Modernization and Improved Operations:
Process Automation Upgrade of the Gilder Creek WWTP

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ABSTRACT
Renewable Water Resources of Greenville, South Carolina (ReWa) is in the process of a major controls upgrade at its Gilder Creek Wastewater Treatment Plant. This upgrade will serve not only to modernize the Gilder Creek facility and relieve growing operation and maintenance difficulties, but also as a model for the similar upgrade of ReWa’s other facilities and the ultimate networking of all facilities for supervisory control and data acquisition (SCADA).

The project, currently in the design phase, consists of retrofitting and replacing local control panels; replacing a PC-based virtual logic controller (VLC) system and obsolete local input/output (I/O) nodes with a distributed programmable logic controller (PLC) based system; and upgrading to a new scalable software solution for SCADA and operator interface. By utilizing existing plant network infrastructure and carefully sequencing construction, impact on facility operation will be minimized. The development of selection criteria for control system integrator candidates and a curriculum of ReWa personnel training will provide for optimum operations at Gilder Creek and at other ReWa facilities in the future. The project is expected to be executed in 2012.

This paper will explore the reasons for the upgrade, the broad scope and the technical details of the upgrade path, and the challenges encountered in selection of hardware and software, integrator qualification, and construction planning.

Introduction
Renewable Water Resources (ReWa) serves 5 counties in the greater Greenville area in the Upstate of South Carolina from 10 active wastewater treatment facilities. The Gilder Creek Wastewater Treatment Plant (WWTP) has undergone numerous expansions and upgrades since it was commissioned in 1987. Originally a 4.0 mgd facility, the plant was upgraded to 5.0 mgd in 2003, expanded to 8.0 mgd in 2006, and re-rated to its current capacity of 11.3 mgd in 2008. The plant is located along the Enoree River in eastern Greenville County, South Carolina.

In conjunction with various process and facilities upgrades, the SCADA system at Gilder Creek has been upgraded as well, providing effective control, monitoring and automation of plant processes. The art,
science and technology of process automation are perpetually and rapidly evolving, but ReWa and their partners in control systems design and integration strived, at each upgrade milestone, to keep up with the state of the art. Concurrently, ReWa performed similar upgrades on their other facilities, and began to develop enterprise-wide information management strategies that integrated input from all of their facilities for operational and maintenance optimization. In early 2011, CDM Smith completed the design of the most recent Gilder Creek process upgrade, Phase IIIA, which has not yet been constructed. In the course of this design, a critical need for replacement of the SCADA infrastructure was identified. ReWa elected to conduct the process automation upgrade separately from the Phase IIIA improvements due to the special demands and challenges of SCADA system upgrades, the urgency of the need to make changes, and the comprehensive scope of improvements.

Current Configuration and Design Criteria

The most recent SCADA upgrade at Gilder Creek had been completed along with the 2006 plant expansion. The current system is based on Steeplechase virtual logic controllers (VLCs) or “soft PLCs”, which consists of a control software application that runs on dedicated PC machines, and which is very rarely used in the municipal water/wastewater treatment market. The Gilder Creek plant is divided into two geographic areas, each of which has a redundant pair of VLCs and a dedicated fiber optic cable loop. Inputs and outputs to field instruments and other devices are collected by GE Fanuc Field Control Distributed I/O and Genius Bus Interface Units (BIUs) mounted in local area control panels, which are connected to the VLCs on a Profibus DP network via fiber optic cable. Data is consolidated from the VLCs to a redundant pair of Wonderware InTouch human-machine interface (HMI) PC-based servers, one in the central control room and another in a secondary location. HMI workstations provide operator access to plant-wide controls from multiple locations; both in the control room and throughout the plant. These HMI locations run on both desktop PCs and on industrial PCs mounted in control panels. An Ethernet network on fiber optic cable supports the VLCs, HMI computers, and several PLCs associated with OEM packaged systems.

The various components comprising the existing system, taken together, served as the key criteria to define the desired goals for this project. These are summarized below:

1. The initial and primary need for the upgrade was the obsolescence of the I/O modules currently installed. The modules are no longer available for sale from the manufacturer and are increasingly difficult and expensive to obtain on the used market. At minimum, the proposed upgrades would need to replace the local I/O nodes with a new model line that would remain available for years to come.

