Green Infrastructure
(for stormwater)
Landscape Performance Research

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Green Infrastructure for Stormwater
LANDSCAPE PERFORMANCE RESEARCH :

LANDSCAPE ARCHITECTURE FOUNDATION

a working knowledge of green infrastructure design

i.e. how do we know landscape/green infrastructure works?

Landscape Architecture Foundation - Landscape Performance Series

Research, documentation, and evaluation of:

Stormwater performance - water quantity, water quality, total water budget impacts
Ecosystem services
Health & well-being benefits
Direct economic cost/benefit (installation, maintenance, savings, pay-back)
Shared economic benefits (to surrounding community, to municipality, to water district)

Case study format - e.g.
Project case studies - excerpts

The Morton Arboretum (Lisle, IL) - public research institution/public arboretum
http://landscapeperformance.org/case-study-briefs/morton-arboretum-meadow-lake-parking
Sarah E. Goode - Chicago STEM public school (Ashburn, Chicago) - learning landscape
http://landscapeperformance.org/case-study-briefs/palmisano-park
Stearns Quarry (Bridgeport, Chicago) - quarry/landfill converted to neighborhood park
http://landscapeperformance.org/case-study-briefs/sarah-e-goode-stem-academy

Green Infrastructure for Stormwater
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Landscape Architecture Foundation - Landscape Performance Series

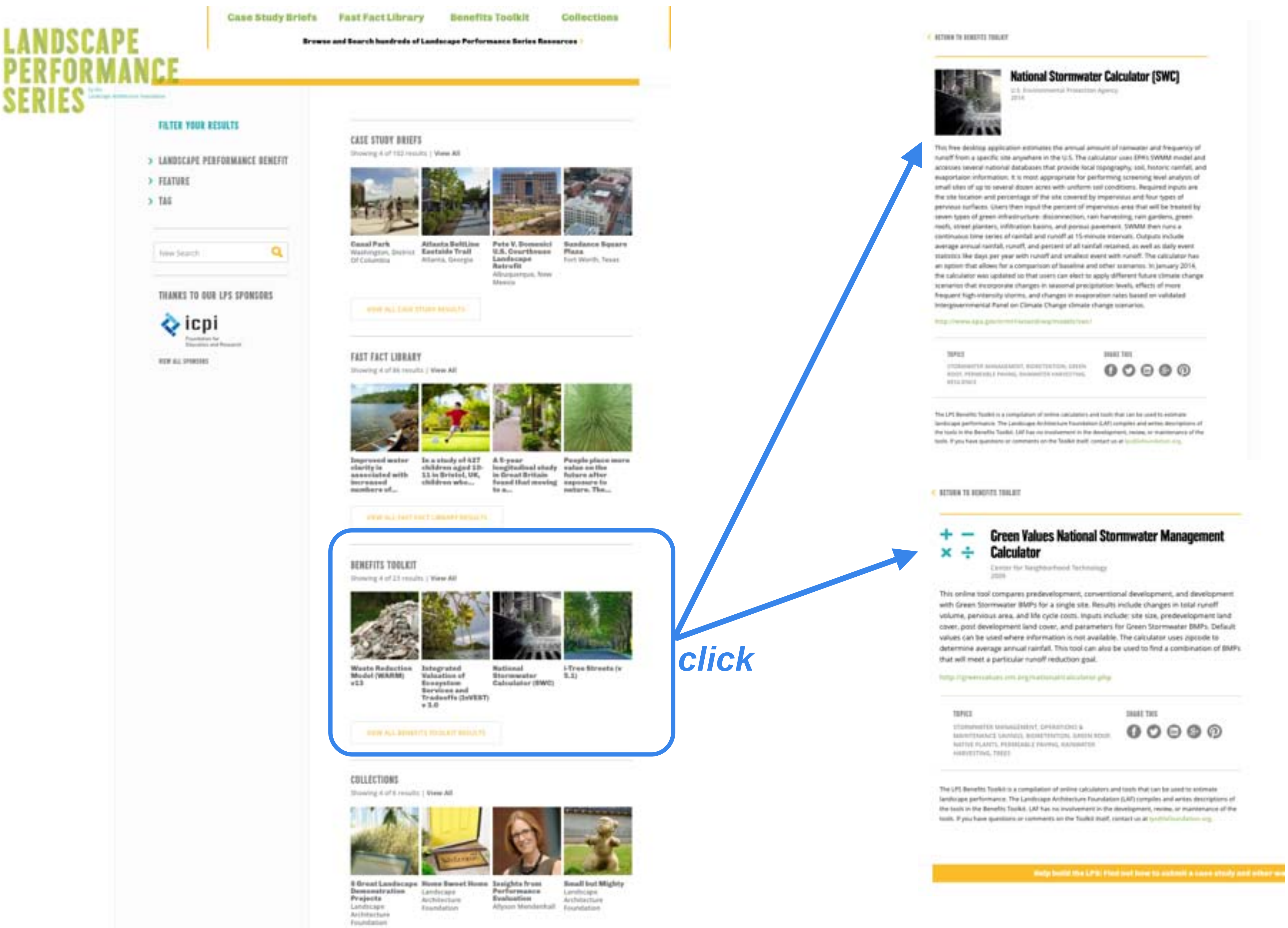
Every year 6 Research Fellows selected nationally to conduct research in the region.
Research process with designers, engineers, contractors, clients, municipalities.
Document research and on-site fieldwork research (surveying, measuring, testing)
The Case Studies are heavily peer-reviewed.
And published on the LAF-LPS website :

http://landscapeperformance.org

Project examples:
The Morton Arboretum (Lisle, IL) - private research institution / arboretum park setting
Advocate Lutheran Patient Bed Tower (Park Ridge, IL) - private health care development OR
Chicago Museum of Science and Industry SMART HOME (Chicago, IL) - demonstration eco-home
63rd Street Beach Restoration (Chicago, IL) - public lakeshore park
Sarah E. Goode - Chicago STEM public school (Ashburn, Chicago) - learning landscape
Stearns Quarry (Bridgeport, Chicago) - former quarry, then landfill converted to neighborhood park

