Pennypack Creek Watershed Act 167 Study

Progress Report
December 17, 2009

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Model and GIS Development:
Temple Center for Sustainable Communities
Philadelphia Water Department – Office of Watersheds

Pennypack Act 167 Meeting

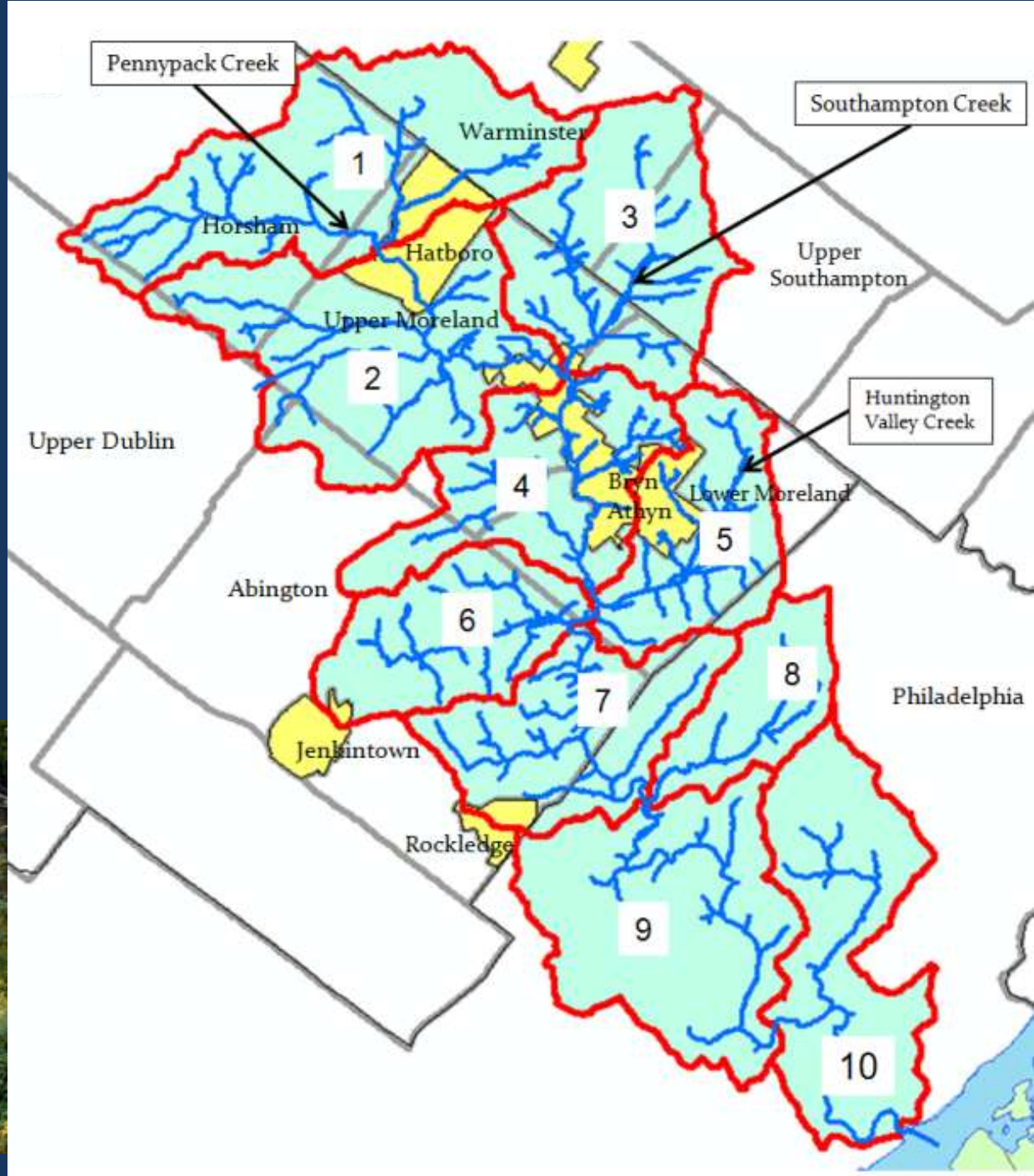
December 17, 2009

Progress Report Topics

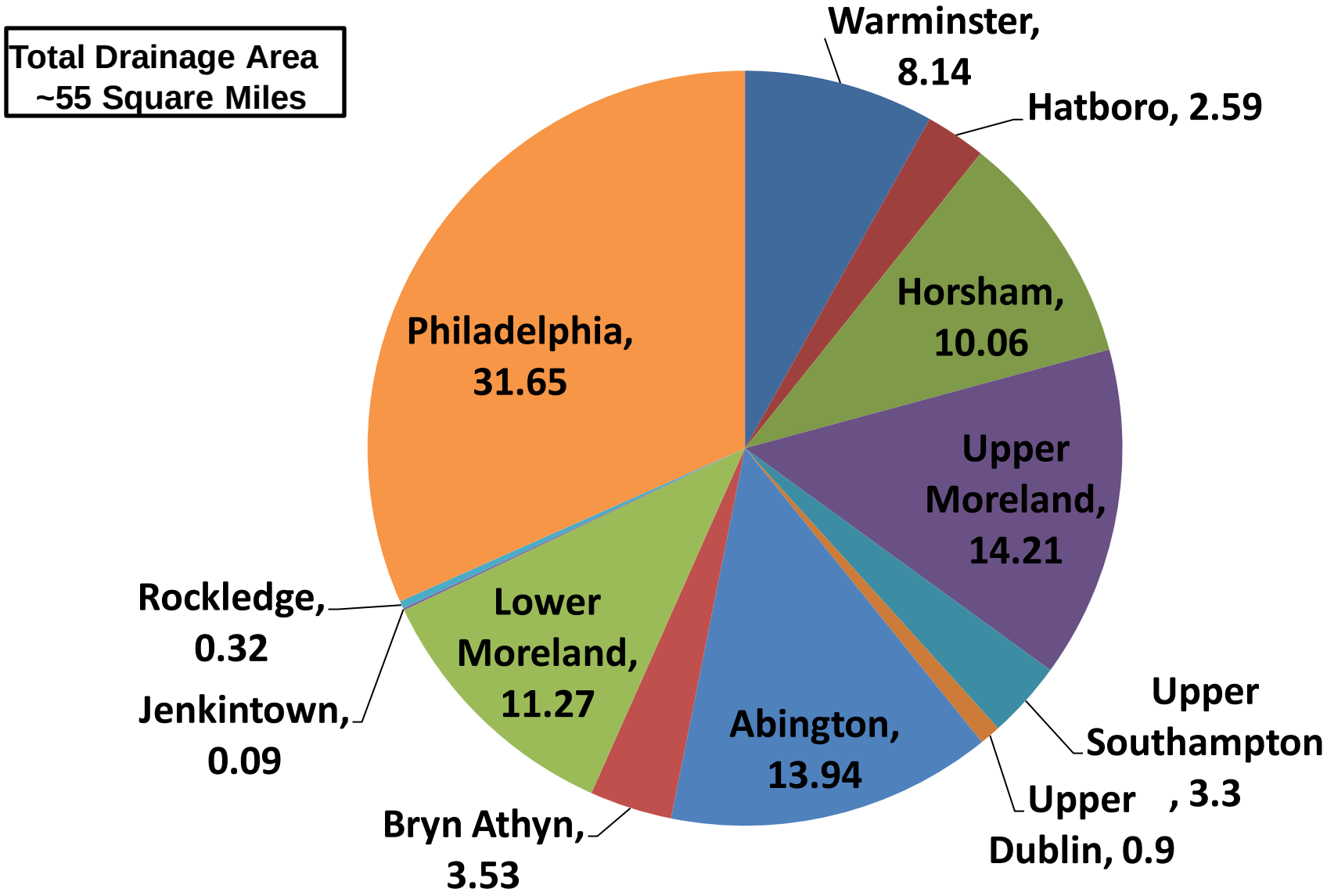
1) Model Development and Testing
2) Flooding in the Pennypack Watershed
3) Site Surveys and BMP Opportunities
4) Development Scenarios

Model Development and Testing

- Testing of Original 10 Subasin Hydrologic Model
- Development of Revised Hydrologic Model



Municipalities in the Pennypack Watershed (Percent of Drainage Area)



Testing of Original 10 Subasin Model

•The 10 subbasin model was originally calibrated for eight large storm events and used in the updated flood insurance study for the Pennypack.

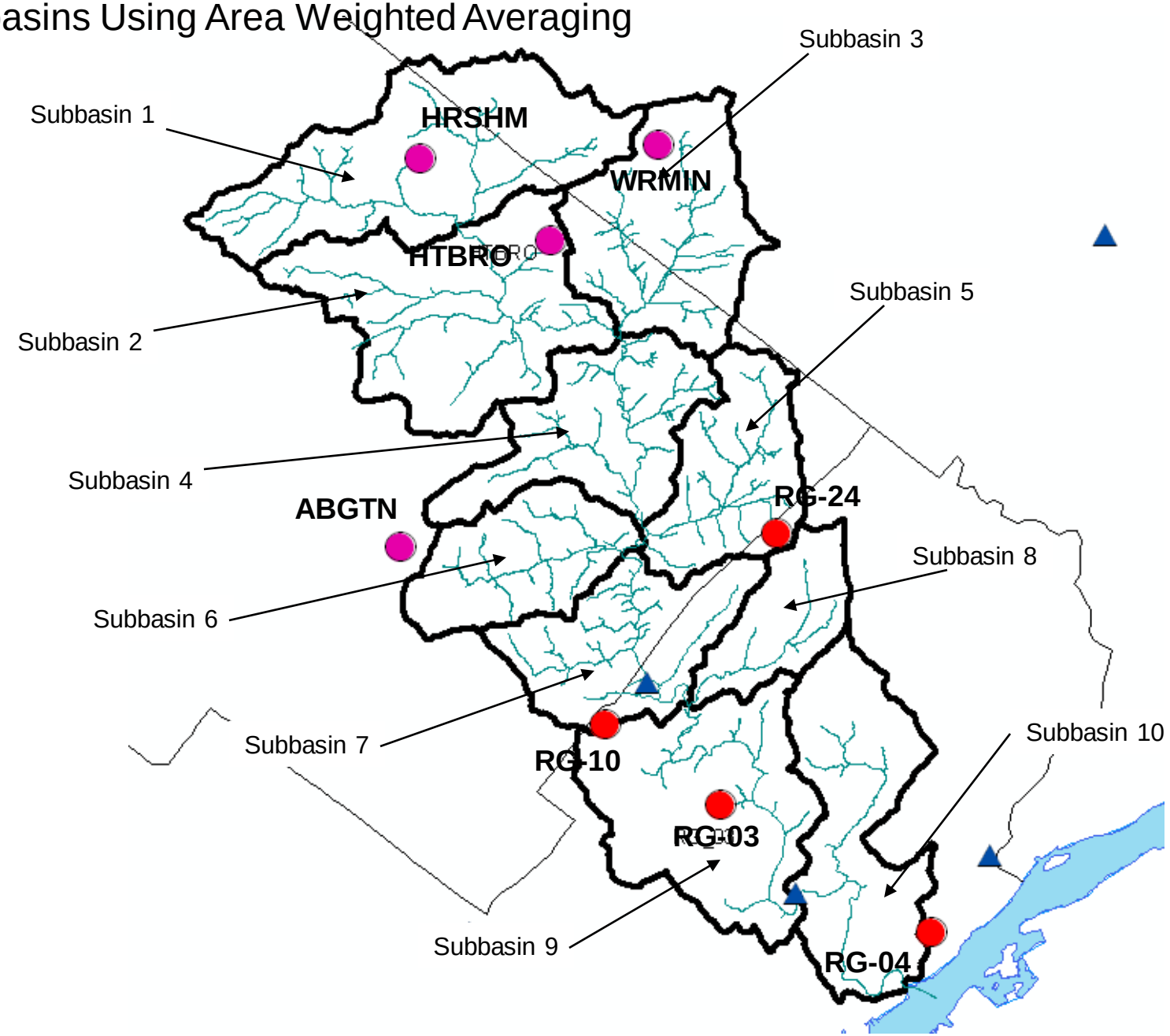
• With the assistance of the Philadelphia Water Department, the 10 subbasin model was tested for 2007 and 2008 precipitation events.

• 15-minute interval precipitation data measured at eight stations in or near the watershed was provided by the Water Department. Data for four of those stations was purchased by the Department from Weather Bug, Inc.

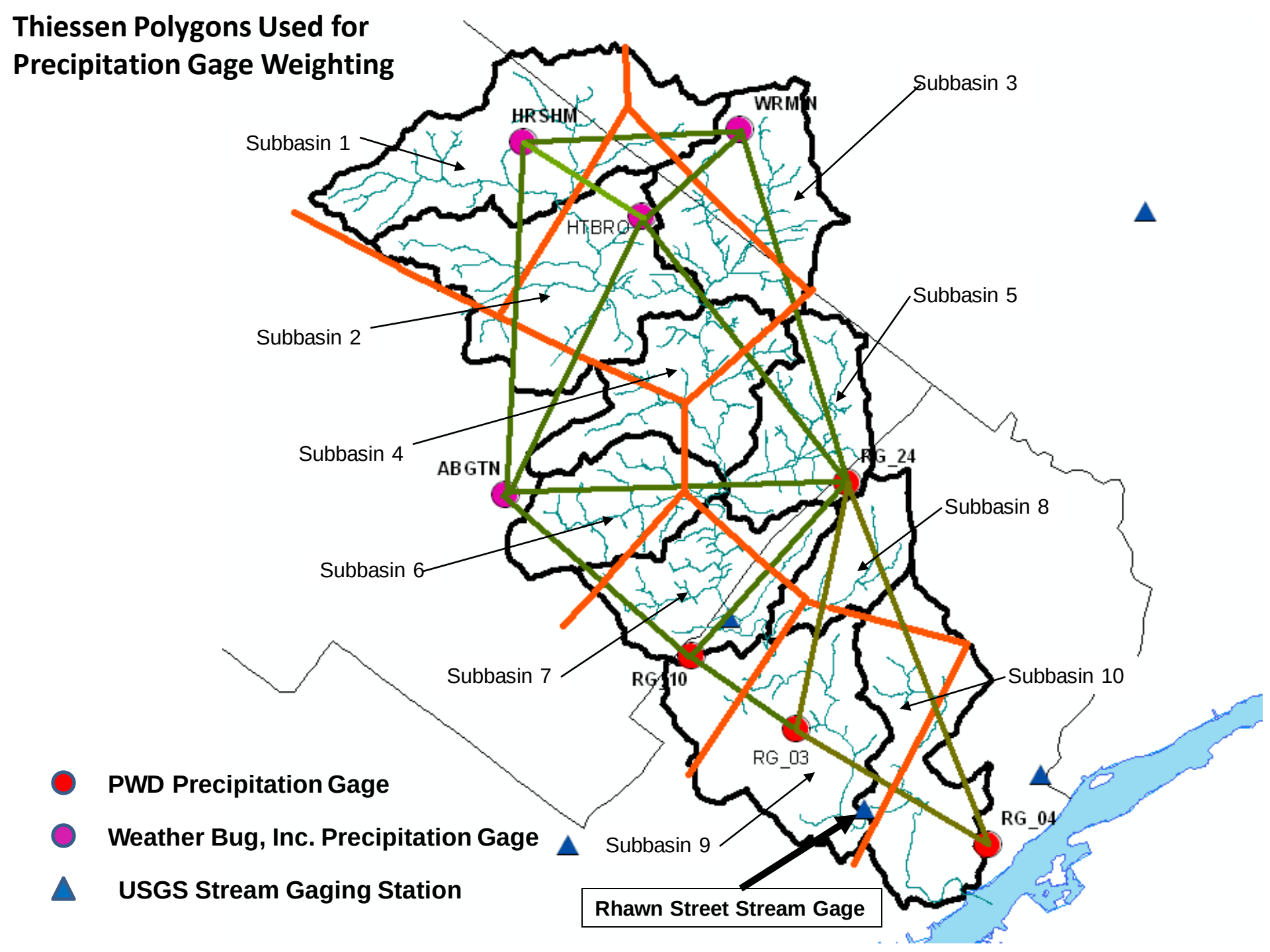
• Thiessen polygons were used to determine weightings for each gage and distribute the precipitation for each event to the 10 subbasins.

• The USGS stream gaging station at Rhawn Street was used to compare predicted vs. observed data for 60 precipitation events.

Rain Observed at Stations was Distributed
Over the 10 Subasins Using Area Weighted Averaging



Thiessen Polygons Used for Precipitation Gage Weighting



Weightings for Precipitation Gages

Weightings are the fractions of a subasin that are assigned to a particular gage

Precipitation Gages

		HRSHM	WRMIN	HTBRO	ABGTN	RG3	RG10	RG24	RG4
Subbasin 1		0.789	0.128	0.083					
Subbasin 2		0.281		0.569	0.150				
Subbasin 3			0.582	0.418					
Subbasin 4				0.361	0.308			0.332	
Subbasin 5								1.000	
Subbasin 6					0.828		0.093	0.079	
Subbasin 7					0.025		0.752	0.222	
Subbasin 8						0.082	0.086	0.832	
Subbasin 9						0.814	0.186		
Subbasin 10						0.360		0.101	0.539

*The model was run for 2007 and 2008 rainfall events.

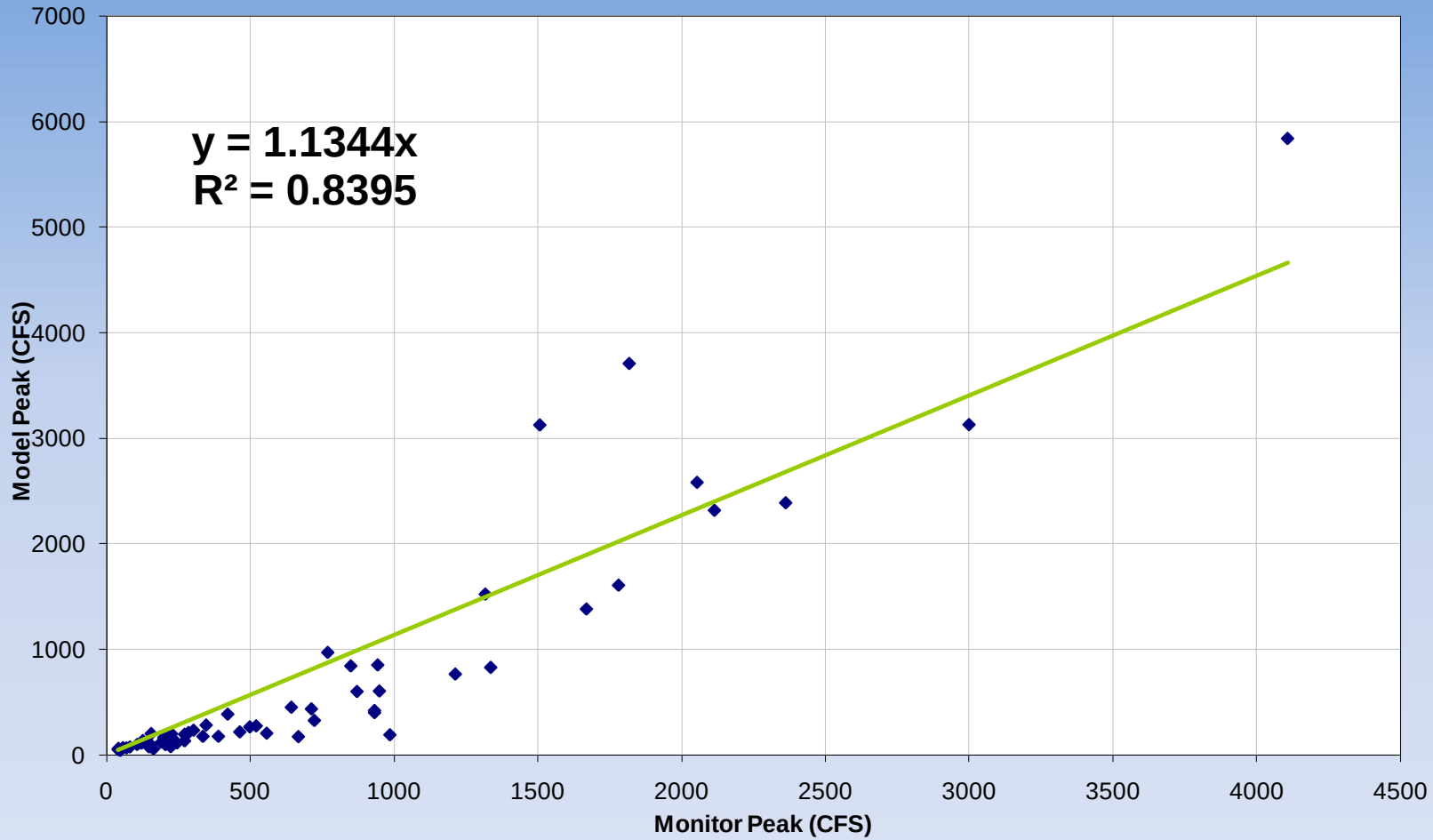
*60 different events were modeled.

*Predicted peak flow and volume from the model were compared to observed data at the USGS gaging station at Rhawn Street.

