Dispelling the Myths: Right Sizing a Wastewater Lift Station for Function and Energy Efficiency

The City of Westminster's 87th Ave. and Wadsworth Blvd. lift station was at the end of its useful life and the City was concerned about its reliability. Additionally, the lift station was experiencing problems with infiltration, was located within CDOT right-of-way next to a busy street and below the 100-year flood elevation, and provided minimal storage in the event of pump failure at peak flow rates. Furthermore, the constant-speed pumps had up to a maximum of 154 starts within a 24-hour period and the lift station was not located within the City of Westminster.

As a result of a site alternative analysis, the design of the replacement lift station and redundant forcemain was at a new location, in the parking lot of an adjacent commercial business area. The project team toured other lift stations and worked together to come up with goals for the new lift station. These included:

- Reducing pump station starts.
- 1 to 2 hours of overflow storage at peak flow rates.
- Remote automated operation through SCADA.
- An energy-efficient pump station with redundant forcemain and the ability to isolate flow to a single side using manual gates. This would allow one side to be shut down for maintenance without taking the lift station out of service.
- A passive overflow port in the dividing wall would ensure that the maximum storage volume of both sides of the wetwell would be used before overflowing to the emergency overflow tank. A 45,000-gallon buried fiberglass emergency overflow tank was designed to fill and drain by gravity, with a manual valve on the drain line preventing it from filling, except in an emergency situation.

Several automated programs were installed to ease operation of the lift station and maximize energy savings. The normal operating mode would be Energy Efficiency Mode, which varies flow to maximize the wetwell level and reduce pumping head. This mode also produces a high-flushing velocity when the pump starts to help clean out the wetwell and forcemain once a day. The combination of this program and the energy efficient pumps on VFDs has reduced the power bill by 42 percent compared to the previous energy costs of the retired lift station. In addition, the average pump starts per day have been reduced from 50 to 2-3, without any clogging issues.
INTRODUCTION

Infrastructure in the 21st Century

By Tim F. Taylor, PE
(taylor@carollo.com)
Director of Infrastructure Practice

Over the course of the last century, many municipalities across the United States have developed and expanded their water and wastewater systems to meet the needs of growing communities. These systems include both treatment and the required infrastructure to convey either domestic water to the customers or back to the wastewater treatment plant prior to discharge. As such, the infrastructure facilities currently in place are rapidly nearing the end of their service life. While it might be an inconvenience to the average person, it can also cause financial impacts on the business communities.

Aging Infrastructure Requires $$$

Once every 4 years, the American Society of Civil Engineers (ASCE) provides a comprehensive assessment of the nation’s major infrastructure categories in ASCE’s Report Card for America’s Infrastructure (Report Card). The last Report Card (2013) gave America’s drinking water facilities a “D” grade and wastewater facilities a “D” grade as well. Understanding that a “D” grade is not really the bar that everyone is shooting for, we know that each and every one of us is doing everything in your power to push that grade to a higher level. With that push comes a significant cost. The Environmental Protection Agency (EPA) reports to the U.S. Congress on a 4-year cycle the water and wastewater needs across the U.S. In 2008, the EPA reported that approximately $146.6 billion would be required to meet the wastewater infrastructure needs over the next 20 years. The EPA is currently finalizing the 2012 Wastewater Needs Assessment and is scheduled to report these revised needs to Congress in 2013. In 2011, the EPA reported that approximately $281.6 billion would be required to meet the water infrastructure needs over the next 20 years. Adjusting for inflation to 2015 dollars, the total water and wastewater infrastructure needs across the U.S. exceed $488 billion over the next 20 years. That is a staggering $24.4 billion per year to address the aging infrastructure needs in the water industry.

Communities Tackle Tough Challenges

There are a number of key challenges that communities must face each year. Those challenges can vary depending on geographic location. For example, there are many communities that have combined sewer and storm systems that were not designed to accommodate the extreme weather events that are becoming more common. Many communities have made important progress in adopting key provisions of the CSO control policy. However, according to the EPA, only about 33 percent of these communities have implemented all of the nine minimum controls, and even fewer have adopted long-term control plans. The EPA has estimated that current efforts have reduced CSO volumes and pollutant loads by approximately 12 percent since 1998. There is still much work to be done to improve water quality and meet regulations.