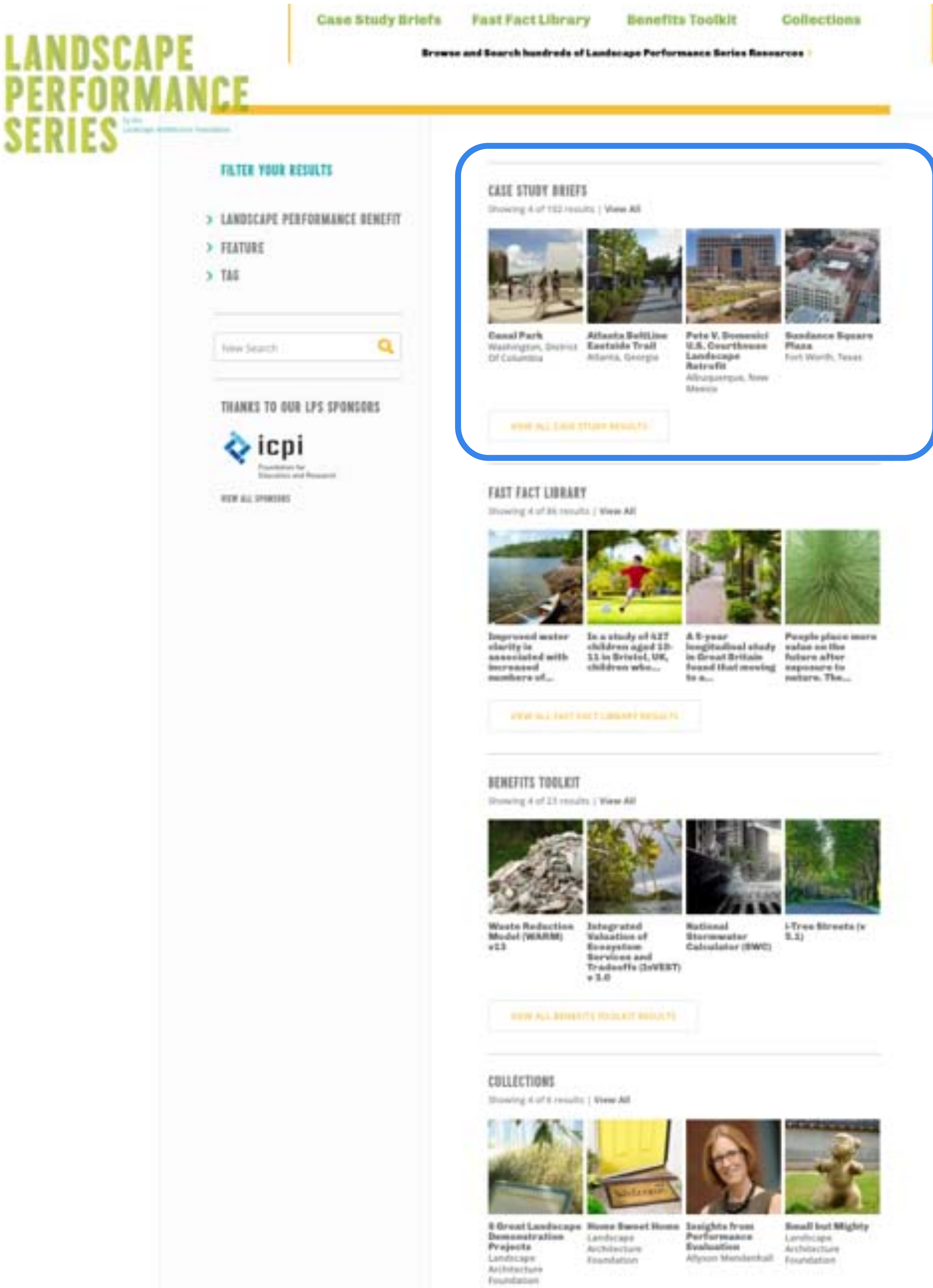
Green Infrastructure for Stormwater

LANDSCAPE PERFORMANCE RESEARCH : Benefits Toolkit (models and calculators)



Green Infrastructure for Stormwater

LANDSCAPE PERFORMANCE RESEARCH : Case Study “Briefs”



click

There is a button for each case study - when you click through you will first see before/after imagery

Green Infrastructure for Stormwater
LANDSCAPE PERFORMANCE RESEARCH : (example) The Morton Arboretum

Each case study includes a <u>description of the project</u> site design, client, background, and lists primary <u>physical features</u> of the sustainable landscape.

OVERVIEW | SUSTAINABLE FEATURES | CHALLENGE/ SOLUTION | COST COMPARISON | LESSONS LEARNED | PROJECT TEAM

The Morton Arboretum Meadow Lake and Permeable Main Parking Lot replaced a former degraded retention pond and asphalt parking lot with a functioning wetland system and permeable lot whose stormwater flow is now integrated with aquatic ecology. The entire project was the beginning of a 20-year capital improvement master plan, aimed at expanding facilities and sites to demonstrate sustainable design to visitors. The Arboretum now receives 850,000 visitors annually. All visitors to the Arboretum pass through the high-performance parking area to reach the Visitor Center. The adjacent Meadow Lake has become an active area for walkers, joggers, and educational programming. The permeable parking lot, the largest of its kind in the Midwest when it was installed, infiltrates and collects rainwater through a subsurface gravel bed, channels water through bioswales, and directs overflow to a final cleansing via the wetland area within the restored lake system. The permeable parking lot was partially supported by a US-EPA grant, and the complete project site is certified by the Sustainable SITES Initiative.

OVERVIEW | SUSTAINABLE FEATURES | CHALLENGE/ SOLUTION | COST COMPARISON | LESSONS LEARNED | PROJECT TEAM

- A 205,600-sf permeable parking lot with 477 car and 11 bus spaces is composed of a concrete paver system underlain by a 4-ft-gravel bed that stores and slows stormwater.
- Runoff from the parking lot is directed into 38,936 sf of bioswales where it infiltrates, and any overflow is directed into the adjacent constructed wetland at Meadow Lake.
- Meadow Lake was enhanced to create a 7-acre functioning wetland and habitat system. Previously, it was a degraded retention pond with undercut banks and no edge plantings that was not conducive for human interaction.
- 68,000 plants of 165 species, 98% of which are native, increase the habitat value of Meadow Lake. Wetland plantings demonstrate submergent, emergent, and wet mesic plant zones, and unique plants such as Dirca palustris (leatherwood) were propagated from the surrounding Arboretum grounds.
- Dense massing and drifts of native species provide a legible, garden-like ecological edge to Meadow Lake.
- A 35-foot slurry wall extending to bedrock surrounds Meadow Lake to prevent groundwater from entering the lake, since the groundwater contains higher than average amounts of naturally-occurring phosphorus due to underlying bedrock.
- During peak growth season from April to November, high efficiency pop-up head irrigation supplements the parking lot bioswale display gardens using non-potable water from Meadow Lake.
- Two 15- to 25-ft-wide limestone stepped-terraces gradually descend 3 ft and10 ft down to the lake, allowing direct interaction with the water's edge and a feeling of immersion within the landscape. Turtles and frogs frequent this edge and provide an opportunity for people to observe them up-close.

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Green Infrastructure for Stormwater

LANDSCAPE PERFORMANCE RESEARCH : (example) The Morton Arboretum

Heart of the research - you may download the methodology for the case study - to read documentation for each benefit.

Landscape Performance Benefits

ENVIRONMENTAL

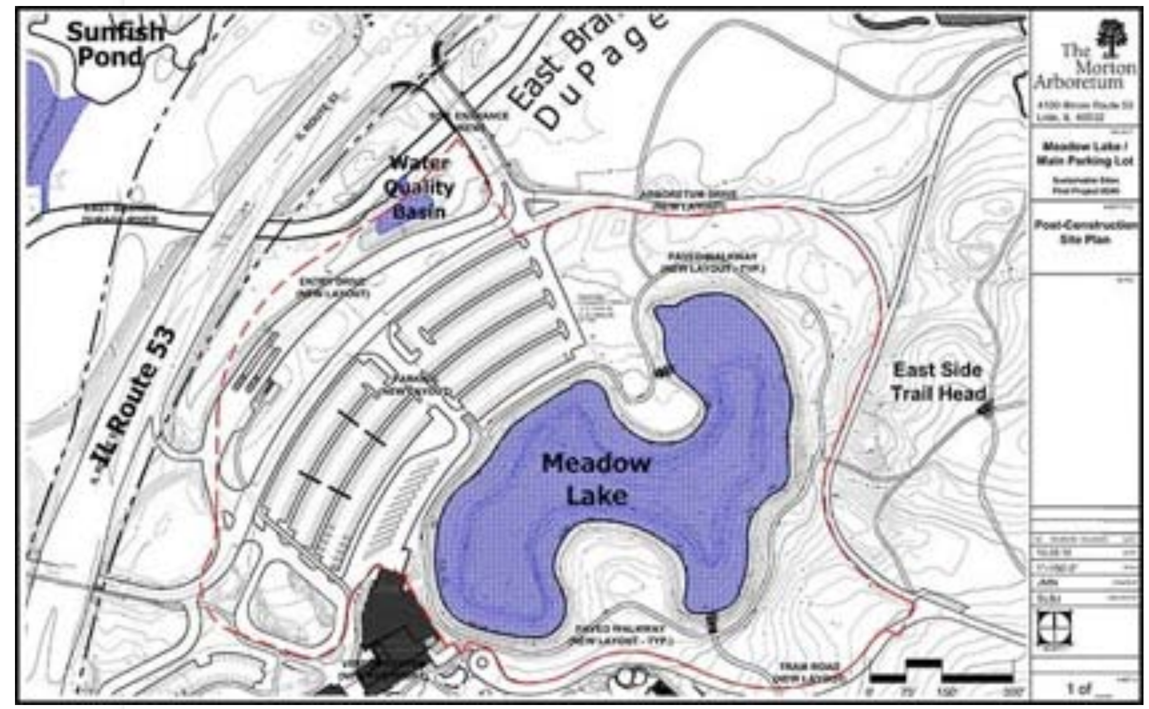
- Retains virtually 100% annual rainfall on the site, as supported by 10 years of observations. Only one unprecedented rain event resulted in flooding.
- Improved water quality in Meadow Lake by helping to reduce Total Suspended Solids (TSS) by 84% and by Total Phosphorus by 39%. Both reductions contribute to the penetration of sunlight and dissolved oxygen, and the increase in aquatic macrophytes.
- Saves approximately 327,700 gallons of potable water for the peak month of July by using nonpotable lake water for irrigation.
- Increased the Biomass Density Index — a measure of the density of plant layers covering the ground — by 10% around Meadow Lake and the parking lot.
- Prevents the establishment of all invasive species around Meadow Lake through ongoing monitoring and integrated pest management.
- Reused approximately 31,000 cu yd of excavated soil and fill materials from the parking lot site to create a portion of a berm to buffer the Arboretum from the adjacent highway.
- Supplements the Arboretum topsoil production with nearly 100% or 138 cu yd of the site's plant debris and clippings composted annually.

