within the last 4 years. A typical HMI computer system has a lifespan of between 5-7 years depending on the quality of the hardware. After that time, the software should be upgraded and moved to newer computer hardware to lower the statistics of a catastrophic computer failure. There are a number of options on how this computer system should be implemented in the future in regard to remote access, alarm notifications, historical trending and system redundancy. These will be discussed in Section 4.

   The Data Management System (DMS) computer should be retired as soon as possible and replaced with modern SCADA historian and reporting software. The S&B DMS system has been obsolete since at least the end of 1990's and is very difficult to maintain on modern computer equipment.

2. **Siemens Simatic 545 PLC System** – The existing 545 PLC system and blue control panel are considered obsolete equipment in the industrial control industry. Siemens sold this technology to Control Technology Inc. for component support so replacement parts should be available for at least another 5 years. Hardwired control panels have been replaced with HMI software over the last 20 years. Circular charts have been replaced with modern historian and report software.

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The scale of this system upgrade will require a full control system evaluation and design. The cost of this upgrade will be substantial and will need to be identified in the near term so that it can be identified in future capital improvement budgets. A pre-design analysis will be necessary to identify the costs of the design, the new control system components, the software development, the installation, the testing and training.

This PLC system is also monitoring and controlling the Tone Control water facilities. Any replacement of this system will first require the replacement of the all of the Tone Control based systems.

3.3 Facility Tone Control System Evaluation

Tone control systems were on the edge of obsolescence by the early 1990's and were being phased out in large numbers by the late 1990's. These systems are very limited in their capabilities as they are basically slaves for a remote PLC system. Due to the limited life span for the water treatment plant Master Simatic 545 PLC, the replacement of the tone control systems should be the highest SCADA system upgrade priority in the next 5 years.

3.4 Siemens/Automation Direct PLC Based Control Systems Evaluation

A typical modern PLC system installed after the year 2000 may have a lifespan of 20-30 years depending on the technology implemented and how well it can be supported. The four facilities included in this system should all be capable of at least 20 years before being replaced. All of them were implemented within the last 14 years and all of the major components are still supported by their vendors. Automation Direct PLC and OI components can be purchased directly from their website. Siemens equipment can be purchased through S&B.

The only components that should be reviewed for replacement are the dedicated phone modems. This will be discussed in section 3.7.

3.5 Dixonville Control System Evaluation

The Dixonville facilities were constructed in the last five years and are using state of the art control, communications and instrument technology. These facilities should be supportable by the City for at least another 15 years if not longer. All of the components are very popular in the control industry and well supported. This includes the pre-packaged control system at Pump Station #4. The only notable improvements to this system would be the ability to integrate Pump Station #4 into the SCADA communications network at a future date.

3.6 Isolated Control Systems Evaluation

The isolated control systems should be integrated into the City SCADA system at a future date. These facilities are typically supporting small numbers of water users so they have never been a high priority for monitoring and control. Dixonville Pump Station #4 remote location has prevented it from easily being integrated into the SCADA network. Of the other five isolated water facilities, only West Military pump station has a PLC and it was only designed for motor control and not for SCADA communications. Because of the low priority of these facilities, there are a number of inexpensive methods of remote monitoring without implementing a full control system replacement.

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3.7 Existing SCADA System Communications Network Evaluation

Slow speed serial point-to-point communications was the original method of wide area SCADA communications up until the late 1990's. This method was not very standardized between vendors and could be difficult to implement.

Modern industrial SCADA communications has been slowly standardizing on the TCP/IP protocol for data transmission and routing of data over the last 15 years. This standardization has make it possible to use a large number of existing technologies for connecting SCADA systems together.

1. **Winchester Water Treatment Plant –** The communications within the water treatment plant is a combination of serial and Ethernet communications. Current best practices for large scale processing facilities is to move to an all Ethernet TCP/IP system using twisted pair wiring for short connections and fiber optic cable for long connections. Any changes to this communications system should be implemented with future upgrades to the control equipment.

2. **POTS Dedicated Phone Lines –** The Tone Control and Siemens/Automation Direct based facilities are currently using dedicated audio phone lines for communications. POTS phone lines have limited features and low bandwidth capabilities. They do, however, have the best reliability of any of the telephony systems currently available. Most POTS land lines achieve a 99.999% up time due to the maturity of the technology.

   Unfortunately, POTS lines are considered legacy technology by the telecommunications industry. This is due to people switching to cell phones for voice and only requiring a land line for Internet data connectivity. Dedicated POTS systems are being replaced by digital systems that are incompatible with the audio tone and modem devices currently used by the City for most of its SCADA communications. The time frame for this replacement is dependent on the priority of the telecommunications company and the density of the population. Urban areas are switching to all digital voice and data communications faster than rural areas. It is highly likely that the audio POTS lines in the City will be upgraded within the next 10 years to digital only connections. These are typically converted to DSL connections so that the existing POTS copper wires can be reused.

3. **Dixonville Control System** – The Dixonville system is currently using the latest SCADA networking technologies available. The Viper TCP/IP radios are reliable and have low O&M costs. They typically will pay for themselves in 3 years in comparison to leased land lines. Radio system technology is inherently proprietary between vendors. This is true for the cellular industry and the data radio industry. The Calamp Viper 450Mhz radios used in this system cannot be integrated with any other radio model. This radio communication system should last at least 10 years as long as spare parts are available. A replacement radio system should be implemented once this system can no longer be supported. Pacific Northwest support for the Calamp data radios is through S&B of Bellevue, Washington or Accu-Comm of Snohomish, Washington.

   Communications back to the WTP is currently over a DSL system using VPN technology for security. DSL and VPN technology will be easily supported for very many decades in the future. DSL modems and VPN routers have a typical life span of about 10 years.

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3.8 Existing SCADA System Instrumentation Evaluation

Instrumentation lifespans are dependent on the age of the device, the type of instrument, where it is installed, how well it has been maintained, its priority for SCADA control and the recommended lifespan from the manufacturer. Water system instrumentation is typically only reviewed for replacement when the device fails or when the facility is upgraded. A more pro-active method of maintaining SCADA instruments is to upgrade devices based on their current lifespan, their ability to produce an accurate measurement and available funding of SCADA system components.

1. **Discrete Instruments –** These types of sensors typically have the longest lifespan for instrumentation. It is not uncommon to use switch type sensors for 20-30 years. Testing and calibration is recommended as part of the City O&M procedures to make sure these devices are working correctly. The float switches, pressure switches, intrusion switches, and smoke alarms should be tested on an annual basis. Discrete instruments from motor control centers and valves are usually tested whenever the facility is running.

2. **Analog/Digital Instruments –** Analog instruments typically have a lifespan of between 10-20 years depending on the type of device. High priority instrumentation that is necessary to run the water system should be checked annually for calibration accuracy and replaced before they fail.

    a. **Water Quality Sensors** – These instruments usually have the shortest life and the highest maintenance in a water SCADA system. Calibration is typically checked on a regular basis so any failures in accuracy and reliability can be quickly identified. The advanced features of these instruments makes it relatively easy to test for failures or calibration issues. Replacement of these instruments are commonly implemented during facility upgrades, when the instrument has failed or when newer technology is available that will lower O&M costs.
    b. **Level/Pressure Sensors –** Calibration of these types of devices should be implemented on an annual basis. Older versions of these types of sensors could be adjusted in the field when the calibration accuracy was found to be outside of an acceptable range. Modern versions of these sensors usually require full replacement once the accuracy range has failed. Sensors that are directly connected to the water system are called “in-process instrumentation” and have a typical lifespan of about 10-20 years. Most manufactures give their sensors a lifespan of 10 years with a higher probability of failure after that time frame. Out of process instrumentation such as ultrasonic level sensors can have a longer life span as they are not directly connected to the water system. Ultrasonic level sensors are also capable of self-diagnoses for component failures where most analog level and pressure sensors do not have this capability. When testing pressure sensors, a high quality calibrated pressure sensor should be used for identifying the baseline pressure. Bourdon tube mechanical pressure gauges should not be used for calibrating electronic pressure sensors. Level sensors can be checked for accuracy using level measurement gear.
    c. **Flow Meters –** The lifespan of these devices is dependent on when they were installed and the type of technology used. Flow meters with moving parts such as turbine meters or insertion meters will lose accuracy over time. Because accurate flow testing is difficult to achieve for most utilities, it is recommended that these devices be replaced based on their age and priority. Electromagnetic (Mag) flow meters are designed not to lose

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accuracy over time due to the lack of any moving parts. Typical failures for a Mag flow meter would be the failure of an electronic component in the meter transmitter. Mag flow meters are also capable of self-diagnosis to identify component failures.

Winchester Water Treatment Plant Instrumentation – This facility has a mix of new and older instruments. These will need to be evaluated during the control system upgrade design of this facility within the next 5 years.

Tone Control Facility Instrumentation– It is assumed that the majority of the existing instrumentation at each of these facilities was installed during last control system upgrade. The Tone Control Facilities and some of the Isolated Control Facilities have the oldest instrumentation that should be replaced as part of a control system upgrade. Because the Tone Control facilities will need to be upgraded in the next 5 years, this will be a good time to evaluate what devices should be replaced.

Siemens/Automation Direct Instrument Facility Instrumentation – The instrumentation at these facilities is most likely in middle age depending on when the facility was upgraded in the last 12-14 years. Due to the anticipated life span of these facilities an annual calibration testing process should be implemented.

Dixonville Facility Instrumentation – The instrumentation at these facilities are new and should also be part of an annual calibration testing process.

Isolated Control System Instrumentation – These facilities are not currently being monitored. Future implementations to connect these facilities to the city water SCADA system may only require monitoring of specific instruments rather than implementing a full control system upgrade.

Instrumentation Standards – It is usually a good idea to standardize on the type and brands of instruments that are used at specific types of facilities. Standardization allows for purchasing a small number of spare parts that can be quickly swapped with failed components. Standardizing also simplifies training of operations staff. Because technology does change over time, standards will need to be reviewed annually to identify new models of instrumentation and newer technologies.

Facility Instrumentation Standards – In addition to instrumentation standards, each type of facility should have a specific minimum standard of the types of instruments that will be implemented. This will simplify control equipment design and also allow generic control panels to be designed for multiple facilities to lower implementation costs. Consistency in data collection will also allow for improved analysis of how water is consumed within the city. Pump stations should always be able to measure discharge pressure and flow to identify any operational failures but to also identify how the upper zone is consuming water. Reservoir storage level is critical to these facilities but they can also identify flow into and out of the facility with flow meters.

4 SCADA System Best Practices Overview

This section will review some of the fundamental concepts in modern SCADA system technology and identify the current best practices used for designing new systems and upgrading existing systems. This information will be used as a reference when identifying alternative upgrade options for each of the existing SCADA sub-systems.

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4.1 SCADA Data

SCADA systems are fundamentally about moving data around a geographically distributed network. SCADA systems have historically been the primary domain of the operations staff; therefore, so these systems have usually been limited in the scope of the data that is collected. Advances in computer technology now allow many different internal and external users to access SCADA data for many different purposes. This section can help define the various data requirements for any new users.

4.1.1 SCADA Data Overview

Data Users – Who will use the SCADA system data?

Data Quality – Do the SCADA system users have the data information that they need?

Data Resolution – Of the data that is currently available from the SCADA system, do the users have the resolution that they need? In other words, how often can the SCADA system obtain data back to the users from the remote sites?

Data Availability – How complete is the SCADA system data and what are the requirements for data availability? Typically this requirement identifies how long communications can be lost to a facility for control or monitoring purposes.

Data Access – What are the various methods that data users will use to access SCADA system data?

4.1.2 Data Users

SCADA system data users currently consist of the following groups.

Water Operations and Maintenance (O&M) Staff – Operations and maintenance staff that handle all issues regarding the City's drinking water system. This system includes reservoirs, pump stations, and water infrastructure.

City Management – Management that handles all decisions regarding utility infrastructure, staff, and accounting.

City Engineers – Engineers that work with the City will use SCADA instrumentation data during water and wastewater infrastructure design. This information could include facility flow rates, flow totals, water/wastewater system levels, zone pressure, and pump run times.

4.1.3 Data Quality

Data quality defines the amount of data points that are collected and the quality of the information that is gathered. The Dixonville and Siemens/Automation Direct PLC systems have very good data quality. This is due to the PLC systems capability to transmit more data over the SCADA network and the data is transmitted in digital format. The Tone Control facilities have relatively poor data quality due to the limitations in their data transmission system. The Tone Control facilities transmit analog data using audio tones instead of transmitting digital data packets. Facility analog signals are converted into audio signals, transmitted over the phone line and are then converted back into engineering units on the receiving side at the water treatment plant. This conversion typically adds error to the data depending on the quality of the phone line and the transmit/receive equipment.

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4.1.4 Data Resolution

Data resolution can be defined as the amount of time that it takes to access data from a remote facility. Landlines typically have good data resolution while some private radio systems have fairly poor resolution.

The existing SCADA communications consist of a wireless radio system for the Dixonville system and dedicated POTS phone lines for all other facilities.

Radio System Data Resolution – Radio systems can only communicate with one facility at a time in a round robin pattern. Due to this delay, the more data collected, the longer the time increments between facility data updates. The speed and bandwidth of the radio frequency is the defining factors for identifying radio system speeds. As more facilities are added or more data is collected, the speed of the communication may compromise the data resolution for some users. The Dixonville system has only 4 facilities currently using the Viper 450MHz radio network. Because there are so few facilities on this radio network, data transmission is fairly fast. A complete polling of all of the Dixonville facilities probably takes less than 15 seconds. Larger systems, however create longer lag times in retrieving facility data and controlling facilities remotely. If 20 facilities where part of the radio network, data resolution could approach 2 minutes between facility polling.

Dedicated POTS Phone Line Data Resolution – Although POTS phone lines are fairly slow at transmitting data via audio signals, each facility has their own dedicated line for continuous transmission. This type of system allows for almost real time response from remote facilities to the HMI computer system. Because the city staff have become used to this level of responsiveness, it might be difficult to move to a system that is much slower.

4.1.5 Data Availability

This section identifies how long the City can withstand communication failures to any of the facilities. Facilities that require data from other facilities require the most availability for the SCADA communications system. If communications between facilities linked for control purposes is lost, then control will eventually fail. Operations staff alarm and monitoring data and historical data users have the second highest priority in data availability. The reliability of the SCADA communications network needs to be analyzed to identify if communication outages are causing the availability of statistics to drop to unacceptable levels. This analysis may necessitate an upgrade to the communications system to increase its reliability.

4.1.6 Data Access

The City is currently accessing all of the system data via the HMI server in the Winchester Water Treatment Plant. There is also limited remote access of the Dixonville system directly over a VPN connection. The data access is defined as follows.

Alarms – Facility alarms are received at the HMI. Because this facility is staffed 24x7, alarms are monitored continuously.

Discrete Events and Analog Data – System data is displayed on the HMI server for the treatment plant operations staff to monitor and control the plant and the water facilities. Water system information is stored in a database on the DMS computer for accessing historical data that can help in operational decisions. This data may also be used by City management and engineers for planning and financial purposes.

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4.2 SCADA Instrumentation

Most instrumentation has a lifespan from 5-20 years depending on how quickly the component wears out, is no longer supported by the vendor or has become obsolete due to newer technologies. Switch type instruments such as floats, pressure switches and intrusion switches usually have the longest lifespan due to their simplicity. More complex instruments such as flow meters and level/pressure sensors should usually be reviewed for their accuracy or obsolescence. As an example, turbine flow meters have been replaced by electromagnetic (mag) meters in recent years due to their very high accuracy. Ultrasonic level sensors have become common to replace level sensor probes. Water quality sensors have had a revolution in quality and lower O&M costs over the last 10 years.

Motor control center (MCC) equipment is the interface between PLC's and motors/pumps and can be categorized as monitoring and control instrumentation. An MCC should have a lifespan of at least 20 years or longer. Modern MCC equipment can be relatively simple or can have very advanced features depending on their size and purpose. Some of the MCC systems in the Dixonville system are connected to the Siemens PLC's over a digital interface called Profibus. This allows for the PLC to easily access literally hundreds of status and control parameters. This capability is not necessary for every facility. Due to the topology of the City, many of the booster facilities use relatively small motors and pumps and may not need a very advanced motor control system.

It is also a good idea to identify future instrumentation for a facility if they may be added at a later date. These future additions can be designed and programmed into the control panel equipment during the initial installation rather than upgrading the system at a later date. In addition, the PLC can be correctly sized for the existing and future instrument electrical connections.

Below is a list of common instrumentation used at various types of water facilities.

Standard instrumentation for every facility

- AC Power Fail
- DC Power Fail
- DC Battery Fail
- Panel/Building/Vault Intrusion
- Panel Temperature (depends on environment)
- DC Voltage Sensor
- Panic Button
- Alarm Reset Button
- Intrusion disable system – Key switch or Operator Interface Password.

Reservoirs

- Level Sensor
- Flow Meters for inflow/outflow
- Reservoir Intrusion
- High Level Float
- Seismic Control Systems
- Valve Status
- Tank Mixer Systems
- Water Quality Instruments

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Booster Pump Station

- Smoke Alarm
- Phase Failure Sensor
- MCC Status/Alarms
    - Across the Line Starter Systems
    - Softstart Systems
    - VFD Systems
- Discharge/Suction Pressures
- Flow Meter
- Water Quality Instruments
- Valve Status
- Power Monitoring Systems
- Electrical Generator/Automatic Transfer Switch Status

Control Valve Facilities

- Pressure upstream/downstream
- Flow
- Valve Status

4.3 SCADA Monitoring and Control Devices

The control equipment that is used for modern SCADA systems are usually based on a number of factors.

Controller Features – Specific applications require specific types of controllers, which are defined by the following specifications.

- Expandability – Controllers are usually sized for small, medium and large applications. The size of the controller defines the number of inputs and outputs that can be connected to it.
- Modularity – This defines how modular the control equipment is for different applications. Modern controllers are usually very modular as they can be built with different sets of inputs and outputs depending on the application.
- Communication Capabilities – This is usually defined by the communication protocols the controller can support.
- Application Development Software – Every control vendor has its own development software. Development software defines the speed of the development process, the ability to efficiently debug applications, and the proficiency to create an automated process that meets the customer's requirements.
- Cost – The difference in cost between control equipment models can be substantial. Premium brand equipment has capabilities that low cost models do not. The question during design is to identify if the high level capabilities of the more expensive models are necessary for simple automation systems.

Local Support – The local integrators usually support a limited number of control equipment brands. This is due to the complexity and cost of supporting many different types of equipment. In the Pacific

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Northwest, Allen Bradley has the largest market share for new control equipment in the water/wastewater industry. This is due to the large support structure that has been built around this equipment for numerous industries. Other brands used the Pacific Northwest for water/wastewater applications consist of Siemens, Schneider Electric, GE, and Automation Direct.

Existing Control Equipment – Utilities usually standardize on specific control equipment vendors and models to limit the amount of spare parts and training necessary for support. This is an acceptable method as long as a control vendor supports existing equipment or provides an upgrade path to new equipment.

Control System Standardizing – The City has long standardized on Siemens control equipment due to their long history of working with S&B. City management has decided to move to a more commonly supported control platform to allow for more integrators to bid on projects instead of single sourcing S&B as the sole integrator. Rockwell Automation/Allen Bradley has been selected for future facility upgrades due to its popularity. The ControlLogix and CompactLogix PLC platforms have been selected as the controllers to be used in future facilities. CompactLogix PLC equipment will be used for small to medium sized facilities. ControlLogix PLC equipment will be selected for larger facilities such as the water treatment plant. Because S&B supports Rockwell Automation products, they will still be available for facility upgrades and future O&M services.

Age of Control Equipment Models – Control equipment should have a minimum lifespan of 15 to 20 years if correctly selected. New control equipment should not be selected at the very beginning or the very end of their design life. Control equipment new to the market may be prone to software bugs that have not been identified. Older control models may be more stable but may not be easily supported once the models are discontinued. Control vendors of today try to create upgrade paths for replacing older equipment so that users are not compelled to move to new brands.

Control Panel Power Systems – One of the most critical items to extend the lifespan of a control system is the design of the power system within the control panel. AC power hits can reduce the lifespan of electronic components substantially. The more protection that is implemented, the longer the system will operate without failures. 10 years ago most control panel power systems consisted of a very simple linear DC power supply and a lightning surge protector. Modern PLC equipment is actually more susceptible to bad AC power than equipment from the 1990's or earlier. This is due to the type of low powered circuits that are commonly used in modern electronic systems. Modern control panel power systems now use the following components:

1. **Lightning surge protector on the AC input** – This is usually located outside of the panel or within a protected area inside of the panel. These devices are designed to self-destruct in case of a large voltage spike to isolate the control panel from the utility power.
2. **DIN Rail Mounted DC Power Supply** – This is the AC-DC converter and is designed for industrial applications. This type of DC converter is usually a switching power supply that only takes as much AC power that is being used by the control panel. Previous linear DC power supplies were power wasters that ended up creating too much heat.
3. **DIN Rail Mounted DC Uninterruptable Power Supply (UPS)** – This DC UPS system works directly with the DC power supply to switch the control panel to backup batteries in the case of bad AC power. These are relatively new devices that replaced AC UPS equipment. The problem with the AC UPS equipment is that they were never designed for industrial applications and were not UL rated for control panels.
4. **DIN Rail Mounted DC-DC Isolators** – These devices were created to isolate the PLC and other delicate electronic devices from facility ground faults. Ground faults are when AC power feeds

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back to the control panel from the ground connection**.** This device adds another level of isolation to the PLC by completely isolating the DC ground from the control panel ground.

5. **Circuit Breaker Isolation** – Every electronic component within the control panel should have its own circuit breaker to prevent a single component from taking out the entire power supply**.** There are typically AC circuit breakers for all of the AC components and DC circuit breakers for the DC components.
6. **Instrument Fusing** – Isolating instruments with fuse holders allows protection for the control panel when an instrument or the instrument wiring fails. Adding fuses to all instrument connections allows the instruments to be isolated from the control panel for maintenance without having to power down the control panel. Modern fuse holder can be obtained with LED lights that light up when the fuse has blown. This helps operations staff identify blown fuses with a quick view into the control panel terminals.

Control Panel Operator Interfaces – Modern facility control systems almost always have some type of operator interface (OI) that acts as a local HMI for the facility PLC system. The information on this OI usually only relates to the local facility although sometimes remote information from other facilities is displayed. An example of a modern OI screen design is located in Appendix A (**Figure A-2**).

4.4 SCADA System Software

SCADA software development is the process of creating software for programmable logic controllers, operator interface touch screens and SCADA HMI computer systems. This process can also include the configuration of communications and instrumentation equipment. Control system software development quality can vary greatly depending on the quality/experience of the programmer, the amount of funding available and the requirements for the system. RH2 typically has a set of minimal requirements for integrators to meet along with a review process by our Clients and a third party to identify any issues.

4.4.1 PLC Software Development Requirements

The critical task for modern PLC software systems is make them as flexible as possible for future tuning of the system without requiring on-site PLC changes. Any value that could be considered a setpoint should not be hard wired into the software. These should always be variables that can changed by the City operators on a local operator interface and/or the SCADA HMI computer system.

1. <u>PLC Software Development Requirements</u>
    a. PLC software functions should organized into separate task files and should be heavily documented by the developer.
    b. Software should be primarily ladder logic coding with function block diagrams used when appropriate. Sequential Function Charts and Structured Text programming is not allowed due to the lack of support among software developers.
    c. All software and software components will be the property of the City and will not be copyrighted in such a way that they cannot updated by other developers.
    d. All PLC software will be given to the City at the end of the project or after any updates.
    e. UDT data structure should be created for each object within a facility of supported by the PLC system. All values will be contained within the UDT. Water system objects would be any component that provides status or can be controlled. Pumps, level sensors, flow

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meters, PLC's, pressure sensors would be considered objects. This data methodology will help organize the PLC data structure.

f. Transmit and Receive data should be organized into data array UDT's. Values will be moved into and out of these arrays in a separate communications routine. This method is necessary to optimize the communications speed to and from the facility.
g. I/O addressing should be handed to specific UDT values in one code location and not used directly in the rest of the software. This virtualizes the I/O values and allows for easy changes in the future code.
h. PLC status should be monitored for major/minor alarm events.
i. Date/Time should be synchronized at 3am with the Master PLC controller at the Treatment Plant. The Master PLC controller Date/Time is synchronized from the HMI computer systems. The SCADA HMI computers are synchronized with a City Time Server service. The City Time Server service is synchronized from an Internet Time Server.

2. Calibration Setpoints
   a. All analog values should have offset/span setpoints available to be change on the facility operator interface. This allows the City to install different instruments in the future without having to reprogram the PLC.
   b. Other setpoints that are used to identify information such as quantity of flow per flow meter pulse should also have operator interface setpoints. These could include the diameter of a reservoir tank or the maximum number of times a pump can be called in an hour.

3. Alarms
   a. All analog alarms should have setpoints that can be changed on the facility operator interface and remotely on the HMI.
   b. All analog and discrete alarms should have delays that can be changed on the operator interface and possibly at the HMI depending on the facility. A delay of zero will disable an alarm. Critical alarms such as panic switches should not have a delay and should not be able to be disabled.
   c. Every analog alarm should have a Low-Low, Low, High, High-High and instrument failure alarm unless specified otherwise. Low-Low, High-High alarms are typically used for control interlocks while the Low and High alarms are meant for operator notification of a possible failure. Instrument failure alarms are used to identify if an instrument connection is lost or outside of its normal operating range.
   d. Each facility will have alarms that are internal to the control panel and external to it. Internal alarms could consist of AC/DC/Battery status power monitoring alarms or PLC failures. External alarms refer to alarms based on any external instrument wired to the control panel.
   e. Alarms at the water treatment plant should have a centralized set of screens on the SCADA HMI computer system for enabling/disabling alarms. This ability can also be extended to the remote facilities if necessary. This allows the staff to disable nuisance alarms until they have been resolved. Typically nuisance alarms are due to instrument failures that require system maintenance.
   f. Pump alarms should include Call No Run, Run No Call, Maximum Pump Runs and MCC failure at a minimum. These alarms only require the PLC to see the Call, Run and MCC

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status inputs for the pumps. Other facilities may have additional pump alarms such as phase fail, over temperature or high discharge pressure switches that can be wired into the control system. In addition, systems such as Dixonville have the ability to digitally communicate with the drive/MCC equipment and can get much more specific alarm information.

g. Control lockout routines should be included in any control facility for locking out control systems based on specific alarms. Typically a master lockout would include power failures, smoke or flood alarms. Pump lockouts would include the master lockout, pump/motor alarms and any instrument alarm that should shut off pump.
h. Alarms such as high reservoir level or reservoir communications failure will need to be transmitted to the control facilities such as booster pump stations. These alarms are critical for pump lockout purposes.

4. Control
   a. Facility control should be based on design criteria for a specific facility. Typical booster control usually involves simple storage start/stop level setpoints where water treatment plant control will be much more complex. The software should be flexible enough so that most control setpoints can be accessed by operator interface screens or SCADA HMI computer system.
5. Summary and Totalizing
   a. Analog values should have daily minimum, maximum and average values calculated constantly. These values should be reset at midnight or a time of the City's choosing. Treatment plant daily values to be moved to yesterday values at this time to help with tuning process control setpoints based on yesterday's information.
   b. Daily, yesterday and grand totalizing values should be used for flow sensors, pump starts and pump runtimes.
   c. Communications statistics should be constantly calculated at the master controller. These statistics include daily communications success rates in percentages, number of concurrent communications failures and last poll time of a facility in seconds. These values are critical to diagnosing communications failures.
   d. Continuous calculation of existing reservoir storage and quantity to fill in gallons should be used at each storage facility.

4.4.2 Operator Interface Development

The use of operator interface equipment has only become very popular in the last 10-15 years. The complexity of facility control systems has necessitated this device be installed in any facility that has a local PLC. This is due to the number of ways that modern PLC's can be configured and changed by the operators to tune the facility. In addition, a facility that is in an alarm condition can be resolved much easier with an operator interface display.

Due to different opinions on the best methodology for screen design, it is best that an integrators create prototype operator interface screen layout for approval by the City staff before actual coding begins. Example screen layouts may also be included in the RFP process to help integrators understand the amount of work required. Modern operator interface should consist of the following screens.

1. Main Screen – The main screen should show the critical information about the facility and does not require any security login. It does not allow for any changes or acknowledgement of alarms.

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This screen may include information such as instrument status, date/time, and alarm status. Depending on how the system is setup, a security login may be necessary at this point to move to the full screen system.

2. Menu Screen – The screen menu would be displayed once an operator has logged into the system. This login process would be sent back to the SCADA HMI system during the next polling cycle for future tracking. Depending on the level of the operator security, only specific options will be available for access other screens. Lower level security can view screens, acknowledge alarms but not change any values. Higher level security can access critical facility setpoints.
3. Current Alarm List – This screen displays the current alarms that are engaged. Some alarms may be latched and need to be reset in order to clear them. This screen will have this reset option if the user is logged into the system.
4. Historical Alarm List – This screen shows a list of about 100 of the last alarms on the system including their date/time.
5. Calibration Setpoints – These screens have all of the instrumentation calibration setpoints.
6. Analog Alarm Setpoints – Setpoints and timer delays that are used to trigger various analog alarms.
7. Discrete Alarm Setpoints – Discrete timer delays that are used to trigger various discrete alarms.
8. Current Discrete Input/Output Status – Current on/off status for discrete inputs and outputs from the PLC controller.
9. Current Analog Input/Output Status – Current analog values for PLC analog inputs and outputs.
10. Summary Screens – Minimum, maximum, averages, totalizers, quantity of storage, starts, runtimes are example of data on these screens.
11. Trend Menu – List of analog trend screens.
12. Trend Screens – 24 hour trend screen for specific analog values such as flow rate, storage level or discharge pressure.
13. Control Setpoints – Setpoints used for controlling facility process.
14. Facility Subsystem Screens – Screens for each facility subsystem to display its current status. Examples would be booster screen, reservoir screen or PRV valve control screen. These screens would display the system graphically along with all of the discrete status and analog values.

4.4.3 HMI Software Development

HMI software has many similar features to the operator interface development. The differences are in the size of the graphical development environment and types of data being monitored and controlled. HMI computer systems typically do not access remote low level information such as calibration setpoints unless the facility does not have an operator interface. This information is rarely changed and only slows down communications to remote facilities by including it for transmission. At the treatment plant, this information may become part of the HMI computer system because it is local to the facility and because the treatment plant may not have a separate operator interface panel when it is updated.

Prototype screen layouts should be created by the integrator for City approval before coding is started. Example screen layouts should be provided to integrators before they propose on a project to help with cost estimating.

1. Sizing HMI SCADA Software – SCADA HMI software is typically sold by the number of data point tags that the system will be monitoring. HMI Database software is sized based on the number of data points that will be stored in a database. Licenses are typically complex and based on each computer used. It is critical to specify the size of a system that the City can afford. This includes

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initial pricing along with annual maintenance contracts or future upgrades. Due to the complexity of replacing an entire HMI software package, it is not uncommon for these programs to be used for decades. Decisions made during initial implementation can affect the system for a long time.

2. Screen Resolution – HMI computer systems are typically designed for HD resolution due to the standards involved. HD resolution is any display with 1920x1080 resolution. This standard should exist for at least the next decade. In addition, remote access devices are now capable of supporting this resolution on phones, tablets and other computers. Screen designs can extend to more than one screen or can have multiple screen types displayed at once. HD resolution also allows for the easy use of large screens in control rooms. It is very common to see 42”-60” screens used around control rooms due to the relatively low cost of these devices. The ability for multiple people to easily view facility status is the main reason for these screen implementations.
3. Screen Layout – No more than two mouse clicks should be necessary to move to any screen on the HMI system. This streamlines the layout to make it much easier to find system information. Screen designs should be consistent. Screen layouts should have specific information located in similar locations across the application.
4. Graphical Object Standards – Graphical objects should be standardized in relation to color and animation. As an example, pumps should have specific colors depending on if they are ready, locked out, running or in alarm. This should be standard across the HMI application and implemented on the Operator Interface screens. Clicking on a screen object such as a pump or a flow meter should display a popup window that shows the properties to that object. These properties include alarm setpoints, current alarms, status and summary data.
5. Trending – Historical Trending is a critical part of any SCADA system. Analog and discrete events/alarms should be stored for at least 5 years depending on storage capabilities. Most modern computer storage devices can hold many years of SCADA data. Trending capabilities are different depending on the SCADA HMI software that is used. Preset trending objects on the HMI screen can help operators quickly view commonly used trends. Clicking on a trending object may pull up all of the storage levels in one trend screen or all of the current system pressures.
6. Reporting – Reporting is typically an extension of the trending system. Reports are typically categorized into standard reports and ad-hoc reports. Standard reports are used on a daily, weekly, monthly, or yearly basis and are designed for specific purposes such as tracking flow usage, pump runtimes or water quality. Ad-hoc reports are used for specific purposes that are unknown until the report is required. This type of report is not defined during the SCADA integration process and may be needed after a water system failure or for an engineering study.

4.5 SCADA Computer Software (HMI)

SCADA computer software systems for water/wastewater utilities have evolved in a number of ways in the last 20 years. These systems originally were fairly simple due to the computer limitations in the 1980s and early 1990s. The first systems were usually proprietary systems that were fairly difficult to implement and maintain. Originally these were only known as HMI software but that has changed in the last decade as more features and software packages have been made available. Modern SCADA computer software should have the following specifications:

1. Graphical user interface design and run time software;
2. Historical database storage and trending;

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3. Historical analysis, reporting, and exporting;
4. Alarm monitoring and notification;
5. Extensive library of communications software for interfacing with many types of PLC controllers; and
6. Remote access capabilities.

Some of these items may be available directly from the one software company; however, usually a SCADA computer system usually consists of software from multiple vendors. The core of the system is the HMI software, but additional programs from third parties may be used for remote access, alarm notification, or interfacing to the PLC equipment.

In addition, modern SCADA system software should have the following features.

Large User Base – A large number of installed software systems is critical for the software to be supported for long periods of time. SCADA computer systems can be expensive to implement and are updated on a regular basis as the SCADA system evolves. The total cost of ownership is reduced when the software does not have to be rewritten from scratch due to a vendor no longer supporting a software product. The more popular a software platform, the more likely that local support can also be found to maintain it.

Local Support – Some SCADA computer software brands have better local support than others. Wonderware and Allen Bradley/Rockwell Automation are currently the two most common brands of software with the most local support.

Modular Design – The software should be capable of being deployed in small or large scale environments. This is important for SCADA systems that may start out small but grow over time. Modular systems allow for multiple computers to work together for viewing or redundancy reasons. The larger the SCADA system, the more critical it is to create a computer system that does not have a single point of failure. Modular software systems allow for multiple sets of software components to operate simultaneously on multiple computer systems. If one system fails, another is capable of taking over.

Consistent Upgrade Path – SCADA computer systems are usually the most common upgraded component of any SCADA system. This is due to the 5 to 7 year lifespan of a typical computer system. The SCADA software vendors need to provide an easy upgrade path for new computer and operating systems.

Modern Features – SCADA computer software should be constantly upgraded to keep up with new features in the control and computer industry. Modern features may consist of the following.

SCADA Server Hardware and Operating System – The control software industry has been recommending the use of server class hardware and software over the last decade. This is because they are designed to run continuously for long periods of time without failing. This is due to redundant error correcting hardware components and heavily tested operating system software and drivers. Workstation class PC computers and operating systems do not meet this level of robustness. The current system is apparently stable so this type of upgrade should probably occur during the next computer system upgrade.

Remote Access – Remote access for development, maintenance, and utility monitoring. This is usually provided by the operating system or third party applications. Remote development and maintenance can reduce travel time for SCADA support vendors. Remote monitoring using laptops, tablets, or smartphones is becoming a critical feature for modern SCADA systems, as it greatly increases the efficiency in which operators can monitor and control their system. This is especially true for utility systems that are not monitored 24/7 but use on-call personnel for nights and weekends.

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The current city SCADA computer software platform is WinCC from Siemens Corporation. This is a very advanced and modular software package but is not supported by many integrators. The most supported SCADA software in the Pacific Northwest is Wonderware InTouch and Allen Bradley RSView32 or Allen Bradley FactoryTalk View SE.

Wonderware InTouch was first released in the early 1990's and has a very large install base in the Pacific Northwest. Most large SCADA integrators and consultants have experience with Wonderware development. Wonderware is capable of interfacing with most of the major PLC controllers on the market and has a very large suite of software. Wonderware also has a very high end software package called Systems Platform. This software is not recommended due to its complexity and lack of capable developers.

Allen Bradley under the brand name Rockwell Automation is a close second to Wonderware in popularity. Their original RSView32 is still popular but their FactoryTalk View SE software suite is very well supported. Pricing is similar among Wonderware and Allen Bradley as they typically compete in the same markets. This type of software typically has a fairly high price tag due to its limited market. A single computer license can cost $5,000 - $10,000 depending on the size and complexity of the system.

4.6 SCADA Communications Functional Requirements

SCADA communications is based on technology standards that have evolved over decades of remote facility monitoring. As new communication methods have been developed, SCADA systems have embraced many of the more robust systems. A typical SCADA communications system requires a higher level of stability than most communication systems. These communications systems require the following functional requirements.

1. **Reliability** – The ability to run 24/7 with very few communication failures. Backup systems allow communications to run during power outages or in case of component failures. Identifying single points of failure in a communications system and how to handle these failures is a critical part of SCADA system design. Spare parts, on-call experts, and redundant communication paths are all methods that increase a SCADA system's reliability.

2. **Redundancy** – The ability to use a backup communications path in case a primary path is lost. This method of SCADA communications can be expensive but may be critical for facilities that require high levels of reliability. There has been discussion of implementing a backup cellular communications path at a number of facilities to increase reliability.

3. **CIP and O&M Costs** – The ability to keep long-term costs down by implementing systems that do not require leasing or selecting low cost options. Most SCADA systems do not require high data bandwidth so communications options that would not work for voice or video can work well with SCADA data. The current SCADA radio system consists of an unlicensed radio network; ongoing costs consist only of maintaining the radio components. If a backup redundant cellular network is added to the existing system the City will incur ongoing monthly charges. These charges will consist of a base cellular rate and an additional data usage rate.

4. **Local O&M** – Most SCADA communication systems require utility operations staff to diagnose issues when communications have failed. This is especially true during nights and weekends when service personnel may not be available to help. The more complex the communication system, the more difficult diagnosing these issues can become. Each utility has to identify what

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communication system they can operate and maintain in case of a system failure. The simplicity of the existing radio network allows for fairly easy O&M at this time; however, the existing system has had communication outages in the past.

a. **POTS Landline O&M** – POTS lines can be easily diagnosed for issues using standard phone testing equipment that is easily available on the internet or at large hardware stores such as Home Depot. A dedicated phone line should be relatively silent when no data is being transmitted. Both sides of the connection can be tested for the audio quality when data is being transmitted. This can easily identify if the failure is in the SCADA system or due to a phone line failure.

b. **Broadband O&M –** Broadband systems consist of digital only communications that typically uses TCP/IP as the data transport protocol. These systems consist of landline technologies such as DSL, Cable Systems, or fiber optics. Radio systems that use TCP/IP consists of cellular modems and private radio equipment. Diagnosing failures on any of these types of systems requires specialized backgrounds in data networking technology. Internal Information Technology (IT) staff or outside IT consultants are usually required to help maintain and diagnose these types of communications networks.

c. **Cellular and Private Radio System O&M** – SCADA Radio systems have a number of issues that need to be understood to keep the system operating at a high level of efficiency. Typical failures on radio systems are either based on equipment failure or signal loss due to issues with the Antenna systems.

   - **Antenna Wire Ages Over Time** – Antenna wire can become brittle over time and can corrode if water leaks into the coax.
   - **Antenna Connector Corrosion** – Water and ice can infiltrate outdoor antenna connectors and cause a lowering of dB signal strength or cause the connection to fail all together. Rubber boots filled with silicon are a necessity for outdoor connectors, but even these will eventually fail. Connectors should be checked for corrosion on a yearly basis.
   - **Antenna System Testing** – It is usually a good idea to bring a radio technician on site at least every 2 to 3 years to check for deteriorating antenna systems. A qualified technician can test the capabilities of the antenna system and identify if there is a certain amount of reflectivity to the signal caused by antenna system failures.
   - **Radio Technology Changes Quickly** – Depending on the cellular or radio vendor, radio equipment usually has a fairly short lifespan. Some vendors will release newer radios that are backward compatible with older models. Other vendors have been known to drop entire model lines if sales are too slow or newer technologies emerge. Cellular radios lifespan is based on how long the cellular company will support the technology the radio is based on. Current cellular systems are based on 3G and 4G technology but each of the cellular providers has a different implementation of these technologies. It is believed that the 3G and 4G implementations should be available for at least the next 10 years.
   - **Spare Parts Can Extent Life of Private Radios** – Once a private radio system such as the Dixonville system is no longer available, then the system is operating on

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borrowed time. Keeping spare radios on hand can extend the life of the system until the day that it can no longer be supported by the City or by third parties such as EBay.

4.7 Modern SCADA Communications Technology

As SCADA systems have evolved into using TCP/IP technology, there has been a growing trend toward decentralized SCADA Communications. Most SCADA systems currently rely on a centralized SCADA communications topology (**Figure 4-7**). In this topology, remote facility PLC data is transmitted through a Master controller at a centralized location.