Test Results for Sixty Precipitation Events – 2007-2008

The model output for each of 60 events and compared to Observed Data

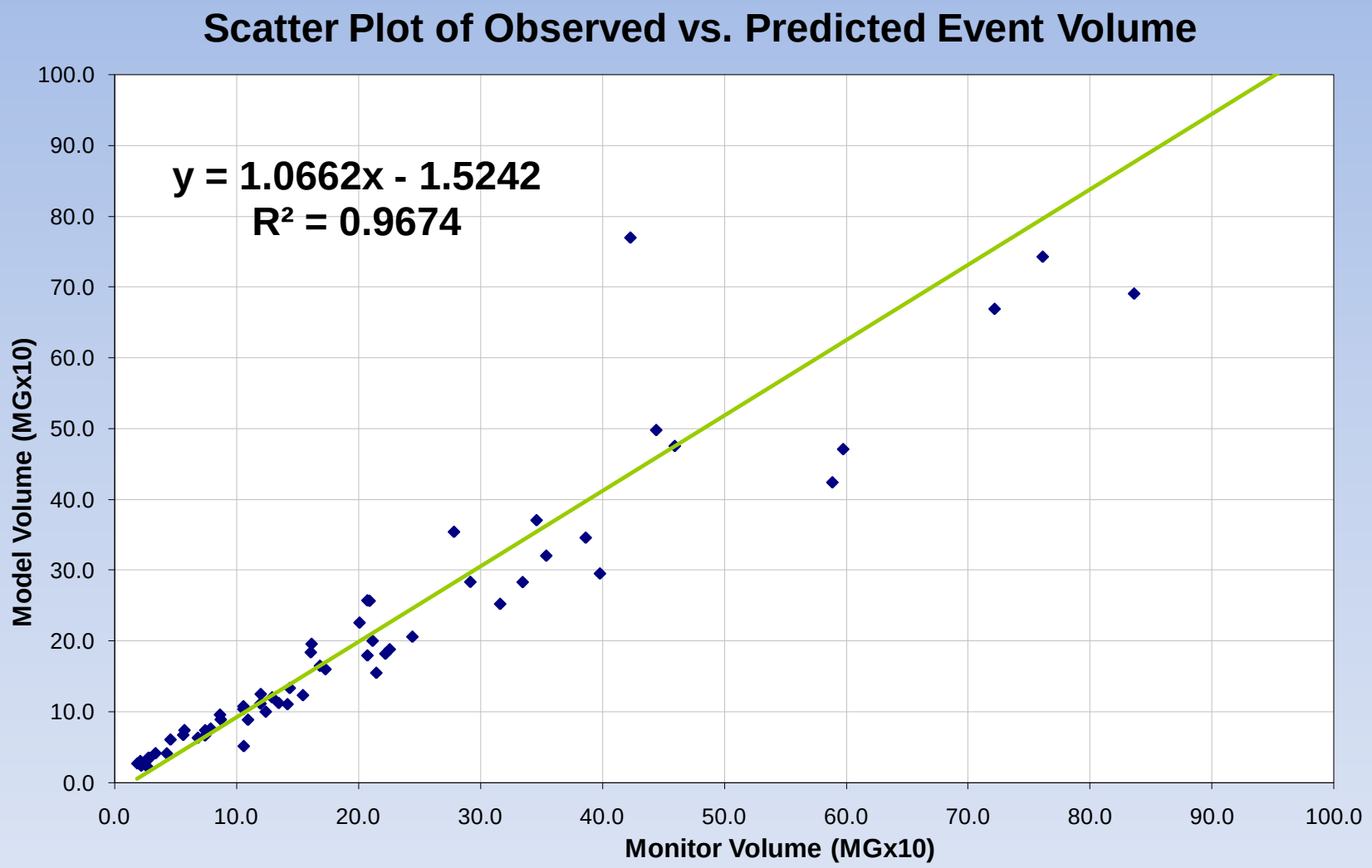
Scatter Plot of Observed vs. Predicted Peak Flows



Observed flow at USGS Stream Gage at Rhawn Street

Analysis of results was performed by the Philadelphia Water Department

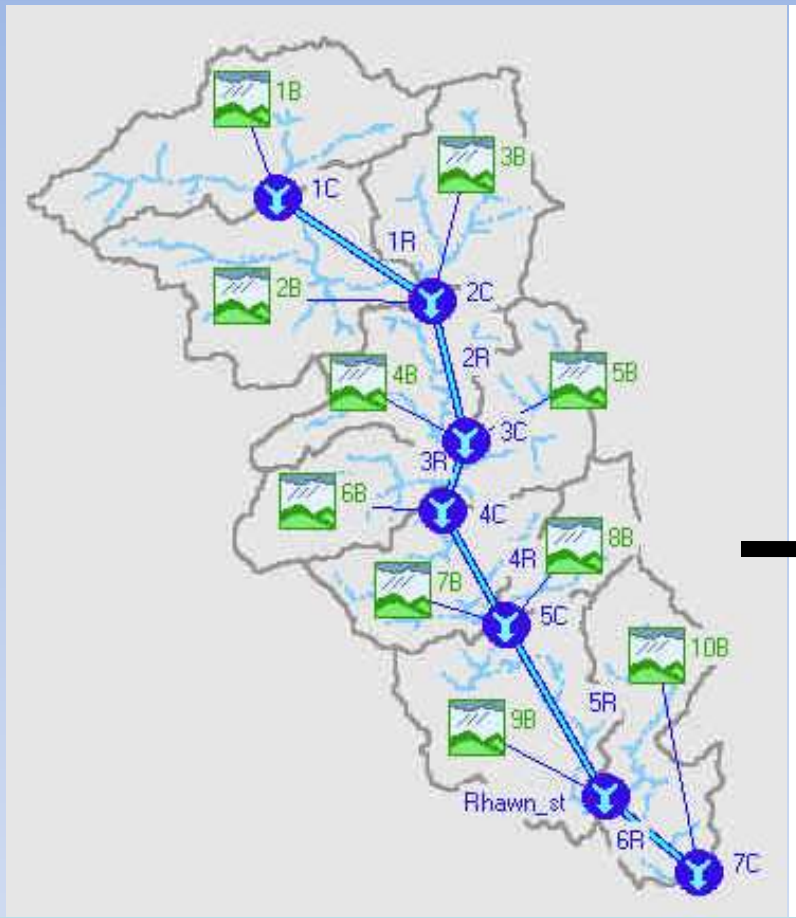
Test Results for Sixty Precipitation Events – 2007-2008

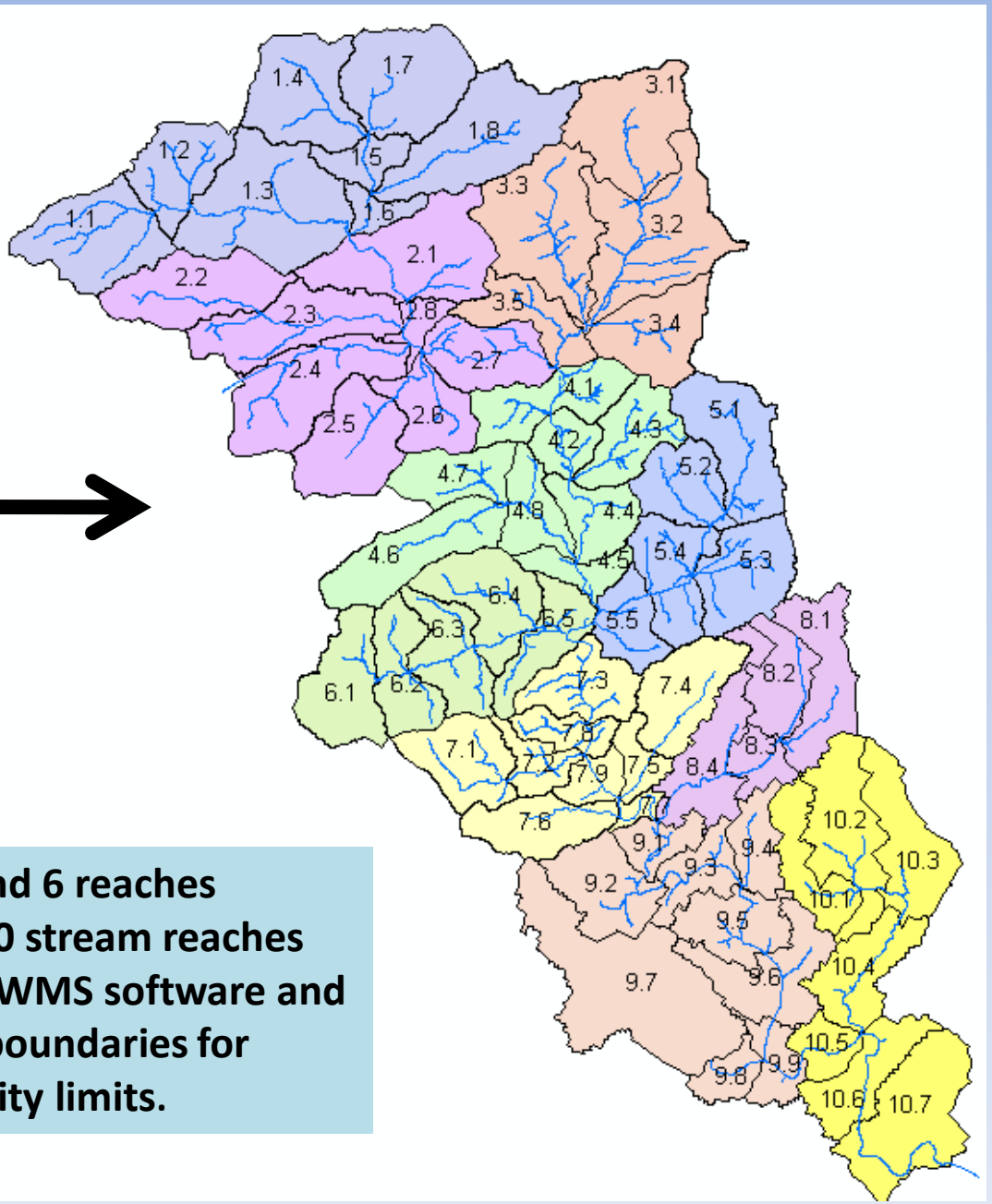


Observed volume at USGS Stream Gage at Rhawn Street

Analysis of results was performed by the Philadelphia Water Department

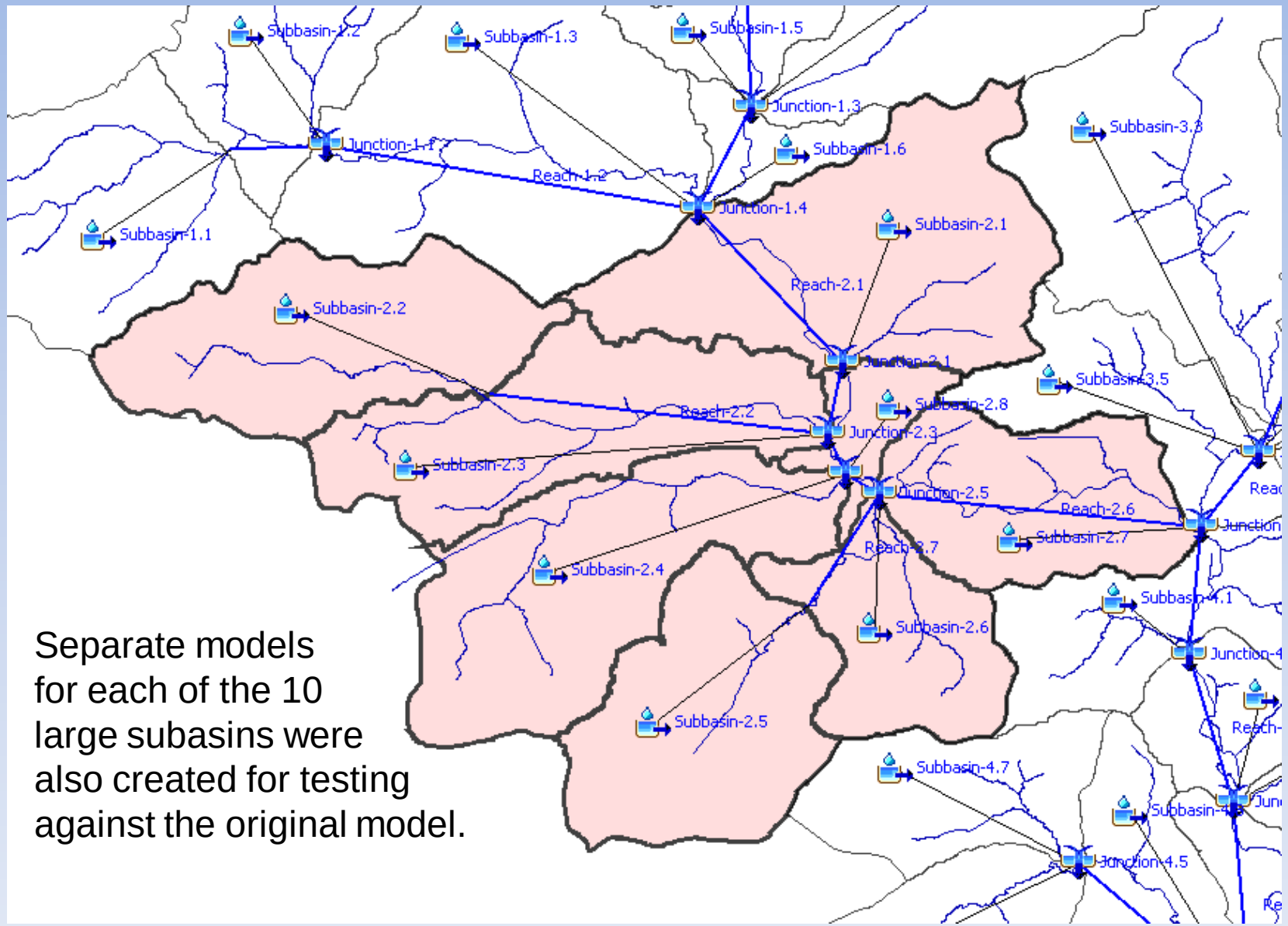
Pennypack Watershed Delineation for Detailed Model





- The Original model had 10 subasins and 6 reaches
- The new model has 68 subasins and 50 stream reaches
- Small subasins were delineated using WMS software and were edited using ArcMap and PWD boundaries for sewer sheds within the Philadelphia city limits.

The new hydrologic model was developed using HEC-HMS and the NRCS Curve Number Method for the 68 subasins

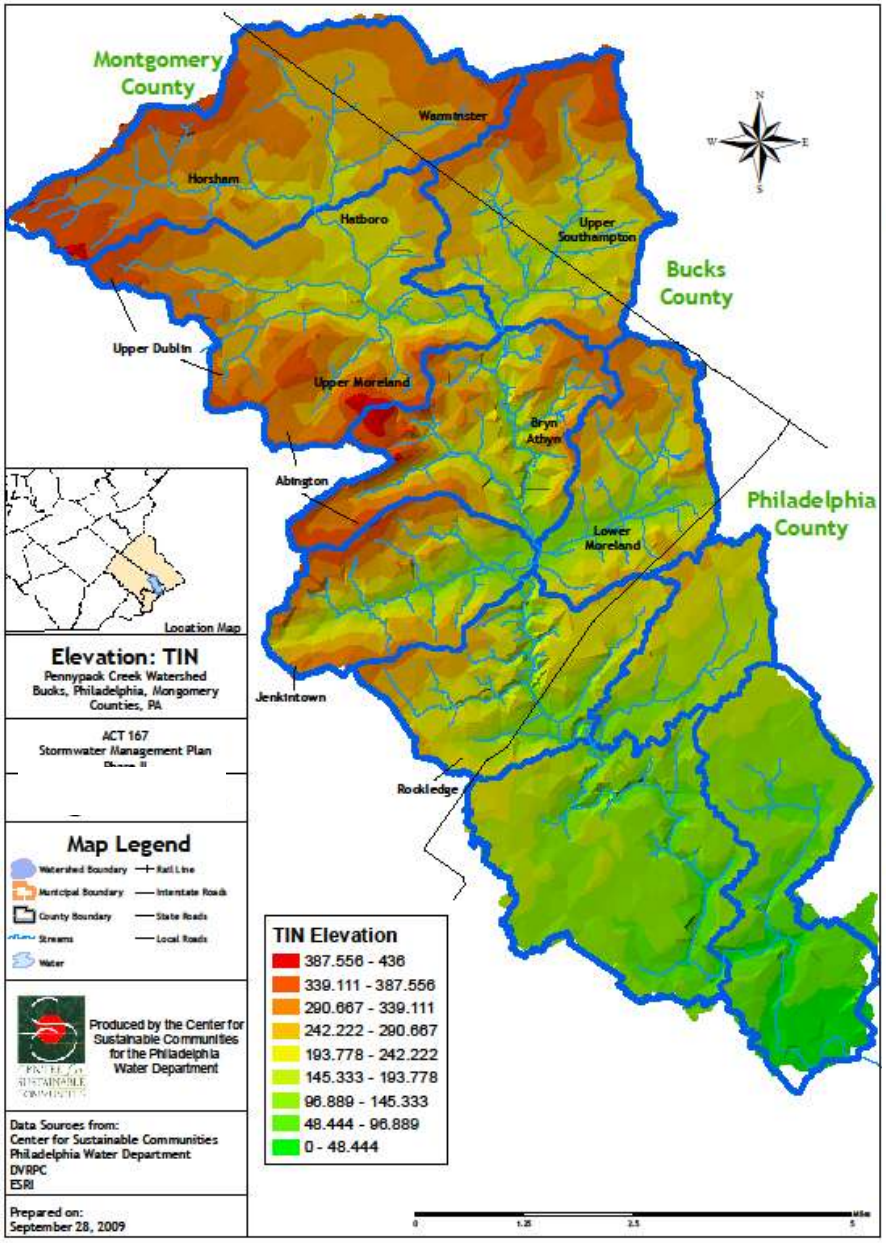


Separate models for each of the 10 large subasins were also created for testing against the original model.

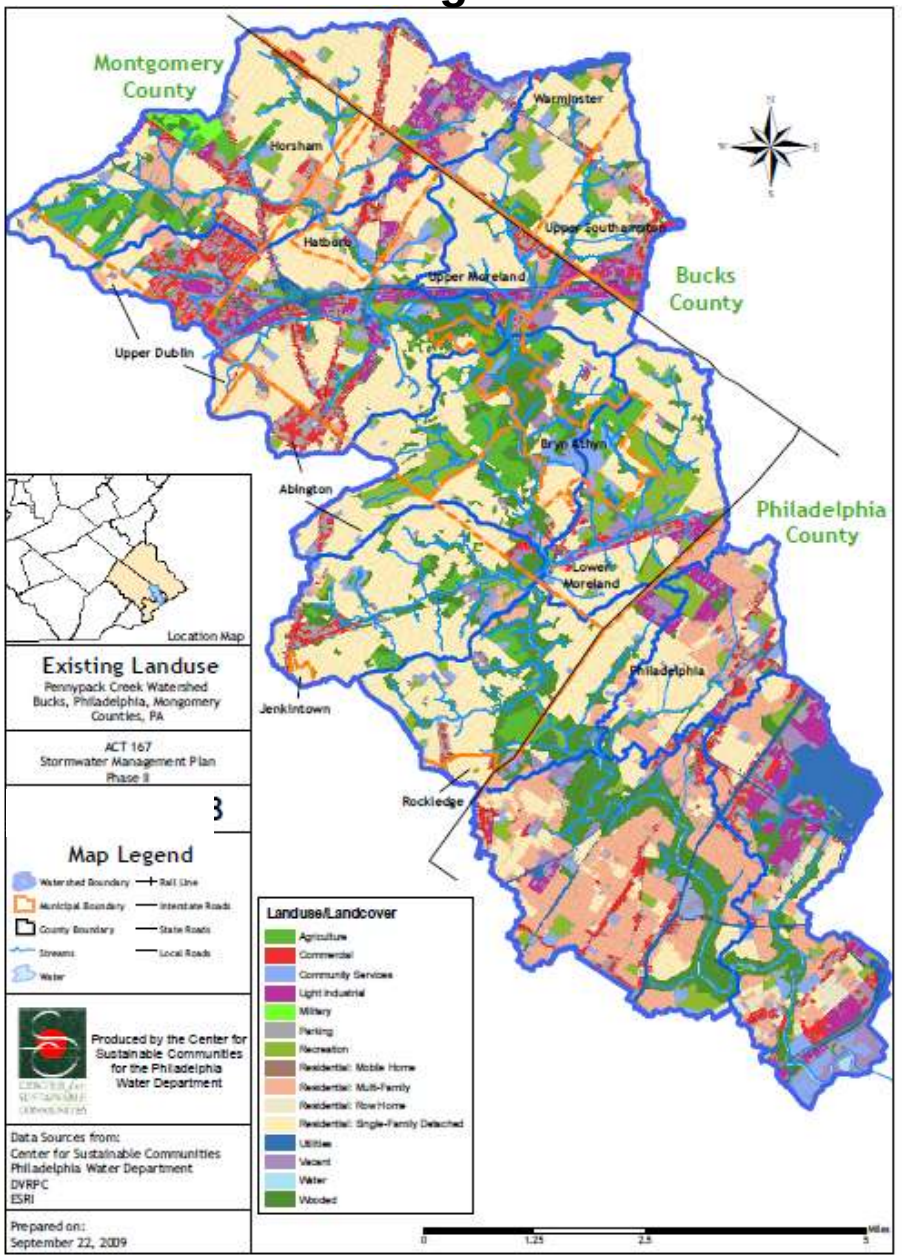
Physical Characteristics of the Pennypack Watershed