SOCIAL

- Educates the Arboretum's 850,000 annual visitors about the stormwater management features with 34% of Arboretum members and 32% of volunteers surveyed saying that they learned something new from the interpretive signs.
- Draws people to the lake, with over 85% of volunteers and 83% of members saying that they visit Meadow Lake every time they visit the Arboretum. Reasons include physical exercise, mental restoration and to experience nature.

ECONOMIC

- Saves approximately $3,300 annually and over 235 maintenance hours through efficient seasonal burning versus only hand weeding around Meadow Lake.
- Reduces parking lot maintenance costs by approximately $25,100 per year when averaged over 50 years by eliminating seal coating, striping and resurfacing.



1. **Retains virtually 100% annual rainfall on the site, as supported by 10 years of observations. Only one unprecedented rain event resulted in flooding.**

The research and methodology for each performance benefit is provided with text description, data, calculations, graphs, and resources and references.

The permeable parking lot, composed of cast concrete L-shaped pavers placed over a 4-foot bed of gravel, allows for storage and percolation of stormwater rather than a direct run-off into Meadow Lake. The reconstruction and expansion of Meadow Lake provides additional water storage, while maximizing filtration through the planted edge and constructed wetland. Before water enters Meadow Lake from the parking lot, it is filtered and infiltrated through bioswales leading to the constructed wetland. Figure 1.1 shows water flow.

The years 2004-2012 are confirmed by project drawings and SITES documentation showing no runoff left the site.[1] However, during discussions with the Morton Arboretum Natural Conservation and Landscape Architecture staff, we learned that one flood event has occurred since the project's completion. In April 2013, the Chicago metro region experienced unprecedented rainfall and overland flooding from the East DuPage River caused water from Meadow Lake to combine with floodwaters.[2] During this time the site performed as an overflow and flood storage for the river, prevent further downstream effects. The Arboretum staff confirmed this to be true during a meeting in May 2014.

Methodology:
Nearly 100% of rainfall on the parking lot infiltrates through the permeable parking lot pavers and the bioswales. Figures 1.2 and 1.3 show rainfall and runoff documentation from 2007. In that year, 31 inches of rain fell at the Morton Arboretum, 97.4% of rainfall infiltrated the parking lot. Only 0.81 inches or 2.6% of runoff left the parking lot to flow into the constructed wetland before reaching Meadow Lake.[3] The 2.6% of runoff leaving the permeable parking lot is captured through the site's stormwater system by flowing to the constructed wetland of Meadow Lake. Whereas, a typical asphalt parking lot (staff lot), in 2007, reported 13.35"or 43% of runoff. The permeable parking lot runoff reduction is particularly impressive considering its tributary area is over 375% larger than the staff lot.[4] Calculations for runoff and infiltration are provided.

[1] The Morton Arboretum. Sustainable SITES Initiative Pilot Program. 3.5 Summary - Manage Stormwater On-Site. 25 June 2012.
[2] Interview. Kurt Dreisilker. Morton Arboretum Natural Resource Manager. 9 May 2014.
[3] The Morton Arboretum. Sustainable SITES Initiative Pilot Program. 3.6 Protect and Enhance On-Site Water Resources and Receiving Water Quality. Wheaton SE NOAA Rainfall Gage, located on Morton Arboretum Property. 25 June 2012.
[4] The Morton Arboretum. Sustainable SITES Initiative Pilot Program. 3.6 Protect and Enhance On-Site Water Resources and Receiving Water Quality. Burke Engineering. 25 June 2012.

Permeable Parking vs. Asphalt Lot Runoff / Infiltration Calculations for 2007
Total Rainfall at The Morton Arboretum based on Wheaton Gage = 31 inches
Total Runoff for the Permeable Parking Lot = 0.81 inches
Total Runoff for Staff Asphalt Parking Lot = 13.35 inches
Runoff of Permeable Parking Lot as Percent = 0.81 in / 31 in = 2.61%
Infiltration of Permeable Parking Lot as Percent = 100% - 2.61% = 97.39%
Runoff of Staff Asphalt Parking Lot as Percent = 13.35 in / 31 in = 43.06%
Infiltration of Staff Asphalt Parking Lot as Percent = 100% - 43.06% = 56.94%

