KNOWLEDGE. SOLUTIONS. ADVANCEMENT.

2012

GLOBAL WATER ISSUES

VOL. III: STORMWATER

Water Environment Federation®
the water quality people®

Table of Contents

Tests conducted for the National Hydraulic Research Institute in Malaysia concluded that Hydro International's Downstream Defender provides "first-flush" treatment in intense storm conditions.

Pollutant trap improves runoff quality in Malaysia

Where intense tropical rain meets rapid urban development, the loser is frequently the local water course, into which all the trash, silts, hydrocarbons, and other pollutants are discharged with the stormwater runoff. The sea is the final recipient, and riverine silts and sediments can be detected and often still seen many miles out from the estuaries of large tropical rivers.

To help mitigate this pollution, recent trials of Hydro International's Downstream Defender® by the National Hydraulic Research Institute of Malaysia (NAHRIM) have shown promise in an installation close to the capital, Kuala Lumpur. This Gross Pollutant Trap (GPT), which is based on a hydrodynamic vortex separation process, reduces gross pollution from storm flows.

Infrastructure and hydrological engineers Weida (M) Bhd conducted the trials

Malaysia's Department of Irrigation and Drainage has recognized for decades that the rapid urbanization that accompanies strong economic growth can exacerbate water pollution problems.

Malaysian market streets pose a challenge for stormwater control management.

Table 1: Data from stormwater pollution sampling

5 day weekday collection	Oil / grease from net point mg/l		Trash and flotables from net point wet weight kg			Silt / sediments from drainage sump wet weight kg		
	Before DDF	After DDF	Before DDF	After DDF	Direct DDF	Before DDF	After DDF	Direct DDF
Av. amount	171.7	14.6	1.125	0	8.1	2.444	0	9.8
Range; variation min/max	59 / 487	9 / 22	0.379 / 3.154	0	0.946 / 42.0	1.083 / 4.983	0	NB. Only 1 collection after 6 weeks
Weekend								
Amount	271.9	18	0.873	0	1.992	2.127	0	Incl. in single
Range variation; min/max	24 / 1530	5 / 37	0.249 / 1.632	0	1.233 / 2.598	0.879 / 7.154	0	collection as above

N.B. The samples were taken on Fridays to examine weekday pollution over five days, and on Mondays to examine weekend pollution. Due to various factors that affected the possible sampling times for different categories, the number of weeks used to calculate the averages ranged between five and ten.

for NAHRIM in a new urban area near Kuala Lumpur. The trial report concluded that the Downstream Defender is an effective gross pollutant trap, which captures and stores nearly all gross pollutants carried in the storm drain over the trial period. "These trials are encouraging because they are helping to test the Downstream Defender's ability to provide "first flush" treatment in intense storm conditions, even though the device was originally developed for more temperate US and UK climates," Hydro Export Manager Graeme Fenton said.

Malaysia's Department of Irrigation and Drainage has recognized for decades that the rapid urbanization that accompanies strong economic growth can exacerbate water pollution problems. As a result, a series of measures have been put in place to guide stormwater volume and quality control measures, culminating in 2001 in the Manual Sahran Mesra Alam Malaysia (MSMA) for Storm Water Management. MSMA emphasizes the need for storm water control, at or near the source, as an effective and efficient method of improving stormwater runoff quality and mitigating the effects of storm flows on rivers.

The onset of rapid urban development in parts of Malaysia has increased areas of impervious surfaces, which deliver high flash flow conditions under intense rain storms. Urbanization also increases the amounts of discarded waste such as polystyrene food trays and other packaging, and organic pollutants such as food, cooking oil and hydrocarbons from vehicle facilities.

Rainfall is a major factor in transporting this pollution into the storm drains. For example, Kuala Lumpur has an annual rainfall of nearly 2400 mm with peaks up to 280 mm in April and November; short duration showers can also total 100 mm or more in an hour in Kuala Lumpur. East Coast areas can double these figures.

Urban Malaysia's typical storm drainage comprises deep roadside drains, which discharge into high volume monsoon drains and eventually into the river.

Real condition trials

Weida (M) Bhd. oversaw a trial installation of the Downstream Defender under actual street conditions in collaboration with NAHRIM to examine its performance under tropical urban conditions. Researchers examined the ability of the process to separate and retain floatables, oil, grease, and sediment from contaminated stormwater.