1. **Centralized Communications Topology** – In this type of topology, all communications between the facilities and to the SCADA computer system is through a Master controller. All of the current communications topologies at the City rely on this topology to some extent. The Tone Control facilities all communicate through the Master 545 PLC at the treatment plant. The Siemens/Automation Direct facilities all communicate through the Master S7-300 PLC at the treatment plant. The Dixonville system uses Pump Station #2 as the Master communications PLC. Although this topology is necessary for some systems such as the Dixonville system, it's main weakness is a single point of failure. If the Master communications PLC fails, communications between the facilities and to the SCADA computer systems will fail unless a backup communications system is implemented.
2. **Decentralized Communications Topology** – This type of topology has no Master controller. Every SCADA component can communicate with every other SCADA component without the need for a centralized Master. This is usually only possible on TCP/IP based broadband systems such as DSL, Cable Systems, private fiber networks, high bandwidth private radios or cellular modems. All of these technologies can be setup to create a single control network with no single point of failure. In addition, multiple SCADA computer locations can be setup in case one location fails.

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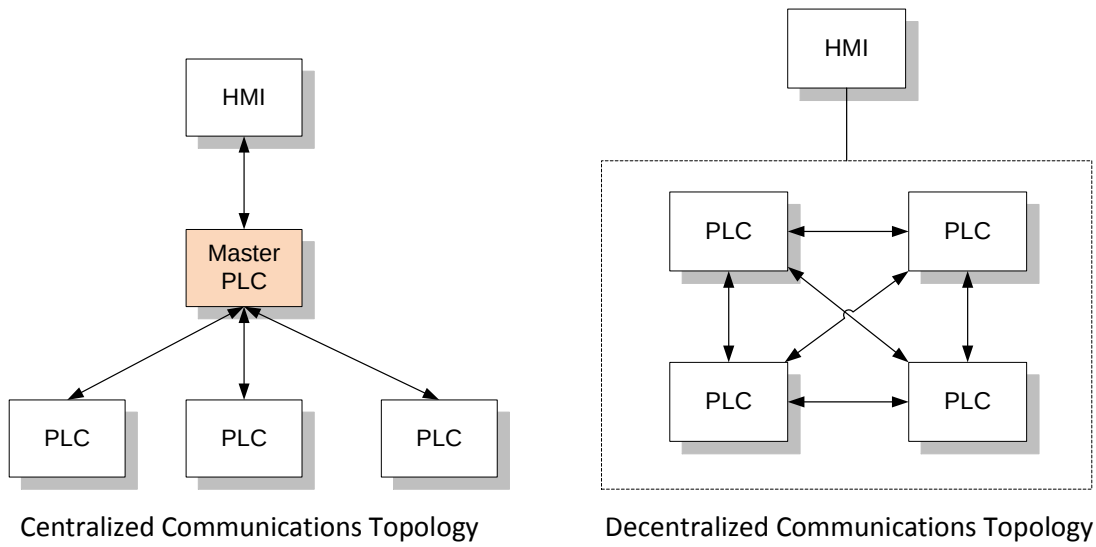
FIGURE 4-7

CENTRALIZED AND DECENTRALIZED SCADA COMMUNICATIONS



The numerous SCADA communications technologies available today can be categorized into three groups.

1. **Land Lines** – This technology consists of leasing communication channels from a local telecommunications carrier or using private fiber optic cable or copper wiring. Land lines can be as simple as a dial-up or dedicated phone line or as complex as a broadband fiber optic cable. Copper POTS land lines that are owned and operated by local phone companies are slowly being phased out for broadband and wireless technologies. Telecommunications companies have been transitioning their copper POTS land lines to broadband DSL connections with voice over TCP/IP. RH2 has been recommending to its clients to slowly move away from audio phone line communications unless there are no options for a specific location. Broadband over DSL, cable modems, and fiber optic cable are much better options for SCADA communications. Bandwidth is usually high, so data collection from the HMI computer allows for almost real-time views of remote facilities. If a broadband system is directly connected to the Internet, then VPN technology is required at each facility to encrypt the data and keep it hidden. Private broadband connections known as virtual LAN/WAN connection are sometimes available from the local telecommunications company. These are usually available on DSL and cellular modem networks for an extra monthly charge and isolate the connections to a private network that is not part of the Internet.

2. **Wireless** – Wireless technology has been used with success for SCADA purposes since the early 1980s and has lowered the overall costs of SCADA communications. Private wireless systems can also create a more robust communications system that usually survives emergency conditions better than land lines. These systems typically consist of the following technologies.

    - **Unlicensed Wireless (Private Network)** – 900MHz, 2.4GHz and 5GHz are unlicensed frequencies available for wireless communications. Because these are unlicensed

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frequencies, other users in the area may be using the same bandwidth for other purposes. Modern radio systems use spread spectrum technology to overcome this limitation by transmitting over a number of different frequencies simultaneously to prevent interference. These frequencies typically require a good line-of-site between facility antennas to guarantee a good data link. There are no ongoing costs for this type of wireless network.

- **Licensed and Unlicensed Wireless (Private Network) –** The 450MHz, 800MHz, and 4.9GHz bands have been allocated by the Federal Communications Commission (FCC) for licensed public safety wireless networks. Frequencies in these bands are licensed to individual entities in a specific area. No other entities are allowed to use these frequencies and interference is usually not an issue. The lower 450MHz frequencies work well in areas with questionable line-of-site transmission such as Dixonville, but are limited in how quickly data can be transmitted. The higher frequencies require line-of-site between locations but can transmit much more data. The 4.9GHz frequencies have started to become popular in flat terrain areas due to the high data speeds that can be obtained and the lack of interference. There are no ongoing costs for this type of wireless network. Unlicensed wireless systems usually start in the 900MHz frequencies and work their way up to many GHz. These systems are designed for carrying high bandwidth data loads but require absolute line-of-site transmission. These high bandwidth systems work well in rough topologies as wireless backhaul networks at high locations such as reservoirs. Lower frequency radios are then implemented to carry the signal the last
- **Cellular Wireless (Public Network) –** Cellular data modems have been available for digital data transmission since the mid-1990s. Modern 3G and 4G data modems for digital transmission of SCADA data have become common in many industries. Cellular links can transmit data over the public Internet or through private virtual networks setup by the cellular carrier. When sending data over the public internet, VPN technology in the radios is necessary to encrypt the data when transmitting between water system facilities. This is also known as a private cloud. Monthly costs include a connection charge and a monthly data usage charge. Emergency situations such as earthquakes or wind storms have been known to disable these types of communication systems for extended periods of time. 4G systems have the ability to prioritize their user base. Fire, police and government agencies are usually categorized as the top priority for cellular signal access. During these situations, lower priority cellular phones would lose connections first.

Hybrid Communication Networks – Different methods of communications can be implemented on the same SCADA network depending on the locations of facilities, the costs of communicating to the remote sites, the speed of the communications, and various other criteria. Many modern SCADA communication systems use hybrid technologies such as land lines for some facilities and wireless for others. The existing system is already a hybrid network consisting of dedicated POTS land lines, DSL and Private Licensed Radio.

Redundant communications may be necessary for high priority facilities. In this type of scenario, a facility has a primary and a secondary path for data communications. These communications paths are typically a combination of landlines and wireless.

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4.8 SCADA Computer System Security

The City staff has expressed interest in identifying improved security methods for remote access to the system. This section will discuss SCADA system security from a number of different directions to help with current and future security issues.

4.8.1 Defense in Depth

Defense in depth is a concept in which multiple layers of security controls (defense) are placed throughout an information technology (IT) system. Its intent is to provide redundancy in the event a security control fails or a software vulnerability is exploited. Exploited vulnerabilities may consist of personnel giving out passwords, procedures not being followed, technical failures in defense software/hardware, and physical connections being bypassed. Defense in depth was originally conceived by the National Security Agency (NSA) and is used throughout government, military, and infrastructure networks.

4.8.2 SCADA Network Separation

If SCADA information is travelling across a TCP/IP network, that network should be isolated from the City network. Access to the SCADA network should be tightly controlled through firewalls or perimeter networks. This should always be the first level of defense in depth (**FIGURE 4-8**).

4.8.3 SCADA Network Firewall/DMZ

Any firewall separating the SCADA network from the City network should implement the following rules.

1. Only specific TCP/IP ports should be enabled for transmitting data between the SCADA network and the City network or the outside world.
2. Standard TCP/IP port numbers should be randomized if possible so that hackers cannot easily find them.
3. Firewall rules should be implemented to notify IT staff of possible attempts to infiltrate the SCADA network.
4. VPN technology should be used to access the City network if it is used as a gateway into the SCADA network.
5. MAC Address security should be added to VPN and firewall layers to allow only specific devices through to the SCADA network.

4.8.4 Remote Access Hardware/Software

1. All remote access software should use encryption between the remote device and the HMI computer system. This is usually implemented using some type of virtual private networking (VPM) process.
2. Remote access devices should have login passwords to access the device.
3. There should be separate passwords for the VPN and the remote access software. Passwords should not be automatically stored on remote access devices.
4. Remote access tablets and smartphones should have remote wipe features in case they are lost or stolen. This is a feature available from the telecommunications company that supplies the cellular link.

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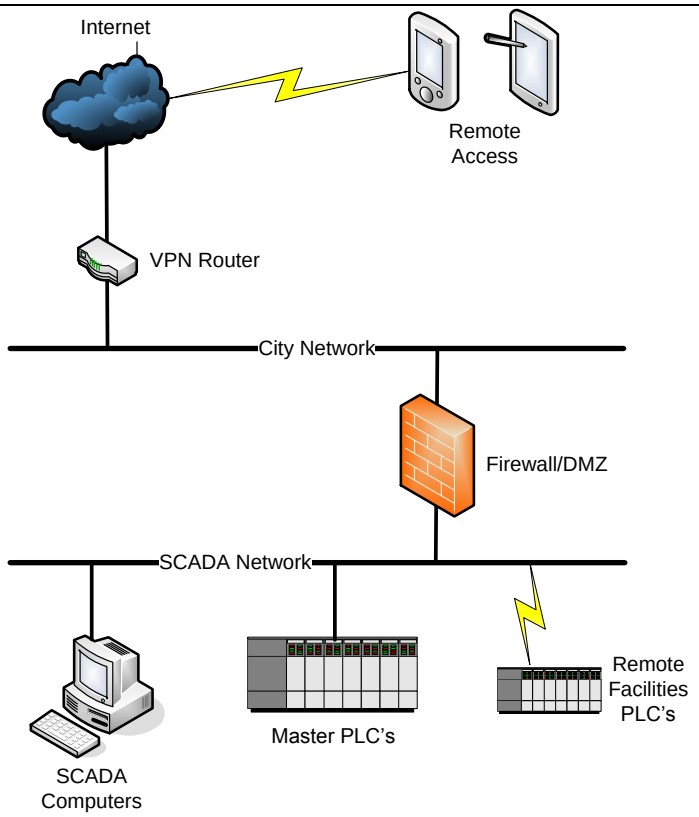
FIGURE 4-8
Network Security



4.8.5 Multi-Factor Authentication

The password is the weakest link in any security system. There are many reasons for this, but typically it is because passwords are too easy to crack, are given to strangers, are not changed very often, or are used on multiple accounts. High security network systems are aware of these issues and have implemented multi-factor authentication systems for access.

Multi-factor authentication is an approach to authentication that requires the presentation of two or more of three authentication factors: 1) a knowledge factor ("something the user knows"); 2) a possession factor ("something the user has"); and 3) an inherence factor ("something the user is"). Most systems use the two-factor authentication process in which the following information is presented for access.

1. **Something the user knows** – This is usually a password but it requires some rules to make sure it is strong and is changed often; and
2. **Something the user has** – This authentication consists of a random number that is generated on a device the user carries with them. These can be generated on a smartphone using a special app or with a LCD display that is typically carried on someone's keychain. RSA provides this service for many large companies and government agencies. Microsoft has also moved into this field with the Azure Multi-Factor Authentication process.

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5 Alternate Approaches for System Upgrading

This section will identify various upgrade options and estimated costs for each of the SCADA sub-systems that have been identified as necessitating system improvements. This section will also identify possible implementation methods that will have the least amount of impact to the water system control.

5.1 Winchester Water Treatment Plant Alternatives

The Winchester Water Treatment Plant is the hub for all of the existing SCADA sub-systems. This facility hosts its own control system for the water treatment plant operations. This same control system is responsible for monitoring and controlling the existing 11 tone control facilities. Both of these sub-systems should be replaced within the next five years due to the obsolescence of their technology. The 11 tone control facilities will need to be upgraded before the plant Simatic 545 PLC system is replaced as these facilities cannot be supported with any modern control technology.

5.1.1 Simatic 545 Based Control System Upgrade Approaches

Replacement of an operating control system for a water treatment plant is a complicated process. Unless the treatment plant can be taken off line for an extended period of time, the control system will need to be upgraded while it is still operating. This is the equivalent of repairing a car while it is driving down the road. It is a complex procedure that requires a higher level of time and costs than just replacing a control system all at once. Upgrading an operating control system usually is done in small phased steps. The control system is broken down into sub systems that are upgraded one at a time. The sub system upgrades are designed to have a minimal impact on the operations of the treatment plant. As a sub system is upgraded to new PLC equipment, the upgraded sub system software needs to be disabled on the existing 545 PLC. Depending on how this upgrade is implemented, the new PLC equipment may require communications to the existing 545 PLC. As an example, the water inflow quantity data may be needed for various upgraded sub systems to operate. If this inflow data only exists on the 545 PLC it will be necessary to send it to the new PLC system.

Extensive planning will be required to identify the upgrade process and the costs involved. Because the system will be transitioned to a new PLC control system in small steps, the labor costs will be much higher than for a facility that can be shut down and upgraded in place.

In addition, new or upgraded water treatment processes may be identified during this upgrade that could have a large impact on the final cost and implementation process. The following task list is an example of how this upgrade process would be implemented over a 5 year period.

1. **Pre-design of Simatic 545 PLC control system** – This is assuming that Tone Control facilities will have been upgraded by the time the 545 PLC is upgraded. This pre-design will do the following:
    a. Identify all of the existing treatment plant control components;
    b. Identify if any new or upgraded treatment processes will be part of the project;
    c. Identify what components will be replaced and what will remain;
    d. Identify a preliminary list of new control components;
    e. Identify phased implementation methodology;
    f. Identify cost of decommissioning existing Simatic 545 PLC during project installation;
    g. Identify preliminary upgrade costs for future CIP budgeting;
    h. Identify preliminary schedule of installation;

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   i. Prepare the groundwork for full system design.
2. **Design of new PLC control system**
   a. Forensic inventory off all existing control system documentation. Older facilities usually require a comparison of the existing documentation to the actual installation conditions to identify any unknown wiring of system components.
   b. Full electrical design of new control equipment and installation wiring.
   c. Specifications for equipment fabrication, electrical installation, software development, implementation phasing, testing and training.
3. **Construction Process (once funding has been identified)**
   a. Bidding process
   b. Equipment purchasing and control panel fabrication.
   c. Panel testing and software testing.
   d. Preliminary equipment installation.
   e. Phased conversion of control from existing 545 PLC to new PLC system.
   f. Training for City staff during each phased upgrade process.
   g. Final decommissioning of 545 PLC system.
   h. Final O&M documentation and training.

The vast majority of the existing plant instrumentation is currently wired to the current control room. This would signify the use of a large scale Allen Bradley Logix controller such as the ControlLogix L6 or L7 series system. There is also the possibility that distributed controllers may be added around the facility as subsystems are moved from the current Siemens PLC to a CompactLogix PLC. These controllers would be networked with fiber optic wiring to create a plant control network. Distributed controllers are typically the most common method of design for new and upgraded treatment plants. This method greatly reduces wiring runs from instruments to controllers.

It also may be necessary for S&B to be involved during this upgrade process even if they are not selected for the new equipment integration. This is due to the process of disabling sections of the existing 545 PLC control software as it transitioned to the new PLC equipment. They will also be critical in moving any instrumentation data between the old and the new control systems until the upgrade is complete (**FIGURE 5-1**).

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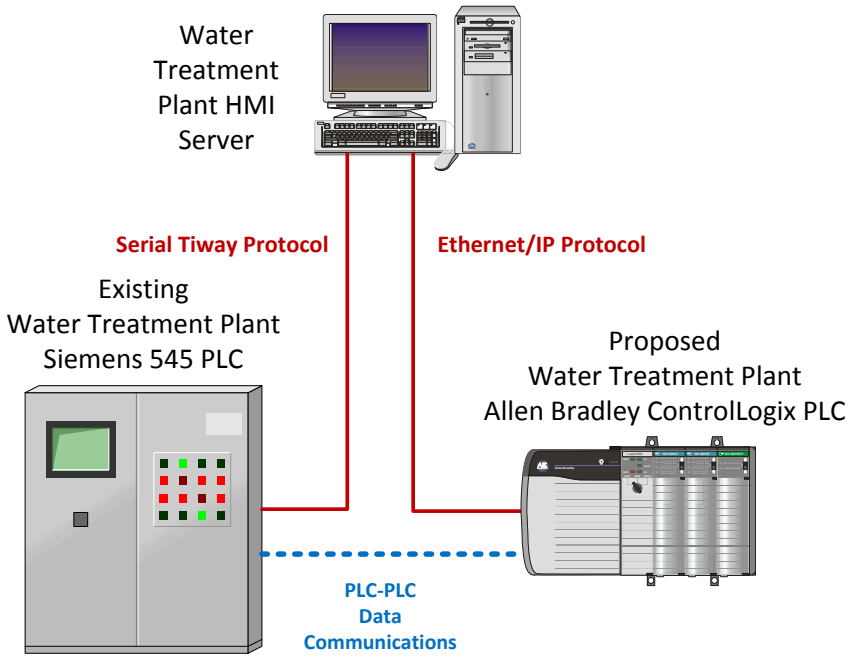
FIGURE 5-1-1
WATER TREATMENT PLANT SIMATIC 545 PLC UPGRADE PROCESS



5.1.2 SCADA Computer System Upgrade Approaches

There are a number of options for upgrading the existing SCADA computer system depending on the features required by the city.

5.1.2.1 Computer Upgrade Option 1: Replacement of DMS Computer

The ability to view and analyze historical SCADA data is critical to the operations of a water system. Water treatment plant operations processes require access to this data for efficiently tuning the treatment process and for city and state reporting purposes. The existing DMS computer should be replaced with a process historian server and report system within the next few years. The reason for the urgency is due to the vulnerability of the existing DMS computer hardware.

If the city decides to stay with the Siemens WinCC software platform in the future, they should implement the SIMATIC Process Historian software (**FIGURE 5-1-2**). This software is designed for long term storage of events, alarms and analog values. Data from this system can be charted, gathered into reports, viewed over web browsers, imported into office documents, exported for analysis into programs such as excel or used to help calibrate the city's water system model.

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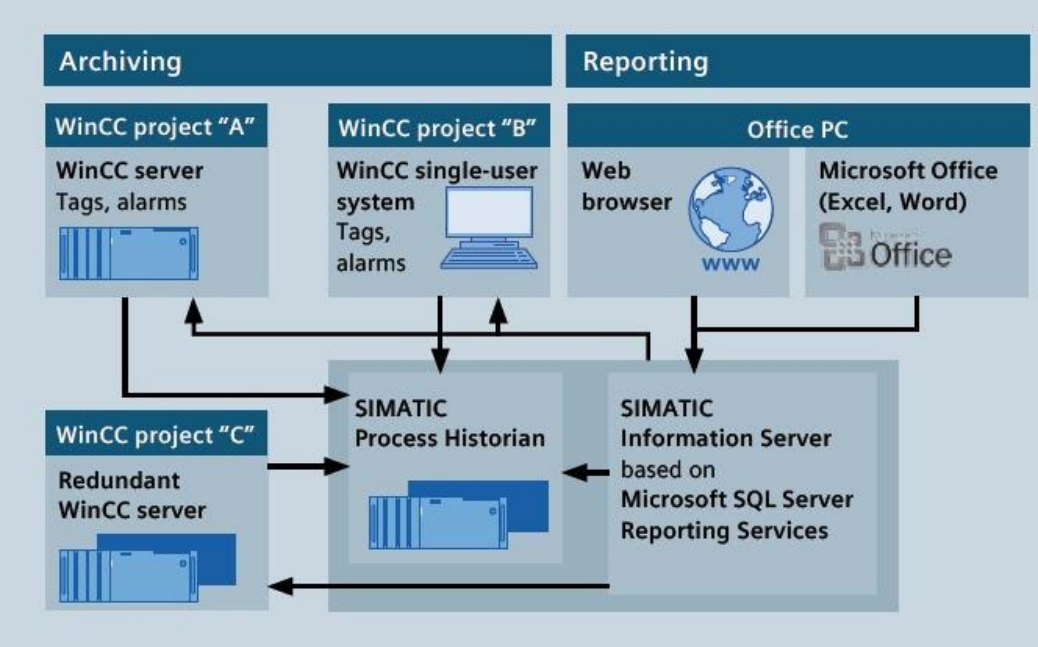
FIGURE 5-1-2

SIEMENS SIMATIC PROCESS HISTORIAN



If the city decides to move to another HMI computer software platform such as Wonderware or Rockwell Automation, they also have process historian software with similar features. This historian would be located on a control network that would be separate from the city network. Accessing this data from a city network computer would require specific firewall rules between the two networks to allow only authorized users and computer access to the data.

5.1.2.2 Computer Upgrade Option 2: Redundant HMI Computer System

Due to the size of the City's SCADA system, RH2 would recommend building a second HMI computer server as either a hot or warm backup to the primary HMI computer server. If the current HMI computer server failed, it could take a number of days before a replacement server could be built to replace it. A hot backup would require purchasing a new server and new WinCC licensing for the software to run concurrently with the existing server. A secondary HMI computer would also allow for more than one city staff member to access the system at the same time either within the control room or from a remote location.

5.1.2.3 Computer Upgrade Option 3: Large Screen High Definition HMI Display

Most SCADA system control rooms have migrated to one or more larger flat panel screens so that system data can be easily viewed by multiple people from a distance. The relatively low cost of a 48 to 60 inch LED display has made this much easier to implement in the last 5 years. Display standards based on HD resolution (1920 x 1080 pixels) will be available for at least the next decade. The existing display is not currently sized for this resolution. HMI software can automatically resize existing graphical screens to new

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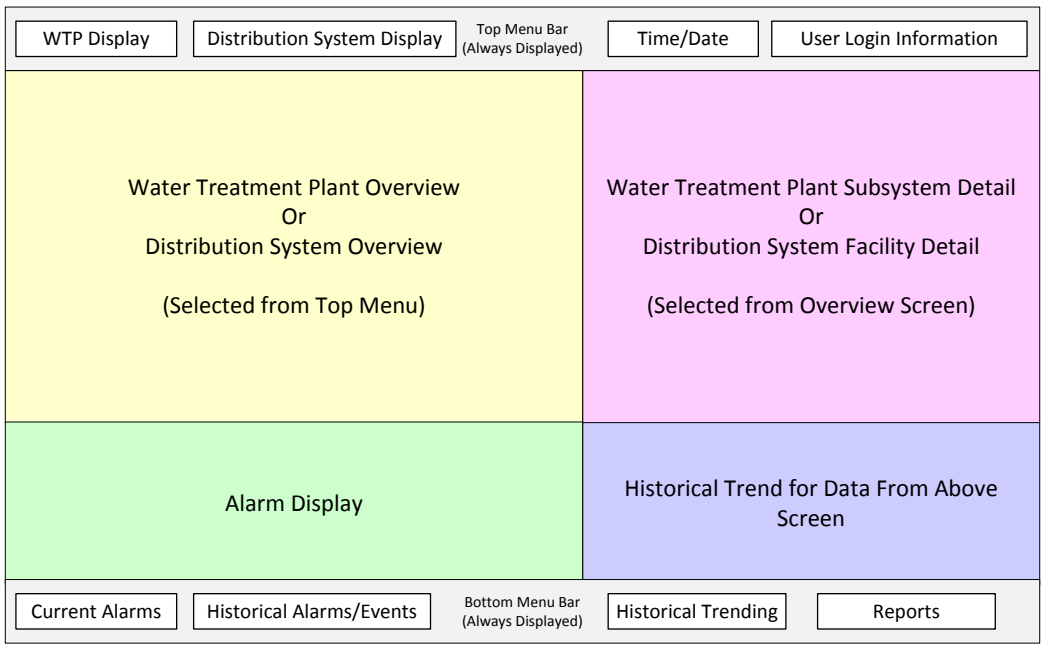
resolutions when necessary. We would recommend some minor changes to the screen design to allow for more information to be displayed at one time. Reusing existing HMI screen designs in the example below is relatively easy to implement rather than recreating all of the screens (**FIGURE 5-1-3**).

This HMI screen layout example would display either the water treatment plant or the distribution system depending on which was selected from the top menu. When the water treatment plant is selected, the upper left section will display the overview screen. Selecting on any of the sub systems on this screen will display a detail of that system on the upper right side of the screen. Analog historical trending data would be automatically charged for that specific subsystem on the lower right corner. All current system alarms would always be displayed on the lower left corner. Selecting any of the buttons on the bottom menu would display a full screen for working with current alarms, historical events and alarms, historical trending charts and system reports.

Many HMI systems have also moved to a multiple screen layout to allow for even more space for viewing the system at once. Using the above example, the system could be laid out with the water treatment plant on one screen and the water distribution system on a secondary screen. The flexibility of this option also allows for the treatment plant or the distribution system to be on both screens simultaneously when necessary.

FIGURE 5-1-3

EXAMPLE HIGH DEFINITION HMI DISPLAY LAYOUT



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5.1.2.4 Computer Upgrade Option 4: HMI Computer System Remote Access

There are a number of options available for remotely accessing information from an HMI computer system. Some remote access options will allow full monitoring and control of the HMI system while other options will only provide specific data.

1. **Remote HMI Display** – The first option is to use software such as VNC (virtual network computing) to remotely view and control an HMI computer screen from a distant location. This location could be within the city network or from a remote or mobile location. Because the HMI computers would be located in an isolated control system network, specific firewall routing would be necessary to allow specific computers in specific locations to access this system. SCADA systems that do not have 24x7 staff available usually have mobile remote access to handle emergencies during evenings, weekends and holidays. Because the city does have staff available at all times at the treatment plant, this option should probably be limited to computers within the city network and not from remote locations. This would give staff members such as the city engineers and management the ability to view the system in real time during emergencies or other system events.
2. **Remote SCADA Data** – Using software such as Win911 and Mobile 911 allows for many city staff members to simultaneously view SCADA system alarms and system data in real time on either a smartphone or a tablet. This type of software can be made very secure and only allows for alarms to be acknowledged remotely. Remote users cannot make any control changes to the SCADA system with this type of software. System data can be organized into real-time reports that can show information such as current treatment plant flow, reservoir storage, facility pumping rates, etc. Because anyone with a smartphone has access to this information, the water system is monitored much more closely than with the existing single HMI computer. Managers know when alarms are acknowledged and when failures are repaired. On-call staff can obtain a better view of the water system when alarms are triggered. This allows for more efficient responses to emergency situations.

5.2 Facility Tone-Control System Upgrade Alternatives

The existing 11 tone control facilities are probably the highest priority in regard to SCADA system upgrades in the next few years. Most S&B control systems have replaced Tone control facilities with facility PLC systems in the last two decades. Examples of what would replace the tone control equipment can be seen in the Dixonville system or the Siemens/Automation Direct PLC facilities.

5.2.1 Facility Control Panel Designs

The Tone Control facilities currently have limited instrumentation due to the limits of Tone systems. As part of the Tone Control facility upgrades, the existing instrumentation should be reviewed to identify if additional sensors should be monitored at these facilities.

The costs involved with designing 11 different control panels to replace the existing tone control panels would be fairly substantial. A less expensive option is to design a few generic control panel that can be used at multiple facilities. This is known as “economy of scale”. By reducing the number of control panel designs, the cost of reduced from the engineering to the fabrication.

Water facility control panel implementation tasks:

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1. Engineering design and specifications
2. Bidding or panel builder selection
3. Panel builder design (more specific than engineering design)
4. Software development (from panel builder or consultant)
5. Fabrication
6. Testing with software developer
7. Installation
8. Testing
9. Training
10. O&M Materials
11. Profit and overhead

Reducing the number of control panel designs can reduce the cost of almost every task on the list. Separate installation plans created in item 1 are still necessary for each facility.

Typical control panel components:

1. NEMA rated panel for the specific environment. Typically a NEMA 3 for indoor use and a NEMA 4 for outdoor use.
2. AC lightning surge protector
3. AC and DC circuit breakers for all panel components.
4. AC monitoring relay used by PLC to identify when AC power is lost.
5. GFI AC receptacle for powering devices under 5 amps such as a laptop.
6. DC switching power supply.
7. DC UPS system and backup batteries for power failures.
8. DC-DC isolator for extended protection from ground faults.
9. PLC Equipment
    a. Central Processing Unit
    b. Discrete input cards
    c. Discrete output cards
    d. Analog input cards
    e. Analog output cards (not always necessary)
10. Operator interface touchscreen
11. Industrial Ethernet switch
12. Instrumentation fuse holders
13. Terminal blocks for wiring
14. Communications equipment such as a radio or router.

The main control panel differences for the tone control facilities include the following items:

1. The number of input and output cards in the PLC.
2. The number of terminal blocks and fuses.
3. The PLC/OI software development.

Smaller facilities will require less of the three items above. The current types of facilities in the tone control system are as follows:

1. Four Reservoir Facilities
2. Two Valve Control Facilities
3. Two Pump Station Facilities

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4. Three Pump Station and Reservoir Facilities

Reservoirs and Valve Control have limited inputs and outputs so they could share a generic control panel design. The differences between a Pump Station and a Pump Station with a Reservoir are also very small so they could possibly share a generic control panel design.

5.2.1.1 Reservoir/Valve Control Panel Design

PLC Selection

Allen Bradley has a new line of very powerful but inexpensive PLC controllers called the CompactLogix Lx series. These controllers were introduced a few years ago to replace the MicroLogix line of PLC's which were based off of technology from the 1990's. The CompactLogix Lx series consists of the L1, L2 and L3 models. The L1 version is the smallest and least expensive of these PLC's. Its main drawback is that it uses non-isolated analog input/output cards known as Point I/O. Most analog cards are isolated from power hits from instrumentation by using optical isolation circuitry to isolate the instruments from the PLC internal circuitry. When using the L1 PLC, a separate analog isolation unit is typically required. The L2 and L3 models use regular optically isolated analog instrumentation cards. The CompactLogix L2 are the recommended minimum sized PLC for the Tone Control facilities (**IMAGE 5-2-1**). There are three different versions of the CompactLogix L2 PLC. Each of these versions have different amounts of embedded inputs and outputs. The 1769-L24ER-QBFC1B model of the CompactLogix L2 has the following specifications.

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CompaceLogix L2 Model Number	1769-L24ER-QBFC1B
User Memory	.75 MB
Secure Digital Memory Card	1 GB (Standard)
Communications Ports	Dual Ethernet Ports, USB
Embedded I/O	• 16 DC inputs • 16 DC outputs • 4 universal analog inputs • 2 universal analog outputs • 4 high-speed counters
Module Expansion Capacity	4 expansion modules and 8 Ethernet nodes

IMAGE 5-2-1

COMPACTLOGIX L2 PLC

Due to the limited instrumentation requirements at the reservoir and valve control facilities, the L2 model identified above would probably not need any expansion modules unless additional instrumentation was added to the facility. It is recommended in the control industry to have at least 25% spare inputs and outputs for future facility upgrades.

The Winchester Water Treatment Plant currently uses a single Siemens controller for most of the facility monitoring and control. Future upgrades of this facility should probably use multiple networked

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CompactLogix L33 PLC controllers or a single ControlLogix L6 or L7 controller. These are mid-size and large-size models in the Logix line of controllers and can support hundreds or even thousands of instrument connections. In addition, they have very advanced digital communications capabilities to interface with modern control instrumentation and SCADA systems.

Operator Interface Selection

Allen Bradley touch screen operator interfaces come in various sizes and resolutions. Because these devices can be the most expensive part of the control panel, it is recommended that the City use the Panelview 600 Compact version in either grayscale or color. These operator interfaces are limited to 25 different screens but cost almost half of what a regular Panelview 600 unit costs. It is unlikely that these facilities would have more than 25 screens of data due to their relatively small size.

Communications Equipment Selection

The CompactLogix Lx series PLC's are Ethernet TCP/IP based systems. They do not have serial communications capabilities. If the existing dedicated POTS phone lines will be reused for SCADA communications, a protocol converter will be necessary to allow the PLC to interface to a serial modem.

The control panel should have an industrial Ethernet network switch from companies such as N-Tron. These are industrial grade Ethernet network switches that use 24VDC power, are UL rated, and are designed for harsh environments. Typical devices that will plug into this switch include the PLC, the OI , power monitors, VFD's and the SCADA communications equipment.

The control panel should be flexible for any type of communications equipment that could be implemented over the lifespan of the system. DIN rail space, circuit breakers and 24VDC power should be available for this equipment.

Power System

The power system components identified in section 4.2 would power the control panel components and isolate them from bad AC power conditions. The DC backup batteries for the control panel should be sized to provide 12-24 hours of backup power. The size of these batteries is typically identified after the communications system is designed.

5.2.1.2 Pump Station/Pump Station and Reservoir Panel Design

The design for the pump station panels would be the same as the reservoir and valve control panel except for additional expansion modules on the PLC. This expanded I/O also requires additional terminal and fuse blocks for instrumentation wiring.

5.2.2 Facility Tone-Control (Allen Bradley) System Master PLC Controller

The water treatment plant Simatic 545 PLC system is the existing Master controller for communicating with the Tone Control facilities. The Tone Control equipment will need to be replaced before the 545 PLC is replaced. The 545 PLC should not be the new Master controller for the new Allen Bradley based facilities. There are a number of options available for integrating the new Allen Bradley facilities into the SCADA network.

1. **Broadband Network** – If the Allen Bradley based facilities are on a broadband TCP/IP SCADA network, they should be able to communicate directly to each other and the HMI computer system. In this case, a Master PLC controller would be used for the odd facility that required

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direct TCP/IP polling. If the Allen Bradley facilities are communicating using a 450MHz TCP/IP radio network or using dedicated POTS phone lines, then a Master PLC controller will be required to handle the routing of data between the facilities and between the facilities and the HMI.

2. **450MHz TCP/IP Radio Network** – If 450MHz TCP/IP radios will be used for primary or backup Allen Bradley communications, a CompactLogix L2 should be selected for the Master PLC controller. The L2 PLC will only be using its Ethernet port for moving data around the SCADA network.
3. **POTS Modem Network** – If dedicated POTS phone lines are used for primary or backup Allen Bradley communications, a full sized CompactLogix L35E PLC with serial communications cards and modems would be necessary. This would substantially increase the cost and complexity of the master controller.

5.3 Siemens/Automation Direct PLC Facility Upgrade Alternatives

The existing Siemens S7-300 and Automation Direct PLC facilities do not currently need any upgrades at this time except for future communications changes.

5.3.1 Siemens/Automation Direct PLC Facility Communications

These facilities are currently communicating with the Master S7-300 at the water treatment plant over dedicated POTS phone lines using slow speed modems. This type of communications is acceptable for the short term but in the long term, these facilities will probably need to be moved to a TCP/IP based communications system. None of the PLC's at these facilities have Ethernet communications ports so they may have to be upgraded or have a protocol converter installed.

Industrial protocol converters can convert Ethernet communications to serial RS-232 and can also convert between different protocols if necessary.

5.3.2 Siemens/Automation Direct PLC Facility Master Controller

The existing Master S7-300 PLC at the water treatment plant only purpose is to route data between the existing Siemens/Automation Direct facilities and the HMI computer system. There is currently no data being transferred between facilities for control purposes.

1. If the POTS phone lines on this system are upgraded to broadband TCP/IP, then the S7-300 Master controller is no longer required as the HMI computer system can communicate directly with the remote facilities.
2. If the phone lines remain, then the existing S7-300 controller should remain in place.
3. If the SCADA communications system will use 450MHz TCP/IP radios, then the facilities should be connected to the new Allen Bradley Master PLC. This would also require a protocol converter as neither the Siemens nor the Automation Direct PLC's support native Allen Bradley Ethernet/IP protocol.

5.4 Dixonville Control System Upgrade Alternatives

The only identified issue with this system is that Pump Station #4 is not connected to the SCADA network. The Dixonville system uses 450MHz radio for SCADA communications. At this time, there is no line of site available between this facility and any of the other Dixonville pump stations. There is also no land lines

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available and cellular service is very weak. Options to integrate this facility in to the SCADA network are as follows:

1. Identify locations for installing radio repeater equipment between Pump Station #4 and any available facility in Dixonville.
2. Identify if cellular service is available with a tall high gain antenna system.

5.5 Isolated Control System Upgrade Alternatives

Except for Dixonville Pump Station #4, these facilities consist of small pump stations that serve small service areas. These facilities have been such a low priority that they have never been added to the SCADA network. There are two options available for these facilities to be added to the existing SCADA network.

1. Installation of control panels similar to those used in the Tone Control facilities. This would be the most expensive option as it would require a full PLC system to be fabricated and installed.
2. Installation of an instrument protocol converter to only monitor the facilities instrumentation. This option would use a device such as the Acromag XT1210 to monitor instrumentation values directly from the facility without the need for a full PLC system. This option would cost about 60% less than the cost of installing a PLC system due to its simplicity. The system would consists of a control panel with a power supply, communications equipment, terminal blocks, circuit breakers, fuses and the instrument protocol converter. Instrumentation such as pressure sensors or flow meters would be wired directly to the instrument protocol converter.

A Master PLC would only be necessary to communicate to these facilities if dedicated POTS lines were used or if a 450MHz TCP/IP Ethernet radio network was implemented. The Master PLC would be the same unit communicating with the upgraded Tone Control facilities.

5.6 SCADA Communications Network Upgrade Alternatives

The city's SCADA system is currently relying on dedicated POTS phone lines for communications to all of the remote facilities except for the Dixonville system. Although this has been an exceptionally reliable system, it is considered a legacy technology by the telecommunications companies and will be phased out in the future. Because almost half of the water facilities are under consideration for control system upgrades, this is an excellent time to rebuild the SCADA communications network.

The Dixonville system SCADA communications is currently using very modern technology and does not require any major changes for the foreseeable future. The Tone Control and Siemens/Automation Direct PLC SCADA sub systems are currently using separate POTS phone lines systems from the water treatment plant. The Isolated Control facilities would most likely share the same communications network as the future Tone Control facilities. Alternatives for these three systems are as follows:

1. **Dedicated POTS Phone Lines** – In this scenario, the city would stay with the existing POTS lines until they are phased out by the Telecommunications companies. The Siemens/Automation direct facilities would remain unchanged. The Tone Control facilities would be upgraded to Allen Bradley PLC equipment with industrial modems. If the Isolated Control facilities are upgraded, they would be part of the same communications network as the new Allen Bradley facilities. A fairly complex Master communications system would need to be created to replace the existing Simatic 545 phone system. (**FIGURE 5-6-1**)

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2. **DSL Broadband** – DSL is a very common method for SCADA communications systems. It uses existing copper phone lines and has a good reputation for reliability after almost 20 years of implementation by the telecommunications companies. For the majority of facilities outside of the Dixonville area, this is probably the only landline broadband option. (**FIGURE 5-6-2**)
3. **450MHz TCP/IP Licensed Radio** – This options would be similar to the DSL Broadband option except that antenna systems would be required at all facilities. Preliminary radio survey data in Appendix B show that the majority of the facilities could be reached with this technology by using the system reservoirs as repeater locations. The main drawback to this system is that it would be significantly slower to access each facility compared to any of the other options. (**FIGURE 5-6-3**)
4. **Cellular Modems** – This would be a similar configuration as DSL Broadband except that each facility would require a modest outdoor antenna. There are a number of options on how this network would be connected at the water treatment plant. The water treatment plant could access this cellular network through another cellular connection or via a broadband landline. These systems have similar bandwidth as DSL systems. The cellular companies have a monthly charge for the connection and another charge for the amount of data that is accessed. The higher O&M costs with this technology usually make it more desirable as a backup communications option. This would work best for facilities that cannot get broadband landlines or require a backup communications path in case of a primary path failure. (**FIGURE 5-6-4**)
5. **Private Wireless Broadband** – This type of wireless system is similar to 450MHz TCP/IP radios but usually has data bandwidth at least as high as 4G cellular modems. There are many different types of private wireless systems on the market. The high speed communication capabilities of these types of systems usually require line of site between facilities due to the high frequencies that are used. A preliminary radio survey has shown that line of site is not always an option for many of the facilities. The City IT staff has expressed an interest to create a City owned high speed wireless network backbone on the city reservoirs. This type of backhaul system could be used in conjunction with 450Mhz radios which would act as subnetworks on the edge of the wireless network. The SCADA equipment layout would still be similar to a 450Mhz radio network. (**FIGURE 5-6-3**)
6. **Hybrid Network** – Combinations of the five options above may be required due to limitations at specific facilities. There are a number of reasons for a hybrid SCADA network. (**FIGURE 5-6-5)**
    a. **Backup Communications** – For high priority facilities, a backup communications path may be desirable. When the primary path fails, the backup path is used until the primary path is reestablished. An example of this would be using DSL as a primary and cellular or 450MHz radio as a backup. This may only be required at facilities that are considered high priority. A high priority facility is one that is required to receive data from other facilities in order to operate in automatic control.
    b. **Primary Communications not available at all facilities** – Many SCADA communication systems have limitations on which facilities they can reach. Some facilities may not be capable of DSL due to limitations in the copper phone lines. Cellular signals may not be strong enough at some facilities. Some facilities may out of range from a 450MHz Radio network. When designing a SCADA system upgrade, it is recommended to select a primary and a backup SCADA communication system even if the backup option is not implemented. Telecommunications companies will not always identify a facility that is capable of DSL until it is converted to this purpose. Radio systems may not work under all conditions even if they are tested beforehand. If a system is put out to bid, the

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contractor should have options if a primary communication path is unavailable or fails during installation.

