COLLEGIATE CONSERVATION

Duke University constructs on-campus water harvesting & reuse pond

By James W. Caldwell

As a part of its Climate Action Plan and as a result of the historic 2007 drought in North Carolina's Piedmont area, Duke University is constructing a $14 million water harvesting and reuse pond on its historic campus in Durham, N.C.

Throughout the summer and into the fall of 2007, a historic drought affected most of the southeast U.S. By October 2007, a Level D4 "Exceptional" drought was recorded by the National Oceanic and Atmospheric Administration. This led the city of Durham to enact multiple stages of water restrictions and emergency measures. At the height of the 2007 drought, Durham's potable water supply reached approximately one month of supply. This prompted the city to evaluate the water use of all customers.

Duke University is the largest user of potable water in the city of Durham. In Duke's fiscal year 2006, campus-wide water use totaled 645 million gal. Out of this total campus demand, approximately 140 million gal were used as makeup water for the university's two centralized chilled water facilities and evaporated into the atmosphere. Because the university's hospital and other life-critical facilities depend on the chilled water system, they could not be shut down or easily reduced.

Planning Ahead

Fortunately, as other drastic emergency plans were being discussed with the city of Durham and Duke, it rained, providing much-needed relief to the drought situation. This event, however, and the fact that every system in the university's chilled water system is redundant with the exception of water supply, prompted the university to make water reuse and supply critical pieces of Duke's initiatives to achieve climate neutrality by 2024 and provide critical infrastructure for emergency public safety hospital operations. Through public outreach, awareness and campus-wide conservation measures, the university's water consumption dropped to 369 million gal in fiscal year 2009 (a 42% reduction). As part of the water saving and reuse initiative, the university asked McAdams, an infrastructure design firm, to utilize the ongoing campus-wide storm water impact analysis to identify sites for water harvesting and reuse. Using the analysis, which McAdams maintains for the university, the firm initially identified eight aboveground sites for drainage areas and potential runoff. Using the chilled water plant's projected demand, irrigation demand and other campus water uses, McAdams ultimately was able to pare down these eight sites to the water harvesting pond site adjacent to Chiller Plant No. 2. The 256-acre, highly urbanized watershed of this site, along with the 2020 projected demand of 198 million gal a year for Chiller Plant No. 2, provides a high-runoff, high-use site for the pond.

McAdams and a geotechnical engineer were commissioned to perform preliminary design and modeling work for the site. This work included a realistic

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"continuous" model, to model actual historical rainfall data and not just theoretical storm events through the facility. With stream gauge data, demand and use projections from Duke, and using 1997 historic rainfall, McAdams modeled a full year of rainfall events including base flow, storm runoff, evaporation, infiltration, minimum release and chiller plant demand. This modeling showed that the pond could supply up to 143 million gal of harvested storm water per year. This is almost 75% of the demand of Chiller Plant No. 2 and a savings of $400,000 annually.

A Detailed Design

The pond is sited on a blue-line stream on the southwest side of Duke's campus, a location that was originally slated for a pond by the university's architect, Horace Trumbauer, in the 1920s. The stream and culvert system downstream of the facility are inadequately sized and therefore a "tailwater" condition exists through each hydraulic element of the system. Interconnected pond and spillway modeling was needed for both the existing and proposed conditions to ensure that no existing roadways, utilities or buildings would be affected by construction of the pond.

After initial design and modeling work, the university brought a renowned landscape architect to the project, along with a structural and mechanical engineer. The final design of the facility includes a 20-ft-tall high-hazard potential dam, a pavilion with the intake structure, boardwalk, footbridge, pump house, amphitheater, outdoor classroom area, and wetland and woodland plants to both provide water quality benefits and serve as a campus amenity. The pond will always have 8 ft of standing water with a reusable "flux" of 4 ft for storm runoff and use in the chiller plant (6.7 million gal). The standing normal pool will provide almost 8 million gal of emergency water storage for natural disasters, when the Duke University Hospital, and therefore Chiller Plant No. 2, would need to function as a regional disaster center with no power or potable water.

The boardwalk and pavilion decking for the project are constructed of wood

from trees harvested and processed during clearing of the site. The pond also features a 0.6-mile walking trail loop that ties into the campus-wide pedestrian plan. McAdams and the design team worked with university professors and research staff from the engineering, environmental and biology departments to design the pond, choose plant species, and learn lessons from other campus and research projects.

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Strong Finish

Permitting for the facility took approximately one year, with 19 permits necessary for construction to commence. The pond impacts 1,700 ft of stream and a mitigation ration of 2:1 was determined for the project through multiple meetings and site visits with regulators from the North Carolina Department of Environment and Natural Resources (DENR) and the U.S. Army Corps of Engineers (USACE). As part of the pond project, McAdams designed and permitted 3,400 ft of stream restoration on another portion of Duke's campus that ties directly into the university's SWAMP (Stream & Wetland Assessment Management Park). Permits for the pond were required from USACE, DENR, the North Carolina Dam Safety Program, the city of Durham, Durham County and Duke University itself. As part of the city of Durham permitting and to benefit other development projects on campus, a high water quality removal rate for nitrogen, phosphorous and total suspended solids was claimed for the facility.

Construction started in April 2013 and the bottom drain valve in the spillway riser was closed in October 2014. The pond was filled in the fall of 2014 and will be fully functional by the summer of 2015. This pond will provide a continuous supply of harvested storm water for use in Duke's Chiller Plant No. 2 as well as serve as a campus amenity as intended in the original university architect's vision. SWS

James W. Caldwell, P.E., is assistant director, water resources and infrastructure, for McAdams. Caldwell can be reached at caldwell@mcadamsco.com.