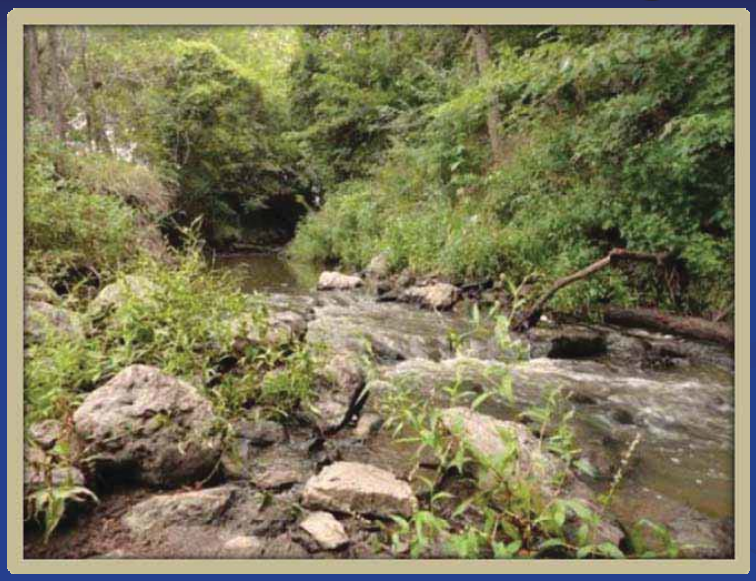
Clean Water Program



Flood Control & Water Quality
Water Quality Standards

February, 2012

Topics

- Hydrology
  - Hydrologic Cycle
  - Rainfall to Runoff
  - Design Storms
- Traditional Flood Control Approach (Peak Discharge)
- Water Quality Approach (WQC Volume)
- Peak Discharge vs WQCV
  - Differences
  - Example of Detention
- Methods to Calculate the WQCV

History of Flood Control & Water Quality

Flood Control

Then...

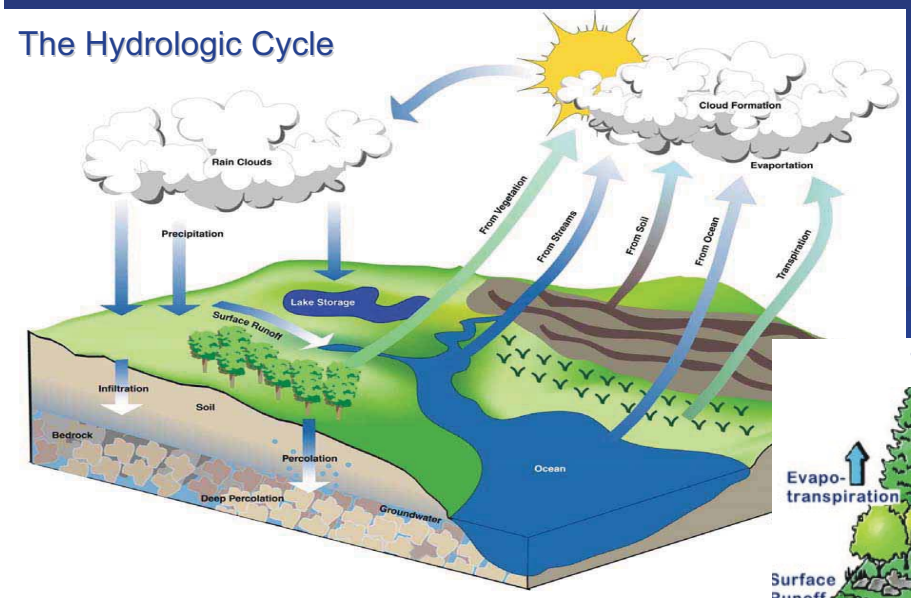
- **1850** As far back as 1850 there has been National Interest in Flood Control
- **1927** Mississippi Flood of 1927 inundated 26,000 sq. mi. caused $1.5 Billion in damages.
- **1927** Flood Control Act of 1927
- **1960's & 70's** USACE led efforts in Flood Control Works
- Continued efforts to Today

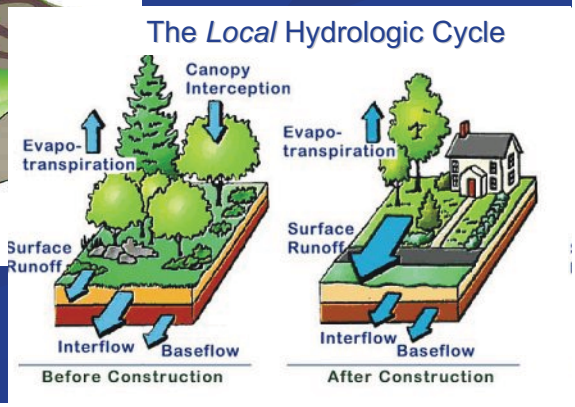
Water Quality

- **1972** Federal Water Pollution Control Act & Clean Water Act
  - Restore and maintain health of U.S. waters (aquatic life & human recreation)
  - Eliminate discharge of pollutants
- **1987** Clean Water Act Amendments
  - Manage urban stormwater pollution
- **1990 & 1999** EPA's Phase I & Phase & II Stormwater Permit Rules
- **1997** Total Maximum Daily Load (TMDL) Program Litigation
- **2006** Section 323 of the Energy Policy Act
- **2007** Energy Independence & Security Act
  - Federal projects must achieve predevelopment hydrology