Planning and design challenges presented by CSOs can vary significantly. CSOs contain a variety of pollutants, vary in volume and frequency, and result in a myriad of impacts on receiving waters. To compound matters, there is also a wide range of available control measures with a wide range of associated costs. Effective abatement strategies must consider site-specific conditions and match technology with economic issues and water quality impacts. While Carollo is well known for its technical excellence on the treatment side of the water industry, Carollo’s Infrastructure Practice provides that same level of technical and project management excellence. The Practice is gaining momentum, demonstrating to our clients that we can and, in fact, do infrastructure projects focused solely on the water industry. Here at Carollo, we define “infrastructure” as the pipelines, pump stations, and reservoir facilities outside the fence of a treatment plant that all of our clients are operating and maintaining. It is my pleasure, as Carollo’s Infrastructure Practice Director, to showcase a few of our infrastructure projects in this special edition of Research Solutions. Specific project highlights include:

- Santa Clara Valley Water District, CA – Seismic Project
- Cascade Water Alliance, WA – Lake Tapps Lower Conveyance System Condition Assessment and Emergency Repairs
- Clark County Water Reclamation District, NV – Paradise-Whitney Interceptor Project
- City of Omaha, NE – Miller Park CSO Separation Project
- City of Westminster, CO – Lift Station Improvements Project

As you can see, the infrastructure needs in the water industry are truly the next item on the list that must be addressed. Ignoring them is not an option, but figuring out unique solutions to maximize your dollars is our way of assisting you in meeting those challenges and keeping your customers content in the long run. We have worked extensively with cities, public utility districts, and local neighborhood groups to implement infrastructure projects that meet public expectations. We match infrastructure rehabilitation/repair/ replacement technologies to each specific project for successful results. We find the combination that works best for your project. As you read this “Infrastructure” special edition of Research Solutions, please take note that we understand the unique needs of infrastructure projects and are always ready and willing to discuss your challenging project.
The most important project objective is to retrofit the existing pipelines to protect the life-safety of nearby residents and the Noble Elementary School. The Landslide toe and 72-, 66-, and 60-inch pipelines intersect in a densely populated area. The deformation at the toe during the design seismic event is estimated at 7.7 feet and will subject the pipeline to compression movement.

A Novel Solution to a Unique Problem: Large Diameter Pipeline Seismic Retrofit Mitigates Landslide Hazard

By Darren Baune, P.E. (dbaune@carollo.com), Lou Carella, P.E., Mike Dajik, P.E.

The Santa Clara Valley Water District (District) initiated the Penitencia Delivery Main and Penitencia Force Main Seismic Retrofit Project to improve the seismic resilience of three critical water supply and delivery pipelines that serve the District’s Penitencia Water Treatment Plant (WTP) in San José, CA. The most important objective of the project is to retrofit the existing pipelines to protect the life-safety of nearby residents and the Noble Elementary School.

The 66-inch Penitencia Force Main (PFM), 60-inch Penitencia Delivery Main (PDM), and 72-inch South Bay Aqueduct (SBA) cross from a stable geologic zone onto the slow-moving Penitencia Creek Landslide (Landslide) near the Penitencia WTP. The Landslide is actively creeping and is susceptible to large seismic deformations. The project team estimates the Landslide displacement as 7.7 feet (seismic) and 1.7 feet (creep), for a total displacement of 9.4 feet over the 50-year design life.

Seismic Hazard Evaluation estimated the displacement at 9.4 feet over a 50-year period. The Landslide is actively creeping and is susceptible to large seismic deformations. The project team estimates the Landslide displacement as 7.7 feet (seismic) and 1.7 feet (creep), for a total displacement of 9.4 feet over the 50-year design life.

Specifically, the finite element modeling was used to predict joint rotations, moment forces, pipe stress, and axial compression. The modeling was critical to selecting the final design option which uses sleeve joints in the areas of high deformation.

The project team developed a sophisticated 3D model of the Landslide and pipeline interactions using Abaqus software to estimate pipe stress, joint rotation/compression, and overall system performance during the Landslide. The modeling found it is necessary to install the ERDIP in non-standard lengths (i.e., shortened) and to use collar joints in key locations to prevent over rotation and reduce pipe joint stress. The collar joints provide 12 inches of compression capacity and 16 degrees of rotation.

The project includes the following key innovations:

- **Full-Scale Testing of Joint and Collar Performance.** A full-scale test of the 60-inch pipeline was performed during design to verify the maximum rotation and moment capacities. A second full-scale test of the 72-inch collar joint is scheduled for August 2015.

