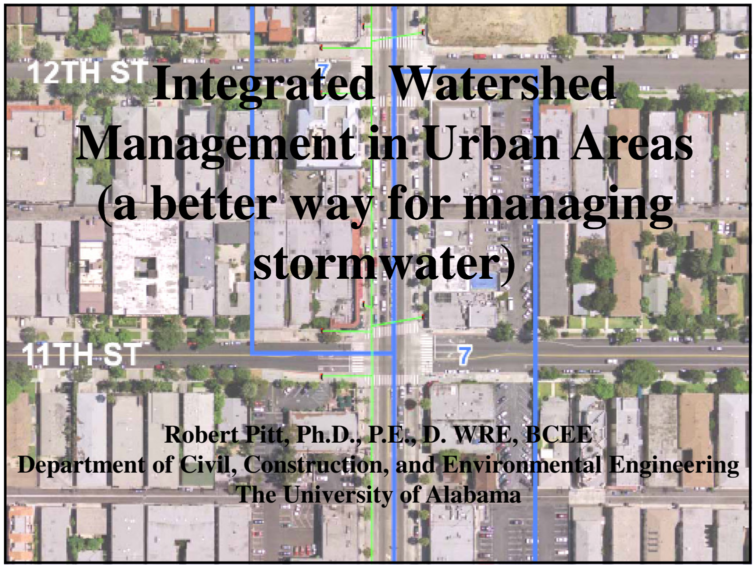


Integrated Watershed Management in Urban Areas (a better way for managing stormwater)

Robert Pitt, Ph.D., P.E., D. WRE, BCEE
Department of Civil, Construction, and Environmental Engineering
The University of Alabama

Presentation Topics

- Historical background of drainage issues
- Need for integration of urban water elements
- Problems that must be overcome
- Emerging approaches and new opportunities

Ancient springs at Delphi, Greece (site of Oracle) (bronze age center of the universe) – water has always been central to our culture

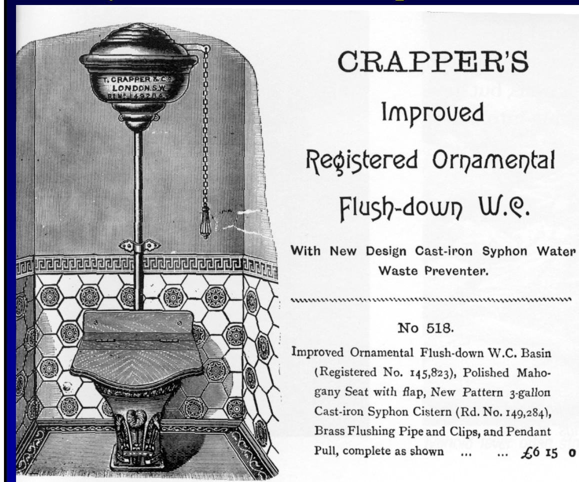
One Early Method of Getting Rid of Wastewater

Wastewater treatment has only been around since the late 1800s. People dumped wastes into gutters, ditches, and out open windows. People started wearing hats at this time….

"Tout-a-la-rue" (all in the streets), with the expectation that dogs, pigs, and rain would effectively remove wastes. This was the waste disposal policy in most western cities until the late 1800s.

"Sewer" is from the old English for "seaward."

Early Flush Toilet Vast Improvement in Sanitation



More people were able to have a flush toilet, not just the rich. The first US wastewater treatment plant was built in NYC in 1886 to protect Coney Island beaches from vast increases in wastewater volume.

Coney Island, NY, summer 1940 by Weegee

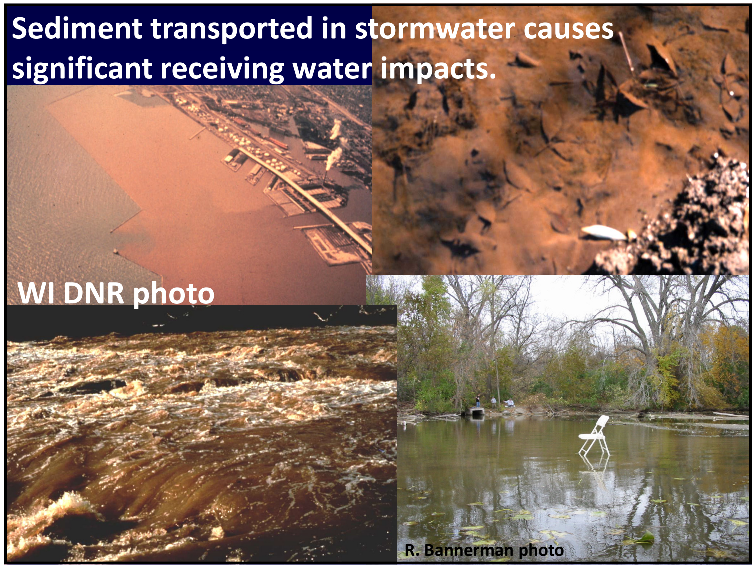
Celebrating 120 years of clean beaches??

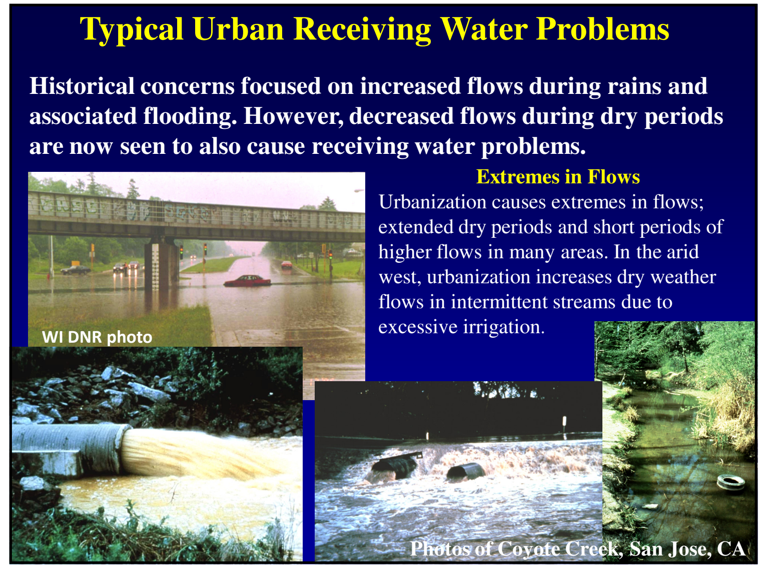
Major Receiving Water Beneficial Uses

- Stormwater Conveyance (flood prevention)
- Recreation (non-water contact) Uses
- Biological Uses (Warm water fishery, aquatic life use, biological integrity, etc.)
- Human Health Related Uses (Swimming, Fishing, and Water Supply)

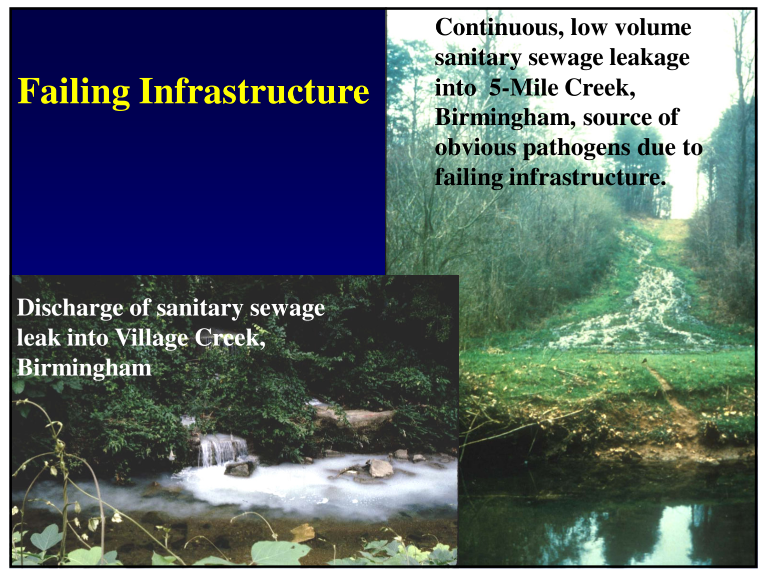
Receiving Water Effects of Stormwater Pollutant Discharges

- Sediment (amount and quality)
- Habitat destruction (mostly through high flows [energy] and sedimentation)
- Eutrophication (nutrient enrichment)
- Low dissolved oxygen (from organic materials)
- Pathogens (mostly from municipal wastewater and agricultural runoff)
- Toxicants (heavy metals and organic toxicants)
- Temperature
- Debris and unsafe conditions
- etc.