FIGURE 5-6-1

DEDICATED POTS PHONE LINES

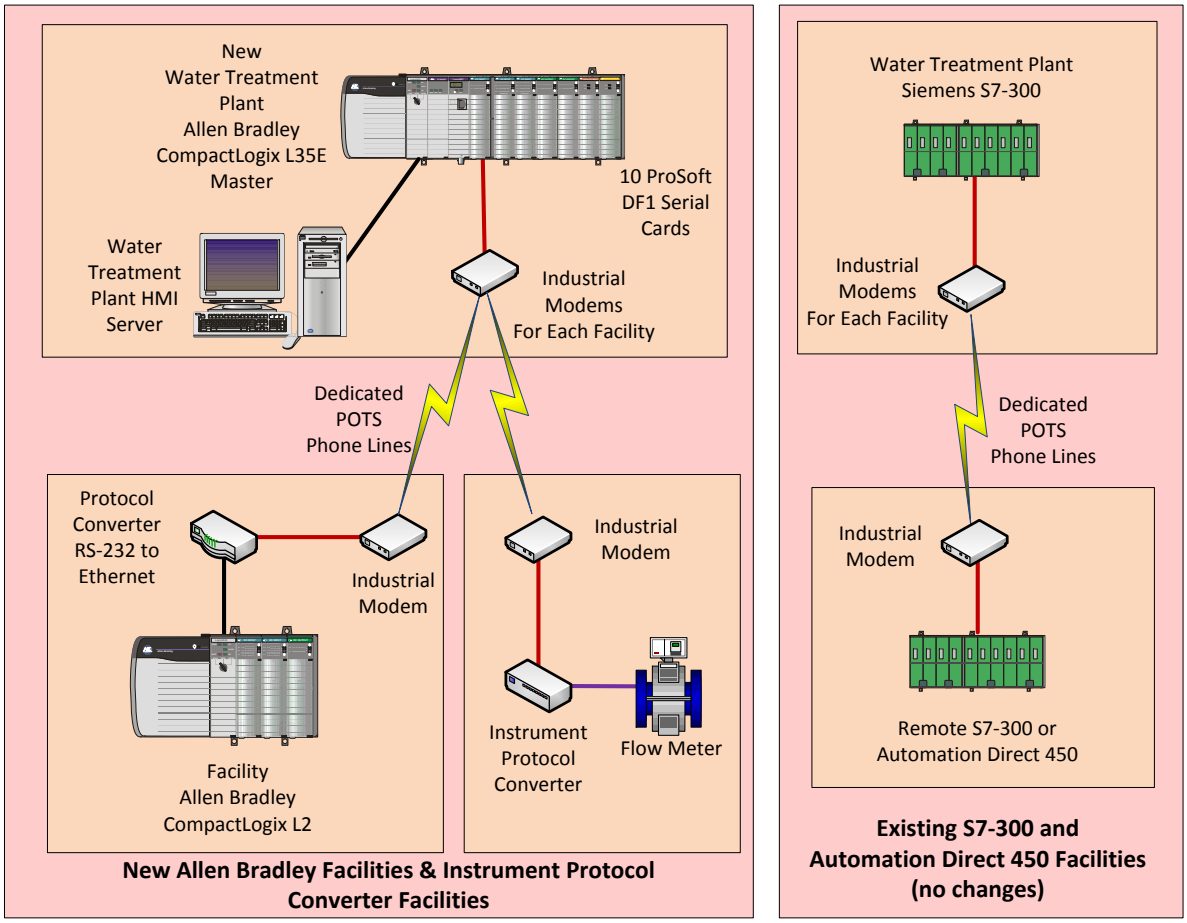

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FIGURE 5-6-2

DSL BROADBAND

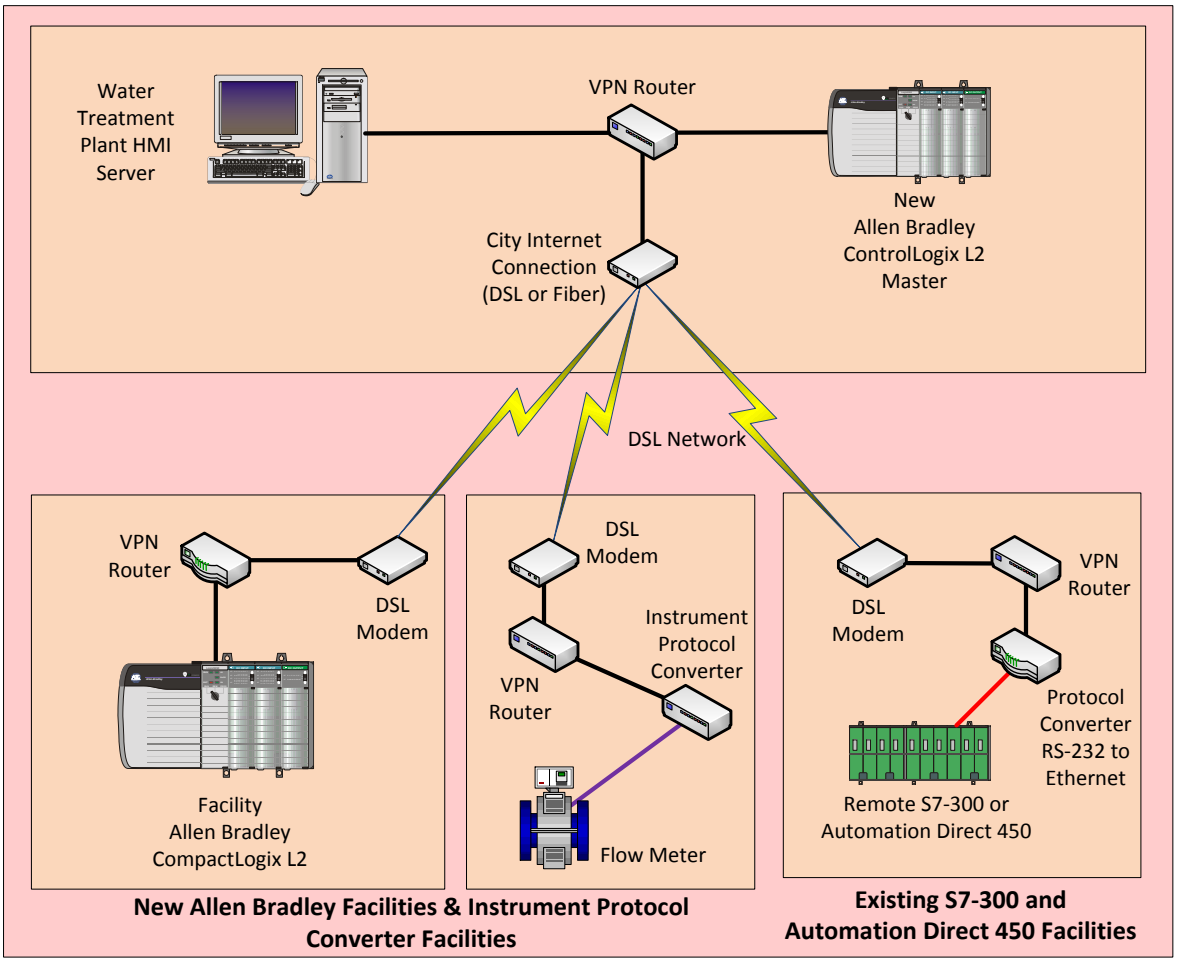

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FIGURE 5-6-3

450MHZ TCP/IP RADIO OR PRIVATE WIRELESS BROADBAND

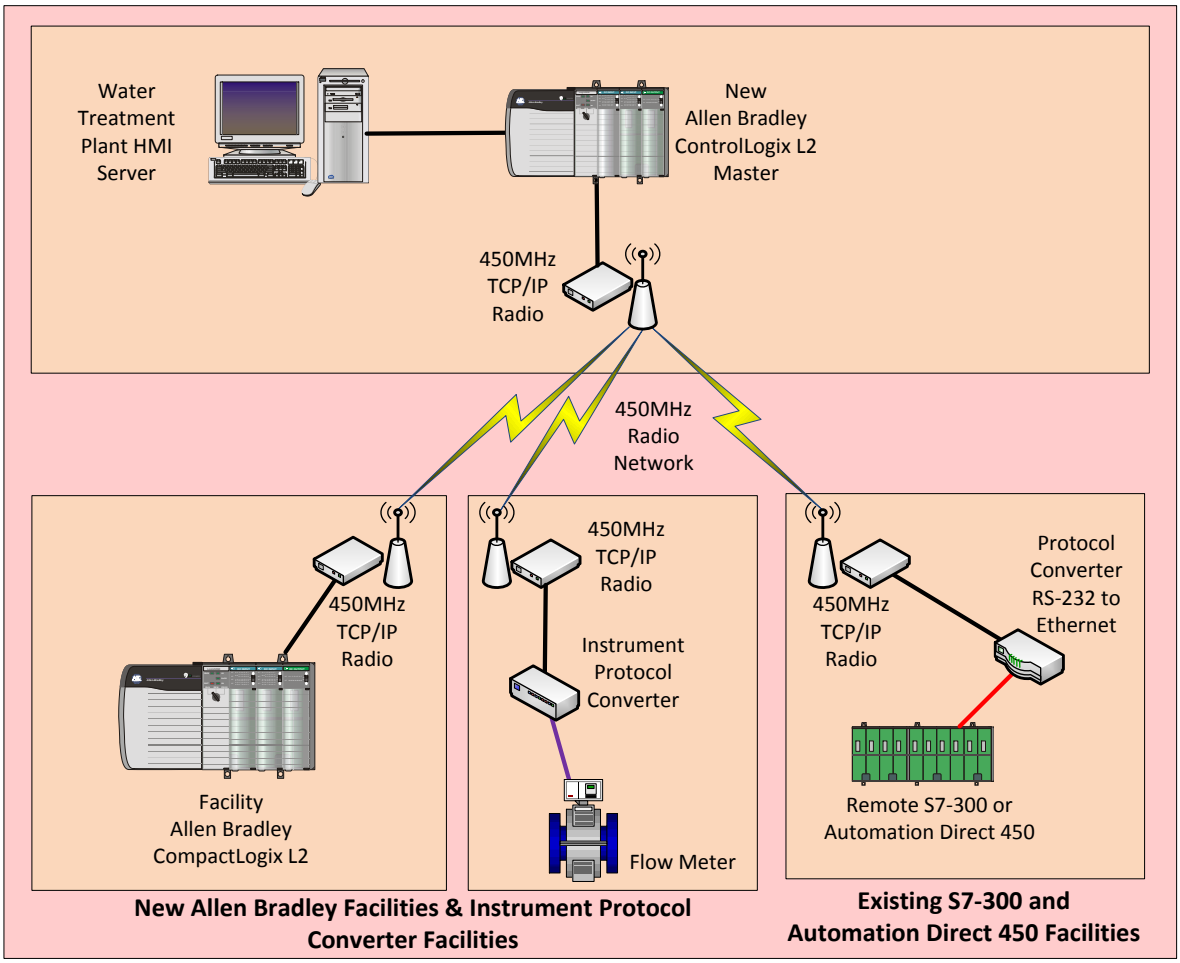

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FIGURE 5-6-4

CELLULAR MODEMS

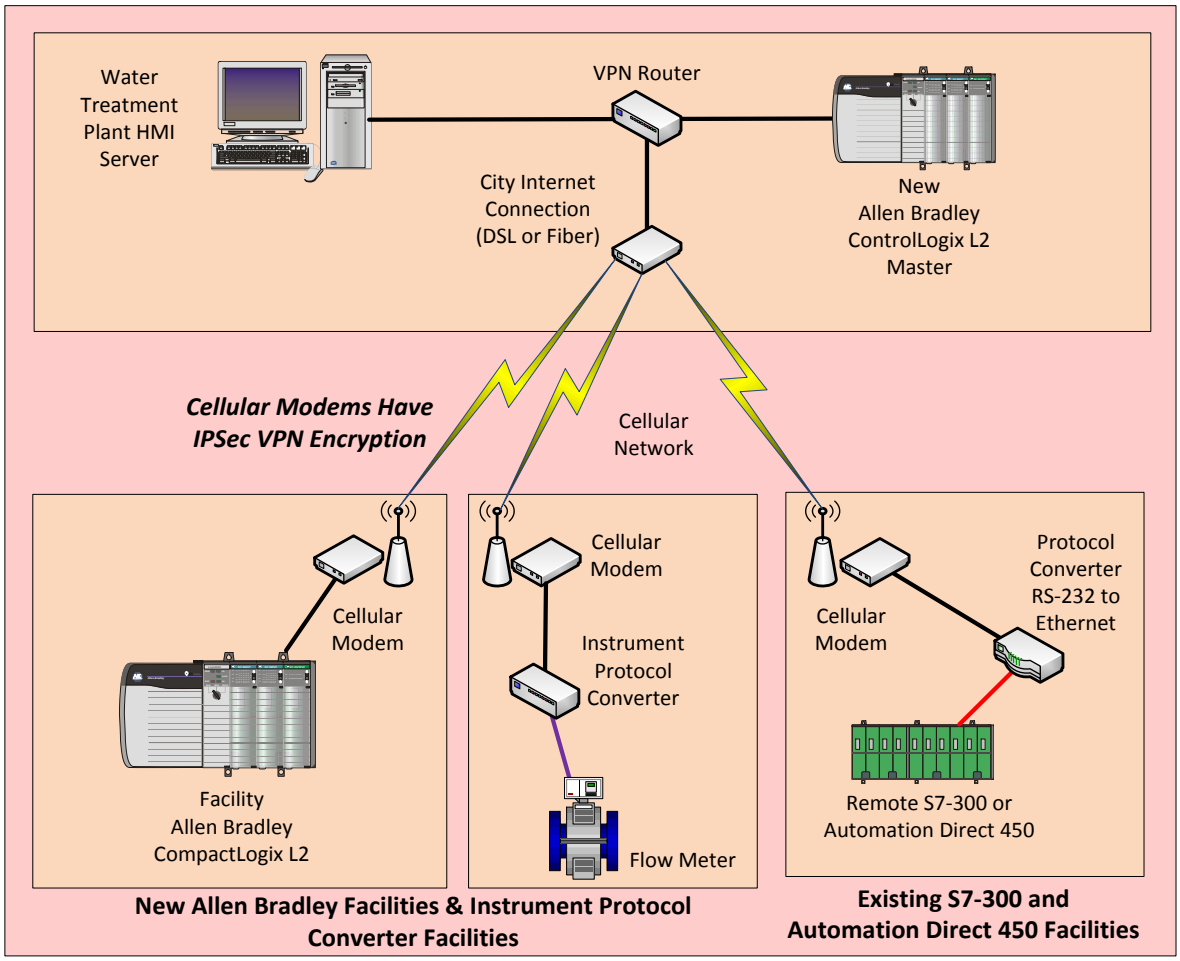

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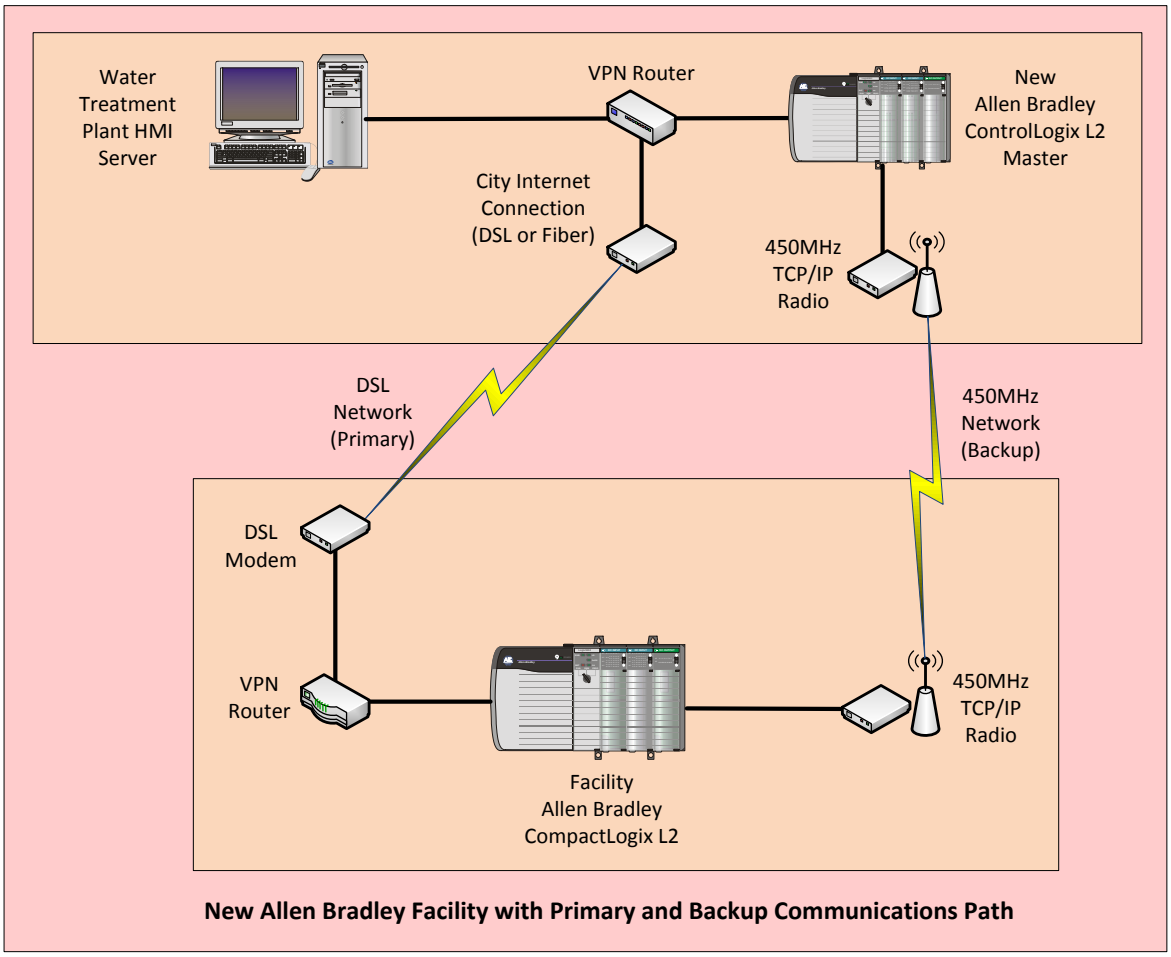
FIGURE 5-6-5

HYBRID NETWORK



5.7 Control System Cost Estimating Issues

Because there is so much labor involved with the implementation of a typical SCADA system upgrade, identifying its true cost is very difficult to obtain. Panel builders and integrators will try to get the most money for their services while trying not to appear that they are over charging for their product. Obviously the more complex the design, the more expensive the final product will be. Software development alone can be substantial if the control software complexity is high. Historical trending of SCADA project bid tabulations has identified a number of issues with estimating costs.

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1. Costs can rise substantially when integrators are busy. This is probably due to the fact that they have little incentive to reduce pricing when business is good.
2. Although collusion is illegal between integration companies, they typically team up with the same electricians. This allows bid information to be indirectly passed between integrators. This allows integrators to raise prices if their competitors are already at a high price.
3. Single sourcing can sometimes cause pricing to be substantially higher than estimates. This is not always the case as many integrators want repeat business with their clients.
4. Cost estimating by integrators is not easy to identify due to labor costs. Labor costs can be 75% or more of the cost of a control panel. When developing HMI software, the cost is close to 100%. Estimating labor costs like software development can be radically different between integrators.

5.8 SCADA Procurement Options

Procurement of the SCADA system upgrades would consist of design, installation, software development, testing, training and maintenance. This process can be handled in a number of different methods. Each method has its advantages and disadvantages in regard to costs, quality of the final product and long term support

1. Full electrical design and bid/RFP process – This procurement process would consist of a formal electrical design and specification task. Once the system has been designed, the system would be bid out to the lowest qualified integrator or an RFP proposal for integration services would be used. Lowest bidding does not always create the best end product due to integrators cutting corners to reach the lowest bid. RFP proposals would allow the City to select an integrator with more than just price as a criteria. A formal electrical design will help with the City identifying other upgrades that may need to be addressed during this process and should reduce any change orders. In addition, it will set specific criteria for software development functions. If the system will be bid, then a full electrical design will be required for integrators to fully understand how to base their bid costs.
2. RFP process with pre-written specifications and review by third party engineer – This procurement process would consist of an RFP process with a formal specification on how the system should be implemented. Another method to implement this process would be for the integrator to create a preliminary design and cost estimate as a first task before moving into the installation phase. A third party engineer would review this design and cost estimate for cost or design issues. The integrator would then proceed with the procurement and installation process. This method may save money in design costs but may cost more due to the sole sourcing of a contractor before the design is complete and costs are identified.
3. Separating procurement/installation from software development – This method would be similar to the first two options except that the software development is handled by a third party. This option is typically used to increase the number of RFP/bidders that have the electrical qualifications for the procurement process but not the software development tasks. In this case the Software Developer would be handled through a separate RFP. This method is also used when the buyer wants to use a specific software developer for a project but does not want to single source the procurement process to one integrator.

The city has identified a yearly budget of $200,000 to be used for the upgrade of the SCADA system. This cost will be necessary for a number of years due to the number of facilities required to be upgraded. Fortunately, SCADA systems are fairly easy to phase in over a number of years due to their modular nature.

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6 Recommendations for System Upgrading

The following SCADA upgrade recommendations have been identified after discussing alternatives with the City operations, engineering and IT staff. This section will identify the following:

- Recommended SCADA standards from previous sections.
- Recommended Process for upgrading the existing system based on specific CIP funding.

6.1 SCADA Component Standards

6.1.1 Instrumentation

As part of the SCADA system upgrade design, the existing facility instrumentation inventory should be reviewed for replacement based on age and condition of equipment. The existing Tone Control Facilities also currently have minimal instrumentation due to the simplicity of the original design. New instrumentation should be added for additional water system data points.

<u>Tone Control Facility Instrumentation Recommendations:</u>

1. Add pressure sensors to all booster pump facilities to monitor their pressure zones on the suction and discharge sides.
2. Upgrade existing turbine flow meters to mag meters.
3. Replace aging smoke alarms that do not trigger with smoke in a can. Install smoke alarms in any facilities with pumps that currently do not have them.
4. Add flood switches to all booster pump facilities.
5. Add intrusion switches to any facilities currently without them. Wooden structure should use indoor motion sensors due to alternate methods of accessing facility. Street panels should have intrusion switches on the control panel doors. High priority vaults and reservoir hatches should have intrusion magnetic switches installed. The operator interface touch screen will be used to disable intrusion alarms by logging in with a PIN number that is changed regularly from the SCADA computer system.
6. Cla-Val valve status switches.
7. Phase failure sensors at booster pump facilities. Most MCC equipment use these devices for locking out pump control. They may already have a spare contact output that can be wired to a PLC controller.

<u>Siemens/Automation Direct PLC Facility Instrument Recommendations:</u>

These facilities currently have most of the common instruments that would be recommended. The equipment should be reviewed to identify if it has reached the end of its lifespan and scheduled for replacement.

<u>Winchester Treatment Plant Instrument Recommendations:</u>

Due to the scale of this facility, it is out of the scope of this project to identify all of the instrumentation that this facility should have and what it should upgrade. This will be necessary during any future SCADA upgrade project of this facility.

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Isolated Booster Pump Station Instrument Recommendations:

RH2 is recommending that these facilities use instrument monitoring equipment instead of PLC's. The Dixonville #4 facility is not included in this recommendation as it already has a full set of new instrumentation.

1. Add pressure sensor to monitor their pressure zones on the discharge sides of booster pumps.
2. Upgrade existing turbine flow meters to mag meters.
3. Add intrusion switches to facility along with intrusion disable key switch.
4. Add smoke alarm to facility.
5. Add flood switch to facility.

6.1.2 Control Equipment

RH2 would recommend the use of Allen Bradley Logix platform PLC equipment for future facilities. The vast majority of the Pacific Northwest SCADA integrators and consultants that would work on a project of this size are typically Allen Bradley developers and authorized distributors.

Tone Control Facility Control Recommendations:

Section 5.2 identifies recommended design options for replacement of the Tone Control equipment. This section identifies the types of panels and features to build for the Reservoir/Control Valve facilities and the Pump Stations/Pump Station with Reservoir facilities.

This section also identifies the Master controller at the Winchester Water Treatment Plant that would be used to poll the remote facilities. Due to the limited bandwidth of 450 MHz radio systems, a polling system is required even if the data travels over a broadband backbone network.

Siemens/Automation Direct PLC Facility Control Recommendations:

These facilities do not currently require control system upgrades at this time. The Automation Direct and Siemens PLC equipment is still supported by their respective manufactures and should be available for at least another 5-10 years. These facilities will require new communications equipment when they will be added to the new City wireless network. This information is identified in Section 5.3.

Winchester Treatment Plant Control Recommendations:

Section 5.1 identifies the recommended design process for this facility. The design of the control panel or panels would follow the same standards as identified in Section 5.2. The type of controller would be dependent on whether one new controller would be located in the existing control room or if numerous controllers would be distributed around the facility. It will require an extensive electrical design process to identify the best approach.

Isolated Booster Pump Station Control Recommendations:

Section 5.5 identifies the recommended approach for monitoring most of the Isolated Booster Pump Stations. Instead of installing PLC equipment at these facilities, we would recommend that instrument protocol converters be used in conjunction with communications equipment. The facility instruments would be wired directly to these devices and would be monitored only over the SCADA network. We typically recommend devices from Acromag Ethernet I/O Modules for this type of application.

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6.1.3 Communications

Recent discussions with the City staff have concluded that they would like to move the SCADA communications system toward a private wireless network similar to the Dixonville system. The preliminary radio survey (Appendix C) that was completed as part of this project has shown good line of site between most of the city reservoirs and the facilities around them. In addition, Reservoirs 5-6-7 have good views of most of the surrounding reservoirs. This arrangement allows for a good wireless radio network were the reservoirs are a central repeater hub and the surrounding facilities are nodes that communicate through that hub.

The City IT staff is also interested in setting up a high bandwidth backbone network on the tops of the city reservoirs. The high frequencies that would be used for this backbone would probably not be appropriate to reach many of the non-reservoir facilities. We would recommend that the "last mile" connections to these facilities be handled with a licensed 450 MHz TCP/IP radio system. 450 MHz systems typically do not require a full line of site to a facility as the signals are very good at bouncing off of ground and land objects to reach their final destinations. Because the City wireless network backbone would most likely be used by other city departments, the SCADA traffic would need to be encrypted and have a quality of service that would prevent high system use from preventing data transmission.

RH2 typically recommends either Calamp Viper SC 400 radios or ESTeem Wireless 210C radios. The Viper radios are newer versions of the models installed in the Dixonville system. These are the least expensive of the two radios models and run about $1,500. The ESTeem radios are probably twice as fast as Vipers and better at handling bad topologies. These radios also cost twice that of a Viper at about $3,000. Calamp radios are supported by vendors around the country. Accu-Comm out of Snohomish Washington typically supports the Pacific Northwest. ESTeem is out of Kennewick Washington and would support their own products due to their proximity to Roseburg.

RH2 recommends that any wireless study and FCC licensing be handled by the radio vendor rather than a third party wireless consultant. Our reasons are based on a history of designing systems with wireless equipment. To pretty much guarantee that communications will work, a computer radio analysis is first implemented. The data from this study is necessary for the FCC license paperwork along with identifying any issues with transmission paths. On site testing is usually the next phase to increase the probability that a radio path will be successful. This type of testing is best done with the exact equipment and with the experts that know that equipment best. If during installation the communication's does not work, the vendor would be able to help identify the issue if they were involved with the initial wireless path testing. The cost of this analysis is dependent on the scale of the work to be accomplished.

Figures 6-1-3-A and **6-1-3-B** show very preliminary diagrams of how data would travel from the treatment plant to the reservoir backbone and then to the water system facilities. It is currently unknown how the data would travel from the treatment plant to the reservoir backbone. The line of site path from the treatment plant to any of the city reservoirs is not possible based on our preliminary radio survey profiles. Data from the treatment plant may travel over a different path or through a landline broadband connection to the wireless backbone network.

An advantage of this type of communications system is that the IT staff would be the local support in case of system failure. This is critical in areas such as Roseburg where SCADA vendors may require hours or days to be onsite. In addition, the speed of the backbone system will increase the SCADA polling speed of the facilities.

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Depending on the cost of building out the wireless infrastructure, it is entirely possibly for it to pay for itself in 5 years or less based on current monthly phone line charges.

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FIGURE 6-1-3-A

PROPOSED HYBRID SCADA COMMUNICATIONS NETWORK DIAGRAM 1

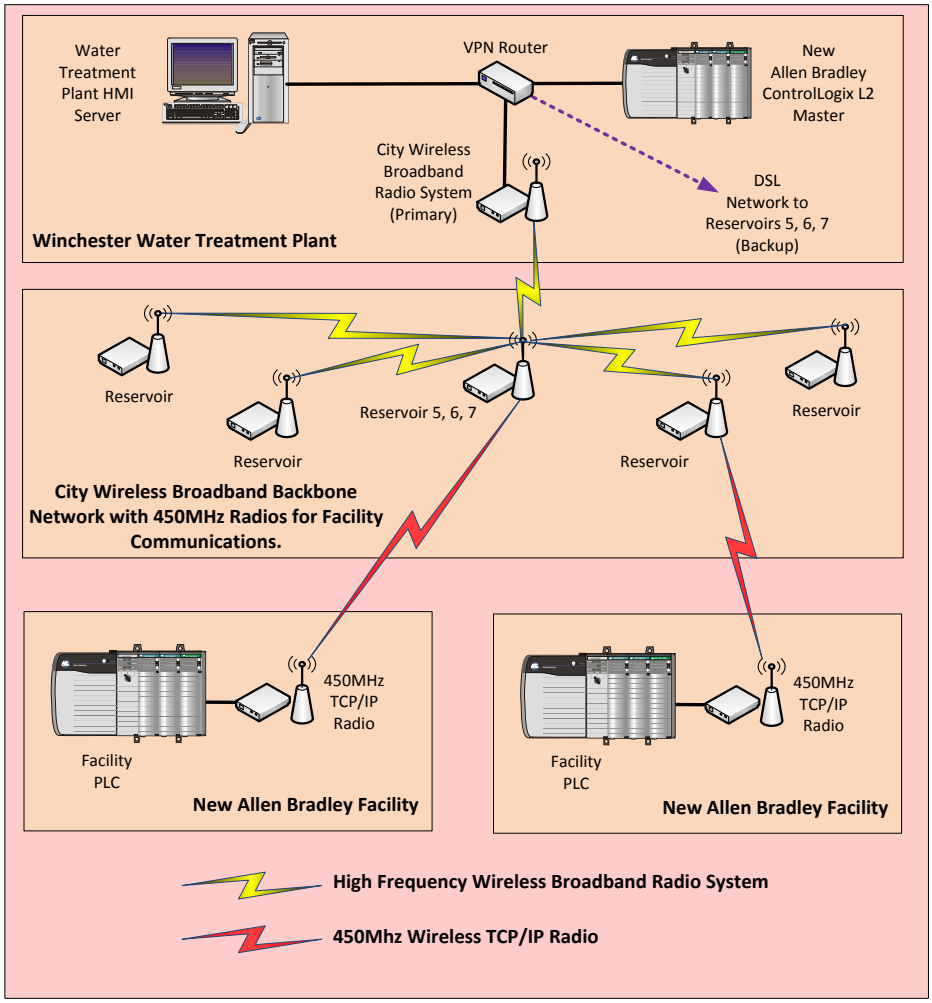

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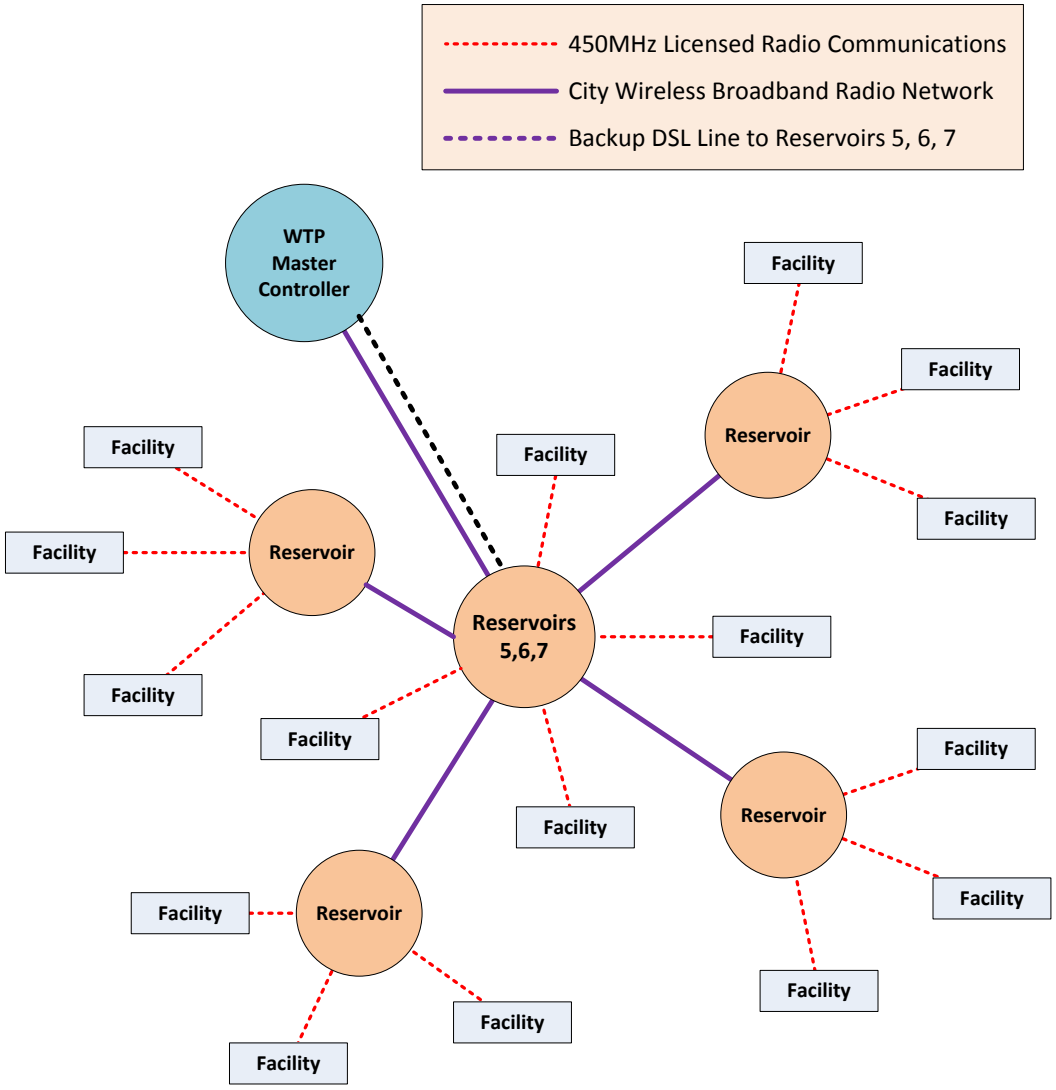
FIGURE 6-1-3-B

PROPOSED HYBRID SCADA COMMUNICATIONS NETWORK DIAGRAM 2



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6.1.4 SCADA Computer Systems

6.1.4.1 SCADA Software

RH2 recommends that the City move to a SCADA system software brand that is easier to support in the Pacific Northwest but can still interface with the existing Siemens and Automation Direct equipment. The Siemens WinCC is very capable software but is only supported by Siemens integrators. The existing WinCC application is not very complex and would most likely need to be vastly upgraded in the future for any upgraded facilities.

The Data Management Server (DMS) is currently being used as a SCADA database historian by the City. This is a UNIX based proprietary system developed by S&B in the 1980's and early 1990's and has been obsolete for over 20 years. Modern SCADA historian systems are far beyond the capabilities of this system.

Our recommendations in sections 4.5 and 5.1.2 discuss the use of software like Wonderware InTouch or Rockwell Automation FactoryTalk View SE. Even though both of these SCADA software brands have large support systems in the Pacific Northwest, RH2 is recommending the City move toward Rockwell Automation FactoryTalk View SE. FactoryTalk View SE is heading in a more sustainable direction for software that may need to be supported for decades. Wonderware has been sold to two different vendors in the last 10 years with the latest owner being Schneider Electric. RH2 has been a Wonderware software developer for 20 years but feels that the platform is not currently well supported. RH2 has had various stability issues with the previous two versions of Wonderware InTouch. We feel that this is unacceptable for a product as old as InTouch and for its intended market. FactoryTalk View SE software is developed in the United States by the same company that created it. Most of the Wonderware software upgrades are being developed in places like India to reduce the development costs.

Based on this recommendation, we would recommend the following suite of SCADA software:

- **HMI Software** – Rockwell Automation FactoryTalk View SE
- **HMI Historian** – Rockwell Automation FactoryTalk Historian SE
- **Voice Phone Alarm Notification Software** – Win911
- **Smartphone Alarm Notification Software** – Mobile 911 (this is an add on package for Win911)
- **Remote Access Software** – VNC or FactoryTalk Viewpoint

The cost of this software is dependent on a number of factors:

1. The number of data points that the software will handle.
2. The number of computers that the software will be deployed on or the number of users that will access that computer remotely.

6.1.4.2 SCADA Computer Equipment

RH2 recommends that SCADA software be deployed on server class equipment. This recommendation is from years of experience in deploying SCADA computer systems. Server class computer equipment is very conservatively designed so that its mean time between failures is usually very high. The hardware usually has redundancy built into it from the power supplies to the memory modules. The existing WinCC is currently deployed on a server so the City is already moving in the right direction.

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RH2 also recommends that the City deploy this software on either two servers or one hot server and one cold server. Deploying this software on two running servers helps remove a single point of failure in case of a computer crash. The problem with this approach is the cost of having to support multiple computer licenses can be substantial. The second option is to have one running SCADA computer and one computer that is built but is waiting as a backup.

RH2 recommends that the SCADA control network be physically or virtually separate from all other city computer systems. Physical and cyber security needs to be much higher than what is usually implemented in an office network. This separation makes remote access to the system difficult but not impossible. If remote access to the network is necessary, we would recommend at least dual-authentication protocols be implemented to prevent unauthorized access.

6.2 Facility Upgrade Implementation Recommendations

The last section to this study will try and identify an implementation process that will allow the City to phase the SCADA system upgrades over a period of time. This will be necessary for financial and logistical reasons. The financial reasons are based on a current budget of $200,000 a year until the project is complete. The logistical reasons are based on steps required to phase out the old system while keeping the entire SCADA system continuously running. This process has been compared to fixing a car while it is driving down the road. The following tasks will need to be accomplished in the following order as part of this project.

1. The new wireless city communications network needs to be designed and licensed. This system will require at least one radio study and at least one FCC license to be obtained for the 450 MHz system.
2. The new wireless city network needs to be deployed before any of the remote water facilities can be upgraded.
3. A new Master controller needs to be designed, manufactured, programmed, installed and tested in the water treatment plant in order to transmit and receive data from any of the upgraded water facilities.
4. A new SCADA computer system needs to be online before any of the facilities are upgraded.
5. The Dixonville system can be added to the new SCADA computer system at any time. This system communicates back to the treatment plant over a DSL line so it does not need the new Master controller or the new wireless city network.
6. The Siemens/Automation Direct PLC facilities can be upgraded for communications any time after the new Master controller and new SCADA computer system is online.
7. The Tone Control facilities need to be upgraded before the treatment plant control system can be upgraded. These can be upgraded at any time after steps 1, 2, 3 and 4 are complete. These can be upgraded as funding is available. When upgrading these facilities, the phasing process requires that facilities that use instrument data from other facilities continue to receive this data. Some sites may require the old tone equipment to continue running even after the new control equipment is installed. Reservoir 5-6-7 is probably one of those locations. The reservoir level needs to be viewable from the original SCADA system along with the new one. This can be handled in a number of different ways such as splitting the signal to both controllers or installing a second level sensor.
8. The upgrading of the Isolated Control facilities should probably be the last task due to the high priority of the water treatment plant.

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9. The treatment plant control upgrade will be one the most difficult parts of this project but can proceed once the Tone Control facilities have been upgraded. Because this system cannot be shut down, it will need to be upgraded in staged phases. New control equipment will first be installed. Various treatment subsystems will then be moved from the existing controller to the new controller. This will need to be done quickly and in such a way that the subsystem is not out of service or can at least be run manually for a short period of time.
10. Once the treatment plant has been upgraded to a new control system, the existing S&B control equipment in the treatment plant can be removed.

Appendix D contains an estimated cost for each of the tasks identified above. The costs included are based on previous projects cost averages in urban and rural areas. In addition, it is difficult to identify true costs before a preliminary or final design is in place. Some of the cost assumptions such as contractor overhead and profit may also be too high for the Roseburg area. These cost estimates should be reexamined during the design process and after the first few tasks to identify a more realistic budget and schedule.

The process for how the City will design and contract the system to be built was discussed briefly in section 5.8. At this time, we would recommend the following upgrade procurement methods:

1. An RFP upgrade for the remote sites based on a third party specification and RFP/submittal review. This would most likely be the least expensive process for facilities that can easily be engineered by a qualified integrator. This would include the new HMI computer system, the tone control facilities, the Siemens/Automation Direct facilities, and the isolated control system upgrades. This does not need to be one RFP but can be implemented with multiple RFP's over a period of years depending on funding.
2. A full electrical design and RFP process would probably be the best approach for the water treatment plant upgrade. The complexity of the facility and identification of how to phase the installation will require a more complete design than the remote facility upgrades.