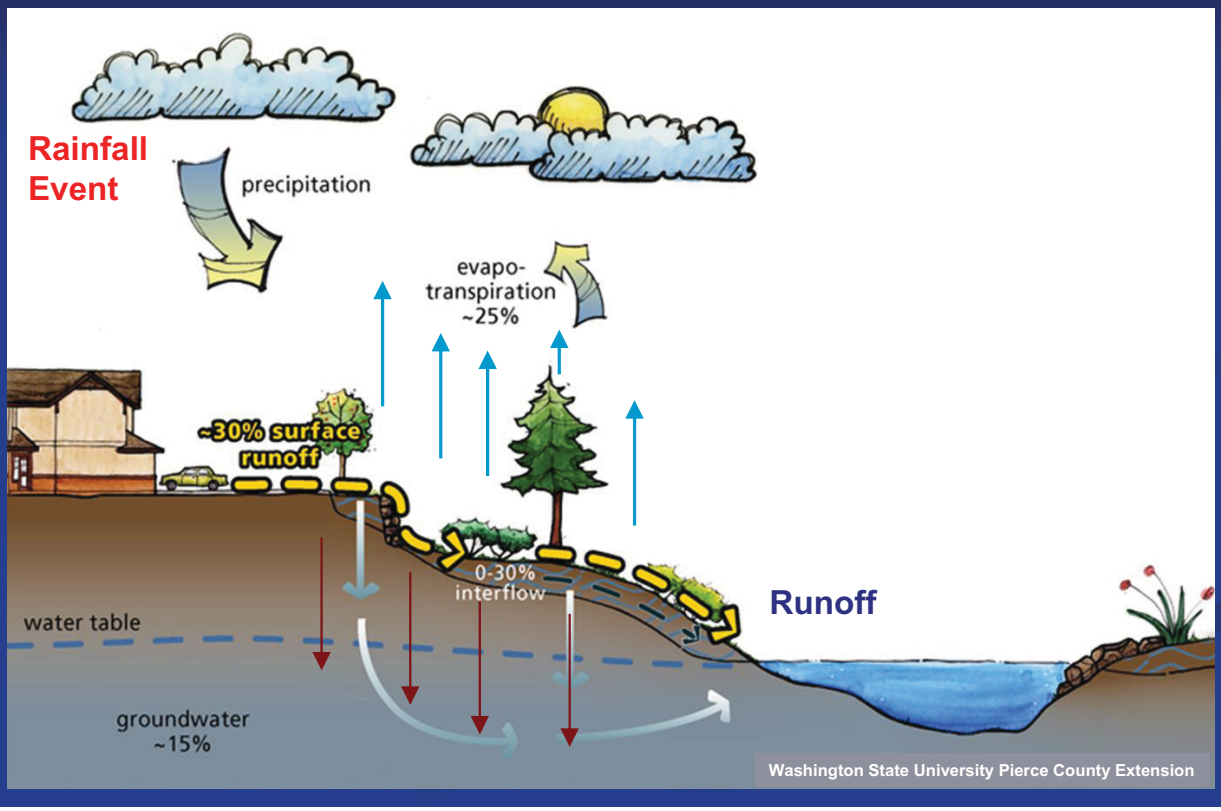
Hydrology: Hydrologic Cycle

The study of movement of water above and below earth's surface



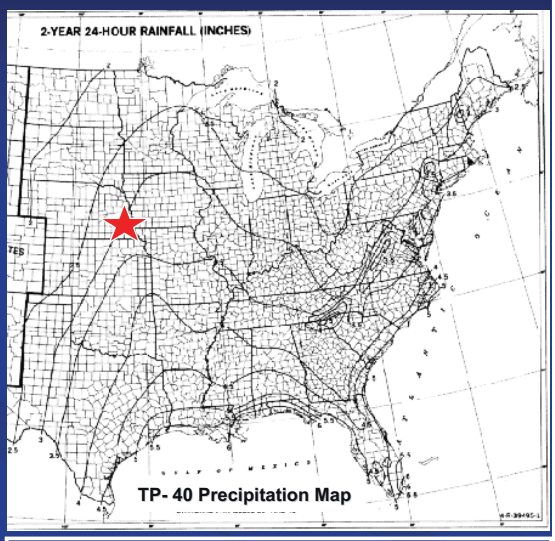


Hydrology: Rainfall to Runoff



Hydrology: Design Storms

- **"Design Storms" are often used in Design Criteria to describe a specific storm event to be applied over an area.**
- Storm Events are described different ways
  - Depth (or Volume)
  - Intensity (Depth/Duration)
  - Frequency (Return Period, Exceedance Probability)
- Commonly storm events are describe by Frequency (how often they occur)
  - Return Period (Length of time between events)
  - Exceedance Probability (% Chance of Occurring in a time period)



The 2-yr 24-hr storm = 3.0" in Lincoln
- Frequency (or Return Period) = 2 years
- Duration = 24 hours
- Depth = 3.0 Inches

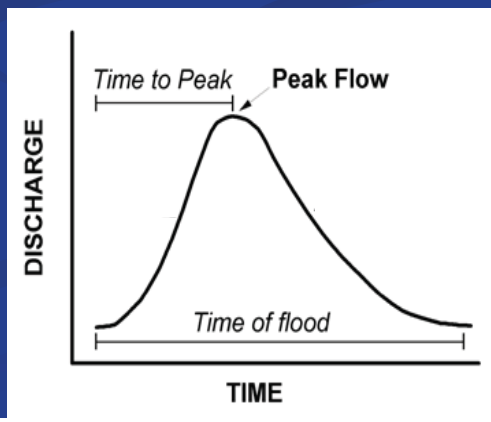
Hydrology: Using Design Storms

- Storm Events are described different ways
  - **Depth (or Volume)** → **Used to calculate the Water Quality Control Volume (WQCV)**
    - → For Water Quality
  - **Frequency** → **Traditionally used to calculate the Peak Discharge**
    - → For Flooding
    - → Urban Storm Sewer Design
    - → & Channel Protection

Traditional Approach: Peak Discharge

- Traditional Approach: Peak Discharge (or Peak Flow)
  - Peak Discharge = Highest flow rate during a storm event
  - Peak Discharge → Directly correlated to highest water level in a channel & velocity
  - Critical that Post-development peak flows don't exceed Pre-development peak flows
  - Peak discharge is more important than volume
- Peak Discharge Methodology uses:
  - Time distribution of flow (e.g. Hydrograph)
  - Frequency Based Storm
- Peak Discharge traditionally **used in**:
  - Flood Control (100yr 24hr Rainfall)
  - Urban Storm Sewer (10yr to 50yr 24hr)
  - Channel Protection (2yr 24hr Rainfall)

DEFINITION: Peak Discharge
The Peak Discharge (or 'peak flow') is the maximum rate of flow of water passing a given point during or after a rainfall event or snowmelt.



Water Quality Approach: Capture Volume

- Water Quality Control Approach: Depth (or Volume)
  - WQCV = Volume of stormwater, if captured and treated, will improve water quality
  - The rate is not as significant as volume
  - Majority of storms are less than 1" and contain majority of pollutants in runoff
  - % of storms captured is more important than fraction of total runoff captured
- WQCV Methodology uses:
  - Rainfall depth or Runoff depth applied over the site (Depth x Area = Volume)
  - A "Volume based Design Storm"
- WQCV **used in**:
  - Water Quality (Variety of methods to determine the Volume)

DEFINITION: Water Quality Control Volume (WQCV)
The volume of stormwater that BMP's are designed to capture and treat in order to improve water quality in the stormwater runoff.

