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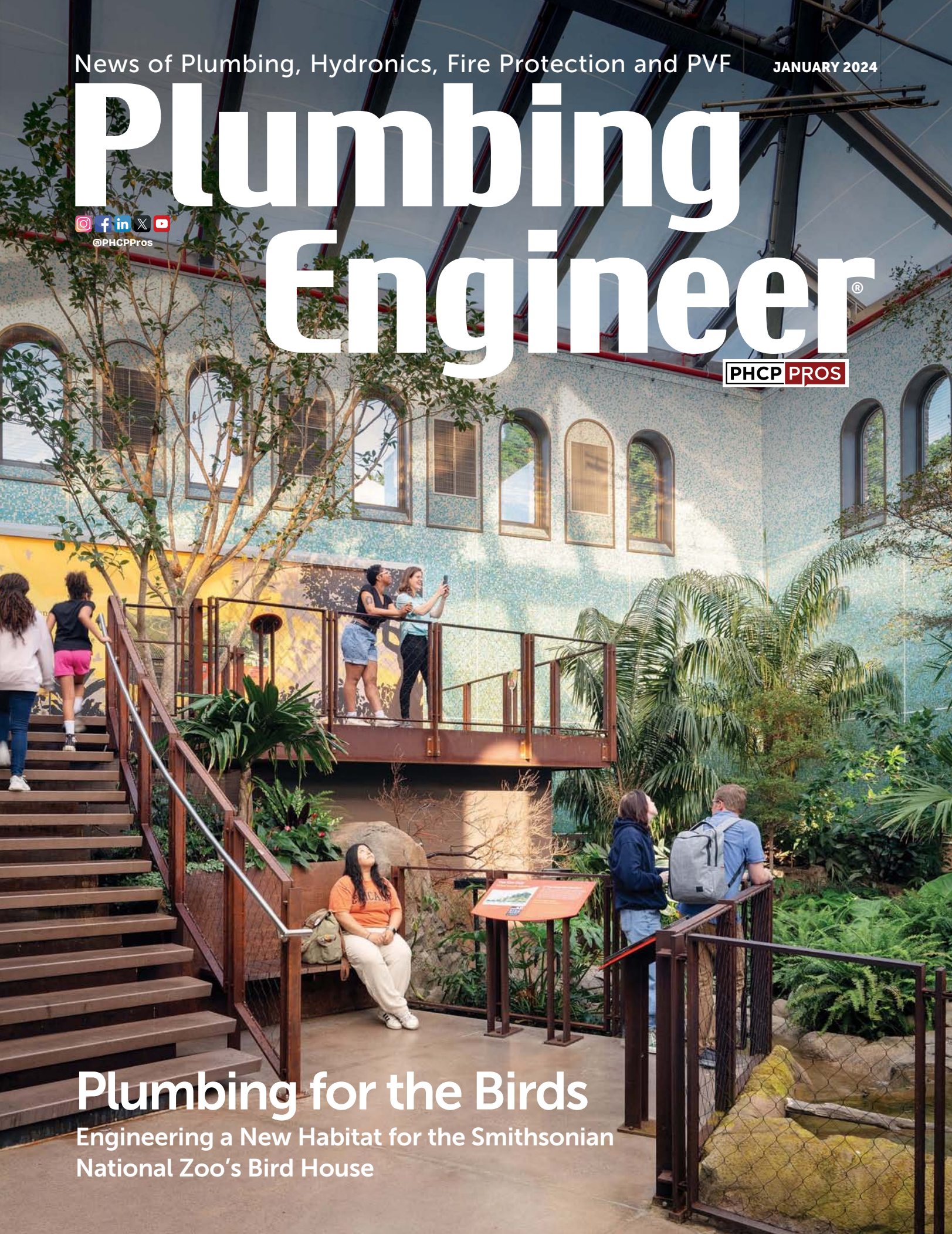
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Plumbing for the Birds

Engineering a New Habitat for the Smithsonian National Zoo's Bird House



The restoration of the Smithsonian's National Zoo and Conservation Biology Institute's Bird House occurred within the walls of the zoo's existing, circa-1928 Bird House, adhering to the U.S. Secretary of the Interior's Standards for Rehabilitation to maintain its historic exterior appearance. Photo credit: © Joseph Romeo

Plumbing for the Birds

Engineering a new habitat for the Smithsonian National Zoo's Bird House with efficient water systems and an innovative HVAC design.