The following section will attempt to schedule the upgrade process over time while staying within the CIP budget allocated by the City. Although this section has many assumptions regarding costs, it does identify the tasks in the order that they should be implemented.

Tasks - 2015	**Costs – 2015**
450 MHz Radio Backbone on all City Reservoirs	$131,520
City Wireless Network	$70,000 (Assuming total cost of this wireless network will be shared by other city departments)

Tasks - 2016	**Costs – 2016**
Tone Control Upgrade RFP Specifications	$10,000
Master PLC Control Panel -*Fabrication, Programming, Testing, Installation*	$35,000

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SCADA Computer System *This includes all screen development for future sites. Dixonville system moved to new SCADA Computer system.*	$94,160
Tone Control Installation Year 1	~$27,000 per site – 2 Facilities Upgraded

Tasks - 2017	**Costs – 2017**
Tone Control Installation Year 2	~$27,000 per site - 7 Facilities Upgraded

Tasks - 2018	**Costs – 2018**
Tone Control Installation Year 3	~$27,000 per site - 2 Facilities Upgraded
Water Treatment Plant Control Design	$90,000
Siemens/Automation Direct Facilities Moved To New SCADA Network.	$55,622

Tasks - 2019	**Costs – 2019**
Water Treatment Plant Control Panel Fabrication	$100,000
Treatment Plant Software Development – *Software can be developed over time depending on the subsystem being moved from the existing system to the new system.*	$100,000

Tasks - 2020	**Costs – 2020**
Treatment Plant Software Development – *Software can be developed over time depending on the subsystem being moved from the existing system to the new system.*	$80,000
Installation of Control Panel at Treatment Plant	$47,000
Treatment Plant Wiring/Testing/Training	$73,000

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Tasks – 2021	Costs – 2021
Treatment Plant Wiring/Testing/Training	$218,000

Tasks - 2022	Costs – 2022
Isolated Control System Upgrades	$113,710

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Appendix A

Existing SCADA System Network

Operator Interface Example

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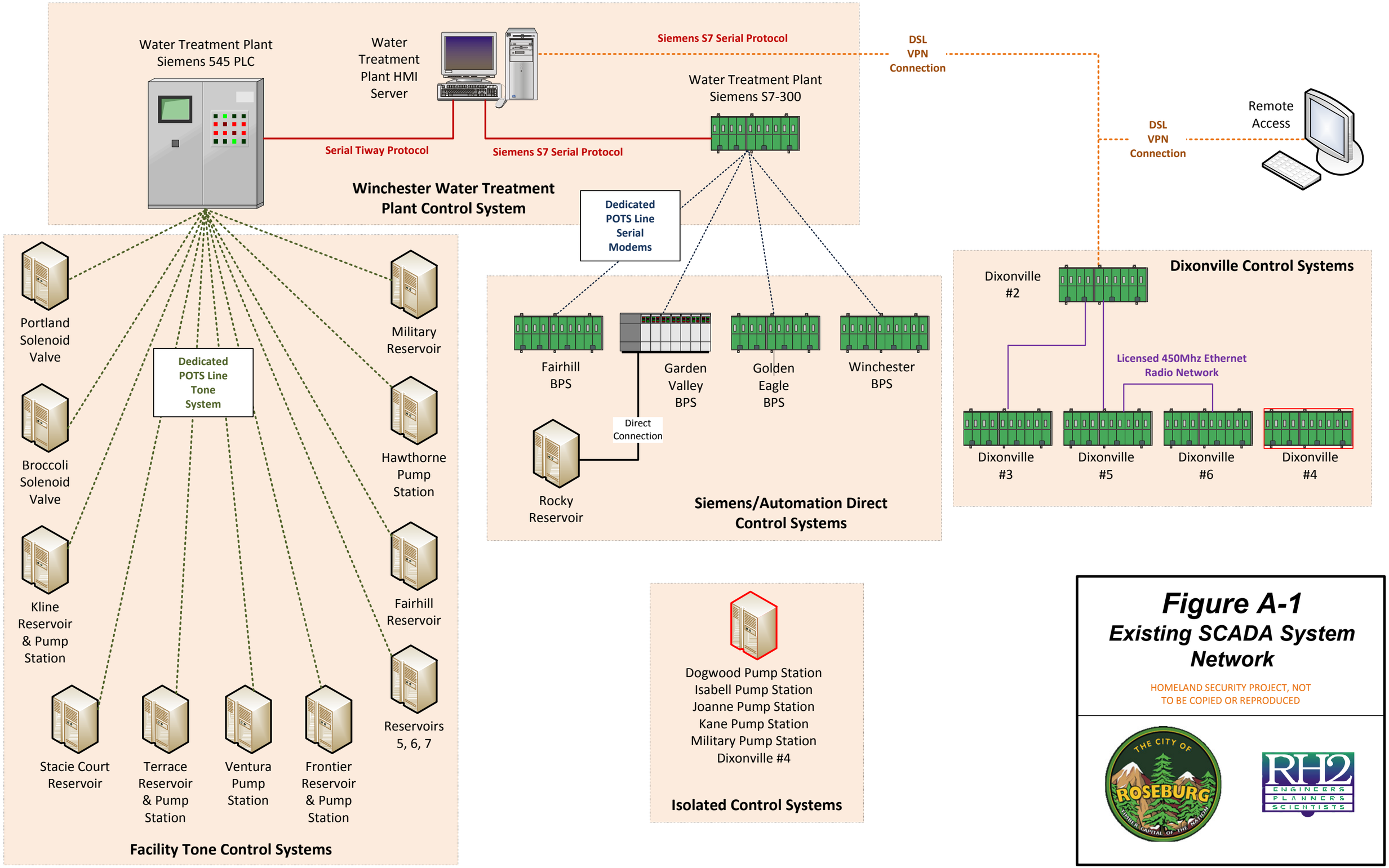

Figure A-1
Existing SCADA System Network

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Figure A-2
Operator Interface Example

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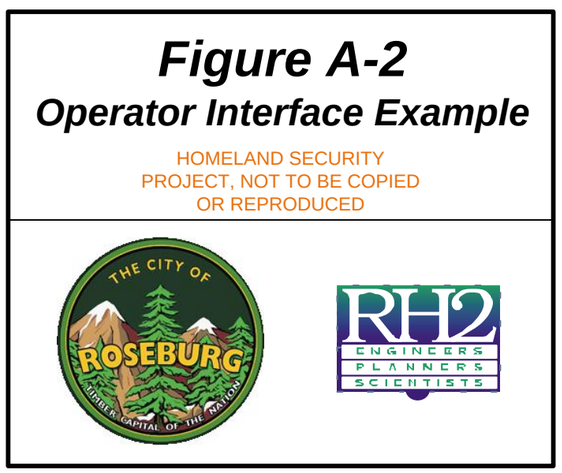

Appendix B

SCADA Inventory

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SCADA Inventory

Update - 9-12-2014

#	Facility Name	Facility Type	Controller Type
1	Broccoli Solenoid Control	Reservoir Fill Control	RTU
2	Dixonville Pump Station #2	Booster Pump Station	Siemens S7-300
3	Dixonville Pump Station #3	Booster Pump Station	Siemens S7-300
4	Dixonville Pump Station #4	Booster Pump Station	Unitronics
5	Dixonville Pump Station #5	Booster Pump Station	Siemens S7-300
6	Dixonville Pump Station #6	Booster Pump Station	Siemens S7-300
7	Dogwood Pump Station	Booster Pump Station	
8	Fairhill Pump Station	Booster Pump Station	Siemens S7-300
9	Fairhill Reservoir	Reservoir	RTU
10	Frontier Reservoir and Pump Station	Reservoir-Booster Pump Station	RTU, AB MicroLogix 1000
11	Garden Valley Pump Station	Booster Pump Station	Automation Direct 405
12	Golden Eagle Pump Station	Booster Pump Station	Siemens S7-300
13	Hawthorne Pump Station	Booster Pump Station	RTU
14	Isabell Pump Station	Booster Pump Station	
15	Joanne Pump Station	Booster Pump Station	
16	Kane Pump Station	Booster Pump Station	
17	Kline Reservoir and Pump Station	Reservoir-Booster Pump Station	RTU
18	West Military Reservoir	Reservoir	RTU
19	Portland Ave Solenoid Control	Reservoir Fill Control	RTU
20	Reservoirs 5, 6, 7	Reservoir	RTU
21	Rifle Range Pump Station	Booster Pump Station	
22	Rocky Ridge Reservoir	Reservoir	
23	Stacie Court Reservoir	Reservoir	RTU
24	Terrace Reservoir and Pump Station	Reservoir-Booster Pump Station	RTU
25	Ventura Pump Station	Booster Pump Station	RTU
26	Winchester Pump Station	Booster Pump Station	Siemens S7-300
27	Winchester Water Treatment Plant	Water Treatment Plant	Siemens 545, S7-300

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SCADA Inventory

Update - 9-12-2014

#	Facility Name	SCADA Communications	Control Method
1	Broccoli Solenoid Control	Tone on Dedicated Phone Line	Level Control off Military Reservoir
2	Dixonville Pump Station #2	450MHz Ethernet - Viper, DSL to WTP	
3	Dixonville Pump Station #3	450MHz Ethernet - Viper	
4	Dixonville Pump Station #4		
5	Dixonville Pump Station #5	450MHz Ethernet - Viper	
6	Dixonville Pump Station #6	450MHz Ethernet - Viper	
7	Dogwood Pump Station		Upper Zone Pressure Control
8	Fairhill Pump Station	Serial Modem on Dedicated Phone Line	VFD Upper Zone Pressure Control
9	Fairhill Reservoir	Tone on Dedicated Phone Line	Direct Connection to Main Zone
10	Frontier Reservoir and Pump Station	Tone on Dedicated Phone Line	Monitors off Frontier Reservoir
11	Garden Valley Pump Station	Serial Modem on Dedicated Phone Line	
12	Golden Eagle Pump Station	Serial Modem on Dedicated Phone Line	VFD Upper Zone Pressure Control
13	Hawthorne Pump Station	Tone on Dedicated Phone Line	
14	Isabell Pump Station		Upper Zone Pressure Control
15	Joanne Pump Station		Upper Zone Pressure Control
16	Kane Pump Station		Upper Zone Pressure Control
17	Kline Reservoir and Pump Station	Tone on Dedicated Phone Line	Reservior Direct Connection to Main Zone
18	West Military Reservoir	Tone on Dedicated Phone Line	Level control off Broccoli Solenoid
19	Portland Ave Solenoid Control	Tone on Dedicated Phone Line	
20	Reservoirs 5, 6, 7	Tone on Dedicated Phone Line	None
21	Rifle Range Pump Station		Upper Zone Pressure Control
22	Rocky Ridge Reservoir	Direct Connection to Garden Valley PS	
23	Stacie Court Reservoir	Tone on Dedicated Phone Line	Upper Zone Pressure Control
24	Terrace Reservoir and Pump Station	Tone on Dedicated Phone Line	
25	Ventura Pump Station	Tone on Dedicated Phone Line	Controls Frontier Reservoir
26	Winchester Pump Station	Serial Modem on Dedicated Phone Line	Upper Zone Pressure Control
27	Winchester Water Treatment Plant	Tone, Serial Modem, DSL	

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SCADA Inventory

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#	Facility Name	Remote Control Data
1	Broccoli Solenoid Control	West Military Level - SCADA
2	Dixonville Pump Station #2	Boyer Level - Direct Connection
3	Dixonville Pump Station #3	
4	Dixonville Pump Station #4	
5	Dixonville Pump Station #5	Cattle Drive - SCADA
6	Dixonville Pump Station #6	
7	Dogwood Pump Station	
8	Fairhill Pump Station	
9	Fairhill Reservoir	
10	Frontier Reservoir and Pump Station	
11	Garden Valley Pump Station	Rocky Ridge Level - Direct Connection
12	Golden Eagle Pump Station	
13	Hawthorne Pump Station	Terrace - SCADA
14	Isabell Pump Station	
15	Joanne Pump Station	
16	Kane Pump Station	
17	Kline Reservoir and Pump Station	Stacie Court - SCADA
18	West Military Reservoir	
19	Portland Ave Solenoid Control	
20	Reservoirs 5, 6, 7	
21	Rifle Range Pump Station	
22	Rocky Ridge Reservoir	
23	Stacie Court Reservoir	
24	Terrace Reservoir and Pump Station	
25	Ventura Pump Station	Frontier Level - SCADA
26	Winchester Pump Station	Reservoirs 5, 6, 7, Klien, Fairhill Levels - SCADA
27	Winchester Water Treatment Plant	

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SCADA Inventory

Update - 9-12-2014

#	Facility Name	Control Zone	Monitoring Instruments		
			Level	Suction Press.	Discharge Press.
1	Broccoli Solenoid Control	Broccoli			1
2	Dixonville Pump Station #2			1	1
3	Dixonville Pump Station #3			1	1
4	Dixonville Pump Station #4			1	1
5	Dixonville Pump Station #5		Grange	1	1
6	Dixonville Pump Station #6		Cattle Drive		1
7	Dogwood Pump Station				
8	Fairhill Pump Station	Fairhill		1	1
9	Fairhill Reservoir	Main System	1		
10	Frontier Reservoir and Pump Station	Frontier Pressure Zone	1	1	1
11	Garden Valley Pump Station	Rocky Ridge	1		
12	Golden Eagle Pump Station	Eagle View Zone		1	1
13	Hawthorne Pump Station	Terrace			
14	Isabell Pump Station				
15	Joanne Pump Station				
16	Kane Pump Station				
17	Kline Reservoir and Pump Station	Stacie Court Pressure Zone	1	1	
18	West Military Reservoir	Main System	1		
19	Portland Ave Solenoid Control	Fairhill Pressure Zone			
20	Reservoirs 5, 6, 7	Main	2		
21	Rifle Range Pump Station				
22	Rocky Ridge Reservoir		1		
23	Stacie Court Reservoir	Warewood	1		
24	Terrace Reservoir and Pump Station	Terrace Pressure Zone	1	1	1
25	Ventura Pump Station	Ventura		1	
26	Winchester Pump Station	Winchester Creek	No	1	1
27	Winchester Water Treatment Plant				

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SCADA Inventory

	Update - 9-12-2014	Monitoring Instruments						
#	Facility Name	Batt. Voltage	Temp.	High Float	Flow	Flood	Smoke	Pump Status
1	Broccoli Solenoid Control	1				1		
2	Dixonville Pump Station #2	1	1		1- Mag			Full VFD Status
3	Dixonville Pump Station #3	1	1		1 - Mag			Full VFD Status
4	Dixonville Pump Station #4	1	1		1			Run
5	Dixonville Pump Station #5	1	1	1	1- Mag	1	1	Run
6	Dixonville Pump Station #6	1	1	1	1- Mag	1	1	Run
7	Dogwood Pump Station							
8	Fairhill Pump Station	1				1	1	
9	Fairhill Reservoir	1		1				Full vfd tatus
10	Frontier Reservoir and Pump Station	1		1	1	1	1	Run
11	Garden Valley Pump Station	1			1	1	1	Run
12	Golden Eagle Pump Station	1			2	1	1	Full VFD Status
13	Hawthorne Pump Station	1			2		1	Run
14	Isabell Pump Station							
15	Joanne Pump Station							
16	Kane Pump Station							
17	Kline Reservoir and Pump Station	1		1	?	1	1	2 pumps
18	West Military Reservoir	1		1		1		
19	Portland Ave Solenoid Control	1					1	
20	Reservoirs 5, 6, 7			2				
21	Rifle Range Pump Station							
22	Rocky Ridge Reservoir	1						
23	Stacie Court Reservoir	1		1			1	
24	Terrace Reservoir and Pump Station	1		1		1	1	Run
25	Ventura Pump Station						1	Run
26	Winchester Pump Station	Yes	No	No	1	1	1	Full VFD Status
27	Winchester Water Treatment Plant							

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SCADA Inventory

	Update - 9-12-2014	Monitoring Instruments					Control Instruments	
#	Facility Name	Valve Status	AC Fail	Panic	Intrusion	Energy	Pumps	Valves
1	Broccoli Solenoid Control	Cla-Valve	1		1			1 Cla-Valve
2	Dixonville Pump Station #2					VFD	3-VFD	
3	Dixonville Pump Station #3			1	1	VFD	4-VFD	
4	Dixonville Pump Station #4						3-VFD	
5	Dixonville Pump Station #5	Refill Valve Open	1	1	1		2	1-Refill Valve
6	Dixonville Pump Station #6		1	1	1		2	
7	Dogwood Pump Station						1	
8	Fairhill Pump Station		1		2	VFD	4-VFD	
9	Fairhill Reservoir		1		1			
10	Frontier Reservoir and Pump Station		1		1		3	
11	Garden Valley Pump Station	2	1		1		2	2 Cla-Valves
12	Golden Eagle Pump Station		1		1		2-VFD	
13	Hawthorne Pump Station	2	1		1		2	2
14	Isabell Pump Station						1	
15	Joanne Pump Station						2	
16	Kane Pump Station						1-VFD	
17	Kline Reservoir and Pump Station		1		1		2	
18	West Military Reservoir	Alt. Valve Open	1		1			1 Cla- valve
19	Portland Ave Solenoid Control	1	1		1		1	1-Cla-Valve
20	Reservoirs 5, 6, 7		1		1			
21	Rifle Range Pump Station						2	
22	Rocky Ridge Reservoir							
23	Stacie Court Reservoir		1		1			
24	Terrace Reservoir and Pump Station		1		1		2	
25	Ventura Pump Station		1		1		2	
26	Winchester Pump Station	no	1	no	2		3-VFD	
27	Winchester Water Treatment Plant							

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SCADA Inventory

Update - 9-12-2014

#	Facility Name	Wireless Repeater Site	Priority
1	Broccoli Solenoid Control		High
2	Dixonville Pump Station #2	Yes	
3	Dixonville Pump Station #3		
4	Dixonville Pump Station #4		
5	Dixonville Pump Station #5		
6	Dixonville Pump Station #6		
7	Dogwood Pump Station		
8	Fairhill Pump Station		
9	Fairhill Reservoir	Yes	
10	Frontier Reservoir and Pump Station		
11	Garden Valley Pump Station		
12	Golden Eagle Pump Station		
13	Hawthorne Pump Station		
14	Isabell Pump Station		
15	Joanne Pump Station		
16	Kane Pump Station		
17	Kline Reservoir and Pump Station	Yes	
18	West Military Reservoir		
19	Portland Ave Solenoid Control		
20	Reservoirs 5, 6, 7	Yes	
21	Rifle Range Pump Station		
22	Rocky Ridge Reservoir		
23	Stacie Court Reservoir	Yes	
24	Terrace Reservoir and Pump Station	Yes	
25	Ventura Pump Station		
26	Winchester Pump Station		
27	Winchester Water Treatment Plant		

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SCADA Inventory

Update - 9-12-2014

#	Facility Name	Comments
1	Broccoli Solenoid Control	
2	Dixonville Pump Station #2	
3	Dixonville Pump Station #3	
4	Dixonville Pump Station #4	Unitronics runs pre-packaged booster pumps.
5	Dixonville Pump Station #5	
6	Dixonville Pump Station #6	
7	Dogwood Pump Station	
8	Fairhill Pump Station	
9	Fairhill Reservoir	
10	Frontier Reservoir and Pump Station	Micrologix 1000 runs pre-packaged booster pumps.
11	Garden Valley Pump Station	
12	Golden Eagle Pump Station	
13	Hawthorne Pump Station	Like Garden Valley Pump Sta: Local control for pump shut off
14	Isabell Pump Station	
15	Joanne Pump Station	
16	Kane Pump Station	
17	Kline Reservoir and Pump Station	Fire Pump is disabled - low pressure uses local control
18	West Military Reservoir	Talks to Brocolli Solenoid
19	Portland Ave Solenoid Control	8-Inch Cla-Valve Plant controlled, pump is not used.
20	Reservoirs 5, 6, 7	
21	Rifle Range Pump Station	
22	Rocky Ridge Reservoir	Directly connected to Garden Valley Pump Station
23	Stacie Court Reservoir	
24	Terrace Reservoir and Pump Station	Suction Pressure, Local control
25	Ventura Pump Station	Has low pressure shut off that is not being monitored.
26	Winchester Pump Station	
27	Winchester Water Treatment Plant	

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Appendix C

Preliminary Radio Survey

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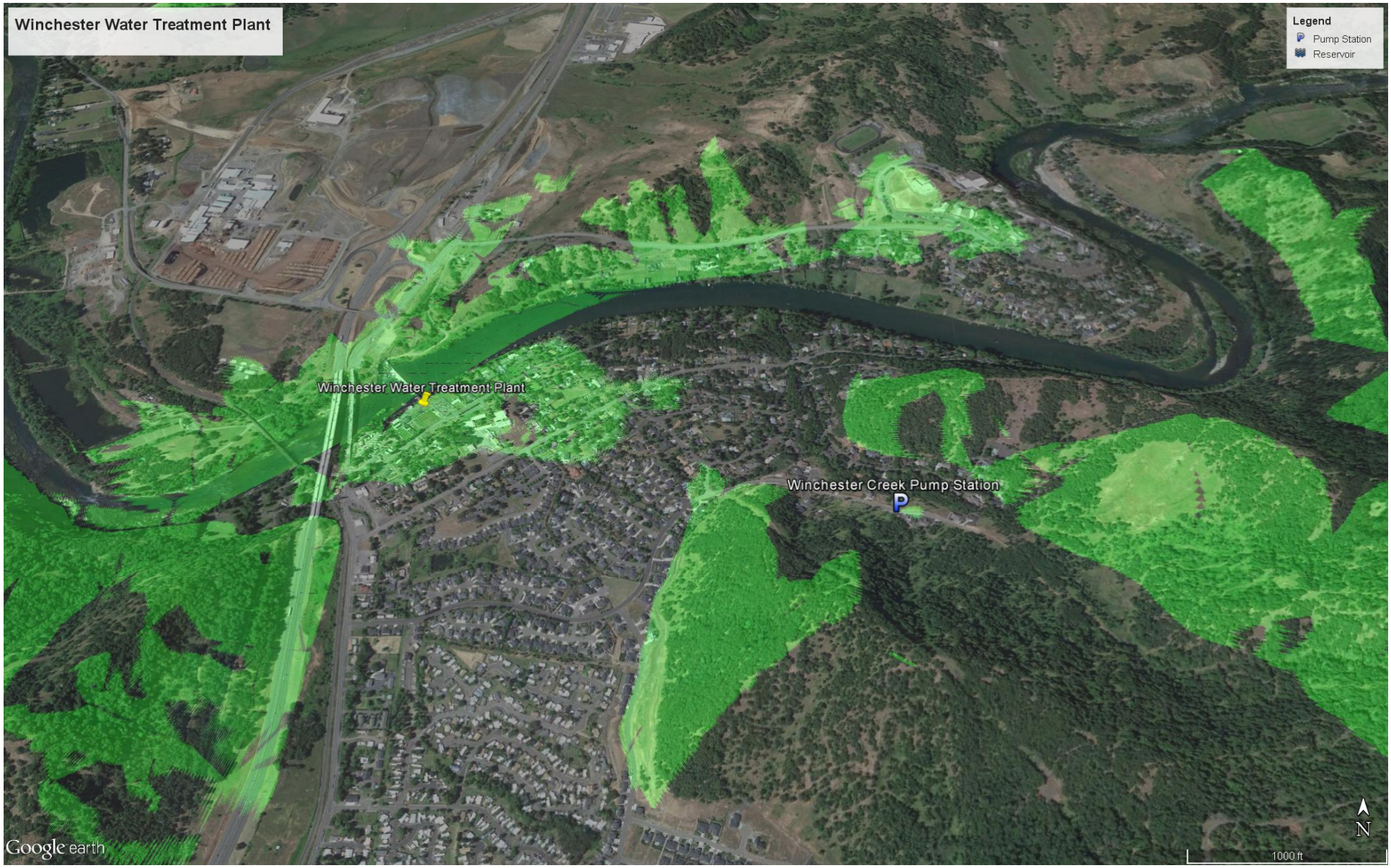
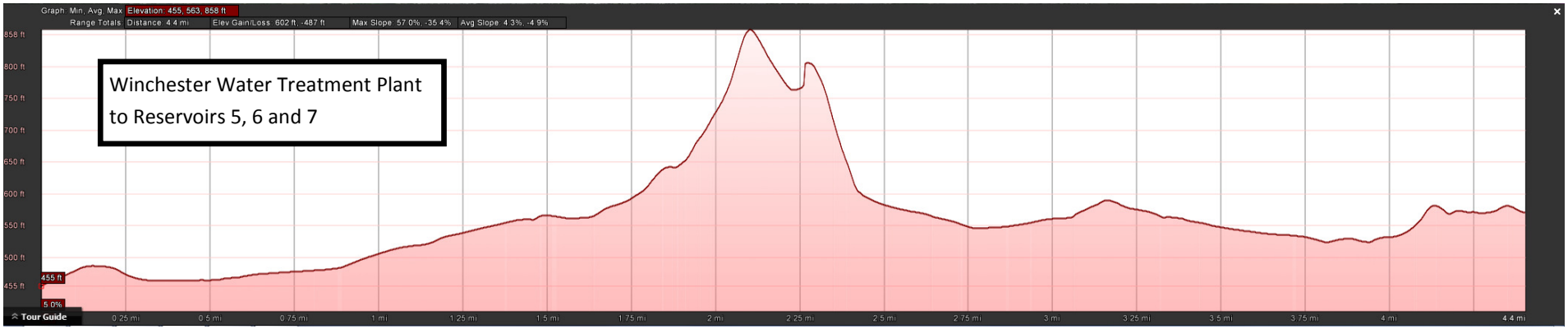
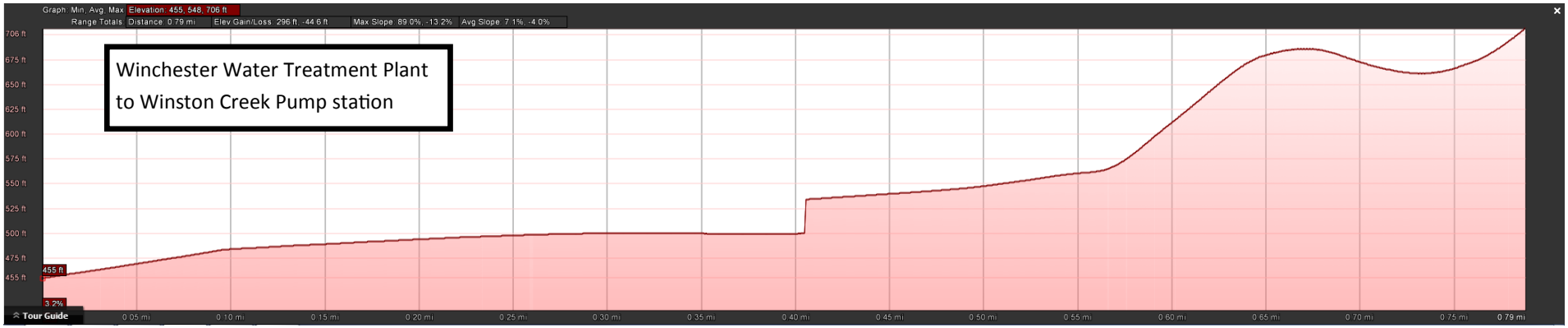
Winchester Water Treatment Plant — Viewshed and Line of Site Profiles



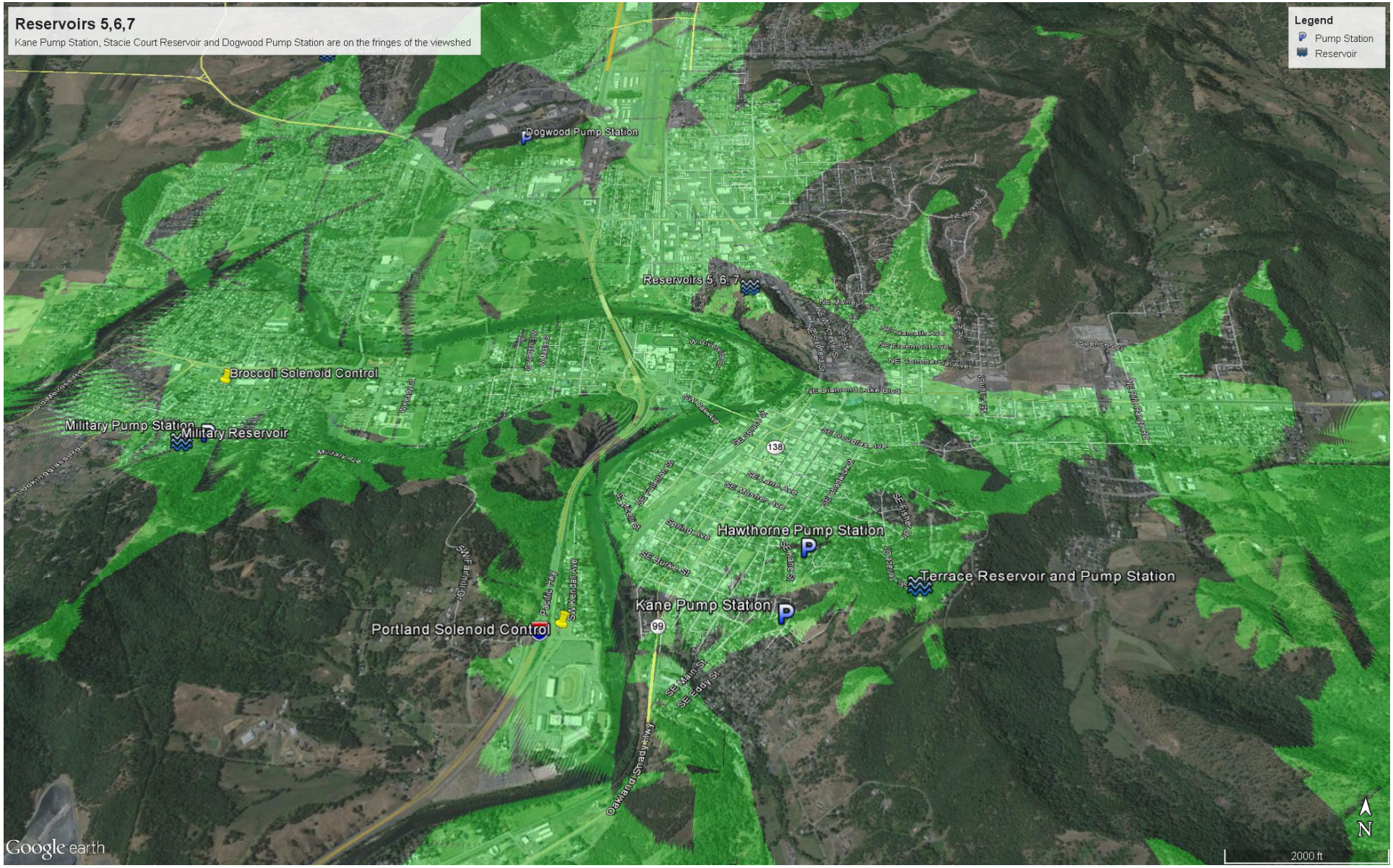
Winchester Water Treatment Plant — Viewshed and Line of Site Profiles



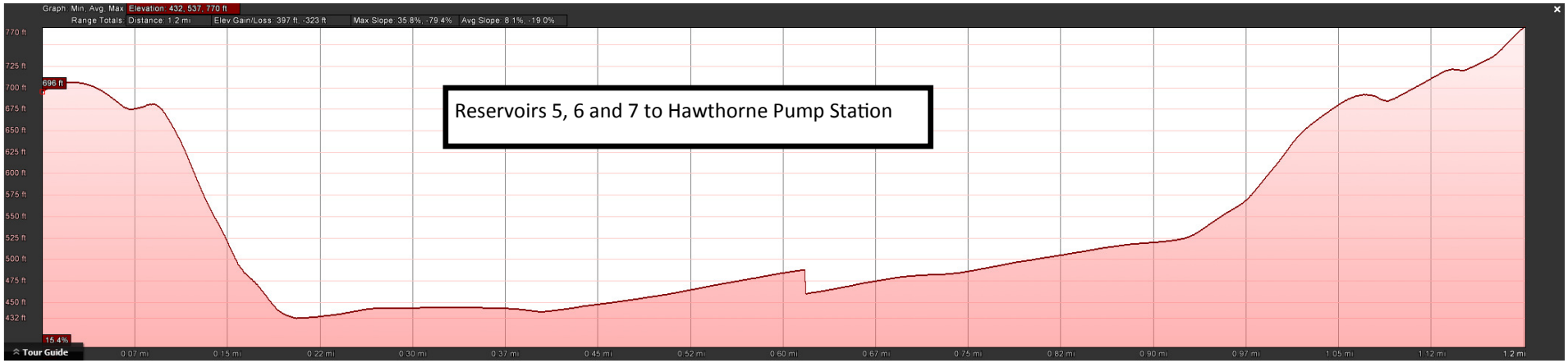
Winchester Water Treatment Plant — Viewshed and Line of Site Profiles



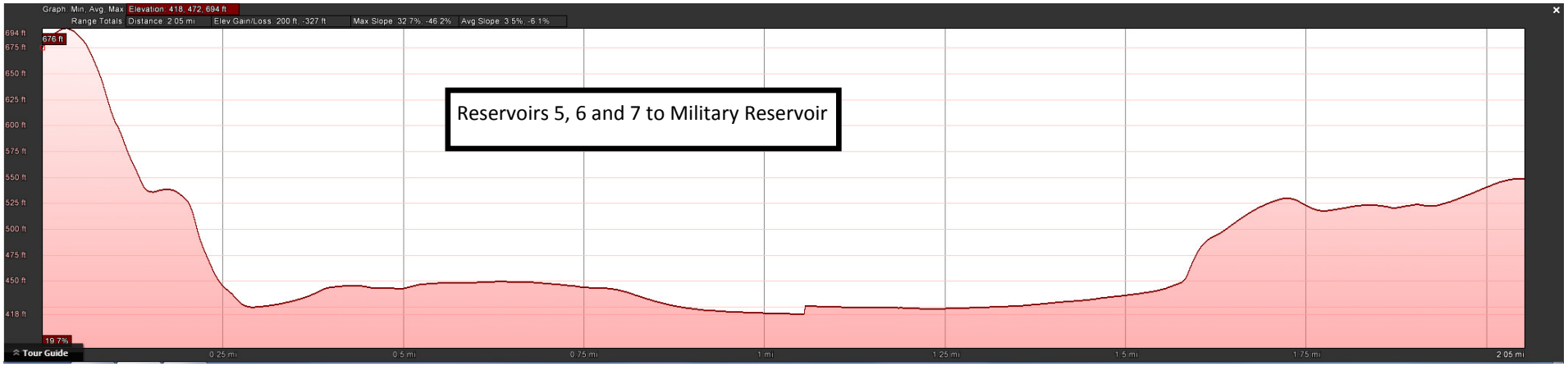
Reservoirs 5-6-7 — Viewshed and Line of Site Profiles



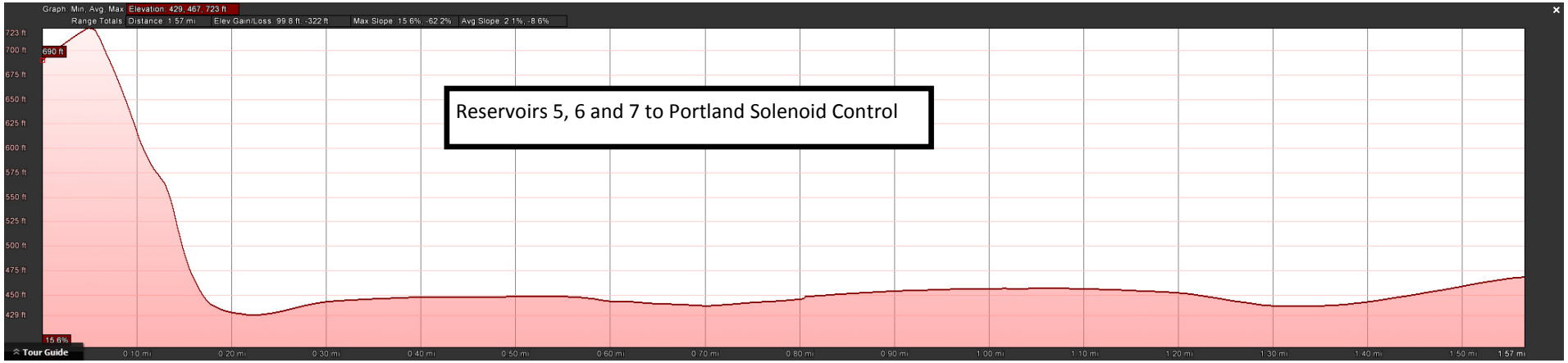
Reservoirs 5-6-7 — Viewshed and Line of Site Profiles



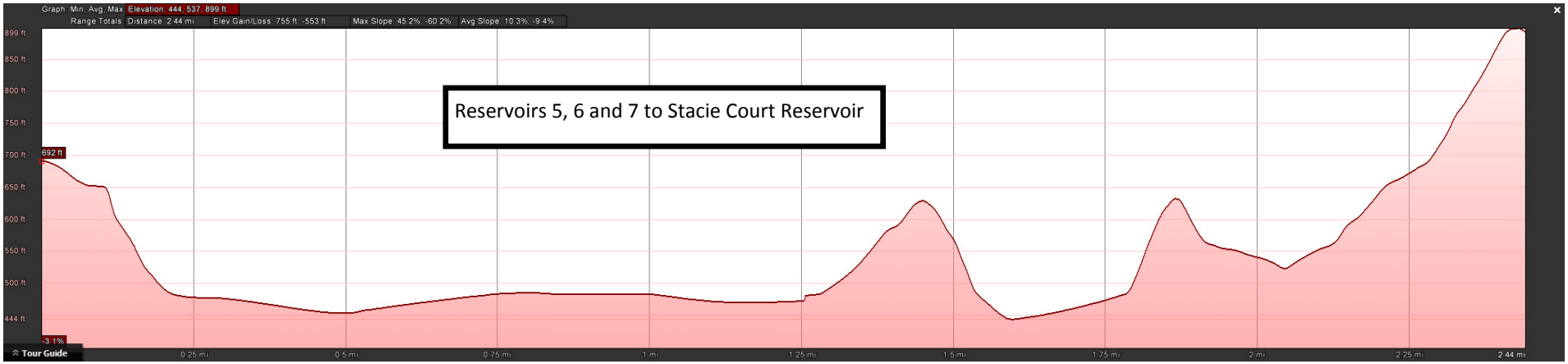
Reservoirs 5-6-7 — Viewshed and Line of Site Profiles



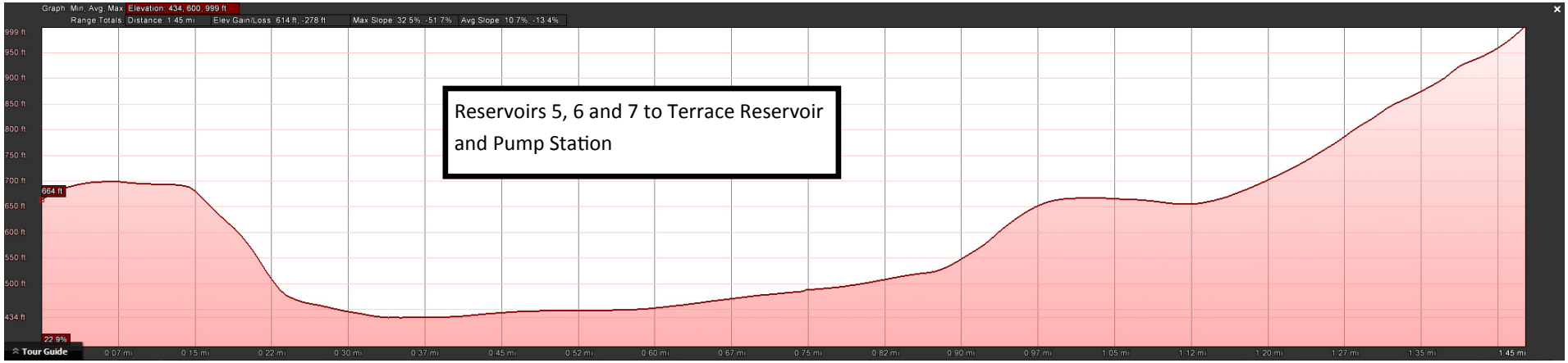
Reservoirs 5-6-7 — Viewshed and Line of Site Profiles



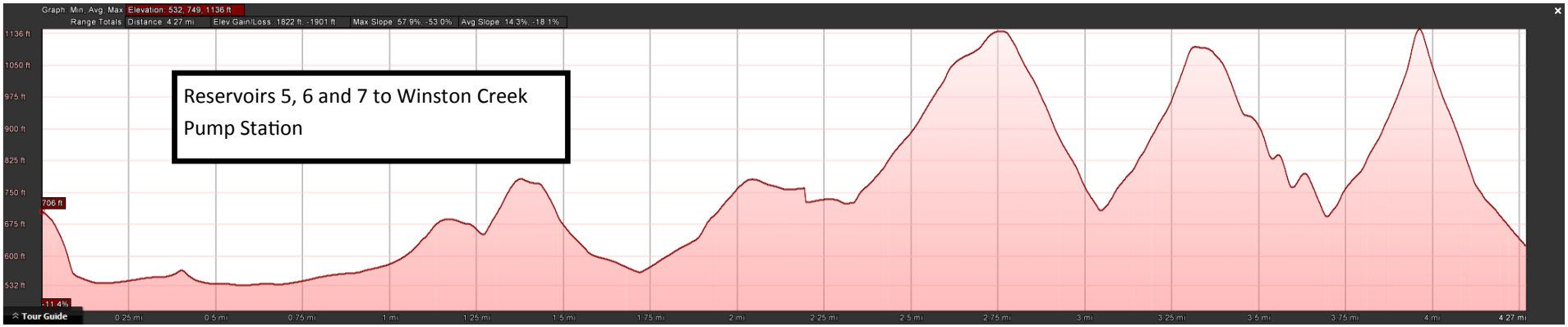
Reservoirs 5-6-7 — Viewshed and Line of Site Profiles



