Stormwater & Flooding: Connecting the Drops

Agenda:
• Cause - Effect
• Programs
• Floodplains
• Stormwater
  • Infiltration
  • Volume Control (Water Quality)
• Stormwater
• Stream Bank Erosion
• Peak Rate Control
• Watershed Assessment & Analysis
• Connecting the Drops
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Hydrologic Balance

\[ P = RO + Re + ET \]

Where:
- \( P \) = Precipitation
- \( RO \) = Surface Runoff
- \( Re \) = Recharge (Baseflow to streams)
- \( ET \) = Evapotranspiration

\[ RO = P - Re - ET \]

Same Equation Whether:
- \( P = .01 \) in, Trace
- \( 7.5 \) in/24 hr. or 100-yr
- \( 45 \) in/yr. Annual Rainfall

High Infiltration – Little Runoff
Erosion / Sedimentation Problem Area

Water Quality Problem Area
Increased and faster runoff

Direct conduits to streams

Undersized Storm Sewers
Undersized Channels / Culverts 
Obstructions

Streams & flood-plains in equilibrium

Streams & flood-plains out of balance
Past Solution: Increase channel capacity

Past Solution: Dikes, levees, floodwalls

Levees & Dikes

Limited Capacity & Limited Lifespan
Hurricane Agnes – June, 1972

Floodplain Encroachment
Floodplains Flood

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PA Act 166 – Floodplain Management Act (1978)

(a) Flooding of large areas of land within the Commonwealth causes unnecessary loss of life, destroys private and public property, damages means of livelihood and economic resources; etc.

(b) Extensive expenditures of public funds have been allocated to costly flood control projects...

(c) The exclusive use of flood control measures, such as engineering projects, has failed to significantly reduce the human suffering and economic losses caused by recurrent flooding.

(d) A comprehensive and coordinated program of flood plain management, based upon the National Flood Insurance Program, is fundamental to the health, safety, welfare and protection of the people of the Commonwealth.

PA Act 167 – Stormwater Management Act (1978)

• In response to the impacts of accelerated stormwater runoff resulting from land development in the state.
• Requires counties to prepare and adopt watershed based stormwater management plans.
• Requires municipalities to adopt and implement ordinances to regulate development consistent with these plans.
(a) This chapter requires persons proposing or conducting earth disturbance activities to develop, implement and maintain BMPs to minimize the potential for accelerated erosion and sedimentation and to manage post construction stormwater.

(b) The BMPs shall be undertaken to protect, maintain, reclaim and restore water quality and the existing and designated uses of waters of this Commonwealth.
Pennsylvania E&S, Stormwater & Floodplain Management Act

• 2002, attempt to integrate its various stormwater management programs (including MS4 Permits, NPDES Construction Permits, and Act 167) and promote a comprehensive watershed approach to stormwater management, PA DEP finalized a Comprehensive Stormwater Management Policy, DEP Policy No. 392-0300-002.
• 2006 PA BMP Manual
• 2010 New Ch 102 – incorporated PCSM into E&S.
• 2013 Act 68 amended the purposes and powers of Municipal Authorities to include financing working capital; stormwater planning, management and implementation.
• 2021? – New (BMP) PCSM Manual

Updates to Regulations to Coordinate Stormwater, E&S and Flooding
Other Policy / Programs:
- NPDES Program
- TMDL’s
- FEMA FIS
- USACE Projects
- Pa DCNR Rivers Conservation Plans
- Growing Greener
- State Water Plan
- Dam Safety Program
- DRBC, SRBC, etc.

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Flooding Caused By:
- High Rainfall Amounts – Can’t do to much to control
- Dam Breaks – Dam Safety Program
- Obstructions, Building in the Floodplain – FEMA Flood Insurance Program
- Runoff – Impervious cover – land use & stormwater management
Current Regulations Allow Fill in the Flood Fringe

\[ Q = AV \]
\[ V = Q/A \]
The Flood Fringe Has Many Purposes

- Infiltration
- Sediment Deposition
- Attenuation
- Floodplain Storage

Deposition of Sediment
Attenuation

Example 1: Riparian Buffer
n = 0.09 Riparian Forest
n = 0.03 Grass
V = 3 Times Faster on Grass

Example 2: Fill in Floodplain
V = 5 fps Natural Flood Fringe
V = 12 fps Constricted Section

Manning Equation
\[ V = \left( \frac{1}{n} \right) \left( R \right)^{2/3} \left( J \right)^{1/2} \]

- \( V \): Velocity (m/sec)
- \( n \): Friction Factor
- \( R \): Hydraulic Radius (m)
- \( J \): Slope of Energy Grade-Line

\[ Q = VA \]
\[ V = Q/A \]