Peak Discharge vs WQCV: Difference?

- Traditional Approach → Control Peak Discharge from 2yr, 10yr, & 100yr Event
  - Peak Discharge = Highest flow rate or runoff from storm event
  - Peak Discharge related to the highest water level in a channel & velocity
  - Peak discharge is more important than volume
  - Protect against peak discharge for:
    - 2yr, 10yr, & 100yr frequency storm
  - Required in LMC, Design Standards, & DCM

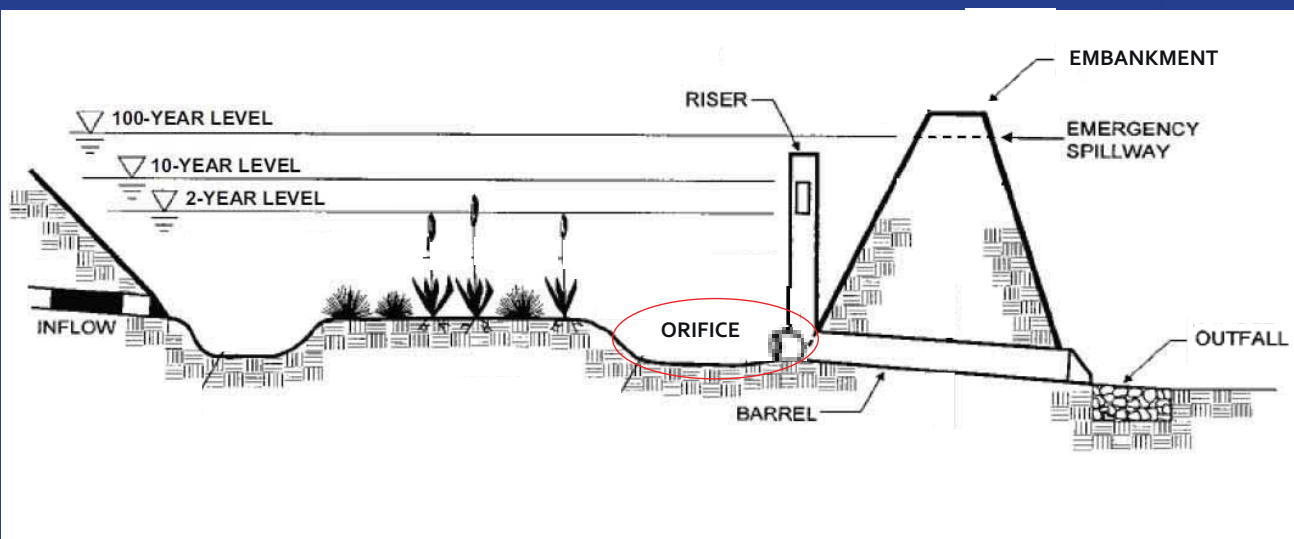
Frequency	24-hour Rainfall
2-year	3.00 in.
5-year	3.93 in.
10-year	4.69 in.
25-year	5.37 in.
50-year	6.00 in.
100-year	6.68 in.

From Table 2-7 of DCM

- Water Quality Approach → Capture & Treat the WQC Volume
  - WQCV = Volume of stormwater, if captured and treated, will improve water quality
  - Majority of storms are less than 1" and contain majority of pollutants
  - The rate is not as significant as volume
  - Best Management Practices be designed to reduce pollutants for a specified volume or percentile of all rain fall events (e.g. 90% would be 1.25 inches or less)

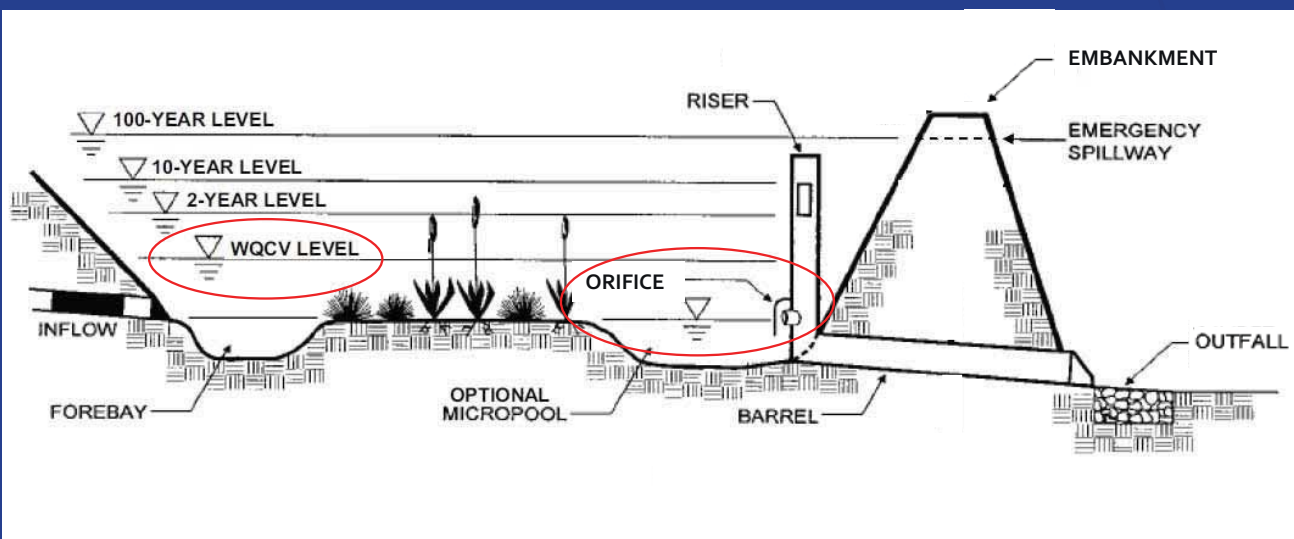
Peak Discharge vs WQCV: Detention Example

- Traditional Approach → **Control Peak Discharge from 2yr, 10yr, & 100yr Event**
- Water Quality Approach → Capture & Treat the WQC Volume



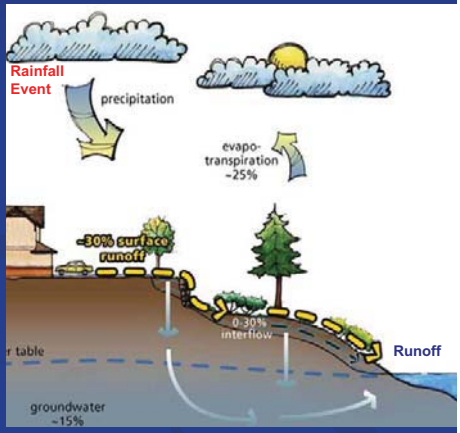
Peak Discharge vs WQCV: Detention Example

- Traditional Approach → Control Peak Discharge from 2yr, 10yr, & 100yr Event
- Water Quality Approach → **Capture & Treat the WQC Volume**



WQCV: Runoff or Rainfall?

