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A photograph of the Sweetwater Creek State Park Visitor Center, a modern building with a concrete and wood facade, situated on a grassy hill with trees in the background. An American flag is visible on the right side of the building.

Conservation Gateway

BY DAN GERDING, AIA

Before entering a 2,549-acre conservation park, visitors are welcomed by a center that, through sustainable design, contributes to the park's purpose of protecting nature.

Sweetwater Creek State Park Visitor Center orients and educates park users on the natural and cultural resources of the park. A large exhibit area includes information on the nearby ruins of the New Manchester Manufacturing Company, a textile mill burned during the Civil War. The building also includes retail areas, administrative offices, audiovisual/multipurpose rooms, a water quality lab/classroom and restrooms.

Site Ecology

The visitor center sits near two trail heads leading into the park and to the historic mill ruins. Although the building serves as the physical and ceremonial gateway to the park, it was designed to blend with the site's natural topography. The roof along the north side of the building follows the natural grade, and the south side of the building opens up to expansive views of the forest.

Landscaping consists of indigenous species. Disturbed areas are returning to natural, predevelopment state as naturally occurring volunteer species repopulate the areas. To minimize impervious surfaces, sidewalks are made of pervious concrete and granite fines, and the fire lane is made of mulch.

Shallow vegetated storm water infiltration basins are integrated into the site design to reduce visual impact. Combined with rain harvesting on the roof and water-retaining vegetated roofs, the infiltration basins prevent any net increase in rate and quantity of storm water runoff compared to predevelopment conditions.

Passive Design Strategies

Passive solar design strategies consider the building's orientation and latitude and include fenestration, shading devices and lightshelves. The long axis of the rectangular building is oriented east-west, and clerestory windows along the north and south façade provide abundant daylight to the building interior. Twin interior lightshelves along the south clerestory bounce light deeper into the main exhibition space.

Three-dimensional computer modeling of the sunlight angles at various times of the day and year aided in designing and sizing the south façade exterior roof overhang and sunshade. With electric lights off or dimmed below 20% during daylight hours, 41% of the total building area uses daylight as the dominant light source. This excludes exhibit lighting.

The center is cut into the hillside on the north, east and west sides. The earth-sheltered approach weaves the building into the site and boosts the building envelope's energy efficiency. Additionally, 37% of the building's roofs are landscaped using



Solar photovoltaic panels on the south-facing portions of the roof generate approximately 20% of the building's electricity.

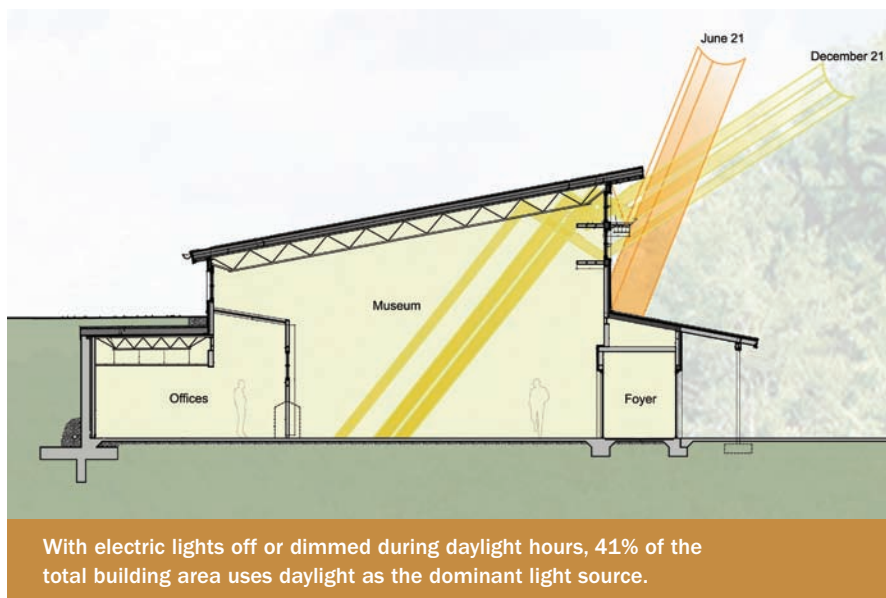


BUILDING AT A GLANCE

- Building Name** Sweetwater Creek State Park Visitor Center
- Location** Sweetwater Creek State Park, Lithia Springs, Ga.
- Size** 8,743 ft²
- Started** Fall 2004
- Completed** Summer 2006
- Use** Interpretive Center
- Cost** \$1,534,393 or \$175/ft²
- Distinctions** LEED-NC Platinum; One of only 20 LEED-NC Platinum buildings in the world at the time of certification and the first in the southeastern United States