Sediment transported in stormwater causes significant receiving water impacts.
WI DNR photo
R. Bannerman photo


Typical Urban Receiving Water Problems
Historical concerns focused on increased flows during rains and associated flooding. However, decreased flows during dry periods are now seen to also cause receiving water problems.
Extremes in Flows
Urbanization causes extremes in flows; extended dry periods and short periods of higher flows in many areas. In the arid west, urbanization increases dry weather flows in intermittent streams due to excessive irrigation.
WI DNR photo
Photos of Coyote Creek, San Jose, CA


Failing Infrastructure
WI DNR photos
Bank instability and habitat destruction due to increased flows

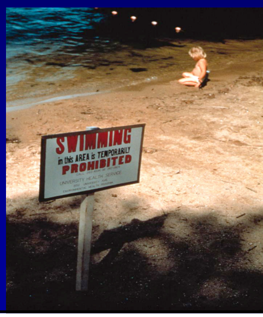

Failing Infrastructure
Continuous, low volume sanitary sewage leakage into 5-Mile Creek, Birmingham, source of obvious pathogens due to failing infrastructure.
Discharge of sanitary sewage leak into Village Creek, Birmingham

Urban Wildlife and Sewage Contamination

Potential health effects due to exposure to pathogens in urban receiving waters.

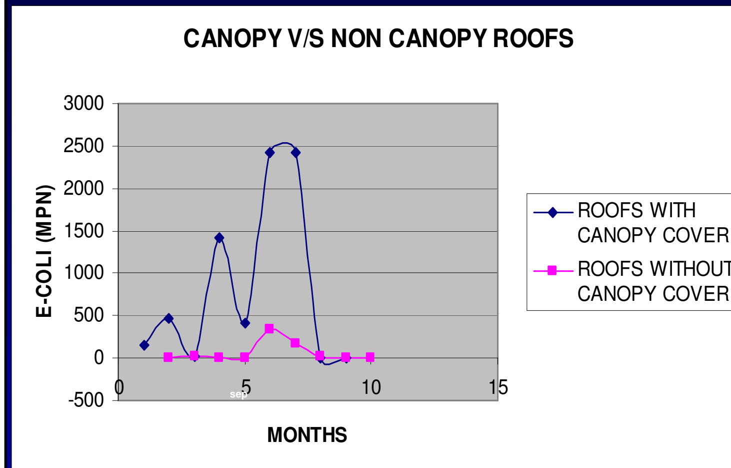
However, kids still play in urban creeks and swim near outfalls

WI DNR photo



Navasink River, NJ, public swimming beach adjacent to CSO discharge and public works yard.

Sewage only source of urban water bacteria?



Canopy is tree overstory and habitat for birds and squirrels

Transportation Accidents

Alabama has about 200 transportation accidents every year involving hazardous materials. This is a typical amount for many states. Many of these accidents affect the stormwater drainage system.

Birmingham News (Alabama)

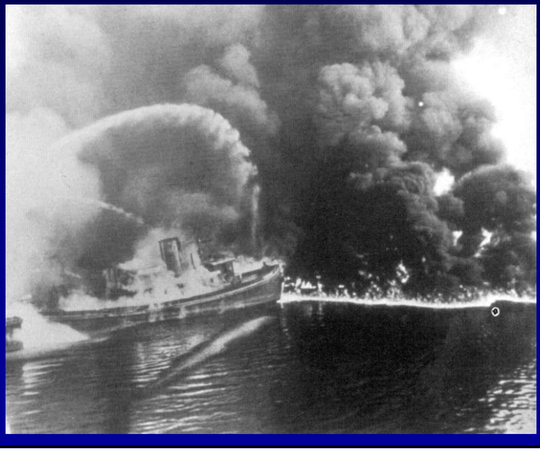
Fire from 200,000 gallons of spilled gasoline into an urban creek, Bellingham, Washington, 2000.

Bellingham News photos

Early Regulations

- The Refuse Act of 1899 (33 USC 407) was used in 1970 to establish a discharge permit system (Public Law 92-500). This act prohibited the discharge of any material, except sewage and runoff, into navigable waterways without a permit from the Dept. of the Army.

Cuyahoga River in Cleveland often Caught on Fire Between 1952 and 1969 (this embarrassment lead to the passage of the 1972 Clean Water Act)



Amendments to the Water Pollution Control Act (92-500)

- 1956 (making the legislation permanent and to fund construction grants for POTWs),
- 1961 (increased funding for water quality research and construction grants),
- 1965 (increased construction grants and started research concerning combined sewer overflows),
- 1966 (removed the dollar limit on construction grants),
- 1972 (the most important advances to this date; act renamed "Clean Water Act"),
- 1977 (to extend some of the deadlines established in the 1972 amendments), and
- 1988 (to require discharge permits for stormwater).

Goals of PL 92-500

- The NPDES was to enable Congress' goal of no pollutant discharges whatsoever by 1985.
- Other goals of PL 92-500 included the protection and propagation of fish, shellfish, and wildlife and recreational uses of water by July 1983,
- to prohibit the discharge of toxic pollutants, to continue the funding of POTWs, to develop areawide wastewater treatment management plans, to fund a major resource and demonstration effort to improve treatment technology, and to protect the rights of the States to reduce pollution and to plan their water resources uses.

TMDL Regulations

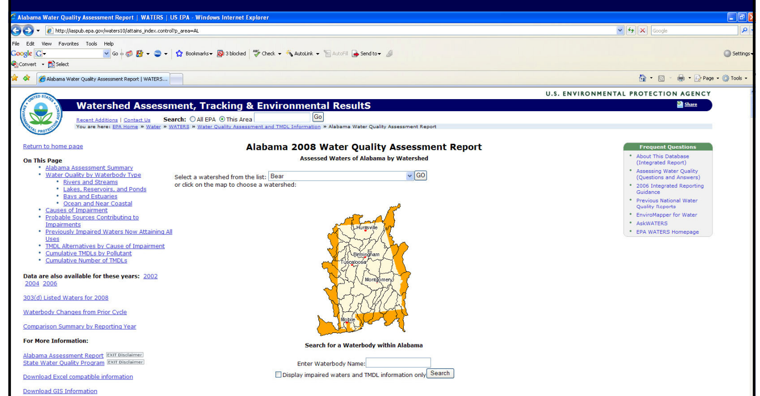
- Another important regulation affecting drainage and stormwater quality is the TMDL program.
- The TMDL program is aimed specifically at assuring attainment of water quality standards by requiring the establishment of pollutant loading targets and allocations for waters identified as not now in attainment with those standards.
- Section 303(d)(1) of the Clean Water Act provides that states, with EPA review and approval, must identify waters not meeting standards, and must establish total maximum daily loads (TMDLs) for them to restore water quality.

- In general, a TMDL is a quantitative assessment of water quality problems, contributing sources, and pollution reductions needed to attain water quality standards.
- The TMDL specifies the amount of pollution or other stressor that need to be reduced to meet water quality standards, allocates pollution control, or management responsibilities among sources in a watershed, and provides a scientific and policy basis for taking actions needed to restore a waterbody.

- Beginning in 1986, and escalating since 1996, environmental public interest organizations have filed numerous lawsuits under the Clean Water Act’s citizen suit provision (section 505) alleging that the EPA had failed to carry out its mandatory duty to disapprove inadequate state section 303(d)(1) lists and/or TMDLs, or to carry out state program responsibilities where states have failed to do so.