The site for the trial was in the old town of Seri Kembangan, south of Kuala Lumpur, which has been recently engulfed by rapid industrialization and urbanization. It is a mix of small and medium industries intermingled with residential, retail, and open shop lots where informal commercial activity can take place.

Additionally, a morning market operates throughout the week and a night market opens on Monday evenings; both combine food and cooking stalls with sales of other goods. Activity is thus

Urban Malaysia's typical storm drainage comprises deep roadside drains, which discharge into high volume monsoon drains and eventually into the river.

Oil and grease were collected with a manual scoop at the netting point before and after the installation, and the density of hydrocarbons per liter of water were analyzed to measure the effectiveness of the trap.

distributed over the whole week and encompasses a wide variety of possible pollutant sources.

The drains in the area comprise a mix of improved natural and man-made structures. In the trial, a 1.2-m-diameter Downstream Defender was installed under a tarmac road and connected offline to a roadside drain carrying stormwater runoff and effluent from the housing, wet market, restaurant and shops from the north. After treatment in the Downstream Defender, the effluent is discharged back into the same drain downstream before the water is emptied into the main monsoon drain. A weir wall is used to direct flow into the Downstream Defender.

Sampling and measuring

Sampling of pollution for several weeks between May 7, 2010, and August 27, 2010, before and after the Downstream Defender installation was carried out at a point five meters downstream of the outlet point from the Downstream Defender.

Trash was collected in a vertical net at this point, while silt/sediment samples were collected in a drainage sump. Once the Downstream Defender had been installed, both trash and silt were also collected directly from the Downstream Defender sump by a standard vacuum suction pump for comparison with the results at the downstream netting point.

Oil and grease were collected with a manual scoop at the netting point before and after the installation, and the density of hydrocarbons per liter of water were analyzed to measure the effectiveness of the trap.

For measurement purposes, pollutants were separated into floatables (including trash) and sediments, which were each wet-weighed both on site and in the laboratory, and oils and grease, which were analyzed and their density measured in the laboratory.

Urban Malaysia's typical storm drainage comprises deep roadside drains, which discharge into high volume monsoon drains and eventually into the river.

Results of trial collection

The before and after installation figures clearly show that the device removes substantial amounts of oil and grease pollution from stormwater in the drain with both the average amount collected at the net point and the peaks of pollution greatly reduced.

NAHRIM concluded that the Downstream Defender is an effective gross pollutant trap that captured and stored nearly all gross pollutants carried in the storm drain over the trial period. In addition, NAHRIM pointed out that it was easy to maintain the device with a vacuum suction truck, and that this would be required in the Seri Kembangan installation at least twice a year for the observed pollutant accumulation or manual collection would be required twice a month. More installations would substantially reduce the maintenance cost of deploying a truck per unit.

Calista Kim Kher San, the project engineer for Weida who installed and monitored the installation for NAHRIM, explained that the device "is also very effective in trapping the large amounts of big floatables, such as liter plastic bottles and polystyrene foam blocks, which are more commonly found in the drains here than in many Western countries." He anticipates further installations planned to start protecting the rivers around Kuala Lumpur such as the Gombak and the Klang. "We have also installed one unit at the main bus station in Petaling Jaya, a large urban area contiguous with Kuala

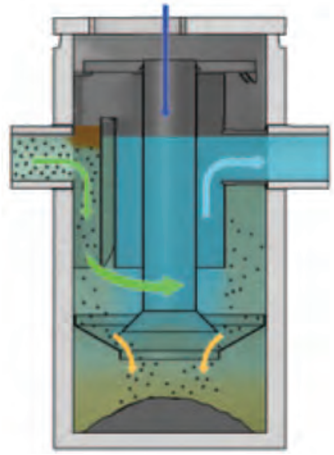


Diagram of the Downstream Defender, developed by Hydro International.

Lumpur, where a substantial reduction in oil and grease pollution has been achieved. We are currently developing river-cleaning stations and on site detention centers using it in conjunction with additional pollution handling equipment," he added.

