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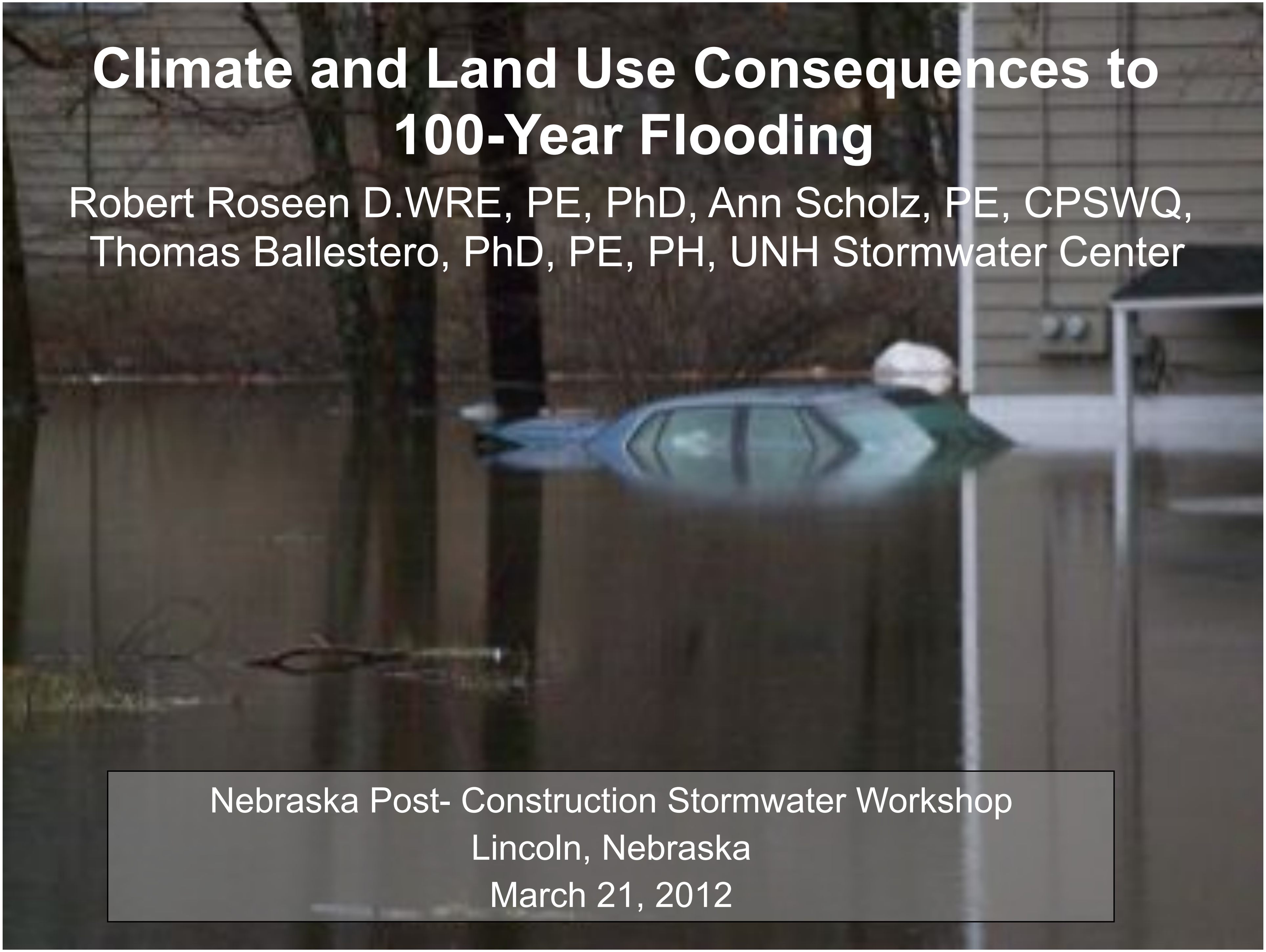

Climate and Land Use Consequences to 100-Year Flooding

Robert Roseen D.WRE, PE, PhD, Ann Scholz, PE, CPSWQ, Thomas Ballestero, PhD, PE, PH, UNH Stormwater Center

