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Technical Memorandum

Prepared for: Sacramento Suburban Water District

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Technical Memorandum

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1. INTRODUCTION

The purpose of this technical memorandum is to discuss the extent of the current Supervisory Control and Data Acquisition (SCADA) system and visualize potential other SCADA needs and uses in the District. This memorandum summarizes the results of the SCADA analysis and discussions with District staff and identifies potential uses of SCADA to aid the District in utilizing their SCADA capabilities to optimize system operations.

2. WATER SYSTEM SCADA DESCRIPTION

The water system is monitored and operated remotely using a Wonderware/Tesco Controls SCADA system. The central computer hardware and software is relatively new with the new database server and hardware server installed in 2006. Almost two-thirds of active wells are connected to the SCADA system, with 37 active wells not on SCADA yet. Operators and managers at the Administrative Office on Marconi Avenue and the Walnut Yard can monitor operations of the water system. Supervisors can override automatic operations with manual control if necessary.

The purpose and use of the SCADA system is to schedule and control water system operations to minimize costs and maximize service and reliability.

3. SCADA SYSTEM COMPONENTS

The District's SCADA system consists of three major components: remote site controls, radio communications, and the SCADA master station. The SCADA system is based on Wonderware's Active Factory 9.1 and includes Tesco's Remote Telemetry Units (RTU), GE's MDS radio transceivers, Wonderware's InTouch 9.5 and Wonderware's SCADAlarm 6.0. Each component as well as what is needed for sites currently without SCADA is described below.

3.1 Remote Sites

Remote site facilities are mostly wells, with a few other facility types as shown in Table 1. Active wells can be categorized into three categories: well fields (multiple wells at a site), groundwater well treatment plants, and all other wells. Variations on the typical well control profile include fluoride injection (in the SSA), variable frequency drive (VFD)/reduced voltage soft start (RVSS) motors, gas or electric power, on-site power generator, and on-site NaOCl generator. For a complete listing of all active sites, see Tables 4 and 5.

Table 1. Summary of SCADA Connected Sites			
Facility Type	No. of Sites	On SCADA	Off SCADA
Active wells	89	48	41
Booster pump station (BPS)	3	2	1
Reservoir and BPS	3	3	
Pressure reducing station (PRS)	4	4	
Elevated tank	4	1	3
Intertie/intratie[a]	3	3	
Flowmeter	1	1	
Total	107	62	45

[a]*Does not include emergency interties.*

Due to the large number of wells without SCADA and inconsistencies in instrumentation, process data is mostly collected manually. This is time-consuming and introduces human error into the process data base. Remote site design standards that include instrumentation would better enable the District to develop an accurate cost estimate to achieve automatic data acquisition. The infrastructure for automatic data acquisition is already in place.

Each RTU panel includes a Tesco Programmable Logic Controller (PLC) with a number of discrete inputs (DI), discrete outputs (DO), analog inputs (AI), and analog outputs (AO). Tesco's High Density Mixed I/O (HDIO) cards include 16 DI, 8 DO, 6 AI, and 2 AO, and each PLC modular rack includes a 5 slot card cage. The PLC provides programming capabilities to process data acquisition, execute control algorithms, and produce control outputs for all instrumentation and control equipment typically used in a water facility.

Control and monitoring functions for larger facilities, such as the reservoir and BPS sites, appear to be within the current SCADA system's capabilities. I/O requirements for typical District facilities are shown in Table 2. Typical costs for a RTU panel are estimated at $35,000 per RTU. These costs include the enclosure, PLC, power supplies, I/O card, radio telemetry and panel equipment, as well as design and programming services to design, program, install, test, train, and document the RTU panel.

Table 2. Summary of Typical I/O Requirements by Facility Type						
Facility Type	HDIO	DI	DO	AI	AO	Total
Reservoir and BPS	5	76	16	21	10	128
Well field	2	24	4	8	3	41
Groundwater well treatment plant	2	12	4	7	2	27
Well w/ options (typical of 83)	1	6	1	3	1	12
PRS	1	16	8	4	0	29

Assuming 41 remote sites remain to be connected to the SCADA system, the estimated cost to purchase, install, and set up RTU panels at all active facilities that are currently without SCADA is $1.9 million. It is likely that the District may choose to not equip all remaining 41 remote sites with SCADA, resulting in a lower overall cost. This cost could also be reduced by developing design and programming standards for each facility type, with standard designs for optional features, and allowing for exceptions as necessary. Design standards would simplify RTU panel fabrication, installation, testing, training, documentation, and maintenance. Implementation of standard control and monitoring also simplifies SCADA system programming and enables development of more advanced SCADA applications.