Calculating the returns on your green infrastructure investment. Trees are used frequently as a “green” infrastructure stormwater control in cities. But when it comes to minimizing urban runoff, all trees are not equal.

Bigger trees, better benefits?

Jennifer Fulcher, WE&T

Trees are used frequently as a “green” infrastructure stormwater control in cities. But when it comes to minimizing urban runoff, all trees are not equal. “[Larger trees] provide a lot more ecological services,” according to Peter MacDonagh, director of design and science at Kestrel Design Group (Minneapolis). For instance, a tree that has a 762-mm (30-in.) diameter-breast-height (DBH), which is the diameter at approximately 1.4 m (4.5 ft) off the ground, provides 70 times the ecological services of a tree with a 76-mm (3-in.) DBH, he said.

In terms of stormwater runoff, Minneapolis uses trees as a part of a green infrastructure strategy to handle the frequent 25-mm-per-24-hr (1 in.-per-24-hr) storms, so gray infrastructure can handle the larger storms, MacDonagh said. During these smaller storms, a 560-mm (22-in.) DBH tree can intercept 80% of the stormwater in its canopy, while a 51-mm (2-in.) DBH tree only can intercept about 15%, he added.

A tree’s size and ability to intercept stormwater often correlate to its age. A 40-year-old tree can intercept 18,925 L/yr (5000 gal/yr) of stormwater, a 20-year-old tree can intercept 5110 L/yr (1350 gal/yr), and a 10-year-old tree can intercept 1890 L/yr (500 gal/yr), MacDonagh said.

However, the average life span of a “street tree” in the 20 largest U.S. cities is only about 13 years, MacDonagh explained. Therefore, the services that urban trees provide often are limited. “We feel that a tree’s life [span] should be at least 50 years,” MacDonagh said.

Helping trees thrive

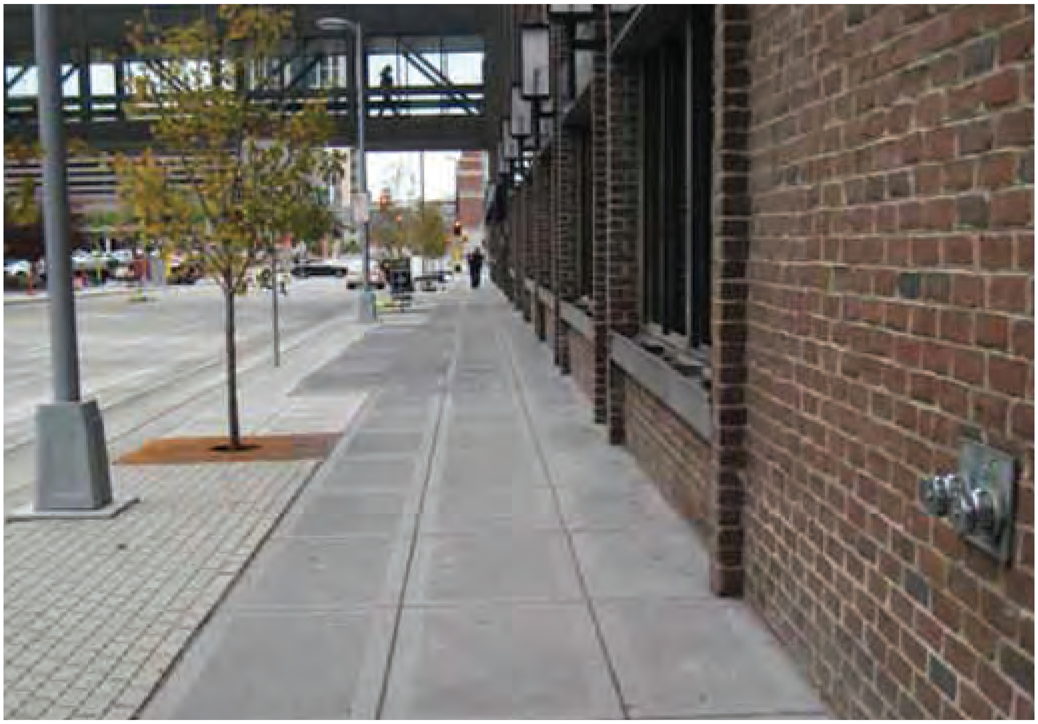
To live up to their stormwater mitigation potential, trees have to reach a mature age.