2. A second need for improvement was that the VLC installation, though functional, had passed end-of-life and was increasingly difficult to support. It would be feasible to recreate the entire control system using the same basic system architecture, as newer versions of the VLC software are available. However, ReWa staff opted for a more distributed control system, with hardware designed for longer life in industrial environments. Therefore, the local I/O nodes were not to be replaced strictly in kind, but with PLCs, each one largely independent of the others, that would form the middle layer of a typical three-layer open-architecture network (field devices, local controllers, supervisory control and monitoring).

3. A third need was to upgrade the HMI software to current versions, to keep abreast of rapidly evolving HMI technology; and to replace the aging PC hardware in kind.
4. As Gilder Creek is an operating facility, there was a clear imperative to maintain plant operations throughout the upgrade. Any amount of downtime for a given process area would require manual operation of that process and any connected processes for the duration of the outage. Therefore, equipment upgrades would need to be conducted efficiently, and in such a way as to keep as much of the system under automatic control as possible.

5. Due to the complexity of the project and the specialized skills that would be required to execute the scope of work, a specialty contractor would be required. Each prospective bidder would need to be a control systems integrator (CSI) qualified in controls and automation, experienced in municipal treatment facility work, and experienced in the programming of the selected software packages.

**Design Process and Challenges**

After a study of the operational and maintenance documentation from the 2006 project, the project team made an initial site investigation to confirm its accuracy, to evaluate the condition of the equipment, and to collect the observations of ReWa staff. This information was leveraged to address each of the design goals described above.

**Goal No. 1 - Replacement of I/O Nodes**

The first design criterion would be met, in most locations, by the replacement of the subpanels – steel plates upon which equipment is directly mounted, and which are then bolted into the main enclosure – within each of the local I/O control panels. The control panel enclosures were in good condition, and no expansion of I/O count or wiring would be required, so there was no need for replacement. Instead, new subpanels would be furnished. The new subpanels would be the same size and basic configuration as the existing ones, complete with PLC and I/O racks, network switches, power supplies, terminal blocks, and all other required ancillary equipment. These new subpanels could be thoroughly tested for basic functionality before installation. Then, all wires and cables could be disconnected, the old subpanel removed, the new subpanel installed, and the wires and cables reconnected. Complete in-place functional testing involving the field equipment, PLC, and HMI could then commence. This method would provide the quickest possible transition from old to new equipment in a given location. During conceptual design, the original idea was to replace PLC and I/O hardware only, but this would involve considerably more downtime, so this concept was abandoned. Measurements of all the panels and subpanels were taken for inclusion in the project specifications.

One exception to this plan was the four rotary drum thickener (RDT) control panels, each of which contained its own I/O rack and a significant number of manual controls installed in a waterproof stainless steel enclosure. Here, operations staff expressed a desire to make more than a minimal design change, specifically, to replace the manual controls with a single touchscreen operator interface terminal (OIT). This change would significantly alter the number of I/O points required in each location, and the RDT subpanels were particularly densely packed, potentially requiring a larger subpanel. It would also require at least the panel door, if not the entire panel enclosure, to be replaced. For these reasons, the four RDT panels were elected to be replaced in their entirety, using a similar procedure as with the subpanels. A maximum panel size was determined based on available space.
Additionally, during site investigation, it was decided to provide a new uninterruptible power supply (UPS) in each new or modified panel, to provide protection from power irregularities and some degree of battery backup. UPS units were already in use, but by conservative standards of operation and maintenance, these units were due for replacement.

**Goal No. 2 - Replacement of VLCs with PLCs**

The second design criterion required a make and model of PLC that is in current production, supports remote I/O and Ethernet networking, is capable of the programming load once borne by the VLCs, and will fit in the space provided. During conceptual design, when the original idea was to replace PLC and I/O hardware only, it was proposed to replace the old equipment with new equipment by the same manufacturer that would be approximately equal to what was being replaced. As the scope of the project broadened, and it became clear that an in-place replacement was not feasible, the possibilities of PLC selection broadened as well. However, space on new subpanels would still be an important factor, so equals would need to be qualified not only on the basis of capabilities, cost, and local service representation, but also physical form factor.