BUILDING TEAM

- Owner** Georgia Department of Natural Resources
- Architect** Gerding Collaborative, LLC
- LEED Consultant** Donna McIntire, RA
- Structural Engineer** Palmer Engineering
- Mechanical Engineer** Johnson Spellman & Associates, Inc.
- Electrical Engineer** Barnett Consulting Engineers, Inc.
- Exhibit Consultant** Deem Loureiro, Inc.
- Landscape Architect** Jon Benson & Associates, Inc.
- Civil Engineer** Long Engineering, Inc.
- Cost Estimator** ADE Construction Consultants
- Commissioning** Commissioning & Green Building Solutions, Inc.



a 12 in. deep intensive vegetated green roof, and 63% are high reflectivity/high emissivity metal roofing, reducing the heat island effect. The earth-sheltered construction and green roofs act as a heat sink and moderate the temperature differentials between the building interior and exterior air. High insulation values of R-40 for the roofs and R-19 for the walls further reduces heating and cooling loads.

Active Design Strategies

A 10.5 kW rated capacity photovoltaic solar array on the south-facing portions of the building's roofs generates approximately 20% or 14,124 kWh per year of the building's electricity. *Figure 1* provides a breakdown of the projected photovoltaic production. Automatic lighting controls regulate artificial lighting with photocells and timers. The building's HVAC system consists of multiple zones using high efficiency HVAC systems with multiple speed fans, two-stage compressors and ratings of 15 SEER and 12 EER.

The building contains sensitive archives of significant historical

and cultural value. The building's ventilation is 100% mechanically controlled because of the importance of filtration and keeping the temperature and humidity within a narrow range. An energy recovery ventilator (ERV), consisting of a supply fan, exhaust fan and rotary enthalpy heat wheel, reclaims some of the sensible and latent heat from the building's exhaust airflow. The ERV uses this heat to pretreat the incoming outside

air, lowering the energy requirements to condition the ventilation air. The CO₂ based demand-controlled ventilation requirements determine the ERV fan speed.

Energy Analysis

Energy analysis for the visitor center is based on the USGBC LEED® Energy Modeling Protocol (EMP) illustrated in the LEED for New Construction (NC) Version 2.1 Reference Guide. The basis for this comparison is the ANSI/ASHRAE/IESNA Standard 90.1-1999, *Energy Standard for Buildings Except Low-Rise Residential Buildings*, Energy Cost Budget (ECB) method. Exceptions and clarifications are noted below.

- The composting toilet system requires continuous ventilation at 75 cfm per fixture. Because energy recovery from this airflow is not possible, restroom air conditioning is not provided and heat is supplied by electrical resistance heaters. Exhaust fans located at each compost bin in

Vegetated green roofs act as a heat sink and moderate the temperature differentials between the building interior and exterior air.



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the basement below draw restroom air through the toilet fixtures and compost bins before being exhausted through ducts routed to the highest part of the building roof. The continuous ventilation and the green roof directly above the restrooms result in relatively comfortable restroom temperatures year-round. Also, the exhaust system draws air down through the toilets instead of up to the ceiling to effectively control odor.

- The basement zone for the composting bins is heated only to protect the space from freezing.
- The museum display lighting is not included in the regulated energy, per the allowed exception to Section 9.3.1 of Standard 90.1-1999. This encompasses a total floor space of 2,092 ft².

Energy Model Development

The eQUEST 3.55 (DOE-2.2) building energy simulation package was used to model the energy use. The proposed building was modeled on construction drawings, while the budget building was modeled in accordance with Standard 90.1-1999 and LEED requirements prescribed for the climate.