- WQCV Approach:
  - Capture & Treat a specified Rainfall or Runoff Depth (i.e. Volume)
- Rainfall or Runoff Considerations
  - Design for a magnitude of Runoff or Rainfall
  - Rainfall Depth → Infiltration , etc. → Runoff Depth
- Different Methods to Calculate the WQCV
  1. Capture a Quantity of Runoff (First ½ Inch of Runoff)
  2. Capture a % of Rainfall (90% Rainfall Depth)
  3. Use Frequency Based Design Storm (1-yr 24hr Storm)
  4. Use Continuous Simulation Modeling



WQCV: Comparison of WQCV Methods

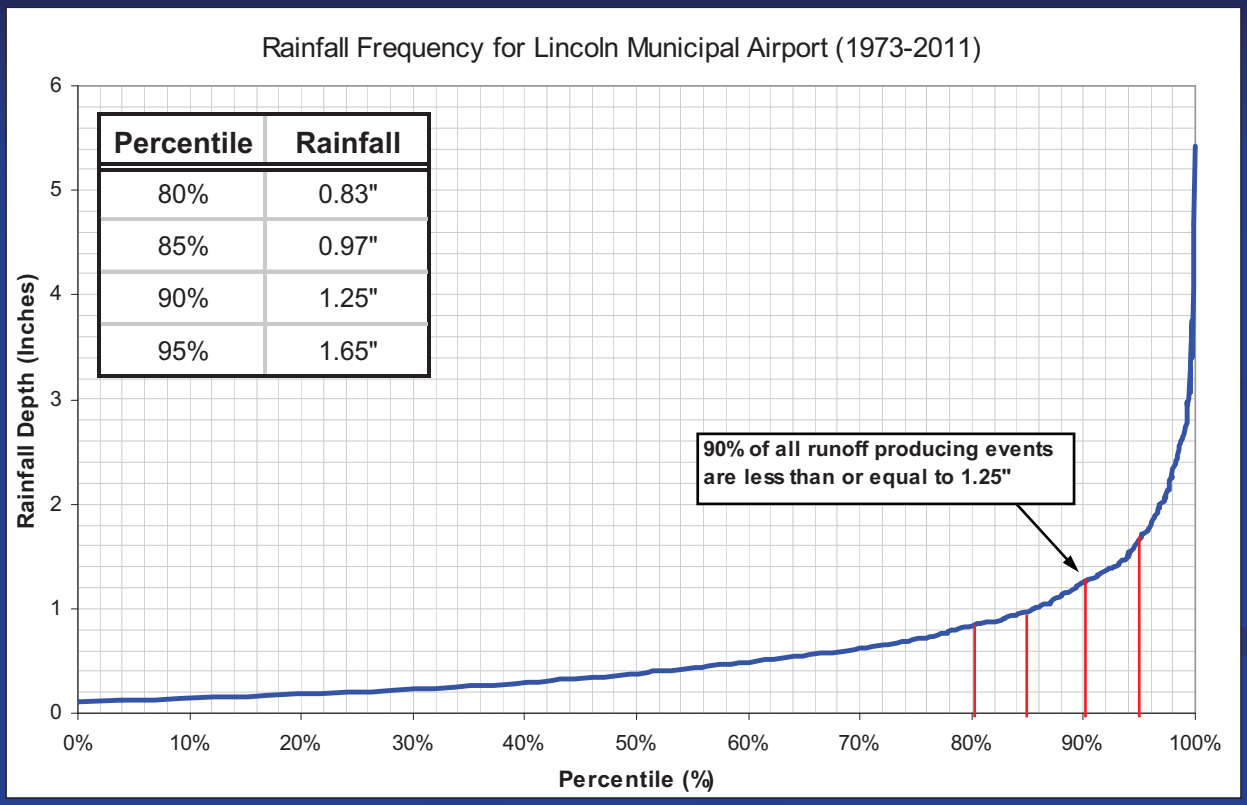
Comparison of Water Quality Capture Volume Methods

Capture Volume Method	Description	Rainfall Depth, P (Inches)	Runoff Depth (Inches)	*Residential WQCV (Ac-Ft.)	**Commercial WQCV (Ac-Ft.)	***Mixed Use WQCV (Ac-Ft.)
1/2" Runoff	Capture & Treat the first 1/2" of Runoff (First Flush) (Doesn't count Impervious area, no incentives)		0.50	0.4	0.4	4.2
90% Rainfall Depth	Capture & Treat 90% of Rainfall from runoff producing rainfall events	1.25		0.3	0.8	4.5
95% Rainfall Depth	Capture & Treat 95% of Rainfall from runoff producing rainfall events	1.65		0.4	1.1	6.0
1-yr 24-hr Rainfall	Capture & Treat the 1-year 24-hour Frequency Event	2.50		0.7	1.6	9.0

*Residential Example site = 10 Acres, 30% Impervious Cover
**Commercial Example site = 10 Acres, 80% Impervious Cover
***Mixed Use Example site = 100 Acres, 25% Commercial with 80% Impervious Cover, 75% Residential with 30% Impervious Cover

WQCV Calculated using site Rv, Runoff Volume Coefficient (Clayton & Schueler, 1996)
where: WQCV = P * Rv* A, Rv = 0.05+0.009*I & I = % Impervious Cover

WQCV: Rainfall Frequency Curve



Percentile	Rainfall
80%	0.83"
85%	0.97"
90%	1.25"
95%	1.65"

WQCV: Take Away Points

1) The traditional approach with stormwater has been to control the peak runoff discharge rates for the 2yr, 10yr, and 100yr 24-hr storm events.

