HAZEN AND SAWYER

Horizons

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Hazen and Sawyer Takes Lead as Owner's Representative on Detroit Water Works Park

Largest Design-Build Project of its Kind

Four years ago, when the Detroit Water and Sewerage Department (DWSD) decided to replace its 75-year-old water treatment plant at Water Works Park, it embraced design-build as the best method of meeting its goal—to build a new, state-of-the-art, automated plant as quickly as possible, good for the next 50 to 70 years.

Design-Build Pros and Cons

In the design-build project delivery method, the same entity or team designs and constructs a project, compared to the traditional method, in which different entities design and construct the project. Far from being a new trend, design-build hails back to the ancient tradition of master builders who had complete accountability for construction.

Design-build differs from the traditional design-bid-build approach in some important ways:

- The design-builder provides single-point contractual responsibility, warranting the success of the completed project, while under design-bid-build, the contractor only warrants its own construction work.
- In dealing with a design-build entity versus a separate designer, some of the owner's interests may be compromised. For instance, a design-builder may factor cost and constructibility far more highly than other issues of importance to the owner.
- The owner must take on some functions that had been traditionally performed by the designer, such as preparing the project specifications and overseeing the project's implementation.
- Design quality must be specified, rather than used as a basis for selecting a designer.

Above: The new 240-mgd plant will be placed into service in 2003, at a cost of about $275 million. Below: Hazen and Sawyer completed a pilot study to establish the plant's basis of design and to obtain regulatory approval for the process.

The attractions of design-build for the owner include potentially faster project delivery time, earlier project cost determination, single-point responsibility, and fewer claims. The design-builder also has potential benefits: higher profit margins, superior marketing ability, greater project control, and a less adversarial relationship between designer and builder.

Possible drawbacks of design-build can primarily affect the owner—namely, not having a design professional protecting its interests, potential reduction in design quality, and higher costs for scope changes.

DWSD's Winning Strategies

One way to minimize design-build's drawbacks is to extend the design-builder's responsibilities to

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Above: The historic High Lift Pumping Station will be retained. Design-build proposers were encouraged to complement the existing architecture in their designs.

Below: Hazen and Sawyer and Detroit's project oversight field team.

include operation of the plant for a fixed period (10 to 25 years). The project specification can then be a true performance specification, in which the owner's primary concern is with the quantity and quality of the final product—in this case, drinking water—and not how it is achieved. However, in the case of DWSD, the owner still wanted to operate the plant, and therefore had a keen interest in how the plant was designed and built. DWSD has succeeded in minimizing design-build's drawbacks and risks, while obtaining its benefits—shortening the implementation schedule from ten to six years. These achievements were the result of the following strategies:

- Retaining its own design professional to prepare the project specifications, including the basis of process design and minimum design and construction standards, assist in evaluating proposals and negotiating the design-build contract, and oversee the selected design-builder's work. DWSD selected Hazen and Sawyer to serve in this role, based on the firm's 40 years of experience with Detroit's water plants.
- Giving the design-builder a financial incentive to provide adequate quality in the design, by making the design-builder responsible for the first seven years of plant maintenance. If there are any significant inadequacies in design or construction quality, they will likely be found within this period, and would be the design-builder's responsibility, not DWSD's.
- Holding informal, confidential, non-binding one-on-one meetings with the proposing design-build teams during the proposal preparation stage, giving teams a chance to explore the acceptability of innovative design and construction concepts.

Hazen and Sawyer began its work on this project in December 1996, with an eight-month pilot study to establish the plant's basis of design and obtain regulatory approval.

Concurrently, Hazen and Sawyer and DWSD developed the project requirements and the design-build-maintain procurement and selection process, and solicited qualifications submittals. After preparing minimum standards for design and construction, and assembling geotechnical, topographical, and other data on the site and the existing plant (to be kept in operation during new plant construction and then demolished), an RFP was issued to the short-listed teams in November 1997. Teams were given four months to prepare their proposals. Hazen and Sawyer and DWSD then entered an intensive phase of proposal clarifications and evaluations, followed by negotiations with the selected team before announcing a contract award in November 1998. The design-build-maintain team began work in December 1998. The new plant will be operational in March 2003, with contractor-provided maintenance through 2010. Supported by design and construction experts in its Detroit, New York, and other offices, Hazen and Sawyer has been overseeing the work, including reviewing and accepting the team's design packages for conformance with the contract, coordinating state regulatory review, and maintaining a nine-person field team on-site. ■

New Roller-Compacted Dam Passes Major Test

In September 1999, eastern North Carolina was hit with a one-two punch by Hurricanes Dennis and Floyd, which ripped through the area, causing widespread damage. Just a few months earlier, in June 1999, Hazen and Sawyer had completed work on the City of Wilson's new Buckhorn Dam—the first dam in North Carolina to be built entirely of roller-compacted concrete (RCC).