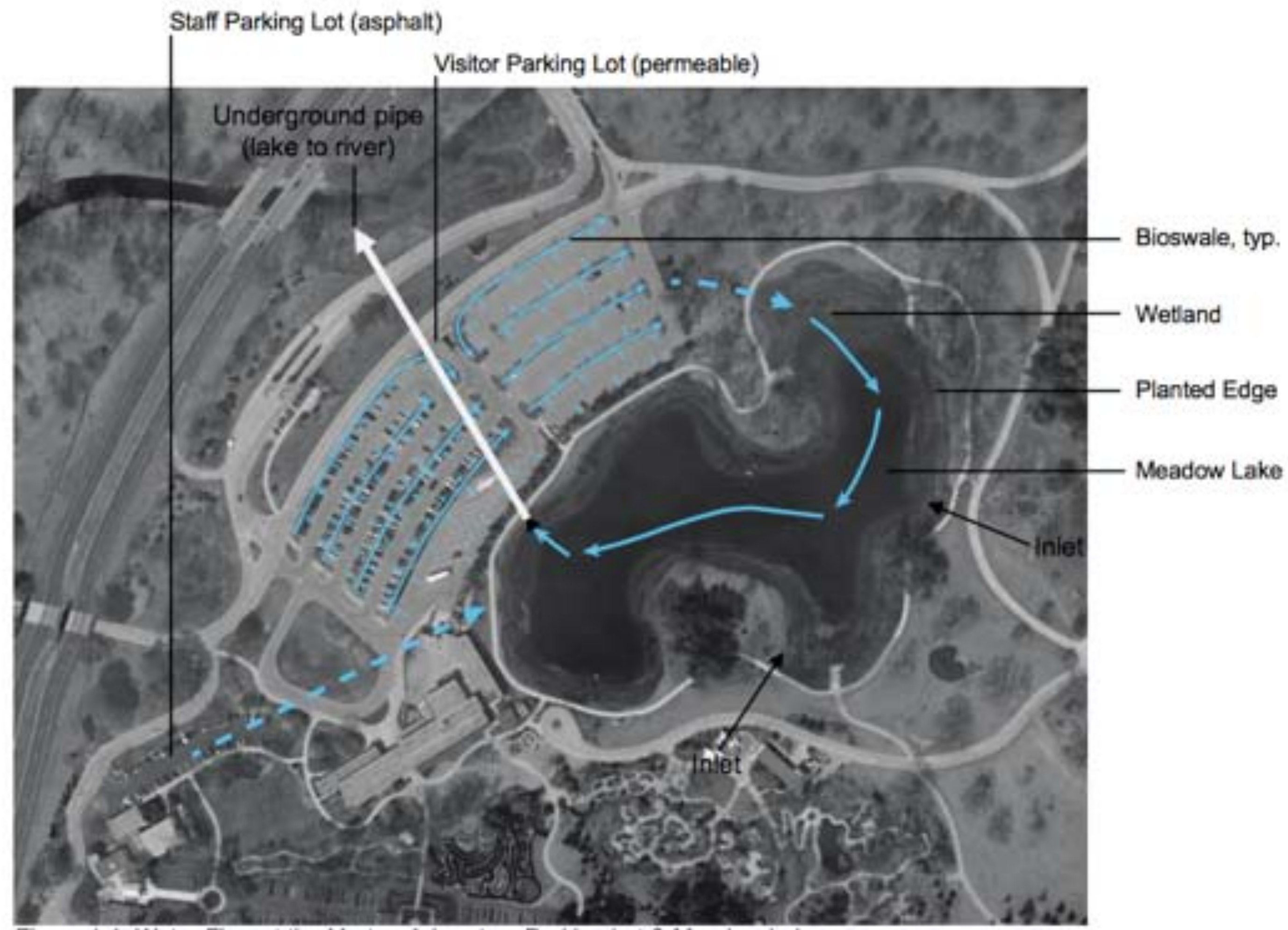


Figure 1.1, Water Flow at the Morton Arboretum Parking Lot & Meadow Lake

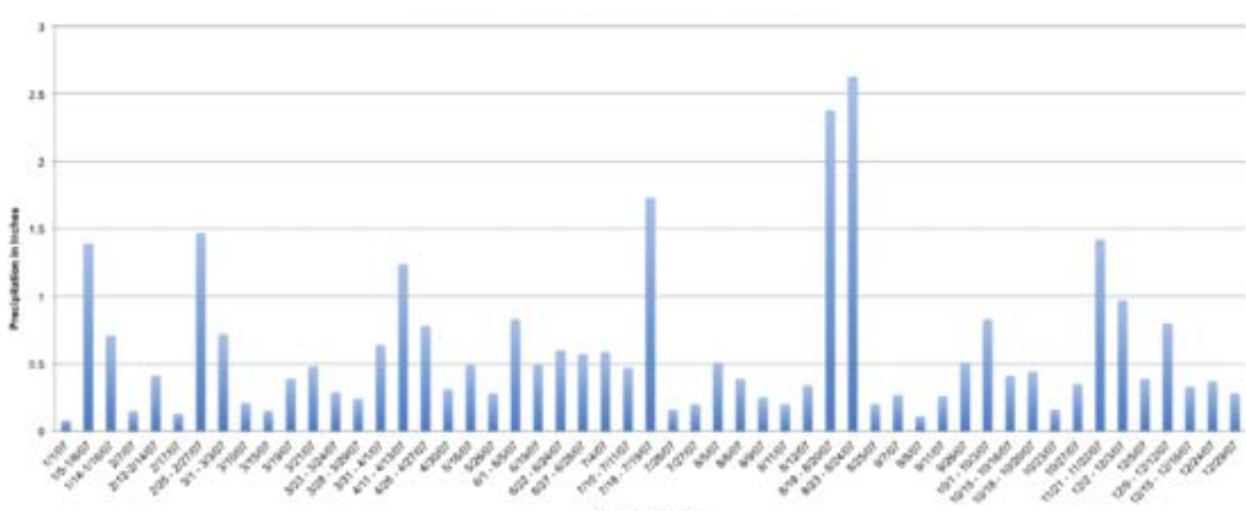


Figure 1.2, Graph of Precipitation at The Morton Arboretum for 2007. Graph based on information from the SITES 3.5 documentation.

Figure 1.3, Graph of Runoff in Permeable & Asphalt Parking Lots at The Morton Arboretum for 2007. Graph based on information from the SITES 3.5 documentation.

Green Infrastructure for Stormwater
LANDSCAPE PERFORMANCE RESEARCH : (example) Sarah E. Goode STEM school

Sarah E. Goode STEM Academy

BEFORE AFTER

OVERVIEW | SUSTAINABLE FEATURES | CHALLENGE/ SOLUTION | COST COMPARISON | LESSONS LEARNED | PRODUCTS | PROJECT TEAM

Sarah E. Goode STEM Academy was designed as part of the $1 Billion Chicago Public Schools' "Modern Schools Across Chicago" Initiative. Headed by the Public Building Commission of Chicago, a strong interdisciplinary collaborative design process and sustainable design ethos led to integrated, sustainable building and site design strategies. As a result, the high school is the first Chicago Public School to achieve a LEED Platinum rating. The 17.2-acre former brownfield features numerous athletic fields set within a landscape of educational, native gardens. Special features include a biology garden, community vegetable gardens, an outdoor classroom/picnic area, built bleachers and custom concrete sport seating, a council ring, rain gardens, a cistern, a geothermal field, and native plant education signs. The site is designed to also function as a neighborhood park and recreation center. The school has an indoor pool and gymnasium that are open to the community during non-school hours.

OVERVIEW | SUSTAINABLE FEATURES | CHALLENGE/ SOLUTION | COST COMPARISON | LESSONS LEARNED | PRODUCTS | PROJECT TEAM

- The site provides an educational landscape consisting of an 8,660-sf-biology garden, a 8,726-sf community garden area, a 7,130-sf reading garden, and a 5,954-sf outdoor classroom/picnic area containing native plant palettes.
- Three rain gardens cover a total of 27,995 sf. Each is approximately 4-ft in depth with a specific soil mix, drainage gravel, underdrain piping, and native plants that include Echinacea (purple coneflower), Lobelia (blue lobelia), and Schizachyrium scoparium (little bluestem).
- The rain gardens are integrated around baseball and softball fields, which are underlain by a geothermal field, and a 142,585-sf synthetic turf football/soccer field and running track.
- A total of 54,875-sf of additional gardens throughout the entire school site contain 18 different plant mixes of 42 species including grasses, forbs, asters, and flowering perennials.
- Different types of educational signage in the gardens communicate information on the water cycle, native plants, and prairie ecosystem to encourage learning about the site through observation and engagement.
- A 32,000-sf extensive green roof covers over 40% of the building and is planted with pre-vegetated mats of 15 varieties of flowering sedum, including white, yellow and red colors. All plant material is contained within 3 inches of engineered growing medium modular trays.
- On top of the green roof, gravel-nesting areas, birdhouses, a shallow water basin, and fallen trees for perches were installed to create habitat for birds. These features provide visual interest from the building's interior in lieu of access onto the green roof.
- A 48,529-sf reflective roof has a reflectance value of 0.84, which is 7 times higher than that of an asphalt roof.
- All landscape spaces are designed to collect, convey, store and/or infiltrate stormwater on-site.
- A 4,000-gallon cistern with a water gauge provides irrigation to community garden plots and overflows to the biology garden.
- The 40 community garden plots, each sized 8 ft by 5 ft, include 10 universally accessible garden plots.
- The outdoor classroom/picnic area provides seating for 74, including 4 universally accessible seats.
- A sustainable landform strategy reuses tons of existing onsite material that would otherwise be construction debris to create seating berms for athletic fields in lieu of traditional aluminum stadium seating.
- The permeable parking lot is composed of light-colored concrete pavers with a solar reflectance index (SRI) of 38. It accommodates 100 cars and provides storage for 35 bicycles.