3.2 Radio Communications

Two non redundant radio networks are used, although the terminal servers that concentrate the SCADA data from remote sites to the historical database server are redundant. A fully redundant communication system would have redundant paths to each remote site, but this level of redundancy is usually cost-prohibitive. FCC licenses and MDS radio equipment are current, and this investment enables active sites to be easily added. Overall, the radio communication system appears to be solid and ready for expansion to include the 41 remaining sites. Security is enhanced by the use of a proprietary communications protocol (Tesco's DataExpress+).

Radio paths to the remaining sites are assumed to be clear of obstacles and easily linked to a radio master station. A radio propagation study conducted in 2005 affirmed radio system readiness for implementing future SCADA RTUs.

3.3 SCADA Master Station

The SCADA Master Station provides operator interface, alarm handling, data storage (real-time, historical, and archival), reporting, and data integration functions.

Operators typically use the operator interface for process monitoring and remote control. The InTouch software provides graphical displays with dynamic data continuously updated in real-time. Dynamic data response performance is usually within (1) one second. The operator interface can also be used for daily report generation and operations scheduling.

Alarm handling includes time-stamping alarms and events and notifying operators appropriately by predetermined priorities and responses. The SCADAlarm software provides configurable alarm priorities to notify operators of pending problems and includes a dialout system to notify operators of high priority alarms. Alarms include descriptive messages to clarify alarm origins and causes. Alarm standards need to be documented for priorities, handling, and logging. Table 3 lists typical alarms by facility type.

Table 3. Typical Alarm Summary by Facility Type												
Facility Type	Equip Fail	Flow		Level		PSI		Cl_2 Syst		Fl_2 Syst		Misc		Total
	X	H	L	H	L	H	L	H	L	H	L	X	X	
Reservoir and BPS	50	2	2	6	6	2	2	3	3			9	9	94
Well field	20	3	3	3	3	3	3	3	3			1	1	46
Groundwater well treatment plant	20	2	2	1	1	1	1	1	1			1	1	32
Active well w/ options	5	1	1	1	1	1	1	1	1	1	1	1	1	17
PRS	5	1	1			1	1					1	1	11

The data storage function captures three types of process data; real-time data which is the most immediate and current process data, historical data which is directly accessible from the master station hard disks, and archival data which is transferred to CD or other media for manual retrieval. Industrial SQL Server 9.0 performs this function and is currently sized for 10 years of 5K tags. Standard procedures for accessing archival data need to be documented.

The reporting function retrieves stored process data and produces reports. Active Factory 9.1 software performs this function. Reporting functions include graphic (e.g., pie, bar, or scatter charts, and line plots) displays, historical trends, and data analysis tools. Active Factory is a solid product, but its capabilities are currently underutilized. Process data reporting can be improved by training and dedicating staff on Active Factory and developing report templates. These skills and templates can also integrate process data with other information systems, such as Cityworks.

The District's master station configuration uses current Wonderware software versions on the historical database server for all master station functions. Fifteen (15) operator interfaces are licensed, with up to three security levels. Managers can view water system operations, operators can view and acknowledge some alarms, and two supervisors can override automatic controls and modify the SCADA system.

4. CONCLUSIONS AND RECOMMENDATIONS

This section lists the conclusions and recommendations as a result of this desktop review of the District's SCADA system.

Conclusions

1. This desktop review of the District's SCADA system shows a solid system in place and in progress.
2. A significant number of active facilities are not currently connected to the SCADA system and standard products and services to complete the SCADA system are not well documented.
3. Master station functions can be substantially improved by consistent application of SCADA standards, and this will prepare the District for more advanced SCADA applications.

Recommendations

1. **Develop SCADA Standards and Guidelines** – SCADA standards and guidelines should be developed because SCADA systems are easier to develop, maintain, expand, and migrate when standards are consistently applied. SCADA design and programming standards are grouped into product (hardware and software) specifications and services (programming and configuration) guidelines. Remote site design standards that include instrumentation would better enable the District to develop an accurate cost estimate to achieve automatic data acquisition. The infrastructure for automatic data acquisition is already in place.