When It Rains, It Pours

Due to a severe drought in North Carolina during most of the summer of 1999, little progress had been made towards filling the new reservoir, and the City of Wilson faced mandatory water-use restrictions. That changed, practically overnight, with the arrival of the two hurricanes in quick succession. First, Hurricane Dennis dumped some eight inches

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Buckhorn dam several days after Hurricane Floyd had passed.

of rain on the area. The new Buckhorn reservoir responded as expected, rising sharply over a period of several days, and it might have reached full pool without any additional rainfall. However, Hurricane Floyd arrived on Dennis' heels, tossing another 20 inches or so of rain on the already-saturated watershed. Much of eastern North Carolina, including the Wilson area, saw flooding of epic proportions. The slow rise of water in Buckhorn reservoir was replaced by raging streams feeding into the lake, which pushed the water level well past normal pool in a single night. The water level crested at some six feet over normal pool, with a peak discharge rate (Q) of about 24,000 cubic feet per second. This compares to a predicted discharge of some 13,000 cubic feet per second for a 500-year storm event (Q_{500}). Flows of this magnitude represent about half of the probable maximum flood for the Buckhorn drainage basin—so rare that they may never occur again during the life of the structure.

Extensive flooding and damage occurred both upstream and downstream of the Buckhorn dam. Many roads, including interstate highways, were severely flooded, and bridge and culvert crossings were washed away by the raging waters. Other dams throughout eastern North Carolina were also severely tested, resulting in some 30 dams failing due to the rising floodwaters. At Buckhorn, one major bridge upstream of the dam was washed out, and the main road below the dam was under about 10 feet of water. Many other roads in the Buckhorn area were also underwater. The tailwater below the dam rose to such levels that the spillway at Buckhorn was almost completely submerged.

Two views of Buckhorn dam immediately after Hurricane Floyd (Q = 24,000 cfs, Q_{500}=12,845 cfs).

A Hard Test

Such conditions are surely not ideal for breaking in a new dam, since there is no opportunity to monitor the new structure or take remedial action should problems develop. However, the Buckhorn dam performed flawlessly and incurred no damage during the extreme flows. Hazen and Sawyer monitored the dam's performance immediately after the hurricane-force winds subsided and made a full inspection once the dam was again exposed. The dam incurred no damage and proved that it is capable of performing as expected, even under the most extreme conditions.

Advantages of RCC

The Buckhorn dam is not only the first RCC dam built in North Carolina, but also the first RCC dam designed by Hazen and Sawyer. (The firm has designed a number of other conventional earthfill dams.) RCC, which is quickly becoming the most popular construction technique for new dams, was selected for the Buckhorn site after a thorough evaluation of the alternatives. The major advantages of RCC are lower construction cost and speed of construction. For the Buckhorn site, RCC proved to be some 20% less costly to build and required about half the construction period of a conventional earthfill dam. ■

Buckhorn Dam: Hurricanes Weren't the Only Challenges

In undertaking its first RCC dam design, Hazen and Sawyer faced the following notable challenges:

- Because the RCC section is founded on partially weathered rock instead of the more common competent bedrock, several design accommodations were required, including a somewhat wider RCC section width to reduce foundation contact pressures. The dam is also constructed of 15 individual monoliths to provide for any movement along the dam's foundation.
- The water supply intake is located "inline" with the RCC monoliths—a Hazen and Sawyer innovation, which eliminated the need for a diversion conduit and an access bridge to the more traditional free-standing intake tower.
- The water tightness of the dam is ensured by an upstream PVC barrier, which was integrally cast with the upstream facing panels—popularly known as the "Winchester" method, a proprietary construction method that is both cost-effective and reliable.
- The RCC was placed with an all-conveyor system, delivering RCC directly from the on-site batch plant to the RCC fill at rates in excess of 400 cubic yards per hour.
- The batch plant also offered nitrogen cooling of the coarse aggregates, providing absolute control of the RCC mix placement temperatures. Traditional hot-weather concrete methods of chilled mixing water or ice substituted for part of the mixing water are not suitable for RCC due to the very low water content. Nitrogen cooling enabled RCC placement during North Carolina's warm weather in late summer and fall.

