

City of St. Joseph, Missouri
Facilities Plan

Technical Memorandum No. TM-WW-8
Instrumentation and Controls



By



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Instrumentation and Controls

1.0 Executive Summary

The purpose of this technical memorandum (TM) is to present an instrumentation and controls (I&C) plan which documents the current I&C conventions at the St. Joseph Water Protection Facility (WPF) and provides recommended practices for future facility improvements.

The WPF previously utilized an Autocon system which has exceeded its useful life, is no longer supported by the manufacturer, and has been removed. This circumstance requires the operators to manually run the local facility except for the following systems: In-plant Influent Pump Station, Intermediate Pump Station, Industrial Primary Clarifier, Thermophilic and Mesophilic Digesters, Belt Filter Press, Boiler, and Gas Dryer. These systems utilize programmable logic controllers (PLCs) which operate in a stand-alone fashion with local operator interfaces (LOIs) and circular chart recorders. PLCs are also located at the following remote pump stations: Whitehead Pump Station, Brown's Branch Pump Station, Faraon Street Pump Station, and South St. Joseph Industrial Sewer District Pump Station. The PLCs are manufactured by Allen-Bradley and are capable of or can be upgraded for Ethernet communications. The facility utilizes instrumentation of the latest technology as existing systems are improved and new systems installed.

It is recommended that the City of St. Joseph continue to install reliable, cost effective instruments of the latest technology and build upon the PLCs already installed by implementing a plant-wide supervisory control and data acquisition (SCADA) system as improvement projects are implemented. The SCADA system should utilize human-machine interfaces (HMIs), Allen-Bradley ControlLogix PLCs which support Ethernet protocol, LOIs, Ethernet switches, and a fiber optic cable backbone. The fiber optic cable backbone for these systems should be installed in conjunction with the upcoming nutrient removal and/or grit removal projects.

2.0 Purpose of Technical Memorandum

The purpose of this TM is to review the current process monitoring and control system utilized at the WPF and provide recommendations for the I&C which could include a SCADA system for operation of current and future facilities.

3.0 Introduction

The City of St. Joseph is developing a Facilities Plan for combined sewer overflow (CSO) control improvements as part of the Long Term Control Plan (LTCP) as well as for improvements required at the existing WPF. As part of this evaluation, the current I&C systems were reviewed and a general approach was developed for future improvements to the systems.

4.0 Existing Process Monitoring and Control System

The following sections summarize the elements of the WPF's existing I&C system.

4.1 Current Process Monitoring and Use of Instrumentation and Programmable Logic Controllers

The WPF previously utilized an Autocon system (manufactured by Control Data) which has exceeded its useful life. The Autocon system was removed in 1989 and is no longer supported by the manufacturer. Operators manually operate the facility, except for the following plant systems which have PLCs: In-Plant Influent Pump Station, Intermediate Pump Station, Industrial Primary Clarifier, Thermophilic and Mesophilic Digesters, Belt Filter Press, Boiler, and Gas Dryer. PLCs are also located at the following remote pump stations: Whitehead Pump Station, Brown's Branch Pump Station, Faraon Street Pump Station, and South St. Joseph Industrial Sewer District Pump Station. The PLCs operate as stand-alone controllers with LOIs on the front of the panels and circular chart recorders in close proximity for historical trending. The PLCs are Allen-Bradley SLC-500 Series as summarized in Table 1. The existing PLCs are provided with or can be upgraded for Ethernet communication capabilities. LOIs include

an Allen-Bradley PanelView Plus 1000 and an Advantech. The LOIs provide operators with convenient local access to acknowledge alarms, change set points, control equipment, and monitor status. The existing LOIs are process specific.

Table 1	
Existing Programmable Logic Controllers	
Location / Service	Allen-Bradley SLC-500 CPU Model
Control Building Belt Press	SLC-5/02
Control Building Mesophilic System	SLC-5/05 (Ethernet)
In-plant Influent Pump Station	SLC-5/02
Industrial Primary Clarifier	SLC-5/05 (Ethernet)
Intermediate Pump Station	SLC-5/02
Thermophilic Digester	SLC-5/05 (Ethernet)
Boiler	SLC-5/04
Gas Dryer	SLC-5/04
Whitehead Pump Station	SLC-5/03
Brown's Branch Pump Station	SLC-5/02
Faraon Street Pump Station	SLC-5/02
South St. Joseph Industrial Sewer District Pump Station	SLC-5/03

The current use of instrumentation is limited; however, new instrumentation has been installed with recent plant improvements which could be monitored by a SCADA system to provide status and historical trending. System parameters that could be monitored include suspended solids at the Aeration Basins, flows at the Industrial Primary Clarifier, status of the Thermophilic Digester, Digester Boilers, Gas Dryers, status of the Belt Filter Press, as well as monitoring and control of the In-plant Influent and Intermediate Pump Stations. The City recently installed a Hach LDO dissolved oxygen sensor and a Hach sc1000 controller at each of the Aeration Basins. The controller has the capability of blower control and monitoring multiple types of other sensors.