- **Design for Large Landslide Displacement.** The Landslide and Seismic Hazard Evaluation estimated the Landslide displacement as 7.7 feet (seismic) and 1.7 feet (creep), for a total displacement of 9.4 feet over the 50-year design life.

- **Sophisticated Finite Element Modeling.** The project team developed the design with a sophisticated 3D model of the Landslide and pipeline interactions.

- **Novel Application of Earthquake Resistant Ductile Iron Pipe.** There have been three “pilot project installations” of small-diameter ERDIP in the United States to date; however, the 60-, 66-, and 72-inch pipelines will be the first large-diameter installation of ERDIP in the U.S.

- **ERDIP Performance.** ERDIP has been used in Japan for critical infrastructure for the past 50 years and has a proven track-record of no failures through several large earthquakes. There have been many innovative projects to harden pipelines at perpendicularly fault crossings. This project includes unique challenges of designing large displacement along the axis of the pipelines which loads the pipelines in compression. This project also has a high visibility within the community because of the risk of failure and proximity of the project to a residential neighborhood. Design of the project will be completed in December 2015; construction is scheduled to start in 2016 and be completed in 2017.

Acknowledgements

A very special thanks to the Santa Clara Valley Water District and the following key subconsultants: Degenkolb Engineers (pipeline and landslide finite element modeling), Leroy Consultants International (seismic expertise and geology), and Cal Engineering and Geology (seismic expertise and geotechnical engineering).
Addressing Emergency Projects Identified during the Condition Assessment Can Be Challenging

By Tim F. Taylor, PE. (ttaylor@carollo.com), Lara Kammoreck, PE, PMP

Introduction
Cascade Water Alliance (Cascade) provides safe, clean, and reliable water supply to seven municipalities (five cities and two water and sewer districts) in the Puget Sound Region (Washington) and serves approximately 350,000 residences and more than 20,000 businesses. Starting in 2019, Cascade’s largest domestic water supply source, wholesale water from Seattle Public Utilities (SPU), will be reduced, thus requiring new sources of water for Cascade.

In 2009, Cascade purchased the White River Project from Puget Sound Energy (PSE) with the full expectation that the water rights could and would be converted from a hydroelectric and recreational water right to a domestic and recreational water supply.

The White River Project historically operated as a hydroelectric power generation facility from its construction in 1911 until being decommissioned in 2004. The project consists of an upstream flow diversion headworks facility that diverts flow out of the White River to fill Lake Tapps and the Lower Conveyance System (LCS) facilities. These facilities provide flow out of the lake and drops approximately 520 feet in elevation prior to discharge back into the White River. Since hydroelectric power is no longer generated, the LCS provides emergency discharge capabilities up to 900 cubic feet per second (cfs) as well as discharge at a rate between 10 and 50 cfs to maintain the lake level.

The current condition of the Lake Tapps LCS facilities has been of concern since being purchased. The Lake Tapps LCS consists of:

- A concrete Tunnel Intake Structure with associated trash rack and vertical steel head gate.
- A 2,780-foot long by 12-foot inside diameter concrete tunnel with a “Bear Trap” overflow structure.
- A 30-foot diameter concrete Forebay Caisson structure with vertical cast iron slide gates.
- Four 8-foot diameter riveted steel penstocks approximately 2,370 feet in length.
- Associated stand-pipes, air release chambers, surge towers, and valves.
- A powerhouse building and associated turbine facilities.
- A Tailrace Discharge Bay consisting of concrete construction and discharge piping.
- An earthen trapezoidal Tailrace Channel approximately 2,100 feet in length.

Addressing Aging Infrastructure
Substantial capital improvements are necessary to convert the over 100-year-old hydropower facility to a water supply project. The Carollo Team’s initial work has been focused on ensuring that the existing facilities can operate under conditions that the facilities were not originally designed for, as well as under a wide range of flow conditions.

Under Phase 1 of the project, Carollo developed a short- and long-term operational strategy to identify which facilities are crucial for operations and what the long-term operational facilities may look like. Phase 1 was followed by a boots-on-the-ground strategic condition assessment (Phase 2) to evaluate the physical conditions of the necessary operational LCS facilities.

