Stroud Water Research Center
Getting The Water Right

By Amy Cornelius

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Stroud Water Research Center has been awarded a LEED Platinum certification for its new environmental science education and public outreach center – the **Moorhead Environmental Complex**. Stroud Water Research Center is all about protecting fresh water and its new building vibrantly reflects the not-for-profit's goal of ensuring a sustainable future for clean water on which life depends. The East Branch of the White Clay Creek that flows through the property is part of a system that starts small and grows deeper and wider as it moves through Pennsylvania into Delaware where it is the main source of drinking water for the City of Newark, DE.

The water that flows into the White Clay comes from a variety of sources including: springs and streams, farm and pavement run-off. The latter source, run-off, provides challenges to the health of the freshwater system.

The guiding design principal for the new Moorhead Environmental Complex was "Getting the Water Right." The result is an innovative rainwater management system for the property and the building that exemplify Best Management Practices (BMP's) that protect clean water by managing it on site — at the source.

Specifically, Stroud wanted to: reduce the amount of groundwater widthdrawal, reduce the amount of organic and nitrogen pollution from septic wastes, and to return the site to natural forest function with regard to rainwater runoff and infiltration. To achieve these goals, the design:

- Starts with **sources** – augmenting ground water fed wells with harvested rainwater,
- Investigates **uses** – drinking, sanitation, laboratory research, irrigation and groundwater recharge
- And then explores alternate **waste management and disposal** solutions – sanitary treatment and disposal, stormwater management

Sources

Situation

Stroud Water Research Center is settled on 50 acres of mixed woodland and farmland of which approximately 7.5 acres are developed. The new 16,000 sf Moorhead building covers 5,300 square feet for a total site building coverage of 3.2%. Approximately three acres drain downhill toward the Center.

To meet the goals, the design team modeled the natural hydrological systems to estimate pre- and post-development runoff. By focusing the design on the science of water, the team created a design to mitigate the effects of the development.

	Natural Predevelopment	Post-development
Runoff	1.78 Million GPY	4.81 Million GPY
Evapotranspiration	4.39 Million GPY	2.88 Million GPY
Groundwater Recharge	2.99 Million GPY	1.48 Million GPY
	Development Affect	
Runoff	+ 3.03 Million GPY	
Evapotranspiration	- 1.51 Million GPY	
Groundwater Recharge	- 1.52 Million GPY	

Source Data: Meliora

Prior to construction, the main source of potable, irrigation, sanitary, and research laboratory water was an on-site well. Approximately 600 gallons of aquifer water was drawn per day to meet user demands. All of the water was treated to potable standards.

Also, the Center, which is partly located within a flood plain, relied on an aging septic system for wastewater treatment.

The existing research facility and storage building had historically been left to drain onto a stone parking area and to surrounding vegetation. This stormwater typically flowed unchecked across the lot down the hill toward the stream.