Landscape Architecture Foundation 2014 (Mattson)

Green Infrastructure for Stormwater
LANDSCAPE PERFORMANCE RESEARCH :

Landscape Performance Benefits

ENVIRONMENTAL

- Reduces stormwater runoff by 38.9% or 311,683 gallons for a 2-year, 24-hour storm event.
- Captures and treats 100% of stormwater runoff from average annual rainfall, removing an estimated 80% of total suspended solids (TSS).
- Reduces annual irrigation needs by 3.45 million gallons as compared to a landscape of fully irrigated, non-native plants.
- Increased ecological quality by over 10 times that of the former industrial site based on the Floristic Quality Assessment, a measurement of native biodiversity of plants.
- Diverted over 20,700 tons of materials from landfills by reusing 90% of concrete, asphalt, and aggregate excavated from the site as backfill and recycling other site preparation materials.
- Reduces urban heat island effect by using a green roof and materials with a solar radiation index (SRI) of at least 29 on over 70% of all hardscape and roof surfaces.

SOCIAL

- Projected to yield nearly 3,500 pounds of food, which has an estimated value of $9,850, through community garden plots.

1. Reduces stormwater runoff by 38.9% or 311,683 gallons for a 2-year, 24-hour storm event.

Stormwater runoff reduction is increasingly mandated through stormwater ordinance and is a significant aspect of sustainable site design. Documentation of the reduction in stormwater run-off for Sarah E. Goode (SEG) Academy is provided by the project's LEED application stormwater modeling by project engineers.

LEED submittal documentation for SS Credit 6.1: Stormwater Design, Quantity Control[1] states that the site reduces runoff by 41,666-CF between pre- and post-development. Pre-development runoff is calculated at 107,162-CF or 802,627.5 gallons, while post-development runoff is 65,496-CF or 489,944 gallons. The runoff calculations represent a reduction from 1.2403 CFS to 0.75805 CFS, or total reduction in runoff by 311,683 gallons. Calculations for runoff reduction rates are provided.

The project achieved LEED credit SS 6.1 primarily through reduction in imperviousness of the site by over 50%. The site implemented a series of water-absorbing features through green roofs, permeable pavements, fields and infiltration gardens. Figure 1.1 diagrams the site's various permeable surfaces and their holding capacities.

The Rainfall Frequency Atlas of the Midwest[2] states that for Chicago's region, a 2-year, 24-hour storm would produce 3.04 inches of rainfall, over the site's 17.3 acres this storm event would produce 1,419,984 gallons of water. The site would infiltrate approximately 930,040 gallons of water post-development compared to 618,357 gallons pre-development. Table 1.1 is a portion of Table 1 from the Rainfall Frequency Atlas of the Midwest.

Stormwater Runoff Calculations for a 2-yr/24-hr Storm Event

Site area = 17.3 acres
1 in rain over 1 acre = 27,000 gallons
3.04 in rain over 1 acre = 27,000 gal x 3.04 in = 82,080 gallons
Total rainfall during a 2-yr / 24-hr storm onsite = 17.3 ac x 82,080 gal = 1,419,984 gallons
1 CF = 7.48502 gallons
Pre-development runoff in gallons = 107,162 CF x 7.48052 = 801,627.5 gallons
Rainfall infiltration onsite pre-development = 1,419,984 gal - 801,627.5 gal = 618,356.5 gallons
Post-development runoff in gallons = 65,496 x 7.48052 = 489,944.1 gallons
Rainfall infiltration onsite post-development = 1,419,984 gal - 489,944.1 gal = 930,039.9 gallons
Runoff decrease in gallons = 801,627.5 - 489,944.1 = 311,683.4
Runoff decrease as percent = 311,683.4 gal / 801,627.5 gal = 38.88%

Pre-development runoff rate = 1.2403 CFS
Pre-development runoff quantity = 1.2403 CFS x (24 x 60 x 60) SEC = 107,162 CF
Post-development runoff rate = 0.75805 CFS

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[1] LEED for Schools 2007 Submittal Template SS Credit 6.1: Stormwater Design, Quantity Control, January 2010

[2] Huff, Floyd A. and James R. Angel. Rainfall Frequency Atlas of the Midwest. Midwest Climate Center and Illinois State Water Survey. 1992. http://www.isws.illinois.edu/pubdoc/b/iswsb-71.pdf.

Permeable Parking Lot, infiltrates & treats water
Turf & Planting, infiltrates water
Green Roof, stores water before overflowing to cistern
Underdrain System, holds & treats water
Gravel Surface, infiltrates water
Bioinfiltration Garden, holds water
Direction of Water Flow
Cistern, 4000 gallon storage capacity

Figure 1.1, Permeable Surfaces at Sarah E. Goode STEM Academy

2. Captures and treats 100% of stormwater runoff from average annual rainfall, removing an estimated 80% of total suspended solids (TSS).

The National Oceanic and Atmospheric Administration (NOAA) monitors rainfall at Midway International Airport, which is 4.5 miles from Sarah E. Goode (SEG) Academy. The National Weather Service, a branch of NOAA, lists average rainfall at Midway to be 39.09 inches.[3] LEED submittal documentation for SS Credit 6.2: Stormwater Design, Quality Control[4] states that the site captures and treats 100% or 18,258,939 gallons of average annual rainfall resulting in an 80% reduction in total suspended solids (TSS). This provides a significant water quality benefit such that infiltration of rainwater will recharge the aquifer without these solids. For any overflow, municipal treatment facilities will not have to cleanse these solids as they enter the treatment facility.

Non-structural controls are accounted for in 4 primary areas for the site, predominantly associated with landscape features, the most significant of which are the turf field and ball field. Figure 2.1 delineates the tributary areas, in addition to the Tributary Areas information.

Average Annual Rainfall & Runoff Calculations
Average annual rainfall at Midway International Airport = 39.09 inches
1 in rain over 1 acre = 27,000 gallons
39.09 in rain over 1 acre = 27,000 gal x 39.09 in = 1,055,430 gallons
Average annual rainfall at SEG Academy in gallons = 17.3 acres x 1,055,430 gal = 18,258,939 gallons

Tributary Areas, Rainfall Treatment
Tributary Area 1 : Infiltration Trench, 46,860 sf = 46,860 / 748,274 = 6.3% of annual rainfall treated by this BMP
Tributary Area 2 : Permeable Pavers, 61,453 sf = 61,453 / 748,274 = 8.2% of annual rainfall treated by this BMP
Tributary Area 3 : Turf Field Underdrain System, 262,381 sf = 262,381 / 748,274 = 35% of annual rainfall treated by this BMP
Tributary Area 4 : Ball Field Underdrain System, 377,580 sf = 377,580 / 748,274 = 50.5% of annual rainfall treated by this BMP
Total annual rainfall treated = 50.5 + 35 + 8.2 + 6.3 = 100%

Tributary Areas, Rainfall Treatment in Gallons
Tributary Area 1 area = 46,860 sf / 43,560 sf = 1.08 acres
Tributary Area 1 average annual rainfall treated = 1.08 x 1,055,430 gallons = 1,139,864.4 gallons
Tributary Area 2 area = 61,453 sf / 43,560 sf = 1.41 acres
Tributary Area 2 average annual rainfall treated = 1.41 x 1,055,430 gallons = 1,488,156.3 gallons
Tributary Area 3 area = 262,381 sf / 43,560 sf = 6.02 acres
Tributary Area 3 average annual rainfall treated = 6.02 x 1,055,430 gallons = 6,353,688.6 gallons
Tributary Area 4 area = 377,580 sf / 43,560 sf = 8.67 acres
Tributary Area 4 average annual rainfall treated = 8.67 x 1,055,430 gallons = 9,150,578.1 gallons

[3] NOAA. National Weather Service Weather Forecast Office. *Chicago, IL Midway Airport 3 SW.* http://www.crh.noaa.gov/lot/?n=111577_Midway

Tributary Areas, TSS Removal Calculations

Tributary Area	*BMP*	*Removal Efficiency (%)*	*Area Ratio*	*TSS Removal Efficiency for Entire Site*
1 : 46,860 sf	Infiltration Trench	75	0.062624	0.046968
2 : 61,453 sf	Permeable Pavers	90	0.082126	0.073914
3 : 262,381 sf	Sand Filter / Extended Detention Wet Pond	80	0.350648	0.280519
4 : 377,580 sf	Sand Filter / Extended Detention Wet Pond	80	0.504601	0.403681
Total: 748,274 sf			1	**0.805081**

Total TSS removal as percent = 0.805081 x 100 = 80.5%

The supporting calculations for these percentage values are based on Table 4-7 within the EPA's Guidance Specifying Management Measures for Sources of Non-Point Pollution in Coastal Waters," Chapter 4 "Management Measures for Urban Areas."[5] An applicable portion of Table 4-7 is provided in Figure 2.1.