Condition assessment field inspections of the LCS facilities required the lake to be drawn down almost 40 feet, which was a 2-month process alone. Additionally, the Carollo field personnel conducted an intensive 2-week inspection of the facilities in December 2014. The inspections identified immediate rehabilitation and replacement projects that were required at the intake structure and in the discharge bay, as well as other urgent (0 to 1 year), near-term (5 to 10 years), and long-term needs (25+ years).

Cascade recognized the fact that the immediate projects must be designed and constructed prior to refilling the lake, as access to the facilities would pose a real challenge with water in the lake. Additionally, it was evident that a typical Design/Bid/Build approach would not be an acceptable approach to address the immediate projects. To save time, Cascade and Carollo outlined a hybrid Design/Build approach. Cascade hired a contractor and steel fabricator under separate contracts, and coupled with the Carollo design team, banded together to assist with the emergency design projects. With the lake refilling to begin by mid-April 2015, the team had just 3 months to complete the project from design through fabrication and construction. The immediate projects included a new trash rack, fill gate, stop logs, concrete rehabilitation, and replacing severely dilapidated wood decking at the Tunnel Intake Structure.

The team was challenged by the tight schedule combined with the site and design requirements of some of the large components. For example, the existing 45-foot wide by 55-foot tall steel trash rack had to be dismantled by crane, all new structural members fabricated at a local steel shop, galvanized at one of the largest galvanization shops on the West Coast, and all components delivered to the site and installed by crane.

Thanks to the efforts and skill of the entire project team, work on the Trash Rack replacement was completed successfully by mid-March 2015. Due to the on-time completion, Cascade was able to begin refill as scheduled.

The Tunnel Intake Structures Trash Rack was severely deteriorated and in desperate need of replacement.

Damaged concrete and steel in the Powerhouse discharge piping area was a major concern for Cascade.

The project team was able to design, demo, fabricate, and install the new trash rack within a 3-month window.

All items normally underwater were thoroughly assessed and repaired/replaced prior to refilling the lake.
The Paradise-Whitney Interceptor Project (PWI) for the Clark County Water Reclamation District will relieve capacity deficiencies for the existing sewer interceptors, improve hydraulic operating conditions for sections of the existing interceptors, and provide capacity for the future 2044 peak hour wet weather flow (PHWF) of 86.4 MGD. The whole PWI project consists of approximately 7,102 linear feet of 48- to 84-inch diameter sewer interceptor and was divided into three design packages, as shown in Figure 1.

Carollo’s design package is located on the downstream end connecting to the existing 84-inch Flamingo Road Relief Interceptor, another project designed by Carollo in 2008. Project No. 669 (Package 2) was the first of the three packages out to bid. It included design and construction of 27,138 linear feet (LF) of new sanitary sewer interceptor with an average depth of 25 feet, utilizing trenchless methods for eight reaches totaling 13,483 LF, see Figure 2. The inside diameter of the interceptor ranges from 60 to 84 inches; some with 76-inch steel casing, and includes 12-, 13-, 24-, and 48-inch lateral pipeline tie-ins. Construction of this project began in late 2014 and is expected to take over 2 years to complete with a total bid price of $62.3M.

Unique features include corrosion-resistant fiberglass reinforced polymer mortar pipe (FRPM) and polymer concrete manholes.

Challenges

The project presented numerous design challenges, including: community and permitting, business impacts, utility coordination and permitting, traffic control, hydraulics and connection points, complicated geology, close proximity to existing underground utilities, limited surface access, high groundwater, dewatering-induced potential settlement (up to 6 inches), and other factors forcing trenchless drive lengths up to 1,500 ft. The tunnels are constructed utilizing trenchless methods that include earth pressure balance machines (EPBM) and microtunneling (MTRM), while ground improvement was required on many of the drives.

The EPBM is manned at tunnel face and conditioning is performed to create soil plug in the screw auger to maintain stabilizing pressure at face to counterbalance earth and water pressure. Spoils are removed via screw conveyor. The MTRM operation is remote controlled. Continuous face support is achieved through fluid pressure balance. Spoils are removed via a closed-loop slurry system. There were two types of tunnel installations: single-pass (direct jack FRPM) and two-pass construction, which included jacketing of a larger diameter steel casing with later installation of the FRPM carrier pipe.

