United States Senate
Committee on Environment and Public Works
Subcommittee on Water and Wildlife

"Finding Cooperative Solutions to Environmental Concerns with the Conowingo Dam to Improve the Health of the Chesapeake Bay"
May 5, 2014
Conowingo Visitors Center, Conowingo MD
Testimony of J. Richard Gray
Mayor, City of Lancaster

Thank you, Mr. Chairman. I appreciate your efforts to improve public understanding of the environmental challenges presented by the Conowingo Dam, and I welcome this opportunity to join with other stakeholders who are working to improve the ecological health of the Chesapeake Bay.

Minutes from a 1927 Lancaster City Council meeting note that “The meandering course of the Conestoga Creek… formerly was a source of pride and largely used for recreational purposes. The continually increasing discharges of untreated sewage and industrial wastes have polluted this stream to a serious degree.” The minutes cite sludge deposits, oil slicks and other pollutants that “do not disappear” before reaching the Susquehanna River and flowing into the Chesapeake Bay.

Nationwide, industrial pollution has been largely eliminated because of the Clean Water Act. That said, stormwater continues to be the main source of pollution of the majority of the 40,000 water bodies that are documented as impaired. Our stormwater engineering practices have not changed in four decades since the Clean Water Act went into effect. It is time to rethink how we approach stormwater management to protect our most precious resource – clean water.

Today, the City of Lancaster is responsible for about 750 million gallons of polluted water flowing into the Conestoga River and eventually into the Chesapeake Bay. This is common in historic cities that rely on a combined sewer system to collect and transport both domestic sewage and rainwater flowing from downspouts, streets, sidewalks, parking lots and over impervious surfaces into storm drains. There are 50 combined sewer communities in the Chesapeake Bay watershed alone. Eighty-five percent of the time, the City’s Treatment Facility is able to manage and clean the volume of water flowing through this combined system. Still, during heavy rainstorms and other wet weather events, the system becomes overwhelmed and, by design, untreated stormwater is allowed to overflow into rivers.

The problem of stormwater runoff and combined sewer overflow is not going away; nor will our responsibility to help clean and restore “the Bay.” To address these issues, we began with two important questions:

1. Can the City realistically eliminate 750 million gallons of storm water runoff in twenty-five years using green infrastructure?

2. Can this approach provide more benefits per dollar than traditional gray infrastructure alternatives?

The answer to both questions is "yes." Lancaster's experience shows that green infrastructure can be used to manage and reduce stormwater runoff in a way that is both cost effective and responsible. Simply stated, green infrastructure prevents stormwater from entering the sewer system using natural systems such as as absorption or infiltration into the soil, or evaporation into the atmosphere. This allows stormwater to be treated as nature intended

Over the past three years, the City has invested in Green Infrastructure projects that demonstrate the effectiveness of this technology: Green roofs that absorb rainwater; renovated public parks with underground drainage systems; parking lots that have permeable areas so that stormwater that would run off into our combined system will now infiltrate into the soil. The ways of doing this are simple; let the stormwater go where it would have gone prior to our paving the planet and preventing its absorption into the ground.

Joining with non-profit and other private sector partners, efforts are underway to engage the community in specific green infrastructure projects in our neighborhoods. To date, some 50 demonstration projects around the City serve as examples of how green infrastructure improvements can benefit residents and businesses while enhancing our our quality of life.

At a time when Mayors of communities large and small are struggling to finance core government services, the question of how to pay for green infrastructure becomes more complex.

Most communities do not have a dedicated revenue source to support aggressive stormwater improvements. At the same time, like most cities, 87 percent of land in Lancaster is privately owned. These two factors combined, make the issue of financing stormwater management more challenging. To fund the City's program, Lancaster has established a stormwater utility with a stormwater management fee. After evaluating various funding and policy options, we have determined that an impervious area-based user fee is the most common and equitable funding mechanism. In Lancaster, stormwater management fees are levied on property owners based on the amount of un-controlled impervious area on their property.

In closing, we can have clean water if we want it: not because of federal mandates, but because we have an ethical and moral obligation to do right by our children and grandchildren. We offer Lancaster City's Green Infrastructure Plan and Stormwater Utility as a model for other mid-size cities. Technological advances have given us the power to preserve our water resources and, at the same time, create a more livable, sustainable and economically viable future for generations to come.

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EXECUTIVE SUMMARY

GREEN INFRASTRUCTURE PLAN

the city of **Lancaster**

a city authentic

March 2011

The City of Lancaster is one of about 770 cities nationwide with a combined sewer system (EPA). Combined sewer systems collect and transport both domestic sewage (wastewater from plumbing in buildings) and rainwater that flows from downspouts, streets, sidewalks, parking lots and other impervious surfaces common in urban areas. Eighty-five percent of the time, the City's Advanced Wastewater Treatment Facility is able to manage and clean the volume of wastewater flowing through this combined system. However, during intense rainstorms and other wet weather events, the system becomes overwhelmed. Each year, this causes about 1 billion gallons of untreated wastewater (mixed sewage and stormwater) to overflow into the Conestoga River. These events are referred to as combined sewer overflows (CSOs) or simply "overflows".

At the time that combined sewer systems were being built across the country 100-200 years ago, they were considered a highly efficient method of treating all forms of waste from urbanized areas since they collected stormwater, sanitary sewage and industrial wastewater all in the same pipe and conveyed them to a treatment plant to be processed before discharging treated water to the nearby streams. What better way to keep streams pristine, fishable and swimmable than to treat **all the waste including runoff**? But as urbanized areas grew and eventually overwhelmed these systems, the methods used did not change or keep up with development. Our forefathers kept adding onto the same system.

Efforts to clean up our local waterways and the Chesapeake Bay have brought renewed federal, state and regional attention on initiatives designed to protect and restore the network of polluted streams and rivers in the Chesapeake Bay watershed, many of which fail to meet water quality standards. The Conestoga River is one such river. The Environmental Protection Agency, for example, has begun enforcing limits on nitrogen, phosphorous and sediment pollution, referred to as a Total Maximum Daily Load (TMDL). The TMDL, or "pollution diet," sets accountability measures for communities located within the 64,000 square mile watershed to ensure that cleanup commitments are kept. The TMDLs are being promulgated not only for combined sewer systems, but also for municipal separate stormwater systems (MS4s) across the Bay watershed. So the costs to comply with these new regulations are going to be felt by every community.

With this backdrop, Lancaster City has been working proactively to reduce combined sewer system overflows and at the same time, to identify economically viable, long-term strategies for mitigating the negative impact of wet weather overflows on our water quality. To date, most of the strategies under consideration have been limited to "gray infrastructure" options, such as increasing the capacity of the City's wastewater conveyance and treatment infrastructure; adding storage or holding tanks to detain wastewater flows until treatment capacity returns; or providing some form of wastewater treatment to the overflow discharges.

Over the past 12 years, the City has aggressively pursued upgrades to its existing gray infrastructure. More than $18 million has been invested in the City's wastewater system including construction of the first wastewater treatment system in the Commonwealth to meet nutrient removal requirements. These nutrient removal projects are being implemented at other treatments plants in the Chesapeake Bay watershed now that the TMDLs are going into effect. Additional capital investment has increased the efficiency of pumping stations to optimize the flow of wastewater to the treatment facility and these investments have resulted in further capture of wet weather flows for treatment.

Despite this progress, there remains a significant amount of untreated combined sewage overflowing into the Conestoga River. Based on prior evaluations and experience in many other communities, gray infrastructure options are expensive to construct and maintain. One storage tank alone in the City's Northeast section of the City has an estimated price tag of $70 million and this would only manage 1/10 of the City's annual CSO volume. The estimated price tag to store and treat the billion gallons of annual overflows would be well over $250 million. This cost does not include the annual operational costs in energy and personnel to run the new gray systems.

Given the expense of gray infrastructure modifications, the City has instead opted for a two-prong strategy for reducing the volume of stormwater entering the combined sewer system:

1. Increase the efficiency and capacity of the City's existing gray infrastructure; and
2. Employ "green infrastructure" methods of stormwater management.

Green infrastructure encompasses a variety of technologies that replicate and restore the natural hydrologic cycle and reduce the volume of stormwater entering the sewer system. This, in turn, reduces overflows. Green infrastructure generally includes stormwater management methods that:

- infiltrate (porous pavements, sidewalks, and gutters; linear infiltration systems)
- evaporate, transpire and reduce energy consumption (vegetated roofs, trees, planter boxes)
- infiltrate and transpire (rain gardens and bioretention)
- capture and reuse rainfall (rain barrels, cisterns, irrigation supply systems, and gray water systems)

In contrast to gray infrastructure, a green infrastructure approach often has a higher return on investment and offers multiple benefits:

- *Environmental* – recharges ground water, provides natural storm water management, reduced energy usage, improved water quality.
- *Social* – beautifies and increases recreational opportunities, improves health through cleaner air and water, improves psychological well-being.
- *Economic* – reduces future costs of stormwater management and increases property values.

In May 2010, the City of Lancaster began to develop Pennsylvania's first- Class 3 Green Infrastructure Plan (GI Plan). Building upon the Lancaster County Comprehensive Plan as reported in the Planning Commission's *Greenscapes: The Green Infrastructure Element*, Lancaster City's plan was developed in conjunction with LIVE Green, the Lancaster County Planning Commission, PA Department of Environmental Protection (DEP), PA Department of Conservation and Natural Resources (DCNR) as well as local stakeholders. The City's GI Plan clearly articulates a vision for Lancaster:

To provide more livable, sustainable neighborhoods for City residents and to reduce combined sewer overflows and nutrients.

The goals of the GI Plan are equally clear:

1. Strengthen the City's economy and improve the health and quality of life for its residents by linking clean water solutions to community improvements (e.g. green streets).
2. Create green infrastructure programs that respond comprehensively to the multiple water quality drivers (e.g. TMDL, CSO and stormwater regulations) to maximize the value of City investments.
3. Use GI to reduce pollution and erosive flows from urban stormwater and combined sewer overflows to support the attainment of the Watershed Implementation Plan for the Chesapeake Bay and to improve water quality in the Conestoga River.
4. Achieve lower cost and higher benefit from the City's infrastructure investments.
5. Establish Lancaster City as a national and statewide model in green infrastructure implementation.

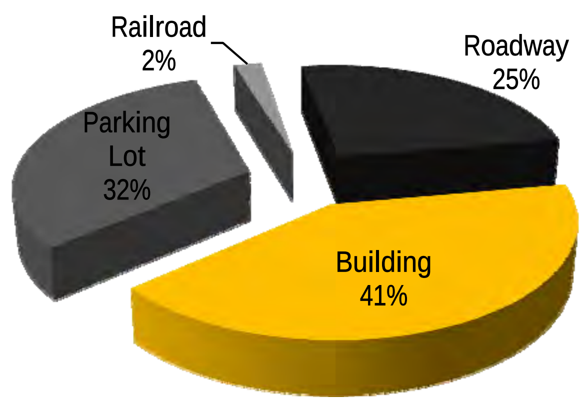
ASSESSMENT

The study involved a three-step process:

(1) evaluate impervious cover by type and land ownership;

(2) identify potential GI project sites and grant funding for early implementation to understand cost/benefit for each; and

(3) determine potential citywide benefits and provide actions and policy direction to institutionalize GI in the City.