Example Alabama 2008 TMDL Status

http://iaspub.epa.gov/waters10/attains_index.control?p_area=AL



Alabama Assessment Summary for Reporting Year 2008

Description of this table

	Size of Water			
	Rivers and Streams (Miles)	Lakes, Reservoirs, and Ponds (Acres)	Bays and Estuaries (Square Miles)	Ocean and Near Coastal (Square Miles)
Good Waters	7,658.1	337,689.9	78.7	
Previously impaired waters now attaining all uses				
Threatened Waters				
TMDL completed				
TMDL alternative				
Non-pollutant impairment				
TMDL needed				
Impaired Waters	2,567.9	91,911.9	426.8	201.0
TMDL completed	746.0	28,886.7		
TMDL alternative	4.3			
Non-pollutant impairment	22.8			
TMDL needed	1,794.8	63,025.2	426.8	201.0
New TMDLs completed	.0	.0	.0	.0
Remaining TMDLs needed	1,794.8	63,025.2	426.8	201.0
Total Assessed Waters	10,226.0	429,601.8	505.5	201.0
Total Waters	77,242.0	490,472.0	610.0	Unavailable
Percent of Waters Assessed	13.2	87.6	82.9	Unavailable

Alabama Assessed Waters
Designated Use Support for Rivers and Streams
Reporting Year 2008*

* Waters assessed for more than one designated use are included in multiple designated use groups below.

Description of this table

Designated Use	Miles Assessed	Percent Good	Percent Threatened	Percent Impaired	% Good / % Threatened / % Impaired
Contact Recreation	7,040.3	85.0	.0	15.0	
Drinking And Food Processing	758.9	96.7	.0	3.3	
Fishing	10,200.7	77.4	.0	22.6	
Industrial And Agriculture Uses	10,217.0	95.7	.0	4.3	
Outstanding Alabama Water	270.1	67.1	.0	32.9	
Propagation Of Fish And Wildlife	7,028.1	73.9	.0	26.1	

Alabama Causes of Impairment
for Threatened and Impaired Rivers and Streams
Reporting Year 2008

Description of this table

Cause of Impairment	Cause of Impairment Group	Miles Threatened or Impaired
Sedimentation/Siltation	Sediment	947.9
Fecal Coliform	Pathogens	806.4
BOD, Carbonaceous	Organic Enrichment/Oxygen Depletion	805.3
Phosphorus, Total	Nutrients	579.1
Nitrogenous BOD	Organic Enrichment/Oxygen Depletion	573.0
Mercury	Mercury	494.9
Nitrogen, Total	Nutrients	186.2
Ammonia, Total	Ammonia	185.5
Iron	Metals (other than Mercury)	118.2
Turbidity	Turbidity	110.5
Aluminum	Metals (other than Mercury)	72.4
Zinc	Metals (other than Mercury)	61.7
Cyanide	Toxic Inorganics	57.0
pH	pH/Acidity/Caustic Conditions	56.0
Endosulfan	Pesticides	50.7
Methyl Parathion	Pesticides	50.7
Benzo[a]pyrene (PAHs)	Toxic Organics	44.6
Polychlorinated Biphenyls (PCBs)	Polychlorinated Biphenyls (PCBs)	42.2
Whole Effluent Toxicity (WET)	Total Toxics	41.1
Cause Unknown	Cause Unknown	36.8
Lead	Metals (other than Mercury)	31.0
Chromium, Trivalent	Metals (other than Mercury)	29.2
Dieldrin	Pesticides	24.3

Alabama Probable Sources of Impairments
for Threatened and Impaired Rivers and Streams
Reporting Year 2008

Description of this table

Probable Source	Probable Source Group	Miles Threatened or Impaired
Livestock (Grazing Or Feeding Operations)	Agriculture	594.6
Urban Runoff/Storm Sewers	Urban-Related Runoff/Stormwater	575.6
Source Unknown	Unknown	528.0
Agriculture	Agriculture	424.0
Municipal Point Source Discharges	Municipal Dishcarges/Sewage	344.3
Impacts From Abandoned Mine Lands (Inactive)	Resource Extraction	311.0
Non-Irrigated Crop Production	Agriculture	302.8
Site Clearance (Land Development Or Redevelopment)	Construction	297.0
Animal Feeding Operations (Nps)	Agriculture	232.3
Industrial Point Source Discharge	Industrial	189.3
Surface Mining	Resource Extraction	114.7
Sanitary Sewer Overflows (Collection System Failures)	Municipal Dishcarges/Sewage	110.6
Atmospheric Deposition - Toxics	Atmospheric Deposition	100.8
Contaminated Sediments	Legacy/Historical Pollutants	65.2
Highways, Roads, Bridges, Infrastructure (New Construction)	Construction	56.4
Habitat Modification - Other Than Hydromodification	Habitat Alterations (Not Directly Related To Hydromodification)	56.4
Loss Of Riparian Habitat	Habitat Alterations (Not Directly Related To Hydromodification)	56.4
Landfills	Land Application/Waste Sites/Tanks	44.8
Impacts From Hydrostructure Flow Regulation/Modification	Hydromodification	31.2
On-Site Treatment Systems (Septic Systems And Similar Decentralized Systems)	Municipal Dishcarges/Sewage	29.3
Mill Tailings	Industrial	17.5
Mine Tailings	Resource Extraction	17.5

Alabama Causes of Impairment for Reporting Year 2008

Description of this table

NOTE: Click on the underlined Cause of Impairment Group to see a list of specific state causes of impairment making up the Cause of Impairment Group.

Cause of Impairment Group	Size of Assessed Waters with Listed Causes of Impairment			
	Rivers and Streams (Miles)	Lakes, Reservoirs, and Ponds (Acres)	Bays and Estuaries (Square Miles)	Ocean and Near Coastal (Square Miles)
Ammonia	185.5			
Cause Unknown	36.8			
Flow Alteration(s)	3.2			
Mercury	494.9	8,794.3		201.0
Metals (other than Mercury)	233.4			
Nutrients	579.1	75,314.0		
Organic Enrichment/Oxygen Depletion	824.9	46,353.5		
Pathogens	806.4		426.8	
Pesticides	95.8	85.7		
pH/Acidity/Caustic Conditions	56.0	12,702.5		
Polychlorinated Biphenyls (PCBs)	42.2	57,715.1		
Salinity/Total Dissolved Solids/Chlorides/Sulfates	.2			
Sediment	947.9	2,840.5		
Total Toxics	41.1			
Toxic Inorganics	57.0			
Toxic Organics	44.6			
Turbidity	110.5			

Alabama Probable Sources Contributing to Impairments for Reporting Year 2008

Description of this table

NOTE: Click on the underlined Probable Source Group to see a list of specific state Probable Sources making up the Probable Source Group.

Probable Source Group	Size of Assessed Waters with Probable Sources of Impairments			
	Rivers and Streams (Miles)	Lakes, Reservoirs, and Ponds (Acres)	Bays and Estuaries (Square Miles)	Ocean and Near Coastal (Square Miles)
Agriculture	1,123.1	4,728.2		
Atmospheric Deposition	100.8	6,592.5		
Construction	297.0			
Habitat Alterations (Not Directly Related To Hydromodification)	56.4			
Hydromodification	31.2	58,712.6		
Industrial	194.2	12,276.8		
Land Application/Waste Sites/Tanks	44.8			
Legacy/Historical Pollutants	69.0	32,281.9		
Municipal Dishcarges/Sewage	448.8	12,276.8	157.6	
Natural/Wildlife	17.0			
Other		50,019.3		
Resource Extraction	425.7	412.5		
Spills/Dumping		412.5		
Unknown	528.0	3,551.2	1.0	201.0
Urban-Related Runoff/Stormwater	575.6	22,499.2	376.3	

Alabama Causes of Impairment for 303(d) Listed Waters

Description of this table

NOTE: Click on a cause of impairment (e.g. pathogens) to see the specific state-reported causes that are grouped to make up this category. Click on the "Number of Causes of Impairment Reported" to see a list of waters with that cause of impairment.

Cause of Impairment Group Name	Number of Causes of Impairment Reported
Organic Enrichment/Oxygen Depletion	76
Sediment	54
Pathogens	50
Mercury	46
Nutrients	44
Metals (other than Mercury)	24
pH/Acidity/Caustic Conditions	12
Polychlorinated Biphenyls (PCBs)	10
Pesticides	7
Ammonia	6
Total Toxics	6
Turbidity	2
Cause Unknown	2
Toxic Inorganics	1
Salinity/Total Dissolved Solids/Chlorides/Sulfates	1

Total: 341 Causes of Impairment

Alabama Cumulative Number of TMDLs

EPA Fiscal Year starts October 1 and ends September 30.

Description of this table

NOTE: Click on the underlined "Number of TMDLs Completed" value for a detailed list of the TMDLs for the fiscal year.

