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# STORM DAMAGE RISK REDUCTION:

## Permanent Canal Closures and Pumps: A Design-Build Overview and Lessons Learned

As presented at the 98th Annual Conference of NC AWWA-WEA

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Figure 1: Aerial photograph of the 17th Street station with major PCCP components labeled. Interim control structures, which are now being removed, are visible in the lower right hand of this photograph. All three stations were designed for the water hydrostatic, boat impact, wave, 200-mph hurricane wind, and unbalanced loads resulting from the stability analysis for each structure.

Hurricane storm damage risk reduction is a significant and growing challenge around the world. In the United States, slower moving and wetter tropical storm events are combining with a surging coastal exposure population to cause more damage than ever before. In 2017, Hurricanes Harvey, Irma, and Maria combined to cause the most expensive year of damage seen in the last 38 hurricane seasons.

Locally, the Carolinas coastal counties – which have more than doubled their population since 1980 – were hit with Category 1 strength winds in 2018, when Hurricane Florence lingered over the area, wreaking havoc with its flood-inducing rainfalls.

Our challenge within the water community should be to share pertinent lessons learned from prior major events such as Hurricane Katrina, which devastated New Orleans in 2005. Here are ours.

Completed in April 2018, the $731-million Permanent Canal Closures and Pumps (PCCP) design-build project represents the final component of the Hurricane and Storm Damage Risk Reduction System (HSDRRS) that serves the greater New Orleans region. This new system included a set of design guidelines that resulted from a top-to-bottom rethinking of the US Army Corps of Engineers (USACE) Gulf Coast levee design approaches, based on lessons learned from Hurricane Katrina.

The City of New Orleans is drained primarily by three outfall canals that flow north from the city into Lake Pontchartrain: the 13,500-ft-long 17th Street Canal, the 11,000-ft-long Orleans Avenue Canal, and the 15,000-ft-long London Avenue Canal. During Hurricane Katrina, rather than draining the city, the 200-ft-wide canals provided conduits for the storm surge to rush into the city through well-documented levee and floodwall failures. This occurred prior to the development of floodwall overtopping conditions.

The three massive pumping stations that comprise the PCCP project are designed to reduce New Orleans's risk of flood surges from Lake Pontchartrain and help the low-lying city maintain its critical drainage flows in the event of a major storm. This system of levees, floodwalls, floodgates, and pump stations is designed to withstand the surging lake levels from a storm that has a 1% chance of being equaled or exceeded each year, commonly known as the 100-year storm.

Among its key project requirements were the stipulated pumping capacities for the three facilities: 12,500 cfs for the 17th Street pumping station, 2,700 cfs for the Orleans Avenue pumping station, and 9,000 cfs for the London Avenue pumping station. The stations had to protect against storm surge to an elevation of 18 ft above sea level as measured by the National Geodetic Vertical Datum, and also plan for key components, such as pump station walls, to achieve a design life of 100 years.

Within this context, here are my top 10 risk factors coastal communities should consider and address in future builds:

Figure 2: Interior of the 17th Street Pump Station showing its array of siphon discharge tubes and combination of blue vertical gear-motors: 2,500 HP motors for the 900 cfs pumps in the foreground and 5,000 HP motors driving the 1,800 cfs pumps in the background.

Figure 3: Bypass gate structure at London Avenue outfall canal site.

### Risk Factor #1 – Develop, Resource, and Charter Strong Teams for D-B Projects.

Design-build projects require each participant to communicate effectively with the entire project supply chain, while focusing on their direct client and contract. The PCCP project was delivered in a highly transparent and collaborative manner. Key representatives of the USACE, Louisiana's Coastal Protection and Restoration Authority, PCCP Constructors, and Stantec's design team were co-located in New Orleans to build a cohesive project delivery team, facilitate communication, and rapidly address questions, concerns, and issues in real time. Stantec also used a distributed design delivery model that included some 500 team members from more than 50 offices across North

America, in addition to 16 specialty subconsultants. The entire team further reduced its delivery risk through an effective chartering process and creation of a mission-based team mentality focused on serving the community of New Orleans.

Risk Factor #2 – Early Planning for Start-Up.
Achieving the successful commissioning and hand-over of a project described by over 2,300 drawings and 150 specifications contained in 140 design packages spanning 350 separate conformance review submittals is challenging. The team reduced the risk of final acceptance testing during commissioning (and future facility performance issues) by implementing a detailed 58-page approach focused on early testing. This ensured the design and fabrication of major components was successful prior to their shipment to the installation sites.