Dense Development with Open Main Stem Corridor in Mid and Lower Reaches

Elevation

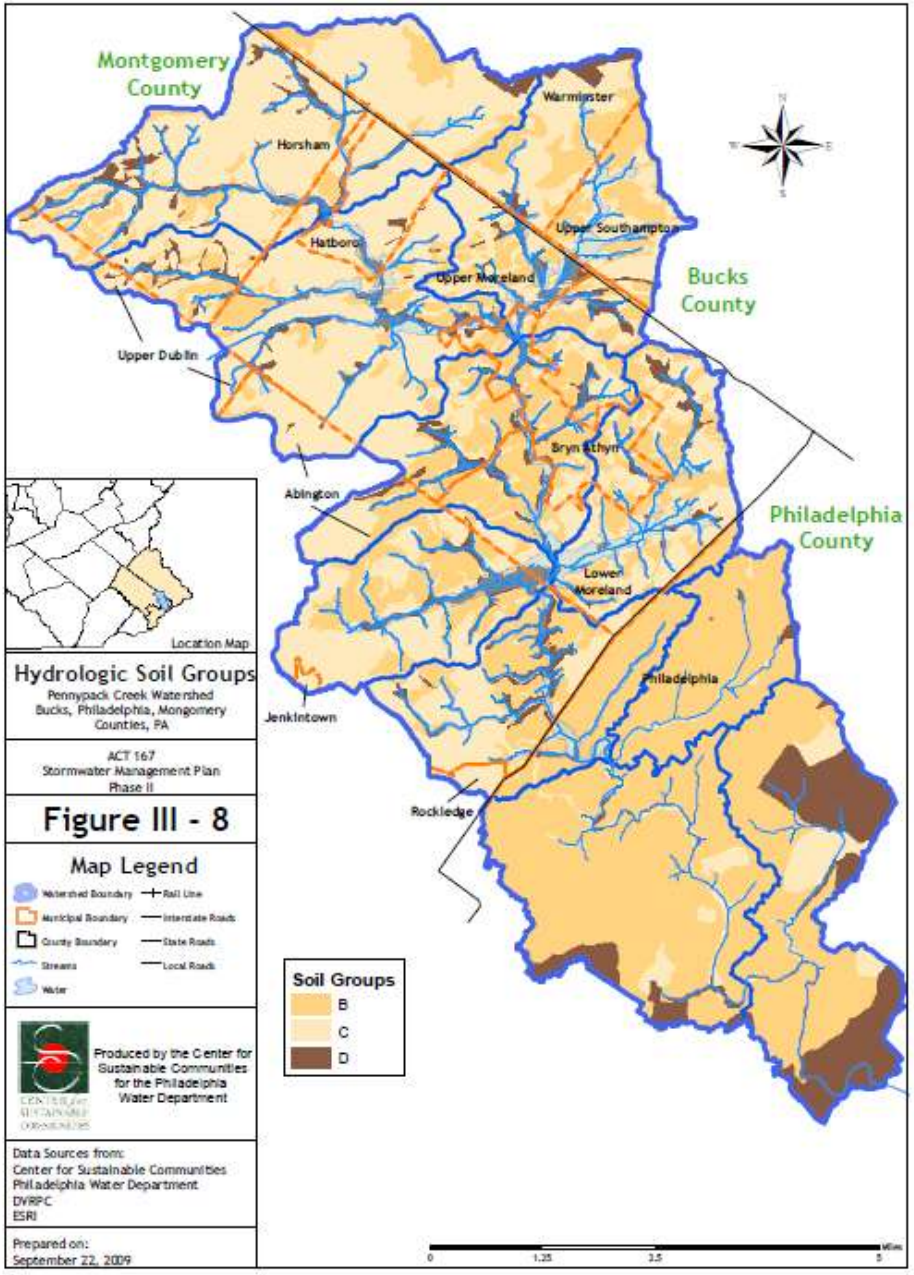


Existing Land Use

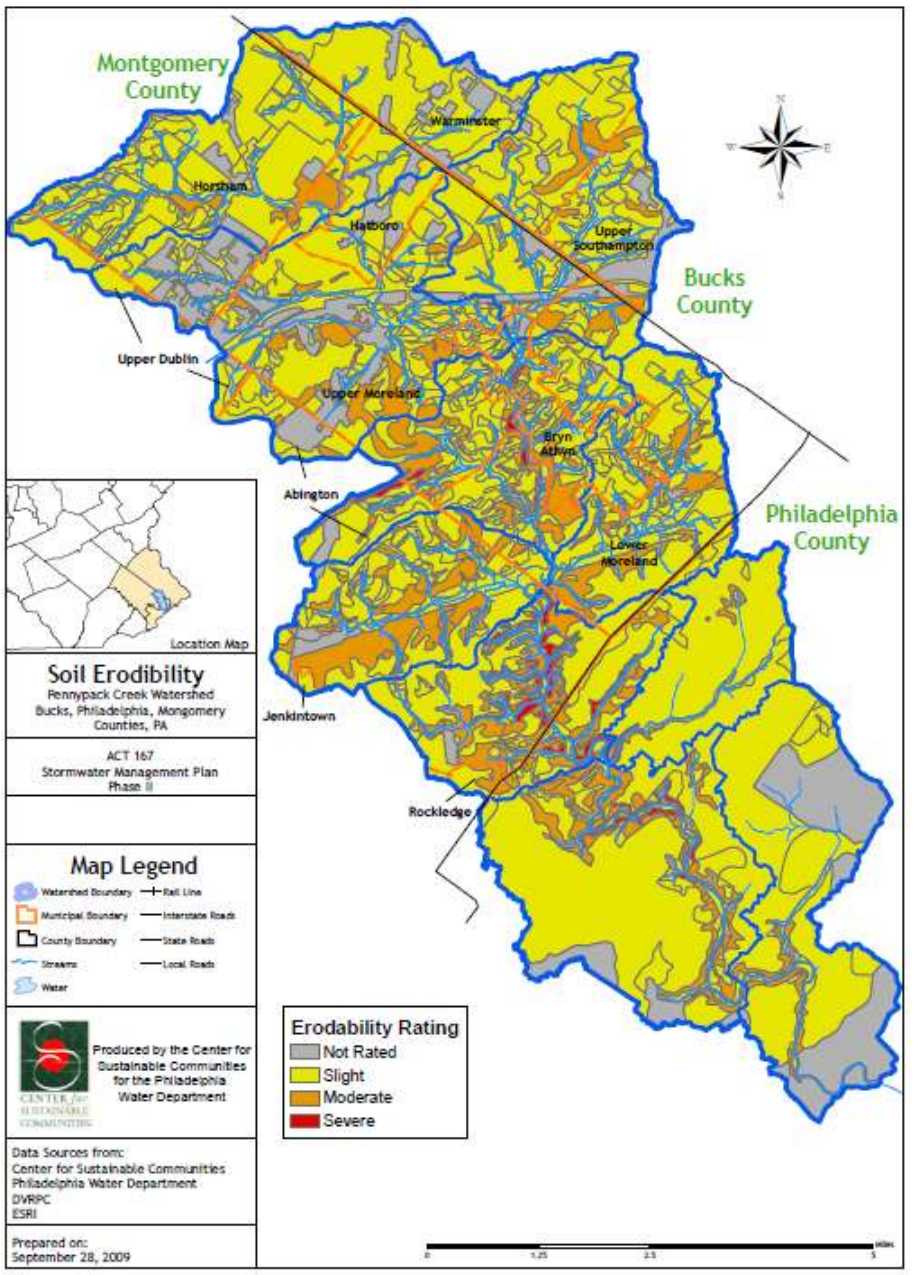


Physical Characteristics of the Pennypack Watershed

Hydrologic Soil Group



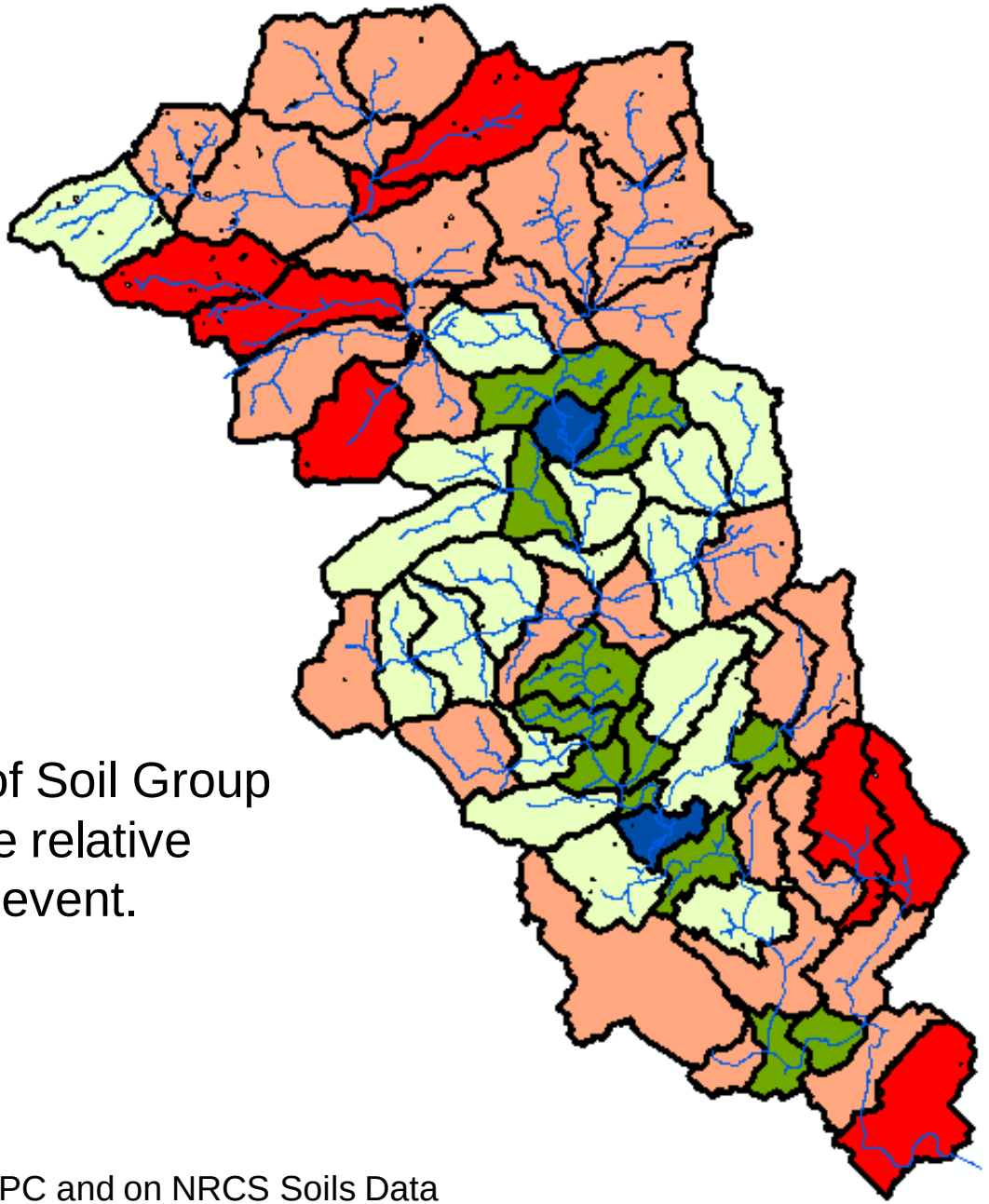
Soil Erodibility Rating



Pennypack Watershed Runoff Curve Numbers Composite Values for 2005 Land Use

(Includes Impervious Cover)

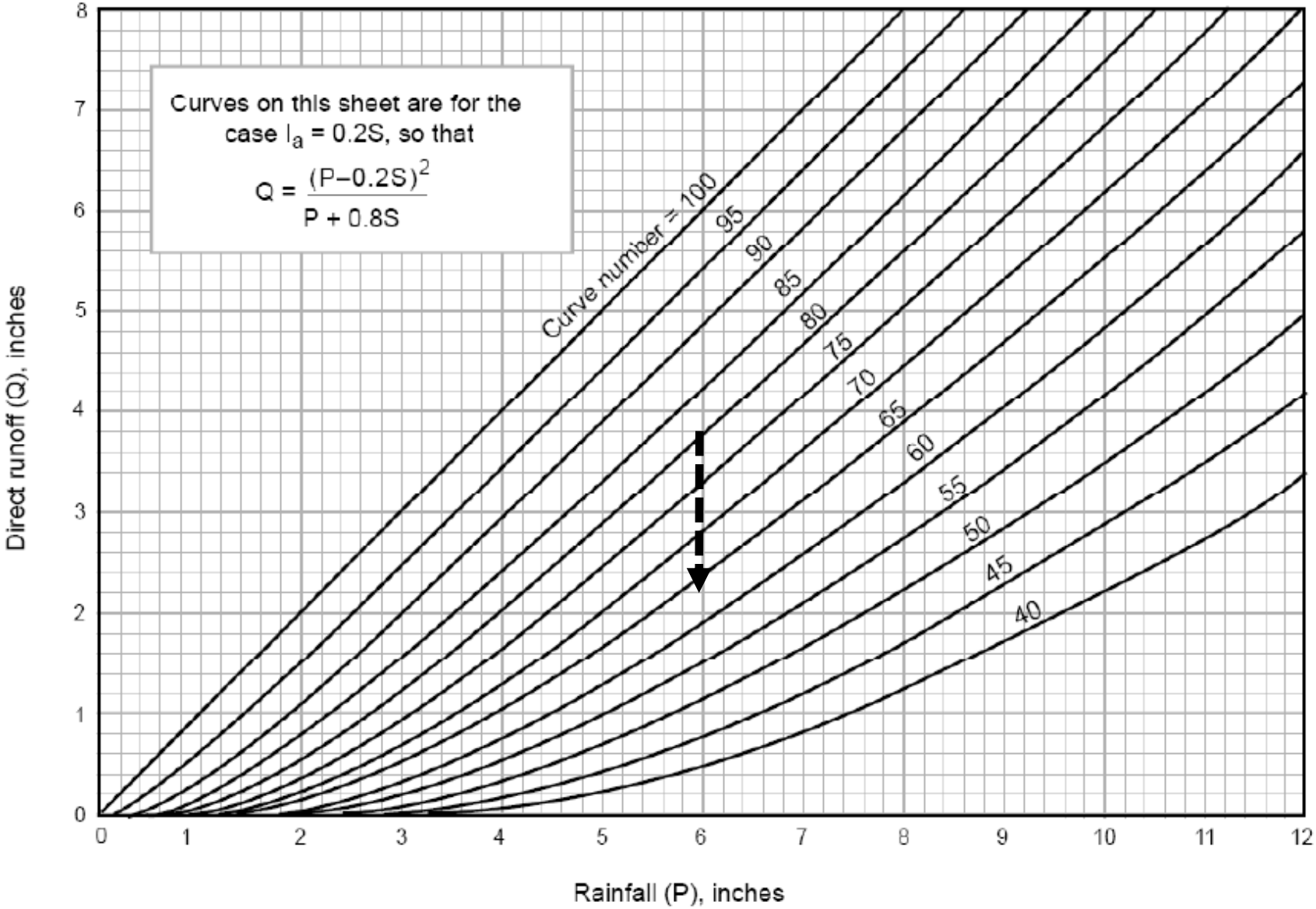
- Less than 70
- 70-75
- 75-80
- 80-85
- Greater than 85



Curve Numbers are a function of Soil Group and land use and determine the relative runoff volume for a given storm event.

Based on 2005 Land Use Data from the DVRPC and on NRCS Soils Data

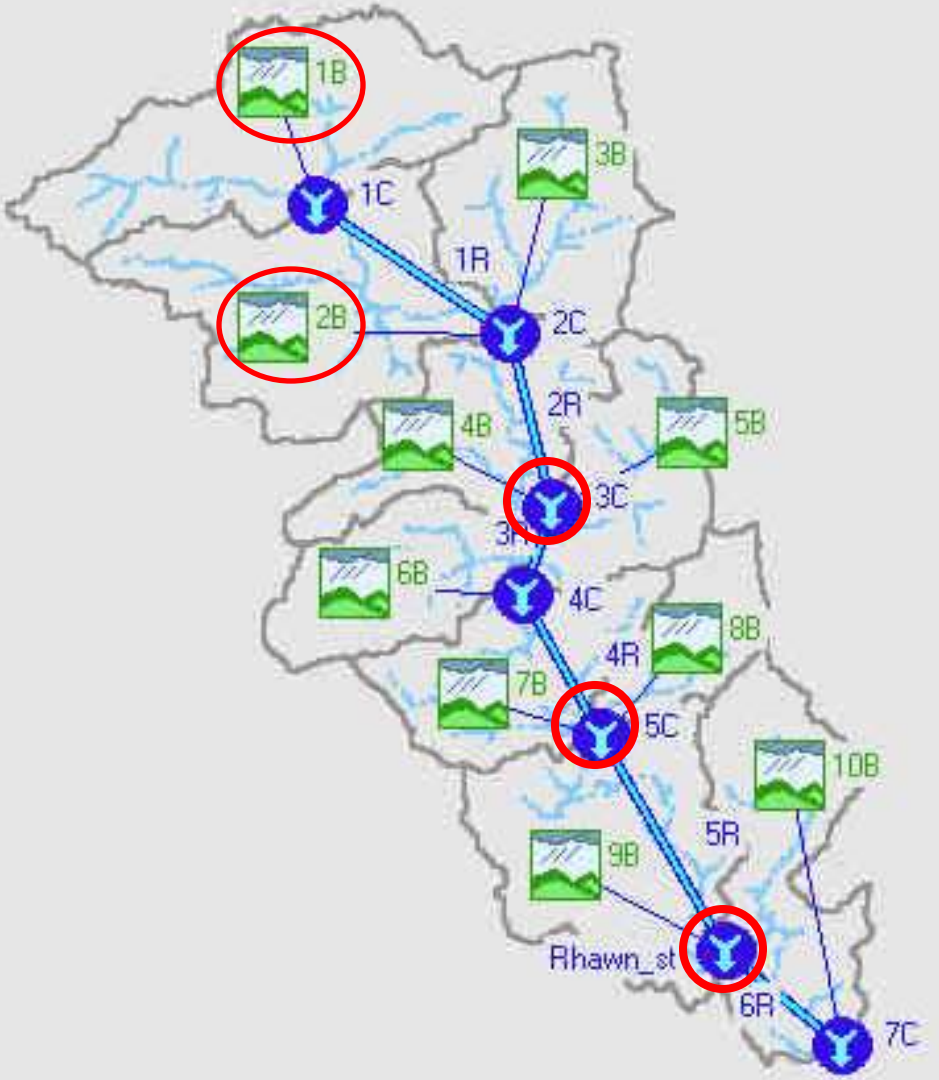
Figure 2: Solution of the NRCS runoff equation



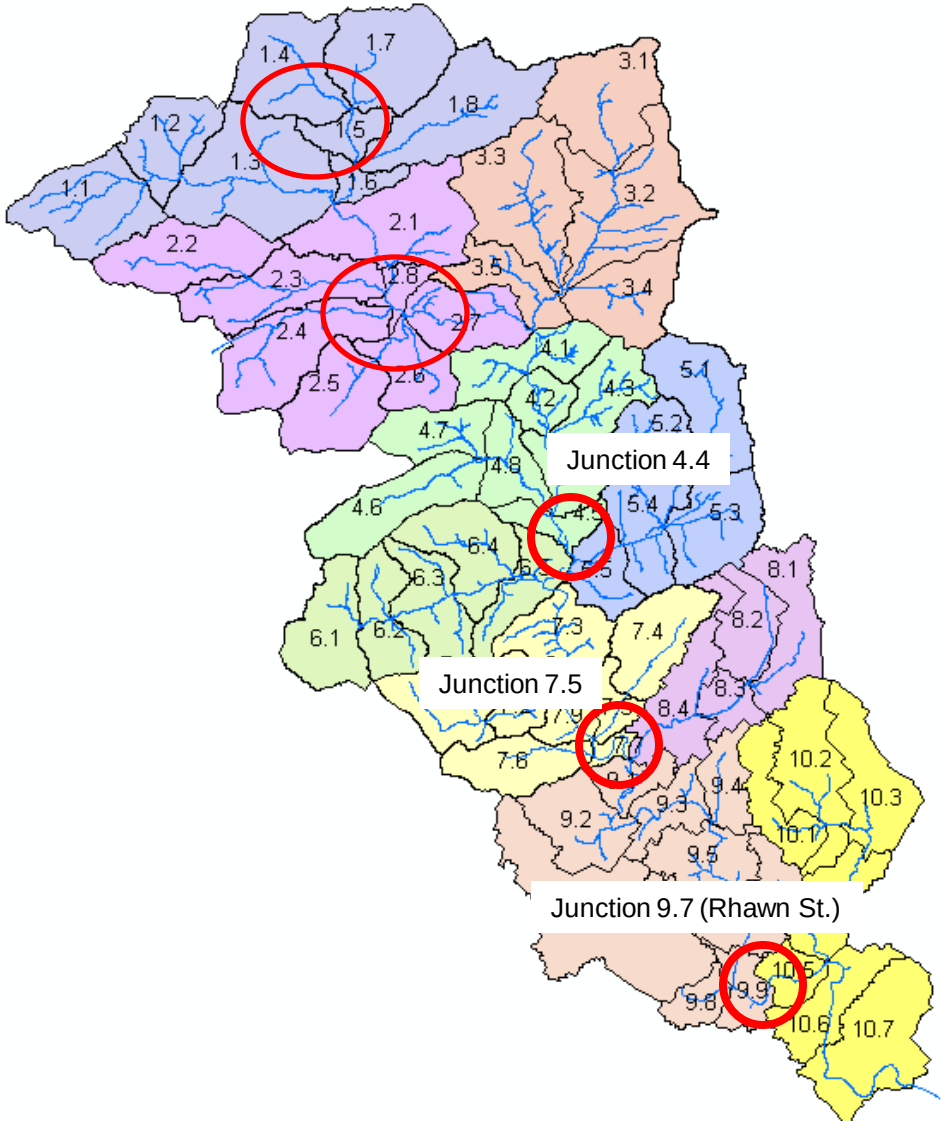
Comparison of Model Results for Design Storms – Pennypack Creek Watershed

-Peak flows and volumes for 1 year thru 500 year events have been compared at junctions and for large subasin outlets

