TWENTY TIPS FOR A SUCCESSFUL PUMP STATION RENOVATION

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ABSTRACT

Pump station renovation projects present a series of unique circumstances that must be considered and properly addressed when rehabilitating critical, in-service pump station infrastructure. Based on experience gained through 22 different water booster and wastewater pump station renovations, this paper provides an overview of key factors to consider in the planning, designing, and construction of municipal pump station renovations.

Good projects begin with good planning which should never be overlooked. The planning process develops a road map of how the project will unfold, determines what technical resources are needed, the capital expenditures required, and defines the end goals. This paper discusses the following key factors concerning the planning of pump station renovations: identifying capacity needs; investigating for hazardous materials; evaluating structure conditions; determining asset criticality; analyzing renovation costs; and preparing for reasonable construction timelines.

Designing for the renovation, retrofit, and rehabilitation of existing infrastructure is typically more complex than design of new facilities. This paper discusses the following key factors concerning the design of municipal pump station renovations: checking duty conditions; building code review; regulatory compliance review; modeling non-standard hydraulic situations; checking important dimensions; and protecting micro-electronics.

Constructing pump station renovation projects requires extensive attention to details. This paper discusses the importance of several construction related considerations that can affect successful construction completion: developing stand-by pumping plan, locating embedded power and controls; coordinating outage plans; proof testing equipment; verifying proper operation of controls and alarms; coordinating storage of equipment and materials; special protections of equipment; and arc flash analysis.

This paper summarizes key successful factors that can be incorporated into a pump station renovation project to guide proper expenditure of capital funds.

KEYWORDS

Pump Station Renovation, Pump Station Expansion, Lift Station, Booster Pump Station
INTRODUCTION

Publically owned potable water and wastewater pump station renovation projects present a series of unique circumstances that must be considered and properly addressed. These facilities are critical, in-service infrastructure. Key factors to consider in the planning, design, and construction of these types of pump stations are discussed herein.

Planning Phase Considerations

During the planning phases of the project is the right time to evaluate big picture issues and set the course of what needs to be done, how the project will develop, and how the facility will be used upon completion of the work. A pump station becomes a prime renovation candidate when it is projected to no longer meet at least one of the following criteria: required capacity, efficiency goals, remaining useful life, and/or code compliance. Often the primary concern is coupled with several other factors raising the need to a point where the project gets funded.

As a project develops from planning through start-up there are a number of details to be addressed. Developing a dynamic document to capture the needs, evaluations, and conclusions along the way is a good way to keep multiple groups of interested people current on the project progression and to keep the prime team focused on the task.

Identify Capacity Needs

One of the first and most important things to do in a renovation project is to evaluate the pumping capacity needs for the pump station. The required pumping capacity needs to be considered in terms of total and firm capacity. The total capacity is the amount of water or wastewater the pump station can convey while the firm capacity is the pumping capacity excluding the largest capacity unit.

It is common to prepare capacity projections at five year increments up to 20 years into the future and also look at capacity needs at ten year increments up to 40 or 50 years into the future. The 20-year flowrate projections are a key consideration for equipment selections, since this is a typical design life for pumping units. Longer term projections are useful in planning structural needs. Piping should be sized based on initial pumping rates, keeping in mind long term capacity needs.

Investigate for Hazardous Materials

Special environment hazardous materials may exist in aged pumping facilities. Lead paint and friable asbestos are two of the more common materials of concern. Preliminary studies and sampling of the facilities can be useful during the planning phases of a project to determine if special measures will be required and to plan for related removal or abatement costs.

Evaluate Structural Condition

During the planning phases an evaluation of the structure should be performed unless the capacity evaluation coupled with the existing structure configuration requires a new facility. Items to look for are settling, cracks in walls, corrosion, sagging, and other signs of compromised structural components.

Determine Asset Criticality

A criticality analysis should be performed on the facility to be renovated. This type of analysis can be broken down into several logical steps that are sequentially evaluated.

The process begins by preparing a list of each asset in the facility. Typically, connected assets can be treated as a combine asset. For example, a pump and motor can be considered as a complete pumping unit. Then consider each asset and determine what would happen to the operation of the facility if that
unit were to fail. For components that result in an unacceptable condition, such as loss of potable water system pressure or a sewer overflow, consider how quickly the impacts will become a problem.

With immediate consequences, evaluate ways to put redundant infrastructure in place. For delayed consequences, evaluate what can be done to monitor and respond to such a failure. This might involve stocking spare parts, automatic fail-over controls, manual operation of equipment, or other protections.