Fiscal Year	Number of TMDLs	Number of Causes of Impairment Addressed
1997	20	22
2003	114	117
2004	26	26
2005	39	42
2006	4	4
2007	24	24
2008	10	11
2009	13	27

Total: 250 TMDLs; 273 Causes of Impairment Addressed

List of TMDLs | WATERS | US EPA - Windows Internet Explorer

http://iaspub.epa.gov/waters10/attains_impaired_waters.tmdls?p_state=AL&p_fiscal_year=2009

U.S. ENVIRONMENTAL PROTECTION AGENCY

Watershed Assessment, Tracking & Environmental ResultS

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You are here: EPA Home » Water » WATERS » Water Quality Assessment and TMDL Information » List of TMDLs

Alabama TMDLs, EPA Fiscal Year 2009

Description of this table

NOTE: Click on the underlined TMDL Document Name to see a detailed TMDL report. Click on an underlined Number of Listed Waters to see applicable listed waters for the TMDL. EPA is in the process of collecting TMDL information from the states. Because these efforts are on-going, there may be additional approved TMDLs that were not included in the listings below.

State	TMDL Document Name	TMDL Date	EPA Action	TMDL Pollutant	Number of Listed Waters
AL	Final Development Of Nutrients, Ph And Organic Enrichment/Low Dissolved Oxygen Tmdls, Coosa Lakes (Lake Neely Henry, Logan Martin Lake, Lay Lake, Lake Mitchell)	Oct-28-2008	EPA Approved	Phosphorus, Total	12
AL	Final Development Of Organic Enrichment/Low Dissolved Oxygen Tmdl, Tombigbee River (Aliceville Reservoir)	Oct-27-2008	EPA Established	Carbonaceous Bod	1

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Last updated on Tuesday, August 25th, 2009.
http://iaspub.epa.gov/waters10/attains_impaired_waters.tmdls?p_state=AL&p_fiscal_year=2009
Print As-Is

TMDL Report | WATERS | US EPA - Windows Internet Explorer

http://iaspub.epa.gov/waters10/attains_impaired_waters.tmdl_report?p_tmdl_id=11567&p_tribe=

U.S. ENVIRONMENTAL PROTECTION AGENCY

Watershed Assessment, Tracking & Environmental ResultS

You are here: EPA Home » Water » WATERS » Water Quality Assessment and TMDL Information » TMDL Report

TMDL Document for Final Development Of Nutrients, Ph And Organic Enrichment/Low Dissolved Oxygen Tmdls, Coosa Lakes (Lake Neely Henry, Logan Martin Lake, Lay Lake, Lake Mitchell)

TMDL ID: 11567 **TMDL Name:** Final Development Of Nutrients, Ph And Organic Enrichment/Low Dissolved Oxygen Tmdls, Coosa Lakes (Lake Neely Henry, Logan Martin Lake, Lay Lake, Lake Mitchell)
State/Tribe: Alabama **TMDL Date:** 10/28/2008
EPA Action: EPA Approved **Comments:** A TMDL WAS PROPOSED ON 10-31-2003. DUE TO SIGNIFICANT COMMENT, THE TMDL WAS REVISED AND RE-PROPOSED ON 8-29-2008

TMDL Documents

Click on the underlined Document Type to retrieve the actual document in PDF format.

Document Type	Comments
TMDL Document	

TMDL Pollutant: Phosphorus, Total

Total Waste Load Allocation:
Total Load Allocation:
Explicit Margin Of Safety:
Implicit Margin Of Safety: Y
Units for Total Waste Load Allocation, Total Load Allocation, and Margin of Safety:
TMDL Pollutant Source Type: Point/Nonpoint Source
TMDL End Point: Narrative Criteria For Nutrients. (Target Mean Chlorophyll A Concentration Of 20 Ug/L During Growing Season) Ph-Cannot Be Greater Than 8.5 Standard Units Or Less Than 6.0 Standard Units Oe/Do-A Daily Average Dissolved Oxygen Concentration Standard Of 5 Mg/L And No Less Than 4 Mg/L At All Times.

NPDES Allocation for Pollutant: Phosphorus, Total			
NPDES ID	Other Non PCS Identification	Waste Load Allocation	Units
AL0053201			
AL0003158			
AL0003140			
AL0053201			
AL0022659			
AL0002887			

Listed Water Causes of Impairment for Phosphorus, Total

FINAL

Total Maximum Daily Load (TMDL)

For
Organic Enrichment & Dissolved Oxygen

Tombigbee River (Aliceville Reservoir) AL/03160106-0402-102

Pickens County, Alabama

Prepared by:

US EPA Region 4
61 Forsyth Street SW
Atlanta, Georgia 30303

October 2008

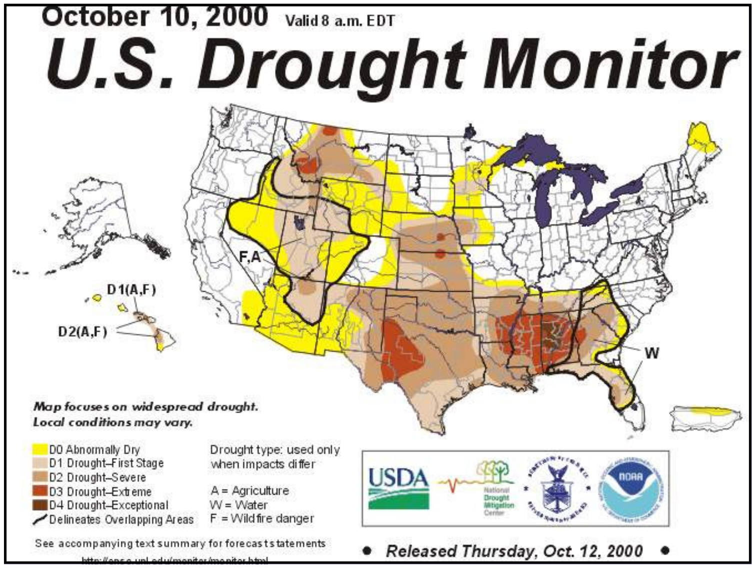
Tombigbee River (Aliceville Reservoir) FINAL – Organic Enrichment/Dissolved Oxygen

Table of Contents

Prepared by US Environmental Protection Agency, Region 4. ii

Tombigbee River (Aliceville Reservoir) FINAL – Organic Enrichment/Dissolved Oxygen

Prepared by US Environmental Protection Agency, Region 4. iii



Stormwater can be a Resource

Ponds and cisterns used for stormwater storage for irrigation and other beneficial uses. Many areas use roof runoff for all domestic needs.

Auckland, New Zealand

Much of the domestic water needs can be met with waters of impaired quality (30% of in-home use, plus most of outside irrigation uses and fire-fighting use).

Rain water tank to capture roof runoff for reuse (winery in Heathcote, Australia)

Tankage volume for 4,000 ft^2 roof (ft^3), Birmingham, AL	Fraction of annual roof runoff used for irrigation
1,000	56%
2,000	56
4,000	74
8,000	90
16,000	98

Cistern tank, Kamiros, Rhodes (ancient Greece, 7th century BC)

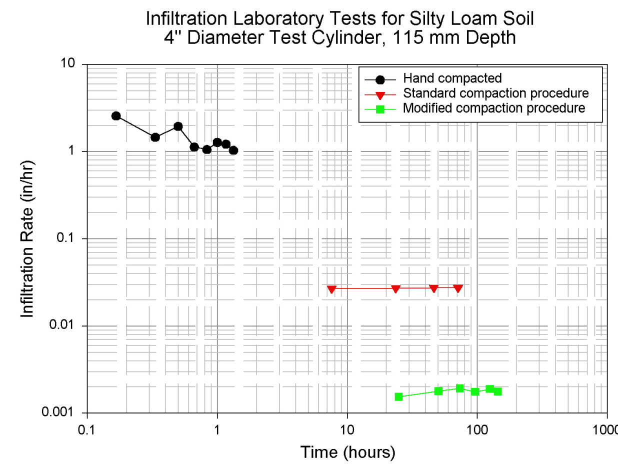
Combinations of Infiltration Controls to Reduce Runoff Volume

3.6 acre new residential area on Birmingham Southern College campus	Total Annual Runoff (ft^3/year)	Increase Compared to Undeveloped Conditions
Undeveloped	46,000	--
Conventional development	380,000	8.3X
Grass swales and walkway porous pavers	260,000	5.7
Grass swales and walkway porous pavers, plus roof runoff disconnections	170,000	3.7
Grass swales and walkway porous pavers, plus bioretention for roof and parking area runoff	66,000	1.4