   SCADA product and installation requirements use Construction Specifications Institute (CSI) Division 17000 (or Div 13000) specifications, and template or example drawings. These standards are the basis for SCADA system additions.

   SCADA components typically described in these standards include:

   1. Instruments/Control Devices
   2. Wiring and Tag Naming Conventions
   3. RTU Panel Diagrams, Loop Drawings, P&IDs
   4. PLC Model(s) processors, racks, power supplies, and associated I/O cards
   5. Network Equipment and Cables
   6. Master Station Workstations, Servers hardware and software
   7. Master Station Software (and version)
   8. SCADA System Testing and Acceptance Procedures
   9. SCADA System Training

   SCADA programming guidelines are dynamic documents that should be updated periodically by District SCADA staff. These guidelines simplify the development of SCADA programs whether those services are procured externally or provided internally. Programming guidelines may be included in design specifications.

Programming topics typically described in these guidelines include:

1. Database Naming Conventions
   a. PLC Tagging
   b. Master Station Tagging

2. Network
   a. Architecture
   b. Addressing
   c. Diagnostics

3. PLC Programming
   a. Control Blocks
   b. Configuration
   c. Documentation
   d. Program Structure

4. SCADA Master Station
   a. Graphic Hierarchy
   b. Graphic Objects
   c. Color Conventions
   d. Security
   e. Alarm Handling (including definition, priority, color, and response standards)
   f. Historical Data Logging
   g. Report Generation

The development of these standards enables the completion of the SCADA system to all appropriate active sites and prepares the SCADA system for future advanced applications.

2. **Develop Master Station Programming Guidelines/Conduct Master Station Functionality Evaluation** - The development of the master station programming guidelines will define most user requirements for the SCADA master station. With the establishment of master station guidelines, advanced SCADA functions can be developed. These include energy management, performance analysis, daily operations planning, and improved coordination with water system maintenance and water quality testing. Standard procedures for accessing archival data need to be documented. The evaluation should identify skills and training needed, as well as programming and configuration changes necessary to improve master station functionality.

3. **Develop a SCADA System Completion Plan** - The SCADA System Completion Plan should summarize user requirements based on SCADA standards and guidelines and develop an action plan. This should include cost estimates, a schedule to improve master station functionality, and a schedule to install an RTU panel at every active site that should be connected to the SCADA system. Active sites that are too small or too old to be cost-effective for inclusion in the SCADA system should be identified. The sequence of installation should consider costs of installation and importance of site inclusion to establish a SCADA system that simplifies process data acquisition and optimizes water system operations to meet demand requirements, water quality regulations, and energy efficiency objectives. The SCADA System Completion Plan should recommend specific actions to improve SCADA usefulness and data access.

Table 4. North Service Area (NSA) Facilities			
NSA Facility Name	Well No.	Facility Type	RTU No.
C-BAR-C		Intertie	2
Mariposa Intertie		Turn out / Intertie	3
I-80 Crossing		Intratie	16
Navion MOV		MOV	4
Verner PRV		PRS	5
Walerga Intertie		PRS	22
Antelope PRVs		PRS	11
NSA-1			
North Antelope	N35	Active Well	6
Poker 1	N32-A	Active Well	7
Poker 2	N32-B	Active Well	Slave
Poker 3	N32-C	Active Well	Slave
Hillsdale	N5	Active Well	8
Cottage	N34	Active Well	9
Antelope Reservoir		Reservoir & BPS	19
Walerga	N33	Active Well	21
Sutter	N25	Active Well	25
Don Julio	N24	Active Well	--[b]
Monument	N26	Active Well	
NSA-2			
Cabana	N15	Active Well	13
Orange Grove	N14	Active Well	
Oakdale	N17	Active Well	
NSA-3			
Walnut	N10	Active Well	12
Walnut Tower	10A	Elevated Tank	1
Engle	N3	Active Well	17
Barrett Meadows	N31	Active Well	18
St. Johns	N12	Active Well	23
Merrihill	N29	Active Well	24
Park Oaks	N30	Active Well	26
Rosebud	N7	Active Well	27
River College	N22	Active Well	28[a]
Cameron	N9	Active Well	29[a]
Freeway	N23	Active Well	30[a]
Evergreen	N1	Active Well	
Palm	N6	Active Well	
Field	N8	Active Well	
Cypress	N20	Active Well	
Jamestown	N27	Active Well	
NSA-4			
Fairbairn / Karl	56A	Active Well	109
Bainbridge / Holmes School	59A	Active Well	110
Galbrath / Antelope Woods	64	Active Well	119