Using the procedures built into the eQUEST program, the energy modeling analysis includes CO₂ based demand-controlled ventilation. Without the CO₂ based demand-controlled ventilation, but including the contribution of the photovoltaic panels, the proposed design building results in energy cost savings of 46% compared to the LEED budget building. The inclusion of the CO₂ based demand-controlled ventilation results in additional savings of 5%, giving total energy cost savings of 51%.

Electricity is the building's sole energy source. The estimated annual grid-supplied, regulated electricity (with CO₂ demand-controlled ventilation included, but not counting the photovoltaic panel generation)

decreased from 117,150 kWh to 70,140 kWh with the proposed building. The CO₂ based demand-controlled ventilation system contributes 5,990 kWh to the annual electrical energy savings by reducing the cooling and

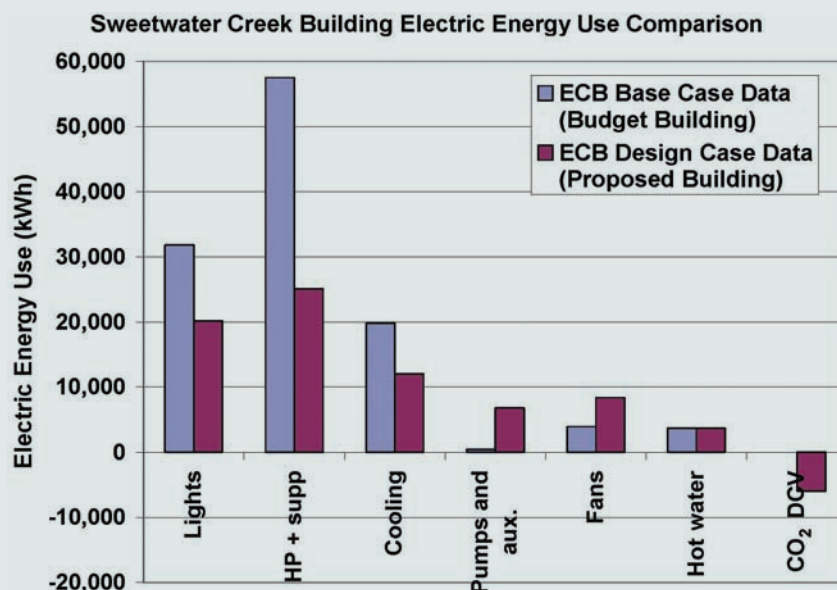
FIGURE 1 SOLAR PHOTOVOLTAIC SYSTEM FOR SWEETWATER CREEK VISITOR CENTER

10.5 kW Photovoltaic System (4.5 kW Evergreen, 6 kW BP Laminate)

	Estimated Production	Estimated Emissions Avoided
Annual	14,124 kWh	52 lb of NO _x 142 lb of SO ₂ 24,043 lb of CO ₂
Lifetime (25 Years)	353,100 kWh	1,300 lb of NO _x 3,550 lb of SO ₂ 601,075 lb of CO ₂

Production numbers based on Atlanta latitude of 33.65 N, fixed array with 34° tilt, 10.5 ac rating, 8.1 dc rating and 0.77 dc to ac derate factor.