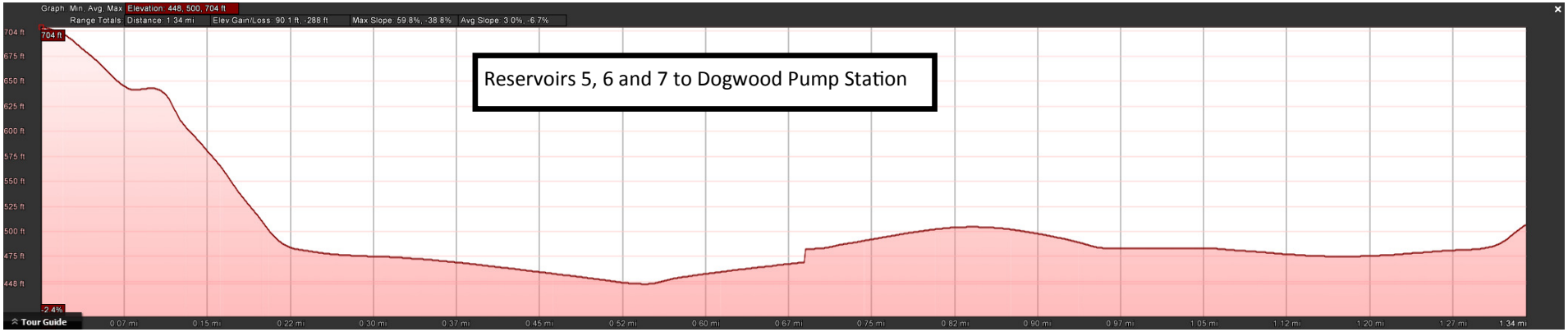
Reservoirs 5-6-7 — Viewshed and Line of Site Profiles



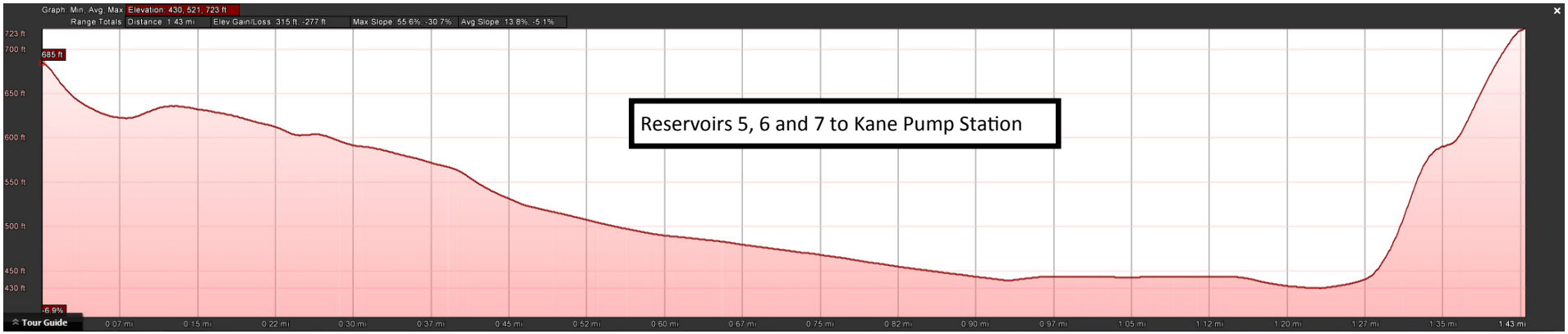
Reservoirs 5-6-7 — Viewshed and Line of Site Profiles



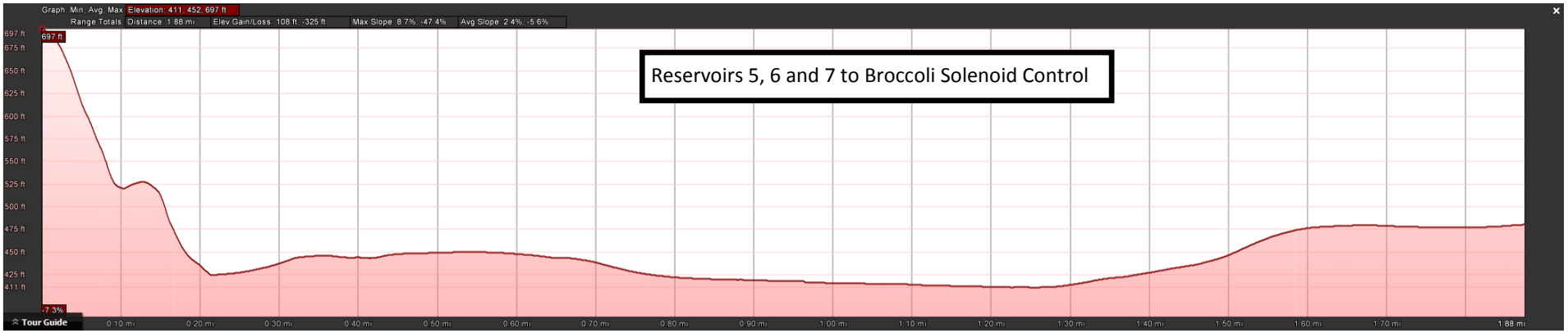
Reservoirs 5-6-7 — Viewshed and Line of Site Profiles



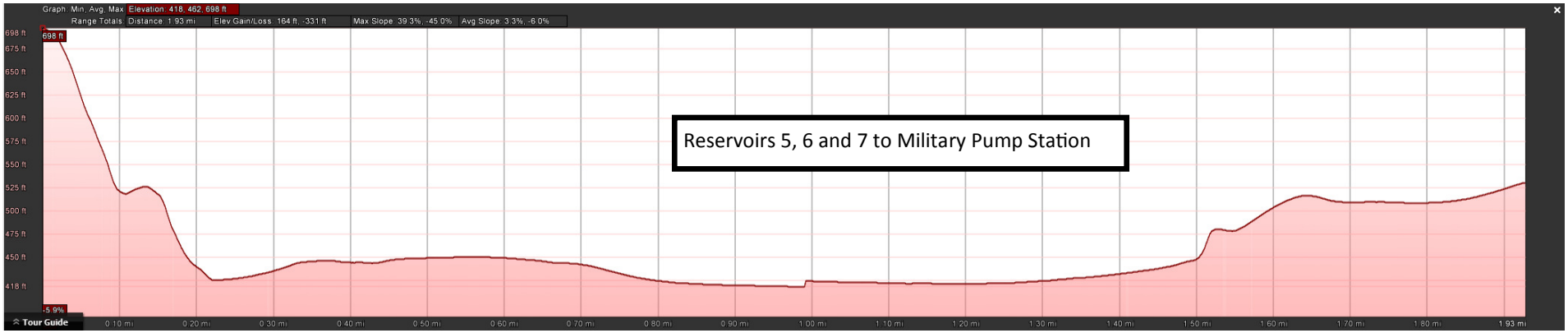
Reservoirs 5-6-7 — Viewshed and Line of Site Profiles



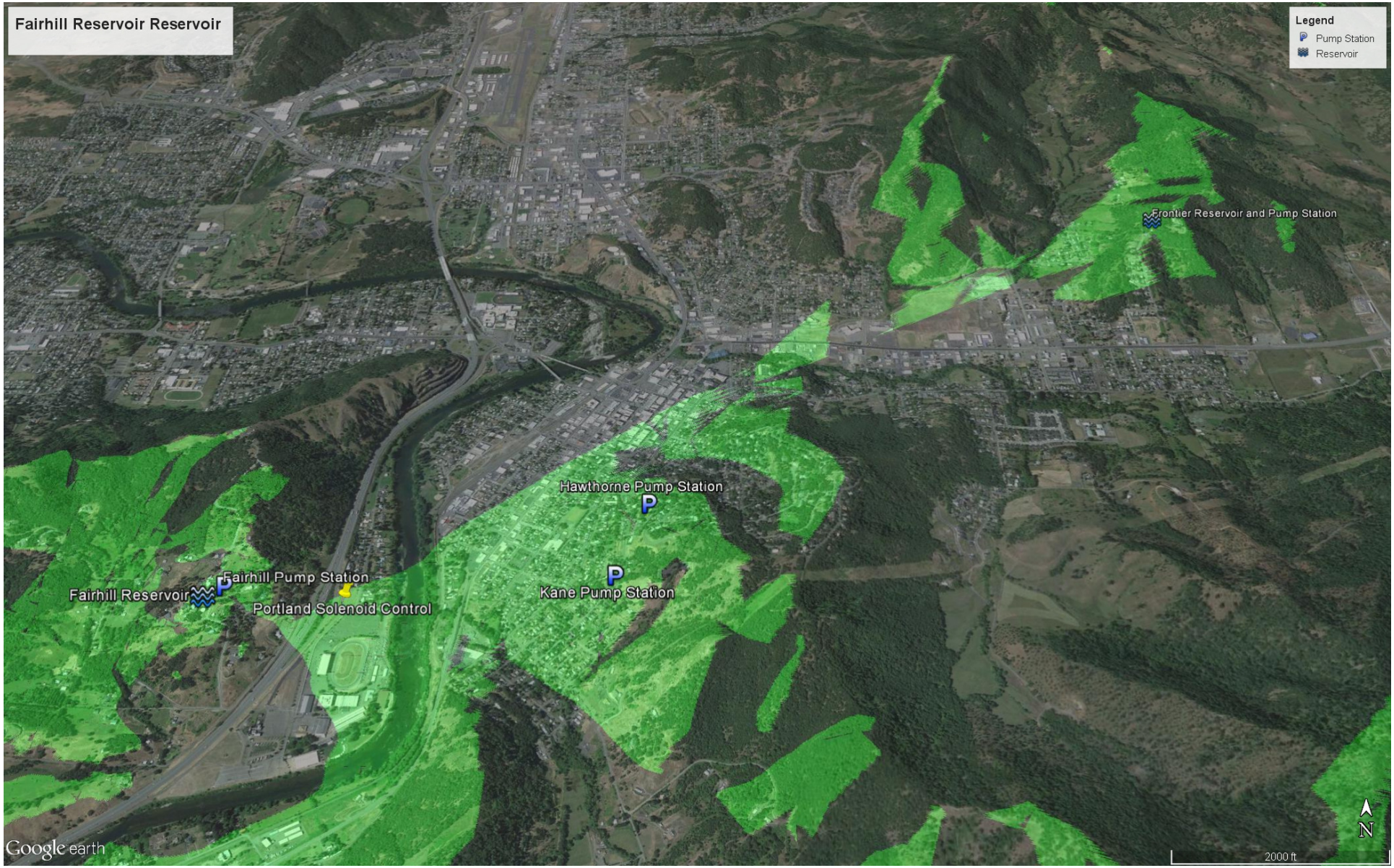
Reservoirs 5-6-7 — Viewshed and Line of Site Profiles



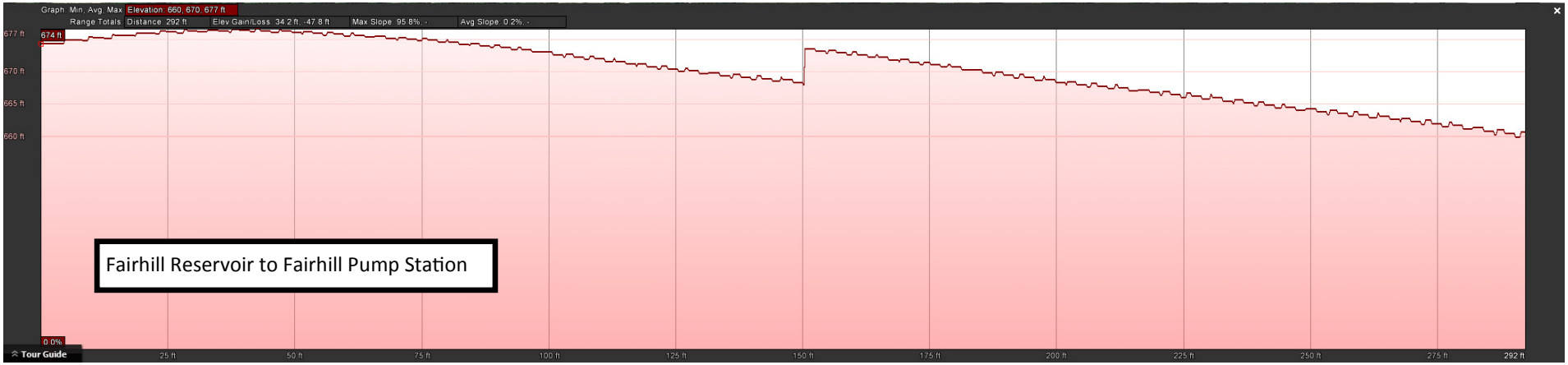
Reservoirs 5-6-7 — Viewshed and Line of Site Profiles



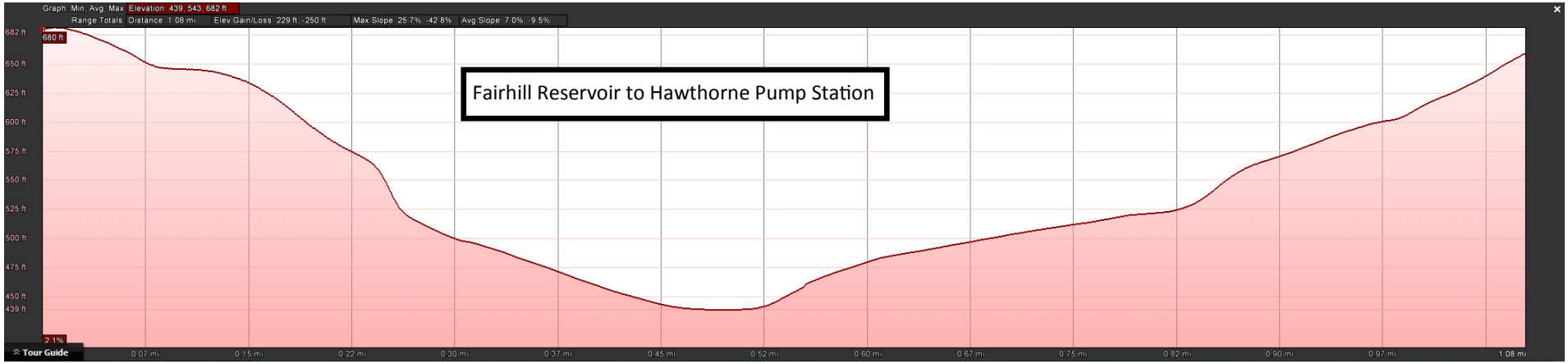
Fairhill Reservoir — Viewshed and Line of Site Profiles



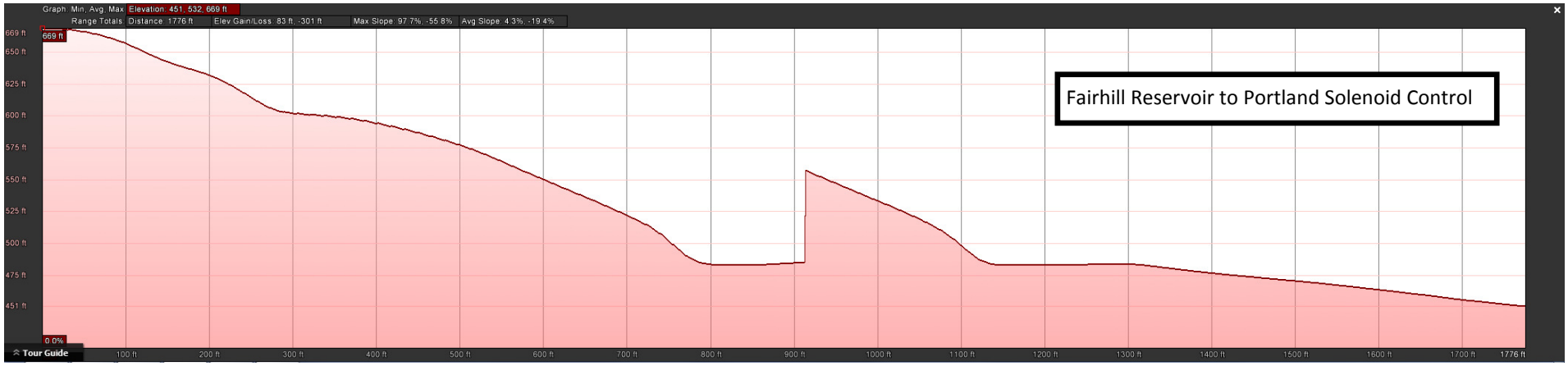
Fairhill Reservoir — Viewshed and Line of Site Profiles



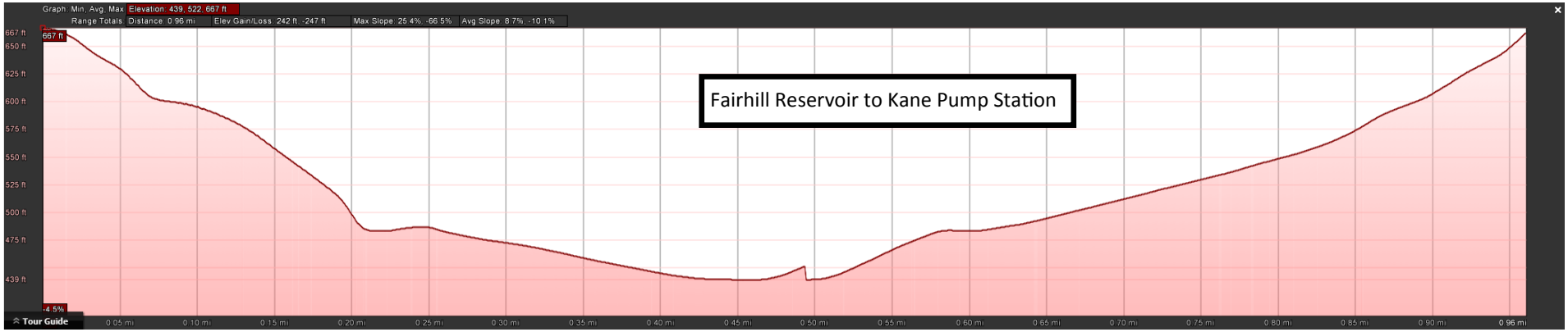
Fairhill Reservoir — Viewshed and Line of Site Profiles



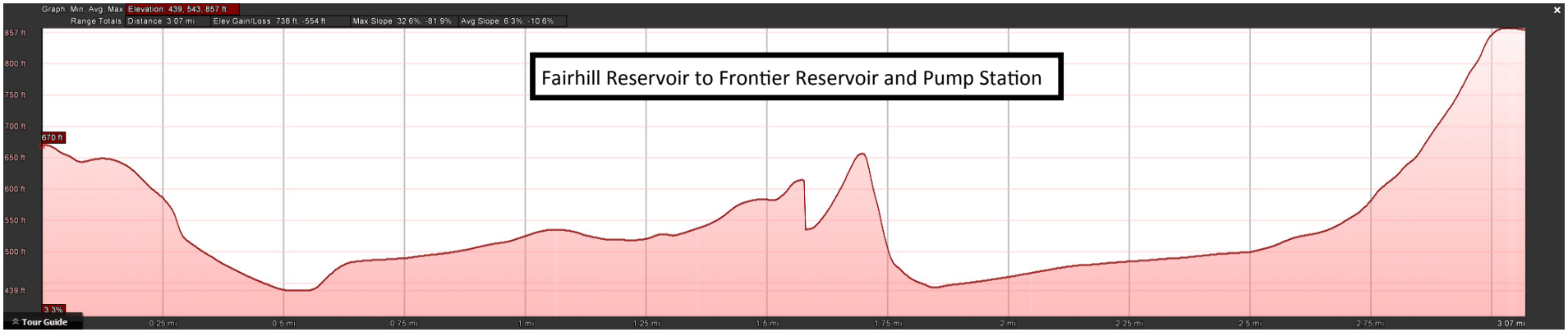
Fairhill Reservoir — Viewshed and Line of Site Profiles



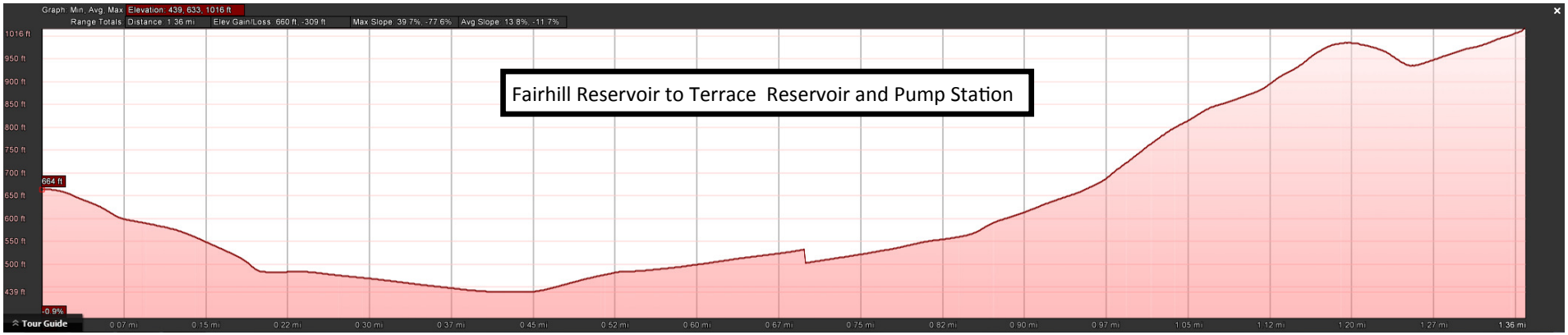
Fairhill Reservoir — Viewshed and Line of Site Profiles



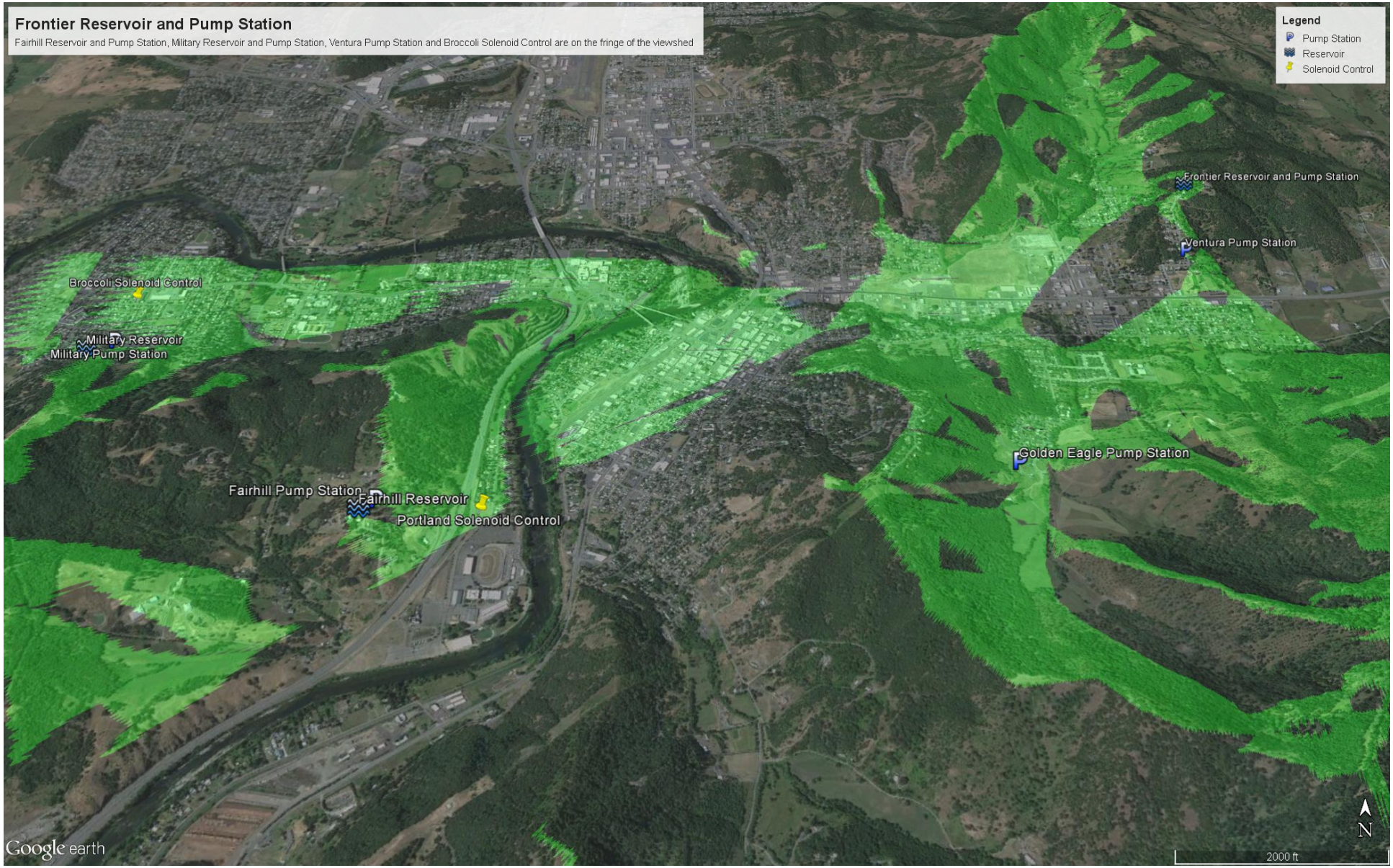
Fairhill Reservoir — Viewshed and Line of Site Profiles



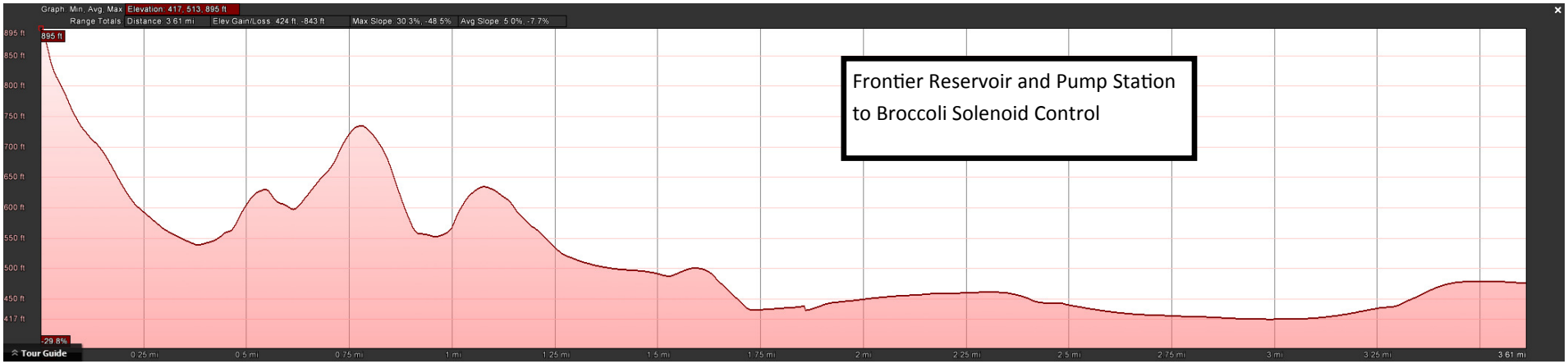
Fairhill Reservoir — Viewshed and Line of Site Profiles



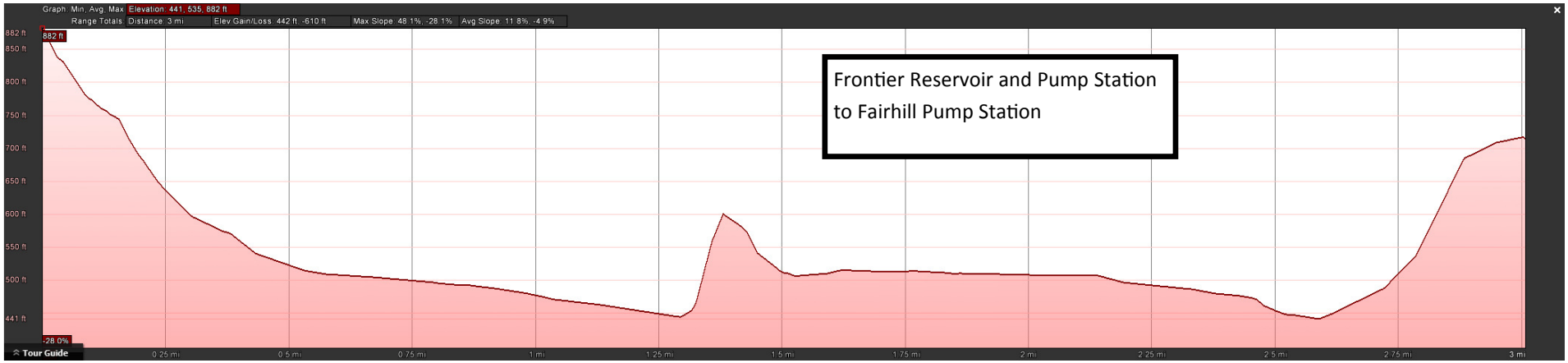
Frontier Reservoir and Pump Station — Viewshed and Line of Site Profiles



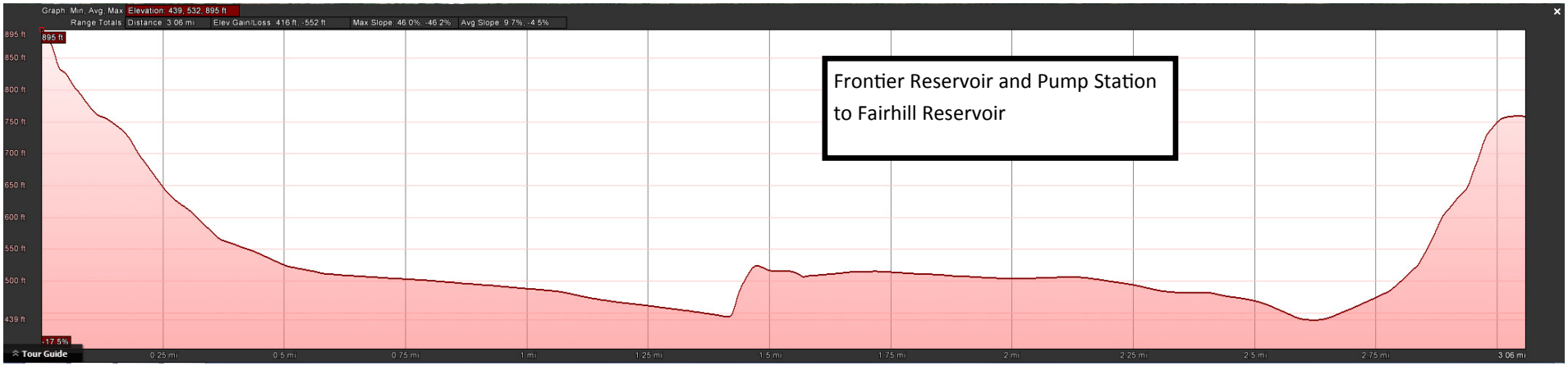
Frontier Reservoir and Pump Station — Viewshed and Line of Site Profiles



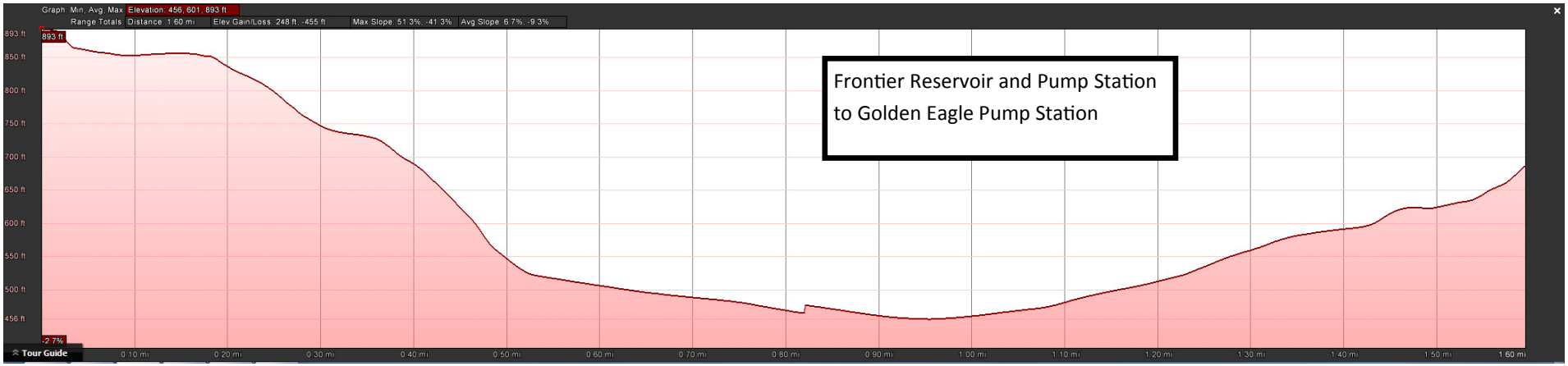
Frontier Reservoir and Pump Station — Viewshed and Line of Site Profiles



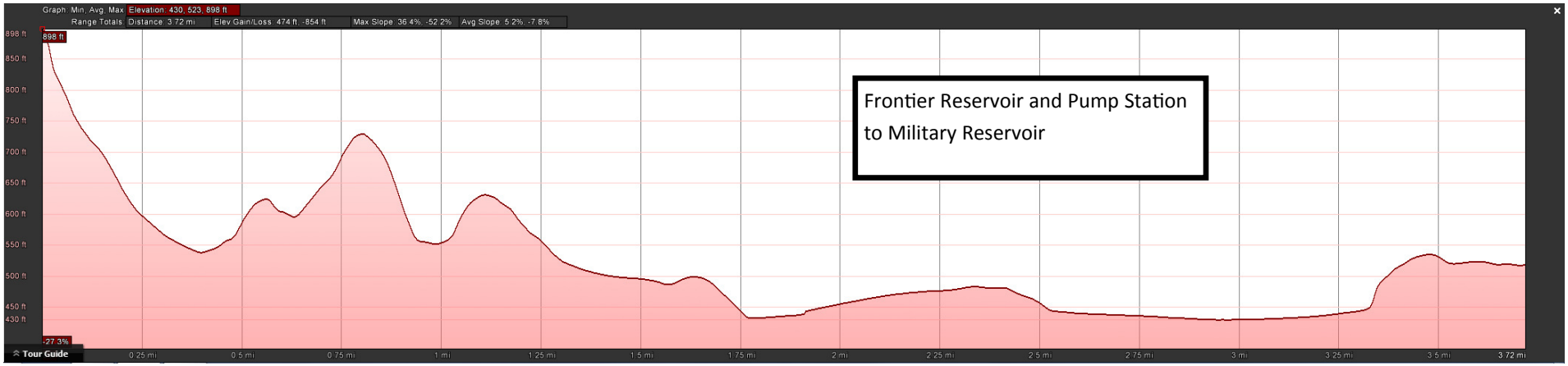
Frontier Reservoir and Pump Station — Viewshed and Line of Site Profiles



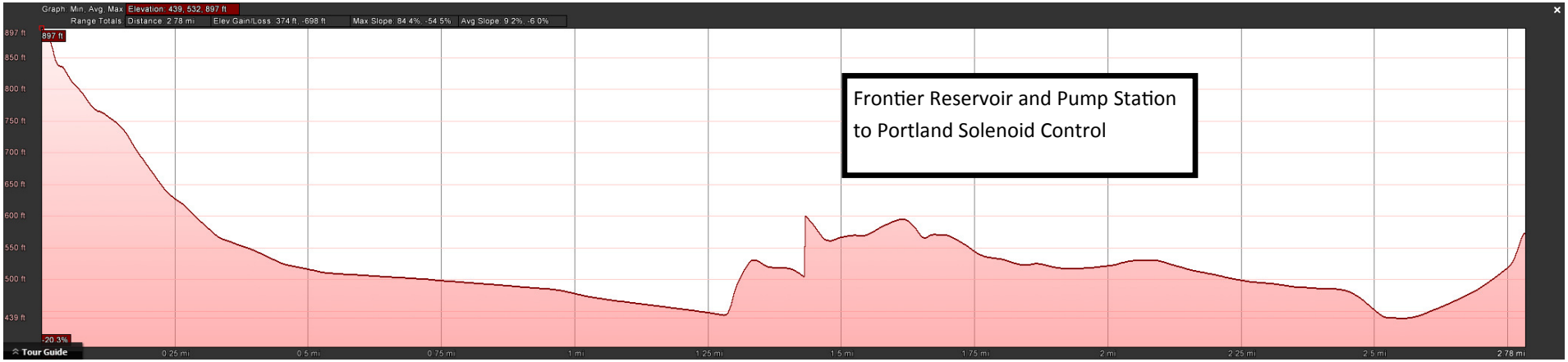
Frontier Reservoir and Pump Station — Viewshed and Line of Site Profiles



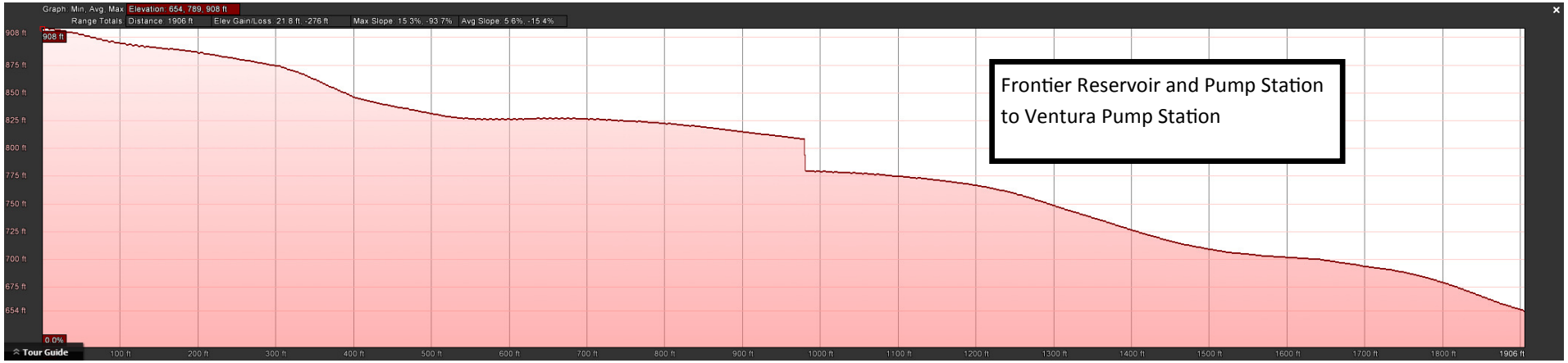
Frontier Reservoir and Pump Station — Viewshed and Line of Site Profiles



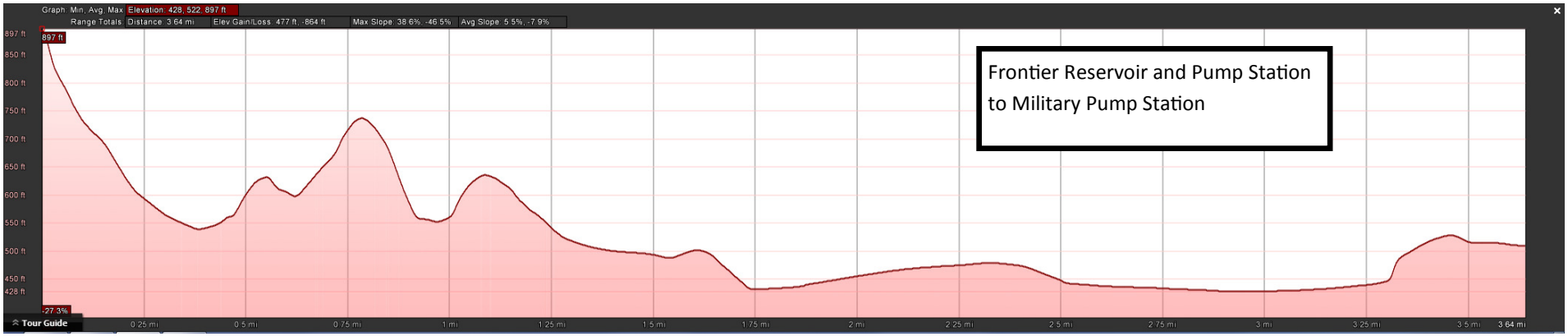
Frontier Reservoir and Pump Station — Viewshed and Line of Site Profiles