Although the PWI was divided into three separate design packages, the District wanted consistency between the contract documents for all three packages for ease of contract administration. This also presented significant challenges during the design phase. Per the District’s request, drawings, details, specification organization, the geotechnical baseline report (GBR) format and baseline statements, and overall contract language needed to be consistent for all three packages. The three design consultants needed to collaborate in partnering style in order to produce a seamless contract document presentation, while incorporating package-specific design constraints to address wastewater bypassing, dewatering, traffic control, and tunneling. Since this project was the first one going out to bid, our design team needed to efficiently streamline this process.

Pipe Material Evaluation

An evaluation of pipe materials was conducted as part of the design phase. Pipe materials for the PWI was estimated to represent 35 percent of the total project cost, and represents the single largest factor that will affect the overall durability, serviceability, and life-cycle cost. Therefore, the Clark County Water Reclamation District requested that the design teams from each package coordinate to make a recommendation for the PWI pipe material. The District also requested that pipe used for the PWI be on the District’s Approved Materials List. The result was conducting an evaluation of several pipe materials, including ASTM D1326 FRPM ASTM F984 Polyvinyl Chloride (PVC) closed profile pipe, ASTM F984 Polyethylene Wall Pipe (HDPE), ASTM 2764 Polyethylene Triple Wall Pipe, ASTM C76 Lined Reinforced Concrete Pipe (RPC), and ASTM D6783 Polymer Concrete Pipe (PCP).

Some considerations in selecting pipe material included: available size range (diameter/joint length), handling load capacity, dead and live load capacity, jacketing stresses, special installation requirements, history of adequate performance, service life (50+ years minimum), hydraulic smoothness, corrosion protection capabilities, ease of maintenance, and pipe production rates. Based on the results of this evaluation, the teams recommended that FRPM be specified for use on the large diameter portions of the PWI project.

The geotechnical subsurface conditions were the largest design challenge on Project No. 669. Brierley Associates was engaged by Carollo early in the design phase due to the anticipated trenchless component of the project. This early involvement allowed input to the subsurface investigation, which was beneficial to the trenchless design. Project No. 669 encountered complicated geology including highly interbedded, but discontinuous, layers of clays, silts, sands, some caliche (layers 7.5 feet thick), shallow groundwater, and sensitive (soft) soils. The number of proposed trenchless sections within the project is the result of the pipe depth dictated by grade requirements, dewatering restrictions resulting from dewatering-induced settlement potential, avoidance of conflicts with other subsurface utilities, minimization of surface disruptions, and reduced public impacts. Some of these considerations contributed to the trenchless treatment and disposal; therefore, the alignment in that vicinity was designated as trenchless with the requirement for watertight shafts.

Additionally, dewatering-induced settlement using laboratory consolidation tests and traditional one-dimensional consolidation theory was evaluated by the geotechnical subconsultant. The result of the analysis indicated dewatering-induced settlements up to 6 inches could occur within the roadway right-of-ways during construction dewatering, see Figure 3. The project alignment traverses through densely populated residential and commercial areas and through highly traveled streets. Settlement in these areas was unacceptable, resulting in several portions of the alignment that were originally designated as open-cut construction to be converted to trenchless construction. The dewatering-induced settlement in these areas limited construction alternatives for shafts and tunneling methods. Eleven of the 24 total shafts were required to be constructed using watertight means. Many tunneling methods became impractical due to the dewatering restrictions and high groundwater table. The dewatering-induced settlements results also dictated a 90-day limit for dewatering at any one well location for much of the remaining open-cut alignment.

Presently, the PWI is approximately 50-percent complete. Many of the challenges we have faced during the design phase and into the construction phase have been solved by a collaborative effort between all three design teams. This allowed for all three design packages to maintain a common approach, appearance, and resolve as directed by the District, while addressing project-specific constraints.

Some solutions would have resulted in costly groundwater monitoring and dewatering-induced settlement modeling results.
Taking Advantage of Existing Infrastructure and Its Hidden Water Quality Benefits

The City of Omaha’s “Clean Solutions for Omaha” (CSO) program’s goal is to reduce combined sewer overflows and to improve water quality in the Missouri River and Papio Creek. One of the projects from the CSO program was the Miller Park to Pershing Sewer Separation Project. The project is located in the Minne Lusa Basin of the Missouri River Watershed in a combined sewer service area. Historically, both the storm and sanitary flows were directed to the 12-foot semi-circular Minne Lusa Trunk Sewer which conveyed the combined flows downstream and eventually to the Missouri River Wastewater Treatment Plant.