Nebraska Post- Construction Stormwater Workshop

Lincoln, Nebraska

March 21, 2012

Lamprey River 100 Year Flood Risk Project

Two year project funded by the Cooperative Institute for Coastal and Estuarine Environmental Technology (CICEET)

Interdisciplinary Team:

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Lisa Townson and Julia Peterson, UNH Cooperative Extension

The New Orleans Hurricane Protection System: What Went Wrong and Why-- 10 Lessons Learned from Katrina by the ASCE Hurricane Katrina External Review Panel and the USACE Interagency Performance Evaluation Task Force

1. Failure to think globally and act locally–We must account for climate change
2. Failure to absorb new knowledge
3. Failure to understand, manage, and communicate risk–Need to take rigorous risk based approach,
4. Failure to build quality in
5. Failure to build in resilience
6. Failure to provide redundancy
7. Failure to see that the sum of many parts does not equal a system
8. The buck couldn't find a place to stop--Poor organization, lack of accountability
9. Beware of interfaces: materials and jurisdiction
10. Follow the money–People responsible for design and construction had no control of the monies.


HIGH
WATER
ROAD
CLOSED

- Research examining impacts of climate change on rainfall depths (28-60% increase) demonstrated existing urban infrastructure (culverts) will be under-capacity by 35% (Guo, 2006)
- This in addition to stressed stormwater infrastructure from land use change

15 Highest Events –

Peak Recorded Discharges on Lamprey River

Rank	Date	Discharge (cfs)
1	16-May-06	8,970
2	18-Apr-07	8,450
3	7-Apr-87	7,570
4	22-Oct-96	7,080
5	15-Mar-10	6,760
6	20-Mar-36	5,490
7	15-Mar-77	5,000
8	15-June-98	4,720
9	3-Apr-04	4,690
10	30-Mar-83	4,570
11	6-Apr-60	4,470
12	11-May-54	4,070
13	2-Feb-81	3,670
14	31-July-38	3,530
15	1-Apr-93	3,400

Of 15 largest events since 1934:
- 8 have occurred in last 25 years
- 5 have occurred in last 15 years
- 3 have occurred in last 5 years

FIS: 7300 cfs =100-Yr Flood Flow

Source: http://waterdata.usgs.gov/nwis

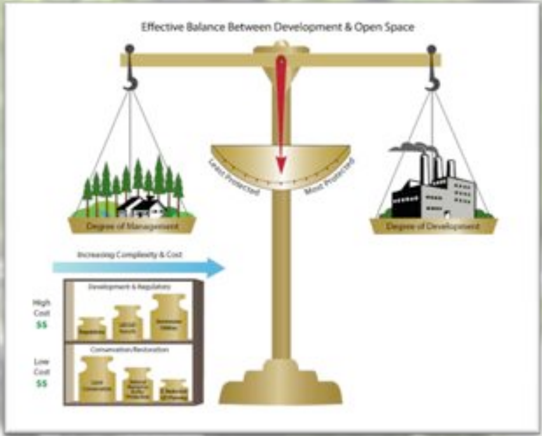
Primary Causes of Runoff Increase

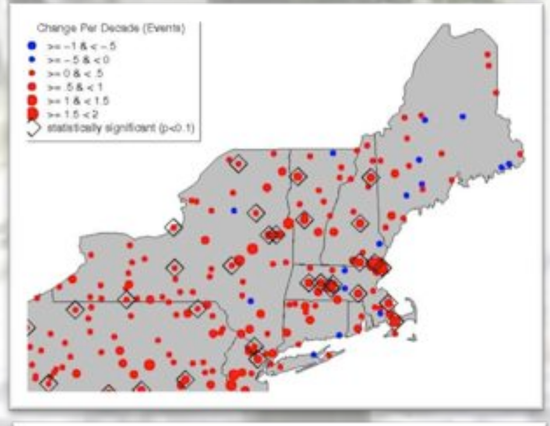
CAUSES

- Land Use Changes→Increase in impervious cover
- Changes in storm depth, duration, and frequency→Increased rainfall depth and runoff volume