FIGURE 2 ELECTRIC ENERGY USE FOR BUDGET AND PROPOSED BUILDINGS



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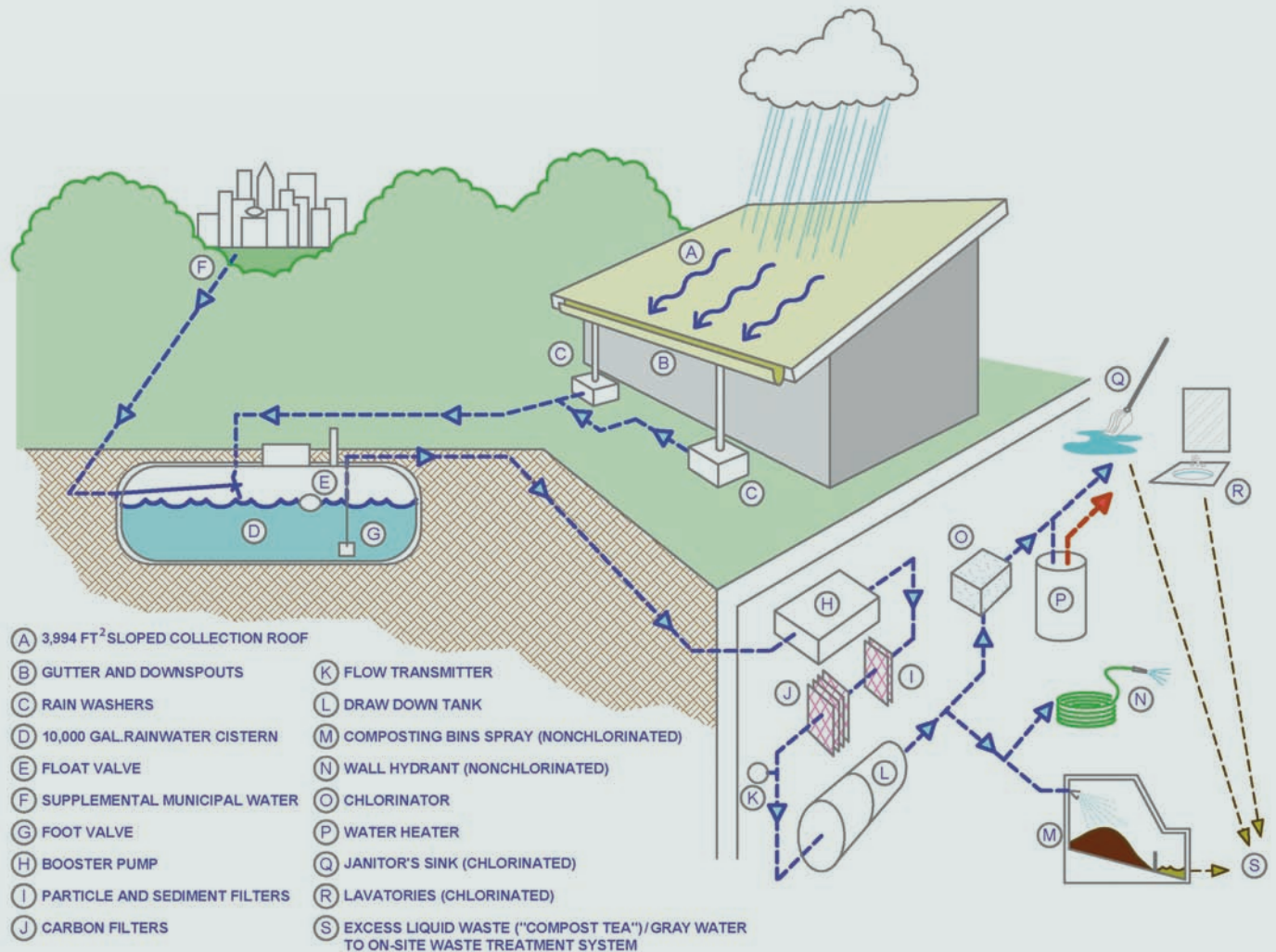
The water use strategy for this building includes rainwater harvesting on a large section of the building's roof. Rainwater collection on 38% of the roof area, 3,994 ft², reduces projected potable water use by 77% compared to a baseline building. Rain from the roof is routed through one of two rain washers. The rain washers strain out large debris such as leaves and twigs before the water enters a 10,000 gallon underground

cistern. Water from the cistern is filtered and chlorinated before servicing lavatories in the restrooms and classroom, as well as the janitor's mop sink.

The exterior wall hydrants and spray for the composting bins, when necessary, use filtered, nonchlorinated water. Potable water from the local municipality services the drinking fountains, a lavatory in the kitchenette, and one of two lavatories in the classroom. A

municipal water connection to the rainwater cistern serves as a backup water supply in the event of extended drought.

North Georgia has experienced extreme drought conditions since the building opened in July 2006. In spite of the drought, the rainwater cistern maintained adequate water for the building's nonpotable uses for 15 months. In October 2007, municipal water was added to the cistern for the first time.



heating required to condition ventilation air. With the photovoltaic energy generation, the estimated annual net grid-supplied energy consumption of this building is 56,016 kWh.