4.2 Existing Computerized Maintenance Management System, Asset Management, and Operations Data Management

The City currently uses Operator 10 for maintenance management as well as for tracking parts inventory and repair frequency. The implementation of Operator 10 Data Management for Operations is currently underway. The City is not satisfied with the functionality of the Operator 10 product.

5.0 Recommended Instrumentation and Control System

The following sections summarize future recommended improvements to the WPF I&C system.

5.1 Supervisory Control and Data Acquisition System

It is recommended that the City build a SCADA system in stages in conjunction with future improvements such as the disinfection facilities and effluent pump station, nutrient removal, and grit removal projects. Key design requirements for a SCADA system are reliability, repeatability, and future expandability. The new buildings or systems would utilize PLCs and LOIs. The hardware and software should be the best available technology that is compatible with the equipment already installed. A fiber optic backbone should be installed in the near future. The backbone routing should take into account plans for long-term projects and connect the existing PLCs to the network. HMIs should be located in central locations such as control rooms.

When construction of remote CSO facilities begins, a new review will be necessary to evaluate communication methodology with remote sites as technology will have likely progressed.

5.1.1 Human-Machine Interface Hardware and Software

A SCADA system utilizes personal computers (PCs) dedicated to the plant control and monitoring. The HMIs typically consist of two process servers, a historical server with monitors in a control room, and workstations distributed throughout the facility in areas such as the plant supervisor's office, maintenance supervisor's office,

and other key locations. The two process servers are set up in a redundant hot-standby configuration such that the primary and backup servers are running simultaneously. The data is mirrored to the backup server in real time so if the primary server were to fail, the standby server will automatically take control without interruption or loss of data. Off-site monitoring is possible with additional cost and proper safeguards such as routers and firewalls. Off-site control is not recommended unless it is provided through a laptop PC taken home by key personnel such as a supervisor or senior operator for access during off-hours and weekends to address abnormal events and aid in troubleshooting. The PCs are specified with the latest technology at the time of purchase to maximize their useful life. PCs typically include CD/DVD or Blu-Ray read/write drives. This is especially important for the historical server and the long term storage of data.

HMIs utilize standard operating system software such as Windows XP and application software such as Microsoft Word and Excel for report generation. Additional application software is required for the SCADA system. This software provides the graphical displays, alarm screens/logging, and drivers which allow the HMI to communicate with the PLCs. There are several SCADA packages with the most prevalent products in the water/wastewater industry provided by Rockwell Automation, GE, and Wonderware. An additional offering is Alarm Notification software which can notify operators of alarms through keying hand-held radios, calling/text messaging pagers, personal digital assistants (PDAs), mobile phones, and e-mailing PDAs via Wi-Fi and smartphones.

5.1.2 Programmable Logic Controllers and Local Operator Interfaces

Future systems can continue to utilize Allen-Bradley PLCs with Ethernet capabilities. The SLC-5/05 series is available; however, it is recommended that ControlLogix be utilized for projects in the near future. This system is fully compatible with the existing PLCs and will have a longer support cycle from Allen-Bradley as part of their latest offering. Due to the rapid pace of change in control technology, projects more than ten years in the future will need to determine the best Allen-Bradley system offering at that time.

The Allen-Bradley PanelView Plus LOIs currently utilized are recommended for projects planned to be in construction within the next five years; future projects will need to investigate the best system prior to design. The existing LOIs are process specific. As part of the SCADA system, it would be possible for LOIs to view all plant processes. It is not recommended to modify the existing LOIs to access plant-wide data because they are part of packaged systems, and the associated cost would be prohibitive. This is also the case for future packaged systems as well, such as the ultraviolet (UV) disinfection and blower systems.

5.1.3 Communication Networks

Radio telemetry and fiber optic cable are the two primary communication technologies implemented at plant sites.

5.1.3.1 Radio Telemetry. Radio telemetry can be utilized at plant sites. However, it is primarily implemented for communications with remote sites such as pump stations and only for transmitting process data. The bandwidth and data rates of radio telemetry do not lend themselves to transmitting process data, video, and telephone over a single radio link without significantly diminished performance. Additional parameters to consider are the licensing amendment and coordination fees associated with the City's existing licensed frequency system or the potential of interference with other radio systems with an unlicensed spread spectrum system.

5.1.3.2 Fiber Optic Networks. The recommended network design for plant sites utilizes metallic cable within buildings and fiber optic cable when leaving the envelope of a building. The fiber optic cable provides electrical isolation from electrical interference and damage, typically related to lightning strikes. Additional benefits include greater bandwidth and incorporation of other systems such as administrative network data; telephone; closed-circuit television (CCTV); security video; and heating, ventilating, and air conditioning (HVAC) control systems. Considering the distance of

fiber runs at plant sites, multimode fiber is recommended with either a 50 or 62.5 micron fiber core.