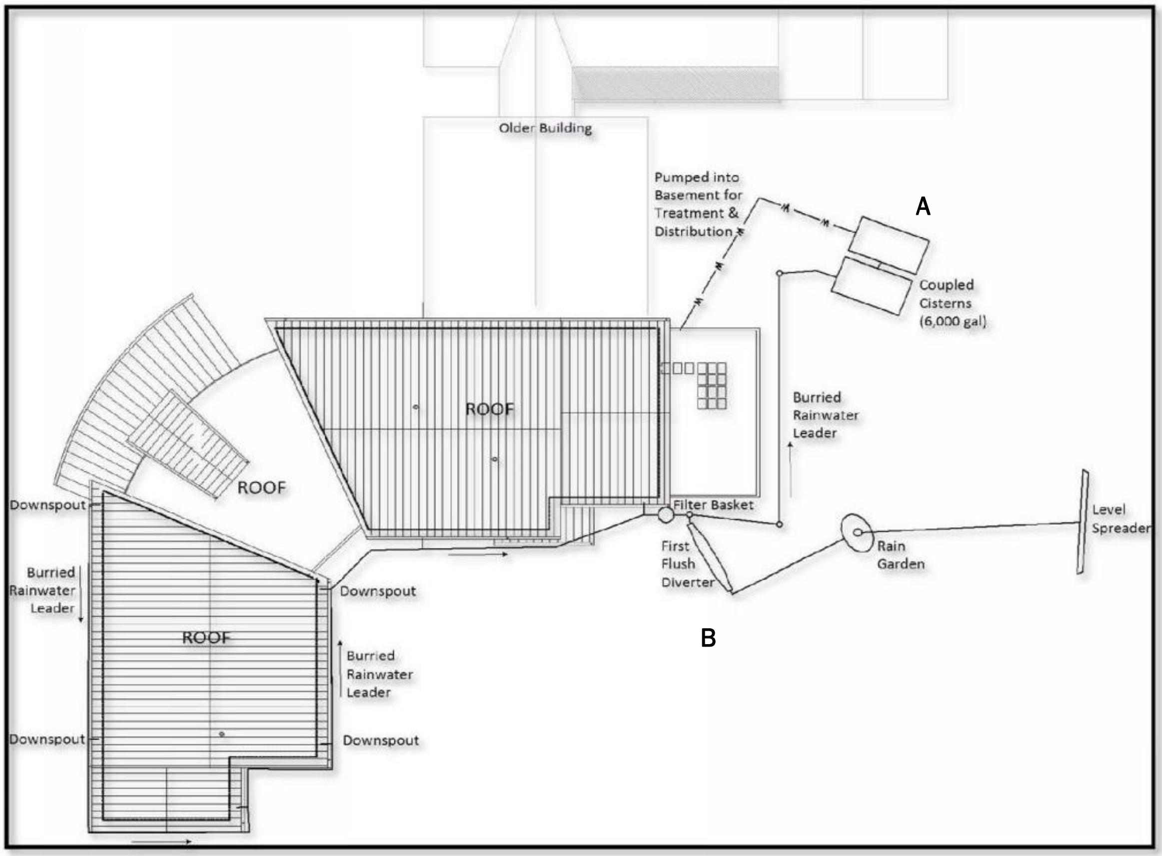
Left uncaptured, the new building's roof would add to this flow. How best to "Get The Water Right" and restore the site hydrology to its natural, pre-development status?

Solution

The design team used an ecological approach to develop a series of water systems to:

- restore the natural site hydrology,
- greatly reduce the nutrient concentration from waste water,
- contribute to ongoing research,
- provide an educational demonstration for students and the public

Active Capture For Reuse



As depicted above, the Center installed a standing seam metal roof to assist in providing a clean catch after the first flush. The Berridge Manufacturing Co. roof is made from 25% post consumer and 7% pre-consumer recycled content. The roof is configured with hips and valleys to channel water flow to gutters and leaders that are piped to two 3,000 gallon underground cisterns for storage. (Shown on right, A on the above schematic). These cisterns are linked together in series and are piped into the building to supply water to the research facility and water to the toilets.

The First Flush System (B on the above schematic) routes collected roof rainwater through a large filter basket from Conservation Technologies to remove coarse debris from the rainwater stream keeping the cisterns

free of large debris. From the filter basket, the first flush routes into a 12" underground diverter kit from Rain Harvest Systems (below). This diverter system shunts the first 0.1 inches of

stormwater to a Bioretention Area and level spreader for dispersion and infiltration.

The front entry canopy rainwater is routed to the front Bioretention Areas via decorative rain chains.

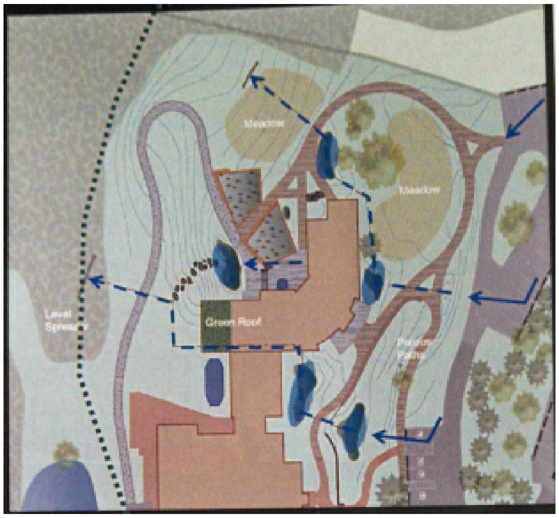
As a visual educational tool, a 1,500 gallon wooden rain barrel (below) from Hall-Woolfard Tank Company, Inc. (locally sourced in Philadelphia) was placed

outside on the patio to show how to capture rainwater at home or office. This rain barrel is fed from the roof directly over the educational labs. It is equipped with a spigot for attaching a hose for irrigation and is piped to overflow to cisterns for use in the building.