Original 10 Subasin Model

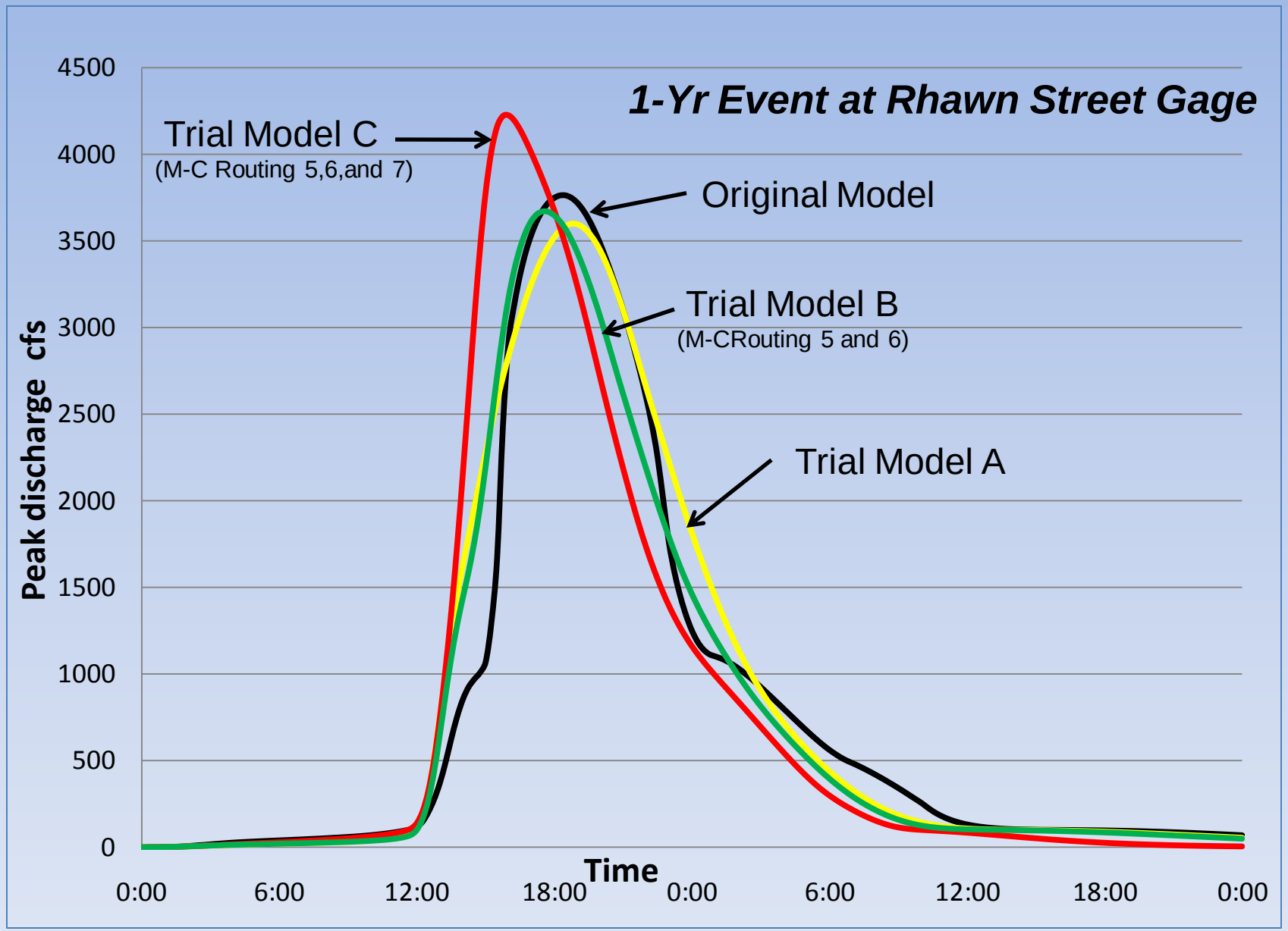


Detailed Model – 68 Subasins

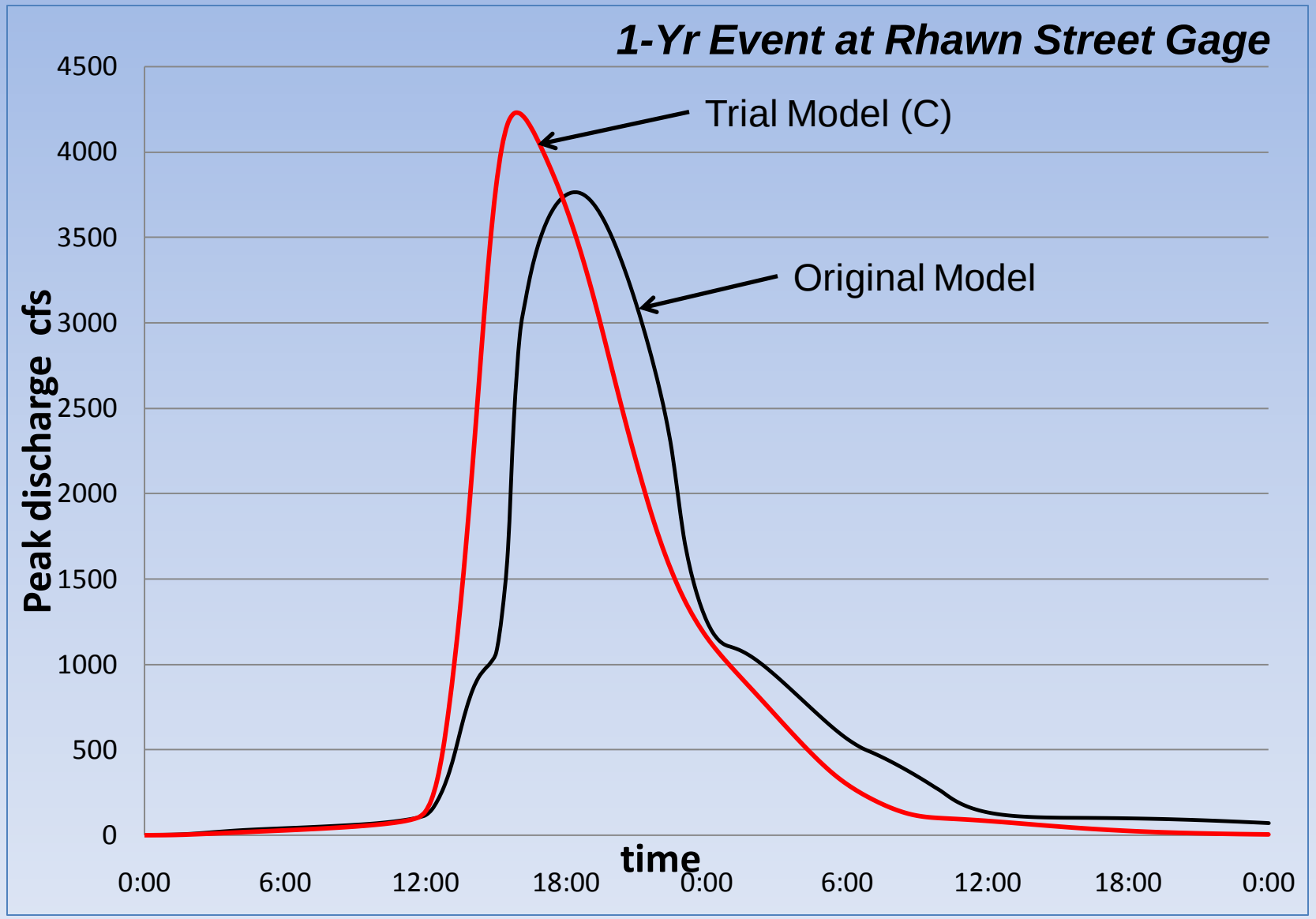


Several Versions of the Model Have Been Tested to Obtain the Best Overall Match

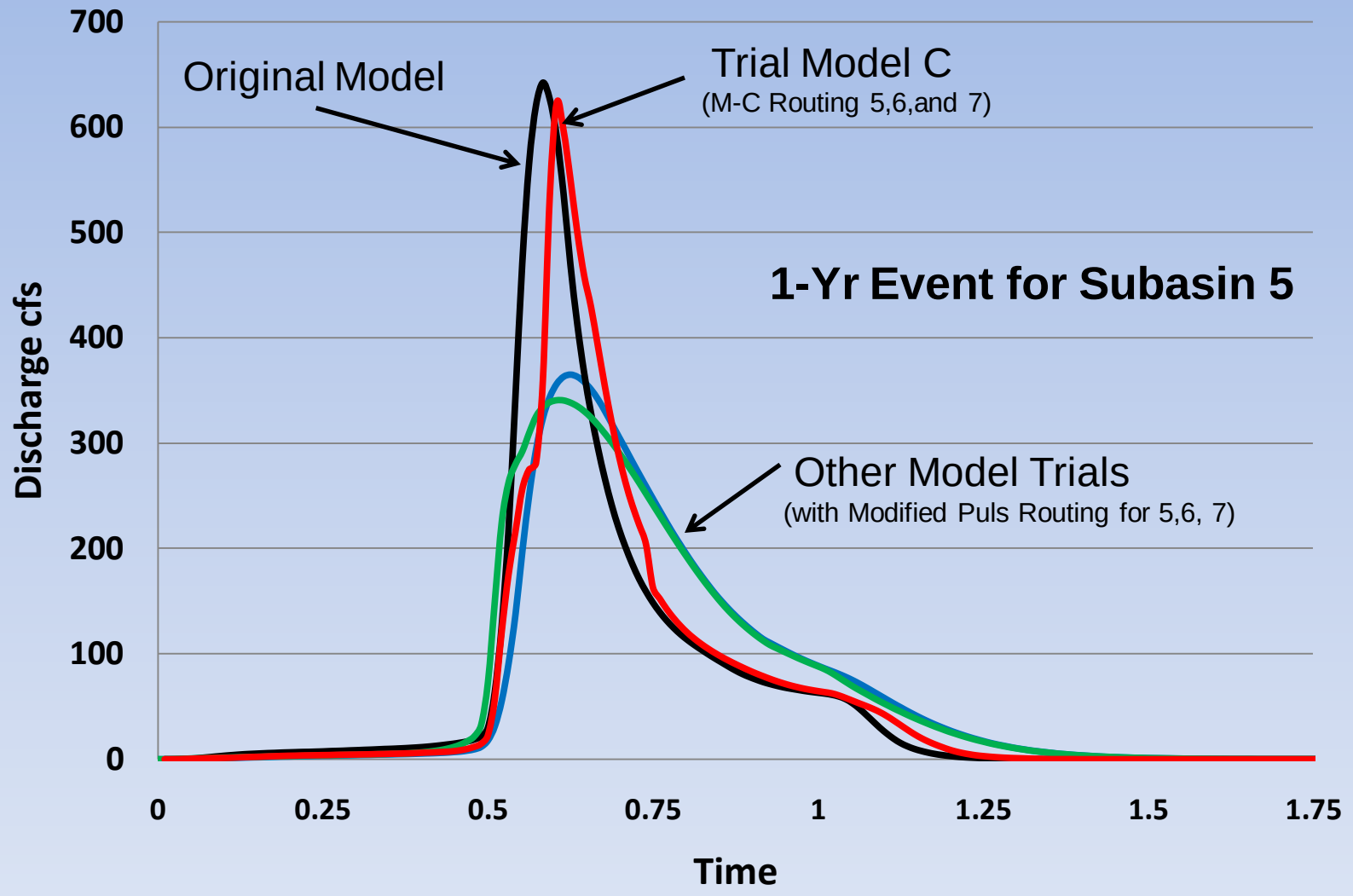
Subasin Lag Times, Initial Abstraction, and Reach Routing Methods Have Been Varied



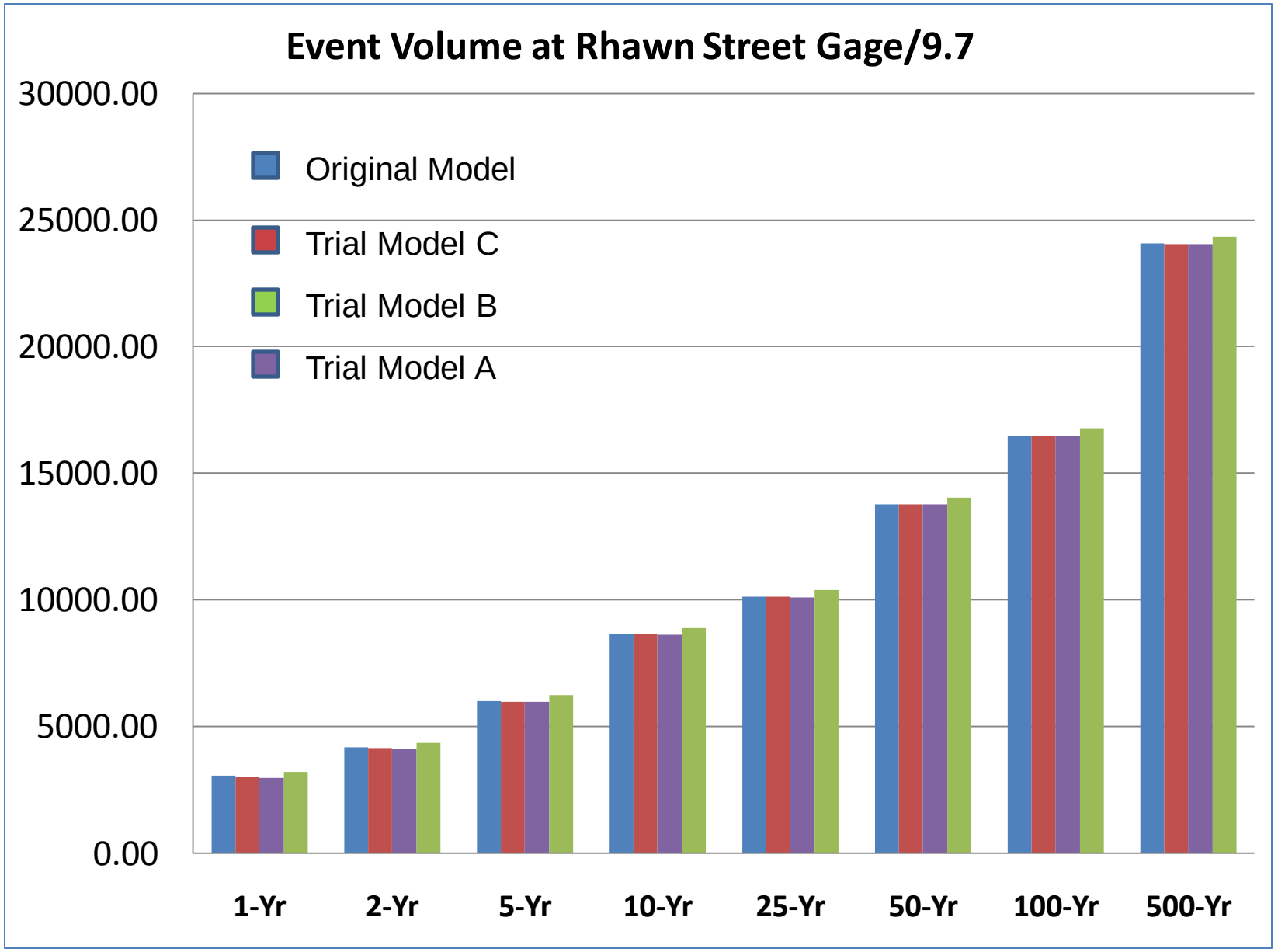
Particular Attention Has Been Given to the 1-Yr Storm Event



Although it Overpredicts Peak Flows at Rhawn Street, Trial Model C Provides The Best Overall Peak Flow Match for the Individual Subasins.



Storm Volumes Match Closely for All Events and Model Versions
In the Absence of Subasin Gages, Trial Model C is the Most Conservative Approach



2) Flood Problems in the Pennypack Watershed

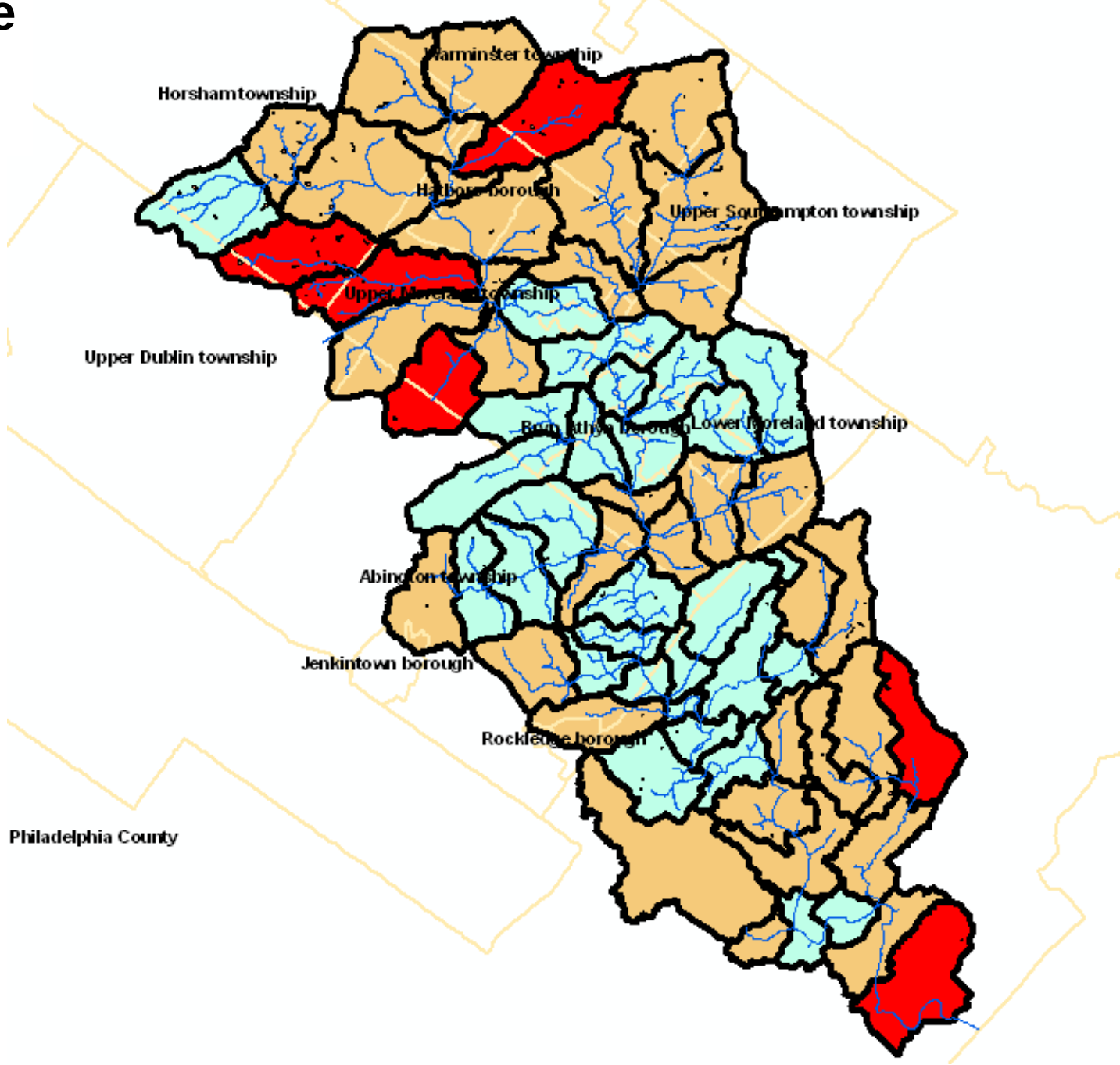
- Runoff Volumes from Smaller Storms
- Erosion
- Overtopping of Bridges
- Flood Damage to Property

Runoff Volume 1-Yr Storm

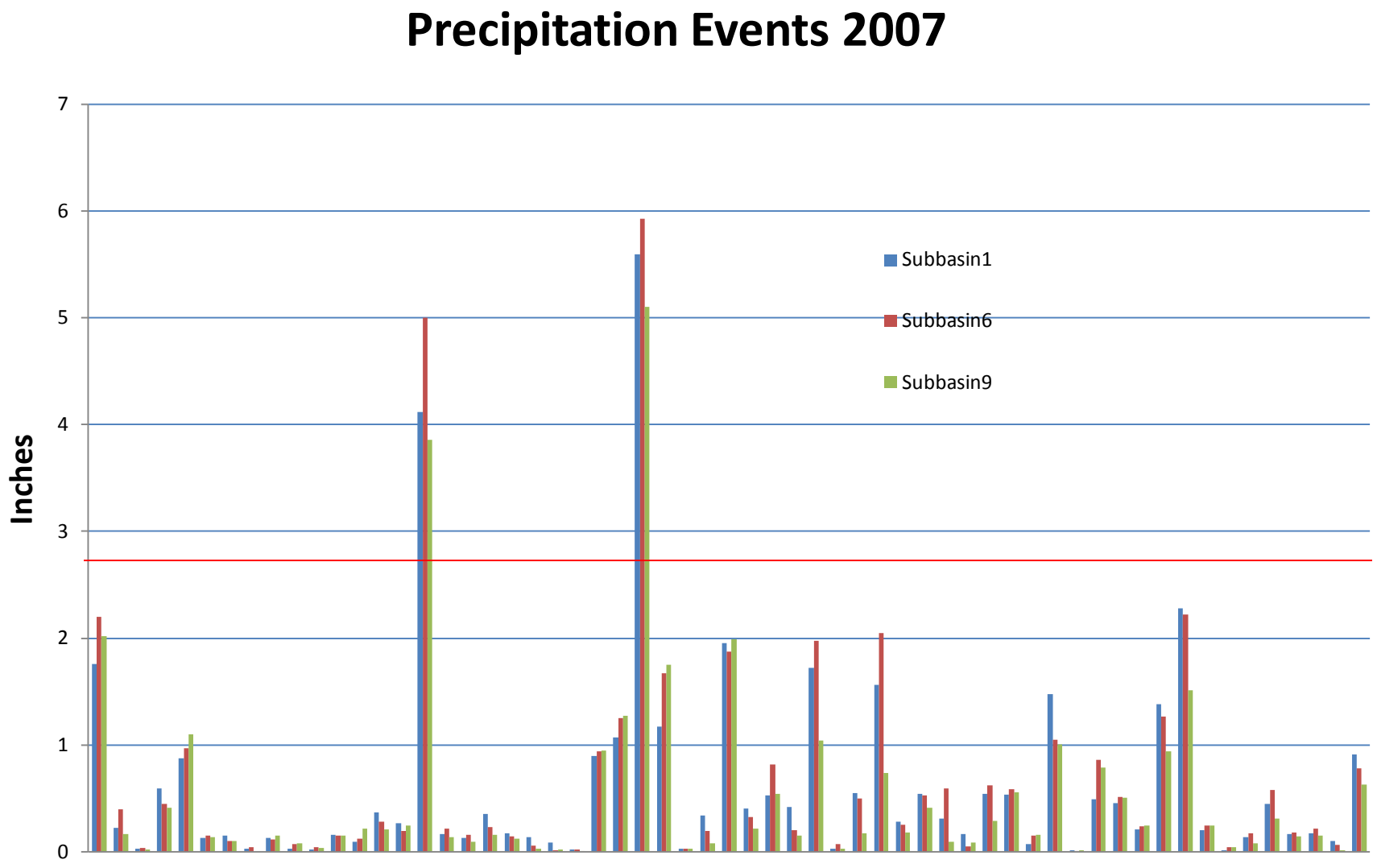
- Runoff > 1.5”
- Runoff = 1”-1.5”
- Runoff = .5”-1.0”

Runoff volumes are for a 24 hour design storm with 2.74” of rainfall.