“...the Miller Park to Pershing Project was one of the first projects completed under the City’s CSO Long Term Control Plan, and has already helped reduce the volume of sewage that overflows to the Missouri River when it rains. The Project team completed a very complex project and helped bring it on time and under budget.”

Jim Theiller, CSO Coordinator, City of Omaha, NE

A previous project undertaken by the City separated the sewers upstream from Miller Park Lake. At the completion of that project, the separated sanitary flows were directed to the Minne Lusa Trunk Sewer and storm flows were directed through new piping to Miller Park Lake. As storm flows entered the lake, they were dampered and stored until they reached the normal pool elevation of 1,015 feet, which was set by a single-stage weir in the existing control structure. Flows above the normal pool elevation flowed over the weir and were directed through the control structure back into the Minne Lusa Trunk Sewer. Additionally, the lake incorporated a 45-foot wide emergency spillway set at an elevation of 1,019 feet.

To eliminate the stormwater flows from entering the Minne Lusa Trunk Sewer, the following project goals were identified:

- Design a lake overflow conveyance stormwater sewer from Miller Park Lake to the Pershing Detention Pond to accommodate a 100-year, 24-hour storm event.
- Eliminate lake discharges from entering the combined sewer system.
- Maximize the use of the existing lake storage in an effort to minimize the size of new infrastructure.
- Utilize existing infrastructure where practical.
- Incorporate Green Infrastructure where economically feasible.

To meet these goals, the system was modeled dynamically using the 10-, 25-, 50-, and 100-year 24-hour storm events (SCS Type II rainfall distribution) to determine the stormwater inflow from the upstream storm sewer and drainage area surrounding the lake. Storage was calculated assuming that the water level in the lake was at the normal pool level of 1,015 feet, and that during the 100-year, 24-hour storm the emergency spillway was not engaged. With these criteria set, the varying storm flow into the lake and the available lake storage was dynamically modeled to define the outlet and conveyance piping parameters, while preventing spillway discharges during the storm events. In addition, a series of back-to-back storms were also modeled to analyze the impacts that antecedent moisture has on the stormwater inflow volumes. During the analysis, it was determined that a multi-stage weir was deepened and better controlled the discharge flows from the lake while maximizing the available storage. The results of the dynamic modeling are summarized in Table 1.

The analysis revealed that during a 100-year storm event, 874 cfs of stormwater was removed from the Minne Lusa Trunk Sewer, and utilizing the available storage in the lake and a multi-stage weir system, the discharge from the lake to the Pershing Pond was limited to 234 cfs.

The existing Miller Park Lake incorporated a membrane liner which would prohibit the use of piles (for a cofferdam) to construct a new multistage outlet structure without draining the lake. Draining the lake would have several negative effects, including the loss of the use of the lake during construction (construction would need to be weather-dependent or stormwater entering the lake would need to be removed, loss of aquatic life including fish, and negative visual impacts to a park area which encompassed the lake). A detailed analysis determined that the existing outlet structure could be modified to operate as a multistage weir system to optimize lake storage and direct the flow to the new conveyance pipeline. More importantly, the modifications to the existing structure could be completed without draining the lake.

The discharge from the outlet structure was to be directed to the Pershing Detention Pond, which is a wetlands area that drains to the Missouri River. The conveyance sewer route from the Miller Park Lake to the Pershing Detention Pond is approximately 2,100 feet. With the use of the multistage weir system and associated optimization of lake storage, the conveyance sewer diameter was minimized. The selected conveyance sewer size was a 60-inch RCP. The sewer was installed using a combination of open-cut and trenchless methods. The trenchless reach was a single drive of 1,300 feet with earth cover that varied from 45 feet to only a few feet near the jacking shaft. The reception shaft was located at the upstream end of the trenchless portion, in an older suburban neighborhood with narrow streets and existing utilities. The jacking shaft was located at the downstream end of the drive where it day lighted through a bluff into the Pershing Detention Pond. The limited work area and congested underground utilities at the upstream end required that the jacking shaft be located at the downstream end. Steep topography and shallow earth cover resulted in challenges for constructing the jacking shaft and for creating adequate thrust capacity. To minimize the potential for scour and damage to the wetlands, an energy-dissipating structure was utilized to calm the discharge prior to the wetlands.