Without the photovoltaic production, the annual energy cost is \$11,996

for the budget building and \$7,380 for the proposed building. Factoring in the energy use reduction from the photovoltaics, the total annual energy cost is \$5,894. Overall, when compared to Standard 90.1-1999 base case, the building saves 57,969

kWh or \$6,102 per year (including the photovoltaic production). An estimated 27 tons of CO₂ emissions are avoided per year. *Figure 2* compares the electricity end use cost breakdown between the base case building and design case building.

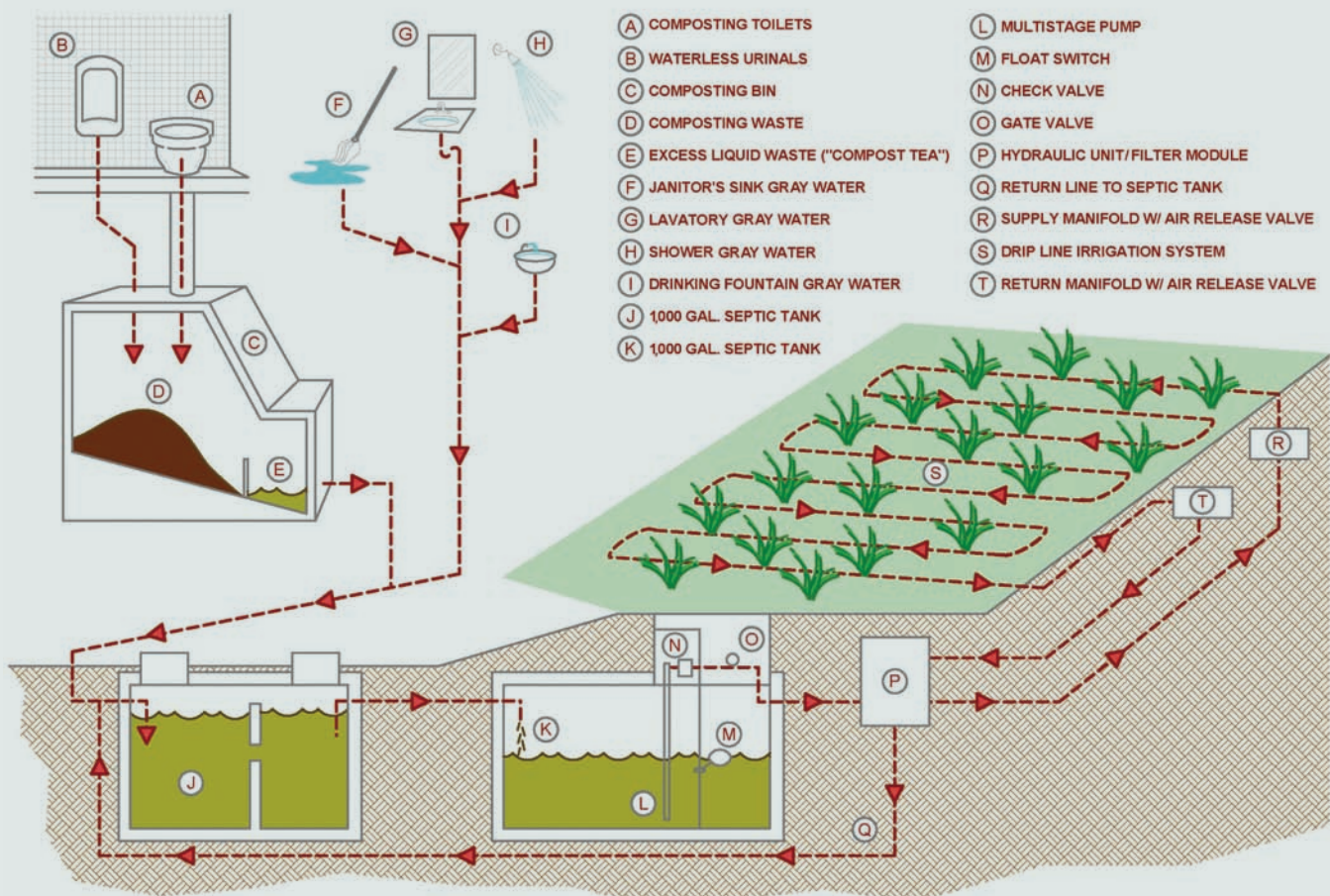
WASTE AND NUTRIENT RECYCLING

The waste treatment system for this project eliminates the use of municipal potable water for sewage conveyance and treats 100% of the waste on-site in an ecological manner, without the use of chemicals. Except for a single foam flush toilet that uses only 3 oz. of foam per flush to discharge waste from the toilet bowl, all toilets and urinals are waterless. The foam flush toilet and the waterless toilets/urinals connect to four composting bins below. Compost, no longer being waste, can be used to enrich the soil in the vicinity of the building.