1000' reach of stream – 11 minutes v. 3.7 minutes
Floodplain Backwater Causing Stormwater Problems

Problems Caused by Obstructed Flow
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Comprehensive Stormwater/Floodplain Management

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Stream Flood Flow

Stream Base Flow
Low Impact Development (LID)
Flow

Infiltration Volume

Flow

Time

Peak Flow After Construction (No Controls)

Infiltration Volume 0.5 to 1" from Impervious Areas

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First Flush

Flow vs. Time graph showing peak flow after construction (no controls) compared to pollutograph showing concentration and volume of pollutant(s).
Detention Basin – Low Flow Channel

Large Volume of Unmanaged Poor Quality Runoff
Water Quality Volume – Retain or Re-use 1” of Rainfall from DCIA

Water Quality & Infiltration Volume On a Watershed Basis

WQ & Infiltration Volume 0.5 to 1” from DCIA
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• Solutions: Analysis/Tools
• Connecting the Drops
Bankfull Capacity:
1.5-Yr. Event
(Leopold, USGS, Valley Ck)

Management:
Reduce 2-Yr Post Event to 1-Yr Pre Event Using BMP
Reconnect Floodplains:
Reduce Channel Velocities +
Infiltration + Sediment Deposition

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Detention Volume for Peak Rate Control

Flow

Time

Storage Required for Peak Rate Control

Peak Flow After Construction (No Controls)

Peak Flow After Construction (With Controls)

Peak Flow Before Construction

Relocation of Runoff Volume (With Controls)

Standard or Extended Detention, Wet Ponds, etc.
DUAL PURPOSE SW CONTROL
(WATER QUALITY AND QUANTITY)

LOW FLOW

WATER QUALITY CONTROL

* CAPACITY OF PIPE = WATER QUALITY STORM

HIGH FLOWS

WATER QUANTITY CONTROL

DISCHARGE TO WATER COURSE

50-Year
LM4 - Existing Basin

Flow - CFS

Time - H:M:S

LM4 Basin Inflow (CFS)

January
February
March
April
May
June
July
August
September
October
November
December

Daily Rainfall Total (inches)
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Solution: Holistic Watershed Approach

Inventory watershed:
- Obstructions
- Problem areas
  - Stormwater (local) (volume/peak)
  - Flooding (regional)
  - Erosion / sedimentation
  - Water quality
- Roads / development
- Flood Insurance Studies data / claims
- Riparian buffers
- Etc.

Solution: Holistic Watershed Approach

- Inventory watershed (problem areas (volume/peak/water quality, streambank), basins, obstructions, etc.)
- Compile GIS data (DEM’s, land cover, soils, geology, inventory items)
- Subdivide & model watershed (HEC-HMS, SWMM, etc.)
- From modeling, determine hydrologic response of subwatersheds
- Formulate Plan with management measures and locations – LID, retrofit sites, BMPs
- Implement Plan
Model Results with Retrofitting

<table>
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<th>Basin</th>
<th>Peak In (CFS)</th>
<th>2-Year</th>
<th>Existing Peak Out (CFS)</th>
<th>Retrofit Peak Out (CFS)</th>
<th>Difference (CFS)</th>
<th>Reduced By %</th>
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<th>50-Year</th>
<th>Existing Peak Out (CFS)</th>
<th>Retrofit Peak Out (CFS)</th>
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Comprehensive Stormwater Management

Peak Flow After Construction (No Controls)

Peak Flow Before Construction

With Detention

Plus infiltration & volume control

Plus Riparian Buffers

Plus Retrofitting

Comprehensive Stormwater Management

Reduces Flood Elevations

No SW Mgmt.

With Detention

+ Infiltration & volume control

+ Riparian Buffers/Reconnecting FP

+ Retrofitting
Recommended Stormwater Improvements

Potential Improvements

- Detention Sites
  Additional 478 Acre-FT
- Infiltration Sites
  Additional 23 Acre-FT
- Riparian Buffer
  Restoration Areas
  Additional 37 Acre-FT

Note: 1 inch of storage is 53.3 Acre-FT
Per square mile, or approximately
3,410 Acre-FT, for the Wissahickon Watershed.

Visualization – 3D Analysis
Geographic Information Systems (GIS) with Watershed and Floodplain Modeling

TOTAL POND FRONT UNITS: 16
TOTAL INCREASE IN UNIT SALES: $7,500
TOTAL INCREASE IN SALES $120,000
TOTAL COST TO CONSTRUCT POND $60,000
TOTAL ADDITIONAL REVENUE $60,000
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Connecting the Drops:
Watershed Stormwater Management Reduces Flooding