DEIONIZATION DONE DIFFERENTLY: Microfiltration + Reverse Osmosis + Mixed-Bed Ion Exchange = Ultra-Pure Water

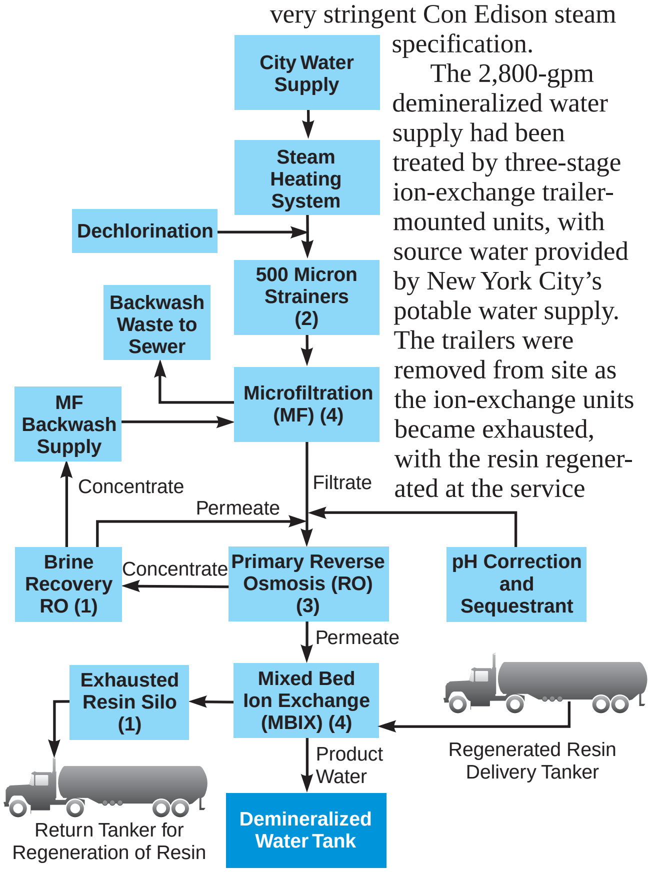
Above: Reverse Osmosis High-Pressure Pumps and Ion-Exchange Vessels. Below: Reverse Osmosis Skids.

Hazen and Sawyer recently helped the Brooklyn Navy Yard Cogeneration Partners (BNYCP) develop and construct a sophisticated water treatment plant to provide demineralized water for a combined-cycle power station in New York City.

Unique Set of Circumstances

BNYCP's four-year-old, 286-MW, combined-cycle power station supplies electrical power and district heating steam to Con Edison. A large part of the demineralized water supplied to the power station is lost to district heating; therefore, the water capacity requirements are much higher than normal. Water quality is critical due to the use of injection water for the gas turbines for power augmentation and NO_x control, and the need to meet a very stringent Con Edison steam specification.

The 2,800-gpm demineralized water supply had been treated by three-stage ion-exchange trailer-mounted units, with source water provided by New York City's potable water supply. The trailers were removed from site as the ion-exchange units became exhausted, with the resin regenerated at the service provider's installation in Virginia. For economic and water quality reasons, BNYCP wanted to replace the trailer system with a permanent facility.



Demineralized water demand varies between 200 and 2,800 gpm. The largest demand occurs during the winter, when exported steam for district heating is at its highest.

Specific project challenges included:

- The use of chlorinated, unfiltered city potable water as a source.
- A very small footprint available for the plant.
- The use of microfiltration (MF), reverse osmosis (RO) membranes, and mixed-bed ion exchange for water treatment.
- The use of resin exchange rather than on-site regeneration to save space and reduce chemical handling and disposal.
- The need to provide robust and reliable automatic control to minimize operational staffing.
- The need to achieve an aggressive project schedule.

Customized Response

The system shown in the diagram at left meets these challenges. In summary, the 4-mgd or 2,800-gpm demineralized water output treatment system consists of:

- A heating system for the incoming city water during winter. Higher water temperature means smaller and less expensive process units.
- Chlorine removal by sodium thiosulfate to protect the MF and RO membranes from oxidation damage.
- Four MF skids for particulate removal, with the MF units backwashed with RO reject.
- Addition of sodium hydroxide to improve ion-exchange resin regeneration periods by reducing the concentration of dissolved carbon dioxide.
- Sequestration using a phosphate chemical to reduce membrane-fouling compounds.
- High-pressure pumps and 5-micron cartridge filters.
- Three primary RO skids to remove dissolved solids.
- One RO reject (brine) recovery unit to minimize overall plant water usage.
- Two trains of lead/lag mixed-bed ion-exchange vessels to polish the RO permeate.
- Resin exchange system to minimize handling of hazardous chemicals.
- PLC and PC-based control system linked to the existing power station's DCS.

"Design-Build" Approach

As the owner's representative, Hazen and Sawyer evaluated different treatment processes, reviewed their operational and construction costs, and recommended a final treatment train. The firm also prepared a design-build specification and requested proposals from prequalified vendors. The three proposals submitted were evaluated and two were selected for further exploration and refinement. Finally, negotiations took place, resulting in a contract for the design, supply, construction, and start-up of the plant. The design-build contract was awarded in February 1998 at a value of $16 million, and was completed in March 2000. ■

Viewpoint: Richard H. Cisterna, P.E., Senior Principal Engineer

IS ON-SITE SODIUM HYPOCHLORITE GENERATION A VIABLE DISINFECTION ALTERNATIVE?