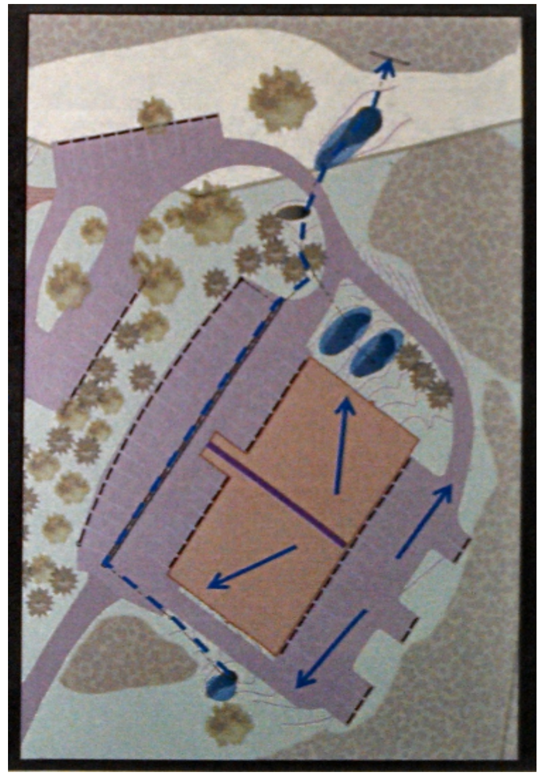
Passive Capture for Infiltration

The buildings, pathways, and parking areas are set on a hillside that slopes to the stream. The new building is poised near the base of the slope. At the top of the slope an existing storage building and gravel parking area had ineffective stormwater management systems in place.

As depicted in the following two illustrations, the design team relied on a series of rain gardens or Bioretention Areas and infiltration devices to mimic the natural hydrology of the land. There are three main interlinked Bioretention series. These are designed to promote infiltration beneath them. In the case of



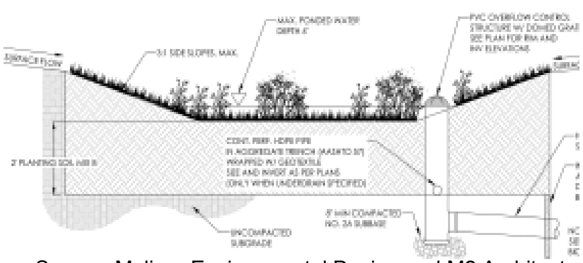
Graphics: Meliora Environmental Design



Graphics: Meliora Environmental Design

severe storms, each Bioretention series is equipped with overflow piping that diverts excess water to the meadow/ forested wetland areas.

Bioretention Area Construction



Source: Meliora Environmental Design and M2 Architecture

Results

With its team, Stroud has designed an Active and Passive Rainwater Management system that significantly reduces the impact of its new building. Most of the rainwater from the new building's roof is captured for use within the facility. Any remaining rooftop water is slowly infiltrated via the Bioretention system

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Uses

Situation

Prior to construction, the Center was using about 600 gallons of potable water each day from its on-site wells for all uses, including laboratory, sanitary and drinking. As most of the Center's usage does not require potable water, the Center was wasting the resources it took to filter and treat the well water to potable standards.

The design team was challenged to increase the size of the campus by 40% while reducing or maintaining the total volume of water consumed.

Clivus Multrum composter set below the toilets above in the bathrooms. There is a parir of these units in the mechanical room.

Solution

Reduce water use and liquid output

using waterless composting toilets

The original building utilized composting toilets. They were so successful that two new Clivus Multrum composting systems (Model: M18) were installed in the new building These units use "natural biological decomposition to convert human wastes into reusable end

products." (*Clivus Multrum)*

The keys to the success of the Clivus Multrum system are: adequate ventilation, efficient liquid drainage, regular additions of bulking agents and the addition of 'red wigglers' – worms – to help reduce maintenance and accelerate decomposition.

The liquid waste from these units is held in two 625 gallon Chemtainer vertical storage tanks for aging. The aged urine can ultimately be

used as liquid fertilizer. Any overflow is fed to the Complex's Constructed Wetland Wastewater Treatment system.

The solid waste from these units can eventually be used as compost on non-food crop areas.

Conserve water

The other four rest rooms in the Complex utilize low-low, dual-flush toilets by Sloan (Uppercut Model WES-111). These fixtures consume 1.6 gpf for solids and 1.1 gpf for liquids. Two clever additions to ensure user compliance are an easy to read sign explaining the toilet and a bright green handle signaling that something is different.