Table 4. North Service Area (NSA) Facilities			
NSA Facility Name	Well No.	Facility Type	RTU No.
Weddigen / Gothberg	52	Active Well	120
Melrose / Channing	27	Active Well	--[b]
Thirty Second / Elkhorn	58	Active Well	--[b]
Watt / Elkhorn	31A	Active Well	
Watt / Elkhorn Reservoir		Reservoir & BPS	112
La Cienege / Melrose	34	Active Well	
Thomas / Elkhorn	39	Active Well	
Airway / Poplar	61	Active Well	
Arbor at Antelope			
Capehart 1-C	MC1	Active Well	
Capehart 2-C	MC2	Active Well	
Capehart 3-C	MC3	Active Well	
Capehart Elevated Tank		Elevated Tank	
McClellan Business Park			
McClellan Well 10	MC10	Active Well	15
McClellan Booster #1A & 1B		BPS	10
McClellan Booster #2		BPS	14
McClellan City Booster		BPS	
McClellan Elevated Tank #769		Elevated Tank	
McClellan Elevated Tank #216		Elevated Tank	

[a]RTU to be installed in 2009.
[b]RTU to be installed in 2010.
Notes:
RTU No. 1 – 99 are on Radio Network 1 (old Northridge system)
RTU No. 101 – 199 are on Radio Network 2 (old Arcade system)

Table 5. South Service Area (SSA) Facilities			
SSA Facility Name	Well No.	Facility Type	RTU No.
PFE PRS & Flow		PRS	132
North Antelope Flow		Flowmeter	133
SSA-1			
Eastern / Woodside Church	66	Active Well	20
Bell / Marconi	4B	Active Well	106
Eden / Root	32A	Active Well	107
Auburn / Yard	40A	Active Well	108
Auburn / Norris	33A	Active Well	111
Balmoral / Yorktown	19	Active Well	115
Merrily / Annadale	65	Active Well	116
Becerra / Woodcrest	24	Active Well	117
West / Becerra	22	Active Well	121
El Prado / Park Estates	2A	Active Well	125
Greenwood / Marconi	26	Active Well	126
Red Robin/Darwin	28	Active Well	128
Ravenwood / Eastern	9	Active Well	129
Rockbridge/Keith	30	Active Well	130
Albatross / Iris	41	Active Well	131
Whitney / Concetta	60	Active Well	134
Bell / El Camino	5	Active Well	
Rubicon / Seely Park	7	Active Well	
Hernando / Santa Anita Park	12	Active Well	
Calderwood / Marconi	13	Active Well	
Marconi South / Fulton	14	Active Well	
Marconi North / Fulton	23	Active Well	
Morse / Cottage Park	37	Active Well	
Watt / Auburn	38	Active Well	
Auburn / Yard	40	Active Well	
Edison / Trua1	43	Active Well	
Jamestown/Middleberry	45	Active Well	
SSA-2			
Watt / Arden	20A	Active Well	114
Ulysses/Mercury	35	Active Well	118
Riding Club / Ladino	18	Active Well	123
Thor/Mercury	25	Active Well	124
SSA-3			
River Walk / NETP	72	Active Well	102
River Walk / NETP East	73	Active Well	Slave
River Walk / NETP South	74	Active Well	Slave
River Drive/ Jacob	71	Active Well	104
Stewart/Lynndale	55A	Active Well	105
Copenhagen/Arden	47	Active Well	127
Columbia/Fair Oaks	50	Active Well	
Sudbury/Elsdon	51	Active Well	

Table 5. South Service Area (SSA) Facilities			
SSA Facility Name	Well No.	Facility Type	RTU No.
SSA-4			
Enterprise / Northrop	75	Active Well	113
Enterprise / Northrop Reservoir		Reservoir & BPS	122
Kubel / Armstrong	3A	Active Well	
Jonas/Sierra Mills	46	Active Well	
Northrop / Dornajo	68R	Active Well	
Hilldale / Cooper	69R	Active Well	
Sierra / Blackmer	70	Active Well	
Fulton / Fair Oaks	76	Active Well	
Larch / Northrop	77	Active Well	

Notes:
RTU No. 1 – 99 are on Radio Network 1
RTU No. 101 – 199 are on Radio Network 2