The impervious cover analysis revealed that 41 percent of the city's impervious surface is attributable to buildings, 32 percent to parking lots, 25 percent to roadways and 2 percent to railroads. In addition, most of the impervious area besides roads is on privately held lands which shows why private investment is necessary to make this a successful program. The City cannot solve this problem <u>cost effectively</u> on its own.

Further analysis of land ownership identified more than 50 existing and potential GI projects in various locations:

- Streets, Alleys & Sidewalks
- Parking Lots
- Rooftops
- Parks
- School and City-owned properties

From these locations, the GI Plan provides conceptual designs and cost estimates for 20 initial projects that the City can use to demonstrate each green infrastructure technology. These demonstration projects will remove an estimated 21 million gallons of urban runoff from the combined sewer system per year, and, at the same time the demonstration projects will provide much-needed data on the long-term effectiveness of employing green infrastructure strategies on a broader scale to reduce urban stormwater runoff and combined sewer system overflows. GI project types were determined to be capable of scaling to significant implementation levels when applied to specific land uses common in urban setting such as Lancaster City:

STREETS, ALLEYS AND SIDEWALKS

Green streets, alleys and sidewalks use existing roadways and the public right of way to manage stormwater runoff with tree trenches, porous sidewalks, curb-extensions, and sidewalk planters. Initial demonstration projects are being located at street corners undergoing ADA ramp upgrades and in areas slated for streetscape improvements. The City has identified approximately 20 blocks of streets that are either scheduled for repair or ADA ramp upgrades in 2011. These blocks will serve as green street prototypes that can be incorporated into the City's on-going street repair program. If the City's current rate of road repaving and reconstruction were adapted to include GI, this will result in approximately 468 blocks of green street development over the next 25 years. Another key strategy in developing green streets is enhanced street tree planting. Lancaster City has an estimated 8% tree canopy. Various studies indicate that a 40% tree canopy in urban areas can provide a substantial reduction in stormwater runoff.

This potential is being verified by the City in a separate DCNR funded study to evaluate existing tree canopy using a top down (high resolution aerial imagery) and bottom up approach (walking inventory). This will provide a baseline measure of the city's existing tree canopy, assess the age and health of existing trees, and identify possible locations for additional plantings. The GI Plan proposes to increase the City's urban canopy tree with 6,250 trees or about 250 plantings per year over 25 years. When complete, the enhanced tree canopy will manage stormwater runoff from approximately 45 acres of impervious area.

PARKING LOTS

Green parking lots are usually created by excavating a portion of an existing lot and installing a stone subsurface infiltration bed in conjunction with porous pavement or water quality inlets that redirect stormwater into the stone bed. Runoff from adjacent areas such as streets and buildings can also be redirected into the infiltration bed. Tree trenches can also be integrated with the design to increase the tree canopy and promote evapotranspiration.

These projects are most cost effective when the pavement is in need of replacement or the lot requires reconfiguration for other reasons. The GI Plan includes conceptual designs for four public parking lots in need of restoration. The GI Plan calls for retrofitting and, managing runoff from 130 acres of primarily privately-owned parking lot over 25 years.

ROOFTOPS

Multiple strategies can be employed to manage the rainwater that falls on rooftops. Lancaster City currently has 51,000 square feet (well over 1 acre) of green roofs. This translates into almost 1 square foot per resident – perhaps more than any municipality in Pennsylvania. Building on the success and lessons learned from the Lancaster County Roof Greening Project administered by the Lancaster County Planning Commission and implemented by LIVE Green, the GI Plan calls for an additional 2 acres of green roofs in the next 5 years and over 30 acres in the long term.

Water from rooftops can also be managed through disconnection of downspouts. Most downspouts in the City go directly into the combined sewer system. Water from downspouts can be redirected to open green space, rain barrels, cisterns, rain gardens or stormwater planters. Through its Urban Watershed Initiative LIVE Green has been providing rain barrels to residents seeking low-cost solutions. The work of LIVE Green demonstrates how the installation of 250 rain barrels and rain gardens can reduce the amount of stormwater that enters the municipal sewer system and local streams by over 3 million gallons per year. The GI Plan calls for an additional 2,000 buildings to disconnect their downspouts.

PARKS

The GI Plan leverages the City's previous investment in the Urban Park, Recreation and Open Space Plan completed in 2009 as it moves forward with recommended park restoration and reconstruction projects. The GI Plan proposes green infrastructure retrofits of 26 of the City's 30 Parks to manage water runoff from 17 acres of impervious surface area. The GI Plan lays out specific concepts for the renovation and restoration of 3 parks and uses these park areas to manage storm water runoff from adjacent roadways and other impervious areas. An example is the recently completed Sixth Ward Memorial Park project that employs a porous basketball court and infiltration bed to reduce runoff from adjacent roadways and other impervious areas by an estimated 700,000 gallons per year. The new court was designed and built at half the cost of separate grey infrastructure designed to achieve the same level of benefit.

1 - The 6th Ward Park porous basketball court provides runoff reduction at 1/2 the cost of separate grey controls, while also providing community improvements

SCHOOLS AND CITY-OWNED PROPERTIES

The GI Plan establishes a long term goal of greening 38 acres of impervious surface area associated with 15 public schools. Implementing a variety of green infrastructure techniques to mange stormwater generated on-site can also manage additional impervious areas from adjacent properties. Libraries and other publicly owned facilities offer the same green infrastructure and storm water management opportunities as schools. The GI Plan includes conceptual designs for the Lancaster Public Library and two public schools.

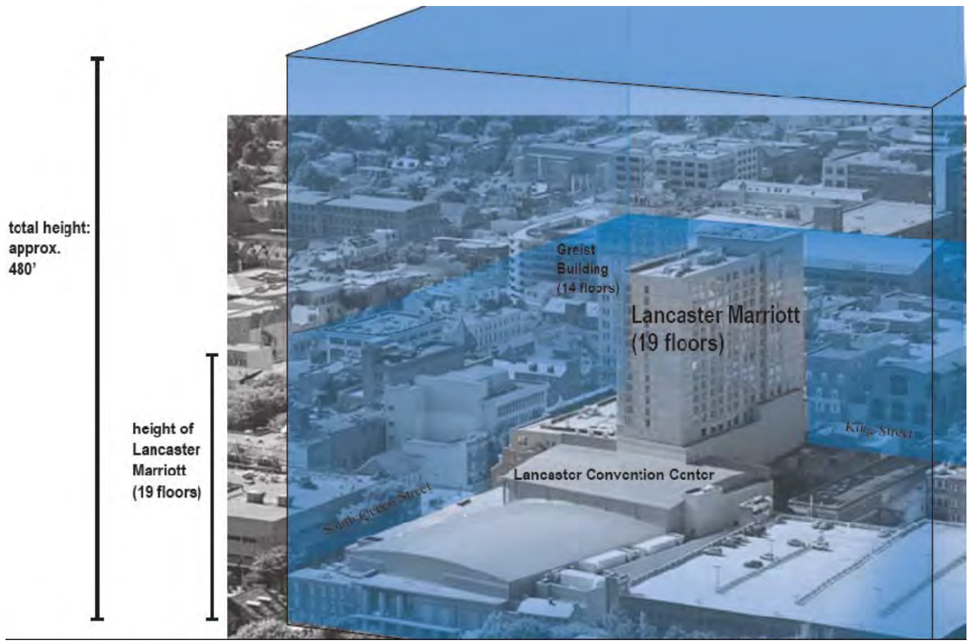
INCENTIVES FOR RESIDENTIAL AND COMMERCIAL PROPERTIES

To fully institutionalize green infrastructure into the City of Lancaster's urban landscape, the GI Plan proposes a combination of policy actions, incentives for residential and commercial property owners, and innovative funding approaches to support ongoing implementation costs.

POLICY ACTIONS: ORDINANCES & STANDARDS- As part of its stormwater ordinance, the City currently has a "first flush" control requirement that requires property owners who are adding new impervious surface areas (e.g., a building addition, driveway, garage or impervious patio) to manage the first 1-inch of rainfall on their property and not allow it to discharge to the combined sewer. The GI Plan recommends that the City's Stormwater regulations be extended to control the first flush from the impervious area within the entire disturbed area of the redevelopment project. For example, if an addition to a building was being built on top of an existing parking lot, runoff from the addition would fall under the ordinance and would need to be managed for the first flush (but runoff from the existing building would not). Over time, this change will gradually reduce stormwater runoff to the combined sewer. In addition to this revision of the storm water ordinance, the GI Plan recommends that the City evaluate other ordinances that may impact green infrastructure implementation, and review its current Streetscape Design Standards to incorporate green infrastructure options.

INCENTIVES - For private properties that may not redevelop in the foreseeable future, the City continues to evaluate programs that can incentivize owners to construct green infrastructure retrofits. The existing efforts have focused on securing grant dollars that can be used to implement demonstration projects on privately-owned property. The GI Plan proposes the establishment of a Green Infrastructure Grant Fund to support the marginal cost (e.g., the cost difference to install a green roof instead of a conventional one) of constructing GI on private property.

FUNDING - The City is evaluating a utility structure that would allocate the costs of stormwater management and water pollution control based on the amount of impervious surface area on each parcel. Known as a "stormwater utility," this would apportion the costs of controlling combined sewer overflows and storm water based on each parcel's proportionate use (as determined by impervious area) of the wastewater collection and treatment facilities. Because controls are now required for wet weather flows, this method of cost allocation would be based on actual use of the sewer system and treatment services and allow reductions in a bill if a property owner installed green infrastructure to manage his or her impervious area and reduce flows to the sewer.



Over 1 billion gallons of stormwater is projected to be removed through long-term implementation of this GI Plan. This would fill a cube 480 feet high over the block containing the convention center and hotel.

BENEFIT AND COST

The GI Plan evaluated the runoff reduction benefits of the initial demonstration projects, a conceptual 5-year implementation scenario and a long-term scenario that might be expected to be achievable over a period of about 25 years or so based on typical rates of redevelopment and renewal rates for other City infrastructure like roads and sidewalks. Based on the characteristics of the demonstration projects, the potential benefits and costs associated with GI were estimated for each implementation scenario. The projected benefits of the program over the long term scenario are summarized below.