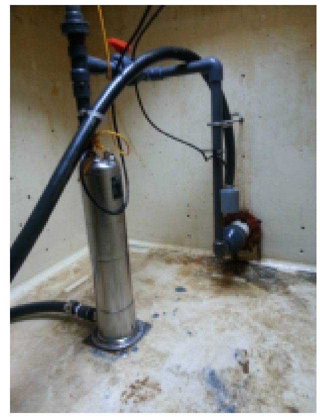
These restrooms also utilize Sloan Solaris touchless solar and indoor light powered faucets that are rated at 0.5gpm.

Use captured and treated rainwater for lab and sanitary water

The roof-captured rainwater is routed via downspouts, leaders and conduits to the two 3,000 gallon cisterns located behind the building. From here the water is pumped on demand into the building. The rainwater is filtered through a 0.5 micro-canister filter and then a UV light treatment. It is then distributed to toilets and to the laboratory water treatment system.

Results

The campus increased its size by 40% size with the addition of the new building yet total water consumption is almost even with pre-construction consumption. (Total treated rainwater use is approximately 51 GPD and total well-water draw for the entire campus is 575



Cistern Pump

GPD for a total water usage of 626 GPD versus pre-construction of 600 GPD).

Management

Situation

To Get The Water Right, the project sought to achieve balance in the water budget, to create "A stormwater management system designed to mimic the earth's natural hydrological cycle," and to treat its effluent in a more natural way.

Balance

Total annual predevelopment demand for well water on the campus was measured at 217,000 gallons. Given the water-saving initiatives taken during construction, actual water demand for the campus has risen only 5.2% and well-water demand has fallen 3.4%. This results in a total post-development demand of 228,000 GPY.

Total rainwater volume available from the roof given 47.56" average rainfall per year is approximately 127,000 GPY. The two 3,000 gallon concrete box cisterns totaling 6,000 gallons were installed with the design intent that they would be drawn down given demand in the buildings. The rooftop rainwater capture system was designed to overflow to the Bioretention system in case of oversupply. Current demand from the cisterns totals 18,600 GPY leaving an estimated total overflow of 108,000 GPY or 290 GPD of water to manage.


Level Spreader

Overflow from the cisterns is designed to backup to the level spreader in the rear of the building for dispersal to the meadow.

Effluent

Predevelopment, the campus relied on a 30 year-old septic system. The design team was challenged to design a system that would naturally treat the effluent.

Partners

Architect: M2 Architecture (www.m2-arch.com)
Landscape Architect: Andropogon Associates (www.andropogon.com)
Land Development: Meliora Environmental Design (melioradesign.net)
Ecological Wastewater Design: Biohabitats (http://www.biohabitats.com/)
Landscaping and Maintenance: Think Green

Structural Engineer: Ann Rothmann Structural Engineering, LLC (http://mysite.verizon.net/vzeotgql/AMR/) –
Engineering: Bruce E. Brooks & Associates (www.brucebrooks.com)
Lighting: David Nelson & Associates, LLC (www.dnalighting.com) -

Construction Management: Nason Construction (www.nasonconstruction.com)
Owner's Representative: Consilience, LLC (www.consilience.net)

Solution

Encourage Infiltration Using:

Pervious Surfaces

The Complex's new walkways are surfaced with nubbed pavers that provide space between the bricks for water to penetrate to a bed of 8-12” gravel where water can then infiltrate into the ground.

The front of the Complex faces the upside of the hill. Using a terrace and berm approach, the pervious hardscape snakes through the landscape to allow easy disabled access, connecting the rest of the campus and guiding the flow of water into the Bioretention Areas and surrounding meadows

The Bioretention Areas, which are planted with native plants, provide habitat and nutrition to indigenous insects and birds while controlling the flow of water.

At the existing storage building, the crushed-stone parking area had historically shed water downhill. During construction, an 18” perforated pipe was installed beneath the entire length of the lot. This infiltration trench is designed to accept roof-captured rainwater from Bioretention Areas adjacent to the structure and sheet water from the lot itself. The trench is designed to allow water to infiltrate into the ground and move any excess away from the hill and the new building into a Bioretention Area that overflows to a Level Spreader into the meadow. The Level Spreader is designed to interrupt concentrated flows that form channels that erode the landscape and eventually form gullies. The Level Spreader gently releases of water allowing it to infiltrate in a dispersed manner, thus avoiding erosion.