Stormwater Discharges to Groundwater

Moderate to High Groundwater Contamination Potential Associated with Stormwater Infiltration (Example Conditions)

Injection after Minimal Pretreatment	Surface Infiltration with no Pretreatment	Surface Infiltration after Sedimentation Treatment
Lindane, chlordane	Lindane, chlordane	
1,3-dichlorobenzene, benzo (a) anthracene, bis (2-ethylhexl phthalate), **fluoranthene**, pentachlorophenol, phenanthrene, **pyrene**	Benzo (a) anthracene, bis (2-ethylhexl phthalate), fluoranthene, pentachlorophenol, phenanthrene, pyrene	Fluoranthene, pyrene
Enteroviruses, some bacteria and protozoa	**Enteroviruses**	**Enteroviruses**
Nickel, chromium, lead, **zinc**		
Chloride	**Chloride**	**Chloride**



However, infiltration severely limited by compaction and clogging of typical disturbed urban soils

Soil modifications for rain gardens and other biofiltration areas can significantly increase treatment and infiltration capacity compared to native soils, plus provide substantial evapotranspiration losses.

(King County, Washington, test plots)

High Zinc Concentrations have been Found in Roof Runoff for Many Years at Many Locations

- Typical Zn in stormwater is about 100 µg/L, with industrial area runoff usually several times this level.
- Water quality criteria for Zn is as low as 100 µg/L for aquatic life protection in soft waters, up to about 5 mg/L for drinking waters.
- Zinc in runoff from galvanized roofs can be several mg/L

Penn State – Harrisburg test site

- Other pollutants and other materials also of potential concern.
- A cost-effective stormwater control strategy should include the use of materials that have reduced effects on runoff degradation.

"Design" Storms for Stormwater Control not Obvious

- Large storms traditionally used for drainage design have several problems when applied to stormwater quality management:
  - a few events cannot adequately represent the wide range of problems that are associated with stormwater quality.
  - large design storms represent a very small fraction of annual discharge.

- Some stormwater controls need to be initially sized according to runoff volumes (e.g. wet detention ponds), while others need to be initially sized according to runoff flow rates (e.g. filters).
- However, continuous simulations are needed to verify performance under the wide range of conditions that can occur, especially as a number of complementary stormwater controls must be used together in most areas as a treatment train.

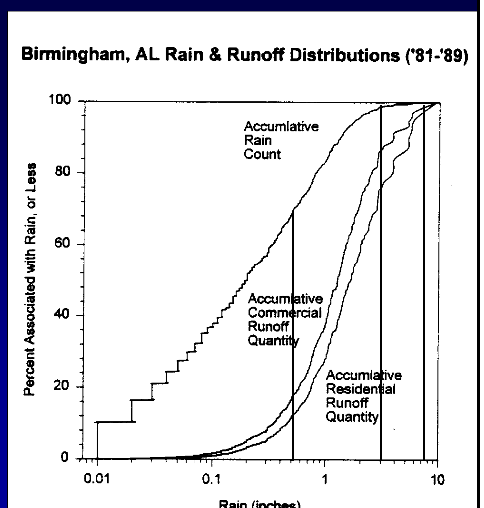
Probability distribution of typical Alabama rains (by count) and runoff (by depth).

<0.5": 65% of rains (10% of runoff)

0.5 to 3": 30% of rains (75% of runoff)

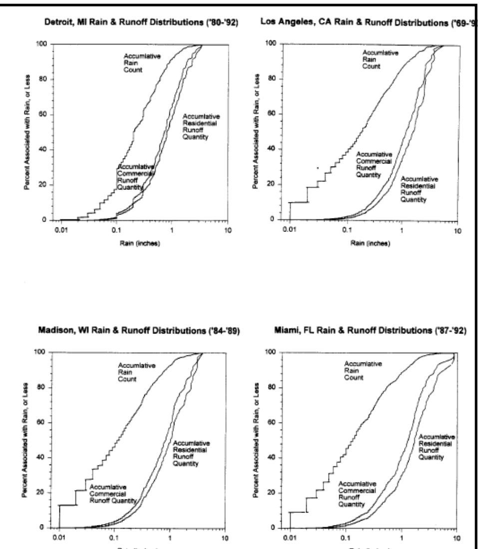
3 to 8": 4% of rains (13% of runoff)

>8": <0.1% or rains (2% or runoff)

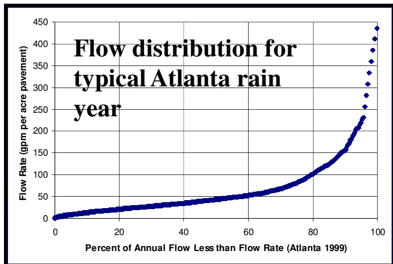


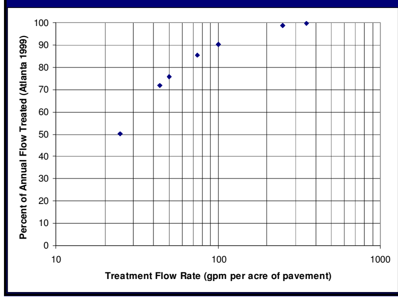
EPA report on wet weather flows, Pitt, *et al.* 1999

Same pattern in other parts of the country, just shifted.



Pitt, *et al.* (1999)





Continuous Simulation can be used to Determine Needed Treatment Flow Rates:

- 90% of the annual flow for SE US conditions is at about 170 gpm/acre pavement (max about 450).

- treatment of 90% of annual runoff volume would require treatment rate of about 100 gpm/acre of pavement. More than three times the treatment flow rate needed for NW US.

Basic Goals for Urban Streams (my opinion!)

- Stormwater conveyance and aesthetics should be the basic beneficial use goals for all urban waters.
- Biological integrity should also be a goal, but with the realization that the natural stream ecosystem will be severely modified with urbanization.
  - "Biological integrity is the capacity to support and maintain a balanced, integrated and adaptive biological system having the full range of elements [the form] and process [the function] expected in a region's habitat." James Karr 1991, modified

- Certain basic stormwater controls at the time of development, plus protection of stream habitat, may enable partial use of some of these goals in urbanized watersheds.
- Water contact recreation, consumptive fisheries, and water supplies are not appropriate goals for most heavily urbanized watersheds.
- **The water quality standards which are the basis for the Clean Water Act and TMDLs are not well related to the most significant problems observed in urban receiving waters (habitat destruction/infrastructure damage and contaminated sediment)!!**

Conservation Design Approach for New Development

- Better site planning to maximize resources of site (natural drainageways, soils, open areas, etc.)
- Emphasize water conservation and water reuse on site
- Encourage infiltration of runoff at site (after proper treatment)
- Treat water at critical source areas
- Treat and manage runoff that cannot be infiltrated at site

Design Issues (<0.5 inches)

- Most of the events (numbers of rain storms)
- Little of annual runoff volume
- Little of annual pollutant mass discharges
- Probably few receiving water effects
- Problem:
  - pollutant concentrations likely exceed regulatory limits (especially for bacteria and total recoverable heavy metals) for each event

Suitable Controls for Almost Complete Elimination of Runoff Associated with Small Rains (<0.5 in.)

- **Disconnect roofs and pavement from impervious drainages**
- **Grass swales**
- **Permeable pavement walkways**
- **Rain barrels and cisterns**

Disconnect impervious areas

Milwaukee, WI, examples from the early 1980s during watershed planning efforts

Street and catchbasin cleaning, and inlet controls most effective for smaller rains in heavily paved areas.