Stormwater percolates and infiltrates through CA-7 and CA-1 course aggregate and sandy soil sub-layers into the groundwater table located at approximately 8' below surface. Stormwater design to capture the above percentages meets City of Chicago Department of Water Management regulations.

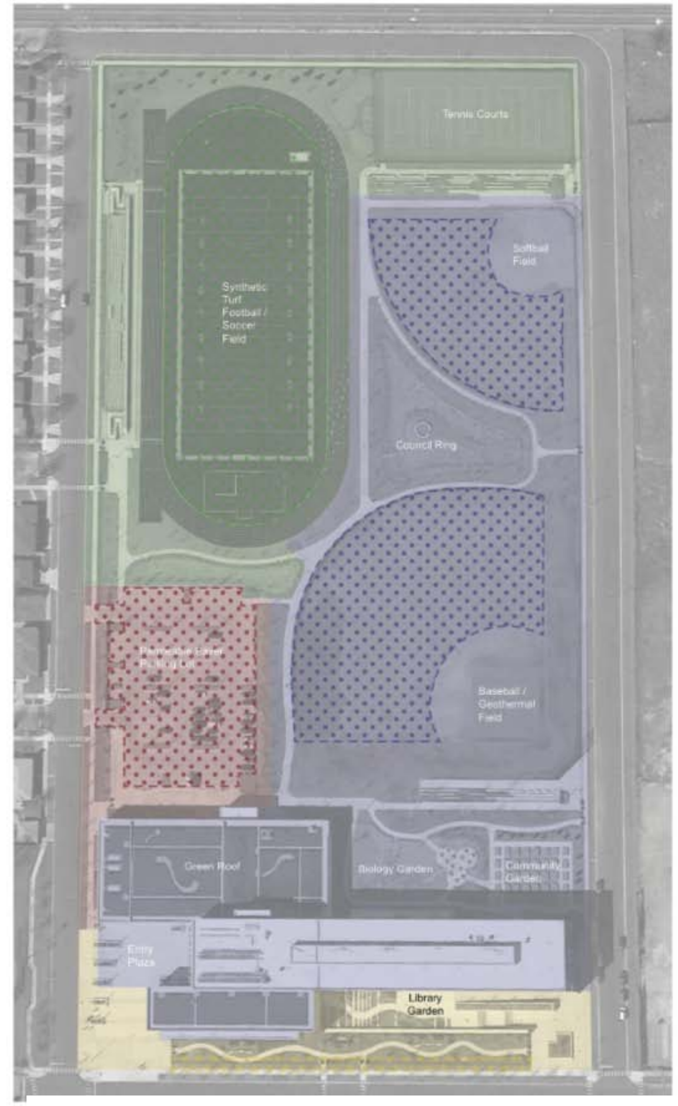


Figure 2.1, Tributary Drainage Map for Sarah E. Goode STEM Academy

Green Infrastructure for Stormwater

LANDSCAPE PERFORMANCE RESEARCH : (example) Palmisano/Stearns Quarry Park

BEFORE AFTER

OVERVIEW | SUSTAINABLE FEATURES | CHALLENGE/ SOLUTION | COST COMPARISON | LESSONS LEARNED | PRODUCTS | PROJECT TEAM

Palmisano (Stearns Quarry) Park is the remaking of a 27-acre, 380-ft deep former limestone quarry turned landfill. The quarry began operation in the 1830s, contributing stone to many of Chicago's first building and infrastructure projects. In 1969, the quarry was closed and the site was used as a municipal landfill for clean construction debris until 1990. The quarry/landfill site was transferred to the Chicago Park District, which, in collaboration with the Open Lands Commission, began converting the site into a public space. The park design reveals its multiple histories by keeping a quarry wall exposed as the backdrop to a major geometric landform that contains the landfill debris. The sculpted landform tapers to a series of wetlands that cleanse water and lead to a pond tucked against the quarry wall. The park is well-used and beloved by the neighborhood and also serves as a destination park for the Chicago area and beyond.

OVERVIEW | SUSTAINABLE FEATURES | CHALLENGE/ SOLUTION | COST COMPARISON | LESSONS LEARNED | PRODUCTS | PROJECT TEAM

- The site incorporates an exposed quarry wall including Silurian bedrock, metal elevator and building remnants, revealing a potent reminder of the site's geologic history as a coral reef and industrial history to park visitors.
- Through the sculpting of a unique landform affectionately called "Mount Bridgeport," the park's hilltop reaches 33-feet above street level and covers landfill materials while providing an elevation point for people to view the surrounding neighborhood and downtown Chicago. The sloped site serves as a winter sledding hill, rare in Chicago's flat terrain.
- The sloped topography of the site infiltrates and/or conveys all stormwater through 3.6 acres of terraced wetland cells to a 2-acre retention pond. Water is mechanically recirculated by a pump from the pond through the wetland system, ensuring regular flow through the system.
- City of Chicago concrete sidewalk and foundation debris was reused to create waterfall/splashplads at the 4-wetland cells' grade transitions.
- The 22 acres of native wetland and prairie ecosystems contain 8 different native plant mixes. These provide habitat for resident and migratory birds, such as downy woodpeckers, crows, cardinals, sparrows, blue jays, and finches. Occasional coyotes and foxes have been sighted in the park.
- Over 1.7 miles of paths – including nature trails, boardwalks, and 1.25 miles of universally accessible pedestrian paths – crisscross the hilly site. The paths are used for a variety of activities from nature walks to trail running, providing a complement to the traditional ball fields of the adjacent McGuane Park.
- Boulders and timber planks found onsite were reclaimed for use within bioswales, the boardwalk, and the regrading of Mount Bridgeport.
- Programming and activities that take place on the site include seasonal stewardship days, ecological learning, overnight camping, catch and release fishing, fossil hunting, passive recreation, music, and an air and water show that attracted over 1,000 visitors in 2013. Fossils found on-site are part of the Field Museum of Natural History's collection.

Landscape Architecture Foundation 2014 (Mattson)

Green Infrastructure for Stormwater
LANDSCAPE PERFORMANCE RESEARCH : (example) Palmisano/Stearns Quarry Park

Landscape Performance Benefits

ENVIRONMENTAL

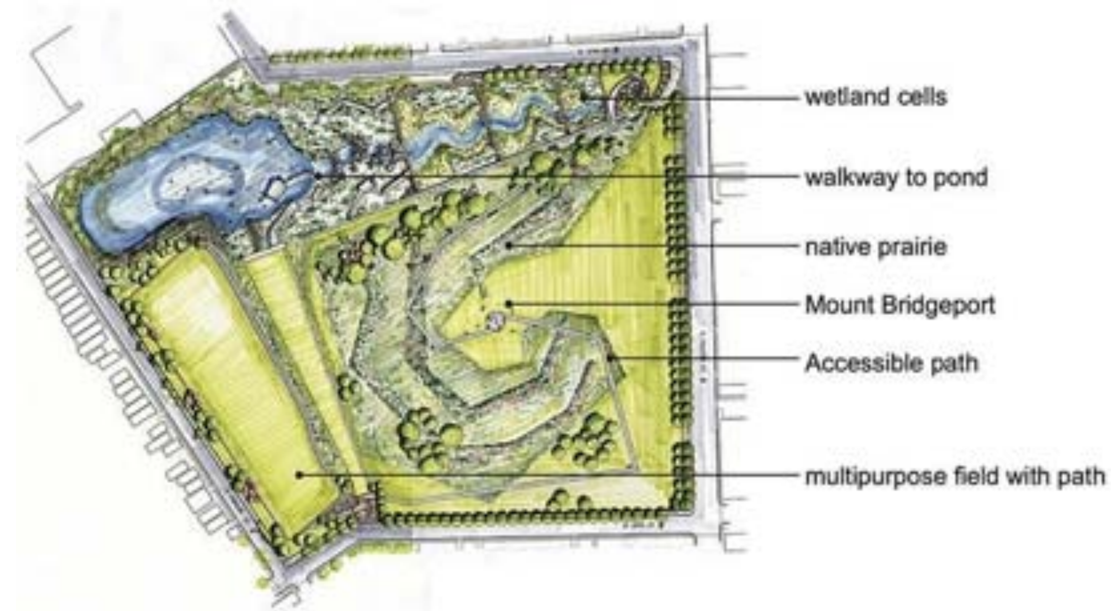
- Manages all rainfall for a 100-year, 24-hour storm (5.56 million gallons) onsite, through bioswales, wetland cells and a retention pond.
- Saves 10.5 million gallons of potable water and $34,700 annually by using native prairie plants, which require no irrigation, compared to irrigating an equivalent area of turf.
- Diverted over 4,280 cf of material from landfills by reusing 78 boulders found on-site and repurposing sidewalk and foundation debris from the City.