By Karen Schulte, PE, CPD, LEED AP BD+C,
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The Smithsonian Institution's Bird House at the National Zoo and Conservation Biology Institute (NZCBI) in Washington, D.C., reopened to the public in spring 2023 after a significant building renewal. The popular facility serves as the first zoo exhibition of its size to highlight the annual journeys of migratory songbirds, waterfowl and shorebirds integral to the North, Central and South American ecosystems.

Designed to LEED Gold certification standards, the six-year, \$69 million project occurred within the walls of the zoo's existing circa-1928 Bird House. The Bird House underwent renovations in the 1960s but, by 2017, required expansive upgrades.

The new facility increases exhibit and education space and animal holding areas while following the U.S. Secretary of the Interior's Standards for Rehabilitation to maintain the historic exterior appearance. More than 80% of the existing masonry walls were retained to reduce the building's carbon footprint, diverting potential waste from landfills.

The 30,405-square-foot building and its surrounding plateau feature three walk-through aviaries that educate visitors on declining bird populations and highlight how visitors can make lifestyle choices that are best for birds, humans and the planet. More than 170 individual birds representing 70-plus species are on view in the house and adjacent outdoor exhibits.

In addition to serving as a centerpiece exhibition at the National Zoo, which receives nearly 2 million visitors annually, the Bird House supports NZCBI's field and husbandry research, which studies what influences songbird and shorebird survival and the sustainability of wild species. Toward that end, the facility reflects the highest standards in

creating a bird-friendly environment to protect the birds and promote their care, including aviculture breeding.

The Marvelous Migration Exhibition

An elegant blue, yellow and green mosaic arch, designed by D.C. artisan John Joseph Earley and part of the historic building's original design, greets visitors as they enter the lobby. Visitors can then visit the Bird Observatory room, where scientists demonstrate bird banding for the Smithsonian Migratory Bird Center and gather groups for guided walks.

Visitors then "migrate" through the Flyway, an immersive experience with various bird images, to enter three multi-sensory aviaries mimicking natural ecosystems and explaining the life cycles of migratory birds and the importance of protecting native species.

Apart from the enclosed outdoor display area, the facility replicates three aquatic habitats that migratory birds often visit during their extensive journeys between Canada, the United States, and Central and South America. This approach marks a departure from the traditional display methods used in the past.

Upon entering the Delaware Bay aviary, visitors embark on an educational journey about shorebird migration. Here, the sandy terrain recreates the ambiance of a Delaware Bay beach, complete with the presence of plovers, sandpipers and sanderlings. The exhibit further enhances the experience with features such as tide pools, driftwood, seagrass, and dynamic indoor lighting that changes to mirror the seasons and the transitions between sunrise and sunset.

The second aviary represents the Prairie Pothole region of the northern Great Plains, where visitors view species of waterfowl and shorebirds while learning the importance of wetlands. Here, two large pools allow underwater views of logs and reeds while ducks of various shades of brown, white

Birdhouse



The Bird House uses 10 water piping subsystems. All water accessible to the birds is carbon-filtered to remove inorganic impurities and tempered to 65 F. It is sent through a double-wall, plate-and-frame, water-to-water heat exchanger, then through a booster pump to increase the pressure to 90 psi to serve the hoses that wash down the bird areas daily. Photo credit: © Joseph Romeo

and green can dive, dabble or waddle out of the pools and onto a visitor's path.

Lastly, in the third aviary, the tropical Bird-Friendly Coffee Farm, visitors enter the songbird aviary to the sound of rain and a lush, tropical climate to learn how shade-grown coffee farms can provide critical habitats for birds and other animals.

The Bird House aviaries are equipped with a total of 10 pools, among which two are saltwater pools, carefully designed to replicate the natural habitats of the resident birds. Together, these pools contain 6,400 gallons of water, roughly matching the weight of four elephants. This comparison is based on Spike, the male Asian elephant residing downhill from the Bird House at the National Zoo.

An Array of Sophisticated Water Systems

Mueller Associates, tasked with engineering the Bird House's mechanical, electrical and plumbing systems, worked closely with the architecture firm Quinn Evans and exhibit designer/landscape architect MIG to complete the rehabilitation and meet NZCBI's precise requirements for the exhibition and animal care areas. The team met frequently with NZCBI curators during the pre-design phase to establish parameters for the water systems, including pressure and temperature requirements, as well as the design of the pools, drains and other features.