Table 1-1 - Summary of GI Plan benefits for 5 year and long-term implementation scenarios

Parameter	5-year Implementation	Long-Term (25-yr) Implementation
Impervious Area Managed by Green Infrastructure (ac)	221	1,265
Average Annual Runoff Reduction (MG/yr)	182	1,053
Average Annual Total Suspended Solids (TSS) Reduction (lb/yr)	252,000	1,457,000
Average Annual Total Phosphorus (TP) Reduction (lb/yr)	4,800	27,800
Average Annual Total Nitrogen (TN) Reduction (lb/yr)	10,700	61,600
Total Marginal Cost	$7,800,000	$77,000,000
Total Capital/Implementation Cost	$14,000,000	$141,000,000
Marginal Cost Per Gallon CSO Reduction ($/gal)	$0.06	$0.10
Total Cost Per Gallon CSO Reduction ($/gal)	$0.10	$0.18

RECOMMENDATIONS

To achieve these benefits and put the GI Plan to action, the following recommendations are made in four key areas described as follows.

1. **Implement a comprehensive demonstration program** to allow the details of each project type and technology to be worked through and adapted for the specific requirements of the City's unique land use types and
   - a) **Establish a prioritized capital program for GI implementation** within Department of Public Works;
   - b) **Apply a screening process to review existing City capital programs for possible green infrastructure project opportunities** (e.g. roofing, pavement restoration and other projects that restore or reconstruct impervious surfaces);
   - c) **Create a Green Infrastructure Grant Fund to incentivize action** by funding the marginal cost of the green portion of improvements on private property.

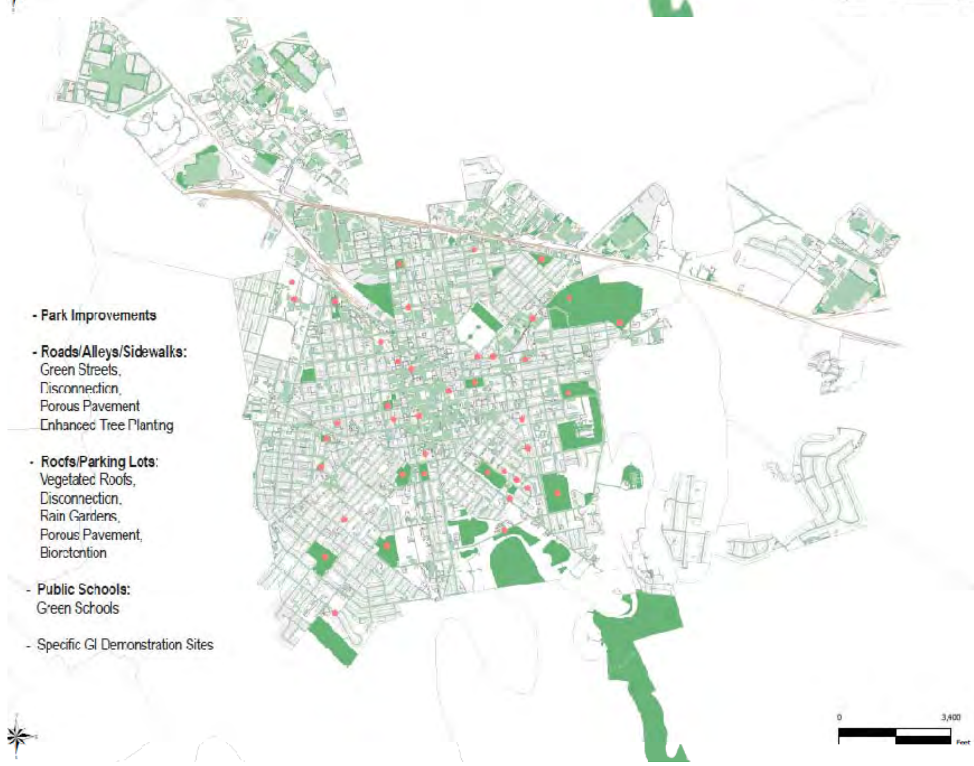
2. **Implement the recommended policy actions including:**
   - a) **Institute a GI advisory committee** comprised of City leaders to discuss and remove implementation barriers and endorse selected implementation programs and projects;
   - b) **Convene a review process to evaluate City Codes to include Green Infrastructure Options**
   - c) **Revise City Standard Design Guidelines and Details;**
   - d) **Evaluate and revise the First Flush Ordinance to manage all impervious area in the full area of disturbance for redevelopment;**
   - e) **Implement an impervious cover-based storm water rate to equitably apportion the cost of wet weather controls;**
   - f) **Develop a program to utilize vacant land (publicly and privately owned) for management of stormwater runoff.**

3. **Implement partnering and outreach including:**
   - a) **Develop and manage a list of key partners and volunteers** to help deliver outreach messages, host workshops, and provide support for grant funding pursuits;
   - b) **Develop partnerships and volunteer efforts to implement the results of the Urban Tree Canopy Project** being conducted by PA DCNR and evaluate additional models for expanding street tree programs;
   - c) Coordinate with County efforts to **implement the state and federal pollution reduction requirements;**
   - d) Coordinate with County efforts to **implement the Greenscapes Plan**;
   - e) **Develop a GI Portal on the City website** to disseminate information to the public about GI technologies, program updates, and what home owners can do to help;
   - f) **Develop a homeowner's guide to GI**;
   - g) **Provide GI Fact Sheets and education materials** on the Portal and brochures for selected audiences;
   - h) **Develop a public outreach plan, presentation materials and schedule** for outreach to key neighborhood groups, business leaders, the Mayor, City Council, and other stakeholders through **public meetings;** and

i) **Leverage learning through local and state key stakeholders** to inform the adoption and implementation of green infrastructure in other urban centers.

4. **Implement other studies & technical tools including:**
   a) **Conduct a Green Streets workshop** to support the selection and development of projects and approaches to demonstrate green streets in various types of road and alley reconstruction practices;
   b) **Update the City Hydrologic and Hydraulic Models to simulate green infrastructure** improvements in relation to other grey infrastructure alternatives;
   c) **Update the CSO LTCP** to include GI Plan recommendations;
   d) **Expand the GI Plan to evaluate the required implementation levels of the Chesapeake Bay TMDL and the nutrient reductions required for Lancaster** in the PA Watershed Implementation Plan (WIP) and **develop an integrated strategy for meeting CSO reduction and nutrient reduction objectives at the least cost and highest benefit to the City;**
   e) **Partner with PA DEP in the development of the revised WIP** for meeting the Chesapeake Bay TMDL requirements;
   f) **Develop a project tracking system** to document GI Implementation projects including the first flush projects and the area that they control; and
   g) **Identify direct stream inflow sources for potential removal from the combined sewer system.**
   h) **Prepare a comprehensive Tree Management Plan** by analyzing and developing a more specific tree planting goal based on the results of the Urban Tree Canopy Project and street tree inventory;
   i) **Address GIS data needs and update** parcel-based landuse data, impervious area data, and parcel ownership information

By implementing these recommendations, the needed investment in expensive, separate new grey infrastructure for water quality improvement can be significantly reduced and the City can realize many additional environmental, social and economic benefits.



The top map shows the existing City green space that does not contribute significantly to runoff problems. The lower graphic illustrates the 1,265 acres of impervious area proposed to be managed over the long term through the GI Plan.

Recommendations for Managing Stormwater

GIAC Presentation to City Council

October 23, 2012

Meeting Agenda

- Stormwater runoff - what is the problem?
- What does the GIAC recommend to address the problem and to fund it?
- Next steps – outreach and ordinance

1 billion gallons of polluted stormwater discharge

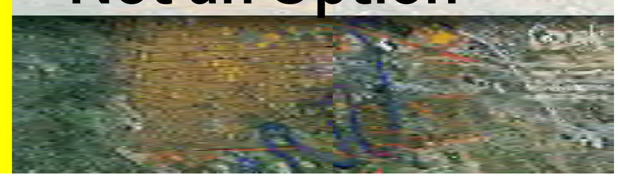
= 1515 Olympic swimming pools

Solutions

Previous Solution →

Proposed Solution →

Doing Nothing is Not an Option



"**Lancaster is in violation** of the AO, and needs to address these deficiencies as soon as possible. Violation of the terms of the AO may result in **further EPA enforcement** action for violation of the order and for the underlying violations including, but not limited to, imposition of **administrative penalties**, 33 U.S.C § 1319(g), and/or initiation of judicial proceedings that allow for **civil penalties of up to $37,500 per day**, 33 U.S.C § 1319 (b) and (d), for each day of violation."

The GIAC :

- Included representatives from:
  - business owners,
  - citizens,
  - institutions,
  - environmental groups,
  - state government,
  - Lancaster City government, and
  - Lancaster County government.

- Met 6 times between April and September 2012 on funding options and policy issues

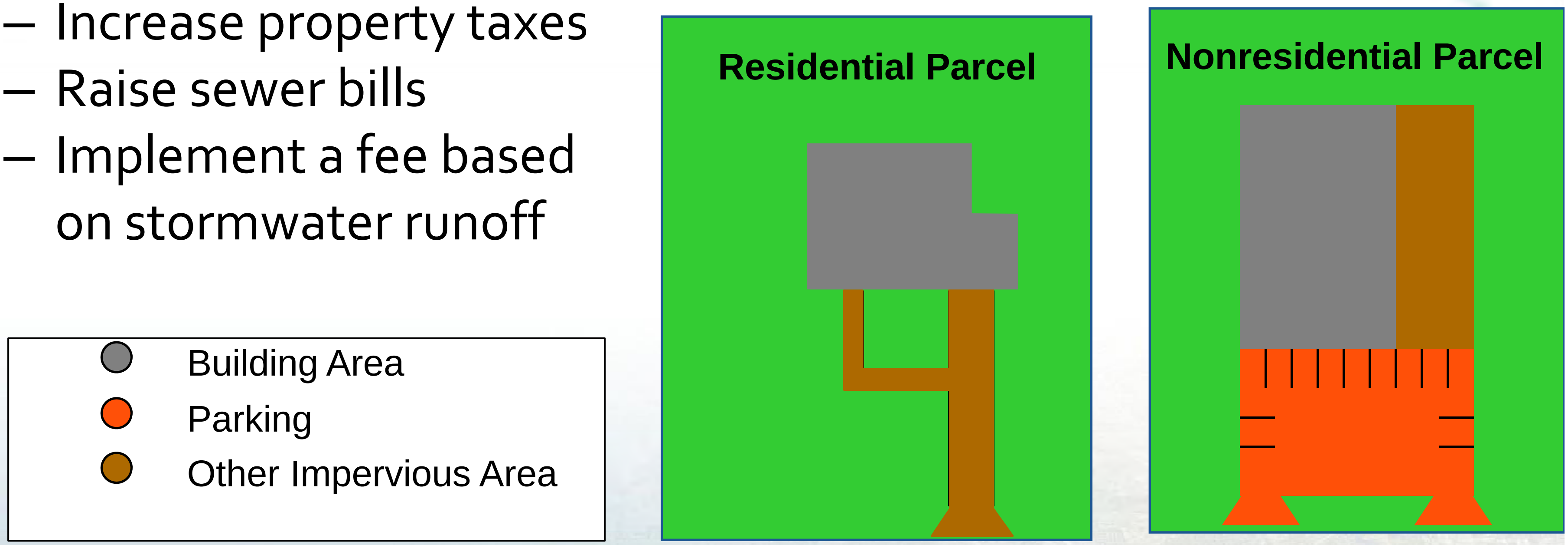
The GIAC :

agreed on criteria for evaluation.