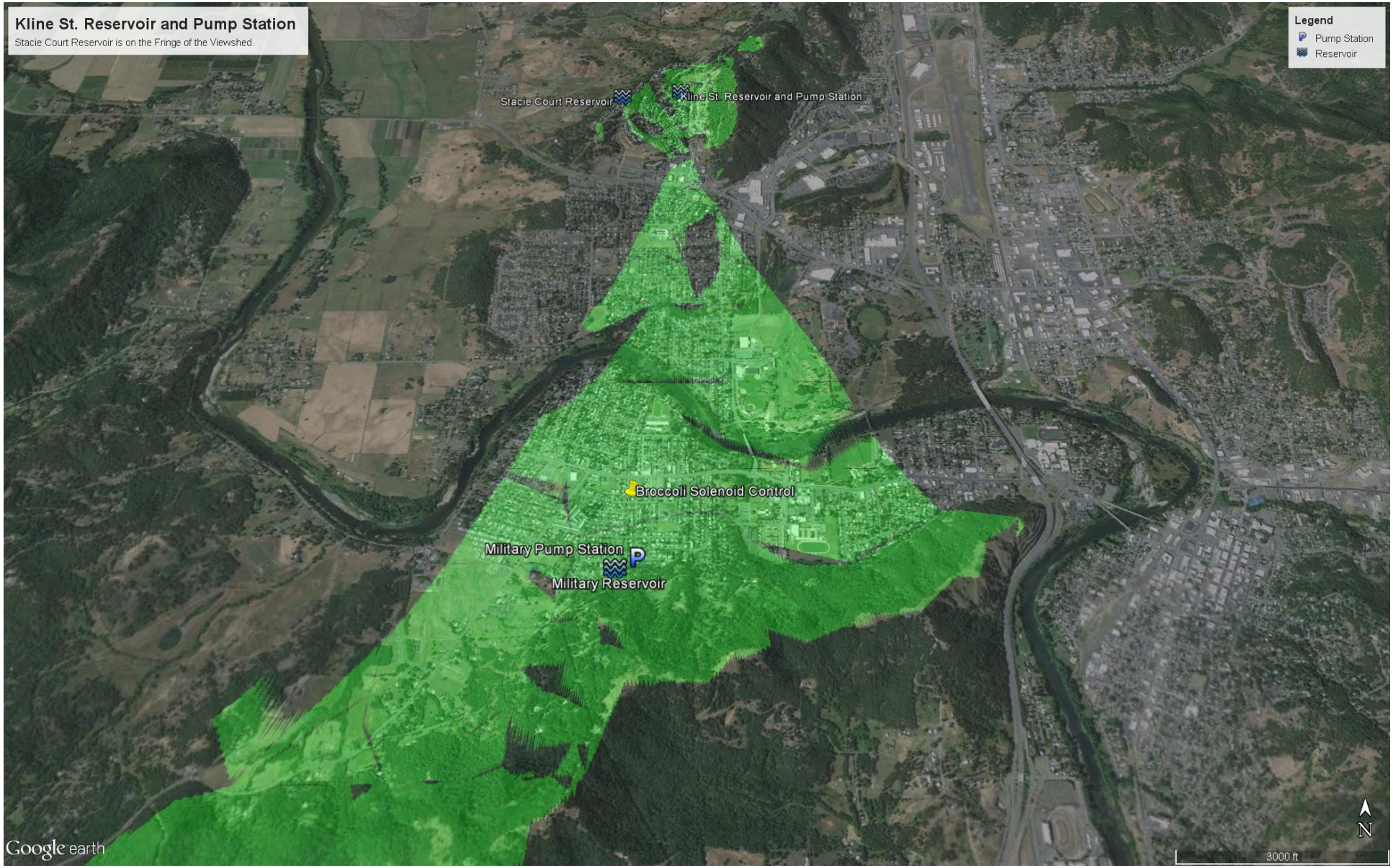
Frontier Reservoir and Pump Station — Viewshed and Line of Site Profiles



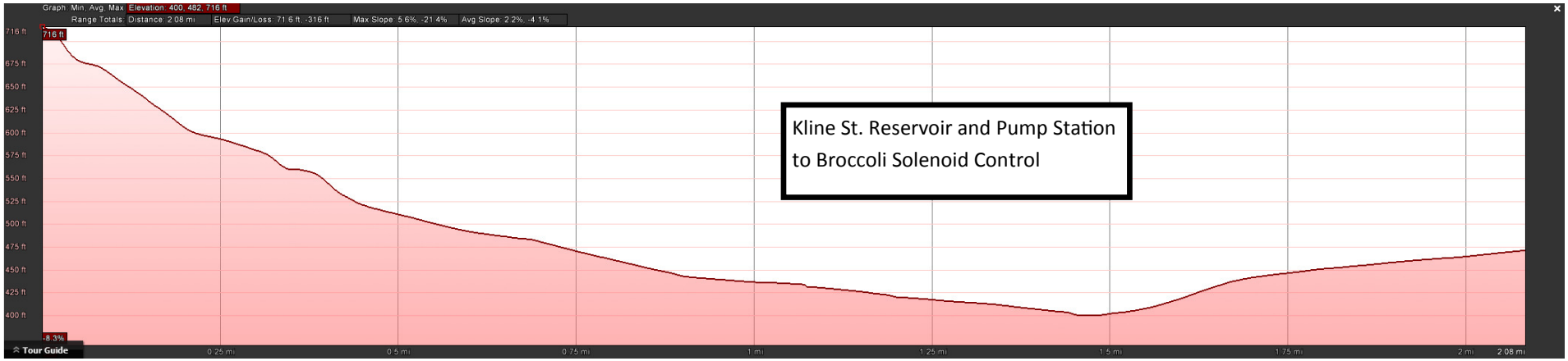
Frontier Reservoir and Pump Station — Viewshed and Line of Site Profiles



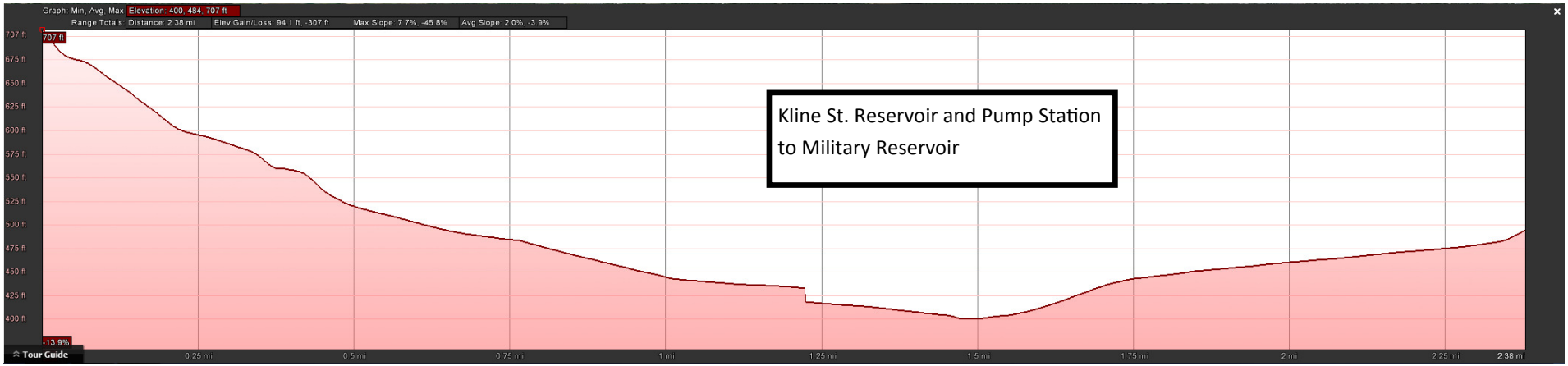
Kline St. Reservoir and Pump Station — Viewshed and Line of Site Profiles



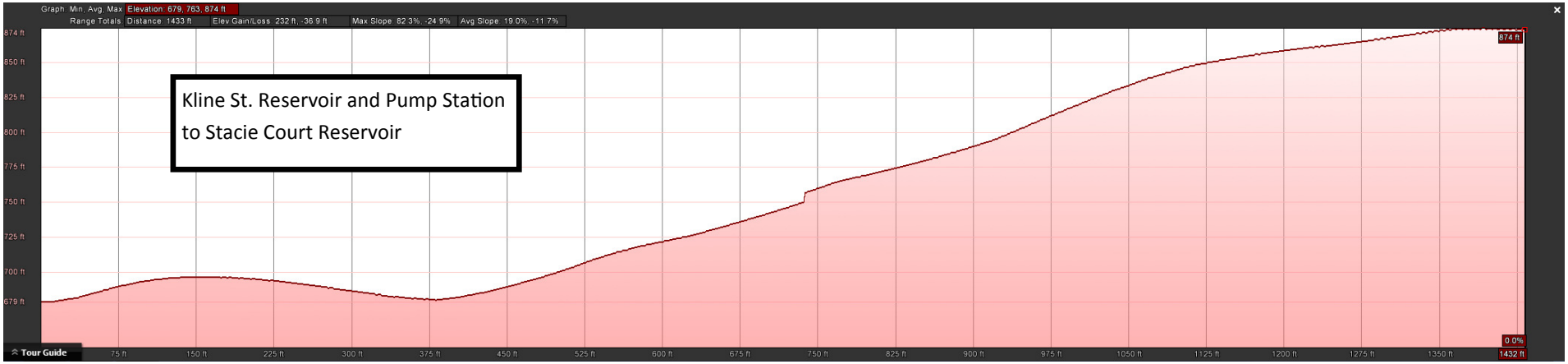
Kline St. Reservoir and Pump Station — Viewshed and Line of Site Profiles



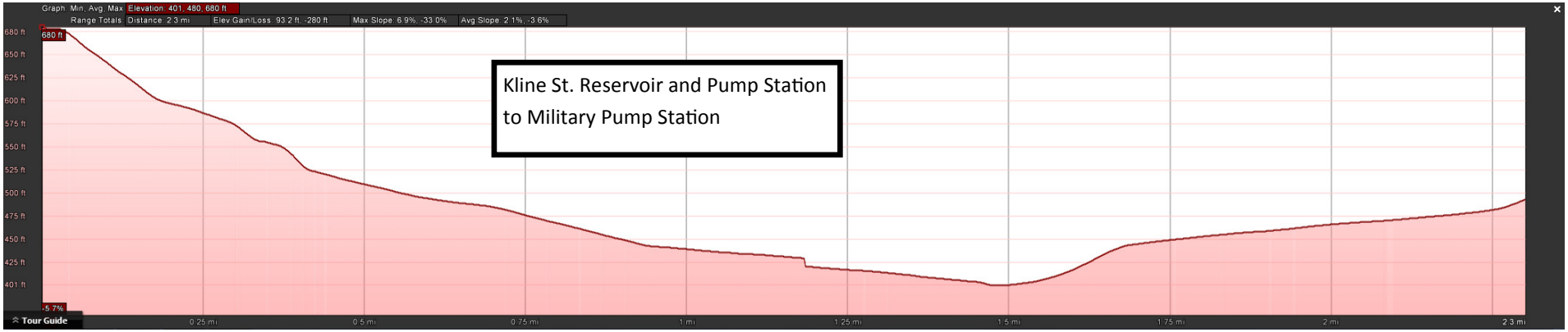
Kline St. Reservoir and Pump Station — Viewshed and Line of Site Profiles



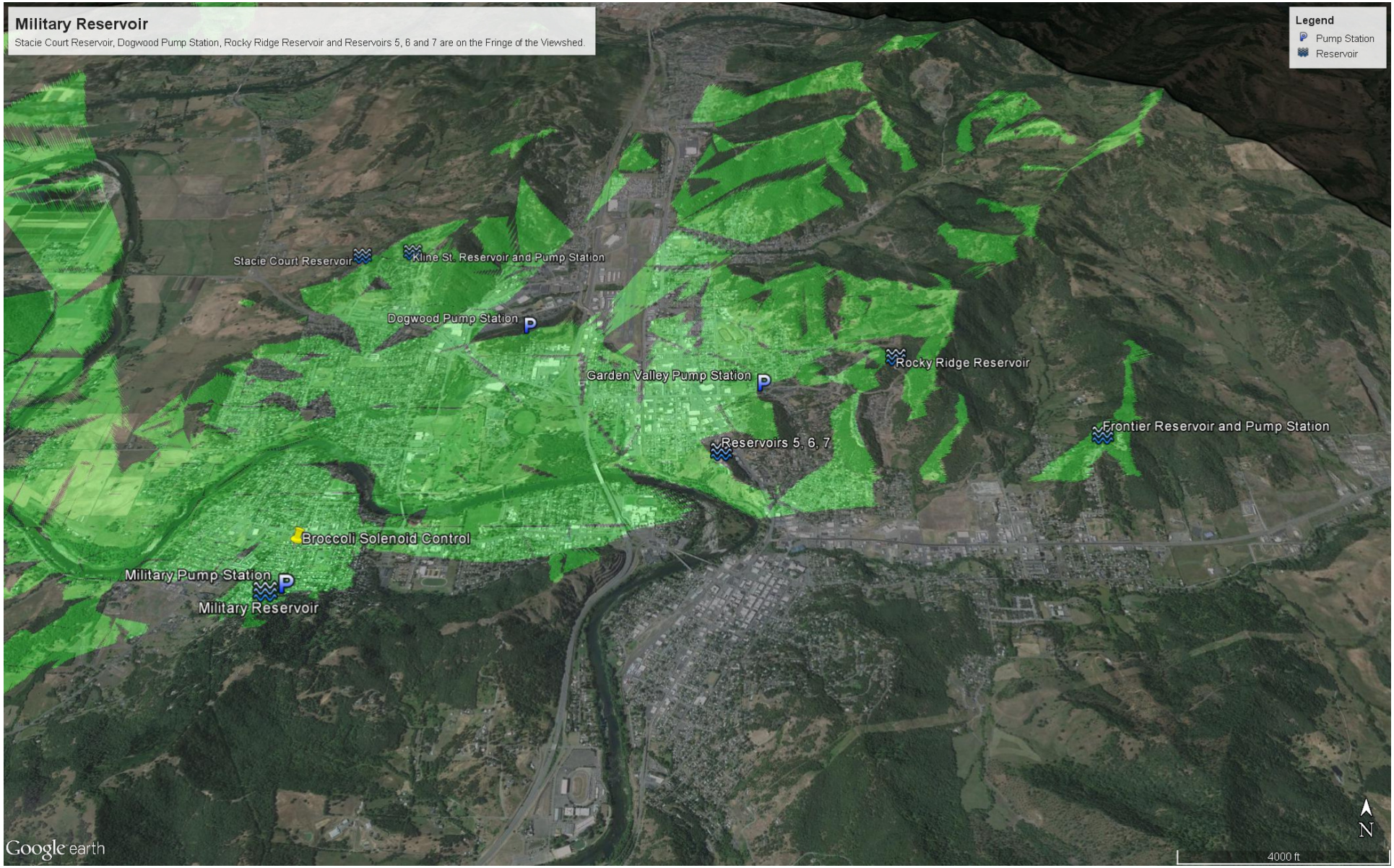
Kline St. Reservoir and Pump Station — Viewshed and Line of Site Profiles



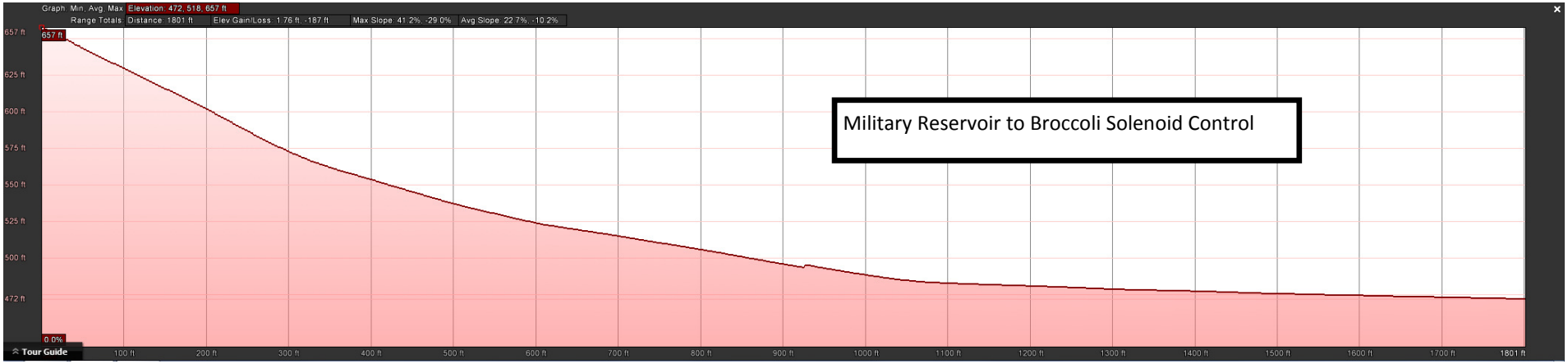
Kline St. Reservoir and Pump Station — Viewshed and Line of Site Profiles



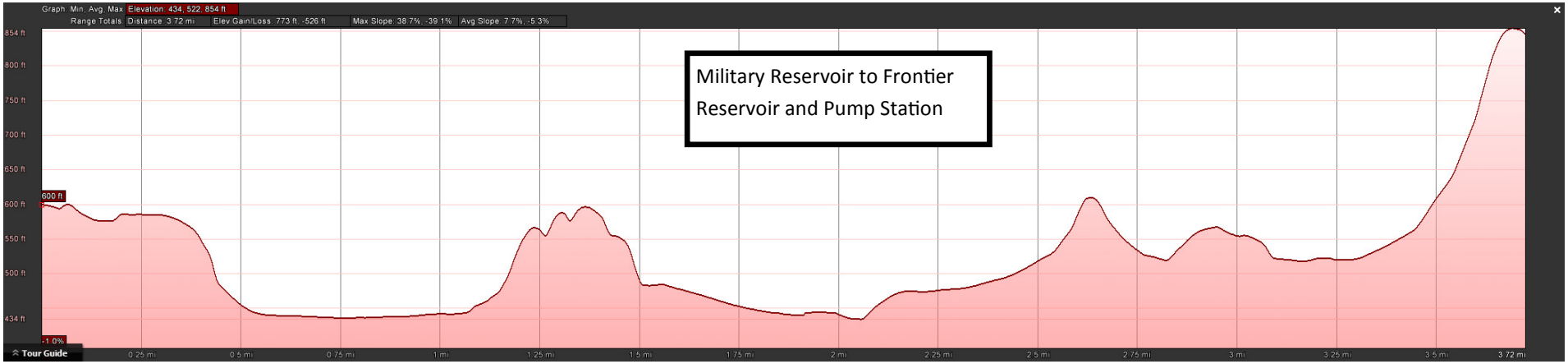
Military Reservoir — Viewshed and Line of Site Profiles



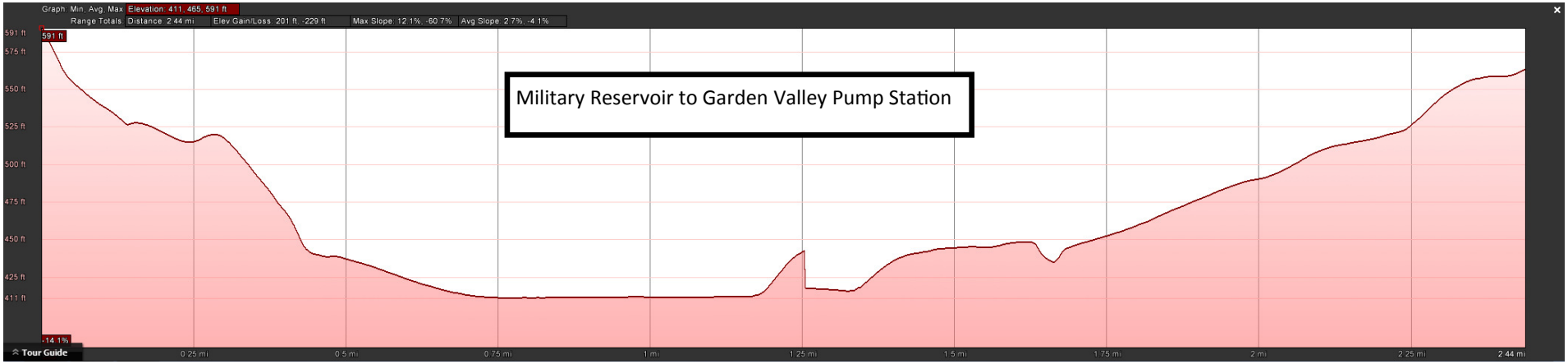
Military Reservoir — Viewshed and Line of Site Profiles



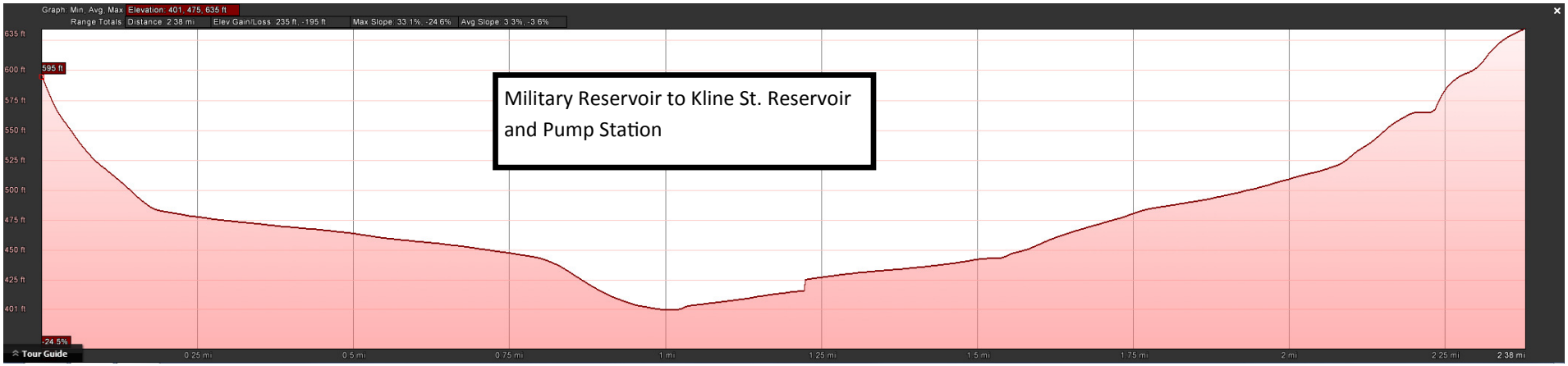
Military Reservoir — Viewshed and Line of Site Profiles



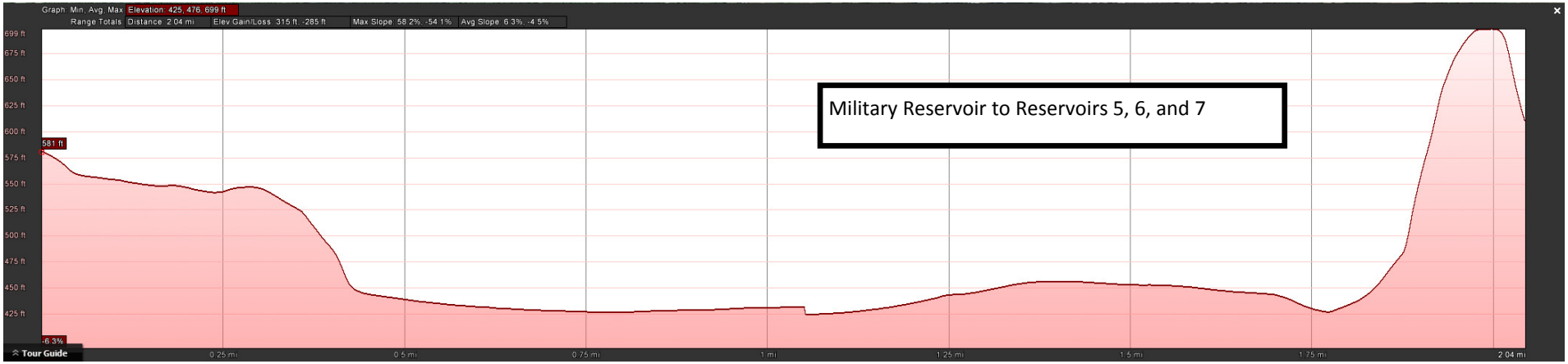
Military Reservoir — Viewshed and Line of Site Profiles



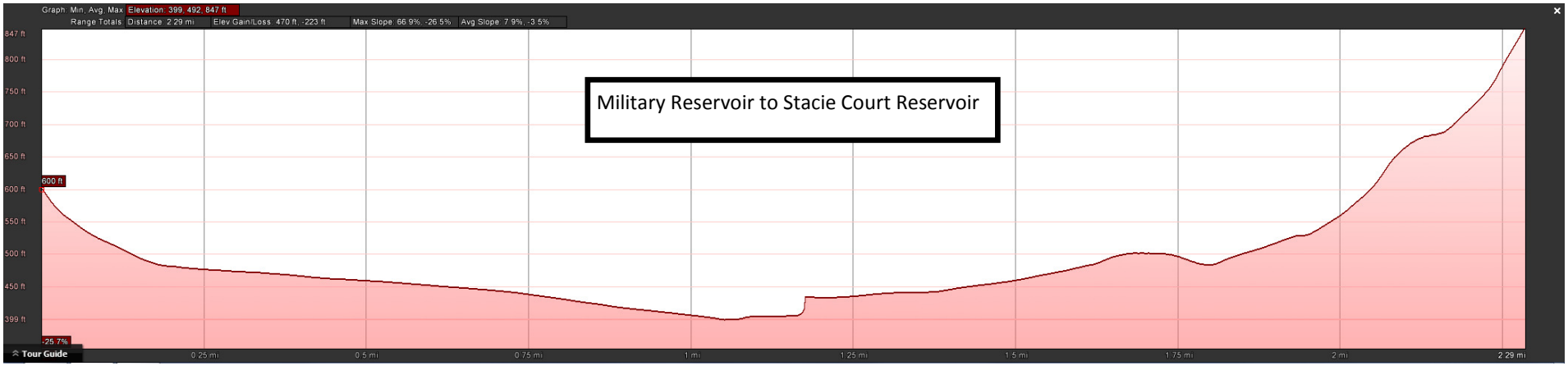
Military Reservoir — Viewshed and Line of Site Profiles



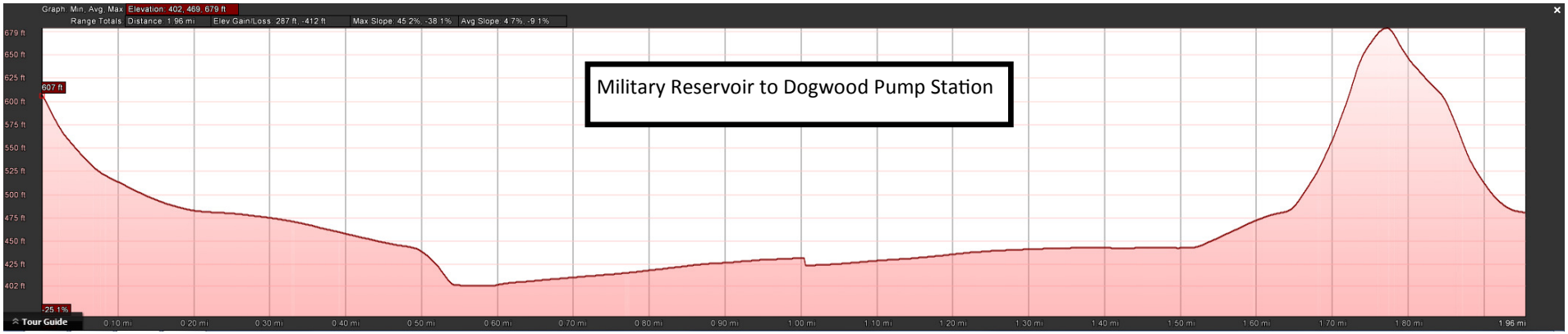
Military Reservoir — Viewshed and Line of Site Profiles



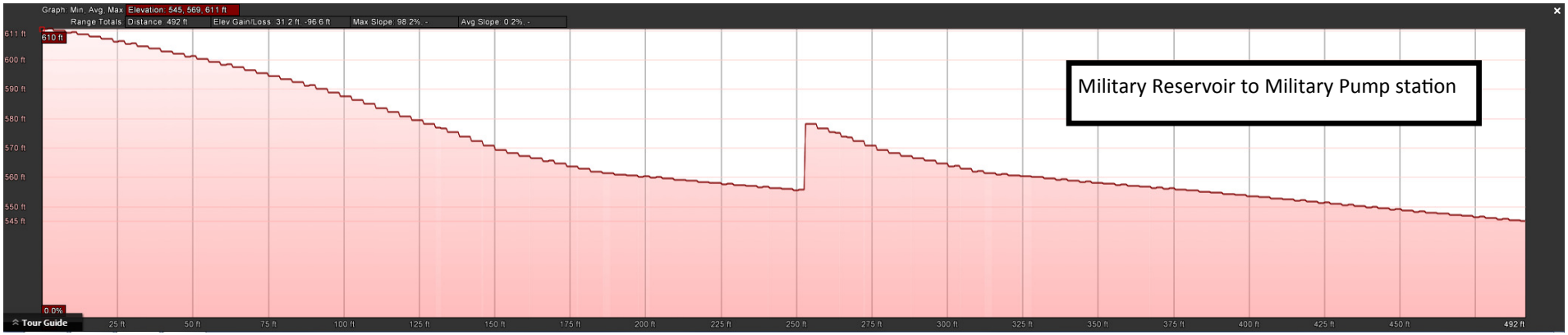
Military Reservoir — Viewshed and Line of Site Profiles



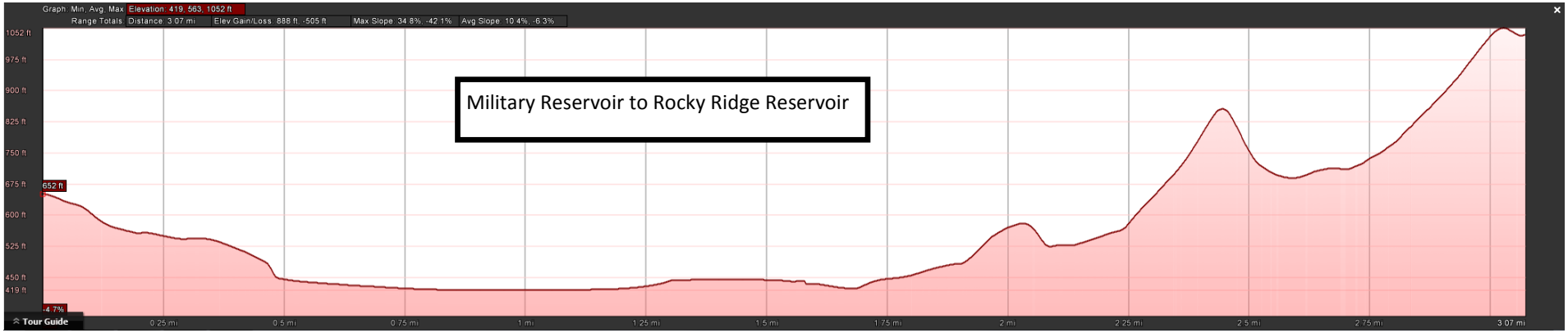
Military Reservoir — Viewshed and Line of Site Profiles



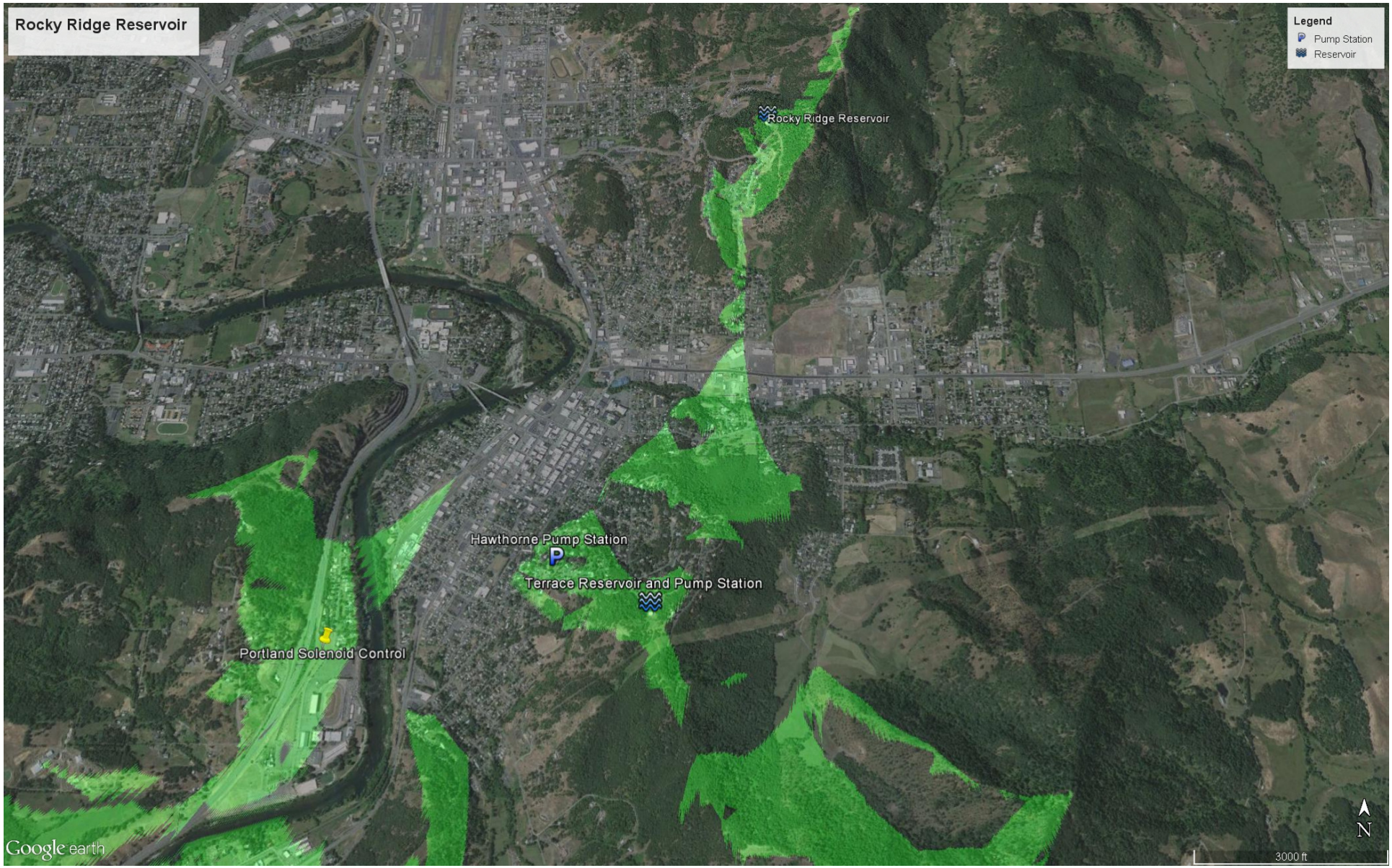
Military Reservoir — Viewshed and Line of Site Profiles



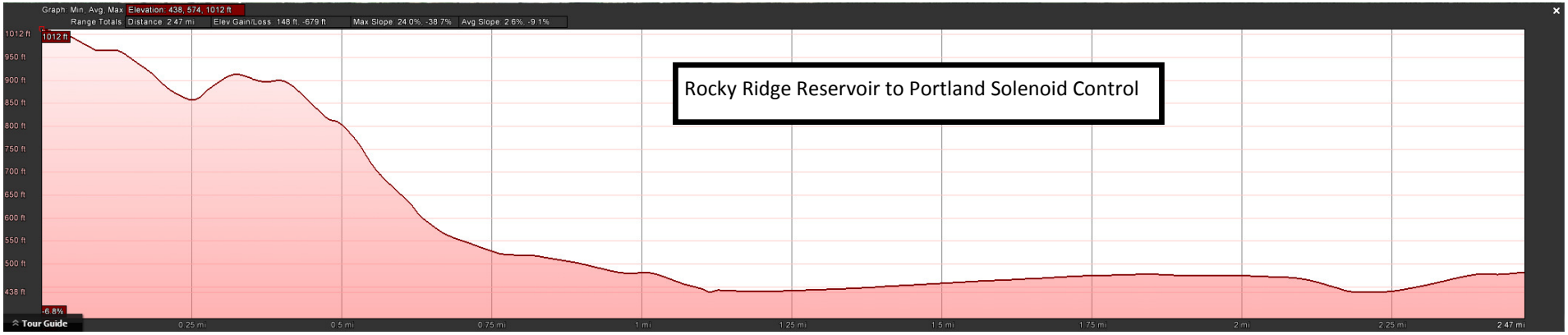
Military Reservoir — Viewshed and Line of Site Profiles



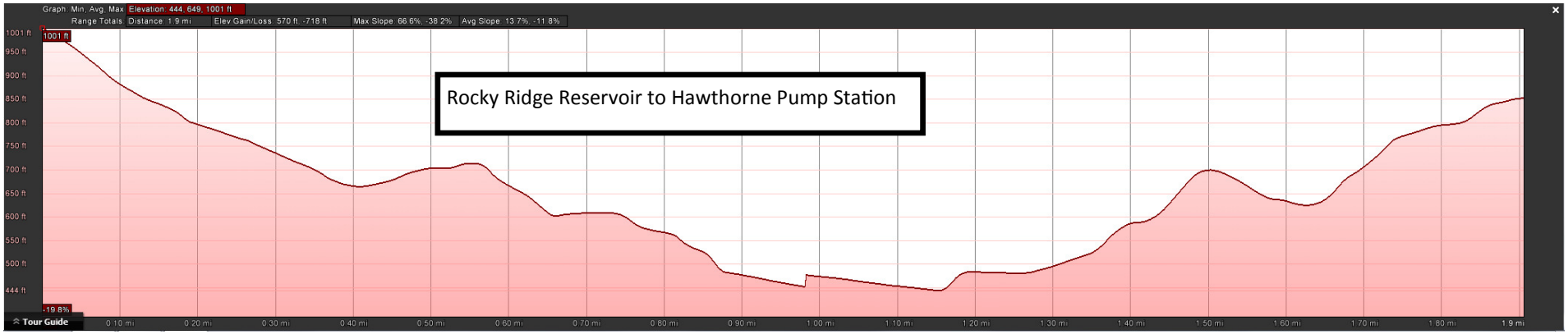
Rocky Ridge Reservoir — Viewshed and Line of Site Profiles



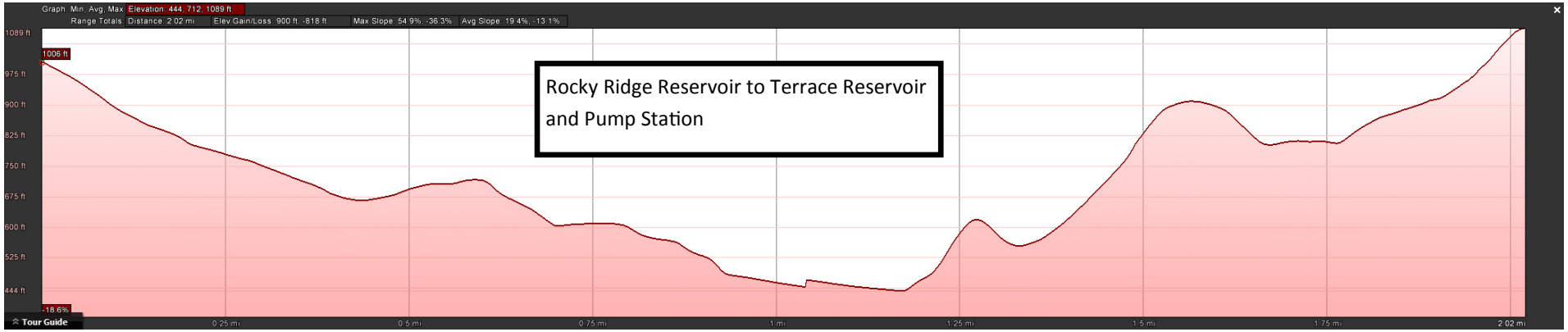
Rocky Ridge Reservoir — Viewshed and Line of Site Profiles



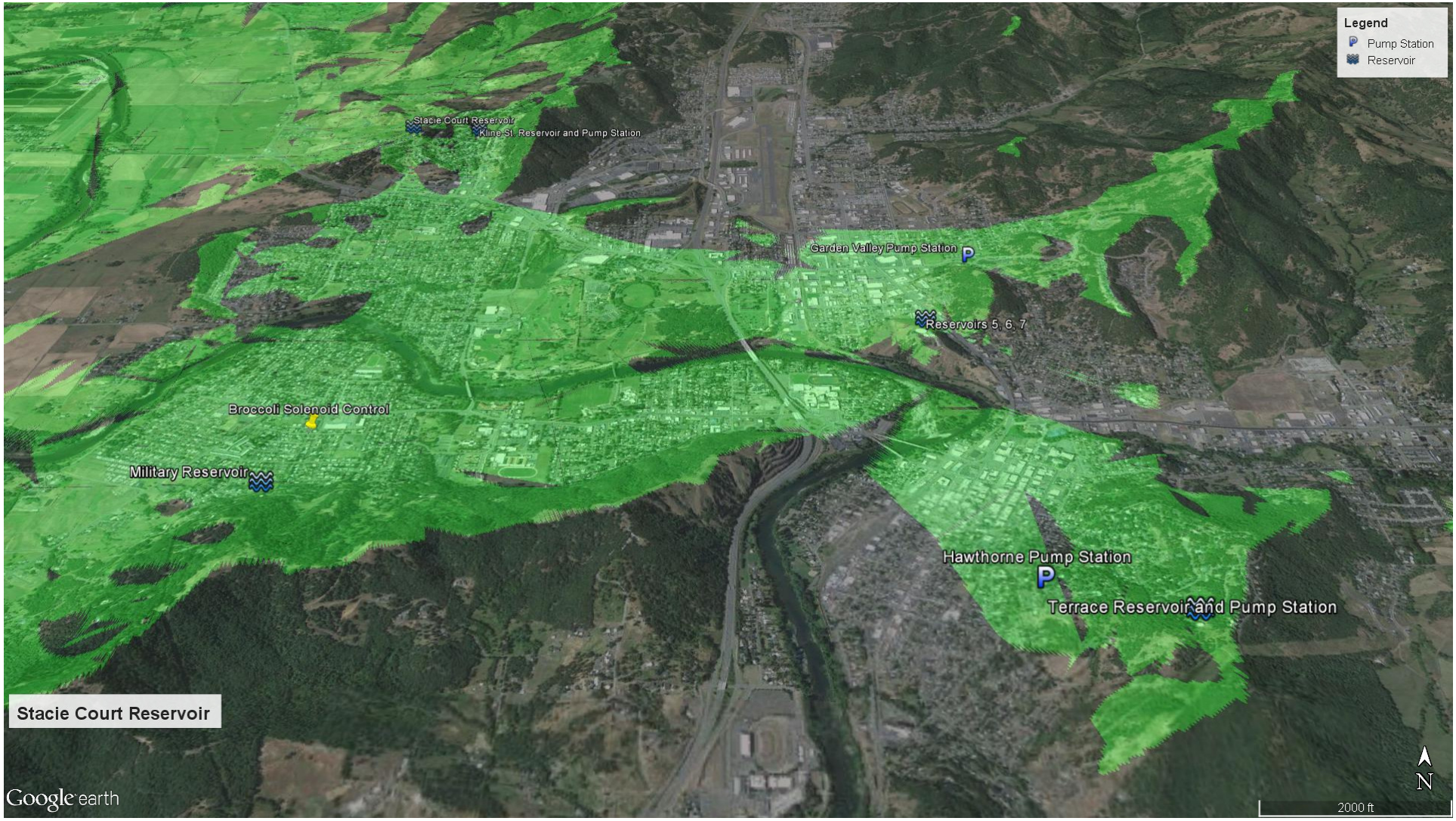
Rocky Ridge Reservoir — Viewshed and Line of Site Profiles