1” of Runoff= 53.3 AF



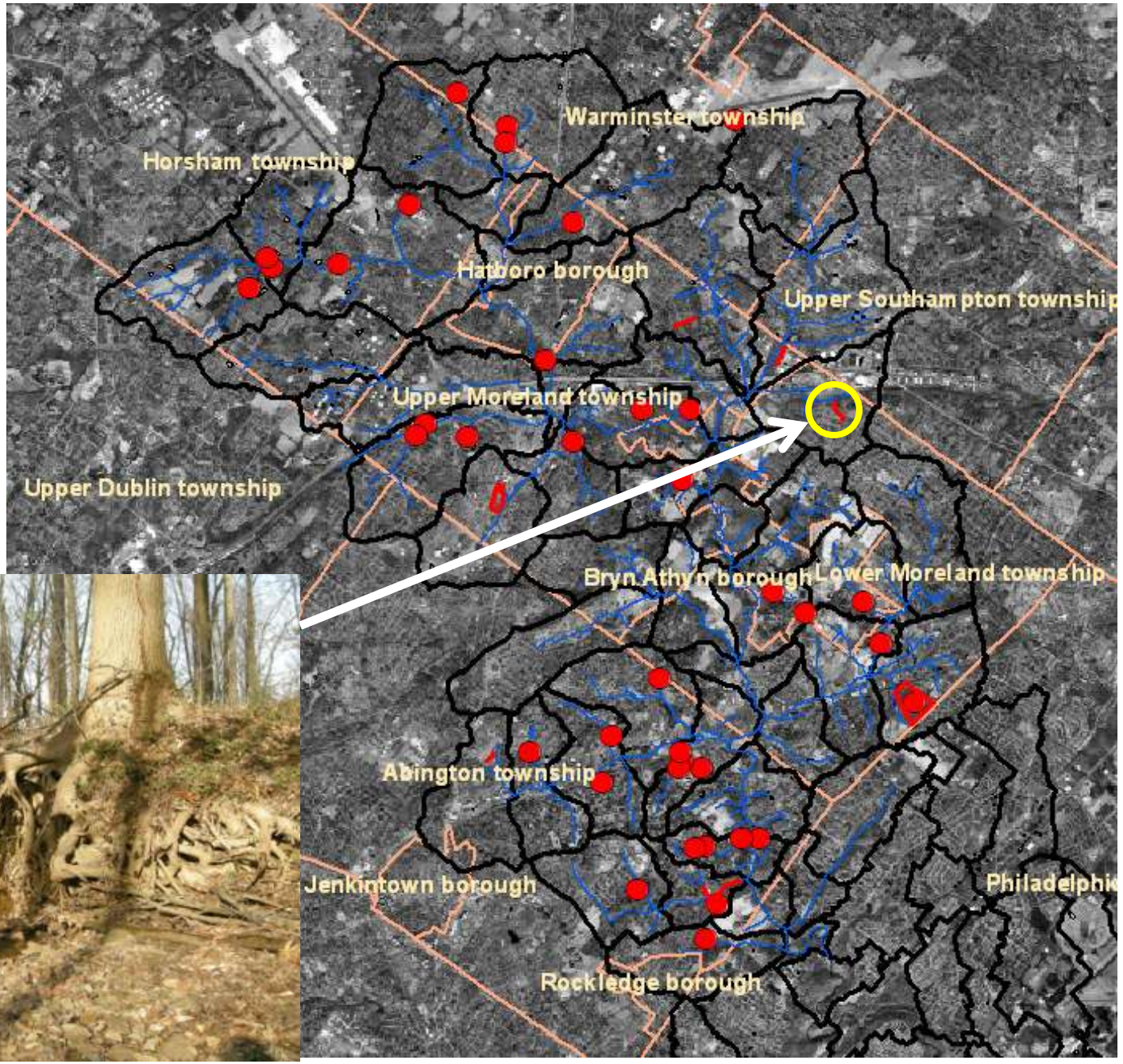
Many existing detention facilities do not retain significant runoff from small events. These events account for a large portion of annual runoff volume.



Precipitation Data Provided by the City of Philadelphia Water Department

Erosion Problem Areas Identified From Field Observations

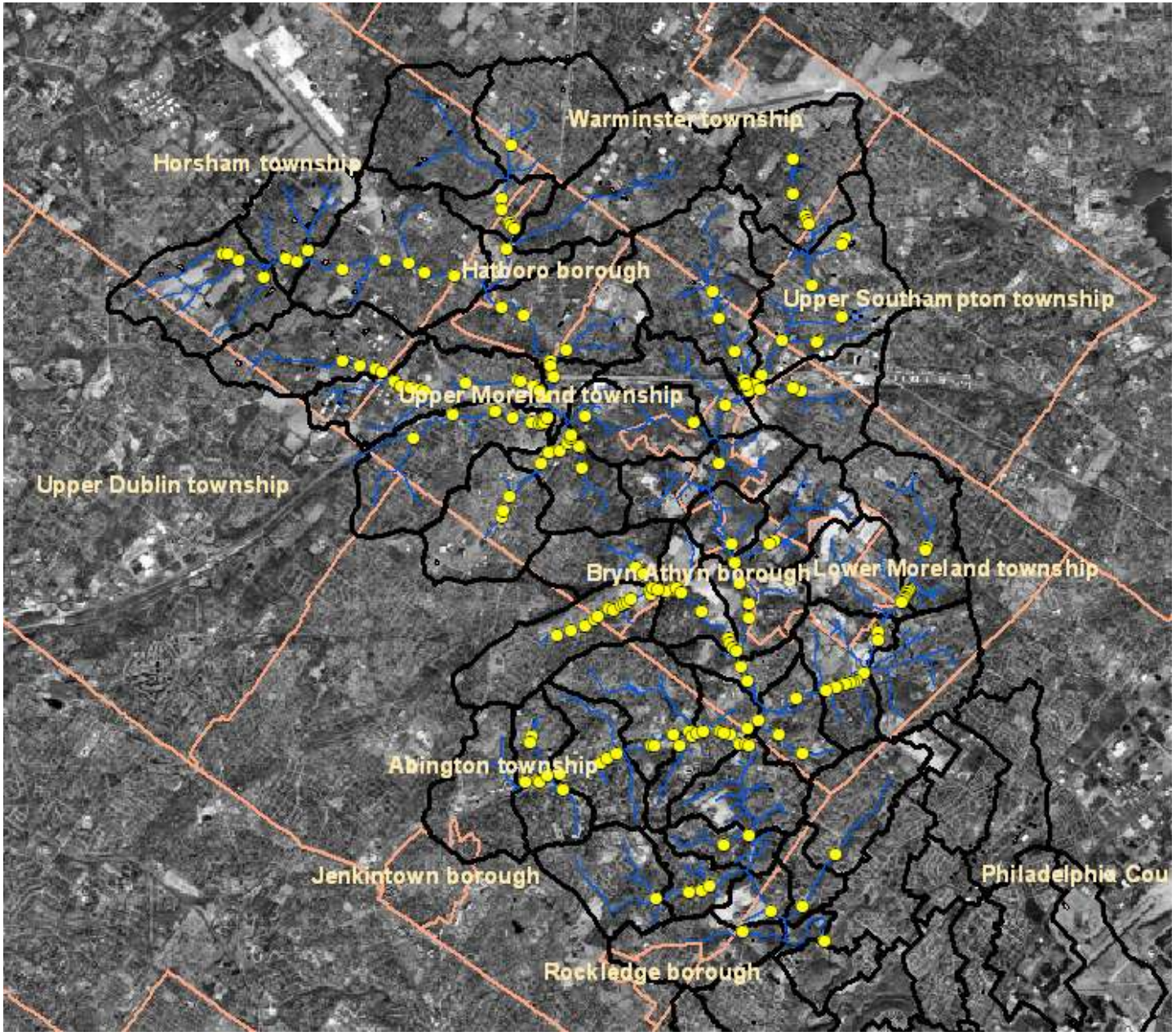
***Any additional municipal input on flood problem sites would be useful.**



Bridges and Overtopping

- Bridges included In HEC-RAS Model

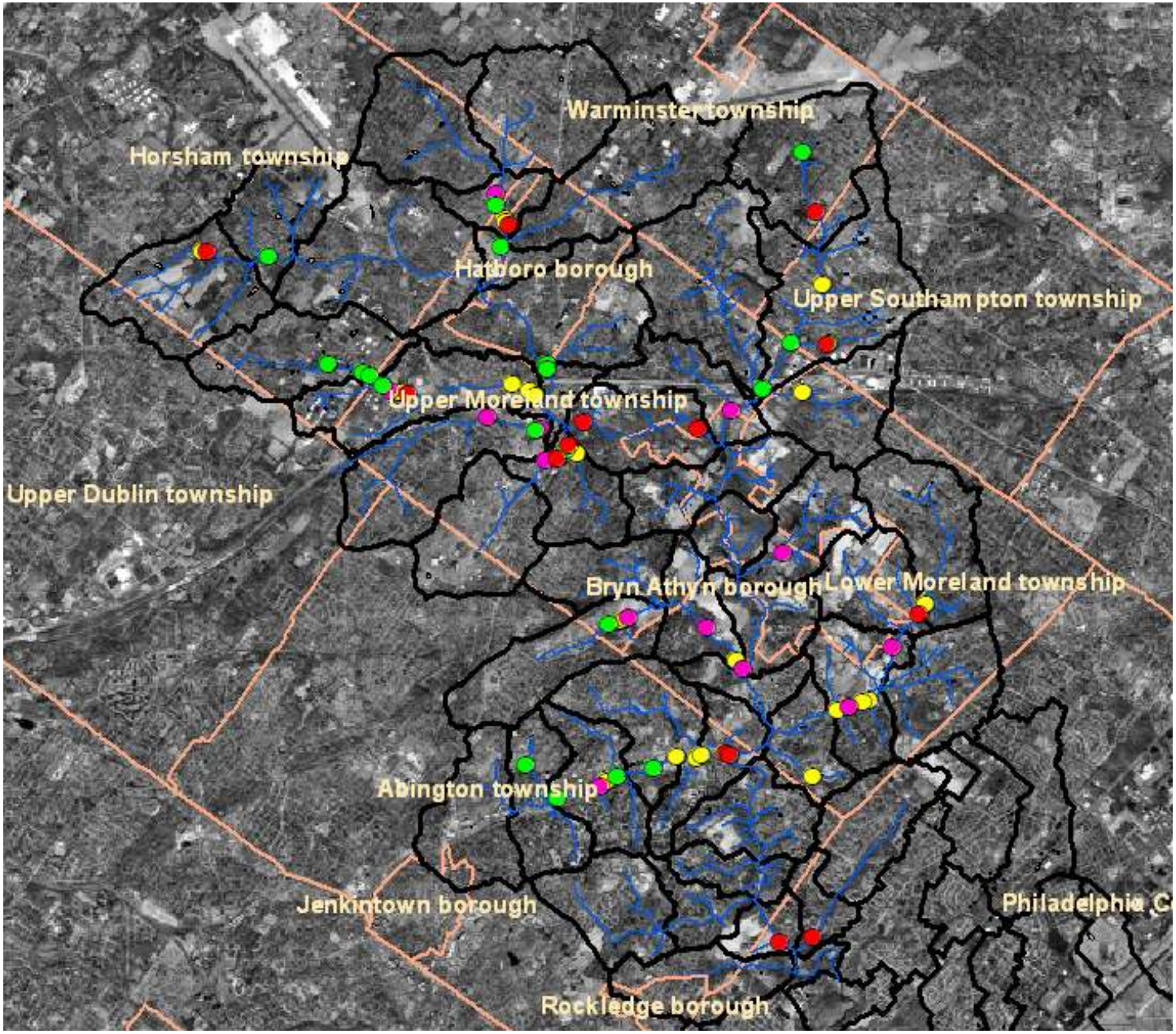
186 Bridges were included in the HEC RAS Modeling in the suburban municipalities.



Bridges Most Frequently Flooded

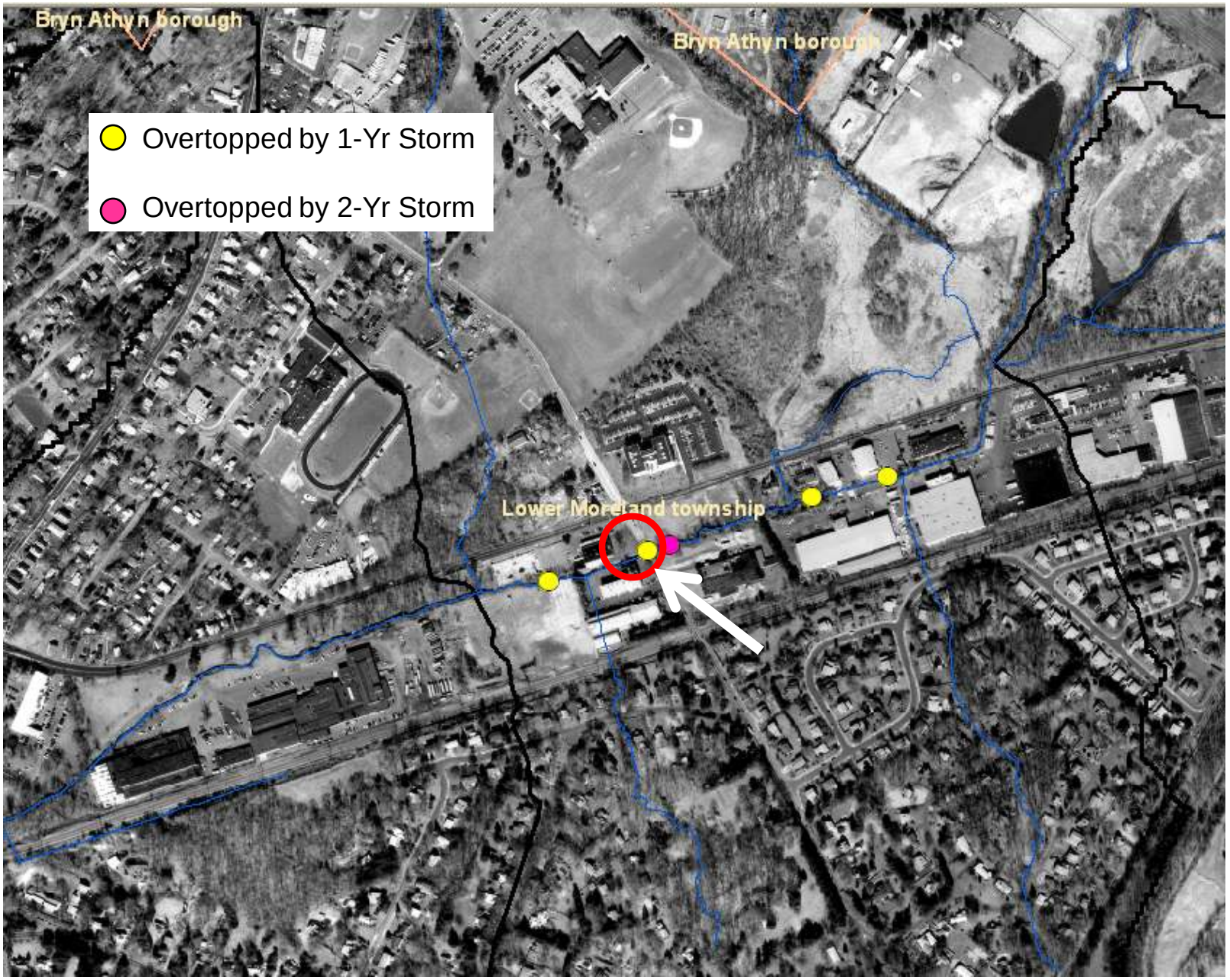
Overtopped By:

- ≥ 1-Yr Storm
- ≥ 2-Yr Storm
- ≥ 5-Yr Storm
- ≥ 10-Yr Storm

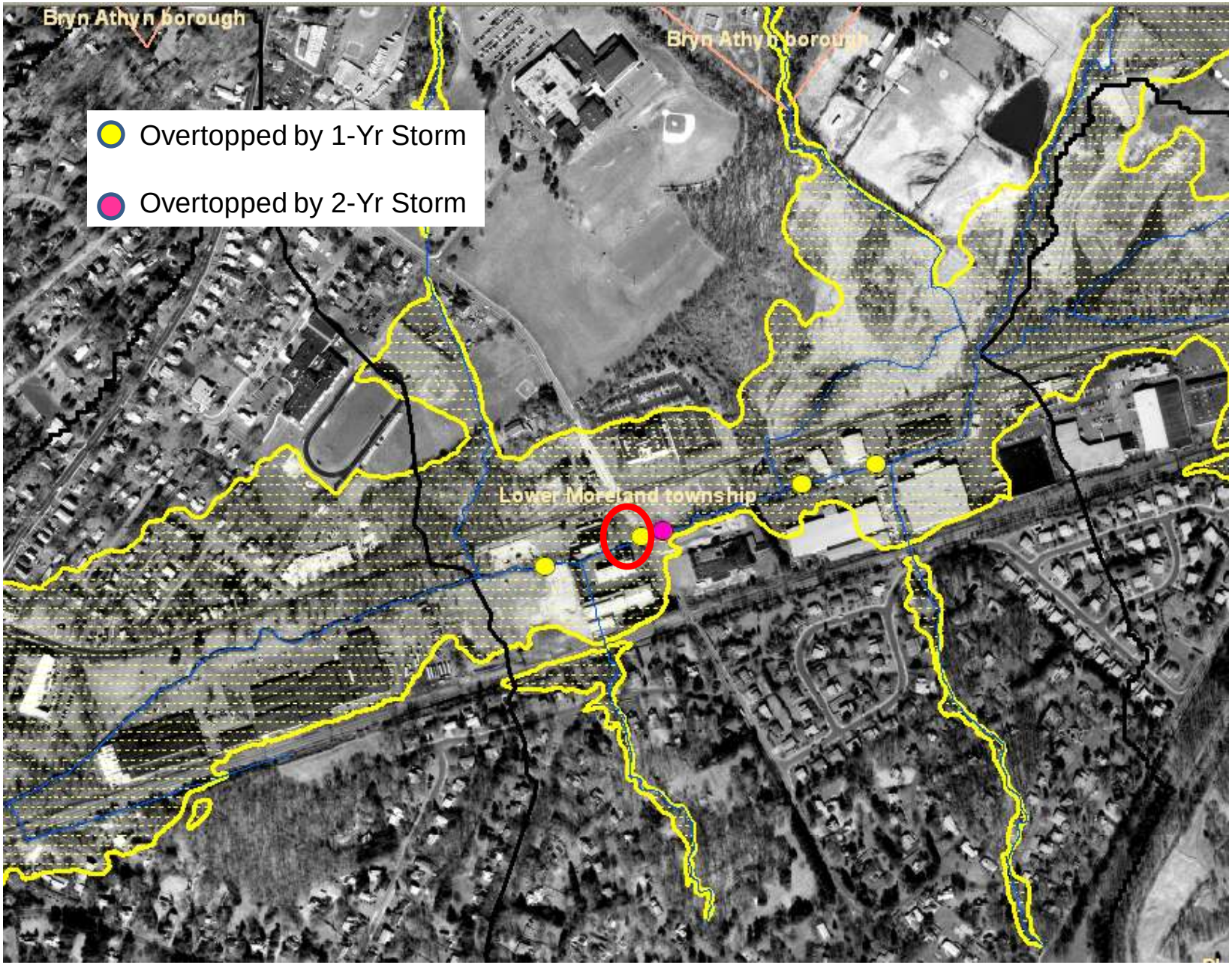


Example Flood Prone Bridge: Philmont & Red Lion Rds. in Lower Moreland Twp.

*Bridges include public roads as well as private access and golf cart paths



Same location showing 100 Year floodplain



The published flood study indicates that Philadelphia City bridges over the main stem of the Pennypack are not overtopped by smaller storms

Pine Road	Overtopped by 100 Yr and 500 Yr
Veree Road	Not Overtopped
Conrail Bridge	Not Overtopped
Krewstown Road	Overtopped by 500 Yr
Bustleton Ave	Overtopped by 100 Yr and 500 Yr
Roosevelt Blvd.	Not Overtopped
Rhawn Street	Not Overtopped
Welsh Road	Not Overtopped
Conrail Bridge	Not Overtopped
Frankford Ave.	Overtopped by 500 Yr
Torresdale Ave.	Overtopped by 500 Yr
Hulme Ave.	Not Overtopped
Conrail Bridge	Not Overtopped

*** Pine Road and Bustleton Ave probability of overtopping appears closer to 1 in 50 using new discharges.**

Flood Insurance Claims

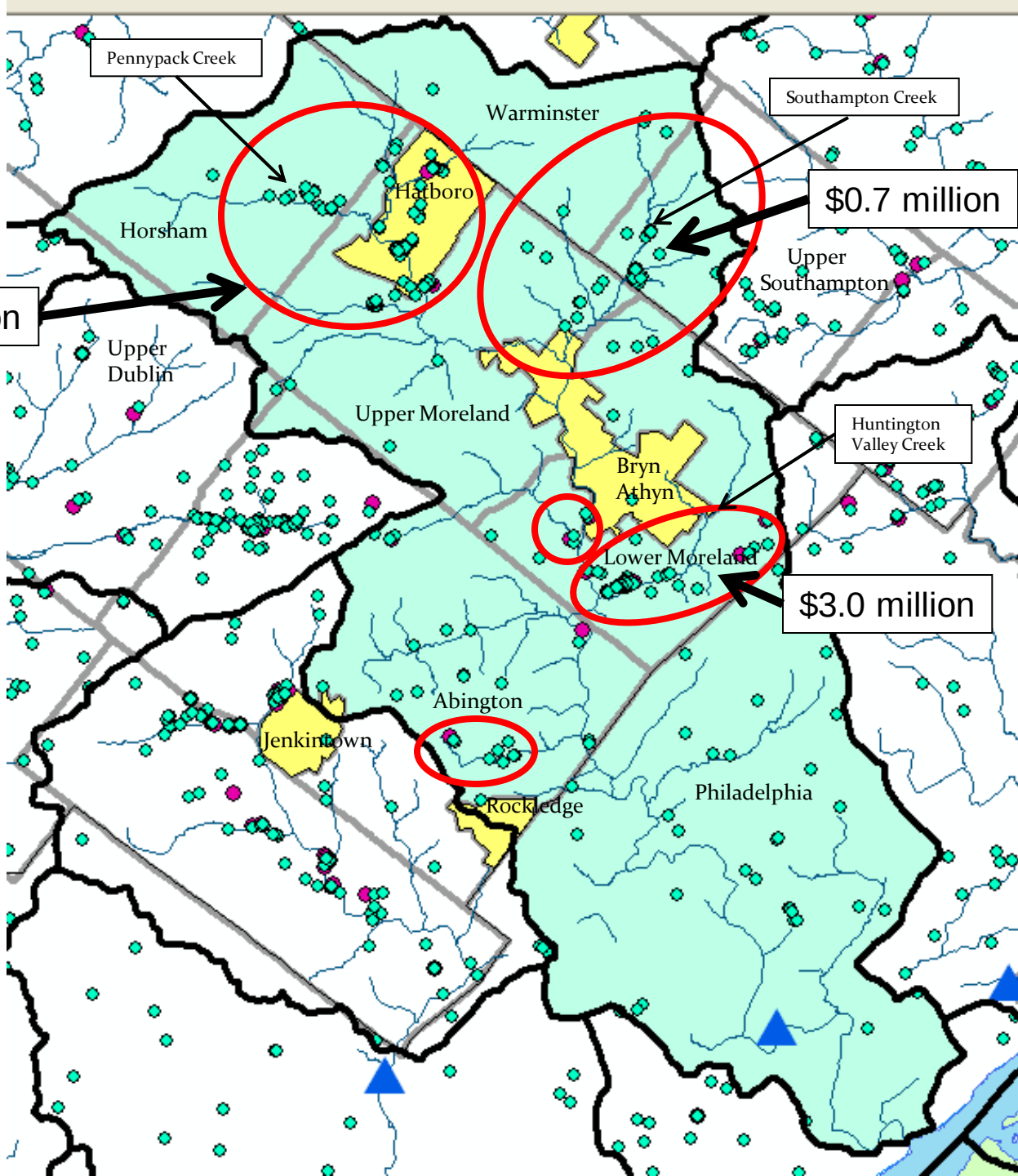
Pennypack Watershed Damage Areas Based on Flood Insurance Claims 1978 to 2007

This slide shows areas with the highest density of flood insurance claims during the past 30 years.