- Equity/Fairness
- Simplicity
- Transparency
- Efficiency/Ease of Implementation
- Consistency with other City goals and objectives

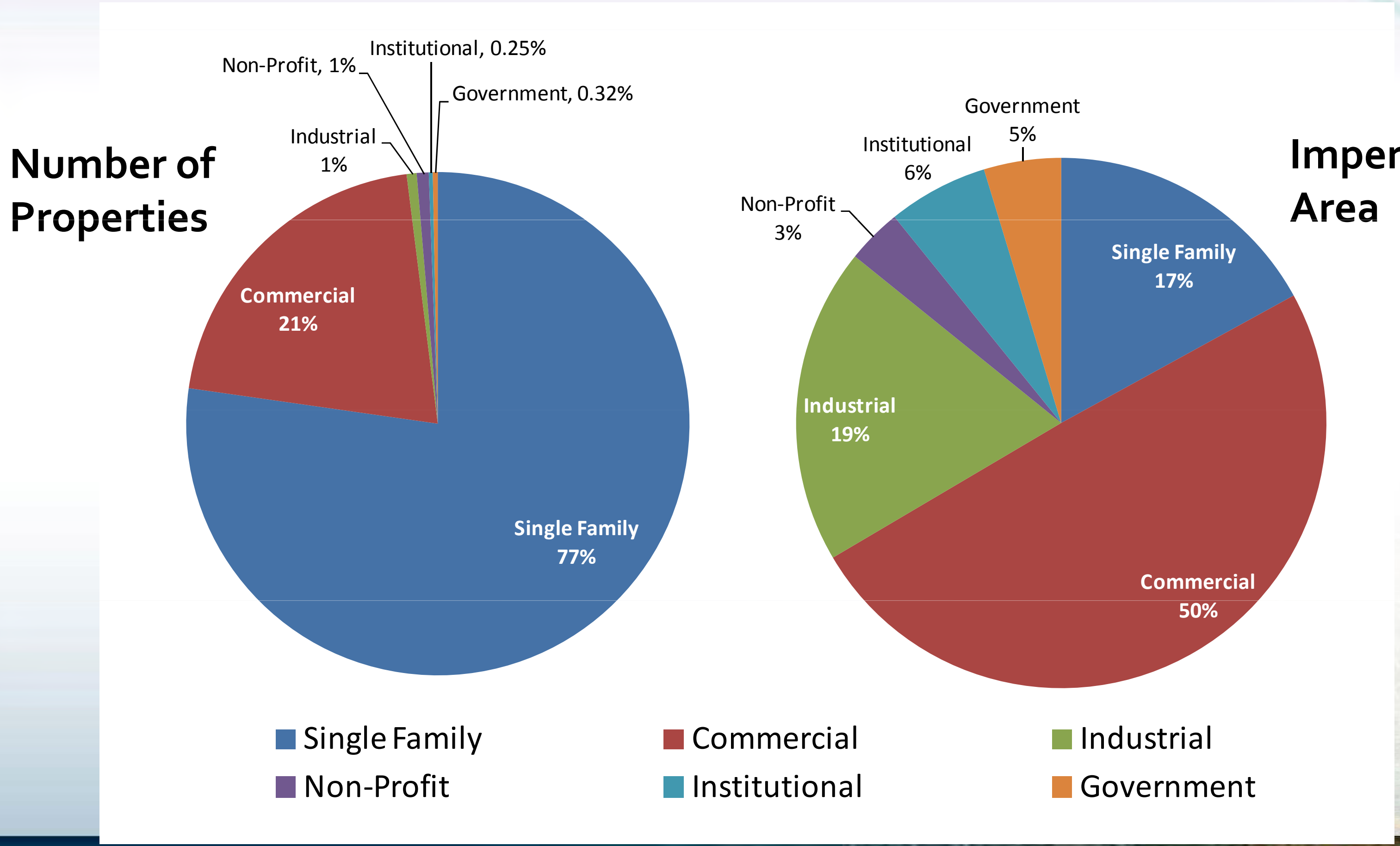
The GIAC : was convened to evaluate fair and equitable ways to fund the City's stormwater program.

- **Potential funding sources:**
  - Increase property taxes
  - Raise sewer bills
  - Implement a fee based on stormwater runoff



Stormwater runoff is measured by impervious area = roofs and pavement where rain runs off, rather than soaking into the ground

The GIAC recommends: **a stormwater management fee based on impervious area as the most equitable approach.**



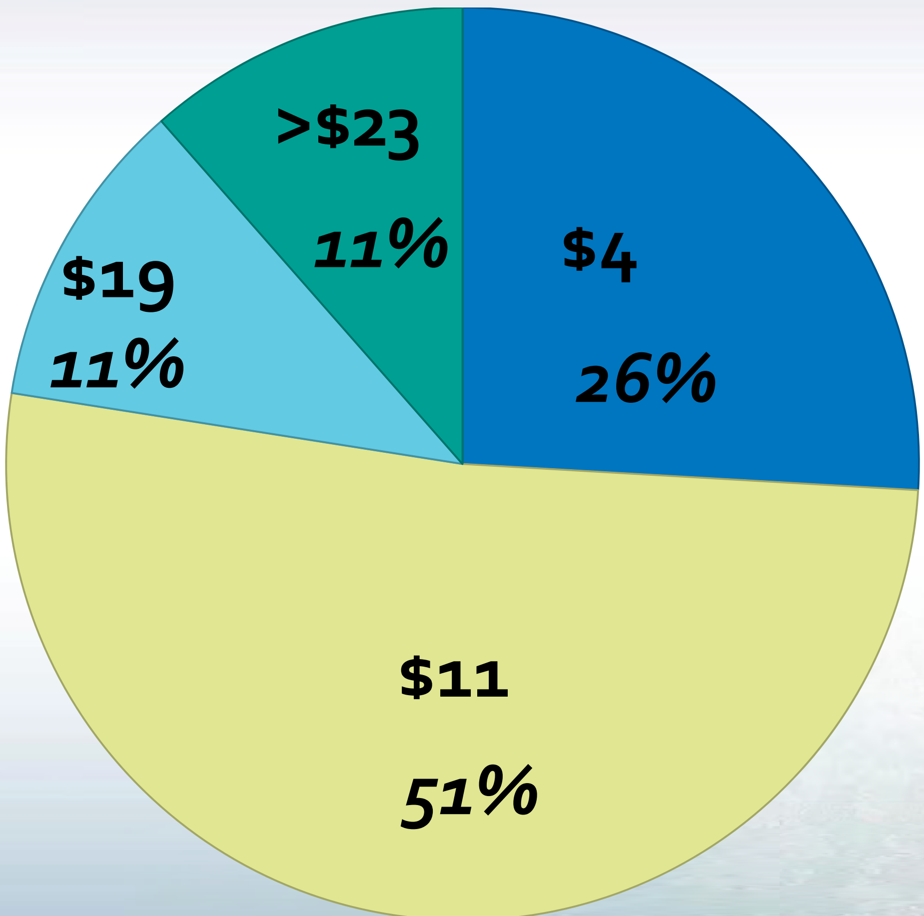
The GIAC recommends: **funding the stormwater program at the medium level of service.**

Level of Service Cost Estimate Summary

	Estimated Annual Costs		
	Low (Current/ Status Quo)	**Medium**	**High**
Operating and Maintenance			
Green Infrastructure	n/a	$162,000	$202,500
Dry and Wet Ponds (inspection)	$2,300	$2,300	$2,300
Street Sweeping	$168,800	$168,800	$234,100
Catch Basin	$201,000	$201,000	$402,000
Storm Drainage	n/a	n/a	n/a
MS4 Implementation	$451,600	$536,400	$612,400
Program Administration	$142,000	$219,000	$296,000
Capital Costs			
Green Infrastructure	$730,600	$1,909,100	$3,652,400
Storm Drainage	n/a	$1,444,000	$1,926,000
Catch Basin	$164,000	$164,000	$164,000
Total	**$1,860,300**	**$4,806,600**	**$7,491,700**

The GIAC recommends:

implementing a rate structure with four "tiers" based on impervious area.



- Tier 1 (0-999 sq. ft.)
- Tier 2 (1,000-1,999 sq. ft.)
- Tier 3 (2,000-2,999 sq. ft.)
- Tier 4 (≥3,000 sq. ft.)

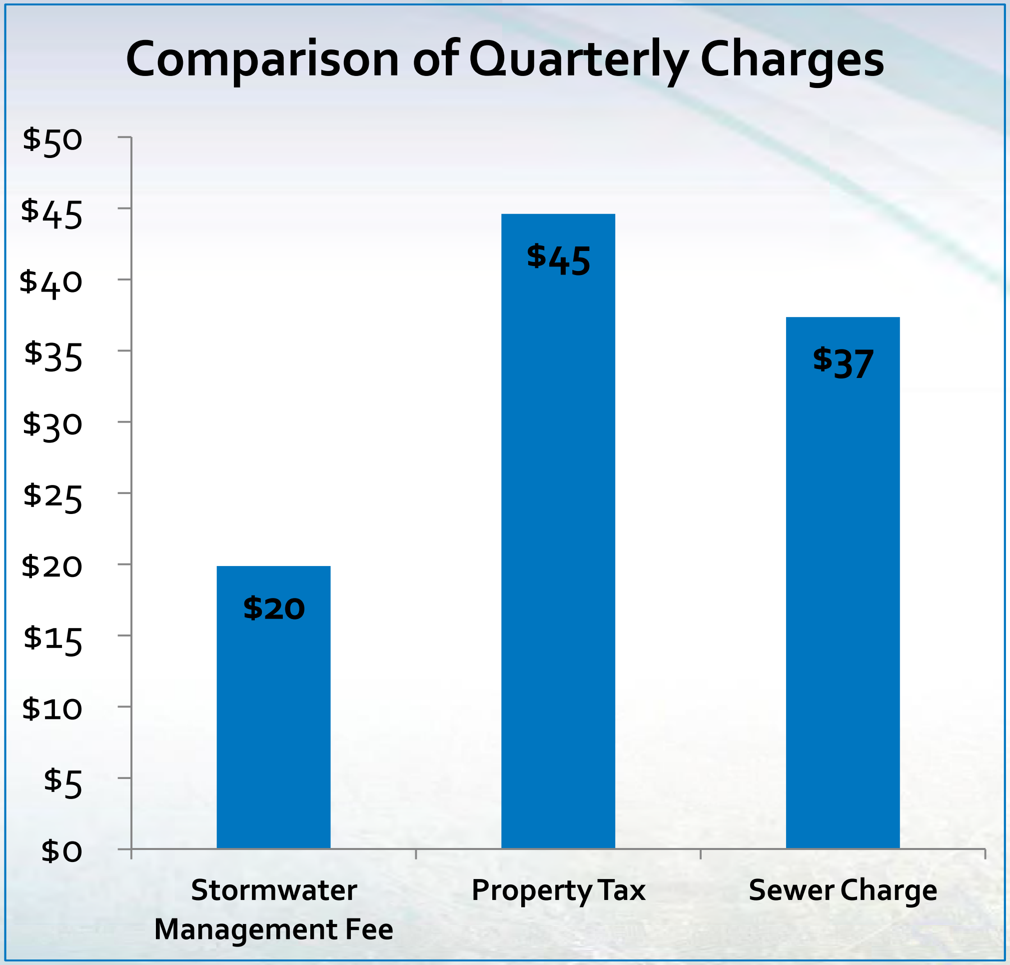
Percentages refer to percent of all properties