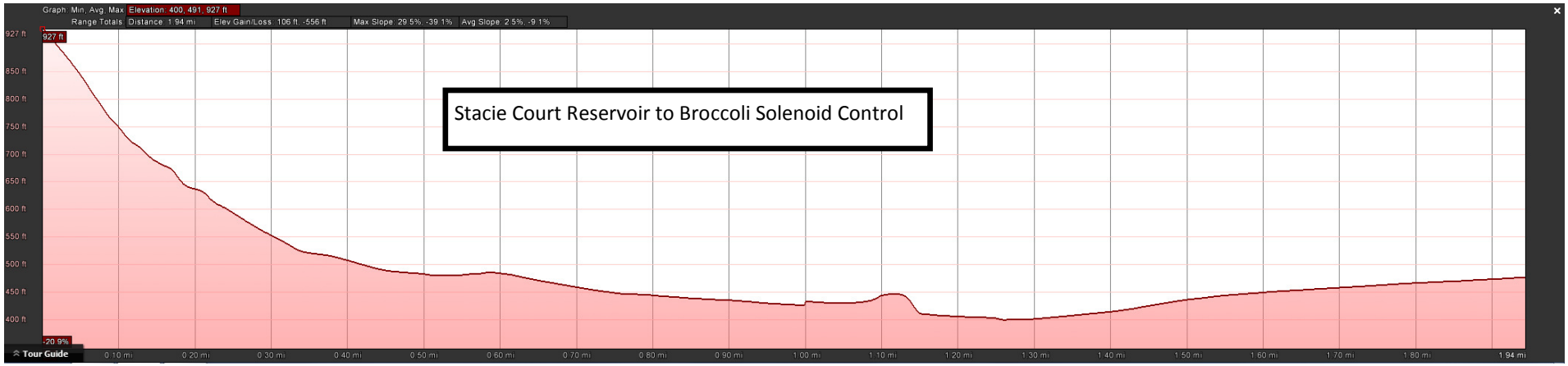
Rocky Ridge Reservoir — Viewshed and Line of Site Profiles



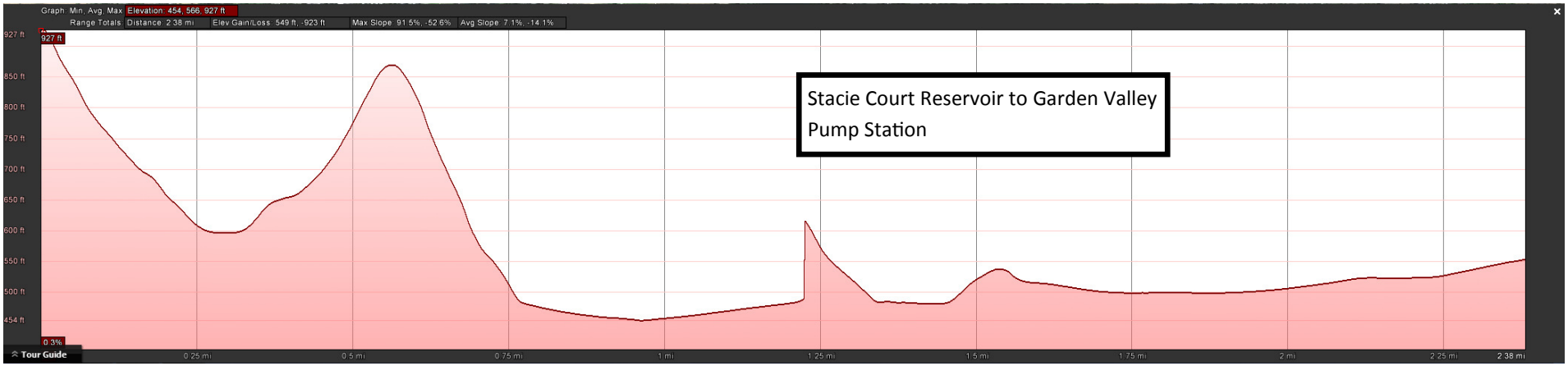
Stacie Court Reservoir — Viewshed and Line of Site Profiles



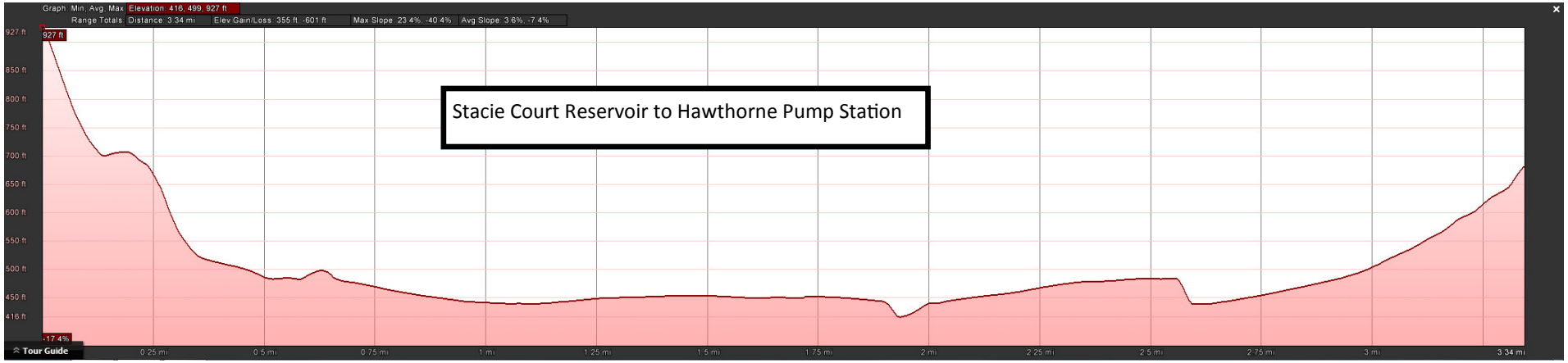
Stacie Court Reservoir — Viewshed and Line of Site Profiles



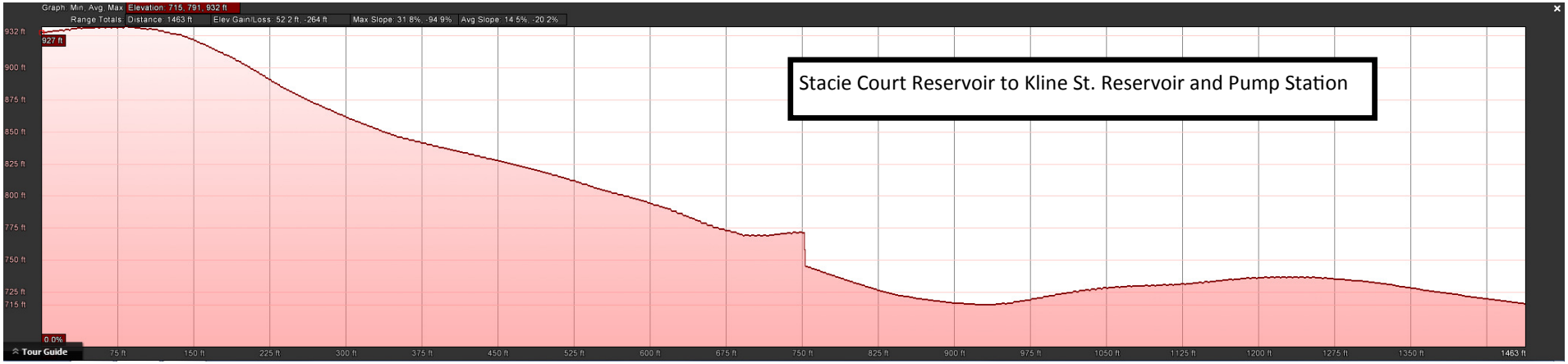
Stacie Court Reservoir — Viewshed and Line of Site Profiles



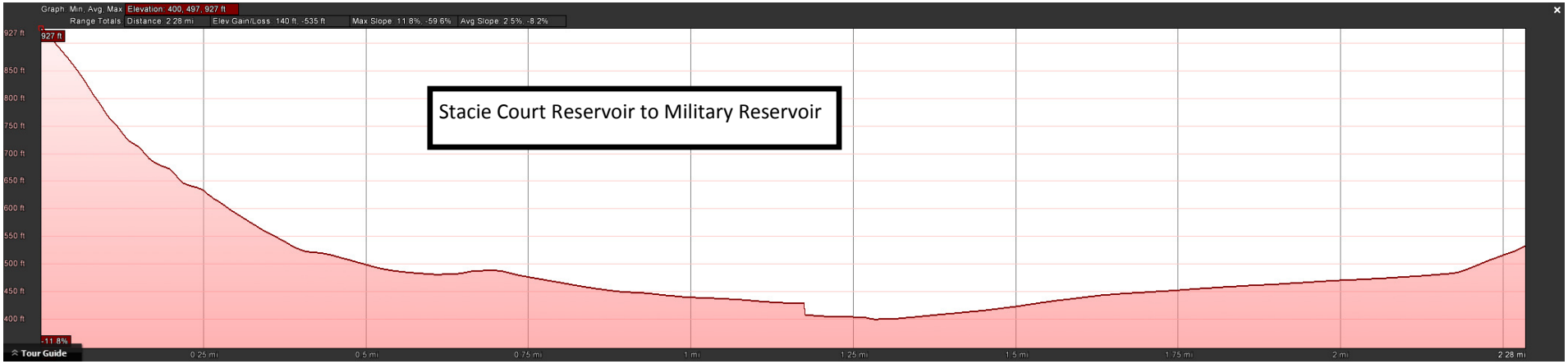
Stacie Court Reservoir — Viewshed and Line of Site Profiles



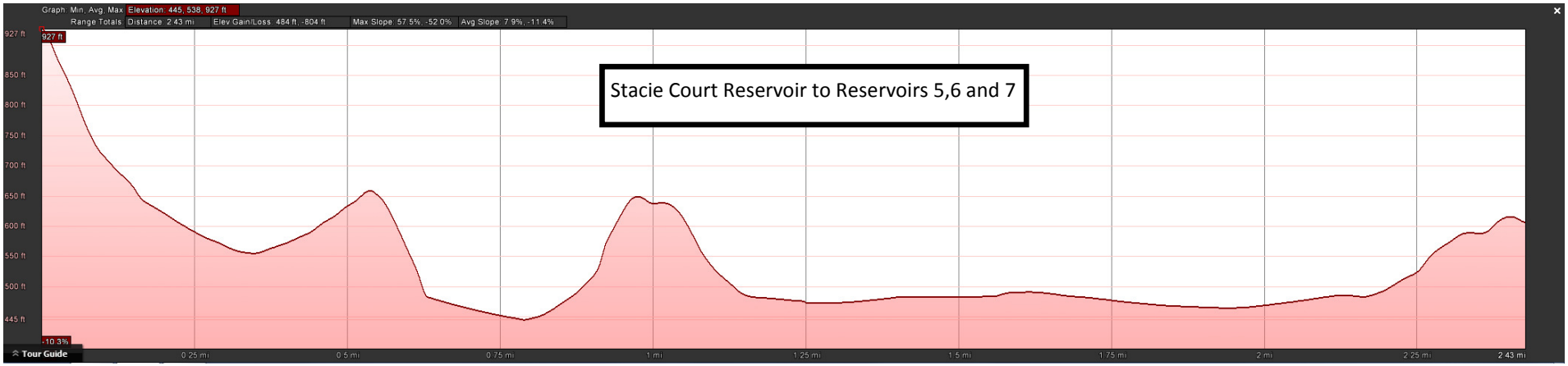
Stacie Court Reservoir — Viewshed and Line of Site Profiles



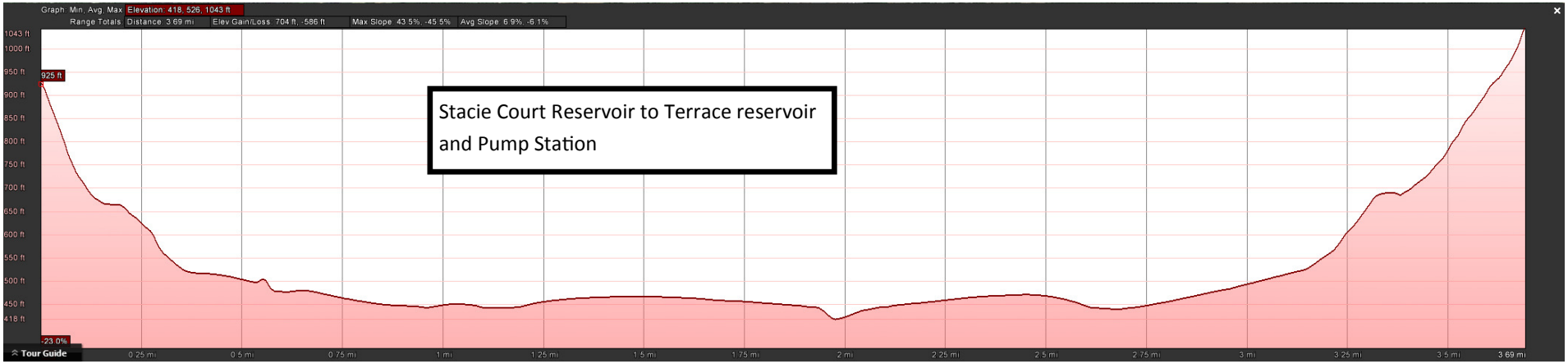
Stacie Court Reservoir — Viewshed and Line of Site Profiles



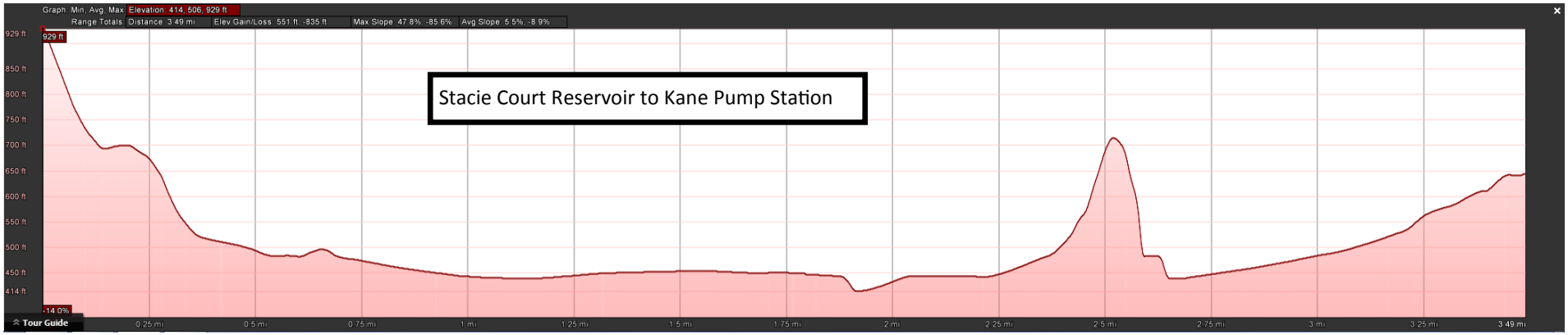
Stacie Court Reservoir — Viewshed and Line of Site Profiles



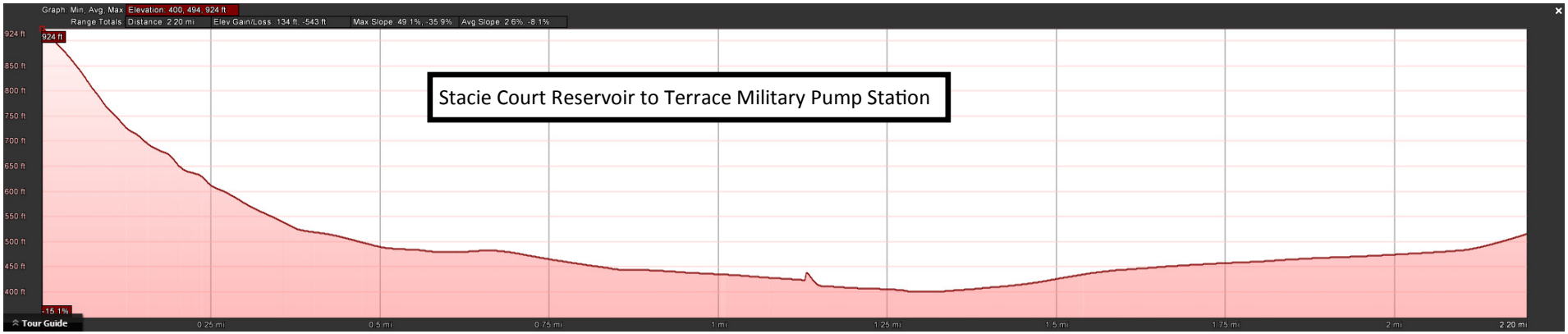
Stacie Court Reservoir — Viewshed and Line of Site Profiles



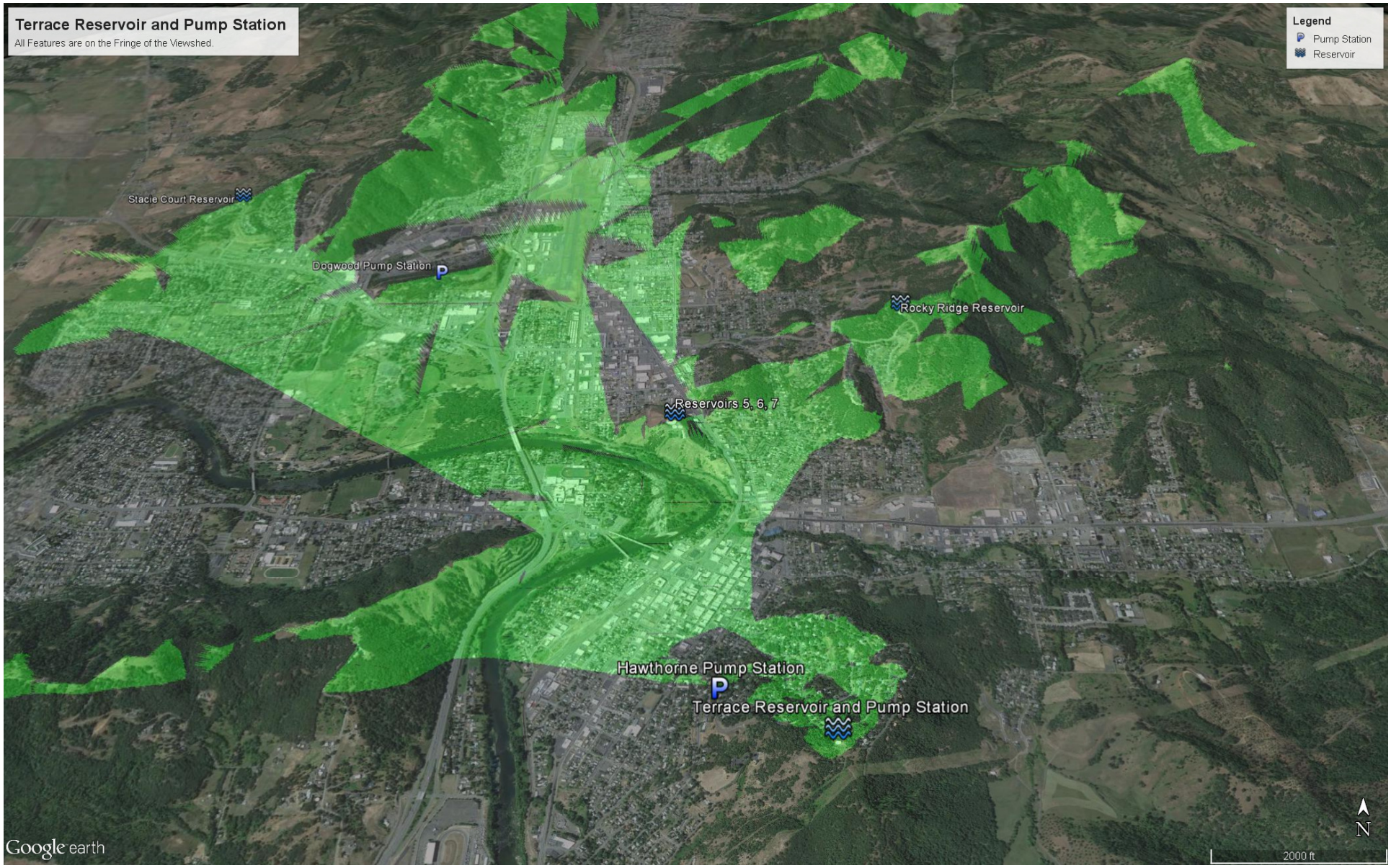
Stacie Court Reservoir — Viewshed and Line of Site Profiles



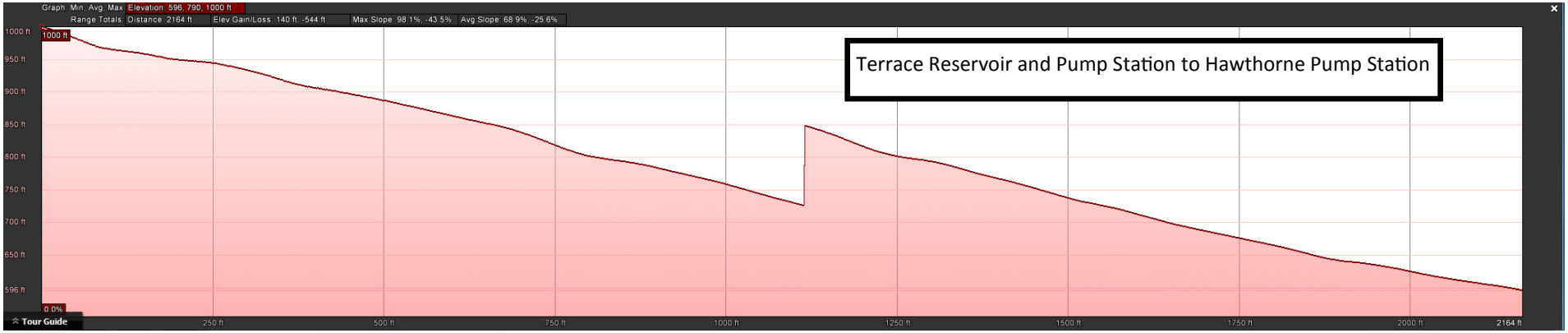
Stacie Court Reservoir — Viewshed and Line of Site Profiles



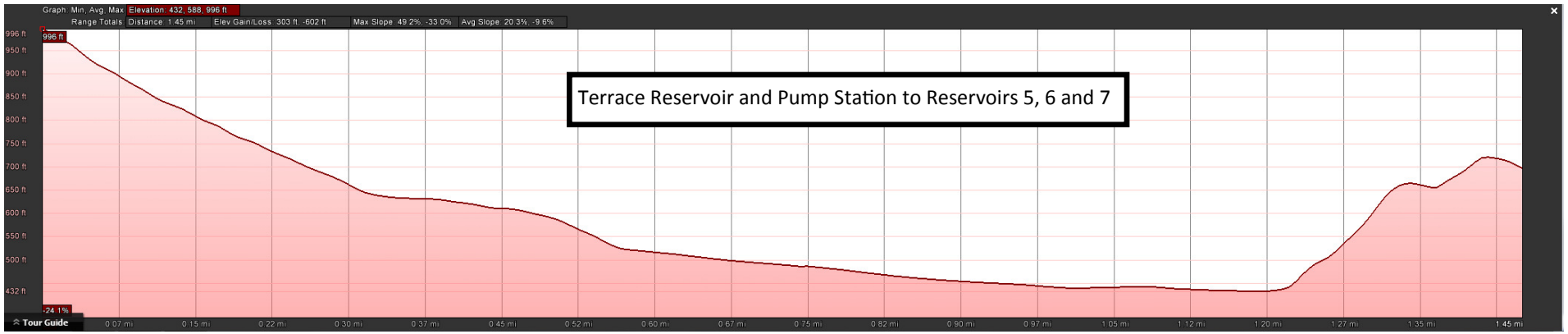
Terrace Reservoir and Pump Station — Viewshed and Line of Site Profiles



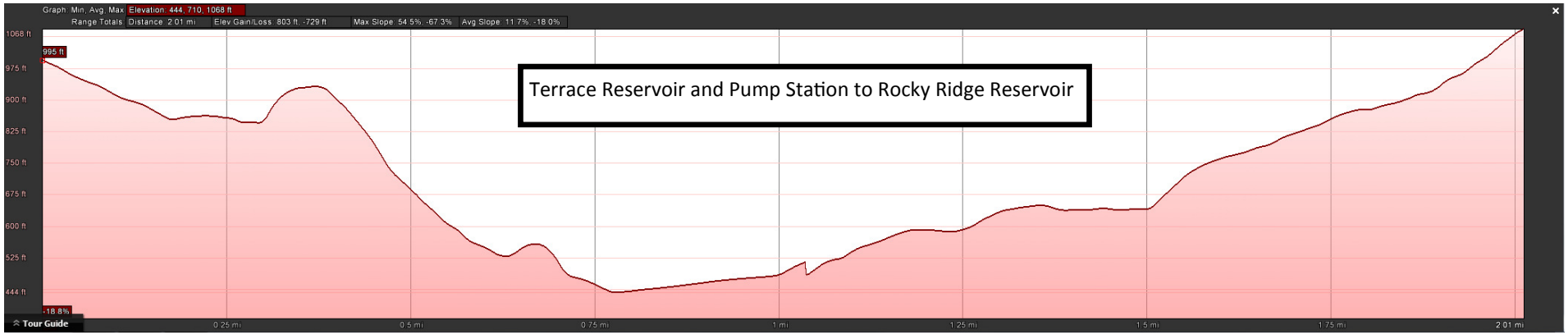
Terrace Reservoir and Pump Station — Viewshed and Line of Site Profiles



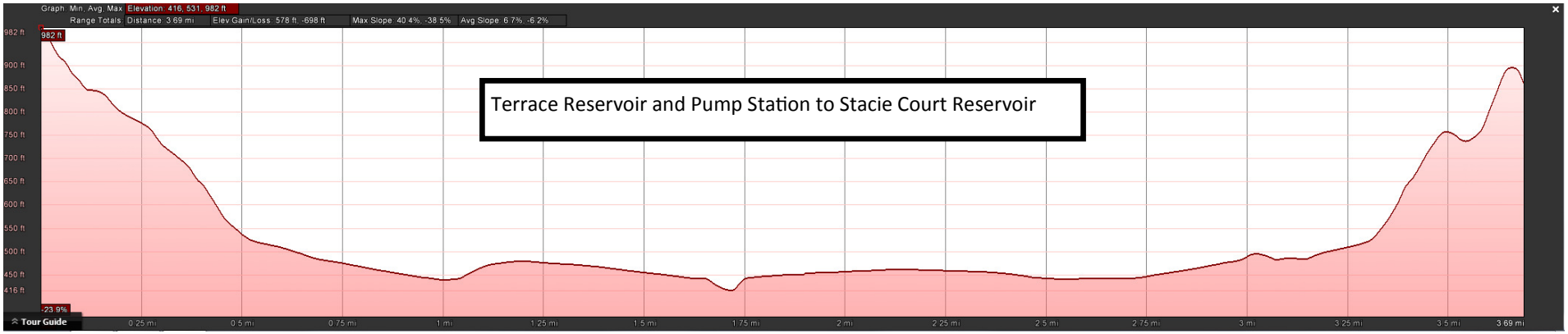
Terrace Reservoir and Pump Station — Viewshed and Line of Site Profiles



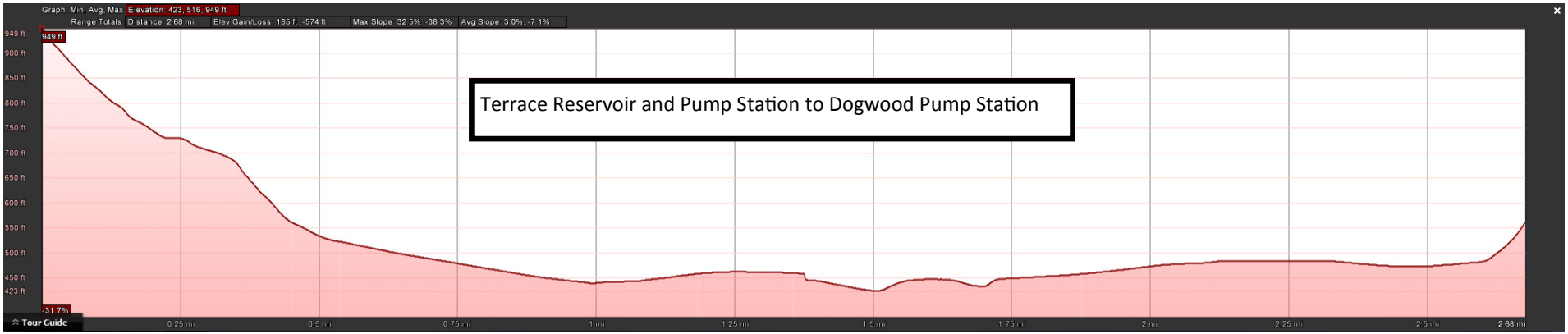
Terrace Reservoir and Pump Station — Viewshed and Line of Site Profiles



Terrace Reservoir and Pump Station — Viewshed and Line of Site Profiles



Terrace Reservoir and Pump Station — Viewshed and Line of Site Profiles



Appendix D

Preliminary Cost Estimates

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City of Roseburg

Telemetry Study

Preliminary Cost Estimates

Winchester Water Treatment Plant Simatic 545 PLC Replacement

Item	Description	Quantity	Unit Price	Price
Design				
1	Forensic Analysis of Existing PLC Connections	1	$ 10,000	$ 10,000
2	Electrical Design	1	$ 80,000	$ 80,000
			Subtotal	**$ 90,000**
Hardware/Software				
3	Control Panel Fabrication	1	$ 100,000	$ 100,000
			Subtotal	**$ 100,000**
Installation				
4	Installation and Wiring	1	$ 47,000	$ 47,000
			Subtotal	**$ 47,000**
Automatic Controls				
5	PLC Software Development	1	$ 180,000	$ 180,000
6	Operator Interface Development	1	$ 15,000	$ 15,000
7	HMI Interface Development	1	$ 30,000	$ 30,000
8	Software Testing/Startup/Training	1	$ 50,000	$ 50,000
9	First Year On-Call Services	1	$ 20,000	$ 20,000
			Subtotal	**$ 295,000**
	TOTAL (ITEMS 1-9)	**$**		**532,000**
	Mobilization/Demobilization 2%	$		10,640
	Contractor Overhead and Profit 25%	$		133,000
	Contingency 10%	$		53,200
	ESTIMATE OF TOTAL PROJECT COSTS	**$**		**728,840**

SCADA Computer System - Historian Replacing DMS Computer

Item	Description	Quantity	Unit Price	Total Price
Design				
1	Coordination	1	$ 1,500	$ 1,500
			Subtotal	**$ 1,500**
Hardware/Software				
2	Server with OS	1	$ 4,000	$ 4,000
3	Historian Software	1	$ 12,000	$ 12,000
			Subtotal	**$ 16,000**
Installation				
4	Installation and Setup	1	$ 6,000	$ 6,000
			Subtotal	**$ 6,000**
Automatic Controls				
6	HMI Interface Development	1	$ 2,000	$ 2,000
7	Software Testing/Startup/Training	1	$ 5,000	$ 5,000
8	First Year On-Call Services	1	$ 1,000	$ 1,000
			Subtotal	**$ 8,000**
	SUBTOTAL	**$**		**31,500**
	Contingency 10%	$		3,150
	ESTIMATE OF TOTAL PROJECT COSTS	**$**		**34,650**

SCADA Computer System - HMI Server Replacing WinCC Server

Item	Description	Quantity	Unit Price	Total Price
Design				
1	Coordination	1	$ 300	$ 300
			Subtotal	**$ 300**
Hardware/Software				
2	Server with OS	1	$ 4,000	$ 4,000
3	HMI Software License	1	$ 6,000	$ 6,000
			Subtotal	**$ 10,000**
Installation				
4	Installation and Setup	1	$ 10,000	$ 10,000
			Subtotal	**$ 10,000**
Automatic Controls				
5	Dixonville Tag and Screen Development	1	$ 15,000	$ 15,000
6	Software Testing/Startup/Training	1	$ 2,500	$ 2,500
7	First Year On-Call Services	1	$ 1,000	$ 1,000
			Subtotal	**$ 18,500**
		$		**38,800**
	Contingency 10%	$		3,880
	ESTIMATE OF TOTAL PROJECT COSTS	**$**		**42,680**

SCADA Computer System - Alarm Notification Win911/Mobile911

Item	Description	Quantity	Unit Price	Total Price
Design				
1	Preliminary Coordination and Design	1	$ 300	$ 300
			Subtotal	**$ 300**
Hardware/Software				
2	Win911/Mobile911	1	$ 4,000	$ 4,000
			Subtotal	**$ 4,000**
Installation				
3	Installation and Setup	1	$ 6,000	$ 6,000
			Subtotal	**$ 6,000**
Automatic Controls				
4	Testing/Startup/Training	1	$ 4,000	$ 4,000
5	First Year On-Call Services	1	$ 1,000	$ 1,000
			Subtotal	**$ 5,000**
	SUBTOTAL	**$**		**15,300**
	Contingency 10%	$		1,530
	ESTIMATE OF TOTAL PROJECT COSTS	**$**		**16,830**

Tone Control Facility Upgrades - 450 MHz TCP/IP Radio Network over Wireless City Network

Item	Description	Quantity	Unit Price	Total Price
Design				
1	Engineering Design Site-Visits	1	$ 6,000	$ 6,000
2	Electrical Design	1	$ 70,000	$ 70,000
			Subtotal	**$ 76,000**
Hardware/Software				
3	Reservoir/Valve Control Panels	6	$ 17,000	$ 102,000
4	Pump Station/Pump Station & Res Control Panels	5	$ 20,000	$ 100,000
5	Master PLC Control Panel	1	$ 15,000	$ 15,000
			Subtotal	**$ 217,000**
Installation				
5	Installation and Wiring	12	$ 10,000	$ 120,000
			Subtotal	**$ 120,000**
Automatic Controls				
6	PLC Software Development (4 different versions)	4	$ 10,000	$ 40,000
7	Operator Interface Development (4 different versions)	4	$ 3,000	$ 12,000
8	Master PLC Software Development	1	$ 5,000	$ 5,000
9	Master Operator Interface Development	1	$ 1,000	$ 1,000
10	HMI Interface Development	11	$ 1,000	$ 11,000
11	Software Testing/Startup/Training	1	$ 30,000	$ 30,000
12	First Year On-Call Services	1	$ 20,000	$ 20,000
			Subtotal	**$ 119,000**
	SUBTOTAL	**$**		**532,000**
	Mobilization/Demobilization 2%	$		10,640
	Contractor Overhead and Profit 25%	$		133,000
	Contingency 10%	$		53,200
	ESTIMATE OF TOTAL PROJECT COSTS	**$**		**728,840**

Isolated Control System Upgrades - Instrumentation Protocol Converter

Item	Description	Quantity	Unit Price	Total Price
Design				
1	Engineering Design Site-Visits	1	$ 2,000	$ 2,000
2	Electrical Design	1	$ 10,000	$ 10,000
			Subtotal	**$ 12,000**
Hardware/Software				
3	Pump Station Control Panels	5	$ 8,000	$ 40,000
			Subtotal	**$ 40,000**
Installation				
4	Installation and Wiring	5	$ 5,000	$ 25,000
			Subtotal	**$ 25,000**
Automatic Controls				
5	Instrumentation Protocol Converter Setup	5	$ 200	$ 1,000
6	HMI Interface Development	5	$ 400	$ 2,000
7	Software Testing/Startup/Training	1	$ 15,000	$ 15,000
8	First Year On-Call Services	1	$ 5,000	$ 5,000
			Subtotal	**$ 23,000**
	SUBTOTAL	**$**		**100,000**
	Mobilization/Demobilization 2%	$		2,000
	Contractor Overhead and Profit 25%	$		25,000
	Contingency 10%	$		10,000
	ESTIMATE OF TOTAL PROJECT COSTS	**$**		**137,000**

Siemens/Automation Direct Facilities Upgrade to Broadband Landines or Cellular Modems

Item	Description	Quantity	Unit Price	Total Price
Design				
1	Engineering Design Site-Visits	1	$ 1,000	$ 1,000
2	Electrical Design of Panel Upgrades	1	$ 6,000	$ 6,000
			Subtotal	**$ 7,000**
Hardware/Software				
3	Serial to Ethernet Protocol Converters	5	$ 700	$ 3,500
4	DSL VPN Router or Cellular Modem with VPN	5	$ 1,500	$ 7,500
			Subtotal	**$ 11,000**
Installation				
5	Installation and Wiring	5	$ 2,000	$ 10,000
			Subtotal	**$ 10,000**
Automatic Controls				
6	Instrumentation Protocol Converter Setup	5	$ 200	$ 1,000
7	HMI Interface Development	5	$ 1,000	$ 5,000
8	Software Testing/Startup/Training	1	$ 10,000	$ 10,000
9	First Year On-Call Services	1	$ 5,000	$ 5,000
			Subtotal	**$ 21,000**
	SUBTOTAL	**$**		**49,000**
	Mobilization/Demobilization 2%	$		980
	Contractor Overhead and Profit 25%	$		12,250
	Contingency 10%	$		4,900
	ESTIMATE OF TOTAL PROJECT COSTS	**$**		**67,130**

Communications Costs - City Wireless Network Costs Unknown

Item	Description	Quantity	Unit Price	Total Price
Design				
1	Engineering Design Site-Visits	1	$ 1,000	$ 1,000
2	450 MHz Radio Survey and License (One Time Cost)	1	$ 15,000	$ 15,000
3	Electrical Design of Reservoir 450 MHz Antenna Systems	1	$ 10,000	$ 10,000
			Subtotal	**$ 26,000**
Hardware/Software				
4	450 MHz Reservoir Radio Repeater Panels	7	$ 5,000	$ 35,000
			Subtotal	**$ 35,000**
Installation				
5	Installation/Testing and Wiring	7	$ 5,000	$ 35,000
			Subtotal	**$ 35,000**
	SUBTOTAL	**$**		**96,000**
	Mobilization/Demobilization 2%	$		1,920
	Contractor Overhead and Profit 25%	$		24,000
	Contingency 10%	$		9,600
	ESTIMATE OF TOTAL PROJECT COSTS	**$**		**131,520**

Appendix E

Product Cut Sheets

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CompactLogix™ 5370 L2 Programmable Automation Controllers

1769L24ER-QB1B, -L24ER-QBFC1B, -L27ERM-QBFC1B

Features and Benefits

The CompactLogix 5370 L2 controllers deliver scalable, affordable control in a space-saving form factor. From small stand-alone equipment to higher performance applications, these controllers are ideal for assembly machines, hoisting systems, process skids, indexing tables, and packaging.

Machine builders and end users can take advantage of the cost-saving features of these controllers:

- Support for Integrated Motion on EtherNet/IP
- Support for Device Level Ring (DLR) network topologies
- Built-in energy storage eliminates the need for lithium batteries
- Support reuse of existing 1769 I/O
- Removable 1GB secure digital (SD) card improves data integrity
- Memory options up to 1MB
- Higher resolution analog capability supports thermocouple and RTD inputs
- Support for Kinematics eliminates the need for additional robot controllers and software
- Open socket capability allows support for Modbus TCP as well as devices such as printers, barcode readers and servers

Build a better machine with with CompactLogix 5370 L2 Programmable Automation Controllers.

Expanding on the scalability of the Logix family of controllers, the CompactLogix 5370 L2 programmable automation controllers (PAC) are designed to meet the growing need for a higher performance controller in a compact and affordable package. Offering a 40% reduction in required panel space and the same capabilities as the CompactLogix 5370 L3, the L2 controllers truly enable you to build a high performance, more cost-effective machine.

As part of the Integrated Architecture system, the CompactLogix 5370 L2 controllers use the same programming software, network protocol, and information capabilities as all Logix controllers, providing a common development environment for all control disciplines.