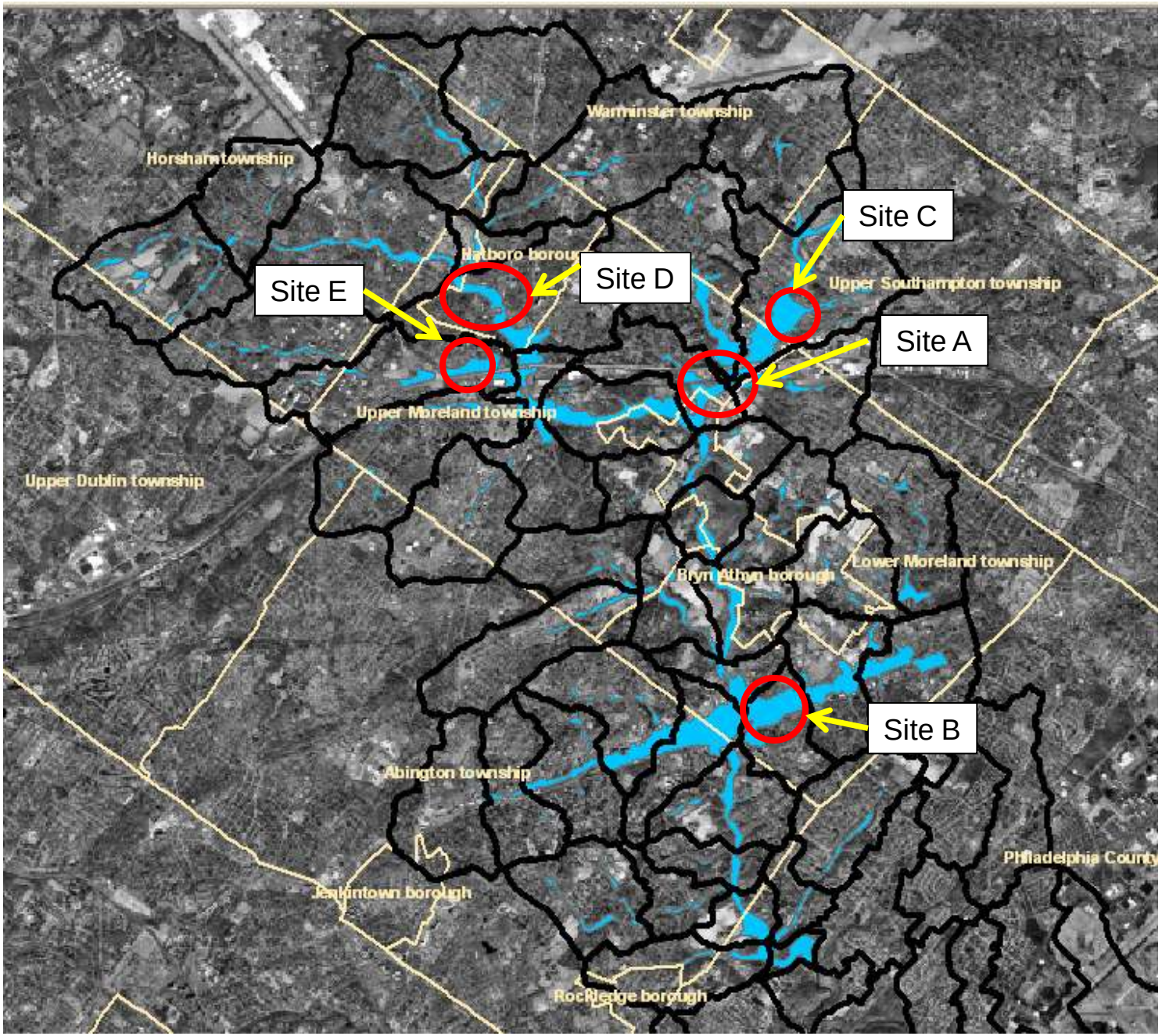
It does not show all flood damage locations because not all floodplain residents purchase flood insurance.

- Flood Insurance Claim
- Repeat Flood Insurance Claims

Source of Flood Claims Data:
Federal Emergency Management Agency

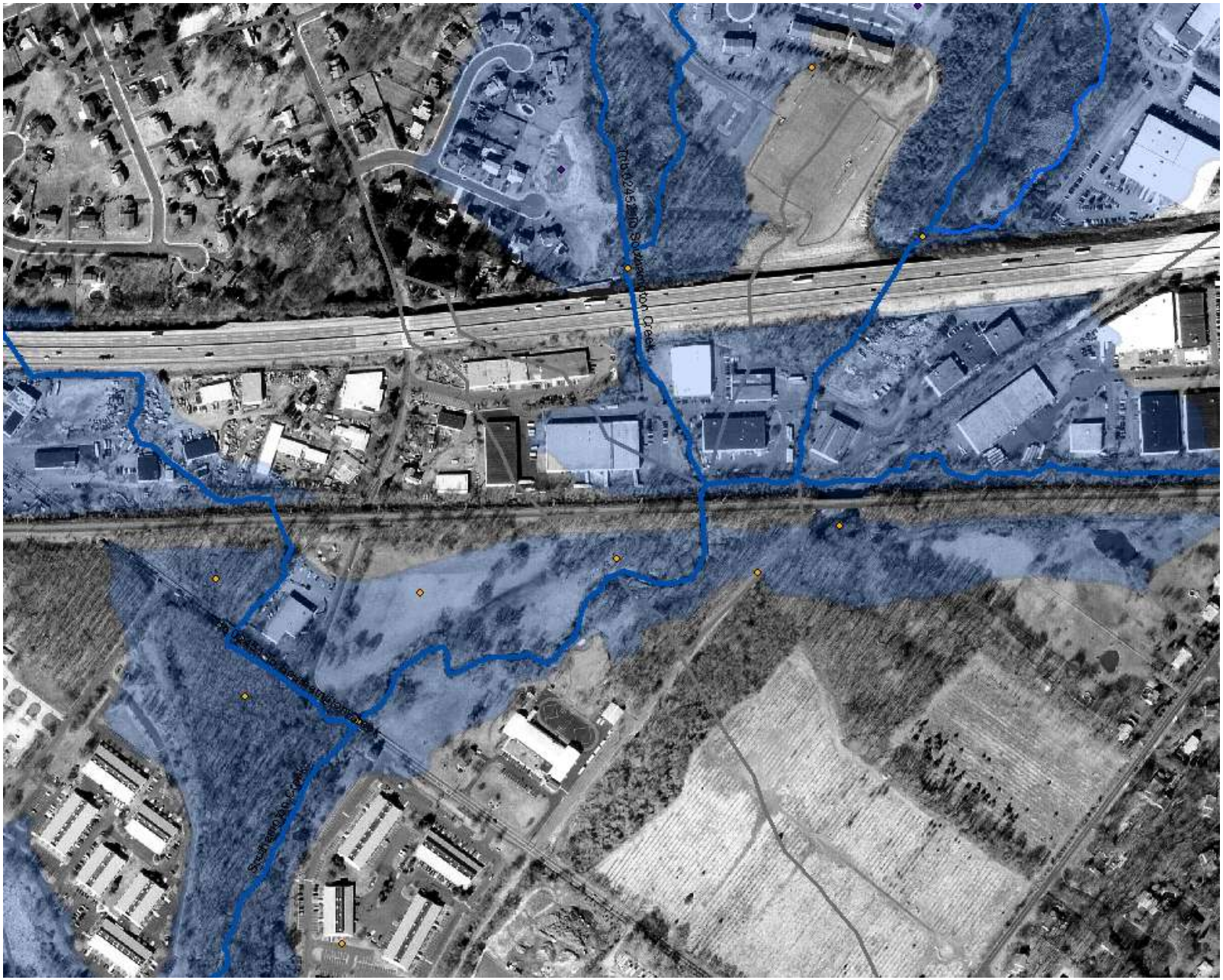


Potential Damage Concentrations Within100-Yr Floodplain Boundary



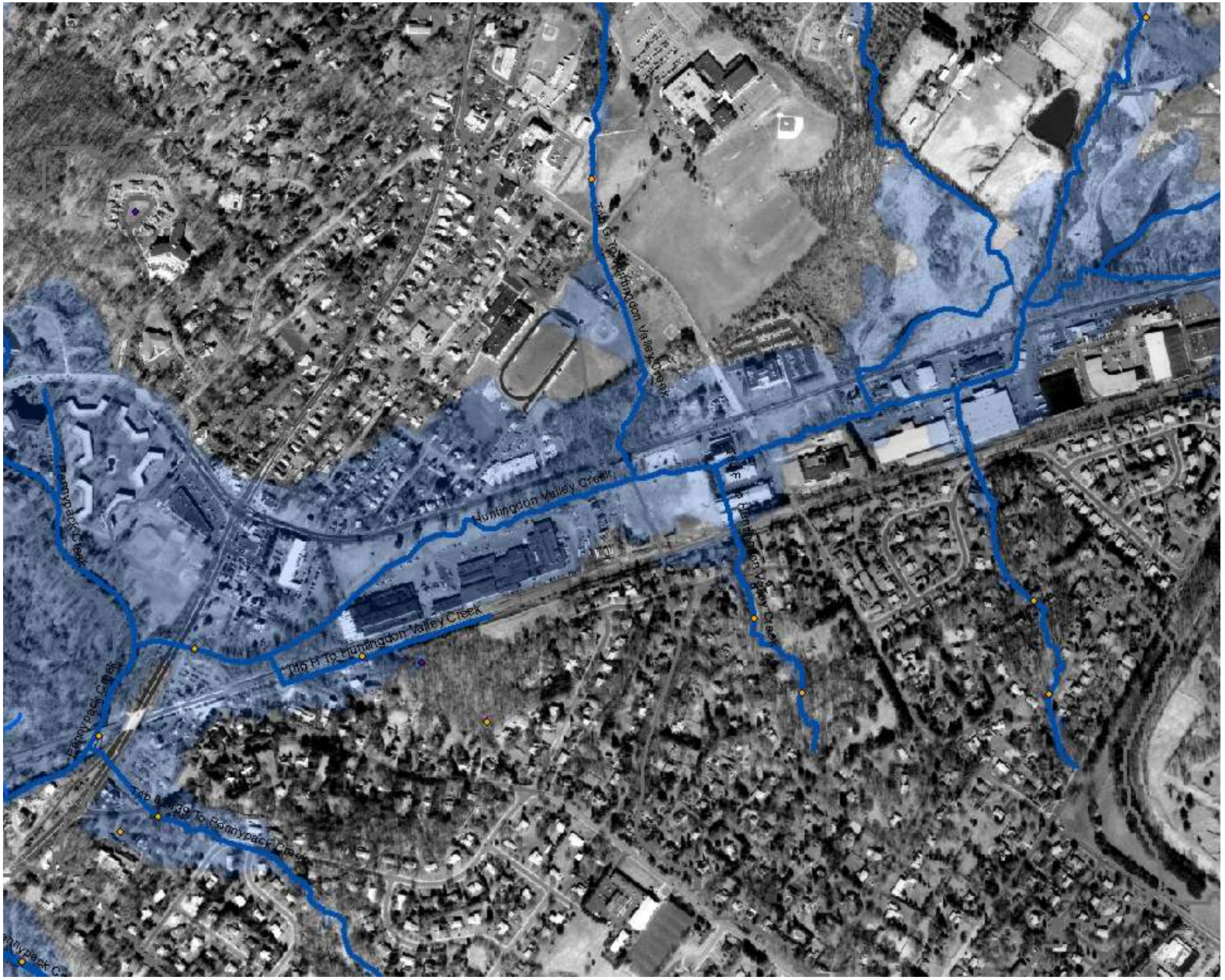
Site A: Southampton Creek and Tributaries near PA Turnpike

Upper Moreland Twp. – Between Pioneer and Heaton Roads ~ 20 Structures



Site B: Huntingdon Valley Creek along Philmont Rd. (Rt. 63)

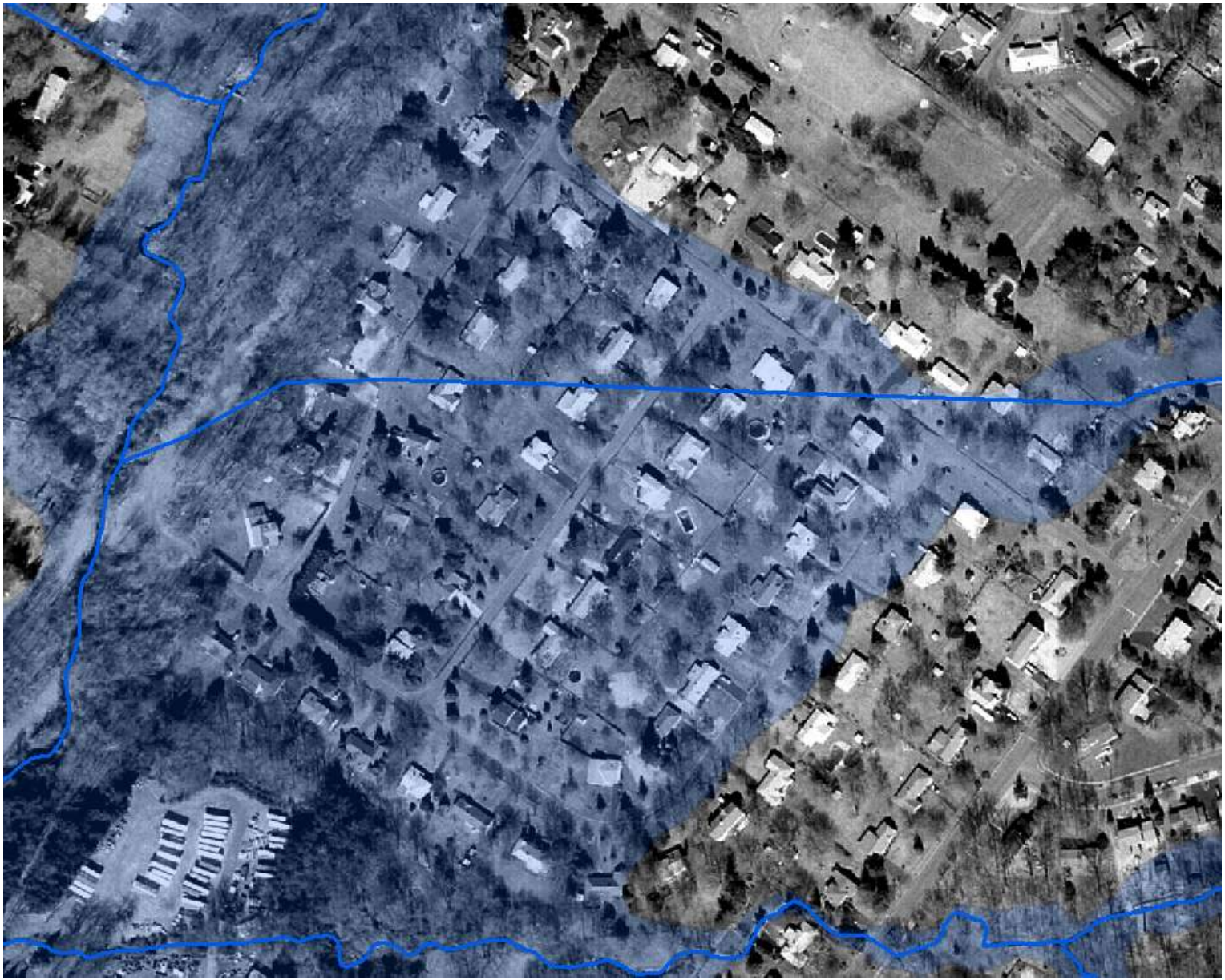
From upstream of Red Lion Rd. to Rte. 232 (Huntingdon Pike) ~50 Structures



Site C: Southampton Creek and Tributaries upstream of County Line Rd.

Charles St., Marian Ave, Russell Dr. Holly Dr, ~ 50 homes

Upper Southampton Township.



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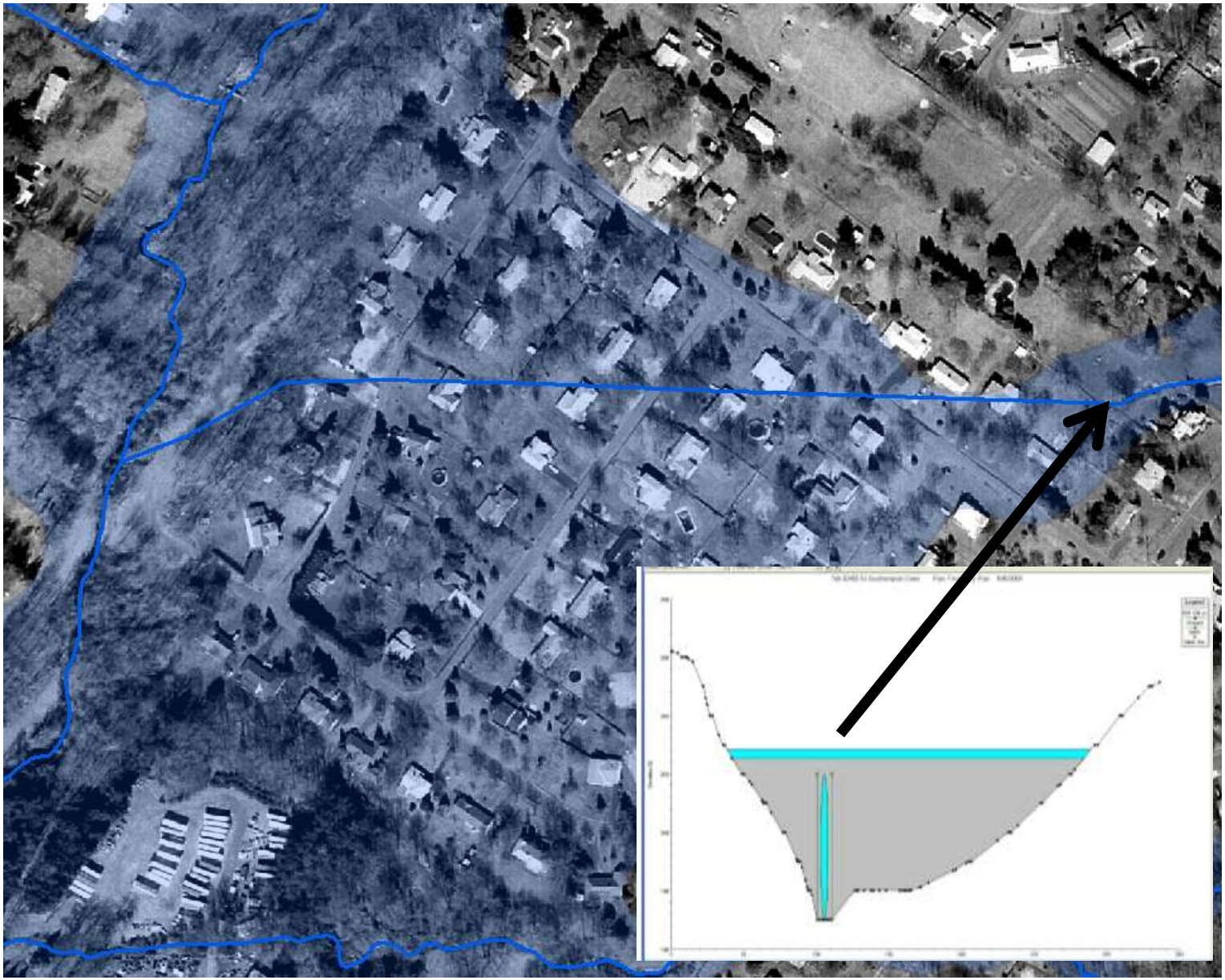


Site D: Pennypack Creek upstream of South Old York Rd. (Rte. 263) and Downstream to PA Turnpike