Also, for critical infrastructure, determine what the common modes of failure are, and develop monitoring plans for equipment degradation as part of the standard operating procedures. Take action prior to failure occurring. For non-critical infrastructure, running the equipment to failure might be an acceptable standard operating procedure.

Set Efficiency Goals

Pumping stations generally present several opportunities to implement high efficiency equipment. Sometimes higher efficiency equipment costs more initially but are economically favorable over time. Consideration of how efficiency goals support sustainable organizational goals should also be considered. Some common components that fall into this category include electrical gear, motors, pumps, and monitoring and/or control systems, such as SCADA systems, that can make operations more efficient.

Analyze Renovation Costs

During the planning phase a project budget should be established based on what is known at this phase of the project. Since there are a number of details that have not been investigated and solutions are still in the conceptual stage it is common to include a large contingency in the project budget. The range of contingency may be 25-40% depending on the complexity of the project, degree of planning development, and volatility of the materials and construction market.

Prepare Timeline for Project

In addition to preparing project budgets it is important to develop realistic timelines for design, permitting, bidding, construction, and start-up. As a facility is approaching capacity, efficiency, or end of life concerns, it is important to begin more detailed work on a schedule that allows the renovated facilities to be placed in service, right-timed with the need. Include contingency float time in the schedule because complex renovation projects generally get delayed more often than they get completed early. When projects must be accelerated or fast-tracked, costs are typically higher or speed pressure may lead to poor quality workmanship.

Design Phase Considerations

Because designing for the renovation, retrofit, and rehabilitation of existing infrastructure is typically more complex than design of new facilities, a higher level of attention and expertise is needed to develop a successful project. Some key factors concerning the design of municipal pump station renovations are discussed below. The design phase of complex projects is sometimes sub-divided into preliminary design and final design phases. However, herein the key aspects of design are not segregated.

Evaluate Pump Duty Conditions

With pump station renovations, suction conditions and discharge conditions should be evaluated for several key reasons. Adverse suction conditions can lead to premature pumping equipment failure, and as such should be evaluated with the new pumping equipment.

Also, the piping configuration and pipe roughness may have changed since the original equipment installation, so even when the capacity is not being changed in the renovation project, the system should be evaluated and pumping equipment duty conditions should be properly selected to maximize pumping
efficiency and pump life. With new piping, pipe roughness factors are well documented; however, on existing systems, there can be a very wide range of effective roughness factors that need to be determined. Field testing can help calibrate existing field conditions of the piping system.

Building Code Review

When renovating a facility, code officials will often require the facility to brought up to current building code requirements. A code review early in the design phase should be performed so that necessary code issues can be addressed in the renovation design. In North Carolina, the North Carolina Building Code references the National Electric Code (NEC) which also references the National Fire Protection Association (NFPA) requirements. NFPA requirements for wastewater pump stations include key electrical, ventilation, and separation requirements that should be evaluated and addressed if needed.

Also be sure that new electrical panels and new materials installed near existing electrical panels, allow adequate code clearance dimensions to be met.

Regulatory Compliance Review

In addition to a code review, a review of regulatory requirements should be performed. These reviews should include environmental requirements as well as safety requirements.

Physical Modeling of Non-standard Hydraulic Situations

In recent years the Hydraulic Institute and pump manufacturers have invested heavily in evaluating pump suction recommendations. With pump hydraulics there are very few specific recommendations that will guarantee long pump life and minimal maintenance; however, there are a number of factors, when properly combined, are believed to contribute to lengthening pumping equipment life.

The ANSI/HI standard 9.8, Pump Intake Design, is a good reference for wet well and piping configurations. When non-standard hydraulic situations are encountered, physical modeling can be an effective method to identify deficiencies and develop solutions to mitigate negative physical and hydraulic influences.

Verify Important Dimensions

During the equipment design development it is easy to overlook how the equipment will be installed. Consideration should be given to the lift capabilities of weight handling equipment and the ability to maintain vertical lifting of heavy equipment for installation and maintenance.

Also, doors, hatches, and floor penetration dimensions should be checked to make sure that electrical equipment and pumping units can be installed without unplanned modifications. Also, access to valves and equipment for installation, maintenance, and removal should be considered. For equipment with access doors, the door swing paths should be checked for adequate clearances.

Protecting Micro-Electronics

Modern controls frequently introduce micro-electronics into pump stations. Pump stations tend to be a moist and harsh environmental condition for micro-electronics. When possible, separate electrical equipment from pumping rooms to prevent damage from moisture and harmful gases.

When variable frequency drives are used, consider installing this sensitive equipment in a conditioned space. Although they may be rated for high temperature environments, the author believes that a conditioned environment is desirable for long-term, reliable service.
Construction Phase Considerations

Constructing pump station renovation projects requires extensive attention to details. Since most publically owned pump stations must remain in service during the renovation construction, special provisions are required to complete the work successfully.