In all, the building provides ten water piping subsystems — significantly more than an average building. Most importantly, all water accessible to the birds is carbon-filtered to remove inorganic impurities and tempered to 65 F. This water source is sent through a double-wall, plate-and-frame, water-to-water heat exchanger, then through a booster pump to increase the pressure to 90 pounds/square

inch (psi) to serve the hoses that wash down the bird areas daily.

Another carbon-filtered, tempered distribution subsystem serves the animal-holding areas. Here, the pressure has been lowered to 60 psi for the sinks in the bird care areas and misting sprays within the bird-holding cages, well under *D.C. Plumbing Code Section 604.8 (Water Pressure-Reducing Valve or Regulator)* standards. A dedicated water heater serves the hot, carbon-filtered water to these sinks.

A third system, also carbon-filtered and tempered, serves the fog production and rain bar system in the Bird Friendly Coffee Farm aviary. This water also requires treatment by a water softener. Mueller's team specified potassium chloride for the salt brine in the water softener versus sodium chloride, which is more typical. The potassium-based salt was specified as more suitable for the plants in the aviaries, as the more common salt can build up in the soil and harm plant life.

After being treated by the water softener, the fog production system water is routed through a reverse osmosis filtration and UV sterilizer, then to a high-pressure, fog-pumping package.

Filtered water is provided for all the exhibit pools. The Delaware Bay aviary has two saltwater and two freshwater pools. Pools also line both sides of the curved walkway in the Prairie Pothole aviary, where ducks and songbirds are abundant. The Bird Friendly Coffee Farm aviary features small pools as visitors learn about migratory birds' overwintering habitat.

Mueller's engineers coordinated closely with Ardurra, the life support systems engineer, regarding the design of the pools and water features in the aviaries. The pool water is recirculated and filtered through bead or sand filters. A UV sterilizer is used on two pools, and a wave machine is



The third aviary represents a Bird-Friendly Coffee Farm and is supported by a carbon-filtered and tempered plumbing design that also serves the fog production and rain bar system. The fog system requires treatment by a water softener and additional reverse osmosis filtration.

Photo credit: © Joseph Romeo

Birdhouse



The Bird House's aviaries are equipped with 10 pools. Together, these pools contain 6,400 gallons of water, roughly matching the weight of four elephants. Photo credit: © Joseph Romeo

featured in one of the aviaries. The volumes in the largest pools range from 830 gallons to 2,864 gallons.

Other plumbing subsystems include:

- Potable cold water for all public fixtures;
- Potable domestic hot water for public fixtures;
- Nonpotable water for HVAC heating water and chilled water;
- A dedicated nonpotable make-up water line for backwash to serve the filters for the life support system;
- Nonpotable water for exterior irrigation.

The project's water-saving design reduces the building's water use by 65% outdoors and 43% indoors through an intelligent irrigation system outside and water-saving fixtures.

Facilitating Maintenance While Protecting Birds

The architecture and engineering team worked intimately with the curators and caretakers to ensure that hose bibbs and drains were appropriately located to facilitate cleaning. Special attention was directed toward the size of the openings in the floor drains, with the strainer openings specified not to exceed 1/4 inch. This detail was necessary to avoid injuring the birds' fragile legs.

Generally, the fire protection system was replaced as part of the renovation project. The incoming 6-inch fire service line, backflow preventer and three-zone control valve assemblies could be retained and reused as they had been recently replaced before the whole building renovation.

Three new zone control valve assemblies create six control zones in the building, allowing each aviary to be a dedicated sprinkler zone separate from the public-only spaces.

Efficient HVAC Systems for Unique Aviary Comfort

Engineering the HVAC solutions for the Bird House presented a captivating challenge, much like its plumbing systems. This endeavor involved addressing the diverse and sometimes conflicting requirements of the exhibit's different

bird species, the Smithsonian's personnel and the visiting public.

At the core of the HVAC design is a high efficiency chiller strategically situated on a specifically designed steel dunnage with spring-type vibration isolators. Additionally, a mechanical vibration isolation pad was placed on the roof below the dunnage, providing a high-mass element in the roof construction to mitigate chiller-radiated noise.

All this is within a specialized acoustic enclosure on the Bird House roof. This design is crucial for minimizing sound transmission through the nearby ethylene tetrafluoroethylene (ETFE) skylight (lightweight fluorine-based plastic), only a few feet from the chiller. Thus, the acoustic treatment of the chiller becomes both critical and intricate due to its direct impact on sound propagation into the aviaries.