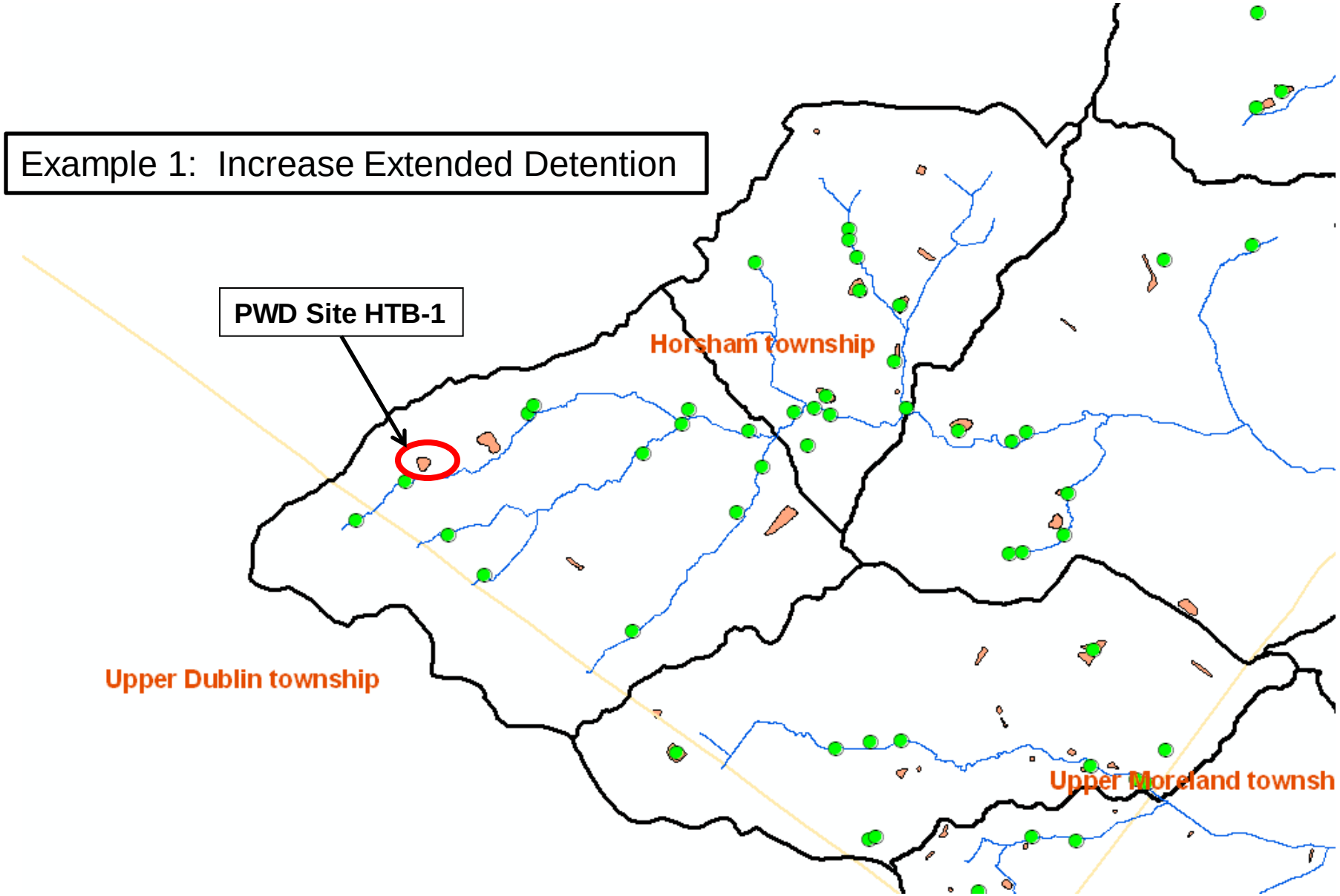
In Hatboro Borough and Upper Moreland Twp. ~ Structures include Pennypack Elem. School

Site E: Example of Structures Removed from 100 Year Floodplain Since Original Orthophotography

Bonnet Lane and West Mill Rd nr. PA Turnpike - Upper Moreland Twp.

Site Surveys and Stormwater Management Opportunities

Sites surveyed by CSC have been supplemented with the detention site Inventory by PWD to assess the potential for additional stormwater management



Site HTB-1 Detention Basin Surveyed by PWD - Constructed Since Original Study
Site revisited by CSC on 11/10/09

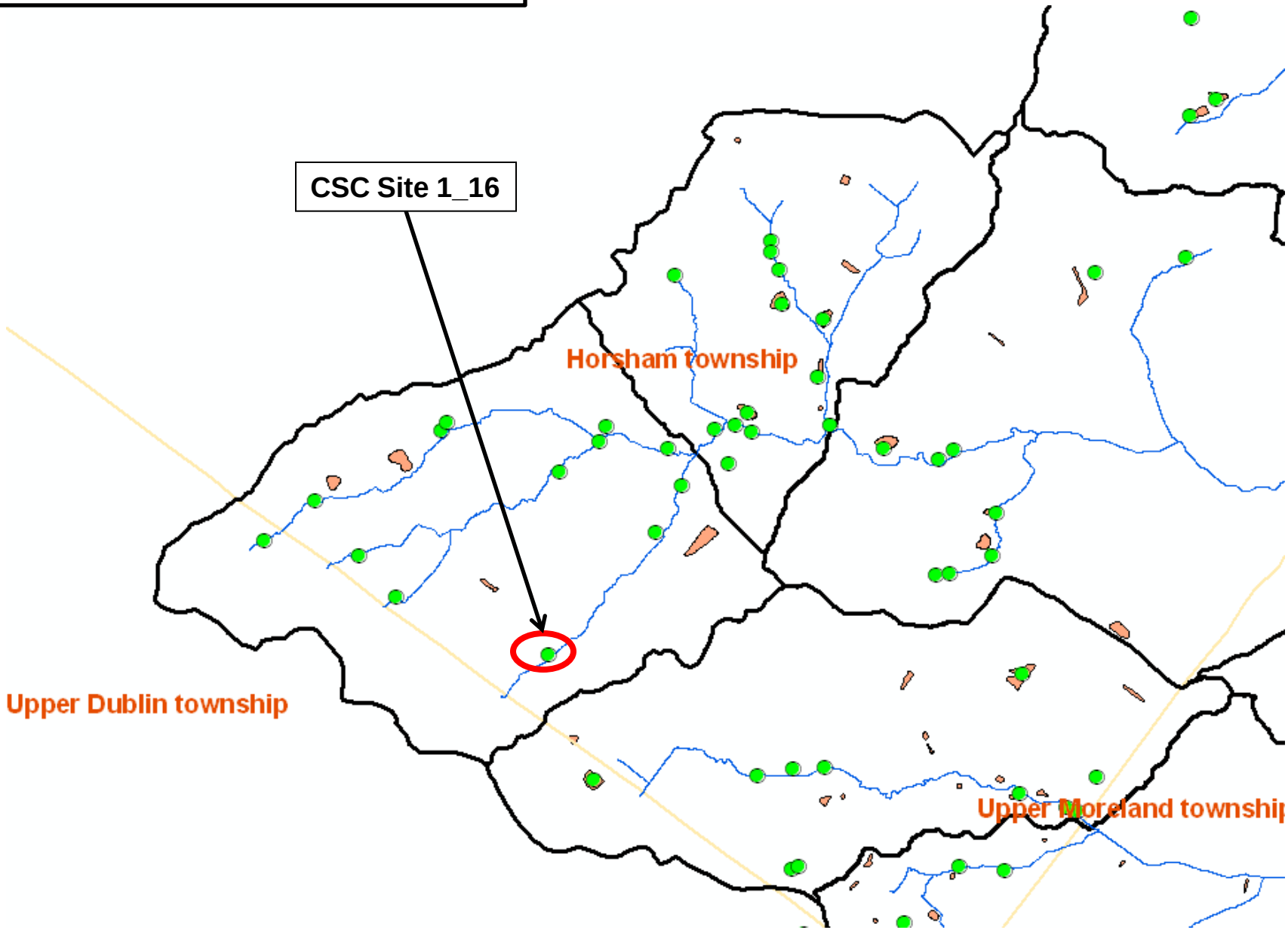
Photo # DSCN08 11/12/09 HTB-1 Surveyed by PWD

Photo # DSCN09 11/12/09 Site HTB-1 Surveyed by PWD

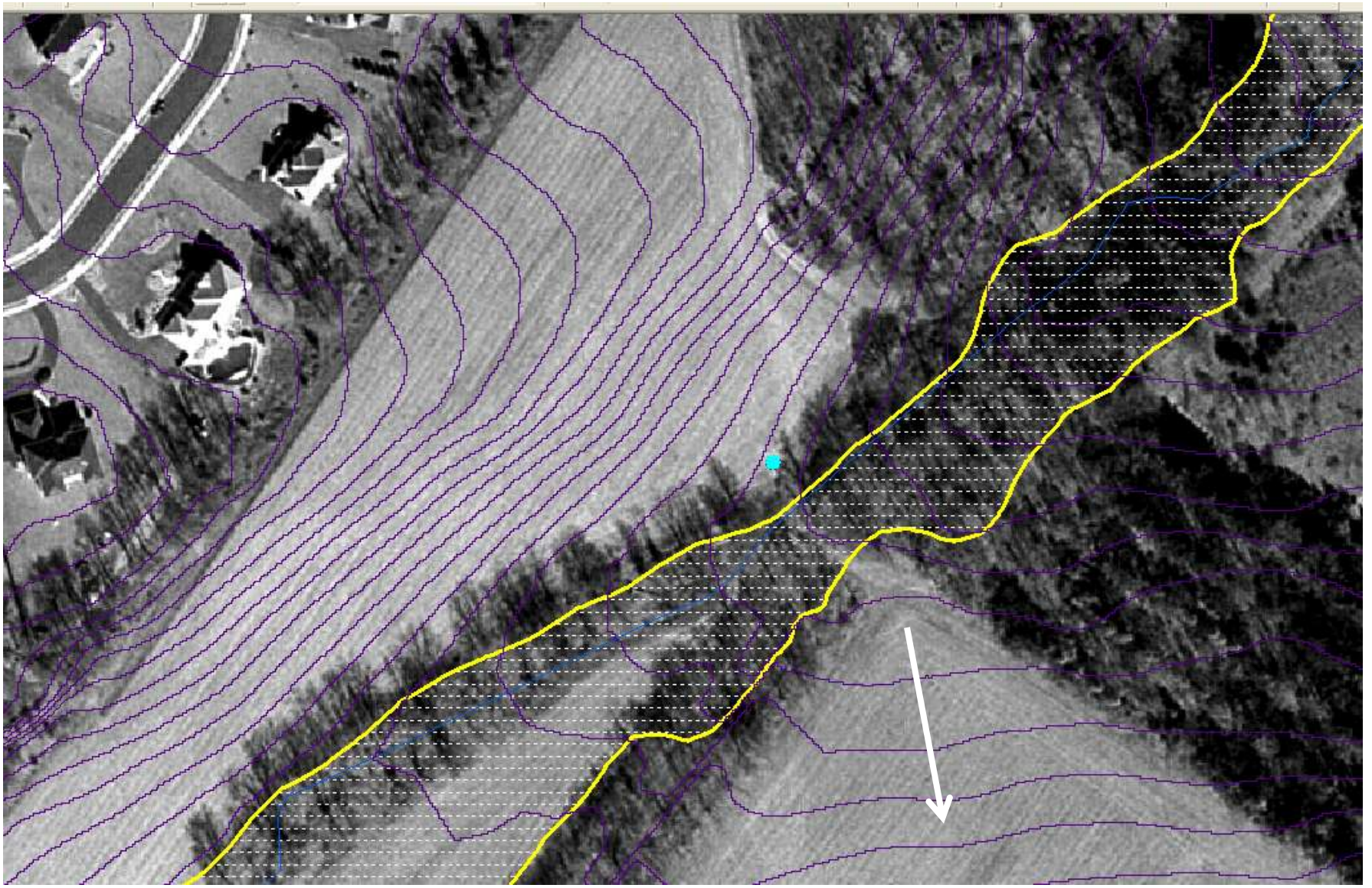
Photo # DSCN010 11/12/09 Site HTB-1 Surveyed by PWD

Photo # DSCN011 11/12/09 Site HTB-1 Surveyed by PWD

Example 2: Improve Infiltration

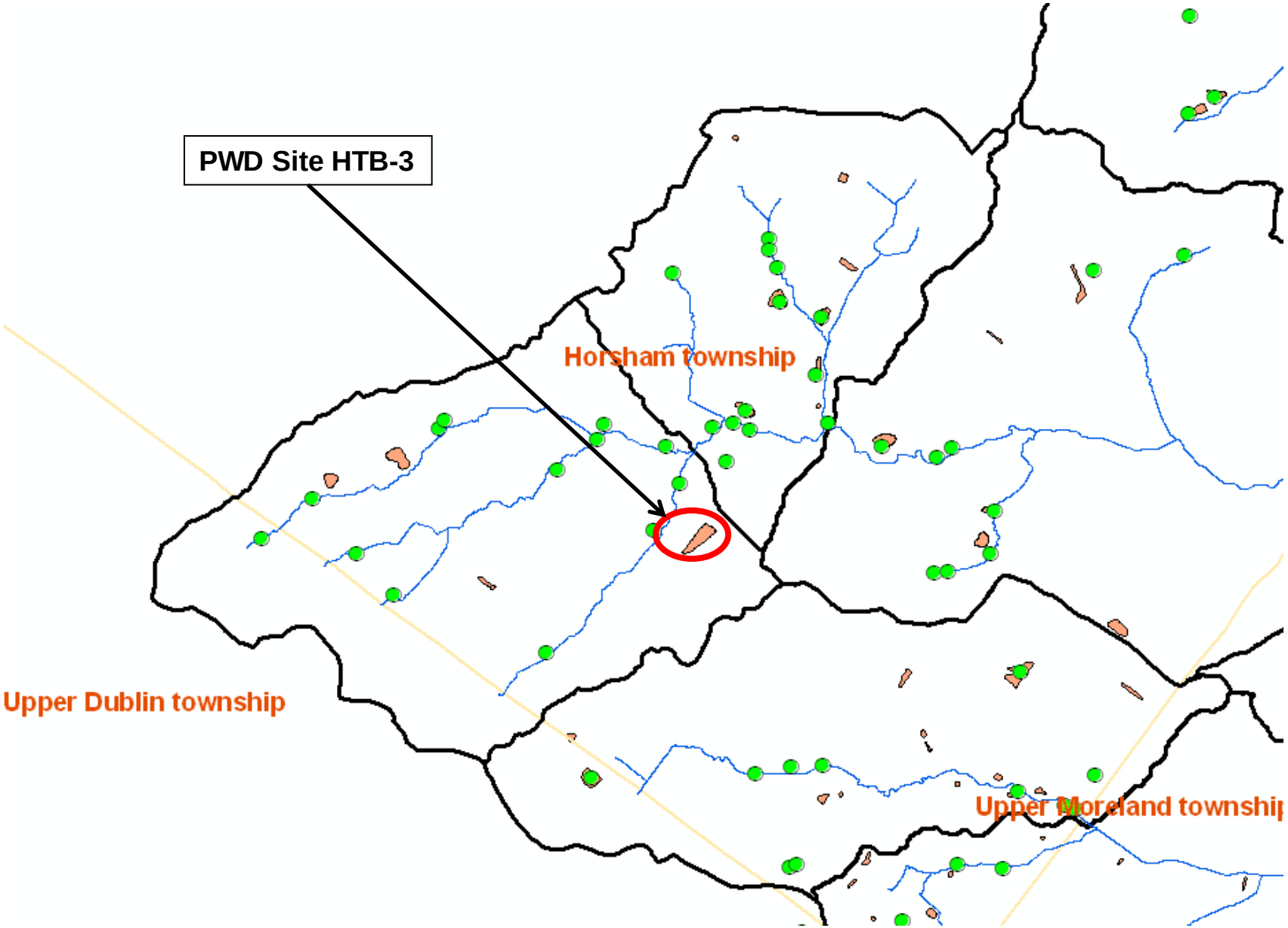


Site 1_16 Potential Infiltration – Both Sides of Tributary Valley



Site 1_16 View Southward Toward Welsh Road at Far Tree Line

Example 3: Retrofit to Outlet and Vegetate Floor of Existing Detention



Site HTB-3 Surveyed by PWD

Site HTB-3 Photo # DSCN 2534 Outlet Structure

Site HTB 3

Low flow diameter = 28”

Top of Overflow ~ 9.5 ft above floor

Berm height ~ 13.5 to 15.5 ft above floor

Floor wet within 60 ft. of outlet.

Opportunity for retrofitting outlet to Improve storage of smaller storms.

Vegetate floor to help extend detention.

Photo Taken Looking into Entrance of Low Outlet Pipe

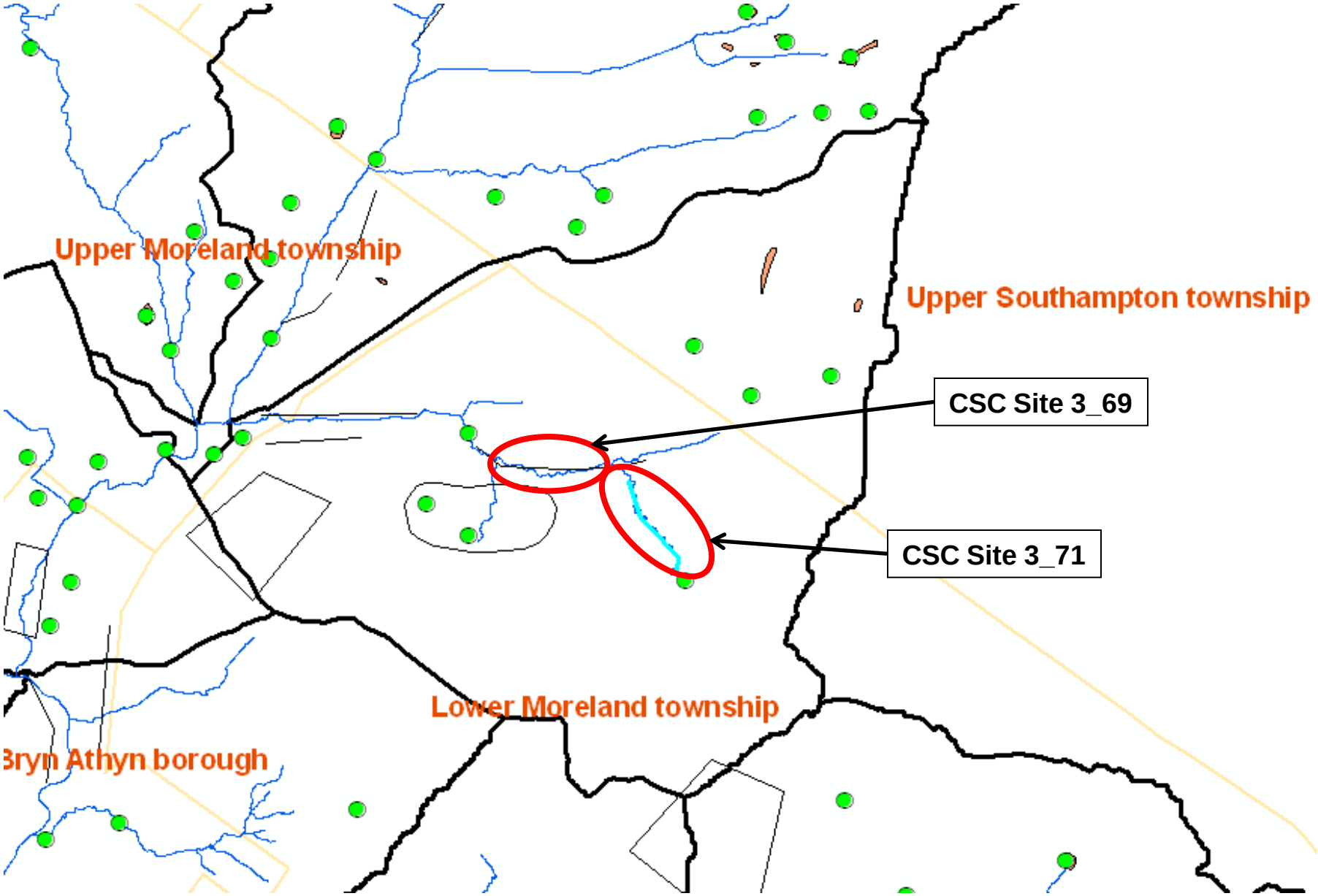
HTB-3

4 ft. diameter inlet at south end.

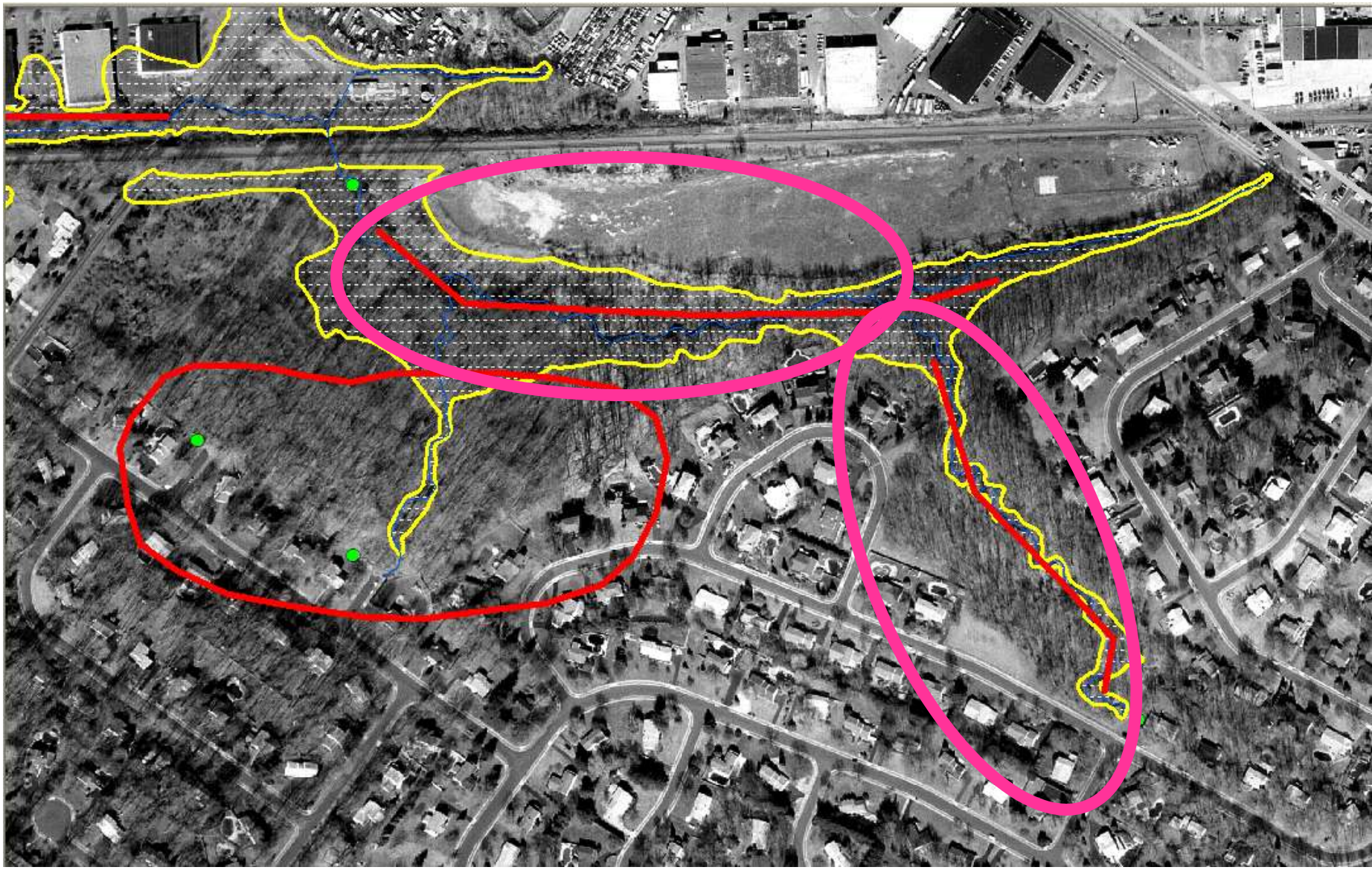
Typical scour puddle, teeming with mosquito larvae.