There are several network configurations: star, self-healing ring, and bus trunk line. In a star configuration, all nodes are connected to a central node such as an Ethernet switch, which routes all data between the nodes. In a self-healing ring configuration, the nodes are all connected to a cable routed from node to node in a loop. If one segment of the loop is broken, data is rerouted along the intact segments. In a bus trunk line configuration, all nodes are connected to a central cable along which data is passed. Each has advantages and disadvantages based on plant layout, cost, etc. Typically, a combination of configurations is utilized. The various network topologies are presented in Figure 1.

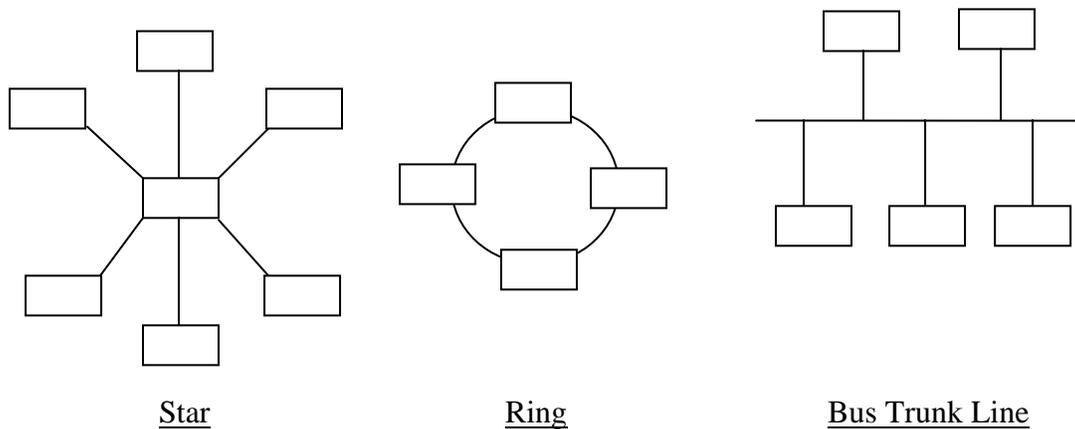


Figure 1 – Network Topologies

The existing WPF layout best lends itself to a self-healing trunk line around the perimeter of the plant with small stars at each drop. The plant process SCADA network would be routed on the backbone to process area PLCs, control room area, and administrative offices as appropriate. The administrative network would be routed to administrative offices and maintenance areas. Telephone and security networks would be routed to process areas, administrative offices, and maintenance areas as appropriate. Each network would be carried over the fiber backbone via separate fiber pairs. A spare

pair of fibers for each identified network, including anticipated future networks, would also be provided.

Within buildings, the Ethernet protocol dictates CAT 5e and CAT 6 unshielded twisted pairs (UTP) for PLCs and HMIs, respectively. If the cable is routed through process areas or equipment that may generate electromagnetic interference (EMI), the cable is routed in rigid steel conduit to provide shielding.

5.2 Instrumentation

For future projects, it is recommended that the City install reliable, cost effective instruments of the latest technology. As permitting requirements become increasingly more stringent, the complexity of processes and the sophistication of the instrumentation increase. This relates to automation such as dissolved oxygen (DO) control. It is important to bring this data to the PLCs to allow the operators to view and trend data.

5.3 Computerized Maintenance Management System and Asset Management

The current Operator 10 software can be utilized on new HMI workstations. Through an Object Linking and Embedding (OLE) for Process Control/Dynamic Data Exchange (OPC/DDE) Interface add-on module, the SCADA application software data can be transferred for use by the Operator 10 software. If Laboratory Information Management System (LIMS) software is added in the future, this data can also be transferred to the Operator 10 and SCADA software.

5.4 Security Cameras

Security cameras can be located throughout the facility to monitor access to the facility, as well as deliveries such as septage receiving or chemicals. The security cameras should utilize the fiber optic cable backbone to a server. The security camera video would be carried on a separate pair of fibers due to its large bandwidth demands. The security server could be a dedicated PC server or utilize one of the SCADA servers

with a dedicated DVR. The monitors should also be located in a central location such as a control room.

5.5 Telephones

Telephones can be located throughout the facility for in-house and/or offsite communications. The telephones should utilize the fiber optic cable backbone to the Administration Building for a land-line interface or connection to a Voice over IP (VoIP) server. The telephones would be carried on a separate pair of fibers to prevent interference with the SCADA network.

5.6 Naming Convention

The existing Computerized Maintenance Management System (CMMS) uses a naming convention based on equipment or facility location from south to north and west to east. For the future CMMS and SCADA software, a standard tagging convention will be provided to the City for review. Standard tagging will provide consistency among existing equipment and future projects in the CMMS and SCADA systems.

6.0 Conclusions

The WPF does not have an existing SCADA system. It is recommended that the City install reliable, cost effective instruments of the latest technology and build upon the PLCs already installed by implementing a plant-wide SCADA system as improvement projects are implemented. The SCADA system should utilize HMIs, Allen-Bradley ControlLogix PLCs which support Ethernet protocol, LOIs, Ethernet switches, and a fiber optic cable self-healing ring backbone. The fiber optic cable backbone for these systems should be installed in conjunction with the upcoming ammonia removal and/or grit removal projects.