2) With decades of focus on flooding, Water Quality has gone largely uncontrolled in urban drainage design & practice.

3) The majority of rainfall events are less than 1" and carry the majority of pollutants, adversely impacting downstream resources.

4) Controlling & treating a volume of stormwater (WQCV) is an easily understood and effective way to reduce pollution in stormwater runoff.

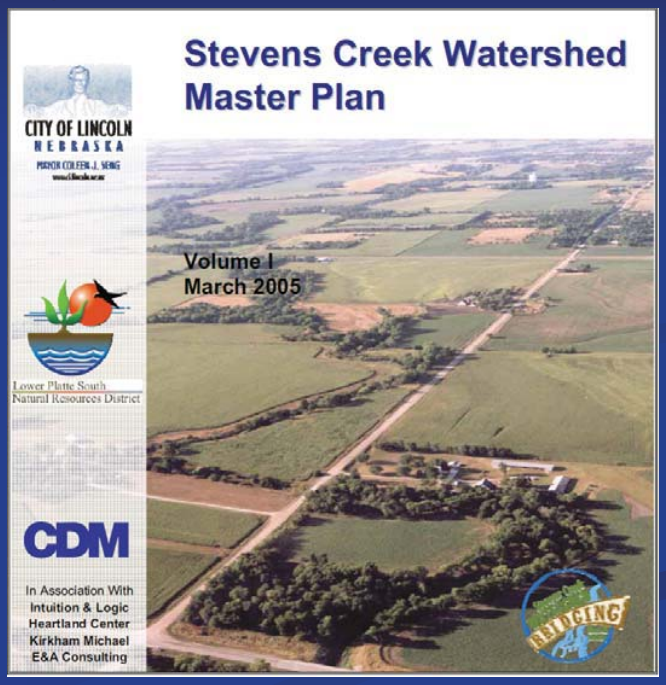
5) There are different ways to calculate and regulate the WQCV. Methodology varies between a generic, un-incentivized ½" of Runoff, to capturing a percentage of annual rainfall events, to complex modeling.

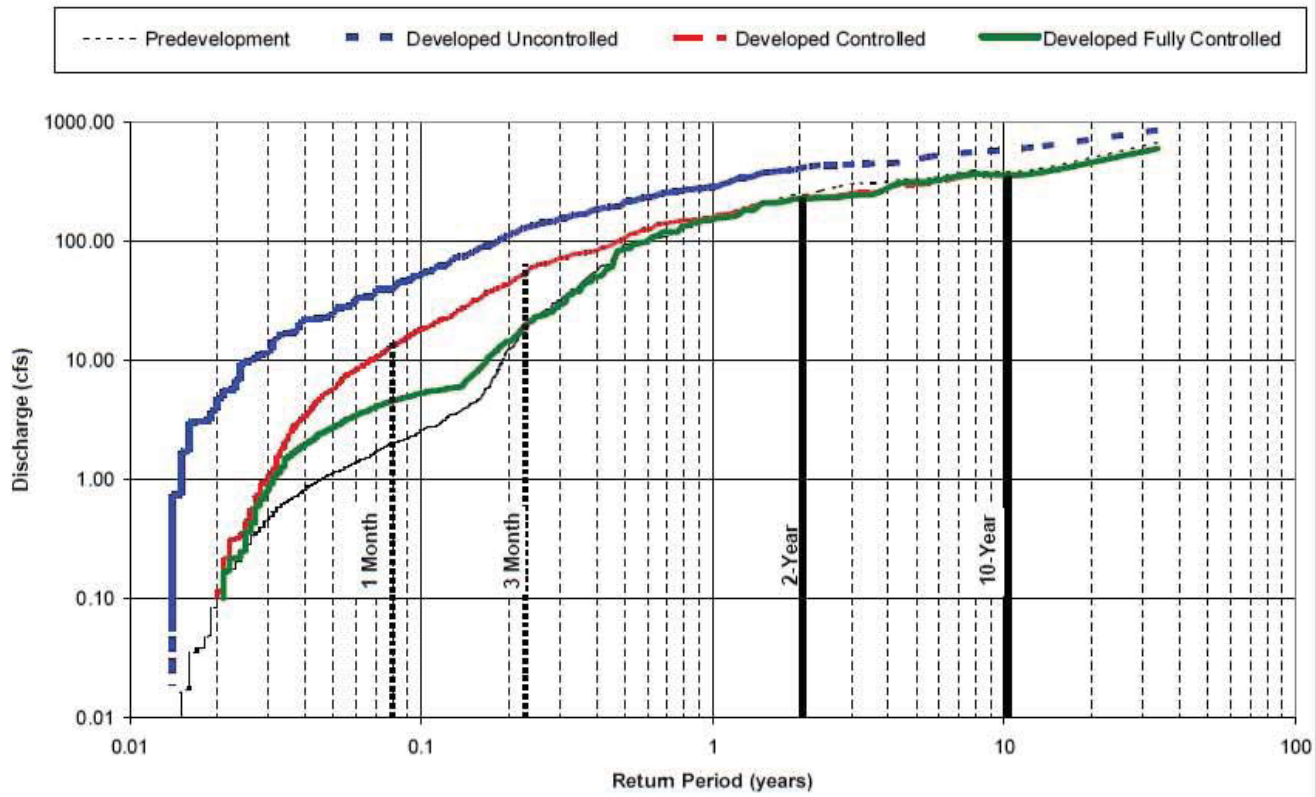
Water Quality Standards

- Lincoln existing voluntary standards
- Guidance documents
- Ordinances related to water quality
- Model ordinances
- City of Lincoln ordinance outline

Lincoln Existing Voluntary Water Quality Standards

- Stevens Creek Watershed Master Plan
  - Approved in 2005
  - Approved Subarea plan to 2040 Comprehensive Plan
  - Section 7