A redesign of the network system architecture was also required such that by the end of the project, the VLCs would be removed, the Profibus network would be taken out of service (with a few exceptions), and the fiber optic cable used for Profibus would become available. The Ethernet network was already extended to all locations along with the fiber optic cable, so all new PLCs and any other hardware added would simply reside on the same network. The amount of additional traffic was not expected to be great, and intelligent use of managed switches would ensure smooth communication. Some additional switch components would need to be provided to fill in the gaps. ReWa’s standard IP addressing scheme was applied to the new system for ease of maintenance.

**Goal No. 3 - Replacement of HMI**

The third design criterion called for thoughtful specification of the supervisory hardware and software. In the course of researching the software, it was found that in the time since the 2006 upgrade, Wonderware had introduced their new System Platform product. In addition to retaining the functionality of their previous InTouch and related HMI products, System Platform is built on a foundation of greater database standardization and scalability, allowing for the easy interconnection of multiple plant sites, improved operator familiarity with multiple plant sites, reduced development time, and ready availability of data for enterprise-level applications.

Using the old approach, the project for each facility would be completely independent of all the others, and in order to achieve standardization, policies regarding tagging, scripting, colors, graphics, and other details would need to be enforced by ReWa during each and every upgrade or modification project. Furthermore, any variations in the data transmitted by each facility to the utility’s operation and maintenance application would propagate into that database as well. Using the new approach, all facilities would use a common format and a common library of control templates. These standards could easily be enforced in any additions or changes to any facility, and changes to the standards themselves could easily be propagated to all the facilities in one easy step. After a comparison of the licensing costs of the old and new approaches, the new was chosen for the Gilder Creek upgrade.
**Goal No. 4 - Construction Sequencing**

The fourth design criterion required the development of a sequence of construction that incorporates all of the foregoing elements into a coherent plan to maintain as high a degree of automated operation as possible during the upgrade. Several challenges shaped the decision-making process.

First, what is neat on paper is sometimes messy in reality, and the installation and field testing of new PLC-based panels and subpanels is no exception. It is intended that the retrofitting of each panel will be quick – perhaps one or two working days – but we must be prepared for difficulties to arise in the transition. Thorough factory testing of new equipment will be included in the project, but even that is not foolproof. Field wiring or cabling might be discovered to be inoperable, or too short to stretch to their new connection points. Additionally, process or weather related outages might stall the work before a panel upgrade is complete. For this reason, it was determined that no two control panels will be converted at the same time. Other approaches might allow for a shorter construction period, but maintaining facility operation is critical, and the slower route was deemed safer. Additionally, most control system integrator (CSI) firms have a very limited number of personnel, so if given the choice, most might opt to convert one panel at a time for that reason alone.

Second, it is anticipated that there will be a certain amount of “learning curve” in the installation and testing procedure. Programming changes may need to be made in the field to accommodate unanticipated conditions or to improve operator convenience. For this reason, an attempt has been made to order the implementation of process areas from least to most complex. This priority list is further divided into two parts, reflecting Gilder Creek’s geographically divided system, such that one “loop” will be completed before the other is started. The last and most complex area on the list will be the four RDTs, since here, the CSI will be installing entire control panel enclosures.

Third, the complete testing of any process area will require the new HMI to be running, and so also will require the control room computer hardware to be set up. Therefore, this step will need to be first in order. PC servers and workstations will need to be located in the control room and connected to the plant Ethernet network at least on a temporary basis for the duration of the upgrade project. At the same time, the old human-machine interface (HMI) project must continue to run on the old computers to maintain plant operations. As each process area is upgraded, its HMI controls will become active on the new system, and will be deactivated on the old system. Operations staff will be inconvenienced by the need to use two different HMI systems for the duration of the project. However, this will also provide ample opportunity for them to become familiar with the new system, allowing them to provide input into the finishing touches of its development, and promote a sense of ownership and comfort.