Two custom rooftop air-handling units (AHUs) provide the Bird House's air supply. AHU-1 caters to nonhabitat sections of the building and is designed for a dew point of 55 F.

Meanwhile, AHU-2 is dedicated to the habitat areas and is designed for a higher dew point (61 F), ensuring that the aviaries' atmospheres authentically mimic their showcased climates.

The aviaries offer varying climate conditions to mimic diverse natural environments. Entering Aviary 1 from the Flyway, the dew point is higher, allowing for a higher temperature and relative humidity than the nonhabitat areas, simulating the Delaware shore coastal areas. Aviary 2, the Prairie Pothole area, is slightly warmer than Aviary 1. However, when entering Aviary 3, the Coffee Farm, the temperature is the highest, reflecting the conditions typical in a tropical environment.

By engineering AHU-2 for a higher dew point, a warmer and more humid environment was created in the habitat



The image is situated on the lower level where bird-holding enclosures are located (rear section of the facility). Each enclosure is equipped with a misting nozzle, hose bibb, and a shallow depression with a drain. By blocking the drain, the shallow depression can be filled and transformed into a pool for the birds. Conversely, the hose bibb can be activated if the drain valve is left open, providing a continuous freshwater supply into the cage. Photo credit: © Joseph Romeo

Birdhouse



On the left is a booster pump serving the bird water systems and the double wall plate and frame heat exchanger. In the center is the HVAC chilled water system pumps. On the right is the fog system skid and water softener. Photo credit: © Joseph Romeo

areas, yielding energy savings compared to the alternative of using a single AHU for the entire building. Using a single AHU for the entire building would have required dehumidifying the air for the habitat areas farther than it needs to be, then having to reheat it since all the building supply air would come from one AHU, and the nonhabitat areas require a lower dew point.

This design approach (two separate AHUs) reduced chiller energy usage by avoiding dehumidifying the habitat areas to typical human-occupancy building conditions and conserved boiler energy by not requiring as much reheat to attain shore and tropical climate temperatures.

The AHUs feature 2-inch pre-filters and employ electrostatic air cleaning systems, specifically the Dynamic V8 system. UV lights are downstream of the cooling coils to maintain cleanliness and efficiency, effectively minimizing organic growth, reducing maintenance requirements, and lowering fan energy consumption by preventing excessive air pressure drops caused by organic growth buildup. Furthermore, it preserves chiller energy by preventing fouling that can impede heat transfer between the air and water within the coil.

Key specialized zones comprise the incubation room, sick bird room, bird holding areas and Bird Observatory. The sick bird room serves the primary purpose of containing and limiting the spread of illnesses among the avian population. It operates under negative pressure compared to neighboring spaces, with air exhaust directly to the building's exterior. Furthermore, the air supplied to the sick bird room is equipped with HEPA filters mounted in the ducts for enhanced filtration.

A Sustainable Avian Sanctuary

The Smithsonian's National Zoo and Conservation Biology Institute's Bird House has undergone a remarkable transformation, the most significant since it opened 95



The domestic water service entrance in the basement feeds several different water systems for the birds and support staff. Incoming domestic water service is on the right, including the reduced pressure principle backflow preventer with an automatic shut-off valve to prevent excessive water discharge in the event of a backflow condition. In the back left corner are the reverse osmosis system and storage tanks associated with the fog system serving Aviary 3. Photo credit: © Joseph Romeo

years ago. The renovated facility serves as a captivating exhibition space at the National Zoo, playing a critical role in supporting field and husbandry research, focusing on songbird and shorebird survival and the sustainability of wild species.

The Bird House now showcases the annual migrations of birds, providing visitors with an immersive experience that educates them on the importance of protecting native species. The exhibit features three walk-through aviaries, replicating different ecosystems and climates to accurately reflect the migratory birds' environments. The Bird House is also a model of environmental sustainability, with efficient water systems, reduced water usage and an innovative HVAC design, ensuring the birds' comfort while conserving energy.

Moreover, this project is a testament to the commitment of the Smithsonian and its partners to conservation, education and wildlife protection. The Bird House provides visitors with a unique and enriching experience and contributes to vital research efforts to preserve the natural world. With its dedication to the welfare of the birds and the planet, the Bird House is a remarkable achievement in sustainable architecture and avian conservation. ●

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