Many water and wastewater utilities are looking into alternatives to non-enclosed chlorine gas facilities to meet their disinfection needs. Their interest has been spurred on by EPA's passage of the Clean Air Act Amendments, including the Risk Management Program, which places tight restrictions on the use of chlorine gas and other hazardous chemicals.

Sodium hypochlorite on-site generation (OSG) has piqued the interest of utilities as a lower-risk alternative, since it does not require hazardous chemical handling and offers potential public relations benefits.

A Simple Process

A fairly simple process, OSG entails passing a brine solution—made by mixing salt and water or by using seawater—through a set of electrodes to form a very dilute (0.8% concentration), nonhazardous sodium hypochlorite solution and hydrogen gas by-product. The solution is stored in tanks and pumped to its application points. The hydrogen gas is diluted with air and discharged to the atmosphere. OSG systems are power-intensive and require approximately 2.3 kWh/lb of chlorine generated. For example, a 1,000-lb/day chlorine demand would require an electric service of 96 kW.

OSG equipment manufacturers have been aggressively marketing their new and improved wares. Samples of their marketing materials are shown below.

OSG: Then and Now

OSG made a limited entry into the water and wastewater disinfection market in the 1970's and early 80's, but resulted in maintenance problems such as electrode fouling. The process had lost favor by the mid-80's.

But within the last few years, some manufacturers have renewed their attempts to break into the municipal disinfection market with upgraded systems. Vigorous marketing appears to be paying off in several states, including Florida and California. In fact, one manufacturer claims to have over 40 systems either installed or under contract. Most range in size from 10 lbs. Cl/day (small-scale remote water supply well applications) to over 3,000 lbs. Cl/day (a 16-mgd filtration/ozone water treatment plant) and are reportedly operating well, without major maintenance problems.

Much of this turnaround can be attributed to the fact that OSG systems have lower chemical hazard risks than chlorine gas and bulk (12% concentration) hypochlorite systems —especially important in light of the new requirement that utilities hold public meetings to discuss the potential off-site consequences of a chlorine gas release. By switching to OSG, utilities can avoid such public relations pitfalls. In fact, some utilities are placing such a high price tag on the potential liability and local community concerns associated with chlorine gas that they've decided to use OSG regardless of the "apparent" costs.

Some Words of Advice

Since cost is a major issue for most utilities, close attention should be paid to OSG's price tag, which can vary greatly based on how a system is set up. In particular, in developing design criteria for OSG, one should carefully look at:

- Unit sizing (average vs. max day chlorine demand and amount of backup generation capacity).
- Location of storage tanks (indoors vs. outdoors).
- Required storage quantity (one to two days of storage typically required vs. 30 days with bulk hypochlorite).
- Need for emergency electrical generator.
- Grade of salt.
- Need for a certain degree of redundancy and reliability (some systems are designed to accommodate bulk hypochlorite in case of emergency).

Depending on the design criteria selected, overall present-worth costs can range from being competitive with chlorine gas to being over 50% higher. And OSG is often cheaper than the bulk hypochlorite alternative.

In addition to looking at cost, it is crucial to obtain buy-in from O&M personnel before switching to OSG.

In summary, our view is that OSG is a technologically viable, low-risk alternative—one that utilities would be wise to evaluate. In doing so, system reliability and redundancy should be carefully studied, along with the risk-reduction benefits and corresponding sentiments of the local communities. ■

Hazen and Sawyer Happenings

Firm Appoints Director of Operations

James W. Fagan, P.E., J.D., has been promoted to Vice President and Director of Operations. Jim continues to be a key member of Hazen and Sawyer's Utility Management Services Group, for which he's had a major role in privatization feasibility studies for the District of Columbia and the Passaic Valley Sewerage Commissioners. As Director of Operations—a newly created position—he will also tackle issues such as operating efficiency, project management, and staff development. Jim is dividing his time among corporate headquarters, Fairfax, and other offices, as needed. ■

Jim Fagan

New Neighborhood for NYC Headquarters

Hazen and Sawyer's corporate headquarters recently moved from downtown in Greenwich Village to midtown south. The new address is 498 Seventh Avenue (at 37th Street), where the firm occupies all of the 11th and part of the 12th floors. Phone/fax numbers and e-mail addresses remain the same.

Selection of the new location was based on a number of considerations, most notably its convenience for commuters and for clients, including our largest client, the NYCDEP. In addition to being very close to the Port Authority and Penn Station, it's a reasonable walk from Grand Central Station and readily accessible through the Queens-Midtown Tunnel. The move also provided an opportunity to customize our space to better match current and future needs, such as the addition of a multipurpose room that can be used as either one large meeting hall or partitioned into three separate conference areas. Plus there's room for growth in the new location, as well as rental options for even more space. ■

New corporate headquarters.

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