Develop Stand-by Pumping Plan

In some cases there are other permanent facilities in place to maintain pumping needs. But in many cases bypass pumping is required for a portion of the construction phase.

A good bypass pumping plan starts with identifying the required capacity and firm capacity needs. Often the bypass pumping system needs to be sized for peak flows, but there are other situations where conveying peak flows may not be necessary due to other facilities.

Space on the site for temporary equipment and corridors for piping routes should be identified. Consideration for the type of pumping equipment should be coordinated with available space, suction lift, and other key factors.

A detailed design of bypass pumping plans should be performed prior to installation. Once the temporary system is installed the piping, pumping equipment, and controls should be proof tested prior to removing the permanent facilities from service.

Considerations should be given to the need for full-time monitoring of the bypass pumping equipment. In some cases, remote monitoring may be adequate. In all critical pumping installations, around the clock manning of the system should be provided and equipment monitoring should be documented.

Because most bypass pumping is wastewater related, special precautions should be used when selecting equipment and installing it in a potable water system. Compliance with public health regulations is imperative.

Locate Embedded Power and Controls

Power conduits are typically installed on the face of concrete and masonry walls, but may be run through wall cavities or imbedded in walls. Power conduit is often run under concrete slabs on grade. Caution should be used when cutting floors or walls where concealed power and control wiring may be routed. Make sure concealed conduits are identified and power is removed prior to creating or modifying penetrations.

Coordinate Outage Plans

During the renovation of a pump station there are often times when the facility needs to be completely or partially removed from service. Short outages may be needed for piping connections, electrical connections, or other various rehabilitation tasks. For long outages more extensive planning, such as bypass pumping might be needed.

The tolerable seasons of the year, times of day, and durations of outages should be clearly identified so that the contractor can plan accordingly. The outage plan should include at least the following components: commencement time, expected duration of outage, equipment and tools needed, and a contingency plan if unexpected events extend the duration of the outage. Adequate notice should be given to the facility operators so that they can plan accordingly.

Proof Testing Equipment

Critical pump station equipment and controls should be factory and field proof tested. Most major equipment should be factory tested to verify proper operation and performance. Once installed in the field
in-place performance should also be evaluated. For pumping equipment this may include flow and pressure testing. For electrical systems test might in include load testing and connectivity testing.

**Verify Proper Operation of Controls and Alarms**

In addition to proof testing the individual equipment units interconnected local controls and alarms, remote monitoring, and remote controls should be verified to confirm proper operation. This can be accomplished by preparing a check-out matrix and simulating various set-points and component failures to make sure the pump station responds as expected. For example, a wastewater pump station with a primary level control system with back-up float switch controls might be tested by unplugging the primary level device and seeing if the float system takes over and properly controls the system.

**Coordinate Material Storage**

During construction, the contractors will need layout space and in many cases storage area in a secure and protected environment. At the same time, system operators need to maintain operation of the facility and maintain access to items that need regular monitoring and maintenance. Since these factors will affect how the contractor approaches the project, any limitations should be described in advance of the work. Coordination of contractor personnel and operations staff is an important aspect of completing the work successfully.

**Special Protections of Equipment and Structures**

During renovation work, it is common for building walls or site fencing to be temporarily compromised for performance of the work. Temporary measures should be defined to maintain security as well as temperature and moisture protection of the pump station.

Also, certain aspects of the renovation will create dust and debris. The impact of introducing foreign materials into the air should be considered. Adequate protection of motors, controls, and electrical gear should be provided.

**Arc Flash Analysis**

With new equipment installed prepare an arc flash study in accordance with NFPA 70E, *Standard for Electrical Safety in the Workplace*, and IEEE 1584, *Guide for Performing Arc-Flash Hazard Calculations*, should be performed. Such a report should include a short-circuit study, protective device coordination study, and an arc flash hazard analysis. The report will define arc flash signage that should be affixed to certain electrical panels and personal protective equipment that should be utilized by workers.

**SUMMARY**

Renovation of publically owned pump stations can be complex, but being knowledgeable about issues that need to be addressed allows the project to be broken down into smaller logical tasks. When each task is properly addressed the result can be a well-coordinated and successful pump station renovation project.

**ACRONYMS**

ANSI – American National Standards Institute

HI – Hydraulics Institute

IEEE – Institute for Electrical and Electronics Engineers

NEC – National Electric Code
NFPA – National Fire Protection Association
SCADA – Supervisory Control and Data Acquisition