Street cleaner outside of the Palace of the Engineers, Moscow, Russia

Design Issues (0.5 to 3 inches)

- Majority of annual runoff volume and pollutant discharges
- Occur approximately once a week
- Problems:
    - Produce moderate to high flows
    - Produce frequent high pollutant loadings

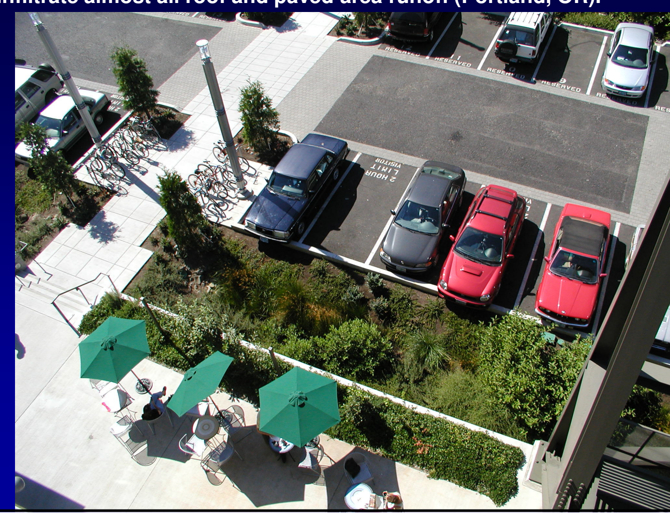
Suitable Controls for Treatment of Runoff from Intermediate-Sized Rains (0.5 to 3 in.)

- **Initial portion will be captured/infiltrated by on-site controls or grass swales**
- **Remaining portion of runoff in this rain category should be treated to remove particulate-bound pollutants**

Rain Gardens can be Designed for Complete Infiltration of Roof Runoff

Madison, WI

Bioretention areas can be located between buildings and parking areas to infiltrate almost all roof and paved area runoff (Portland, OR).



Calculated Benefits of Various Roof Runoff Controls (compared to typical directly connected residential pitched roofs)

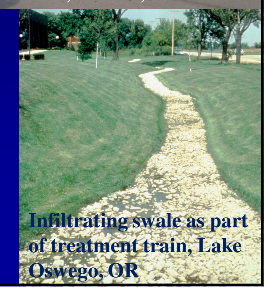
Annual roof runoff volume reductions	Birmingham, Alabama (55.5 in.)	Seattle, Wash. (33.4 in.)	Phoenix, Arizona (9.6 in.)
Cistern for reuse of runoff for toilet flushing and irrigation (10 ft. diameter x 5 ft. high)	66	67	88%
Planted green roof (but will need to irrigate during dry periods)	75	77	84%
Disconnect roof drains to loam soils	84	87	91%
Rain garden with amended soils (10 ft. x 6.5 ft.)	87	100	96%

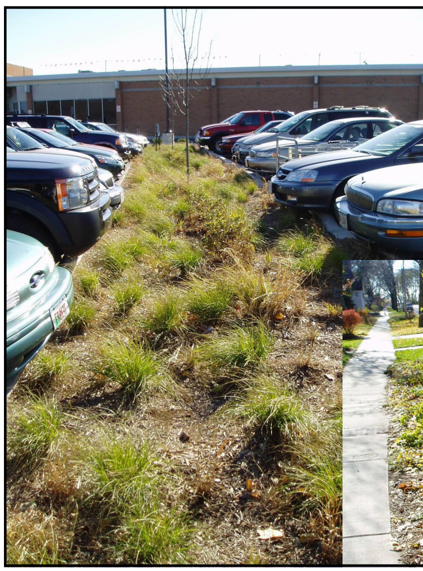
There are therefore a number of potential controls for roof runoff, from the conventional to the unusual, that can result in large runoff reductions.

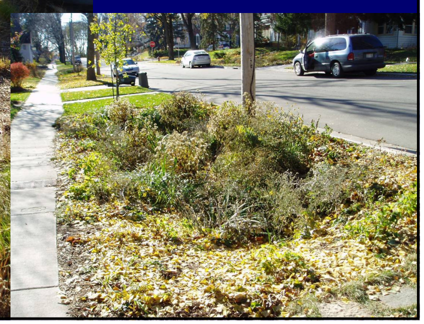
Percolation areas or ponds, biofiltration areas, and French drains can be designed for larger rains due to enhanced storage capacity.


Edison Museum, Detroit, MI


Berlin, Germany


Infiltrating swale as part of treatment train, Lake Oswego, OR





Recent Bioretention Retrofit Projects in Commercial and Residential Areas in Madison, WI

Permeable paver blocks have been used in many locations to reduce runoff to combined systems, reducing overflow frequency and volumes (Sweden, Germany, and WI).


Essen, Germany


Malmo, Sweden


Madison, WI

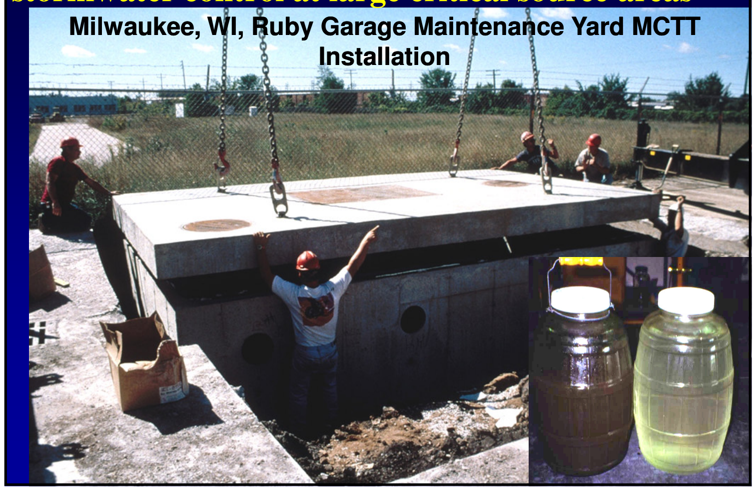
Wet detention ponds, stormwater filters, or correctly-sized critical source area controls are needed to treat runoff that cannot be infiltrated.

One of the original sand filters in Austin, TX

Pre-treatment pond before infiltrating swale, Lake Oswego, OR

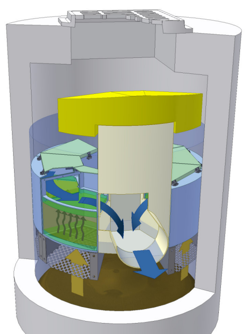
Multi-chambered treatment train (MCTT), Minocqua, WI

Multi-Chambered Treatment Train (MCTT) for stormwater control at large critical source areas



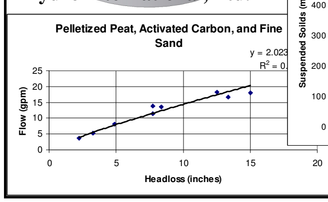
Milwaukee, WI, Ruby Garage Maintenance Yard MCTT Installation

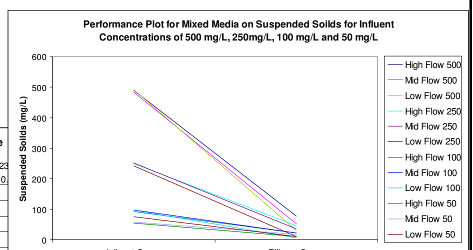
Upflow filter insert for catchbasins at smaller critical source areas



Hydro International, Ltd.

Able to remove particulates and targeted pollutants at small critical source areas. Also traps coarse material and floatables in sump and away from flow path.





Design Issues (3 to 8 inches)

- This range of rains can include drainage-design storms (depending on rain intensity and site time of concentration). Most of these storms last for one to two days. Drainage design storms of these depths would last only for a few hours.
- Establishes energy gradient of streams
- Occur approximately every few months (two to five times a year). Drainage design storms having high peak intensities occur every several years to several decades)
- Problems:
  - Unstable streambanks
  - Habitat destruction from damaging flows
  - Sanitary sewer overflows
  - Nuisance flooding and drainage problems/traffic hazards

Stormwater drainage channels in the Agora, Athens, Greece, built by Peistratus in the 6th century, BC and still working today.

Excavation of ancient Roman stormwater drainage pipes, Rome (about 100 AD)

J. Harper photo

Our approach to urban drainage can be devastating to the environment, including recharge of groundwaters

Infrequent very high flows are channel-forming and may cause severe bank erosion and infrastructure damage.

Controls for Treatment of Runoff from Drainage Events (3 to 8 in.)

- Infiltration and other on-site controls will provide some volume and peak flow control
- Treatment controls can provide additional storage for peak flow reduction
- Provide adequate stormwater drainage to prevent street and structure flooding
- Provide additional storage to reduce magnitude and frequency of runoff energy
- Capture sanitary sewage overflows for storage and treatment

Storage at treatment works may be suitable solution in areas having SSOs that cannot be controlled by fixing leaky sanitary sewerage.