SOCIAL

- Doubles park space in the Bridgeport community to 54 acres, which is 4% of the land area. This is still lower than the 9% park space average for the City of Chicago.
- Has had a positive impact on the Bridgeport community for 94% of 122 survey respondents through reported stronger community relations, aesthetic improvements, and opportunities for nature exploration.
- Demonstrates prairie as a landscape aesthetic with 46% of survey respondents saying they would use prairie plantings at home. 39% like the prairie in the park but would not use it at home.

ECONOMIC

- Contributed to an average $34,000 increase in sales price for homes within two blocks of the park, as compared to similar homes 5-8 blocks from the park.
- Saves over $87,000 in annual maintenance costs by using native prairie plants instead of turf grass.



1. Manages all rainfall for a 100-year, 24-hour storm (5.56 million gallons) onsite, through bioswales, wetland cells and a retention pond.

Due to a mandate for previous landfill sites by the Illinois Environmental Protection Agency (IEPA),[1] Palmisano Park's stormwater management features must not cause erosion, scour drainage routes or release uncontrolled water off-site during a 100 year/24-hour storm.[2] To meet this requirement, site engineering capped the landfill, thus preventing water infiltration beneath the membrane. The site design manages stormwater through overland flow to bioswales that flow into and through cascading wetland cells. Both the swales and wetland cells function to slow and filter water before entering the pond. An emergency overflow to the City of Chicago sewer can only be utilized when pond levels get too high. An alarm alerts the Chicago Park District to manually turn on a pump that discharges water to a sewer located on Halsted Street. According to the Chicago Department of Water Management, the pump may not be turned on sooner than 24 hours after a rainstorm.[3] This emergency overflow is a mandatory requirement of the City of Chicago. Figure 1.1 shows water flow at Palmisano Park.

Methodology:
Weston Solutions, Inc. modeled the stormwater system for Palmisano Park with StormNET Version 4.18.7 by Boss International and the Natural Resource Conservation Service's Technical Release 55 method.[4] After calculating the peak flow for each swale, FlowMaster version 5.15 by Haested Methods helped measure peak flow velocity and depth. Overflow rates from the wetland cells were determined using wet well inflow data. Researchers reviewed this data and stormwater management was further examined by calculating total site holding capacity for a 100-year/24-hour storm.

According to the Table 1.1, "Rainfall Frequency Atlas of the Midwest, Table 1 (Bulletin 71)" a 100-year/24-hour storm event in Cook County, Illinois would produce 7.58 inches of rainfall.[5] Over Palmisano Park's 27 acres, this storm event would accumulate 742,916-cf of water, which is equivalent to 5,557,397 gallons.

Palmisano Park 100-yr/24-hr Rainfall Calculations

1 acre = 43,560 square feet

27 acres = 1,176,120 square feet

7.58 inches = 0.63 feet

0.63 feet x 1,176,120 square feet = 742,915.8 cubic feet

1 cubic foot = 7.48052 gallons

742,915.8 cubic feet x 7.48052 gallons = 5,557,396.5 gallons

Figure 1.1, Water Flow at Palmisano Park

[1] http://www.epa.state.il.us/land/site-remediation/landfill-info.html

[2] WESTON Solutions, Inc. William F. Karlovitz, P.E. Letter to Hana Ishikawa. Site Design Group. Re: Stormwater Modeling Steam's Quarry Park Development, Chicago Park District. 9 October 2009.

[3] City of Chicago. Department of Water Management. Blocking Rainwater and Preventing Sewer Backup. http://www.cityofchicago.org/city/en/depts/water/provdrs/engineer/svcs/blocking_rainwaterandpreventingsewerbackup.html. Accessed 9 Jun 2014.

[4] Natural Resource Conservation Service. Urban Hydrology for Small Watersheds,TR-55. http://www.hydrocad.net/pdf/TR-55%20Manual.pc June 1986.

[5] Huff, Floyd A. and James R. Angel. Rainfall Frequency Atlas of the Midwest. Midwest Climate Center, Climate Analysis Center, National Weather Service, National Oceanic and Atmospheric Administration, and Illinois State Water Survey: Division of the Illinois Department of Energy and Natural Resources. Page 114. 1992. http://www.isws.illinois.edu/pubdoc/b/iswsb-71.pdf. Accessed 9 June 2014.

Limitations of research:
Bulletin 71 containing a table of rainfall data was used to calculate gallon savings. The data within Bulletin 71 dates from 1992, and stormwater calculations for Chicago continue to use these rainfall numbers because up t date numbers are not published. Storm events have been changing in the last two decades, but the Illinois Stat Water Survey has not published current data. The need for more accurate rainfall information is critical for landscape architects and allied professionals to understand and guide stormwater design, particularly in the context of climate change.

Table 1. Sectional Mean Frequency Distributions for Storm Periods of 5 Minutes to 10 Days and Recurrence Intervals of 2 Months to 100 Years in Illinois

Sectional code (see figure 1 on page 4)

01 - Northwest / *06 - West Southwest*
02 - Northeast / *07 - East Southeast*
03 - West / *08 - Southwest*
04 - Central / *09 - Southeast*
05 - East / *10 – South*

Rainfall (inches) for given recurrence interval

Section	Duration	2-month	3-month	4-month	6-month	9-month	1-year	2-year	5-year	10-year	25-year	50-year	100-year
02	10-day	2.02	2.48	2.80	3.30	3.79	4.12	4.95	6.04	6.89	8.18	9.38	11.14
02	5-day	1.66	1.98	2.24	2.60	2.99	3.25	3.93	4.91	5.70	6.93	8.04	9.96
02	72-hr	1.53	1.83	2.02	2.34	2.70	2.93	3.55	4.44	5.18	6.32	7.41	8.78
02	48-hr	1.44	1.70	1.90	2.18	2.49	2.70	3.30	4.09	4.81	5.88	6.84	8.16
02	24-hr	1.38	1.61	1.76	2.03	2.31	2.51	3.04	3.80	4.47	5.51	6.46	7.58
02	18-hr	1.26	1.47	1.61	1.86	2.12	2.30	2.79	3.50	4.11	5.06	5.95	6.97
02	12-hr	1.20	1.40	1.53	1.77	2.01	2.18	2.64	3.31	3.89	4.79	5.62	6.59
02	6-hr	1.03	1.21	1.32	1.52	1.74	1.88	2.28	2.85	3.35	4.13	4.85	5.68
02	3-hr	0.88	1.02	1.13	1.30	1.47	1.60	1.94	2.43	2.86	3.53	4.14	4.85
02	2-hr	0.81	0.95	1.05	1.20	1.36	1.48	1.79	2.24	2.64	3.25	3.82	4.47
02	1-hr	0.65	0.76	0.84	0.96	1.09	1.18	1.43	1.79	2.10	2.59	3.04	3.56

Table 1.1. Rainfall for the Chicago region, courtesy of *Rainfall Frequency Atlas of the Midwest*

2. Saves 10.5 million gallons of potable water and $34,700 by using native prairie plants, which require no irrigation, compared to irrigating an equivalent turf area.