Recommend establishment of native vegetation to provide habitat for mosquito predators

Example 4: Severe Channel Erosion



Site 3_71 Example of Severe Channel Erosion

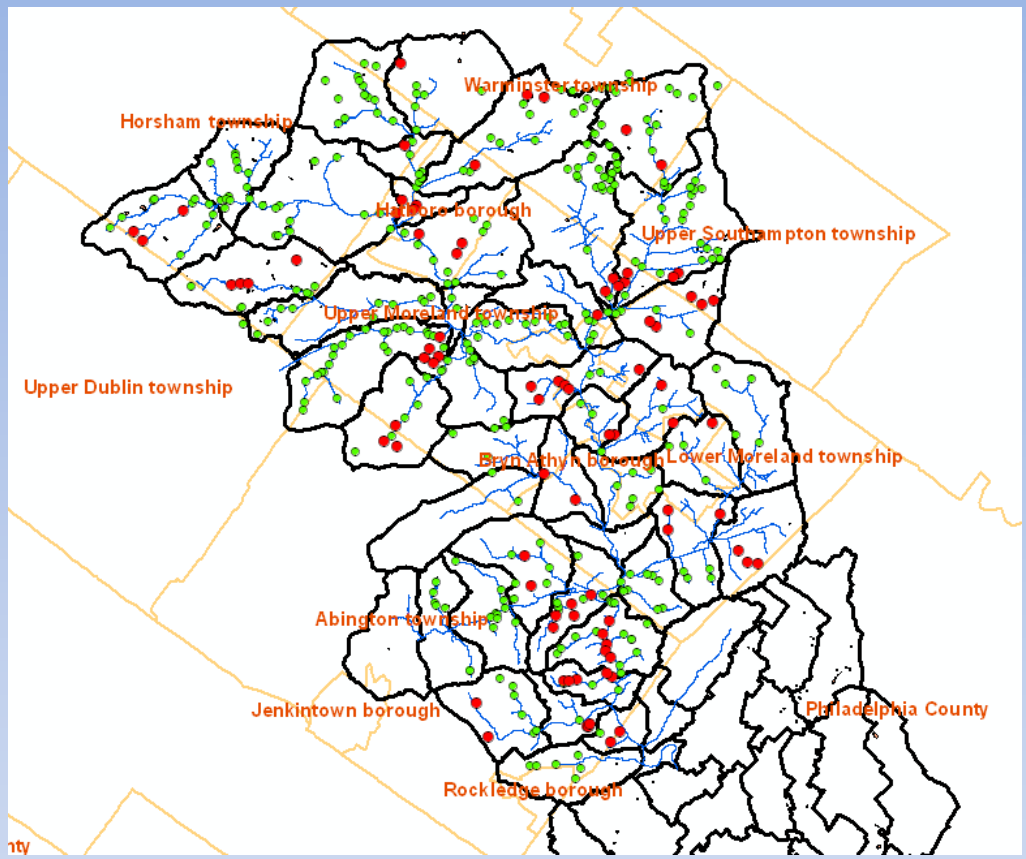


Sample Field Notes

7/28/09	Photo (Field #)	DSCN #	Notes
1 - At Orchid Rd. & Ridge Ln. (just NE of Pennypack watershed boundary) **2_125** Intersection of Orion Dr. & Viking Dr. Intersection of Orion and Seaking	p-1 p-2 p-3 p-4 p-5 p-6 p-7	2155 2156 2157 2158 2159 2160 2161	N inlet, dry detention basin S inlet, ~240' x 100' x ~7'd Both inlets 22" in diameter Outlet, 12" diameter View S down Viking Dr. View S down Seaking Dr. View West over playground
7 – **2_109**	p-21 p-22 p-23 p-24 p-25	2230 2231 2232 2233 2234	- Extended detention SW of football stadium. Well vegetative, Cyclone fence 6'H (for scale) - Standpipe estimated as ~4'H. Top of berm ~12', but emergency overflow at level with top of outlet structure. Basin ~150'W x 150'. Finished approx. 1 year ago. - View of basin from W corner. Note low berm ~30' from outlet - Overflow spillway. Note permeable concrete pavers to control erosion
8 – **2_108**	p-26 p-27 p-28 p-29 p-30	2235 2236 2237 2238 2239	Temporary parking field noted in Appendix C of original study being used for soil stockpile and staging. Good E & S controls, e.g. silt fences, grading, containment. (6 acres of possible infiltration – noted above)

Example of Proposed Table for Detention Facilities

Similar Tables would be Prepared For Infiltration and Riparian Buffer Sites to Indicate Additional Storage Potential



Facility_id	Existing Volume (Acre-Ft)	Potential Add'l Volume (Acre-Ft)	Estimated Cost ($)	Notes
AB_1	1.3	1.3	102,000	Excavate 2 ft over 1 Acre area to develop constructed wetland.
AB_2	0.3	0.3	35,000	Elevate berm 2 feet, modify outlet structure and piping
CH_3	1.7	0.5	86,000	Excavate 2 Ft. Potentail retrofit of outlet and convert ot constructed wetland.
HO_1	0.4	0.2	30,000	Rough Estimate not measured from contours or field surveys
LG_1	1.9	0.0	0	Not accessible. Surrounded by private residences and fenced off.
LG_2	0.4	0.2	30,000	Rough Estimate not measured from contours or field surveys
LG_3	0.3	0.8	73,000	Excavate 2 Ft. Raise Berm 2 Ft.
LG_4	0.6	0.6	106,000	Excavate 3 Ft. Retrofit Outlet. Vegetate Floor
LG_5	0.4	0.2	30,000	Rough Estimate not measured from contours or field surveys
LG_6	0.5	0.8	73,000	Raise berm 2 Ft. Excavate 2 Ft. Vegetate Floor
	0.4	0.2	30,000	Rough Estimate not measured from contours or field surveys

Development Scenarios

1)The future land use projection (2030) is in progress. So far, an initial projection using year 2000 land use data showed very little change in Curve Numbers at the scale used for the modeling.

2) The hydrologic model will be applied to access the effect of potential additional detention and infiltration storage. Existing available detention storage capacity is ~ 180 Acre-Ft for the Pennypack Watershed. (0.06 inches)

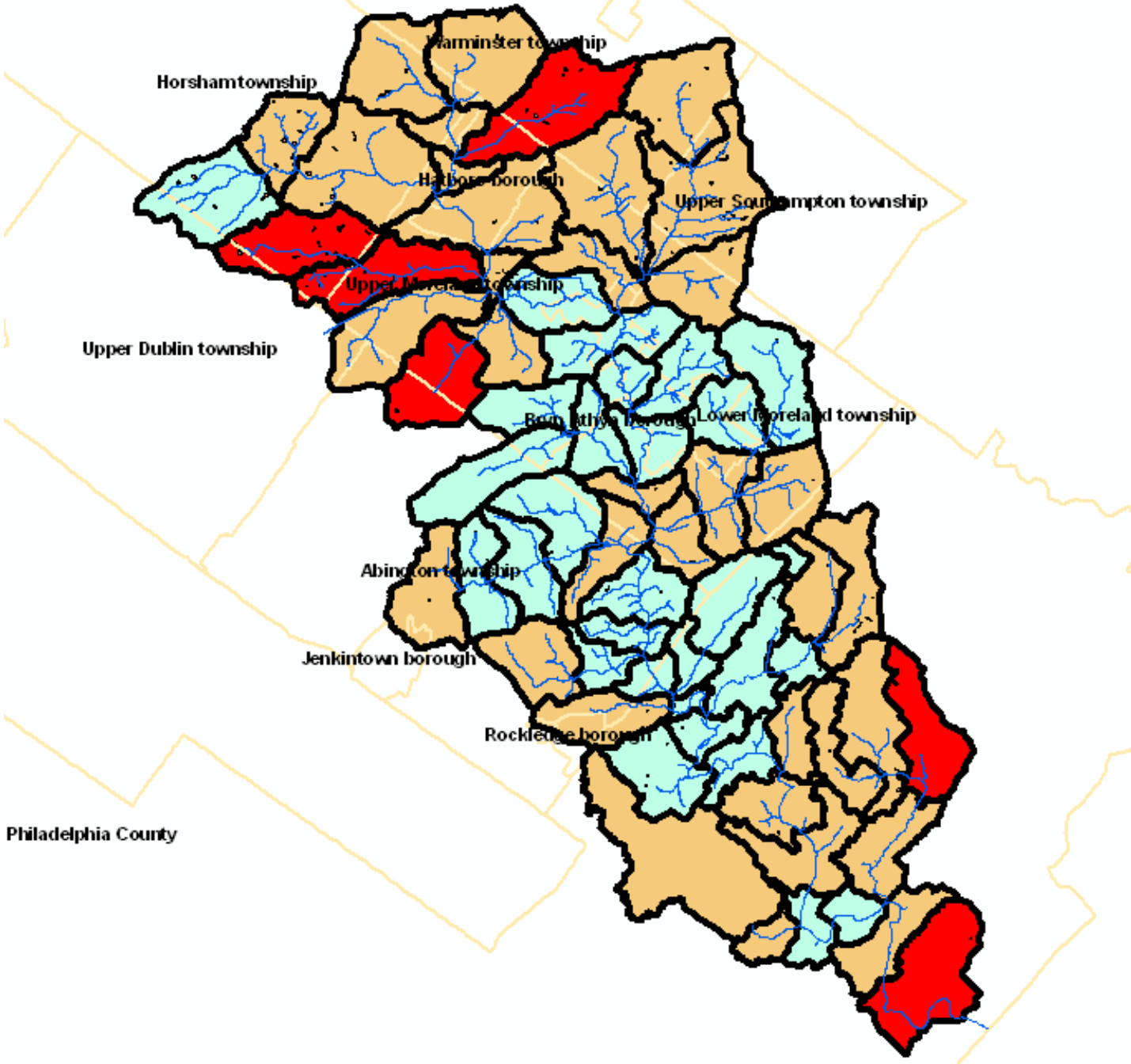
Goal: Reduce Runoff Rate for Smaller Storms

1-Yr Event Runoff Volumes (Inches)

- Runoff > 1.5”
- Runoff = 1”-1.5”
- Runoff = .5”-1.0”

Runoff volumes are for a 24 hour design storm with 2.74” of rainfall.

1” of Runoff
= 53.3 AF/SqMi



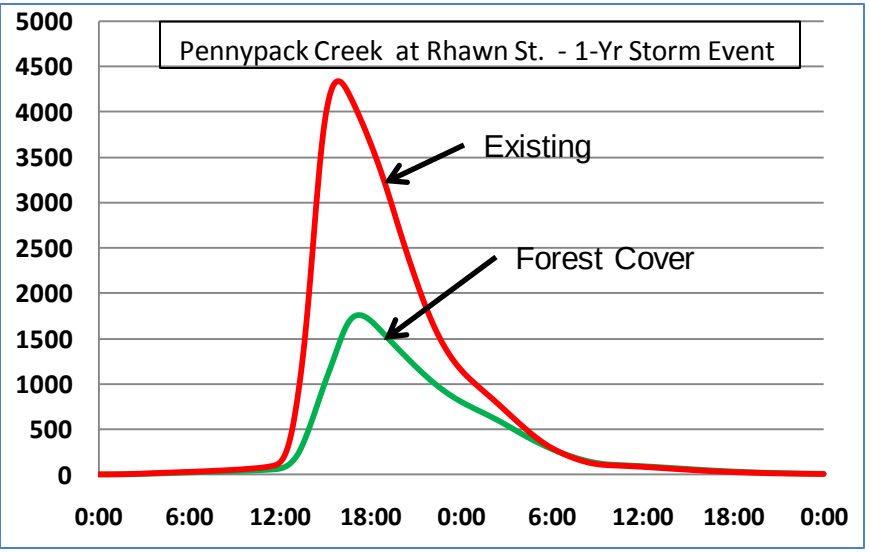
Estimate of the Effect of Existing Development

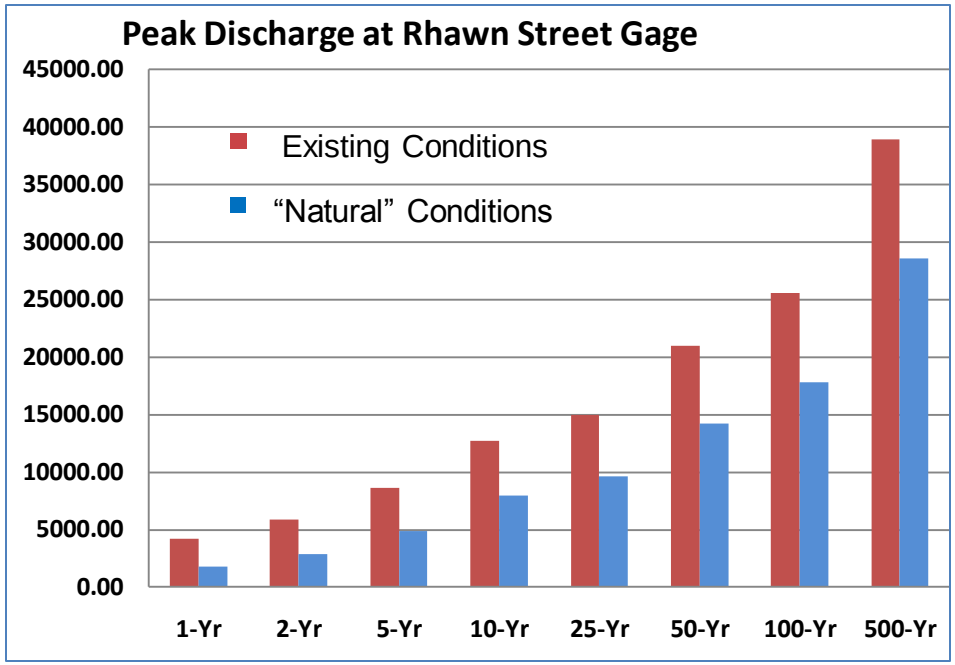
Pennypack Creek at Rhawn Street

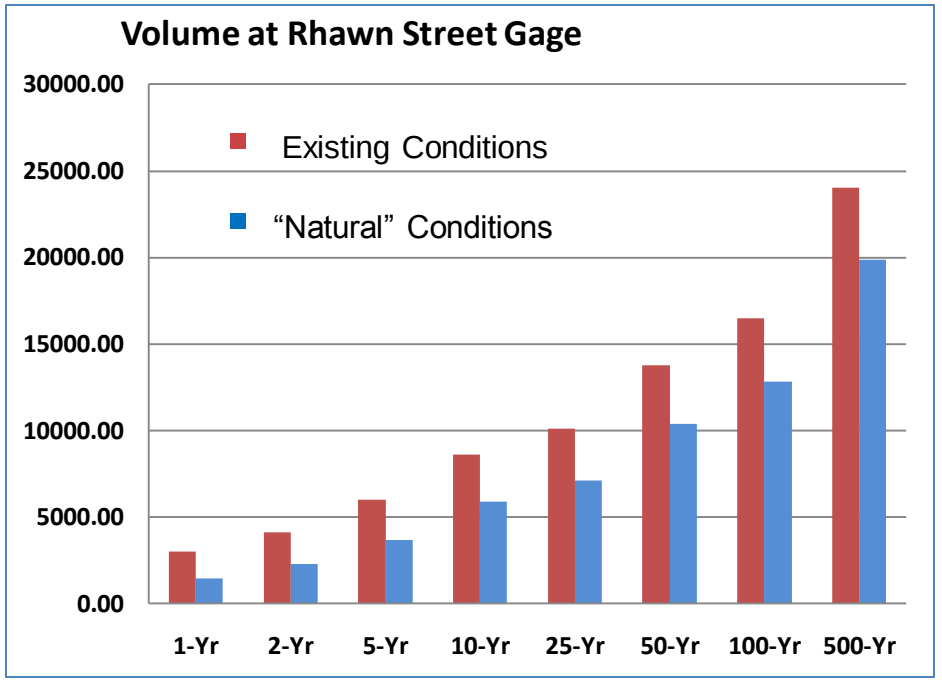
Model Run assumes a natural condition of forest cover with a Curve Number value of 68.

The plots show the impact for each of the design storms.

Assumes 1-Yr storm precipitation = 2.74 inches.







Notes:

Model results shown in this presentation are preliminary, since the model may be further modified.

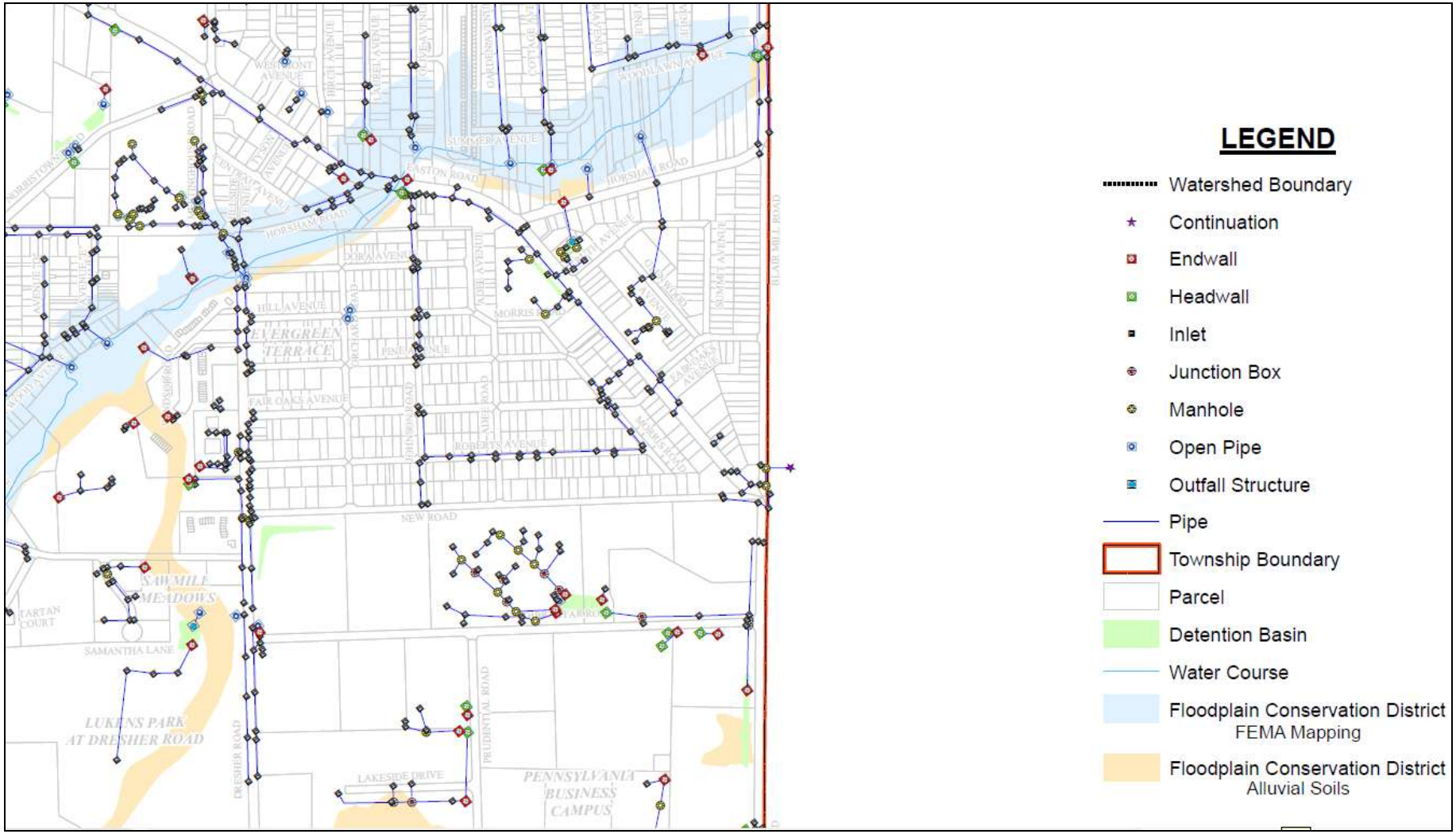
The results provide a watershed scale measure of stormwater impacts and do not reflect the local benefits immediately downstream of facilities.

One inch of runoff = 53.3 acre-ft per square mile.

One half inch of runoff = 26.7 acre-ft per square mile.

Total estimated detention storage in the Pennypack watershed is ~ 180 Acre-ft. This is an average of ~ 3.3 acre-ft per square mile.

Note: Information on flood problems or maps of stormwater collection systems would be useful.



Stormwater System Map Provided by Horsham Township