Additional opportunities to remove stormwater from the combined sewer system were identified along the conveyance sewer route. This was accomplished by removing street inlets from the combined system and connecting them to the new stormwater pipe between Miller Park Lake and the Pershing Detention Pond. This separation resulted in removing another 155 cfs from the combined system. Due to the dampening effect of the Miller Park Lake storage and the use of a multistage weir, the 60-inch pipe was adequate to convey the additional 155 cfs without causing backwater effects.

Multiple water quality benefits were realized as part of this project. The first and most obvious is removing the stormwater from the combined sewer system. Removing this water resulted in minimizing the occurrence of CSOs, and reduced the volume of water to be conveyed and treated at the Missouri River WWTP. Maximizing the use of the Miller Park Lake storage volume resulted in water quality improvements by providing suspended solids and contaminant removal, while minimizing the downstream infrastructure. Finally, discharging the water into the Pershing Detention Pond prior to the Missouri River also provided an additional opportunity to improve the water quality by utilizing the wetlands to further reduce the contaminant loading prior to discharge to the Missouri River.

Table 1. Dynamic Modeling Results

<table>
<thead>
<tr>
<th>Storm Event</th>
<th>Stormwater Inflow to the Lake</th>
<th>Outflow from the Lake</th>
<th>Lake Water Surface</th>
</tr>
</thead>
<tbody>
<tr>
<td>10 yr., 24 hr. storm</td>
<td>720 cfs</td>
<td>133 cfs</td>
<td>1016.7</td>
</tr>
<tr>
<td>25 yr., 24 hr. storm</td>
<td>747 cfs</td>
<td>149 cfs</td>
<td>1017.4</td>
</tr>
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<td>50 yr., 24 hr. storm</td>
<td>822 cfs</td>
<td>217 cfs</td>
<td>1018.1</td>
</tr>
<tr>
<td>100 yr., 24 hr. storm</td>
<td>874 cfs</td>
<td>234 cfs</td>
<td>1018.9</td>
</tr>
</tbody>
</table>

Figure 1. Directing the stormwater from the separated sewer area to Miller Park Lake and Pershing Detention Pond dampened the peak stormwater flows and provided water quality benefits prior to discharging to the Missouri River.
Dispelling the Myths: Right Sizing a Wastewater Lift Station for Function and Energy Efficiency

The City of Westminster’s 87th Ave. and Wadsworth Blvd. lift station was at the end of its useful life and the City was concerned about its reliability. Additionally, the lift station was experiencing problems with infiltration, was located within CDOT right-of-way next to a busy street and below the 100-year flood elevation, and provided minimal storage in the event of pump failure at peak flow rates. Furthermore, the constant-speed pumps had up to a maximum of 134 starts within a 24-hour period and the lift station was not located within the City of Westminster.

As a result of a site alternative analysis, the design of the replacement lift station and redundant forcemain was at a new location, in the parking lot of an adjacent commercial business area. The project team toured other lift stations and worked together to come up with goals for the new lift station. These included:

- Reducing pump station starts.
- 1 to 2 hours of overflow storage at peak flow rates.
- Remote automated operation through SCADA.
- An energy-efficient pump station with VFD control.
- No increase in clogging.
- Large hatches for safe access to the buried structures.
- Odor control, redundancy improvements, including a portable generator connection, a quick connect for temporary pump discharge to the forcemains, and the ability to isolate between pumps and forcemains for maintenance limit impacts to the Westminster commercial areas during and after construction.

As a major component of the lift station, the project team focused on getting the right size and correct number of pumps for the new lift station. Through the evaluation of multiple pump sizes and combinations, it was determined that a single pump provides the turn-down from 1,100 to 200 gpm with VFD control. In addition, the new pump horsepower (hp) was reduced to 34 hp, compared to the old constant speed pump horsepower of 47 hp. One pump was provided in each side of the wetwell for duty/standby service. By reducing the size of the pumps, all of the surrounding equipment was reduced resulting in significant capital cost savings.

Another major focus of the project team was the wetwell. A bifurcated wetwell was designed to be able to split flow to each wetwell or isolate flow to a single side using manual gates. This would allow one side to be shut down for maintenance without taking the lift station out of service. A passive overflow port in the dividing wall would ensure that the maximum storage volume of both sides of the wetwell would be used before overflowing to the emergency overflow tank. A 45,000-gallon buried fiberglass emergency overflow tank was designed to fill and drain by gravity, with a manual valve on the drain line preventing it from filling, except in an emergency situation.

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