Integrated Motion on EtherNet/IP

The CompactLogix 5370 L2 controllers provides a strong motion solution for customers looking for performance and cost competitiveness.

- Supports up to 4 axes of integrated motion
- Together with the Kinetix 350, offers cost-effective, scalable motion solution

Network Capabilities

With dual Ethernet ports and an integrated Ethernet switch, these controllers now support Device Level Ring (DLR) network topologies, simplifying integration of components in your control system and reducing system cost:

- Provides resiliency from loss of one network connection
- Allows replacement of devices one at a time without stopping production
- Reduces the number of Ethernet switches in the control system

CompactLogix 5370 L2 Controller Product Specifications

	1769-L24ER-QB1B	1769-L24ER-QBFC1B	1769-L27ERM-QBFC1B
User memory	750 KB	750 KB	1 MB
Controller tasks	32	32	32
Programs per task	100	100	100
Integrated Motion	--	--	4 axis CIP motion position loop axis
Package Size	115mm wide x 118mm high x 105mm deep	140mm wide x 118mm high x 105mm deep	
Certifications	cULH (Class I Division 2), KCC / UL (UL 508), ULH (Class I & II, Division 2 and Class III, Divisions 1 & 2) / ATEX, CE, C-Tick / Marine and GOST certifications in 2012		
Local Expansion Modules	4	4	4
Embedded I/O	16 digital inputs 16 digital outputs	16 digital inputs / 16 digital outputs, 4 universal analog input, 2 analog output, 4 channels HSC	
Local Expansion I/O Points	160	160	160
Communication Module Additions	DeviceNet with 1769-SDN or 3rd party		
Flash Memory Card	Industrially rated and certified Secure Digital (SD) memory card (1 and 2 GB options); all controllers shipped with 1 GB card		
Servo Drives (Position Loop CIP)	--	--	4
Ethernet I/O IP nodes	8	8	16
Virtual axes	100	100	100
Feedback only, torque, velocity, Vhz (max CIP motion drives)	--	--	16
Axes/ms	--	--	2
Kinematics support	--	--	yes
Software / Firmware	RSLogix 5000 V20 and RSLinx Classic V2.59 Firmware v20.1x or later		

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www.rockwellautomation.com

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Publication 1769-PP011A-EN-E – November 2011

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PRODUCT SHEET
MODEL 210C

Wireless Ethernet Serial Ports

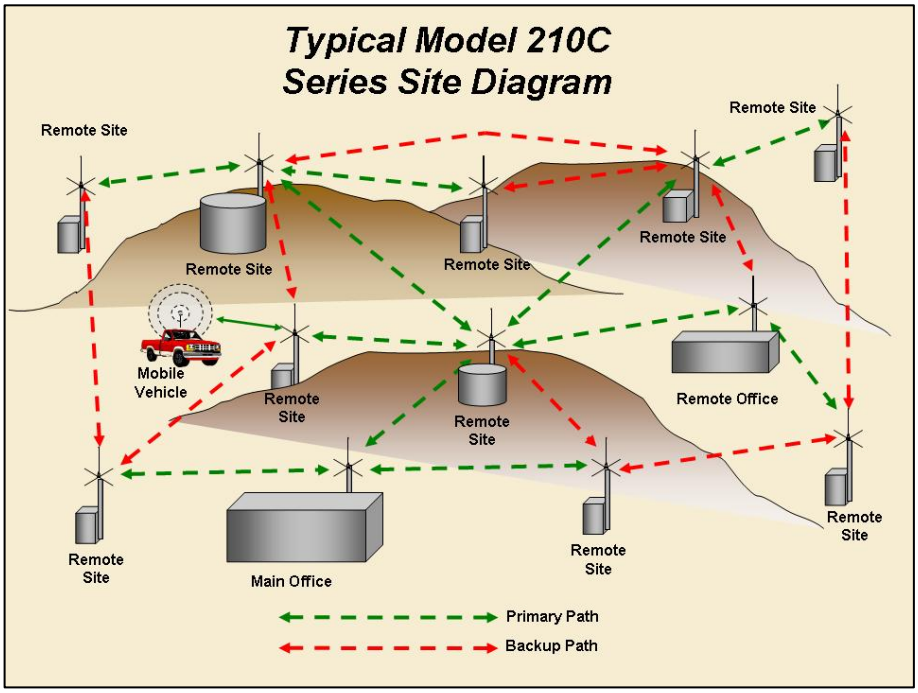
The ESTeem Model 210C with ***one Ethernet port (10/100/1G) and one independent Serial RS-232C data port*** is the perfect radio solution designed for the rigors of the Industrial, Public Safety, and Federal markets when the low UHF band is needed for terrain coverage. The Model 210C is a narrowband compliant licensed radio with selectable Quadrature Amplitude Modulation (QAM) that delivers up to ***64.8 Kbps*** of data rate over distances greater than 10 miles in high noise environments depending on the antenna used. Wireless networks over large geographical areas can be a reality using the internal ***Mesh Repeating*** feature. The 210C also has a ***Client Mode*** feature so it can be used in mobile applications for roaming under a 210C RF canopy.

Frequency	RF Data Rate
450 to 470 MHz Narrow Band Licensed	9.6 to 64.8 Kbps

Software Features

- **High Security AES Encryption.** The 210C uses the high-security 128-bit AES-CCMP required in most municipal, public safety and federal applications.
- **Simple Network Management Protocol (SNMP).** SNMP protocol support is standard in the 210C that is used for critical network diagnostics and management.
- **Mesh Networking.** The 210C supports multiple redundant repeaters to create a self-healing Mesh network.

Multiple Modes of Operation. The 210C can be configured as a Master, Mesh Repeater, Remote or mobile client through programmable selection.



Features
- 10+ Mile Nominal Range
- Mesh Repeating Feature
- Extended Temperature Specifications
- Ethernet (10/100/1GHz) Port
- Serial RS-232 Communications Port
- User Programmable from Ethernet or USB Configuration Port

Modes of Operation
- Ethernet Networks
  - Ethernet Bridge Mode
  - Router Modes
  - Repeater Modes
  - Client Modes (Mobile)
- Serial Networks
  - Point-to-Point
  - Point-to-Multipoint
  - Repeater Mode
  - Client Modes (Mobile)
- Ethernet and Serial Networks
  - Legacy Product Support
  - Simulations Ethernet and Serial Devices Connections

Security
- AES Encryption (CCMP)
- Temporal Key Integrity Protocol (TKIP)
- Access Control List (ACL)
- 128/64 Bit WEP Encryption

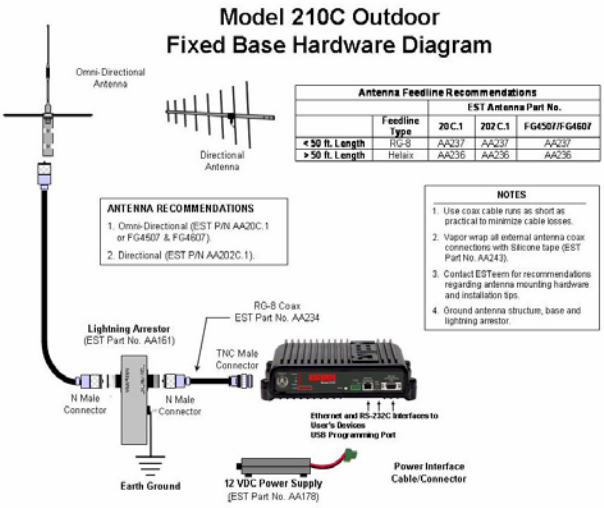
ELECTRONIC SYSTEMS TECHNOLOGY, INC.
415 North Quay Street • Kennewick, WA 99336
Phone (509) 735-9092 • Fax (509) 783-5475

Specifications subject to change without notice

www.esteem.com
Revised: 1 Oct 2013

Technical Specifications Model 210C

ESTeem 210C Specifications	
Transceiver	
Frequency of Operation (Software Selectable)	450 to 470 MHz
Frequency Selectability	6.25 KHz
Frequency Stability	± 1.5 ppm
RF Data Rate @ 6.25 KHz Channel Bandwith	9.6 Kbps (4 QAM), 19.2 Kbps (16 QAM), 28.8 Kbps (64 QAM) (software selectable)
RF Data Rate @ 12.5 KHz Channel Bandwidth	21.6 Kbps (4 QAM), 43.2 Kbps (16 QAM), 64.8 Kbps (64 QAM) (software selectable)
RF Output Power @ 50 ohms (Z)	2 Watts (average)/ 10 Watts (peak)
TX Duty Cycle	100%
Transmitter Spurious & Harmonics	> 55 dB down from carrier
Transmitter Rise Time	1 mSec
RX Sensitivity	-109 dBm (4 QAM) to -100 dBm (64 QAM)
Receiver Spurious & Image Rejection	> 50 dB
Receiver Squelch Sensitivity	Software Adjustable
Receiver Adjacent Channel Rejection	> 70 dB
LED Indicators	
Front Panel	Power (On/Off) - Transmitter (On/Off) - Rx Carrier Detect (On/Off) - Status (On/Off) - RSSI (16 levels)
Input/Output Interfaces	
Ethernet Port (10/100/1G)	RJ-45 Female
Radio Configuration Port	Mini-USB Port
RS-232C Comm Port (2,400 to 115.2 K baud)	9 Pin D-Sub Female
Antenna Input/Outputs	TNC Female Connector (50 ohm)
Input Power	Mini-Combicon, 3 pin Female
Switches	
CPU Reset	Front Panel (Push button)
Power Requirements	
Power Supply Voltage	10.8 to 16 VDC
Power Supply Current	400 mA Receive
	2 A Transmit (2 W)
Case	
Temperature Range	-30 to +60 degrees C.
Humidity	95% Non Condensing
Dimensions	2.45 in. (H) x 8.16 in. (W) x 9.37 in. (L)
Weight	5 lbs.
Product Warranty	1 Year
Type Acceptance	
FCC (USA)	ENPESTEEM210C
Industry Canada	2163A-ESTEEM210C



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Specifications subject to change without notice

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Revised: 1 Oct 2013

FactoryTalk® Historian Site Edition

Data Management for Global Manufacturing

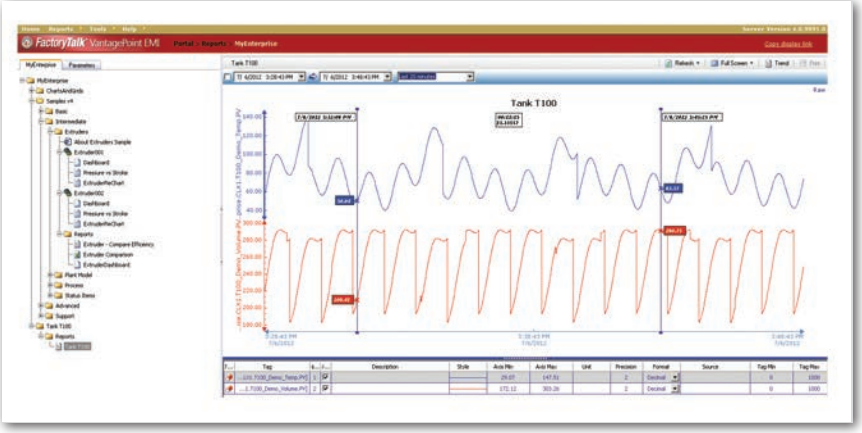
Rockwell Software

Advantages

- Scalable real-time process historian
- Premier integration to FactoryTalk® and Integrated Architecture™ allows for better and faster data collection from machines and devices on the plant floor
- Auto Discovery and Auto Configuration helps reduce deployment time and lowers total cost of ownership
- Robust and reliable data collection application
- Powerful archive technology to help provide long-term data storage and fast, efficient retrieval of data
- Comprehensive support for redundancy and high availability to ensure minimal data loss and constant access to data
- Powerful Advanced Server option providing Data access through standard interfaces (OPC/OLEDB/JDBC and Webservices), Advanced Calculation Engine and Notification Server.

"FactoryTalk Historian SE provided us with the ability to automate data management. We were able to identify line interruptions and places we needed to take corrective action to open up our high-speed bottling line. Ultimately we were able to achieve a six-percent increase in efficiency on this line."

Production Manager,
Soft drink bottling company



Visualize Historian Data in FactoryTalk VantagePoint EMI Trend

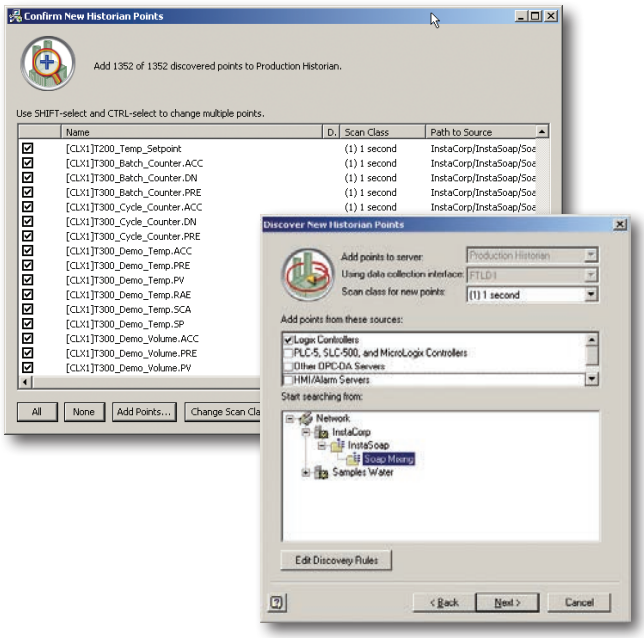
Secure, scalable, accessible: World-class Historian

Driving data management for a better bottom line.

Real-time access to reliable information is the key to improving productivity and efficiency. When you know what's happening on the plant floor, you can make better decisions—about process, time and material management—whatever key performance indicators (KPIs) you've identified as contributing to your continuous improvement objectives. The expanded capabilities of FactoryTalk® Historian SE provide you with the data capture, management and analytical capabilities to help provide for improved decision-making, driving better results all the way to the bottom line.

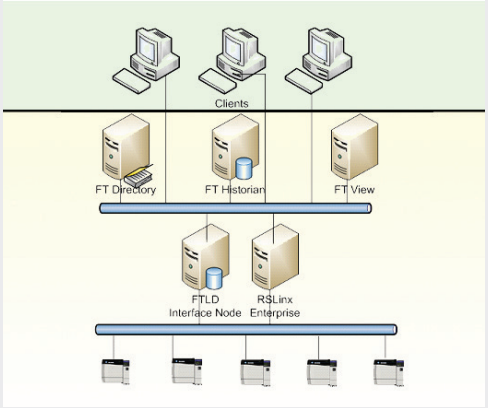
FactoryTalk Historian from Rockwell Automation is an integrated toolkit for obtaining real-time process and production information. The platform supplies complex manufacturing data to a centralized location, providing insight into performance parameters from a single subassembly, to a production line, and across the enterprise. The system is also easy to adopt. It uses off-the-shelf interfaces, and it automates installation procedures with Logix control systems or can be configured for interoperability with other makes of legacy controls systems. As a result, FactoryTalk Historian SE is faster and easier to bring online than traditional historians.

For example, plant supervisors can view individual historical data for machines, process equipment or production lines on demand; production supervisors can analyze batch operations for an individual site against enterprise-wide corporate production parameters; enterprise managers can compare KPIs among locations. This enhanced visibility into the full breadth of enterprise data helps locate and correct sources of inefficiencies quickly, helping you to improve manufacturing consistency, energy use, first-pass quality and other factors that impact your overall manufacturing results.

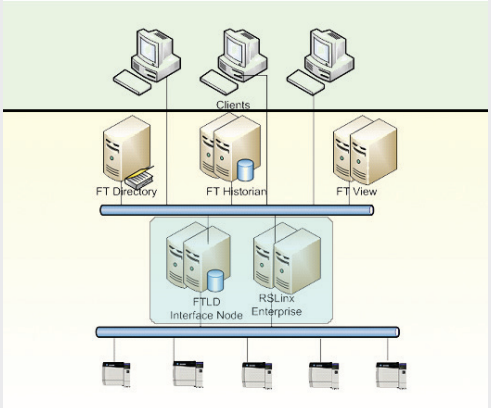


FactoryTalk Historian Architectures

Standard Architecture



Redundant Architecture



FactoryTalk Historian SE introduces a highly efficient system for automatically discovering data sources and relevant tags to historize and to configure these automatically with the most optimal parameters.

Features

Visualize your enterprise using the powerful data collection and analysis engine of FactoryTalk Historian SE and its extensive series of Microsoft®-compatible reporting tools.

Easy.
Automated Install and Configuration

FactoryTalk Historian will automatically install and configure itself on a standard FactoryTalk platform. It will auto-detect Logix and other Rockwell Automation controllers and automatically detect and configure all relevant tags to be historized.

Flexible.
Interoperable Data Collection Capabilities

FactoryTalk Historian can connect to virtually any control system or human-machine-interface (HMI) software and collect real-time data at high speeds and at full resolution.

Available.
Built-in Redundancy

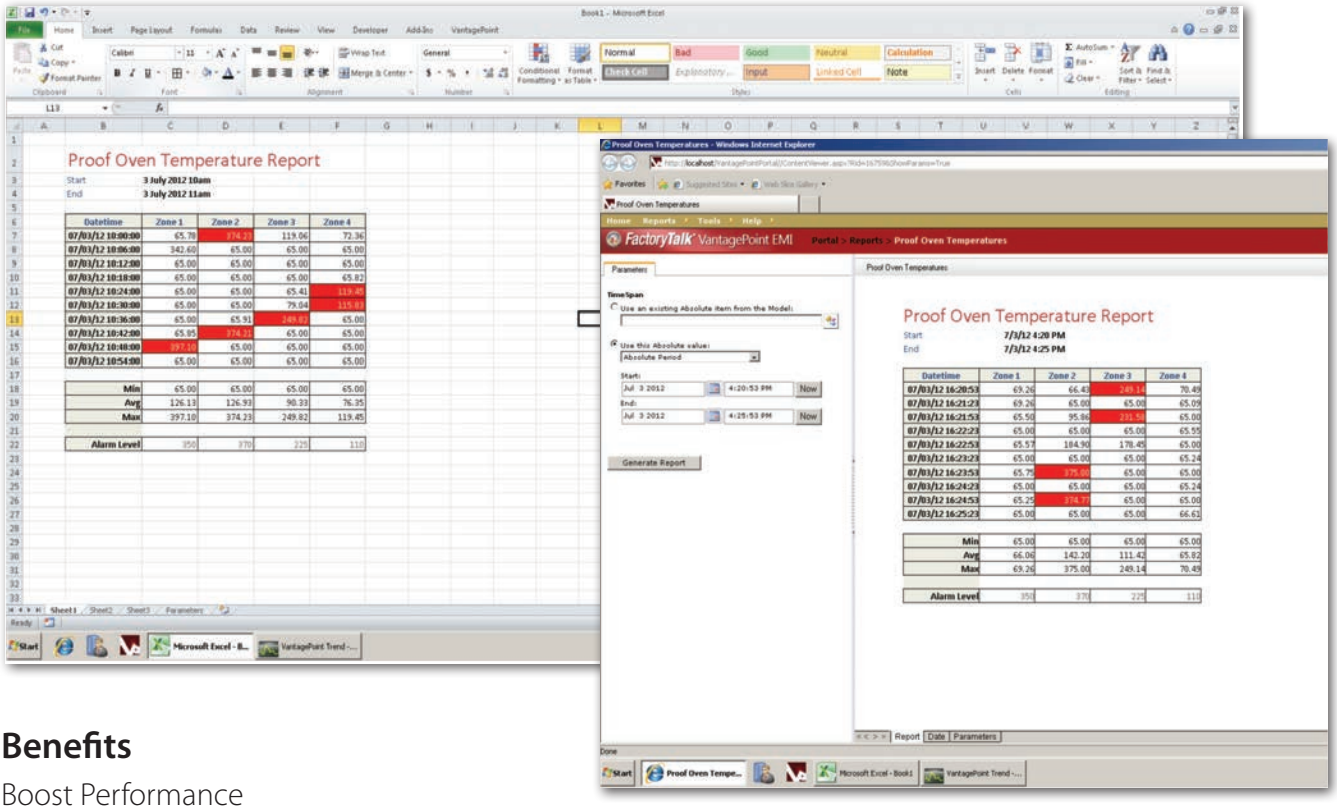
FactoryTalk Historian supports several layers and methods for redundancy and high availability above hardware redundancy and Microsoft clustering. The first level collects data to the server using redundant interface nodes; the second level places servers in server "collectives," where interface nodes will feed both the primary server and secondary server.

Automated.
Simplified Calculation Engines and Totalizers

An embedded, advanced computing engine allows programming of complex calculations like asset efficiency, real-time cost accounting and batch summary. In addition, you can program communication applications such as alarming, emailing, and paging, and data integration programs or applications that do not require user intervention.

Reliable.
Accurate Archiving with Optimized Data Store

FactoryTalk Historian uses tag and historical archiving. This method records only those data points that exceed an acceptable range of values and reduces the required amount of stored data points, while increasing accuracy. In addition, the FactoryTalk Historian SE data store is optimized to handle storing and retrieving time-series data.



Benefits

Boost Performance

- Monitor materials consumption and production (raw, intermediates, final product utilities, etc.). Help reduce the amount of materials lost due to overproduction, as well as help reduce materials lost during operation product or grade changes.
- Monitor or calculate effective equipment usage and performance. Detect degradation of performance, initiate alerts or requests for operations and maintenance actions.
- Help improve transformation of raw materials to product and overall equipment effectiveness and utilization.
- Help improve scheduling and tactical execution of equipment maintenance.
- Provide real-time operation and production data to other supply-chain management functions (maintenance, scheduling, accounting, etc.).

Reduce Time-to-Market

- Monitor and analyze operation and product quality in accord with specifications and operations and product constraints.
- Help reduce time to execute grade or product changes.
- Help reduce product waste, recycle and blending. Increase effective equipment capacity and positively impact materials cost management.
- Help improve product development by collecting and evaluating data related to new operation actions, materials, equipment, equipment capabilities and procedures.
- Identify operation or production bottlenecks and improve operating efficiency to avoid unnecessary capital spending.

Increase Compliance

- Facilitate, validate and document performance within regulatory or permitted boundaries.
- Help reduce validation by including in OEM delivery and testing.

Maximize Delivery Quality and Continuous Process Improvement

- Document actual vs. model production and identify deviations.
- Analyze for new process and operational boundaries when throughput, material or equipment changes occur.
- Identify sources of operation and product quality issues.
- Increase effective (downstream) capacity by identifying and isolating off-spec product earlier (upstream) in production.

FactoryTalk Services							
FactoryTalk® Services deliver value. They are a shared set of common features that enables superior interoperability and commonality between applications for reduced engineering, operations and training costs, while extending the life of existing investments. The FactoryTalk Services provide a solid foundation for today and a path for the future.							
	Activation	Directory	Security*	Diagnostics	Audit	Live Data	Alarms & Events
FactoryTalk Historian SE	✓	✓	(✓)	✓	✓	✓	

** Historian SE supports Windows integrated security model that can be utilized through FactoryTalk Security Windows linked users.*

Client and Server Requirements

Interfaces & Clients

- Windows 2008 R2 SP1 (64 bit)
- Windows 2008 SP2 (32 & 64 bit)
- Windows 2003 R2 SP2 (32 & 64 bit)
- Windows 7 Pro SP1 (32 & 64 bit)
- Windows XP Pro SP3 (32 bit)

Server

- Windows 2008 R2 SP1 (64 bit)
- SQL Server 2008 R2 (32/64 bit) Express or Standard Edition

Case Study

Excellent Visibility Drives Consistency and Quality Improvements as Manufacturer Goes Global

The power of information-driven manufacturing operations management is well documented. Driving bottom-line performance improvements across a manufacturing enterprise is a direct result of the ability to visualize, gather and analyze production date. For one high-tech manufacturer, achieving its stringent, first-pass quality requirements required it to make critical improvements in its ability to manage its supply chain and to improve process consistency across several newly opened global production facilities. FactoryTalk® Historian SE provided the toolset the manufacturer needed to achieve those performance goals.

"Our production facilities—and our supply chain—literally cover the globe," said Plant Manager Steve Marsh. "The tools that FactoryTalk Historian SE provided us gave us the visibility we needed to identify areas that needed improvement and to collaborate on problem-solving. It's made us much more responsive and able to get ahead of potential issues before they can affect production."

The application provided plant managers visibility into every aspect of its supply chain. A tagging system providing rapidly available genealogy for subassemblies coming from suppliers and performance data for parts installed in its customers' plants. In addition, performance data could easily be compared among existing plants and those that had recently come online in new locations. Machine, labor or process inefficiencies could be identified and corrected to bring across-the-enterprise improvements in key performance indicators.

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FactoryTalk® View Site Edition

FactoryTalk®

Powerful, scalable visualization solutions

Advantages

- Scalable HMI solutions from single station to multi-client / multi-server systems
- Continuous system visibility through FactoryTalk and redundancy-enabled HMI, Alarm, and Data Servers
- Integration and sharing of data with other Rockwell Software products
- Restricted access to control system assets and ability to meet the most stringent security requirements such as FDA 21 CFR Part 11
- Alarm management through a comprehensive alarm summary and alarm history viewer
- Highly reliable client and server communication
- Fast and reliable data access to the Logix Family of Controllers
- Easy connectivity options for non-Logix and 3rd-party controllers
- Reduction in application development time with global objects, pre-engineered faceplates, and tag-less HMI Server
- Extended visualization and real-time decision capabilities to web-enabled users

Build a better view with FactoryTalk View Site Edition.

Overview

To meet plant floor expectations, HMI software must meet the demands of multiple stakeholders.

- Engineering and Maintenance demand the tools to quickly develop applications, scale architectures, and easily maintain systems once deployed.
- The Operations group demands robust products that have easy to understand display screens, quick access to alarming, and system-wide diagnostics.
- Production Information Technology (IT) demands system-wide security, web capabilities, high available systems and alignment with virtualized solutions.

FactoryTalk View Site Edition meets the demands of each of these groups, providing robust and reliable functionality in a single software package that scales from a stand-alone HMI system to a distributed visualization solution. With FactoryTalk View SE, HMI challenges in process, batch and discrete applications are managed in a single software solution that enables critical visibility when and where you need it.

Engineering and Maintenance

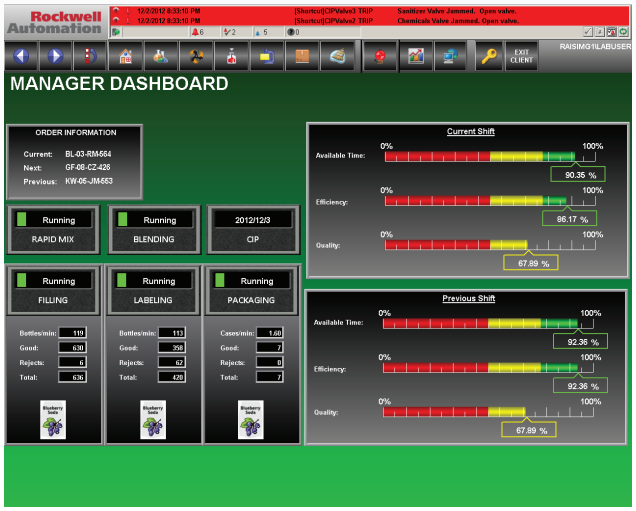
Delivering tools to quickly develop applications, scale architectures, and easily maintain systems.

Design Time Effectiveness

FactoryTalk® View Studio provides a centralized application framework for managing and editing any of the components of an HMI solution. Import / Export a component from previous work or leverage pre-engineered faceplates to speed along application development. While commissioning the system or in full operation, make edits to the application while the system is running. Once the edits are saved, the changes are rolled out to the clients dynamically.

With Global Objects you can create a core set of functionality to build out a library of faceplates or other common components to be used on multiple graphic screens or multiple instances on a single graphic screen. These objects can be defined with parameters that are passed in at runtime for each unique instance. From maintainability perspective, when the base object is edited, all linked instances of the object are updated with the changes – all while the system is running! This reduces the overall maintenance effort and the probability of introducing errors.

Finding and replacing a tag or string value in an HMI application can be time consuming and prone to errors. Using the built-in Find and Replace capability streamlines this operation for you. Leveraging the Cross-Reference capability, you can get a complete listing of where the specified string is referenced throughout the application. Selecting any one of the items in the list opens it for editing without having to search for the project file.



The new gradient shading capability enhances graphical look and feel while maintaining operator effectiveness.

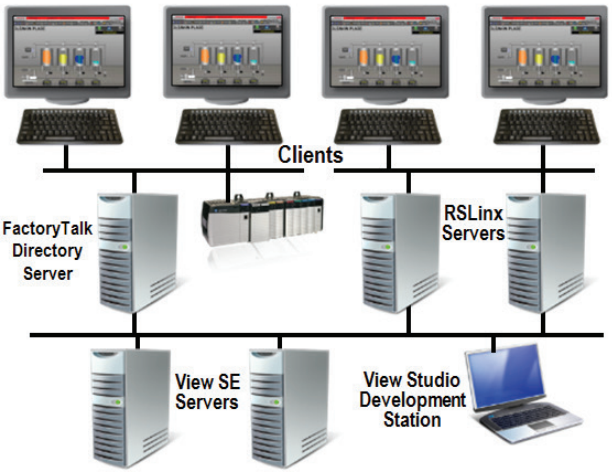
Scalable Architecture to Meet Your Needs

Architect the right solution to meet today's needs while supporting future expansion as your system grows. FactoryTalk View Site Edition (SE) is scalable from a single station HMI to a multi-client / multi-server site-level supervisory solution. Within a complex architecture, the use of FactoryTalk® Live Data optimizes connections between FactoryTalk View SE and other FactoryTalk-enabled products, providing highly-reliable communication within the architecture. This provides optimized, real-time data transfer and more reliable, efficient connections to data servers. FactoryTalk View SE accesses other FactoryTalk-enabled components through the FactoryTalk Directory. The directory is a common address book that tracks the location of other servers configured in the system in order to enable sharing of data.

FactoryTalk View SE Station

Common development environment with FactoryTalk View Studio

FactoryTalk View SE Distributed

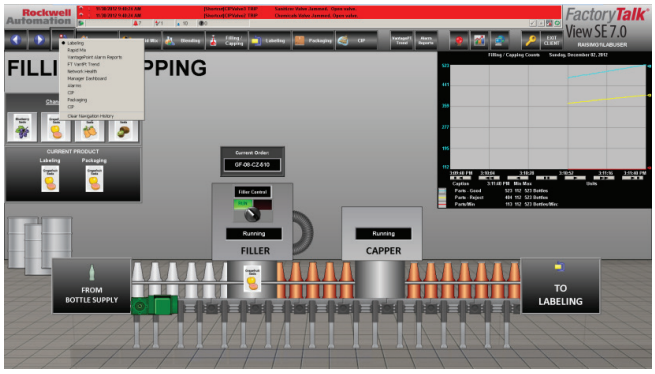


Operations

Delivering robust products that have easy to understand display screens, quick access to alarming, and system-wide diagnostics.

Operator Effectiveness

The ability to quickly visualize the situation and navigate to a more detailed screen is essential when monitoring an alarm condition. With web browser style navigation buttons, you can quickly navigate to previous screens or select a specific screen from the history list.



The ability to enhance the graphical look and feel with tools like gradient shading gives operators a better ability to interpret machine or system performance.

Alignment with Standards

To align with ISA Standard 18.2, FactoryTalk Alarms and Events support all of the standard alarming states, including the Shelved state- similar to the Suppressed state but with an expiration time. Select one or more alarms to shelve in order to remove them from visibility. The shelved alarm will become visible again when the shelve time expires, or when the alarm is manually unshelved.

System Wide Diagnostics

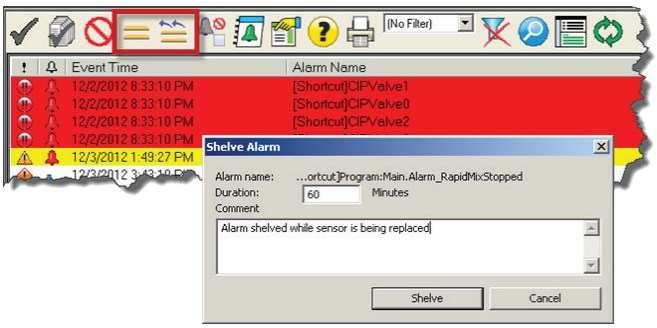
FactoryTalk® Diagnostics allows FactoryTalk-enabled products to report, route and store information about events that happened in a system . This information can be correlated across multiple PCs in order to provide a system wide diagnostic solution for trouble-shooting and determining root cause.

Extensive Alarming Capabilities

Alarm monitoring is a critical function the operator must perform. Providing the alarm management components in an HMI solution is a requirement. FactoryTalk® Alarms and Events provide reliable, real-time visibility into critical conditions that require immediate attention. Operators view and interact with alarm conditions throughout the integrated architecture with easy-to-use graphical items, Alarm Summaries and Alarm Logs.

FactoryTalk Alarms and Events support two different types of alarming options –tag based alarms and device based alarms (which reside in the Logix controller).

- Tag-based Alarms are similar to traditional alarm systems where data points in the controller are polled looking for a state change as an alarm condition. All processing and alarm management is done at the server level.
- Device-based Alarms are alarmed based instructions (ALMA and ALMD) that reside in the Logix controller. All of the alarm detection and management is done in the controller. Clients are set up to be notified when an alarm condition has occurred in the controller. Because alarms are detected in the controller, network traffic is reduced (no longer polling tags for alarm condition), and alarm time stamps are more accurate.



New FactoryTalk Alarms and Events capability aligns with the ISA 18.2 alarming standard. Now, you can select alarms to Shelve, which removes them from visibility for a configured amount of time.

Production IT

Delivering system-wide security capabilities, web capabilities, alignment with virtualization, and high availability.

Stay Secure

Security on the production floor is critical. Restricting who has access to the system and tracking changes when they are made provides the functionality that is expected in today's environment. With FactoryTalk® Security, production system security can be integrated with existing IT infrastructure leveraging Windows authentication services and other security access procedures such as enforcing unique passwords or automatically logging out accounts after unsuccessful logon attempts. Security administrators have the ability to further restrict access based on line-of-sight for machine-level applications.

Satisfying Validation Requirements

For critical operations like set point changes, the system requires user verification. Additional controls are available to support validation requirements such as 21 CFR Part 11. All activity is then logged through FactoryTalk® Diagnostics, a common diagnostic sub-system across all FactoryTalk products and can be used to generate validation audit reports.

Reduce Risk by Maintaining Visibility

Implementing a redundant server configuration ensures visibility to the system should a hardware or network failure occur. The underlying FactoryTalk services provide health detection between FactoryTalk components and automatically switch over to the secondary server in the event of failed primary server. All clients are then switched over to the new active server to allow continuity for operations personnel to control vital plant processes in real-time.

Web Visibility into Production Systems

FactoryTalk ViewPoint extends a FactoryTalk View HMI application to a web browser interface for the casual user outside the production environment. Create View SE screens and publish them to the FactoryTalk ViewPoint server for web clients to access. Changes to View SE graphic displays are automatically synchronized with the ViewPoint server.

Step into the World of Virtualization

All components of a FactoryTalk View SE system have been tested in a virtualized environment and come with VMware® Ready Status. To further support virtualization, Rockwell Automation offers Virtual Image Templates that provide pre-installed FactoryTalk View SE on the appropriate Microsoft operating system, minimizing the setup and configuration time required to deploy FactoryTalk View SE in a traditional IT environment.

Get More Information

For ordering information, contact your local Rockwell Automation® sales office or Allen-Bradley® distributor. Or learn more by visiting

http://discover.rockwellautomation.com/HMI

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CalAmp
connecting tomorrow today

Viper SC™

Intelligent IP Router for Licensed Spectrum

VERSATILE, SECURE COMMUNICATIONS WITH MULTISPEED FUNCTIONALITY

Designed for the energy and utility segment as well as the water or wastewater industries, the CalAmp Viper SC is an intelligent, point-to-multipoint bridge or router for licensed narrowband spectrum holders. This robust communications IP router for VHF & 900 licensed networks features an internal web browser with a familiar interface for IT and network administrators to set up and view device information, configure network parameters and deploy unit upgrades from any location. Using a Software Defined Radio, Viper SC is programmable for 50, 25, 12.5 or 6.25 kHz channels.

FAST & RELIABLE

MultiSpeed operation allows each remote Viper SC to communicate to a Viper SC Base Station at the fastest speed supported by a given signal strength. MultiSpeed operation results in an adaptive network which is optimized for performance and reliability. Each Viper SC features single device store and forward and route redundancy for extended range and easy network expansion. With advanced diagnostic capabilities, over the air firmware upgrades, channel migration and RoHS compliance, you can bet your investment today is protected well into the future.

INTELLIGENT & SECURE

Featuring advanced QoS, the Viper SC allocated guaranteed RF bandwidth to critical, high-priority user-defined applications. Able to support multiple applications simultaneously, the Viper SC also boasts data prioritization for the ultimate in router intelligence. The Virtual Local Area Network (VLAN) routing capability of the Viper SC improves scalability, security and traffic-flow management. Versatile and scalable for the future, the Viper SC can be used as an IP router, terminal server, Ethernet bridge, access point or remote site.

CENTRALIZED MANAGEMENT

Viper SC can be managed via an intuitive webpage, SNMP, or telnet enabling remote management for every application. Viper's device management capabilities allow administrators to set-up and view device information, configure network parameters and deploy unit upgrades from any location. These remote management tools reduce the time and cost of maintaining network infrastructure while improving workforce efficiency for managing and monitoring industrial equipment in the field.

Experience The Advantage

- Advanced Multi-Level Modulation allows up to 128 kbps in a 50 KHz channel
- 1-10 Watts output Power, software selectable
- Multi - Hop store and forward routing to avoid obstructions and extend range
- FIPS 140-2 compliant providing AES 128/256 encryption, Radius authentication and Multiple VPNs
- Viper functions as an IP Bridge or IP Router
- Viper supports Terminal Services allowing IP to Serial Conversion
- QOS for simultaneous use of multiple applications and data transfer prioritization

VIPER SC SPECIFICATIONS

PRODUCT HIGHLIGHTS

- QoS
- Bridge and Router Modes
- Secure VPN Tunnels
- MultiSpeeds

CONNECTORS/INTERFACE

Ethernet	10 BaseT Auto-MDIX RJ-45
Serial COM 1, COM 2	RS-232 DB-9
Antenna	TNC Female (Tx/Rx), SMA Female (Rx)-Dual port models only

MECHANICAL

Dimensions	5.50 W x 2.125 H x 4.25" D, (13.97 x 5.40 x 10.8 cm)
Weight	2.4 lbs, 1.1 kg

ENVIRONMENTAL

Operating Temperature	-40° to +70° C, (-40° to +158° F)
Specified Temperature	-30° to +60° C, (-22° to +140° F)
Storage Temperature	-40° to +85° C, (-40° to +185° F)
Operating Humidity	5% to 95% Non-condensing RH

POWER

Tx Current	1.2-3.6A@10V; 0.6-1.8A@20V; 0.4-1.2A@30V
Rx Current	450mA@10V; 240mA@20V; 170mA@30V
Primary Power	10-30 VDC

STANDARDS & CERTIFICATIONS

- FCC
- IC
- UL

TRANSMITTER

Frequency Stability	1.0 ppm
Carrier Output Power	1-10 Watts (VHF/UHF), 1-8 Watts (900)
Duty Cycle	100% (Power Foldback for High Temps)
Output Impedance	50 Ω

FREQUENCY BANDS

	Frequency	Channel Bandwidth
VHF:	136-174 MHz	6.25/12.5/25/50kHz
200:	215-240 MHz	12.5/25/50kHz
UHF:	406.1-512 MHz	6.25/12.5/25/50kHz
900 (NPCS, MAS):	928-960 MHz	6.25/12.5/25/50kHz

Modes of Operation	Simplex, Half-Duplex
Modulation	2FSK, 4FSK, 8FSK, 16FSK

RECEIVER

VHF/UHF BER @ 1x10-6		
	6.25 kHz	-115@4 kbps; -106@8 kbps; -100@12 kbps
	12.5 kHz	-116@8 kbps; -109@16 kbps; -102@24 kbps; -95@32 kbps
	25 kHz	-114@16 kbps; -106@32 kbps; -100@48 kbps; -92@64 kbps
	50 kHz	-111@32 kbps; -104@64 kbps; -97@96 kbps; -88@128 kbps
MAS BER @ 1x10-6		
	12.5 kHz	-112@8 kbps; -106@16 kbps; -99@24 kbps; -90@32 kbps
	25 kHz	-111@16 kbps; -104@32 kbps; -97@48 kbps; -89@64 kbps
	50 kHz	-108@32 kbps; -101@64 kbps; -94@96 kbps; -85@128
Adjacent Channel		
	(VHF/UHF)	45 dB@6.25 kHz; 60 dB@12.5 kHz; 70 dB@25 kHz; 75 dB@50 kHz
	(MAS)	55 dB@12.5 kHz; 65 dB@25 kHz; 70 dB@50 kHz

About CalAmp
CalAmp (NASDAQ: CAMP) is a proven leader in providing wireless communications solutions to a broad array of vertical market applications and customers. CalAmp's extensive portfolio of intelligent communications devices, robust and scalable cloud service platform, and targeted software applications streamline otherwise complex machine-to-machine (M2M) deployments. These solutions enable customers to optimize their operations by collecting, monitoring and efficiently reporting business-critical data and desired intelligence from high-value remote assets. For more information, please visit www.calamp.com.

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