Rates are estimated first year fees per quarter, for Medium Level of Service

For example – average fee per quarter:
Residential: $20
Commercial: $237

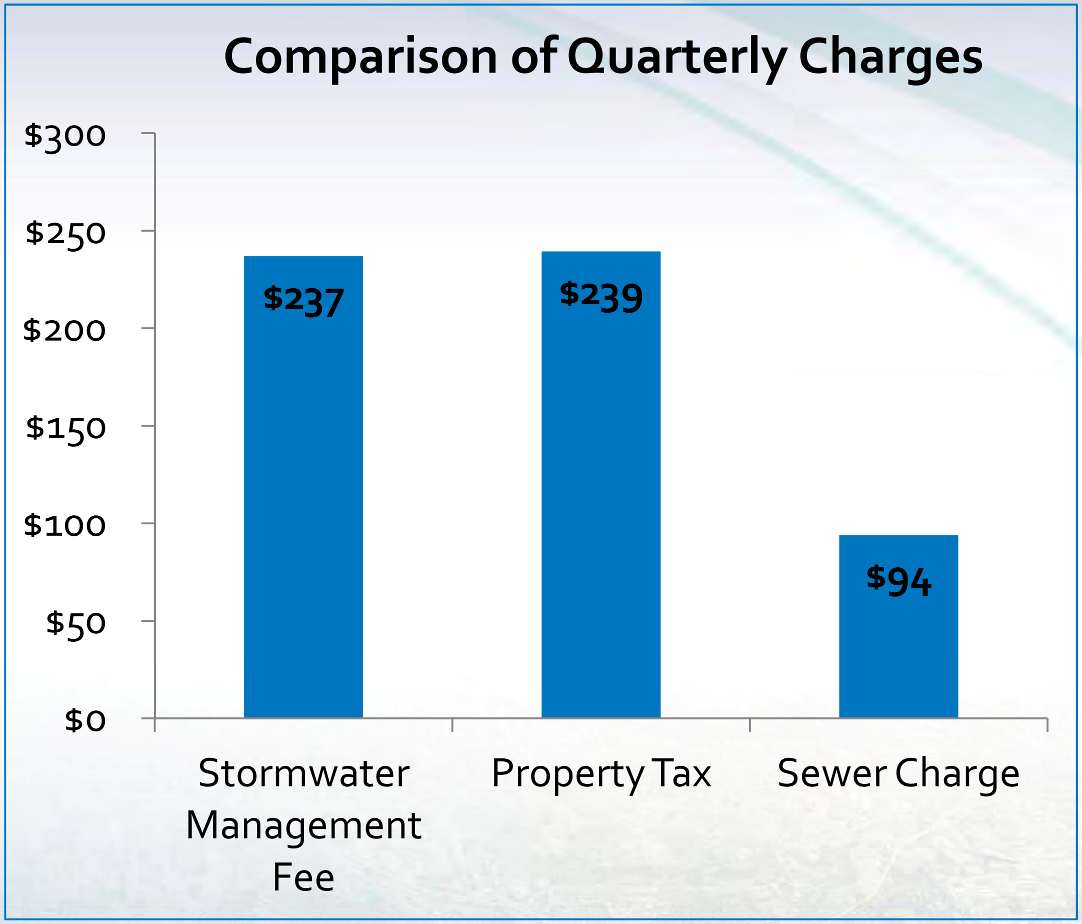
Comparison of Charges – Average Residential

Residential	Impervious Area (sq.ft)	Assessed Value ($)	Water Total (x1000 gal)
Min	1	400	1
Avg	1,367	72,558	48
Max	35,441	522,800	912



Rates and charges assume medium LOS
($4,800,000 annual program)

Comparison of Charges – Average Commercial

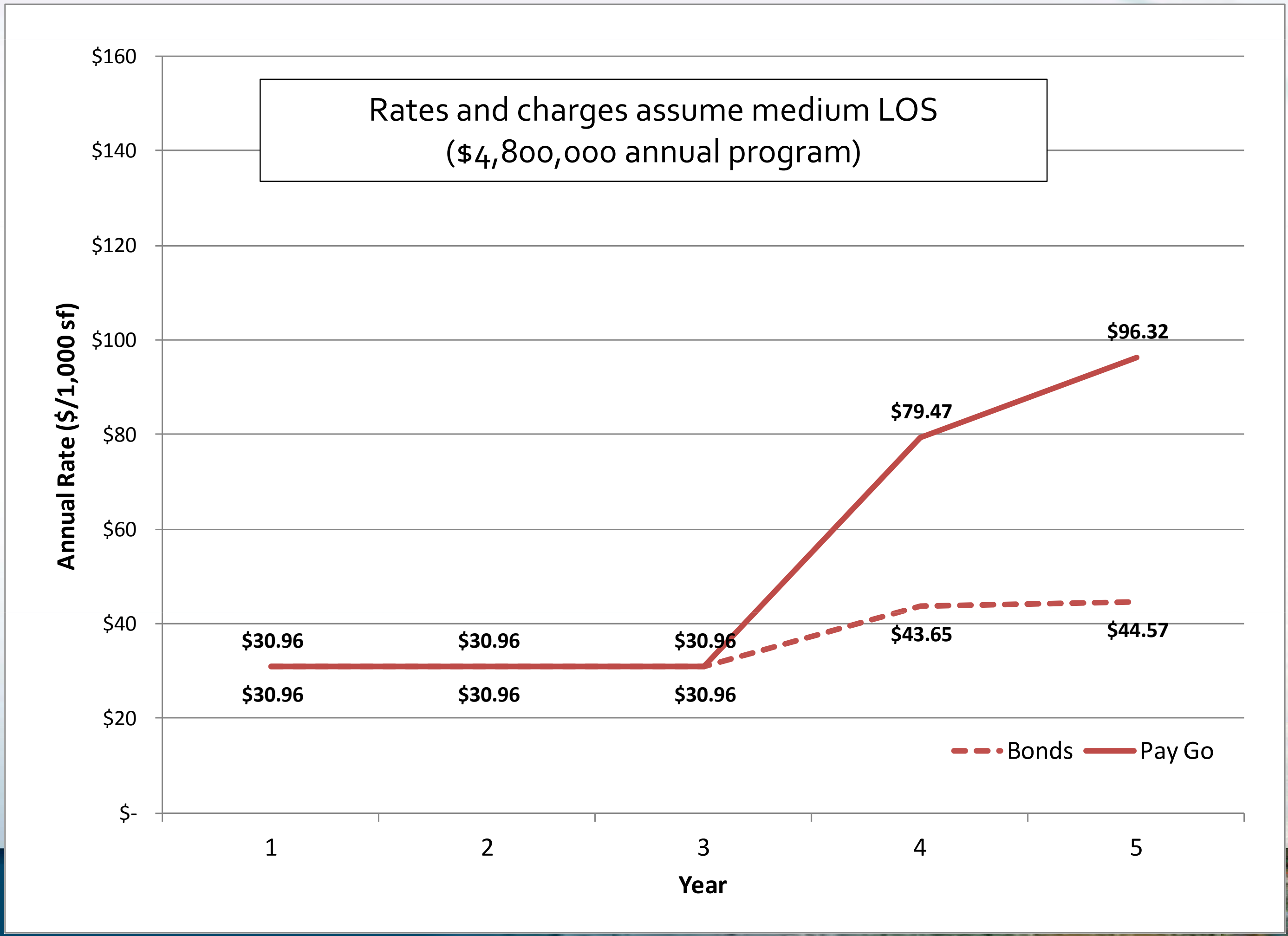


Rates and charges assume medium LOS ($4,800,000 annual program)

Commercial	Impervious Area (sq.ft)	Assessed Value ($)	Water Total (x1000 gal)
Min	7	300	1
Avg	17,882	389,338	120
Max	4,246,304	129,942,300	6,749

The GIAC recommends:

leveraging the SWMF by issuing bonds to keep rates low and spread costs over time.



The GIAC recommends:

including an incentive program to provide fee relief.

- **<u>Rebates or Grants</u> – 1 time assistance with construction cost:**
  - For example up to $1200 for residences, and up to $5000 for businesses to install green infrastructure projects
- **<u>Credits</u> – a percentage reduction in the annual impervious area fee**
  - For example up to 50% for businesses treating impervious area with green infrastructure projects

- **Benefits:**
  - Help property owners reduce their annual stormwater fee, thus
  - Provide incentive for implementing green infrastructure on private property
  - Provide incentive to maintain facilities

City Administration recommends:

billing the SWMF as a new line item on sewer bills.

