MODELING THE EFFECTS OF MULTIPLE DETENTION BASINS ON STORMWATER FLOW AT THE WATERSHED SCALE

Clay Emerson$^{1,2}$
Claire Welty$^1$ Robert Traver$^2$
$^1$Drexel University
$^2$Villanova University
OUTLINE

• History of Stormwater Management
• Purpose of Research
• Methods
• Results and Conclusions
HISTORY OF SWM

• Limit post development peak flowrate to predevelopment levels (2yr-100yr events)
• 1983 revised Act 167 “watershed plan”
• Watershed wide Act 167 plans often not prepared
• No WQ and no volume requirements
PURPOSE

Valley Creek Watershed
Over 100 detention basins

24 sq. miles
17% Impervious
PURPOSE

To quantify the performance of traditional methods of stormwater management at the watershed scale.
METHODS

Software

• HEC-HMS 2.2.0
  - Green and Ampt
  - Muskingum Routing
  - Distributed ModClark Transform

• HEC-GeoHMS

• ArcView GIS 3.3

• HEC GageInterp
METHODS

Data Input

• Precipitation
• Drainage Structure Information
• Aerial Photos
• Topography
• Soil Characteristics
• Streamflow Data
• Visual Observations
METHODS

Precipitation Data

- Spectrum Technologies Rain Gauges
- Drip through mechanism
- Network of five recording gauges
- Five minute interval
- Precipitation grids created using GageInterp
METHODS

September 20, 2001 Event
Drainage Structure Information

Comprehensive Survey of Detention Basins

- Conducted Summer 2001
- 111 Basins Surveyed
- Storage vs. Outflow Curves
- Photographic Record (~500 pictures)
- GPS Location Record
METHODS
METHODS

Scaled topographic drawings were created for each basin.
METHODS

The incremental storage method and basic hydraulic calculations were used to create storage vs. outflow curves.
METHODS

• Each detention basin’s catchment area was modeled as an individual subbasin.

• The DEM was manually edited to create the desired drainage patterns.
METHODS

A USGS stream gage is located near the mouth of the Valley Creek watershed.

http://water.usgs.gov/pa/nwis/uv?01473169
RESULTS

Final model consists of 91 subbasins, 82 reservoirs, and 165 reaches.
RESULTS

- Simulations were performed both with and without detention.
- Peak flowrate only mitigated by 4 cfs.
RESULTS

• Detention or storage only occurs when inflow exceeds outflow.

• Storage is a function of both the outlet structure design and precipitation intensity.

• In order to explain the results it is necessary to further investigate this particular storm’s intensity.
RESULTS

Spatial variability between the most westerly, most intense, and easterly, least intense rain gauges.

Rain Gauge 1: 2.61in
Rain Gauge 5: 1.40in
RESULTS

The watershed as a whole experienced a storm that was well below even the 1-year rainfall event.
RESULTS

• The peak flowrate from this storm was less than the annual peak for every year in the 18yr record maintained by USGS.

• It can be said that this was less than a 1-yr flow event.
RESULTS

These smaller, more frequent storms may be responsible for more than the majority of sedimentation and stream bank erosion.
RESULTS

These photos are from a storm of similar magnitude to the September 20th event.

July 18th 2001 9:30AM

9:30AM: 375cfs
RESULTS

Large plume of sediment is seen at the confluence of Valley Creek and the Schuylkill River. Sand bars are also visible.
RESULTS

50 years daily rainfall record from local rain gauge.

- Storms of a return frequency of 2 years or more only constitute 3% of the yearly precipitation.
- Stormwater management practices have neglected the remaining 97%.
RESULTS

Poor maintenance of existing facilities

- Rusted out hole in outlet structure with large sediment loss.
- Large (8ft deep) scour hole just downstream of a detention basin.
RESULTS

Outlet pipe exposed after berm failure.
CONCLUSIONS

Traditional methods of SWM are not sufficient.

Detention basins in Valley Creek watershed:

- have a negligible impact on stormwater flow
- do little to protect stream channel
- are not designed at the watershed scale
- are designed for only 3% of the annual rainfall
- are often poorly maintained
CONCLUSIONS

Recommendations:

• focus on volume control, infiltration
• design for smaller storms
• SWM could be addressed in earlier stages of design
• watershed wide approach in design
FUTURE WORK

• model storms of various intensities
• compare rain gauge data to radar rainfall data
• optimize current detention basin structures
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