> Regardless of constraints, MacDonagh believes that all cities have the potential to increase their total tree canopy.

Planting 100,000 trees so they can grow large is more beneficial than planting a million small trees that will not reach maturity, according to MacDonagh. For example, in Minneapolis, Dutch elm trees larger than 762 mm (30 in.) in DBH constituted 10% of the total tree population but provided about 32% of the stormwater benefits from the city’s tree population, he said.

One of the keys to large, long-lived trees is adequate

A project in Minneapolis used a suspended pavement system to support loading on sidewalks while keeping soil loose for tree growth.
Kestrel Design Group



Supporting sidewalks with structural cells avoids soil compaction and enables trees to thrive in less soil.
Kestrel Design Group

moisture. If planned properly, trees do not need to be irrigated, because they can rely on stormwater, MacDonagh said. Stormwater can be directed toward trees through pervious paving, catch basins, or trench drains, to provide trees both the moisture and nutrients they need to thrive.

Trees also need an adequate volume of loose, oxygen-rich soil, MacDonagh said. At 85% compaction in soil, tree roots stop growing. "If the soil conditions are better, there's a much larger range of species that can be put in there," MacDonagh said. Planting a wide variety of tree species also helps avoid a massive number of tree deaths if a disease affecting a single species spreads through a city, he said.

To avoid compacted soil, structural cells can be installed that support surrounding pavement while maintaining loose soil. With this system, 17 m^3 (600 ft^3) of shared soil is needed to grow a large tree, while 68 m^3 (2400 ft^3) of soil would be needed to grow the same tree using structural soil, MacDonagh said.

Excavating even more area, especially horizontally, and then backfilling will have a positive effect on long-term tree growth and is "the least expensive solution," according to Greg McPherson, research forester with the U.S. Forest Service Pacific Southwest Research Station.

Quantifying benefits

In addition to helping reduce stormwater runoff and intercepting rainfall, trees reduce air pollutants and sequester carbon dioxide. Trees also help keep buildings warm on cold days by blocking wind and cool on hot days by providing shade.

Trees help to reduce the urban heat-island effect because, through evapotranspiration, they disperse heat more efficiently than pavement or masonry, MacDonagh said. During a 29°C (85°F) day, the temperature in the interior of the city would be about 33°C (92°F), but 152 mm (6 in.) above the tree leaves, the temperature will be about 29°C (85°F), he said.

In the long term, trees with 50-year life spans prove more cost-effective than trees with 13-year life spans, MacDonagh said. It costs $6000 to replace a tree every 13 years for a return on investment of $3000; every $1 invested produces $0.50 in benefits, he said. However, a case study in Minneapolis showed that a group of trees that grew through 50 years without being replaced cost $7500, for a return on investment of $20,000; every $1 invested produced $2.50 to $3 in benefits.

McPherson said the U.S. Forest Service has worked for many years to calculate both the environmental and economic values provided by trees.

"To convert [environmental benefits] into a dollar value is complicated, because no one is paying the tree for doing these things," McPherson said. The Forest Service equates these benefits to cost savings provided, he noted. For example, it calculates the cost of electricity needed to heat and cool a home during the year without trees and then models the placement of trees around that home to calculate how much the tree saves in energy costs. The agency has developed an online urban tree-benefit calculation tool called i-Tree, available at www.itreetools.org.

Planting the right tree

Even though large trees provide many benefits, not every site in a city can support a large tree. Constraints, such as pipelines or other underground infrastructure, as well as buildings and electrical wires aboveground, "affect the size of the tree that you will plant, because you want a tree that will grow and thrive in the site," McPherson said. "The goal is to get a tree that will perform admirably for a long period of time with minimum maintenance," he said.

The optimal size of a tree varies based on site conditions and the goals for the tree function. If a tree is planted for social and aesthetic purposes, it does not have to grow as large as a tree planted to mitigate stormwater or to capture air pollutants, McPherson said.

McPherson also points out that approximately 75% of the land in U.S. cities is privately owned. Therefore, planting the right type of tree with adequate soil and moisture often depends not on professional foresters and arborists but on the public. He encourages citizens to seek out resources and assistance online and through local environmental organizations.