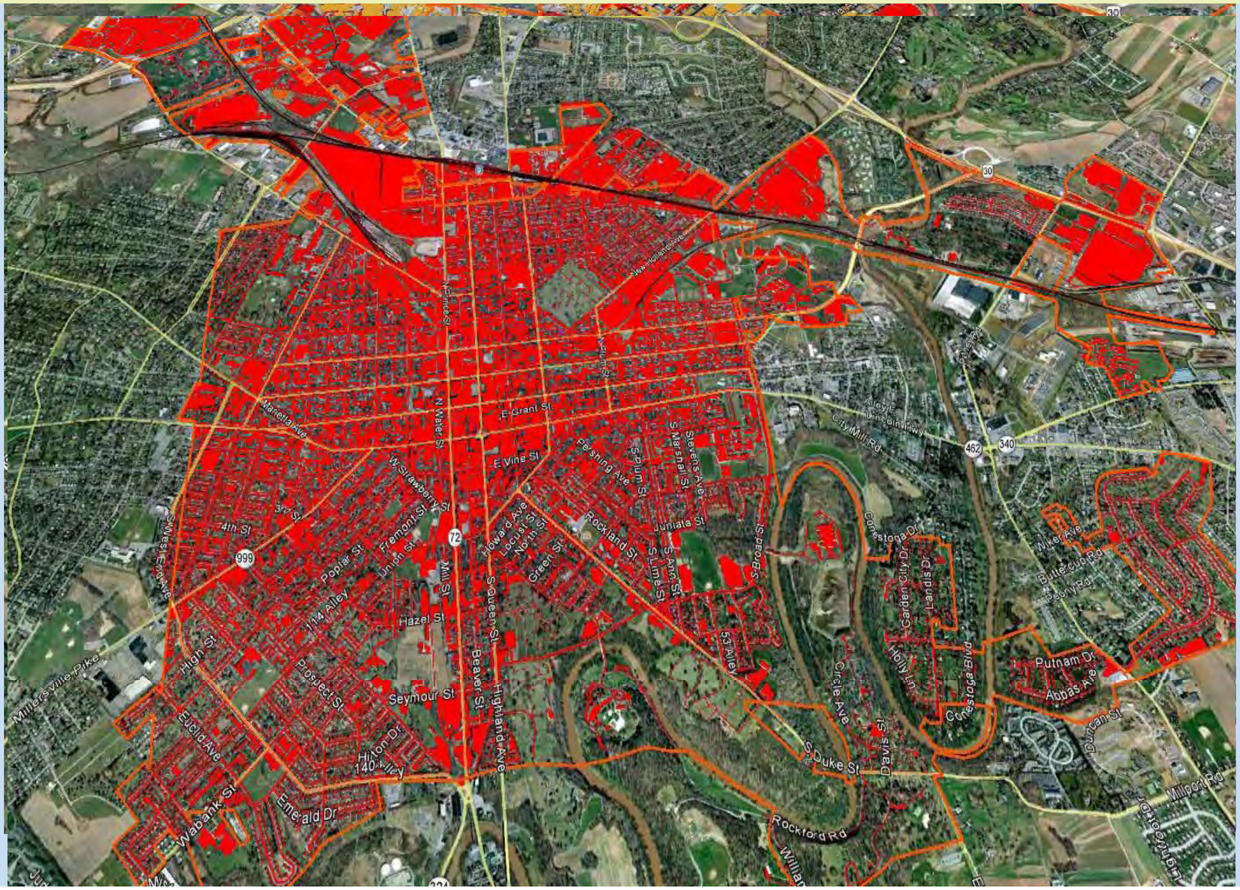
- Bills are quarterly or monthly depending on class
- Reaches all properties except those with no water/sewer account (e.g. parking lots), which will be billed separately

City Administration recommends: **including an appeals system.**

- Items that could be appealed:
  - Impervious area
  - Tier category
  - Credit calculation
- Appeals deadline would be 6 months before first bills go out in a given fiscal year
- Estimated first year fee should be sent out before bills are issued, to allow appeals

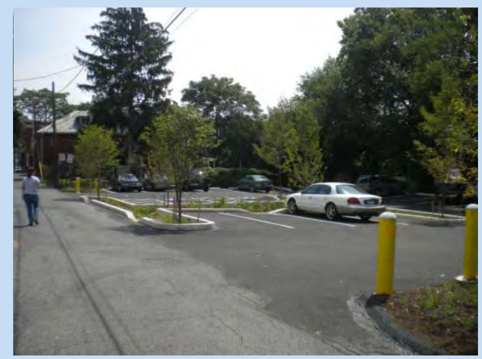
The GIAC recommends:

implementing a stormwater management fee to support regulatory compliance, and continuing to implement the Green Infrastructure Program



Roads & Alleys

Parking



Rooftops

Next Steps - Targeted Stakeholder Outreach

- Business Community:
  - Chamber of Commerce
  - Commercial
  - Industrial
- Non-profits
- Faith Community
- Neighborhood and Latino Communities
- Landlords
- Environmental groups
- City Council
- County Government
- School District
- Other Media
- Developers
- Realtors
- Parking Authority
- Parking lot owners without water accounts

Next steps – Ordinance Development

- Outreach
- GIAC Review of Feedback
- Ordinance Development
- Presentation to Council

Questions?

www.baltimoresun.com/news/opinion/bs-ed-conowingo-dam-20121217,0,1752299.story

baltimoresun.com

Conowingo Dam is not the problem

County leaders are using the Susquehanna issue to divert attention from their responsibility to protect the Chesapeake

By J. Richard Gray

6:00 AM EST, December 17, 2012

The Susquehanna River and its big dams have been in the news lately. A handful of Maryland county officials would like you to believe the dams are the primary ill of the Chesapeake Bay.

They claim that because sediment reservoirs behind the Conowingo Dam are at capacity, instead of trapping pollutants during storms, the dam now allows two pollutants — phosphorus and sediment — to flow downstream at alarming rates. They argue that years of restoration progress have been erased and that current bay restoration efforts do not address these issues. And finally, these local leaders contend that Maryland's investments in restoring the bay would be "futile" and all of the efforts to help our local waters should now come to a standstill.

Well, as chair of the Local Government Advisory Committee (LGAC) for the Chesapeake Executive Council, which includes the state governors, Environmental Protection Agency administrator and other senior officials who guide the cleanup effort, I write today with good news — every bit of scientific information available says they are wrong on all counts.

First, they claim 80 percent of the pollution to the bay comes from the Susquehanna River. This figure is not in any of the scientific information I've seen, and no expert I've contacted knows where the number comes from.

Second, the nutrients and sediment passing through the Susquehanna's dams, under all conditions, are indeed accounted for in the state-of-the art tools the bay restoration scientists use.

Third, while storms do increase the freshwater and pollutants flowing through the dam, they by no means erase the progress we have made. For example, the large grass bed on the Susquehanna Flats, located right where that river meets the bay, withstood the flow of fresh water and sediment downstream during last fall's storms precisely because we put time and effort into restoring it to health.

And finally, whatever pollutants get past the dam primarily affect the northernmost tidal waters of the bay and its rivers.

So let's talk about things that are true.

The recent introduction of pollution limits in the effort to clean up the Chesapeake Bay recognized that we could no longer point our fingers at someone else. We all have to do more to protect our local streams and, by doing so, help the Chesapeake Bay. Many Pennsylvania and Maryland localities are already investing wisely in projects to restore their own local waters and send cleaner water downstream.

In Lancaster, Pa., even before the clean water blueprint was established, we changed our thinking and began to put projects in place to stop polluted runoff before it reaches local waters. We are continuing to invest our money in sewage treatment and stormwater infrastructure, using green technologies and following our comprehensive green infrastructure plan.

Meeting our local goals will be costly in the short term, but recent studies done in and on our city actually show a cost savings in the long run. In other words, if we postpone what has to be done, future generations will bear an even greater financial burden. So we are building Lancaster into a more appealing, livable community right now, with more trees and gardens and healthier waters, all of which give us a better chance of attracting new residents and economic growth.

So, why, LGAC members wonder, would any county or city spend its citizens' dollars on lawyers to fight against clean water rather than using that money to improve its communities and its local streams?

Maryland's local officials should recognize that their counties and towns have the most vital interest in the bay. If they give up their efforts, many in Pennsylvania, Virginia and other states will use that as an excuse to do nothing. Rather than pulling back or arguing, I would expect Maryland localities to fully appreciate the value of clean local waters and set the example for all of those upstream.

There is so much financial assistance available, so many creative "green" engineering firms at work and so many solid, new ways to manage polluted runoff that we are dumbfounded by the resistance from these local leaders toward cleaner local waters for their communities and the bay.

To the extent the Conowingo Dam is an issue, let's get the right people to the table to talk constructively about the facts and solve the problem. The timing is perfect, because the license for that dam is up for renewal.

Enough of creating diversions and pointing fingers to distract from the work that is so sorely needed. It's time to recognize that we are all in this together. It's time — past time, in fact — to get busy on the work we were entrusted to do as our communities' leaders.

J. Richard "Rick" Gray is Mayor of Lancaster, Pa. and the chairman of the Local Government Advisory Committee, an independent group of elected local leaders from Maryland, Pennsylvania, Virginia and the District of Columbia that advises the Bay Program's Chesapeake Executive Council. This article is distributed by Bay Journal News Service.

WE&T

water environment and technology

- Nutrient removal
- Biosolids & residuals
- Public outreach
- Energy and resource recovery

April 2013

Green infrastructure

Employing nature to meet water quality standards

Going green to save green

The City of Lancaster, Pa., develops an integrated green infrastructure plan to reduce CSOs and stormwater and nutrient runoff

Charlotte Katzenmoyer, Brian G. Marengo, Andrew Potts, and Courtney Finneran

The City of Lancaster, Pa., is integrating the use of green infrastructure with its core public works practices to reduce the impacts of pollutant sources and achieve cost savings. The city also is updating its long-term control plan to reduce the frequency and volume of combined sewer overflows (CSOs) and address its stormwater discharges. The hope is to become a model example of the application of the integrated municipal planning and green infrastructure promoted in the U.S. Environmental Protection Agency's Oct. 27, 2011, memorandum, "Achieving Water Quality Through Integrated Municipal Stormwater and Wastewater Plans."

A historic solution with emerging problems

Lancaster is one of about 770 U.S. cities with a combined sewer system (CSS). Eighty-five percent of the time, the city's advanced water resource recovery facility (WRRF) is able to manage and clean the volume of wastewater flowing through the CSS. However, during intense rainstorms and other wet weather events, the system can become overwhelmed. This causes 3.8 billion L/yr (1 billion gal/yr) of CSOs into the Conestoga River.

When CSSs were being built across the country 100 to 200 years ago, they were considered a highly efficient method of treating all forms of waste from urbanized areas, because they collected stormwater, municipal wastewater, and industrial wastewater all in the same pipe and conveyed them to a facility to be processed before the system discharged treated water to nearby streams. But as urbanized areas grew and eventually overwhelmed CSSs, the methods used did not change to keep up with development.

The city's existing CSS has come under further scrutiny because of efforts to clean up Chesapeake Bay. These efforts have brought renewed federal, regional, and state attention to initiatives designed to protect and restore the network of polluted streams and rivers in the Chesapeake Bay watershed, many of which fail to meet water quality standards. The Conestoga River is one such river. There is increased regulatory interest in enforcing limits on the total maximum daily load (TMDL) of nitrogen, phosphorus, and sediment runoff. The TMDL sets accountability measures for communities located within the 166,000-km^2 (64,000-mi^2) watershed to ensure that they keep cleanup commitments. The TMDLs are being promulgated not only for CSSs but also for municipal separate stormwater systems across the watershed.

◀ **A photo of a green roof, one of the initiatives of the Lancaster County Roof Greening Project.** LIVE Green

Shifting focus from gray to green

Both the inadequacy of traditional CSSs to address modern treatment needs and the new Chesapeake Bay TMDL mandates have led the city to proactively work to reduce CSOs and identify economically viable, long-term strategies for mitigating the negative impact of wet weather overflows on local water quality.

During the past 12 years, the city has aggressively upgraded its existing gray infrastructure, investing more than $30 million in its wastewater system, including making it the first system in the state to meet nutrient removal requirements through a biological nutrient reduction project. The city also used capital investments to increase the efficiency of pumping stations to optimize the flow of wastewater to the WRRF. These investments have resulted in future capture of wet weather flows for treatment.