A typical neighborhood park in the City of Chicago consists of ball fields and grass lawns. In contrast, the warm season prairie planting of Palmisano Park does not require irrigation once established.

Methodology:
Computing irrigation costs from the "Sourcebook on Natural Landscaping for Local Officials" provides cost comparisons of turf grass lawns versus native prairie planting.[6] The numbers provided in Table C1.1 are based on an example from Applied Ecological Services (AES) found on page 92 of the "Sourcebook." However, because the "Sourcebook" was published in 2004, cost of water had increased at the time of completion of Palmisano Park in 2010 and has since increased further, with additional raises forthcoming. To understand the impact of water rate increases, the AES example from the "Sourcebook" has been compared against the rising cost of water.

Based on Table C1.1, an average of $522.73 would be spent annually on irrigation of one acre of lawn in 2003. Of Palmisano Park's 27 acres, 22.02 are planted with native prairie that does not require irrigation once established, therefore, annually saving over $11,510. Table C1.2 shows that this park saves 10,478,767.5 gallons of potable water each year as a result of planting native species. This number is determined based on the suggestion from the University of Georgia's College of Agricultural and Environmental Sciences[7] that a typical one-acre lawn requires one inch of water per week over the course of the growing season or 27,000 gallons of water per acre for irrigation purposes. In Chicago, lawns require slightly less, between 0.5" to 1" per week, therefore, an average of 0.75" has been used for calculations. For Chicago, the growing season is approximately 23 to 24 weeks long, averaged at 23.5 weeks.

[6] Chicago Wilderness. Sourcebook on Natural Landscaping for Local Officials. http://www.chicagowilderness.org/files/4413/3087/4878/natural_landscaping_sourcebook.pdf

[7] Keith Mickler. *How to Water Our Lawn Correctly.* University of Georgia College of Agricultural and Environmental Sciences.. No date provided.

Located along Lake Michigan, fresh water is often taken for granted and low water rates historically reflected this readily available resource. Yet, beginning in 2003 the City of Chicago started increasing water rates to pay for infrastructural upgrades to over 100-year-old piping, water treatment facilities and water pumping stations.[8] By 2008, the City began aggressively raising the cost of water 15% over the previous year, and continued to do so until 2010. In 2012, water prices rose 25%, and have or will be raised 15% each year until 2015.[9] From 2003 to 2014, water rates have increased from $1.25 to $3.31 per 1000 gallons. These numbers reflect a 265% increase in price. The current water rate has been factored into the cost of irrigation for a park and the savings are calculated in Table C1.3, showing that $34,685 would more accurately describe the irrigation cost savings in 2014 and predicts over $39,920 savings in 2015.

Native Plants vs. Turf Irrigation & Potable Water Calculations

2003 Cost of Water, based on "Sourcebook on Natural Landscaping for Local Officials"

Average annual cost to irrigate one acre = $522.73

Native planted area of Palmisano Park = 22.02 acres

Total Irrigation Savings = $522.73 x 22.02 ac = $11,510.51

Estimated Potable Water Savings

Water needed to irrigate one acre of lawn = 0.5" to 1" per week for 23.5 week growing season, average irrigation = 0.75" per week

Gallons needed to irrigate one acre of lawn with 0.75" of water = 20,250

Annual water needed to irrigate one acre of lawn = 20,250 gal x 23.5 wks = 475,875 gallons

Native Planted Area of Palmisano Park = 22.02 acres

Annual irrigation savings at Palmisano Park = 475,875 gal x 22.02 ac = 10,478,767.5 gallons

Estimated Water Savings Over Time

2003: Cost of 1,000 gallons of water = $1.25

2003: Annual cost to irrigate one acre of lawn = (475,875 gal / 1,000 gal) x $1.25 = $594.84

2003: Water savings at Palmisano Park = $594.84 x 22.02 ac = $13,098.38

2010 (Year of Park Completion): Cost of 1,000 gallons of water = $2.01

2010: Annual cost to irrigate one acre of lawn = (475,875 gal / 1,000 gal) x $2.01 = $956.51

2010: Water savings at Palmisano Park = $956.51 x 22.02 ac = $21,062.35

2014: Cost of 1,000 gallons of water = $3.31

2014: Annual cost to irrigate one acre of lawn = (475,875 gal / 1,000 gal) x $3.31 = $1,575.15

2014: Water savings at Palmisano Park = $1,575.15 x 22.02 ac = $34,684.80

Difference: 2003 to 2014 Water Rate Increase = $3.31 - $1.25 = $2.06 = $3.31 / $1.25 = 2.648 = 265% increase

Difference: 2003 to 2014 Water savings at Palmisano Park = $34,684.80 - $13,098.38 = $21,586.42

Difference: 2003 to 2014 Water savings at Palmisano Park, using AES numbers = $34,684.80 - $11,510.51 = $23,174.29

Average Difference: 2003 to 2014 Water savings at Palmisano Park = ($21,586.42 + $23,174.29) / 2 = $22,380.36

Difference: 2010 to 2014 Water Rate Increase = $3.31 - $2.01 = $1.30 = $3.31 / $2.01 = 1.647 = 165% increase

Difference: 2010 to 2014 Water savings at Palmisano Park = $34,684.80 - $21,062.35 = $13,622.48

[8] City of Chicago. Department of Water Management. Report: lmo2-2011. 2011 Annual Water Use Audit Form. Illinois Department of Natural Resources. Page 6. http://www.cityofchicago.org/content/dam/city/depts/water/general/Engineering/LMO-2_2011.pdf.

[9] City of Chicago. Department of Water Management. Water Sewer Rates. http://www.cityofchicago.org/city/en/depts/water/provdrs/cust_serv/svcs/know_my_water_sewerrates.html. Accessed 2 June 2014.

Table C1.1, Estimated Irrigation Savings adapted from "Sourcebook on Natural Landscaping for Local Officials"

Native Planted Area (Acres)	Irrigation Cost Per Acre for Turf Lawn (Annual Avg, 2004)	Total Irrigation Savings (Annual, 2004)
22.02	522.73	11,510.51

Table C1.2, Estimated Potable Water Savings

Native Planted Area (Acres)	Gallons Per Acre Needed for Irrigation (Weekly)	Gallons Per Acre Needed for Irrigation (Annual)	Total Gallons Saved (Annual)
22.02	20,250	475,875	10,478,767.5

Table C1.3, Estimated Water Savings Per City of Chicago Cost of Water

Native Planted Area (Acres)	Year	Cost of 1000 Gallons of Water	Cost of Total Gallons of Water Per Acre (475,875 Annual/Acre)	Potable Water Cost Total Savings (Annual, 2014)
22.02	2003	1.25	$594.84	$13,098.38
22.02	2004	1.29	$613.88	$13,517.64
22.02	2010	2.01	$956.51	$21,062.35
22.02	2014	3.31	$1,575.15	$34,684.80
22.02	2015	3.81	$1,813.08	$39,924.02

Limitations of research:
This method compares Palmisano Park against a baseline condition of a typical park on a national level. In an email mentioned in the following Cost Comparison, Kal Moy, the Chicago Park District (CPD) McGuane Park Supervisor, states that CPD parks are not regularly irrigated other than by rainfall. However, in extreme instances, certain staffed parks include emergency watering systems. McGuane Park includes this buffalo box watering capability, and the park is located adjacent to Palmisano Park but does not have the capability to reach Palmisano Park for irrigation purposes. Additionally, the Chicago Park District requires more information on how well native plants have adapted to fully understand the benefits; however, the success of the warm season prairie at Palmisano Park could be an indication for CPD to begin replacing turf with this mix, or other drought tolerant planting.

Questions/comments:
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