Regardless of constraints, MacDonagh believes that all cities have the potential to increase their total tree canopy. "There's really no reason in most cities in the United States that [we] can't obtain a 40% canopy," he said.

How Onondaga County implemented innovative infrastructure in Syracuse, N.Y., to prevent wet weather from entering the sewer system.

A 'Save the Rain' Solution

Bj Adigun and Matthew J. Marko

Twenty-three years ago, pollution in Onondaga Lake was the subject of a Clean Water Act lawsuit. The resulting judgment required Onondaga County, N.Y., to take certain steps to reduce pollution from the Metropolitan Syracuse (N.Y.) Wastewater Treatment Plant (Metro) and lower the impact of combined sewer overflows (SOs) on the lake and its tributaries. As the understanding of the problem and how best to solve it evolved, the consent judgment was amended four times.

In the early 1900s, Syracuse's expanding population and diverse manufacturing industry dramatically increased lake pollution. In 1907, the city began to try reducing wastewater pollution, but by 1940, the lake was declared unsafe for swimming. Within 30 years, the government placed a ban on fishing, and Onondaga Lake was widely regarded as one of the most polluted lakes in the United States. The lake is about 1.6 km (1 mi) wide and 7.4 km (4.6 mi) long, with a maximum depth of 19 m (63 ft).

A comprehensive green infrastructure program will capture the city's stormwater and reduce impacts of runoff to the sewer system.

The 1988 lawsuit against Onondaga County by Atlantic States Legal Foundation (Syracuse) was not a surprise. The foundation wanted the county to clean up the pollution in the lake caused by ineffective wastewater conveyance and treatment practices. The parties settled with a "judgment on consent" approximately a year later; however, the county did not submit its proposed municipal compliance plan and draft environmental impact statement until 1996. After some negotiation, the parties entered into an amended consent judgment in early 1998. This legal order required the county to improve and upgrade the Metro plant, establish a monitoring program that would evaluate the effects of those improvements on lake water quality, and eliminate or decrease the effects of CSOs. In response, Onondaga County implemented sewer separation projects and constructed floatable control facilities and large conveyance projects.

Through a partnership with Syracuse University, the performance of the green roof atop the Nicholas J. Pirro Convention Center will be measured via real-time monitoring and data collection.

Solution

Most significantly, the county upgraded the Metro plant, building new facilities that provide treatment for up to

This porous concrete parking surface is one of many parking lots that were retrofitted with green infrastructure.

908,000 m^3/d (240 million gal/d) of sanitary and wet weather flow. The plant features the largest biological aerated filter process in the United Sates and the first large-scale ballasted flocculation process for phosphorus removal in the Northeast. The total cost of these improvements was about $175 million.

A monitoring program showed significant decrease in levels of ammonia and phosphorus in Lake Onondaga. The program collects data and information needed to assess the effectiveness of improvements and includes field and laboratory components to identify the sources of materials(nutrients, sediment, microorganisms, and chemicals) to the lake, evaluate lake water quality conditions, and examine the interactions between Onondaga Lake and the Seneca River.

CSO abatement program

Like many northeastern cities, Syracuse has a combined sewer system with both sanitary water and stormwater entering a single sewer line. Under heavy precipitation and snowmelt, this combined flow triggers SO events that overload sewer system capacity and release the flow into local waterways. Forty-nine CSO discharge points throughout the 3140-ha (7750-ac) combined sewer service area account for more than 1.9 million m^3 (500 million gal) of CSO discharge annually. The Onondaga Lake watershed extends approximately 460 km (285 mi).

The amended consent judgment included a provision for comprehensive "gray" infrastructure for CSO mitigation. The county planned to construct regional treatment facilities (RTFs) throughout Syracuse. In 2008, a residential neighborhood in the Midland sewer district became home to the first RT. The 20,800-m^3 (5.5-million-gal) subsurface facility captures and treats flow from five CSO outfall areas. When it rains, the facility can provide storage with eventual diversion to the Metro plant for comprehensive treatment. When the storage capacity is exceeded, the facility provides limited primary treatment with direct discharge to Onondaga Creek. These reduced levels of treatment, coupled with community dissatisfaction about the building of a treatment facility in a residential neighborhood, set the stage for a change in direction of the CSO abatement program.