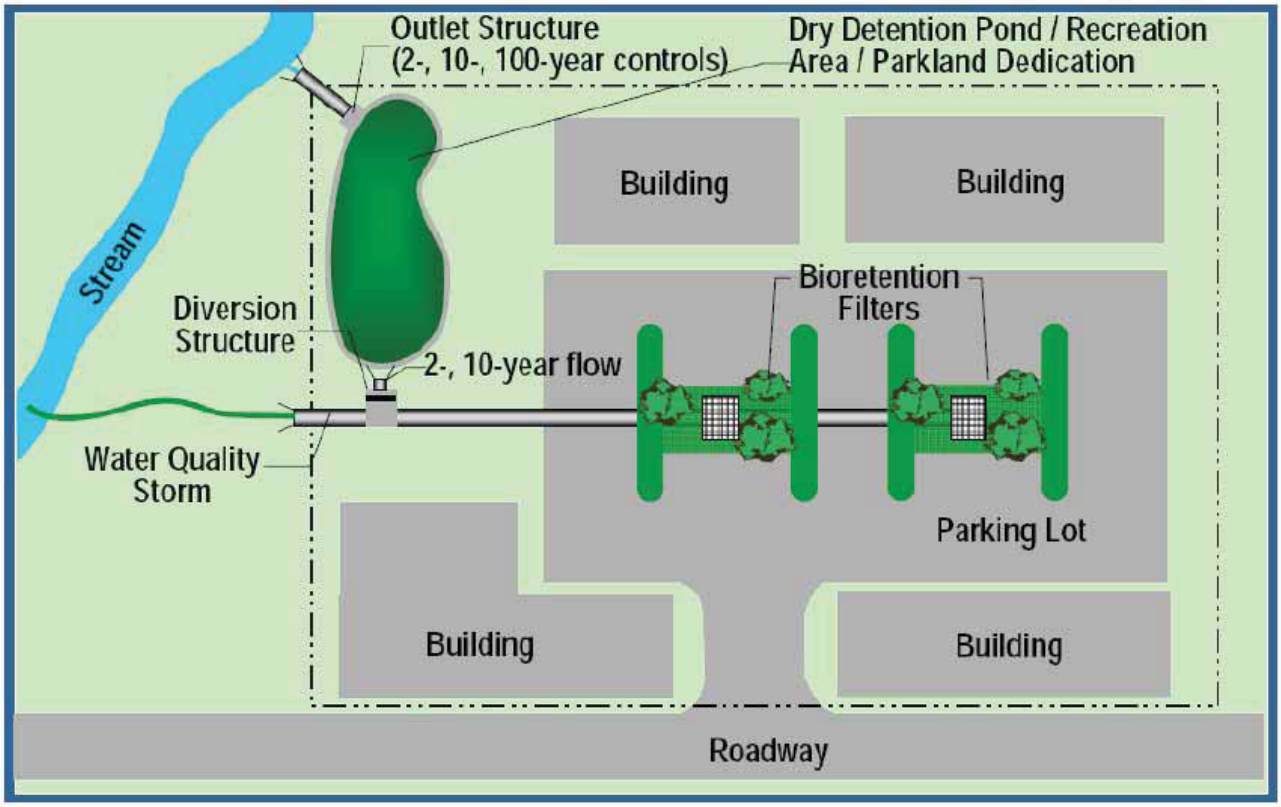
Stevens Creek Watershed Master Plan

- Recommends water quality for the 90% storm event (1.3")
- Typical residential area would be 0.5" of runoff
- Typical commercial area would be 1.0" of runoff

Stevens Creek Watershed Master Plan

- Alternatively could use BMP's that are sized for the 1.3" storm event
- BMP's such as pervious pavement, bio swales, etc

Lewis Ballfield 24th & M Street

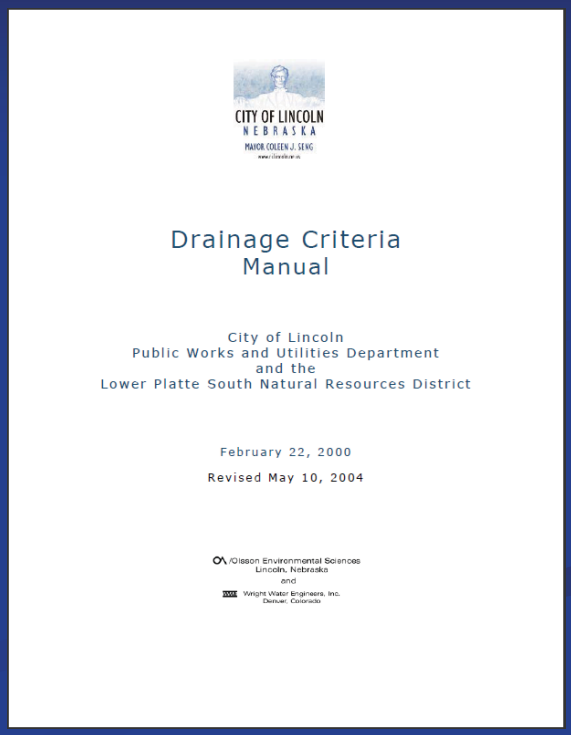


City of Lincoln Guidance Documents

Alternative Stormwater Best Management Practices Guidelines

City of Lincoln, Nebraska
and the
Lower Platte South Natural Resources District

April 2006



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Drainage Criteria Manual

City of Lincoln
Public Works and Utilities Department
and the
Lower Platte South Natural Resources District

February 22, 2000

Revised May 10, 2004

Olsson Environmental Sciences
Lincoln, Nebraska
and
Wright Water Engineers, Inc.
Denver, Colorado

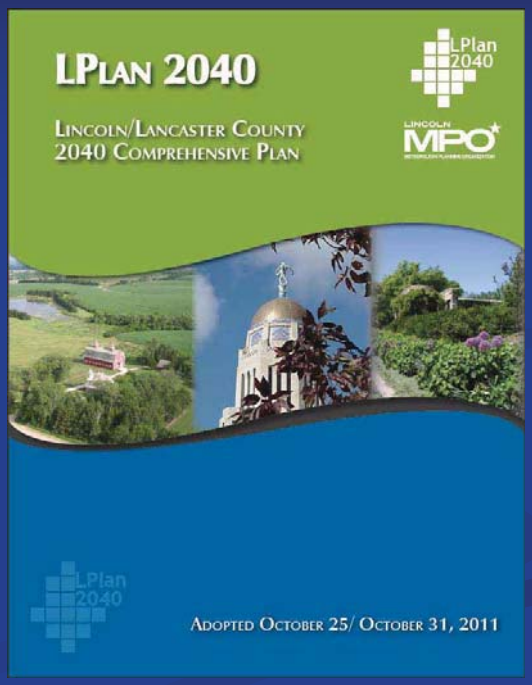
City of Lincoln Best Management Practices Documents