To date, most of the additional strategies the city has considered have been limited to gray infrastructure options, such as increasing capacity of the city's wastewater conveyance and treatment infrastructure, adding storage or holding tanks to detain wastewater flows until treatment capacity returns, or providing some form of wastewater treatment to the overflow discharges. But prior evaluations and experience in many other communities show that the gray infrastructure option can be expensive to construct and maintain, and it only serves the single purpose of holding CSO volume for later treatment at the WRRF. The cost of one storage tank alone in the city's northeast section is estimated at $70 million. This would manage only 10% of the city's annual CSO volume. To store and treat the current CSO volume is estimated at more than $250 million in constructed costs, not including the annual operational costs in energy and personnel to run the new system.

Given the expense of gray infrastructure modifications, the city has instead opted for a two-pronged strategy to reduce the volume of CSOs: Increase the efficiency of the city's existing gray infrastructure, and employ green infrastructure stormwater management methods. These methods generally include

- infiltration (linear infiltration systems and porous pavements, sidewalks, and gutters);
- evaporation, transpiration, and reduction of energy consumption (vegetated roofs, trees, and planter boxes);
- infiltration and transpiration (rain gardens and bioretention); and
- capturing and reusing rainfall (rain barrels, cisterns, irrigation supply systems, and graywater systems).

In contrast to gray infrastructure, a green infrastructure approach often has a higher return on investment and offers multiple benefits. Most importantly, integrating green infrastructure with traditional infrastructure (for example, parks, parking lots, and roads) can decrease implementation costs; decrease the reliance on separate, single-purpose, gray infrastructure needs; and provide triple-bottom-line benefits with regard to

- environmental concerns (such as recharging groundwater, providing natural stormwater management, reducing energy usage, improving water quality, reducing heat-island effects, and increasing habitat);
- social considerations (beautifying and increasing recreational opportunities, improving health through cleaner air and water, and improving psychological well-being); and
- economic concerns (reducing future costs of stormwater management and increasing property values).

In May 2010, Lancaster began to develop Pennsylvania's first Green Infrastructure Plan for a Class 3 city. (Class 3 cities are medium-size communities in Pennsylvania after Philadelphia and Pittsburgh.) Building upon the Lancaster County Comprehensive Plan as reported in the planning commission's *Greenscapes: The Green Infrastructure Element*, the city's plan was developed in conjunction with LIVE Green (Lancaster), the county planning commission, the Pennsylvania Department of Environment, the Pennsylvania Department of Conservation and Natural Resources, and other local stakeholders. The plan clearly articulates that the vision for the city was developed to support the mission to provide more livable, sustainable neighborhoods for city residents and reduce CSOs. The program was developed also to support the following program goals:

- Strengthen the city's economy and improve health and quality of life for its residents by linking clean water solutions to community improvements.
- Create a green infrastructure program to respond comprehensively to the multiple water quality drivers to maximize the value of the city's investments, meeting the numerous overlapping environmental regulations and programs.
- Use green infrastructure to reduce nutrients and erosive flows from urban stormwater runoff and CSOs to support the attainment of Pennsylvania's Watershed Implementation Plan for Chesapeake Bay.

Before and after photos of Brandon Park. This park is part of the Green Parks program of Lancaster, Pa. Brandon Park reduces runoff by 4 million gal/yr at $0.15 per gallon. CH2M Hill

The Mifflin Street lot was one of many projects where the City of Lancaster incorporated green infrastructure design as part of the improvements. CH2M Hill

- Achieve lower cost and higher benefit from the city's infrastructure investments.
- Establish the city as a national and statewide model of green infrastructure implementation.

Analyzing the area

In order to implement its green infrastructure plan, the city conducted an evaluation/study that required a three-step process:

1. Evaluate impervious cover by type and land ownership.
2. Identify potential green infrastructure project sites and grant funding for early implementation to understand the cost and benefit of each.
3. Determine potential citywide benefits, and provide actions and policy direction to institutionalize green infrastructure throughout the city.

The size of the study area, which is 1957 ha (4835 ac), or 19.7 km^2 (7.6 mi^2), was defined as the city and the CSO sewershed area that includes a small portion of the Manheim Township and Lancaster township residing outside the city (see Figure 1, p. 44). About 45% of the city, or 854.7 ha (2112 ac), drains to a combined sewershed, according to geographic information system analysis, and a small portion of the combined sewershed (53.8 ha [133 ac]) drains portions beyond the city boundary. The total land area served by the CSS is 908.5 ha (2245 ac), and more than half of the city (1008 ha [2591 ac]) drains into a separated stormwater sewer system.

Overall, about 363 parcels are owned by a public entity, totaling 256 ha (632 ac), or 13% of the study area (see Table 1, below). Publicly owned parcels are the basis for analysis and overall implementation of the green infrastructure techniques, as these parcels offer a defined process for incorporating green infrastructure into redevelopment or the new land development process.

An impervious-area analysis (see Figure 2, p. 44) revealed that approximately 41% of the city's impervious surface is attributable to buildings, 32% to parking lots, 25% to roadways, and 2% to railroads. Most of the impervious area besides roads is on privately held lands, which shows why private involvement is necessary to make the program successful. The city cannot solve the problem cost-effectively on its own.

Further analysis identified more than 50 existing and potential green infrastructure projects in various locations, such as streets, alleys, sidewalks, parking lots, rooftops, parks, and school and city-owned properties. From these locations, the city included in the green infrastructure plan conceptual designs and cost estimates for 20 initial projects that the city could use to demonstrate each green infrastructure technology. These demonstration projects will remove an estimated 79 million L (21 million gal) of urban runoff from the CSS per year and simultaneously provide much needed data on the long-term effectiveness of employing green infrastructure strategies on a broader scale to reduce urban stormwater runoff and CSOs.

The city determined it possible to scale the projects to significant implementation levels when applied to specific land uses common in urban settings, such as Lancaster. The implementation levels were initially determined using professional judgment based on field surveys, geographic information system analysis, demonstration projects, cost/benefits analysis (see sidebar, p. 45), and other communities seeking to widely implement green infrastructure. They provide a guideline as to what might be possible to achieve within these approximate timeframes and could be increased or decreased depending on a variety of factors, such as capital budget, regulatory need, restoration priorities for the various impervious surfaces, redevelopment rates, the urban tree-canopy assessment, and others.

Each green infrastructure project can be classified into a broader green infrastructure program; for example, all publicly owned school sites can fall within a common classification of green schools and city-owned sites. Classifying the programs helps organize the drivers for implementation and can help shape the priorities for short- and long-term city efforts. The city considered eight program types in relation to the specific land uses common to the city, with an initial focus on public ownership. They were green streets/alleyways, green sidewalks, green parking lots, green roofs, private disconnection/rain gardens and rain barrels, enhanced street tree plantings, green parks, and green schools and city-owned sites.

Making changes

To illustrate how the city is achieving low-cost runoff reduction by using integrated green infrastructure, select implementation examples are provided below.

Green parks program. In 2009, the city completed an Urban Park, Recreation, and Open Space Plan through grant funding from the Pennsylvania Department of Conservation and Natural Resources. The plan lays out specific concepts for city-owned and -managed park renovation and restoration, recommending the implementation of green infrastructure techniques that can be undertaken at a reasonable cost.

Table 1. Total number and area of publicly owned parcels for the study area

Public ownership – major category	Total number of parcels	Total parcel area (ac)
City	195	185
School	20	175
Parks	17	241
Other	131	31
Total	**363**	**632**

Table 2. The 6th Ward Park porous basketball court results

Runoff reduction	694,600 gal/yr
Construction cost	$116,300
Cost of court only	$49,650
Incremental cost of GI	$66,650
Total cost/gallon	$0.17 per gal
Incremental cost/gallon of GI	$0.10 per gal
Comparable grey storage cost	$0.23 per gal

GI = green infrastructure.

Implementation of green infrastructure techniques on park properties manage stormwater from adjacent impervious surfaces, such as surrounding neighborhood streets, and manage stormwater runoff from adjacent roofs through downspout disconnections. They also provide a natural source of irrigation for green spaces.

One example is the 6th Ward Park. The city incorporated a porous-pavement stormwater system with a proposed new basketball court to manage runoff from the park and adjacent streets at a marginal cost of $0.03/L ($0.10/gal; see Table 2, above). Another example is Brandon Park, which is situated in the valley of a former creek where a CSS was constructed during the early 1900s. The city re-envisioned the valley with green infrastructure to capture runoff from the impervious features in the park and adjacent upland areas from Wabank Street. Parking areas and basketball courts were replaced with porous paving. The city used bioretention facilities throughout the park to re-create the historic stream valley. Also, at the intersection of Brandon Court and Wabank Street, the city used curb extension planters to calm traffic at the park entrance and along a main pedestrian thoroughfare to the local elementary school and city recreation center.

Green streets. The city of Lancaster has 217 km (135 mi) of streets, with 43 km (27 mi) classified as alleys within the Conestoga River watershed, a small portion within the Little Conestoga Creek watershed, and a minor portion draining to the Mill Creek watershed. Green streets and alleys use the existing form and construction of roadways to enable the public right-of-way to manage the runoff it creates. Green infrastructure features are incorporated during street repaving or reconstruction. Impervious surfaces can be replaced with porous pavements (asphalt, concrete, or pavers) or with standard pavements with inlets routed into a storage and/or infiltration bed below. Landscaping and vegetation (trees, curb extensions, and sidewalk planters) can be incorporated.

The first alley demonstration project was built by modifying an existing unit-quantity paving contract to include material components and installation services needed to include porous pavers, a subsurface stone storage bed, and perforated drain pipe. Modifying the existing contract made it possible for the alley to be built in 1 month and at a cost of only 10% more than a conventional concrete alley.

Green parking lots. A green parking lot typically is built by excavating an existing lot and installing a stone surface infiltration bed and a porous pavement or stormwater inlets and/or catch basins redirected into the stone bed. Runoff from adjacent areas, such as streets and buildings, can be redirected into the infiltration bed and tree trenches, or the city can integrate bioretention with the design to increase tree canopy, promoting evapotransipiration. These projects are built more cost-effectively when pavements need replacing or when the lot requires reconfiguration for other reasons. The Mifflin Street parking lot not only incorporated green infrastructure in its reconstruction, but the layout improvements and increased tree canopy will provide other benefits to the community, such as improved traffic flow management, increased property values, and reduction in crime. The lot was designed, bid, and recently completed.

Green roof program. The Lancaster County Roof Greening Project is a grant program that provides funding to offset the higher capital cost of green roof construction. The City of Lancaster currently has 10 green roof installations (see Table 3, below) that manage an estimated 3.79 million L (1 million gal) annually of stormwater runoff from the CSS.

Moving forward

To fully institutionalize green infrastructure into the city's urban landscape, the city is moving forward with several policy actions, incentives for residential and commercial property owners, and innovative funding approaches to support ongoing implementation costs. Some examples are described below.