Leeds, AL, wastewater treatment plant, SSO storage tank

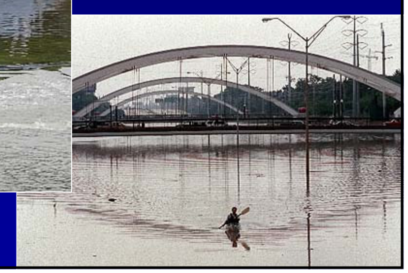
Golf courses can provide large volumes of storage.

Madison, WI

Design Issues (> 8 inches)

- Occur rarely (once every several years to once every several decades, or less frequently). Three rains were recorded that were >8 inches in the 37 years between 1952 and 1989 in Huntsville, AL.
- Produce relatively small fraction of the annual pollutant mass discharges
- Produce extremely large flows and the largest events exceed drainage system capacity (depending on rain intensity and time of concentration of drainage area)

WI DNR photo



Photos from *Houston Chronicle*.

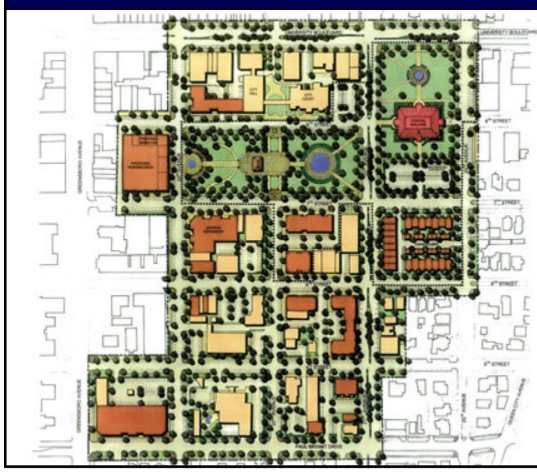
Controls for Treatment of Runoff from Very Large Events (> 8 in.)

- Provide secondary surface drainage system to carefully route excess flood waters away from structures and roadways
- Restrict development in flood-prone areas

A suitable urban watershed management plan should incorporate many of the features described above to meet the many site objectives of interest.

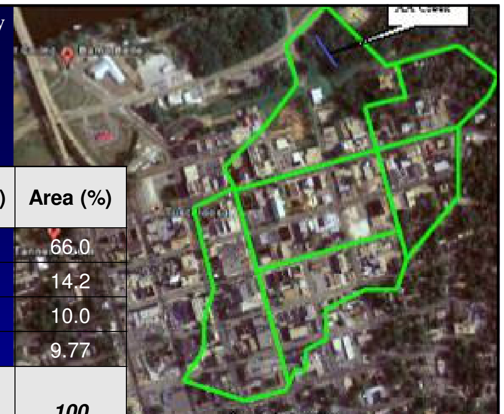
- Good site design to fit site conditions (topography and natural drainage pattern; site soils; surrounding land uses and traffic patterns, etc.)
- Pollution prevention to minimize contamination due to material exposure (roofing, for example)
- Combination of infiltration and sedimentation unit processes in large-scale treatment train
- Critical source area treatment (storage areas, loading docks, etc.)

Downtown Tuscaloosa Redevelopment



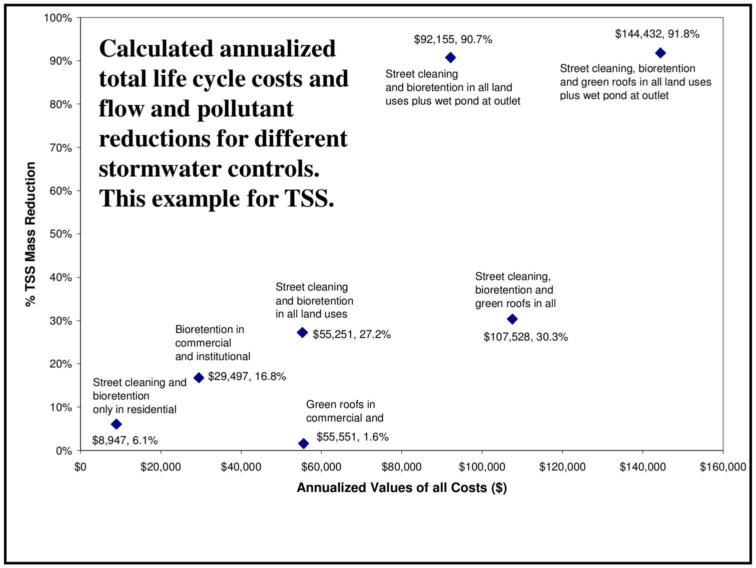
DOWNTOWN TUSCALOOSA

Conducted a preliminary evaluation of the downtown Tuscaloosa area that contains the redevelopment sites.

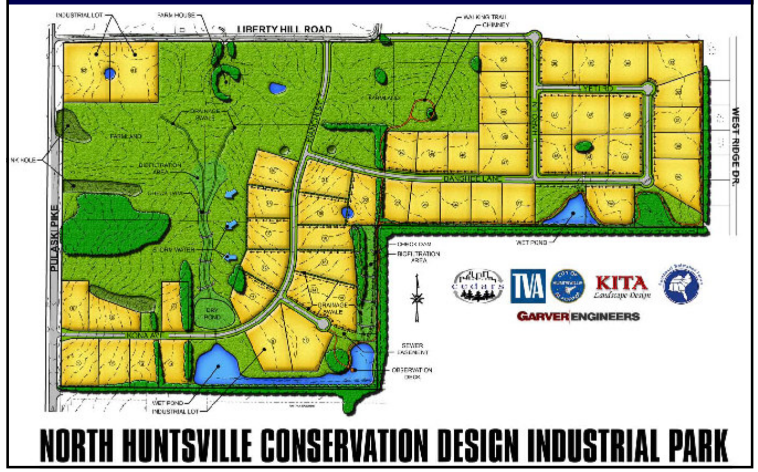


Land Use	Area (ac)	Area (%)
Commercial	72.9	66.0
Residential	15.7	14.2
Institutional	11.0	10.0
Other	10.8	9.77
TOTAL	*110*	*100*

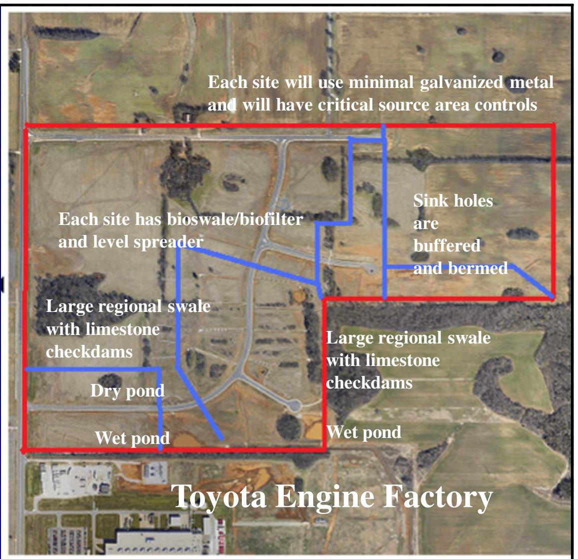
Soils are mostly hydrologic group B and are classified as silt or loam, having typical infiltration rates of about 0.5 in/hr, although most of the soils are highly disturbed and will need to be restored.