Best Management Practices (BMPs)	Typical EPA Recommended BMPs	Alternative Stormwater BMP Guidelines (2006)	Drainage Criteria Manual Chapter 8 (2004)
Bioretention	X	X	X
Grass Swales & Strips	X	X	X
Extended Dry Detention Basin	X	X	X
Green Roof	X	X	*
Manufactured Device (e.g. hydrodynamic seperator)	X	*	*
Media Filter	X	*	*
Permeable Pavers	X	X	X
Treatment Train	X	X	X
Wet Retention Basin	X	X	X
Constructed Wetland	X	X	X
Wetland Channel	X	X	X

* Not in City's BMP Guide, but have been or are being built by City/NRD

City of Lincoln 2040 Comprehensive Plan

- Use public projects to set good examples for water quality
- Preserve vegetative corridors along stream corridors
- Develop project approaches that view stormwater as an asset



Existing Ordinances related to Water Quality

- 2, 10, and 100 year event detention/retention
- Minimum corridor
- Erosion and sediment control (LMC 28.01)
- Illicit discharge control (LMC 28.02)

Existing Water Quality Programs

- Public Education
- Good housekeeping/ industrial discharge
- City/NRD demonstration projects
- NRD cost share program

Model Ordinance, EPA

- EPA's model ordinance
  - Standards apply to any construction activity disturbing X or more square feet of land
  - Reference to a Stormwater Design Manual (e.g. City's Drainage Criteria Manual)
  - Stormwater treatment practices designed in accordance with these criteria are presumed to meet minimum water quality standards
  - Require best management practices for the first X amount of runoff or percentage of rainfall

www.epa.gov/ owow/NPS/ordinance/mol6.htm

Ordinance, Omaha

- Omaha's ordinance
  - Applies to land development and significant redevelopment projects
  - All developments shall include BMPs to provide water quality for first ½" of runoff
  - For significant redevelopment projects the area requiring control of the first ½" of runoff will be the impervious area added or disturbed
  - Includes maintenance provisions

Ordinance, Wichita, KS

- Wichita's ordinance
  - Applies to land development and redevelopment projects over one acre
  - BMPs will remove at a minimum of 80% of the total suspended solids load from a 1.2" rainfall event (85% storm event)
  - Includes maintenance provisions

Lincoln Ordinance Outline

- New ordinance in Chapter 28 – Stormwater Quality and Erosion and Sediment Control
  - Provisions
  - Definitions
  - Procedures
  - Design Criteria
  - Maintenance
  - Enforcement

Critical Issues for Discussion

- New ordinance in Chapter 28 – Stormwater Quality and Erosion and Sediment Control
  - Water quality standards apply to what type of developments (type and size)
  - Applicable at what date/Exceptions
  - Water quality criteria (% rain event, reduction of pollutant %)
  - Maintenance Agreements/Sureties
  - Enforcement

THE APPLICATION OF STORMWATER BEST MANAGEMENT PRACTICES (BMPs) IN LINCOLN

Why BMPs?

- Reduced stormwater runoff volume
- Improved water quality
- Reduced landscape maintenance
- Stream stability
- Reduced infrastructure cost downstream

The best way to mitigate stormwater impacts from new developments is to use practices to treat, store, and infiltrate runoff onsite before it can affect water bodies downstream.

U.S. EPA

Why BMPs?

- They're practical
- They're aesthetic amenities in the community
- Reduce demands on Public Works
- Changes to existing practices are minimal

Why BMPs?

Structural BMPs include storage practices such as:

- Rain gardens and bioretention gardens
- Wet ponds and extended-detention basins
- Filtration practices such as grassed or vegetated swales, and filter strips
- Pervious pavements
- Silva cells
- Green roofs

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Conventional Stormwater Management

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BMP-Based Stormwater Management

BMPs in Lincoln

27th and F Street

Pervious pavement & rain garden

BMPs in Lincoln

Aspen Greens Common Area

Norris Lane and Allen Road

Vegetated swale

BMPs in Lincoln

Havelock Rain Garden

Rain gardens

BMPs in Lincoln

Lewis Ballfields Parking Lot

Capital Parkway and J Street

Grass paver, pervious pavement & bioretention garden

BMPs in Lincoln

Peterson Park Wetland

Stormwater detention/treatment wetland

BMPs in Lincoln

Pine Lake Heights

Stormwater detention, native landscapes

BMPs in Lincoln

56th Street and Old Cheney Road

Submerged gravel wetland

BMPs in Lincoln

Tierra Park

Stormwater Treatment Wetland

BMPs in Lincoln

Lower Platte South NRD Office

Rain garden

BMPs in Lincoln

Bioretention garden

Federal Requirements

- Phase I and Phase II communities must develop, implement, and enforce a program to address stormwater runoff
  - new development
  - redevelopment projects
  - structural and non structural controls
- Any program must ensure that controls are in place that would prevent or minimize water quality impacts.

State Requirements

Mirror Federal requirements, including

1. Public Education and Outreach
2. Public Participation and Involvement
3. Illicit Discharge Detection and Elimination
4. Construction Site Runoff Control
5. Post Construction Runoff Control
6. Pollution Prevention and Good Housekeeping
7. Industrial and Related Facilities
8. Monitoring Program

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Concept of Sustainable Design

Community planning and design that:

- Integrates sustainable, natural environment to
  - reduce water consumption
  - improve water quality
  - reduce energy use
- Native landscapes balance function with aesthetic
- Reduces long-term costs for operations and maintenance

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Sustainable Design Benefits

- High aesthetic value -- seasonal changes, diverse foliage, flower and fruit, healthy plants, year-round interest, wildlife

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Sustainable Design Benefits

- **Easy on the environment** -- reduced pesticides, fertilizers, water use, habitat enhancement

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Sustainable Design Benefits

- Potential for cost savings -- less maintenance, healthier plants, reduced resource inputs

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Effective stormwater management requires integrated management of water, vegetation, and soil