Policies, ordinances, and standards. As part of the stormwater ordinance, the city has a "first flush" control measure that requires property owners who are adding new impervious surface areas – such as building additions, driveways, garages, or impervious patios – to manage the first inch of rainfall on their property and not allow it to discharge to the CSS. To gradually reduce overall stormwater runoff to the CSS, the green infrastructure plan recommends that the city's stormwater regulations be extended to control the first flush from the impervious area within the entire disturbed area of the redevelopment project. For example, if a building addition were being built on top of an existing parking lot, runoff from the addition would fall under the ordinance and would have to be managed for the first flush. In addition to the revision to the stormwater ordinance, the

Table 3. Summary of implemented green roof projects under the county incentive program

Project reference ID	Project name	GI area (ft²)
P-022	Wharton Elementary	13,150
P-023	Lafayette Elementary	11,500
P-024	Ross Elementary	2500
P-025	National Novelty Brush Co.	16,900
P-026	F&M Brooks Bump out	1250
P-027	F&M Wohlson Center for Sustainable Environment	1825
P-029	Groff Family Funeral Home	8910
P-080	Tellus	9600
P-112	F&M Weis Hall	820
P-113	F&M Schnader Hall	9400
Total		**75,855**

GI = green infrastructure.

This project's green infrastructure improvements included an increased tree canopy. CH2M Hill

plan also recommends that the city evaluate other ordinances that might affect green infrastructure implementation and review the current streetscape design standards to incorporate green infrastructure options.

Green incentive programs. The city continues to evaluate programs that can incentivize owners to construct green infrastructure retrofits on private properties that may not be redeveloped in the foreseeable future. It has focused existing efforts on securing grant dollars that can be used to implement demonstration projects on private property. The green infrastructure plan proposes establishing a green infrastructure grant fund to support the incremental cost of adding green features to a project on private property (for example, the cost difference to install a green roof instead of a conventional one). This program is being implemented using funding from the state revolving loan fund, PENNVEST, and property owners are paying for 10% of the project costs for more than 35 projects.

Impervious area fee. The city is implementing an impervious-area-based fee structure that would allocate the costs of stormwater management and water pollution control based on the amount of impervious surface area on each parcel. Known as a "stormwater utility," this would apportion the costs of controlling CSOs and stormwater based on each parcel's proportionate use (as determined by impervious area) of the wastewater collection and treatment facilities. This allows for reductions in a bill if a property owner installs green infrastructure to manage his or her impervious area and reduce flows to the CSS.

Charlotte Katzenmoyer *is director of the City of Lancaster (Pa.) Public Works.* ***Brian G. Marengo*** *is principal water resources technologist,* ***Andrew Potts*** *is senior water resources project technologist, and* ***Courtney Finneran*** *is an environmental planner in the Philadelphia office of CH2M Hill Inc. (Englewood, Colo.)*

The City of Lancaster would like to thank the Pennsylvania Department of Conservation and Natural Resources (DCNR) Environmental Stewardship Fund and the Lancaster County Planning Commission for their financial support in developing the green infrastructure plan. It would also like to thank the National Fish and Wildlife Foundation (Washington, D.C.) for its generous support through three grants for funding demonstration projects and institutionalizing green infrastructure. It would also like to thank

Figure 1. Green infrastructure plan study area

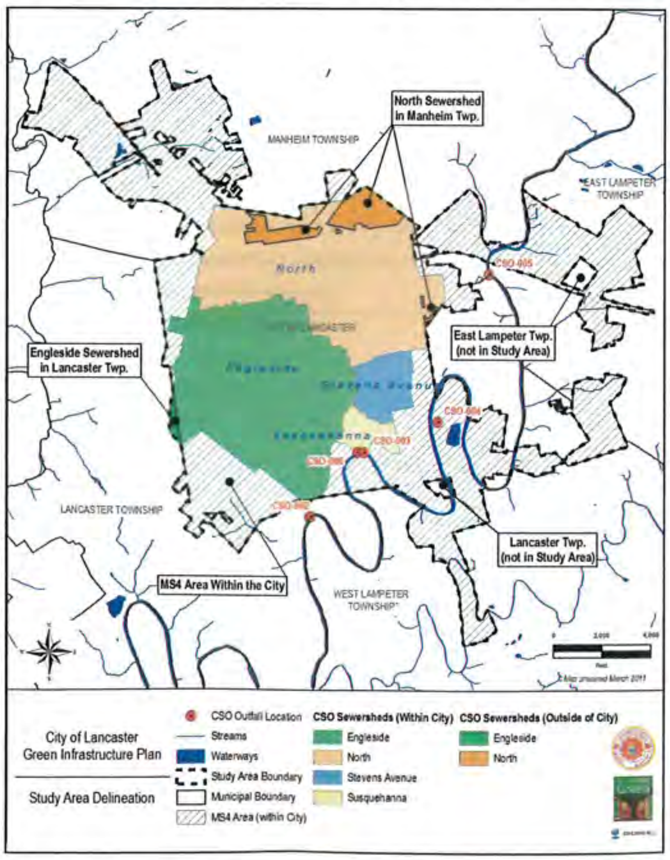
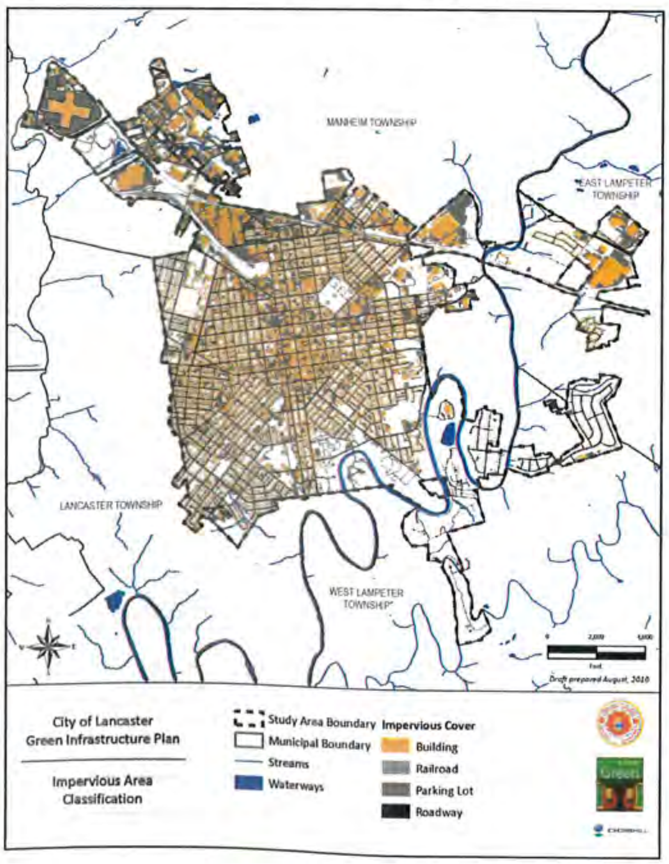


Figure 2. Impervious area classification



Jay Braund of the Pennsylvania Department of Environmental Protection; Green Collins of the School District of Lancaster; Mike Domin and Mary Gattis of the Lancaster County Planning Commission; John Hershey of Thomas Comitta Associates (West Chester, Pa.); Chris Peiffer, Ashley Rebert, and Lori Yeich of DCNR; Rob Ruth of the City of Lancaster Department of Public Works; Fritz Schroeder and Danene Sorace of LIVE Green (Lancaster); and J. Richard Gray, mayor of the City of Lancaster.

Estimating green infrastructure benefits

The City of Lancaster, Pa., developed a green infrastructure calculator to evaluate the potential stormwater benefits and costs associated with green infrastructure implementation in the study area at two implementation levels: approximately a 5-year period and a 25-year period. Major inputs to the calculator included impervious area by type, implementation levels (by percentage managed), capture volume, annual rainfall, annual impervious runoff coefficients, average redevelopment rate, green infrastructure loading ratios, unit green infrastructure costs (total and marginal), and typical event mean concentrations for stormwater and combined sewer overflow (CSO) discharges (see Table A, below).

Table A. Green infrastructure calculator inputs

Area/impervious source	Impervious/ contributing area (ac)	Approx. percent imperv.	Green infrastructure project/program type	Assumed percent of impervious area managed	Impervious area managed (ac)	Assumed BMP capture volume (in.)
Roads/alleys	529	100%	Green streets	2.5%	13.2	1.0
Parks	241	8%	Park improvements/greening	20%	4.0	1.0
Sidewalks	124	100%	Disconnection, porous pavement	2.5%	3.1	1.0
Parking lots	648	100%	Porous pavement, bioretention	1%	6.5	2.0
Flat roofs	218	100%	Vegetated roofs/disconnection	1%	2.2	1.0
Sloping roofs	654	100%	Disconnection/rain gardens	2.5%	16.4	1.0
Street trees	N/A	N/A	Enhanced tree planting	N/A	9.0	0.3
Public schools	175	29%	Green schools	10%	5.1	1.0
Various (ordinance)	1615	100%	First-flush ordinance	10%	161.5	1.0

BMP = best management practices.
N/A = not applicable.

Some of the outputs generated by the green infrastructure calculator included total annual stormwater runoff by impervious area type, annual stormwater runoff reduction by green infrastructure type, benefit/marginal cost ratio by green infrastructure type, and estimated pollutant removals from stormwater/CSO reductions, as well as total pollutant reductions.

A summary of results from the calculator for both the approximately 5-year and 25-year implementation periods is included in Table B (below). The calculator estimates that the 25-year implementation of green infrastructure can reduce the average annual storm runoff in the study area by more than 3.79 billion L/yr (1 billon gal/yr), total suspended solids by 660,895 kg/yr (1.457 million lb/yr), phosphorus by almost 13,608 kg/yr (30,000 lb/yr), and nitrogen by more than 27,216 kg/yr (60,000 lb/yr).

The total implementation cost of this program for the city in 2010 dollars is estimated at $141 million, although the marginal/increased cost of incorporating green infrastructure as part of other projects is estimated to be $77 million. Perhaps most importantly, the estimated cumulative total cost of CSO reduction ($0.05/L [$0.18/gal]) is competitive with the preliminary cost of a large storage tank in the north basin ($0.06/L [$0.23/gal]). Furthermore, the estimated cumulative marginal cost for green infrastructure, ($0.03/L [$0.10/gal]) is significantly less than the preliminary cost of gray infrastructure.

Table B. Green infrastructure calculator outputs for 5-year and 25-year terms

Parameter	5-year implementation	Long-term implementation
Impervious area managed by green infrastructure (ac)	221	1265
Average annual runoff reduction (million gal/yr)	182	1053
Average annual total suspended solids reduction (lb/yr)	252,000	1,457,000
Average annual total phosphorus reduction (lb/yr)	4800	27,800
Average annual total nitrogen reduction (lb/yr)	10,700	61,600
Total marginal cost	$7,800,000	$77,000,000
Total capital/implementation cost	$14,000,000	$141,000,000
Marginal cost per gallon CSO reduction ($/gal)	$0.06	$0.10
Total cost per gallon CSO reduction ($/gal)	$0.10	$0.18

CSO = combined sewer overflow.