<u>Native plants for Stroud’s Bioretention Areas</u>

Trees and Shrubs

- *Amelanchier leavis* “Service Berry”
- *Acer rubrum* “Red Maple”
- *Magnolia virginiana* “Sweetbay Magnolia”
- *Fothergilla gardenia* “Dwarf Witch Adler”
- “Dwarf Inkberry Bush”
- *Hydrangea quercifolia* “Oakleaf Hydrangea pee wee”

Perennials

- *Phlox x*. “Minnie Pearl Phlox”
- *Liatris spicata* “Blazing Star”
- *Coreopsis rosea* “Pink Tickseed”
- *Lobelia siphilitica* “Great Blue Lobelia”
- *Iris versicolor* “Blue Flag Iris”
- *Waldsteinia ternate* “Barren Strawberry”
- *Crocus* sp.
- *Veronia noveboracensis* “NY Iron Weed”
- *Pennstemon digitalis* “Husker Red” Beard-stongue
- *Aster oblongifolius* “Raydon’s Favorite”
- *Chalone Glabra* “White Turtlehead”
  Amsonia “Blue Ice” Blue Star

Grasses

- *Juncus effuses* “Common Rush”
- *Panicum Virgatum* “Shenandoah” Red

<u>Green Roof</u>

A 554 sf green roof was installed as a demonstration garden. The multi-ply roof is designed to reduce runoff and provide some insulative properties. It is planted with typical drought resistant southeast Pennsylvania meadow plants and grasses including Big Bluestem and Yarrow.

Encourage Infiltration and Capture

The Bioretention Areas that the Stroud team designed look like traditional gardens, but they are shallow, constructed spaces planted with deep-rooted native plant species. The bowl shape of the Bioretention Areas slows and captures the rainwater as it runs off paved and other surfaces allowing the water to slowly infiltrate into the ground, mitigating stormwater runoff. The Bioretention Areas are designed for 100-year storm events but are equipped with overflow drains that outlet to level spreaders to distribute the excess water into the meadow and the forest edge.

Constructed Wetland Wastewater Treatment System

Rather than use a traditional septic system to treat sanitary waste and other building effluent, the team designed and constructed a five-stage system that includes a Constructed Wetland to treat all effluent from both the new and existing portions of the campus.

The constructed wetland (above right) is set directly outside the educational lab and the building's entrance. Integrated into the landscape it appears more like a raised water garden than a sanitary system. It is designed as a sub-surface flow wetland which treats wastewater by moving the liquid through a gravel/ pea-gravel medium on which wetland

plants are rooted. The wetland plants and microbes in the system filter pollutants including nitrates from waste out of the water before it is allowed to infiltrate back into the groundwater – literally cleaning the water.

The system is designed to handle 2,000 gallons per day. The two wetland cells receive input from a Primary Treatment and Equilization tank. From the wetland, the treated water runs through a trickling aerobic filter tank, back into

Constructed Wetland with tank, trickle system and piping.

the Primary Treatment and Equalization Tank and then back in a loop to the constructed wetland cells. Waste water moves through this cycle multiple times, based on volume of flow, before it is pumped uphill to a two-chamber recirculating sand filtration bed for final polishing. The filtered water is stored in an irrigation dosing tank and then is pumped to an underground drip irrigation system for infiltration. This four-zone drip system runs through a half-acre field. Five observation/testing wells are used to monitor groundwater quality: one above the field; two directly below the field; and three a field away.

Stroud conducts periodic testing on the polished water and has found that the system removes 90% of total nitrogen – basically, the water is cleaner than the ground water in the field to which it is dispersed.

Conclusion

The Moorhead Environmental Complex is a year old now and it has had marked quantitative success:

- Increased campus size by 40% while holding increased water consumption to 5.2%
- Treated 100% effluent in the Constructed Wetland with 90% nitrogen removed
- Captured 100% roof rainwater and used it or allowed slow infiltration.
- Implemented stormwater management system that mimics the land's natural hydrology

The Stroud experience provides qualitative lessons as well:

- The enthusiastic corporate commitment to Getting the Water Right was key to every step of the design, construction and to occupant behavior.
- Outreach is key to spreading the word about techniques, technologies, and public acceptance.
- An in-depth study of the land's natural systems is key to a successful design.
- It isn't just about capturing rainwater. A good design addresses sources, uses and overall management.

Education

Children are learning about stormwater issues in their school classrooms through textbooks. Stroud strives to take those obtuse concepts and makes them come to life through visual interaction and hands-on learning in the lab and the field. In addition to teaching labs, the Complex has educational signage throughout that explains what is happening in the system and why it is a part of the building.

Looking from the classroom out over the water treatment system to the stream and the forest beyond underscores what the complex is all about: Educating by Getting the Water Right.

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