While $250 million worth of RTF contracts were readied, the newly elected Onondaga County executive petitioned the federal courts for an extension to the amended consent judgment to allow for the development of a revised plan.

> With the support of the U.S. Environmental Protection Agency (EPA), the U.S. Department of Justice, the New York attorney general's office, the New York Department of Environmental Conservation, and numerous community partners, green infrastructure in Syracuse became a reality.

'Save the Rain'

In November 2009, the federal courts approved a new plan using "gray" storage facilities to address wet weather flow in the combined system and innovative "green" infrastructure to prevent wet weather from entering the sewer system. With the support of the U.S. Environmental Protection Agency (EPA), the U.S. Department of Justice, the New York attorney general's office, the New York Department of Environmental Conservation, and numerous community partners, green infrastructure in Syracuse became a reality. At the time, Onondaga County was the only regional authority in the country to include the use of green infrastructure in a consent judgment.

The Save the Rain program, planned and designed in 2010, uses two underground storage facilities to collect CSO flow during wet weather events and transfer stormwater to the Metro plant after peak levels subside. A comprehensive green infrastructure program will capture the city's stormwater and reduce impacts of runoff to the sewer system. The combined approach will treat 95% of the annual CSO volumes and achieve water quality standards in Onondaga Lake and its tributaries by December 2018. The capture rate reflects 89.5% of flow though gray infrastructure and 6.5% (946,000 m^3/yr, or 250 million gal/yr) through green infrastructure.

While planning the green infrastructure program, the county continued work on several gray projects, including sewer separation and restoration efforts and construction of an interceptor replacement sewer. It also constructed several pilot green infrastructure projects throughout the city, including renovation of several surface parking lots downtown.

In 2011, the county executive announced the Project 50 campaign, initiating 50 distinct green infrastructure projects within the calendar year. This aggressive plan features several signature projects. The county has installed a 6130-m^2 (66,000-ft^2) green roof on the Nicholas J. Pirro Convention Center, one of the largest in the Northeast. A capture-and-reuse system at the Onondaga County War Memorial Arena will store up to 56,775 L (15,000 gal) of rainwater and snowmelt runoff from the roof. The system filters, disinfects, and reuses the captured stormwater to provide ice at the rink for the Syracuse Crunch minor league hockey team, the first team in the United Sates to skate on "green ice." The county also is building an innovative wetland system to treat CSO discharge before it enters Harbor Brook, one of two main tributaries within the combined sewer service area. These projects follow successful demonstration projects completed in 2010, including work at city-, county-, and state-owned parking lots, as well as the Rosamond Gifford Zoo at Burnet Park.

To engage the local business community, the county's Save the Rain program created a Green Improvement Fund, offering grants to private property owners in the combined sewer districts. The program is the most successful public–private partnership for green infrastructure in the country. More than 70 applications have been received. More than a dozen green infrastructure projects have been installed on private property to date, and Onondaga expects more than twice as many projects in 2012.

The Project 50 campaign exceeded campaign goals, with 60 projects either complete or under construction. This effort is expected to reduce CSO discharges by more than 189,000 m^3 (50 million gal) annually. The 2011 construction season also saw significant progress made on the gray infrastructure side of the program, and the start of construction on both storage facilities is expected to be completed by the end of 2013.

Since Onondaga decided not to build three more RTFs and to better balance gray and green infrastructure, the community will realize additional benefits, such as fewer construction impacts; reduced operation and maintenance costs; and improved neighborhood aesthetics, habitat, and air quality. Local residents and community organizations have worked closely with Onondaga County to implement projects that serve the dual purpose of CSO reduction and neighborhood improvement. Syracuse neighborhoods also participated in workshops and community forums to contribute ideas for implementation of various projects. The comprehensive nature of the program has provided the opportunity for significant community input.

The program garnered national recognition in April, when EPA identified Syracuse as one of 10 communities throughout the nation being recognized as a Green Infrastructure Partner.

Bj Adigun *is a program coordinator, and* ***Matthew J. Marko*** *is a vice president in the water business group and manages the Syracuse, N.Y., office of CH2M Hill (Englewood, Colo.).*

This porous basketball court minimizes stormwater runoff.