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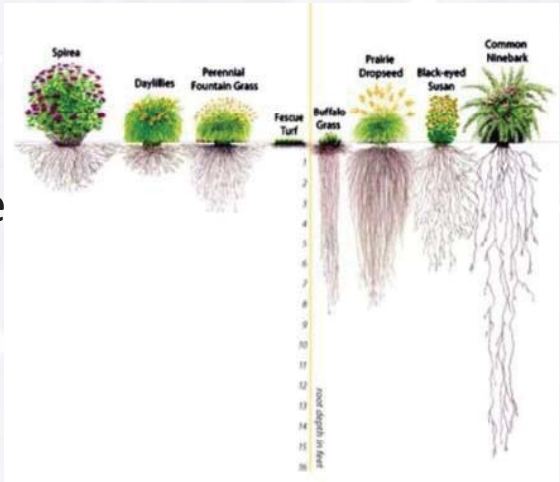
BMP Concepts

The Wisdom of Native Plants

- Adapted to this region
- Water and nutrient stingy
- Deep roots
- Beautiful leaves and flowers



BMP Concepts

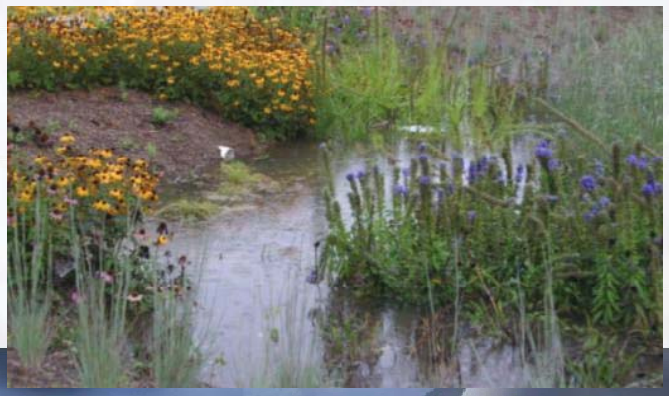
The Health of Soil

- Key to the health of plants
- Storage of water, nutrients
- Filtering/cleansing pollutants
- Base support of vegetation

BMP Concepts

Managing Water

- Capturing and filtering stormwater
- Conserving water deep in the soil
- Reducing volume discharged to streams
  - Reduced erosion and property destruction



BMP Concepts

BMPs can be located in many environments

- Urban landscapes and open spaces
- Riparian corridors/drainages
- Linear rights of way

A Fallbrook stream incorporates native plants to filter and slow stormwater runoff

Evolution of the BMP Concept

- The concept of rain gardens began in the early 1990's in Maryland
- Concepts and designs for "rain gardens" evolved into other, similar structures that mimicked nature and filtered stormwater
- Rain gardens and similar BMPs quickly spread to other states such as Minnesota
  - Conducted substantial research in design and function

Evolution of the BMP Concept

- Watershed Management's first BMP was in 2005 at 63rd and Platte
- A BMP guidance manual was developed in 2006
- BMPs of varying design and application constructed around the City

Are BMPs the Best Solution for Every Site?

- Drainage
  - How much runoff?
  - Connected or disconnected
  - Slope
- Space
  - Is there enough available space?
- Sustainability
  - Will it be maintained
  - Is it affordable
- Is there a better or more appropriate system?

BMP Costs

- Costs for Stormwater BMPs vary
  - type of BMP,
  - size and structure
  - amount of stormwater captured and treated.
- **Cost is less** when design and construction is part of the planning process.
- BMPs integrated into community design **reduce infrastructure needs and reduce costs**.

BMP Costs

- Cost is more for retrofitting into existing landscapes
- Costs will come down as BMPs become more common, and as design standards are developed and implemented

BMP Costs

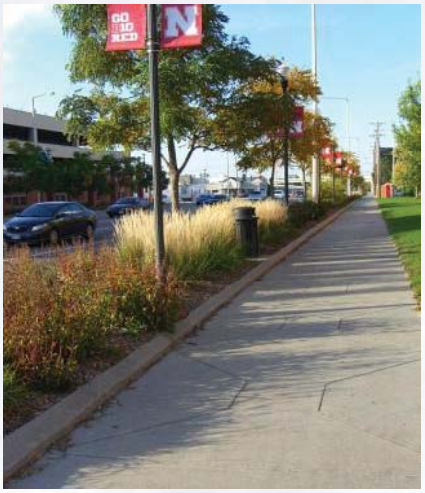
- Benefits
  - Increased land values – people enjoy natural amenities
  - Sale-ability of land – neighborhoods with BMPs and Low Impact Development concepts have been shown to sell quicker than conventional neighborhoods

BMP Maintenance

- BMP maintenance is highest after installation and during the first year
- Maintenance requirements diminish during second year, and beyond
- Minimal or no need for fertilizers, pesticides, water
- Maintenance cost about 10% of construction during first year, about 2% to 3% of construction cost during subsequent years

BMP Opportunities in Lincoln

Downtown Lincoln



10th Street at Q

12th Street & Q Street

Native Landscapes

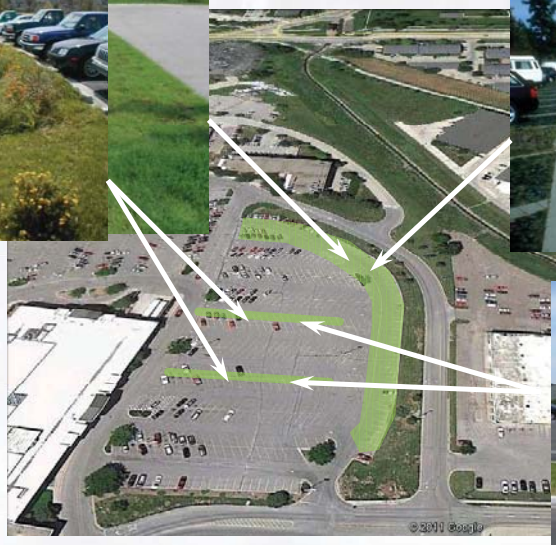
BMP Opportunities in Lincoln

Industri

South 14th Street and Center Park Drive

BMP Opportunities in Lincoln

Commercial Areas



Gateway Mall – Q Street and No

Stormwater BMPs in Lincoln

- A beautiful and functional alternative to conventional "gray" stormwater management.
- Can be comparable or even lower in cost than conventional stormwater management strategies
- Can fit within existing landscape areas

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Stormwater BMPs in Lincoln

- Are sustainable with time, and conserve valuable natural resources
- Design and construction improvements are occurring all the time, making these structures for stormwater management a better alternative
- Great, local experience base exists