Gray water generated from lavatories, water fountains, a mop sink and a shower is mixed with excess effluent compost tea liquid from the composting bins. Diluting the compost tea with large amounts of gray water allows more frequent irrigation than would be possible with undiluted tea. A 1,000 gallon septic tank filters out particles that may be suspended in the gray water. The water then goes through a 1,000 gallon dosing tank before entering the drip irrigation system. The system does not use chemicals or biocides.

Typically, after separating solid waste from effluent, traditional septic systems distribute

nutrient-rich effluent into the soil below the roots of plants growing above the drain lines. The high-nutrient concentrations from the drain lines can leach downward and contaminate the groundwater. In contrast, the visitor center's system of drip irrigation lines distributes the mixture of gray water and tea into a demonstration garden at a depth between 6 in. and 10 in. below the surface, where the plant roots can absorb and use the nutrients. The demonstration garden is the final component of a system that uses innovative collection and use of water and redefines the concept of waste.



Post-occupancy systems evaluations are currently underway. Not all building systems were fully operational and/or monitored when the building opened. As part of the building's exhibits, an energy monitoring system was installed to provide a more accu-

rate picture of the building's energy consumption, photovoltaic production and water use. In January 2008, the system was partially running; however, communication problems between the building's server and the vendor's server slowed down data production.

Materials

Primary considerations for building material selection were first cost and life-cycle cost economy; amount of recycled content and future recyclability; materials extracted and/or manufactured regionally; materials

COMPARING ENERGY MODEL USE TO ACTUAL ENERGY USE

By Commissioning Agent H. Jay Enck of Commissioning & Green Building Solutions, Inc.

Reality is often different from assumptions made in energy modeling. In general, energy modeling has limitations, and comparing energy model results to actual energy recorded at the utility meter presents several obstacles. Assumptions were made for Sweetwater Creek State Park Visitor Center's energy model regarding improved energy efficiency of demand based ventilation with CO₂ concentrations to regulate the volume of outside air delivered over a given period. Variables include:

- Daily population in the visitor center and time in a building;
- Number of days represented by utility consumption for a given year (typically does not equal 365 days); and
- Weather elements such as dry and wet bulb temperatures, enthalpy, clear sky percentages, precipitation, wind speed and direction.

Typically, energy modeling programs use a variety of long-term average weather data files to estimate average energy consumption. Even with verified plug and equipment loads and schedules, weather files can create obstacles to accurate comparisons of calculated versus actual. For the visitor center, we used the original energy input file and actual weather data from the area. The closest weather station with the most complete data was Atlanta Hartsfield-Jackson International Airport, located 25 miles away. What we imagined as a relatively easy task was complicated by:

- A plethora of weather file formats, each containing its own set of observational measurements, format and availability of reliable actual weather year data, expected data format versus indicated weather data format, and missing data;

- Proximity of weather station to project site; and
- A general lack of information or sparse and outdated information on alternative ways to accomplish actual weather year modeling.

Sweetwater Creek State Park Visitor Center's estimated annual energy consumption is 81,660 kWh. Using the actual dry and wet bulb temperatures in lieu of the historic averages raised the estimated energy consumption to 85,200 kWh. However, the actual energy use for 2006 was 94,680 kWh, 11% higher than estimated. Without measurements of actual occupancy, actual plug loads or contribution from the solar photovoltaic system for the same time period, it is difficult to determine the causes of the variance.

Twin interior lightshelves below clerestory windows bounce daylight into the main exhibition space.



that would be durable and easy to maintain; and materials that had minimal VOC off-gassing. Twelve percent of materials by cost, including photovoltaic solar panels recovered and reused from a gas station canopy, were salvaged. Additionally, 29% of the project's materials by cost were manufactured within 500 miles of the project site. In response to the criteria listed earlier, primary exterior materials consist of masonry stucco, galvanized steel siding, prefinished steel roofs, vegetated roofs, and aluminum storefront and window systems. The provisions diverted 125 tons or 80% of the construction waste from landfills.