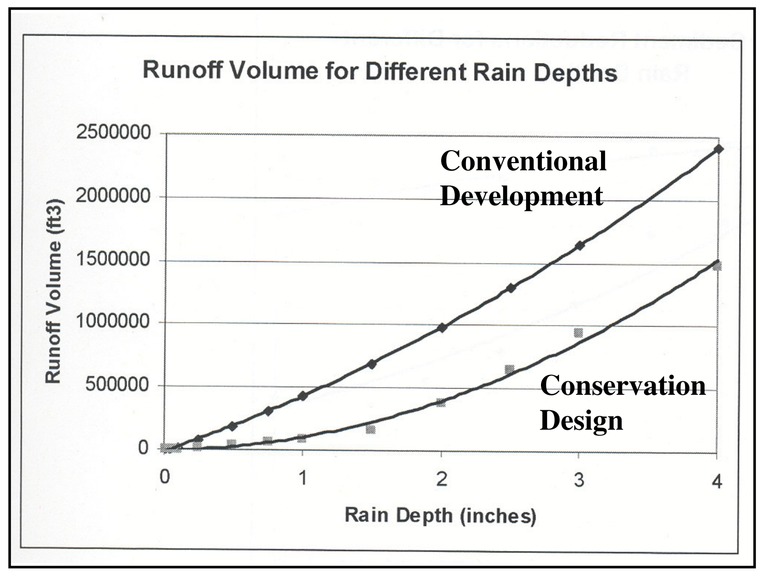


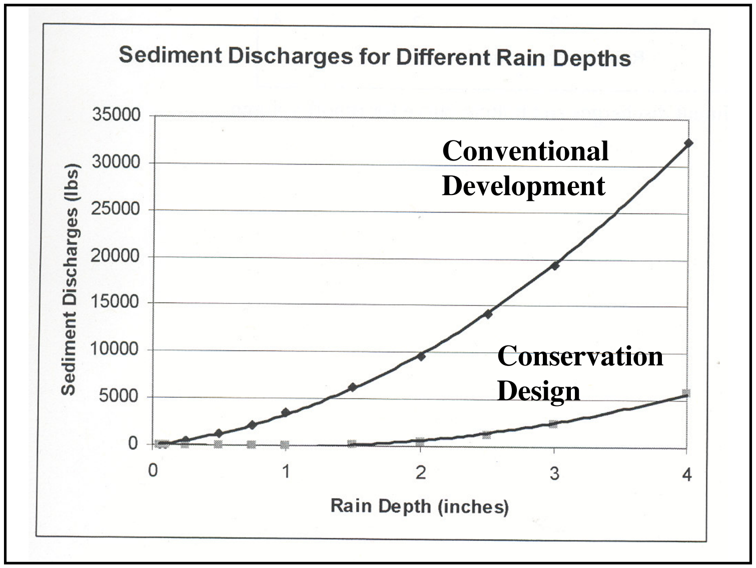
Case Study for Industrial Park Incorporating Stormwater Conservation Design



The North Huntsville Industrial Park is a new development of 250 acres with 50 lots, each about 2 to 4 acres.







In cooperation with the Wisconsin Department of Natural Resources

A Comparison of Runoff Quantity and Quality from Two Small Basins Undergoing Implementation of Conventional- and Low-Impact-Development (LID) Strategies: Cross Plains, Wisconsin, Water Years 1999–2005

Scientific Investigations Report 2008–5008

U.S. Department of the Interior
U.S. Geological Survey

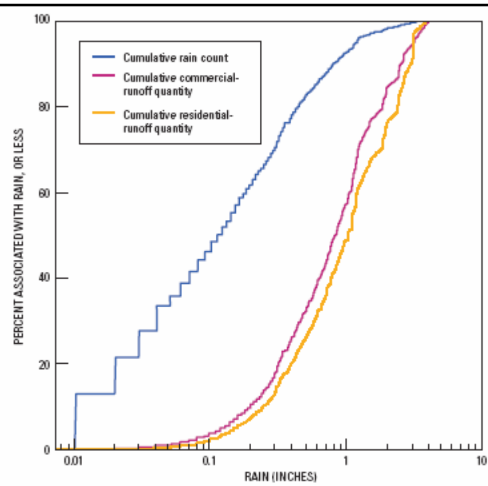


Figure 9. Relation of cumulative-discharge volume to precipitation depth for residential land use in Madison, Wis., based on model predictions (modified from Pitt,1999).

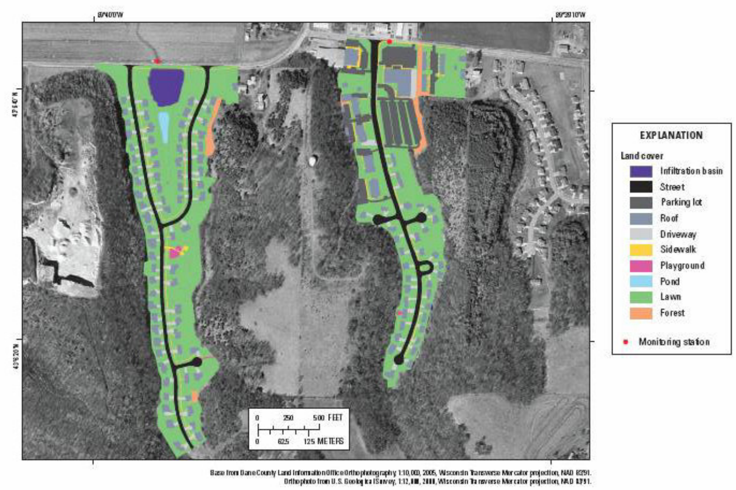


Figure 2. Land use in the low-impact-development (left) and conventional-development (right) basins and location of water-quality monitoring stations, Cross Plains, Wis.

- Grass Swales
- Wet Detention Pond
- Infiltration Basin/Wetland
- Reduced Street Width

Reductions in Runoff Volume for Cedar Hills (calculated using WinSLAMM and verified by site monitoring)

Type of Control	Runoff Volume, inches	Expected Change (being monitored)
Pre-development	1.3	
No Controls	6.7	515% increase
Swales + Pond/wetland + Infiltration Basin	1.5	78% decrease, compared to no controls 15% increase over pre-development

Performance of Controls at Cross Plains Conservation Design Development

Water Year	Construction Phase	Rainfall (inches)	Volume Leaving Basin (inches)	Percent of Volume Retained (%)
1999	Pre-construction	33.3	0.46	99%
2000	Active construction	33.9	4.27	87%
2001	Active construction	38.3	3.68	90%
2002	Active construction (site is approximately 75% built-out)	29.4	0.96	97%

WI DNR and USGS data

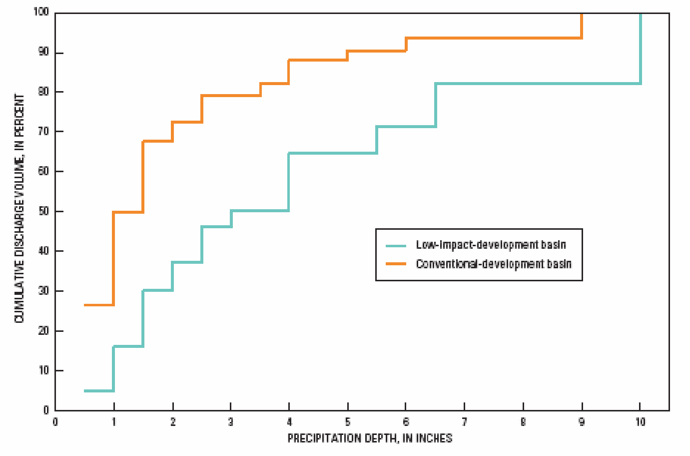


Figure 8. Relation of cumulative-discharge volume, as a percentage of total discharge volume measured between 1999–2005, to increasing precipitation depth in the low-impact-development (LID) and conventional-development basins.

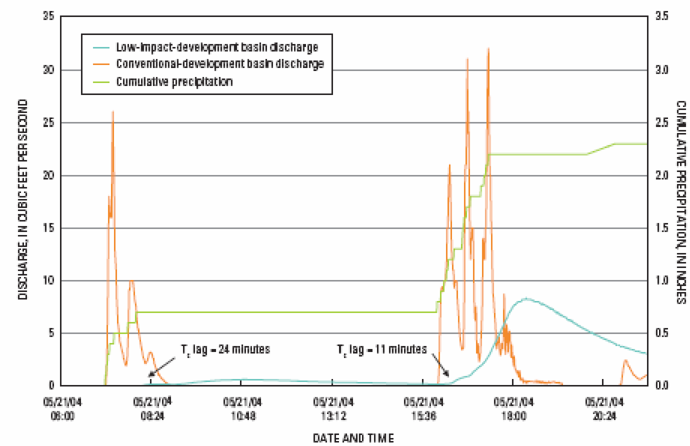


Figure 10. Hydrologic response of low-impact-development (LID) and conventional-development basins to two consecutive precipitation events, Cross Plains, Wis. [T_c, time of concentration]

Combinations of Controls Needed to Meet Many Stormwater Management Objectives

- Smallest storms should be captured on-site for reuse, or infiltrated
- Design controls to treat runoff that cannot be infiltrated on site
- Provide controls to reduce energy of large events that would otherwise affect habitat
- Provide conventional flooding and drainage controls