Risk Factor #3 – Create Clear Procedures for Fast-Tracked Construction.
Certain elements of the PCCP project were designed and constructed prior to the overall design being completed. This fast-tracked process was necessary to implement the required construction sequence. Figure 3 shows the gravity flow bypass gate structure at the London Avenue Outfall Canal. This structure was constructed at-risk early in the project to allow for simultaneous rainfall event drainage and in-the-dry pumping station construction using large OPEN CELL™ cofferdams. A robust process for at-risk construction like this is critical to fast-tracked project success, along with prioritization of early procurement decisions and effective review processes.

Risk Factor #4 – Team Safety.
Completing large projects using a performance-oriented, fast-tracked, design-build approach makes many personal demands on the team. In New Orleans, we took the time to diligently safeguard all individuals, as team members with viable work / life balances are more likely to be undistracted, healthy,

Figure 4: Early dredging at 17th Street outfall canal site.

and safety-conscious over the life of the project. At times, it was necessary to mandate time-off periods for team members who naturally felt drawn to over-committing on such a critical project to the community of New Orleans.

Risk Factor #5 – Know and Respect the Critical Path.
The risk of major project disruptions can be largely mitigated through effective project communications, particularly when it comes to the fundamental goals and expectations of the involved parties. For example, the owner and end operators of the facilities expect they will get what they asked for through contract conformance. The construction contractor expects the design and review process will not stop construction in the field, and the design professionals expect they will be able to meet their environmental, ethical, code, and contract obligations all while keeping to the scheduled critical path. Developing a "project-first" mentality shared by all team members – while knowing and respecting expectations and obligations – goes a long way to reducing delivery risks.

Risk Factor #6 – System of Well-Connected Parts.
Hurricanes have become notorious for exploiting vulnerabilities and weak links in the infrastructure they encounter, resulting in the need for a clear, consistent, and systematic approach to risk reduction. The New Orleans drainage system dates to colonial times and includes many long-lived facilities operated by the Sewerage and Water Board of New Orleans, formed in 1899.

By 2005, the piecemeal drainage components operated by multiple entities had created a system in name only. Not all sections had been developed, levels of reliability varied, and transitions between protective systems with differing capability had not been hardened. The influence of the dimension of time (leading to ground subsidence, moving populations, and changing hurricane patterns) also created systematic challenges. Using this knowledge, the HSDRRS design criteria called for system integration and awareness of all points of connectivity, failure modes, and possible interactions between the various facilities.

Risk Factor #7 – Focus on Redundancy, Reliability, Resiliency, and Adaptability.
In addition to the need for redundancy (no single points of failure) and to enable personnel to operate the systems safely for up to five days without access to the electrical grid or other supporting utilities, the USACE requested the design be adaptable to future conditions like

increased flows and deepened outfall canal profiles. As a result, the PCCP facilities were designed for two independent sets of design criteria: current and possible future conditions. This consideration of a longer baseline time reflects the fact that many utilities today are operating facilities more than 100 years old. We, the water industry, should be imaginatively considering how today's designs may need to adapt to future challenges, including building in low-cost solutions that allow for easier transitions and avoid costly, heavy civil reconstruction efforts.

### Risk Factor #8 – Establish Contingency Plans, Funds, and Release Processes.

The PCCP project successfully maneuvered around several emergent challenges, including the discovery of contaminated sediments within the outfall canals during early dredging work as shown in Figure 4. The risk to project schedules and budgets was reduced through contingency planning, as well as clear and effective funding authorization and release processes.

### Risk Factor #9 – Innovate and Optimize within Technical Bounds.

Large projects come with large blank canvases, allowing for innovation and optimization within the design criteria. Delivering a best-value solution requires all parties to be open to new means and methods. Numerous innovations were deployed on the PCCP project, representing both significant benefits and possible risks to the entire team. A clear focus on the performance and design criteria – backed with an open attitude toward achieving the fundamental goals – is required in order to reduce these risks to tolerable levels.

### Risk Factor #10 – Learn Lessons from Others.

The PCCP design team began its efforts with a comprehensive review of lessons learned from Hurricane Katrina, and future teams tackling similar challenges should never circumvent this step. The PCCP team has strived to share the lessons they have learned, and in September 2018, the entire team was thrilled when the PCCP project was featured in the History Channel's second season of Project Impossible, a show that celebrates the ingenuity and excitement of engineering. A professional film crew captured not only the engineering complexity involved, but the importance of this infrastructure to members of the community, some of whom live just yards from the outfall canals. Learn more here: *https://ideas.stantec.com/featured-content/with-video-project-impossible-not-when-you-have-the-right-team*.

The world of water is always changing. The water community needs to constantly adapt to this evolving environment by better planning, learning, innovation, and people development, to safely deliver critical facilities on time and within budget.

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