Financial Contributions

Several financial partnerships contributed to the success of this project. State funds represented less than 75% of the total project costs. The Friends of Sweetwater Creek State Park raised more than

LESSONS LEARNED

Monitor Building Performance Implementing a measurement and verification plan helps confirm that the high performance building is operating within anticipated parameters. Without monitoring the main building systems, the owner of the best designed and best constructed building in the world may not be aware that the building is not performing as intended. In the case of Sweetwater, a 77% reduction in potable water use was anticipated while over 90% was achieved. In contrast, achieved energy savings were lower than anticipated. Comparing actual meter readings to the energy model baseline and the design case is unrealistic without matching actual conditions. Nevertheless, adjustments are being made to the building energy use, particularly lighting, to achieve readings closer to the anticipated savings.

Nutrient Recycling Three times during the design process, owner, architect, LEED consultant, structural engineer, mechanical engineer,

electrical engineer, landscape architect, civil engineer, construction cost consultant, commissioning agent and a representative from Friends of Sweetwater Creek State Park gathered to consider cross-disciplinary strategies and make decisions based on team consensus. On several occasions, the integrated design process yielded ideas and solutions that developed the project design into a more intelligent and elegant expression. A good example is the nutrient recycling aspect of the project, where excess liquid from the composting toilet system is combined with the building's gray water before being pumped to the exterior landscaping as liquid plant food, thereby eliminating the waste stream to a treatment plant or conventional septic system. No single discipline was responsible for the solution; rather, it required input and expertise from the owner (a civil engineer by training with a willingness to explore an unconventional solution), the mechanical engineer (the portion of the

system inside the building), the civil engineer (the portion of the system outside the building), the landscape architect (the plant material), and the architect (integrating the system into the building).

Display Lighting Efforts to optimize building performance can continue even after building operation begins. To further improve the building's performance, the design team encouraged the owner to implement newer technologies for the display lighting when available. The interpretative exhibits' track lighting is a significant power consumer in the building. Because this lighting is associated with the displays, it was not included in the energy modeling of the base building. When the building opened, reliable dimmable compact fluorescent lighting lamps were not available; thus, dimmable incandescent lighting lamps were used. The owner plans to swap out these lamps with dimmable compact fluorescents when feasible.

\$500,000 for this project, including \$250,000 from a major corporate donor and varying amounts from other businesses. Grants were received for some of the renewable energy features including a large donation of salvaged photovoltaic panels valued at approximately \$85,000 and a grant from the Georgia Environmental Facilities Authority for new photovoltaic panels valued at approximately \$20,000.

If the value of the donated recycled photovoltaic panels (about \$85,000) was included in the cost of the building (excluding exhibits and site work), the final cost of the building would be approximately \$185/ft². However, the actual cost of the building, not including the value of the donated panels, was \$175/ft².

The majority of the contributions were made because the project was going to be an exemplary sustainable

building. The sustainability of the project made the fundraising significantly easier and brought in many partners and donors interested in promoting green buildings.

Teaching Tool

Recognizing its place within a conservation park, the facility preserves and interprets the cultural history of the area; conserves and protects the local natural ecosystem; and educates the public in environmental stewardship, using the site and building design as a teaching tool. The interactive facility allows visitors to experience areas inside, beside and on top of the building. Sustainable systems, incorporated into exhibits inside the building, teach visitors about conservationism. With the exhibits and site design, Sweetwater Creek State Park Visitor Center has become a destination for

those interested in learning more about resource conservation and high performance, green buildings.

Acknowledgments

This article contains data from an energy analysis and modeling report prepared by Commissioning & Green Building Solutions, Inc. One World Sustainable Energy Corporation provided the estimated solar photovoltaic production for the visitor center in *Figure 1*. The emissions information was derived from the U.S. Environmental Protection Agency's (EPA) Emissions & Generation Resource Integrated Database (eGRID) for the calendar year 2000. ●

ABOUT THE AUTHOR

Dan Gerding, AIA, is managing principal of Gerding Collaborative, LLC.