Fourth, some processes are dependent on other process areas for automated operation. This does present a challenge to the one-at-a-time sequence described, but it was not deemed to be of sufficient importance to demand a different approach. The project will be conducted with the expectation that some plant processes will not be able to be operated in a fully automatic mode. Certain pieces of equipment will have to run in manual mode, or in some cases, artificial values of some process variables may need to be forced temporarily within the system. A list of the major anticipated dependencies will be provided to the CSI for their development of a final, detailed construction plan.
Goal No. 5 - CSI Qualification

The fifth and final design criterion called for the careful prequalification of the control systems integrator (CSI) candidates to be allowed to bid to perform the work. On account of its combination of several difficult elements and scheduling sensitivity, this project will be quite demanding, and for a CSI to succeed, they will need substantial experience in key areas. This will be even more crucial on this upgrade than most, since the scope is strictly limited to controls and automation work. Therefore, the CSI will not be operating as a specialty subcontractor under the umbrella of a general contractor or electrical contractor as is often the case, but alone, assuming all project responsibility.

The project team has significant experience with CSI firms, and was able to provide a baseline for prequalification that would apply to any municipal wastewater treatment upgrade project of substantial size and complexity. Expected qualifications include number of years in the water and wastewater sector, number of similar projects completed, staffing levels, required professional licensing, panel shop size, financial solvency, involvement in project-related legal claims, and ability to respond quickly to service requests. These qualities serve to illustrate the degree of stability and the depth of experience of the firm, and form a reasonable prediction of their ability to carry out the work as promised.

Additional project-specific qualifications were naturally suggested by the scope of the project. The most potentially difficult aspects of its implementation are related to its specific software packages. The ideal control systems integrator (CSI) would employ project management and software engineering personnel with sufficient faculty in these software packages. Knowledge of the virtual logic controller (VLC) software would be required in order that the program currently running on the VLCS may be translated into code on the new programmable logic controllers (PLCs) quickly, accurately, and efficiently, without time wasted on the learning curve. Knowledge of the human-machine interface (HMI) software would be required to make the most of the planned upgrade from the earlier HMI software version currently in use. For the latter requirement, the vendor suggested their own certification program as a minimum standard of design capability for this project. However, for the former requirement, there was no such readily available benchmark. Brainstorming amongst the project team produced a minimum number of years and successful projects expected of a full-time employee for a given CSI to meet the qualification.

With all of this, however, came a concern that not enough CSIs could meet all of these requirements at once. A matrix was generated that assigned certain point values, or a Pass/Fail rating, to each criterion or to degrees of fulfillment of that criterion. Which criteria should be assigned what values was a topic of considerable debate amongst the project team members. CSI firms with whom project team members were familiar were polled, and it was found that few had the HMI vendor certification, and even fewer had current experience with the VLC software. If these criteria were weighted too heavily, we might have too few qualified bidders for robust competition. On the other hand, if these criteria were truly indispensable for successful project completion, then weighting them too lightly could admit a CSI who cannot do the work.

At this stage of the project, final prequalification criteria reflecting an open and balanced approach have been issued to the public for solicitation of control systems integrator (CSI) applicants. A template that was used for prequalifying bidders on prior automation projects, which assigns point values to each item in a list of criteria, was adapted for the current project. A distinction was drawn amongst the qualifications and
experience of the CSI firm, the project manager, and the lead software programmer. Experience in the chosen VLC and HMI software systems were not absolutely required, but would grant bonus points to the applicant.

Summary
At this writing, the technical design of the process automation upgrade is complete. The PLC and control panel equipment that will replace the existing VLC and I/O system has been selected, and the HMI upgrade path has been confirmed. The construction sequence has been laid out in detail, except that the list of known significant process dependencies has not yet been finalized. The development and issuance of the CSI prequalification criteria is complete. Bidding is anticipated to take place in Autumn of 2012, and construction is expected to commence immediately thereafter.

List of Acronyms:

BIU ................... Bus Interface Unit
CSI .................... Control Systems Integrator
HMI................. Human-Machine Interface
I/O................. Input/Output
OEM ................. Original Equipment Manufacturer
OIT ................. Operator Interface Terminal
PC................. Personal Computer
PLC ................. Programmable Logic Controller
RDT ................. Rotary Drum Thickener
ReWa ............... Renewable Water Resources of Greenville, South Carolina
SCADA .............. Supervisory Control And Data Acquisition
UPS ................. Uninterruptible Power Supply
VLC ................. Virtual Logic Controller

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