SOLUTIONS

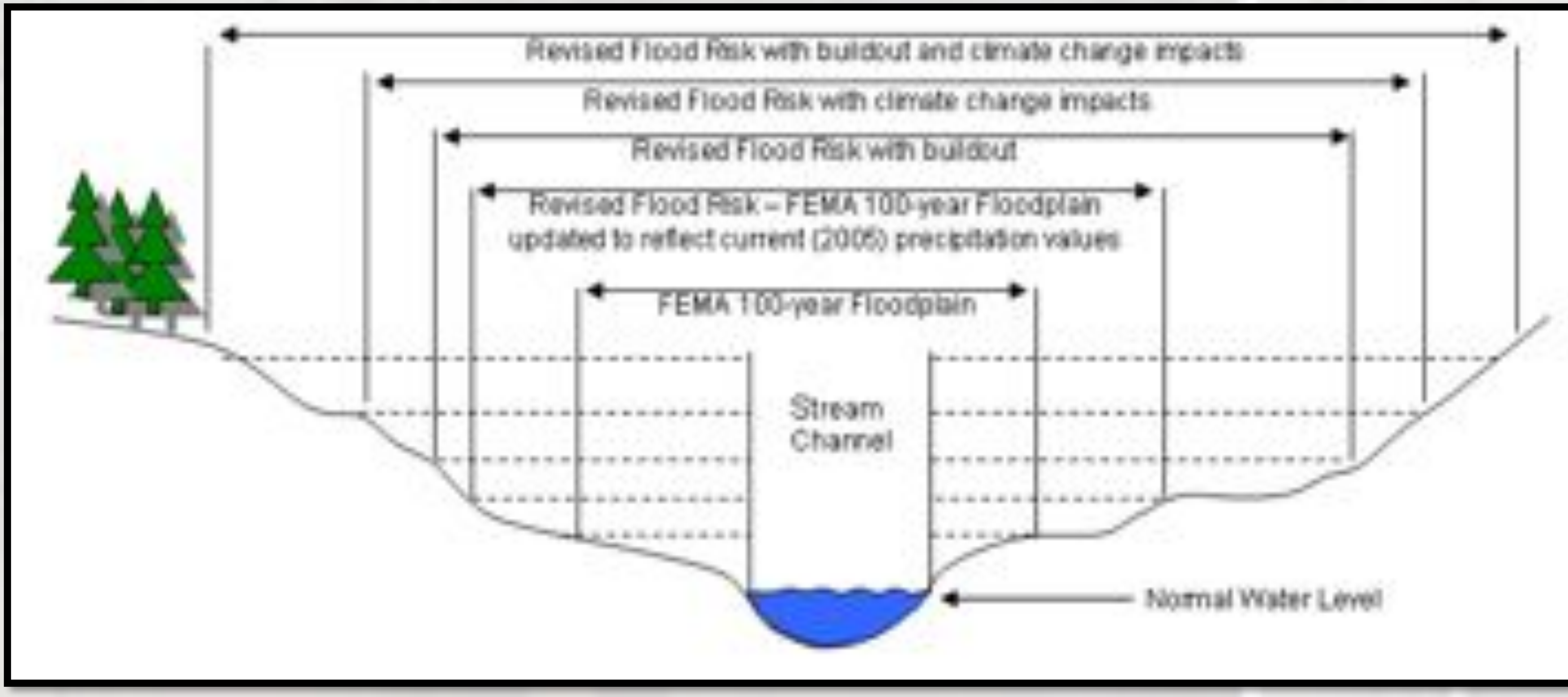
- Land use management strategies to mitigate runoff volumes





Project Hypothesis

The use of LID planning and technologies can contribute to building community resiliency in managing water resources and reduce the flood risk associated with current and projected changes in land use and climate.



Project Models				
Land Use Conditions	Rainfall Rates and Global Change Model Scenario			
	Rainfall Atlas		Climate Period 2035-2069	Climate Period 2070-2099
	TP-40	NRCC	NRCC	Regional Model
	6.3 in/hr	8.5 in/hr	8.5 in/hr	X in/hr
Current	2005	2005		
Build-out			2050	2085
LID/Build-out			2050	2085

Lamprey River

FEMA Requirements for Redelineation

- Hydrologic Analysis:
  - o Bulletin 17B for gaged streams

    Effective Model – 1935 through 1987

    Q_{100} = 7,300 cfs

  - o Criteria for revised hydrologic analysis

    ➢ Statistically Significance (68-percent confidence interval)

    $L_{0.01,0.68}$ = 6,886 cfs $H_{0.01,0.68}$ = 7,834 cfs

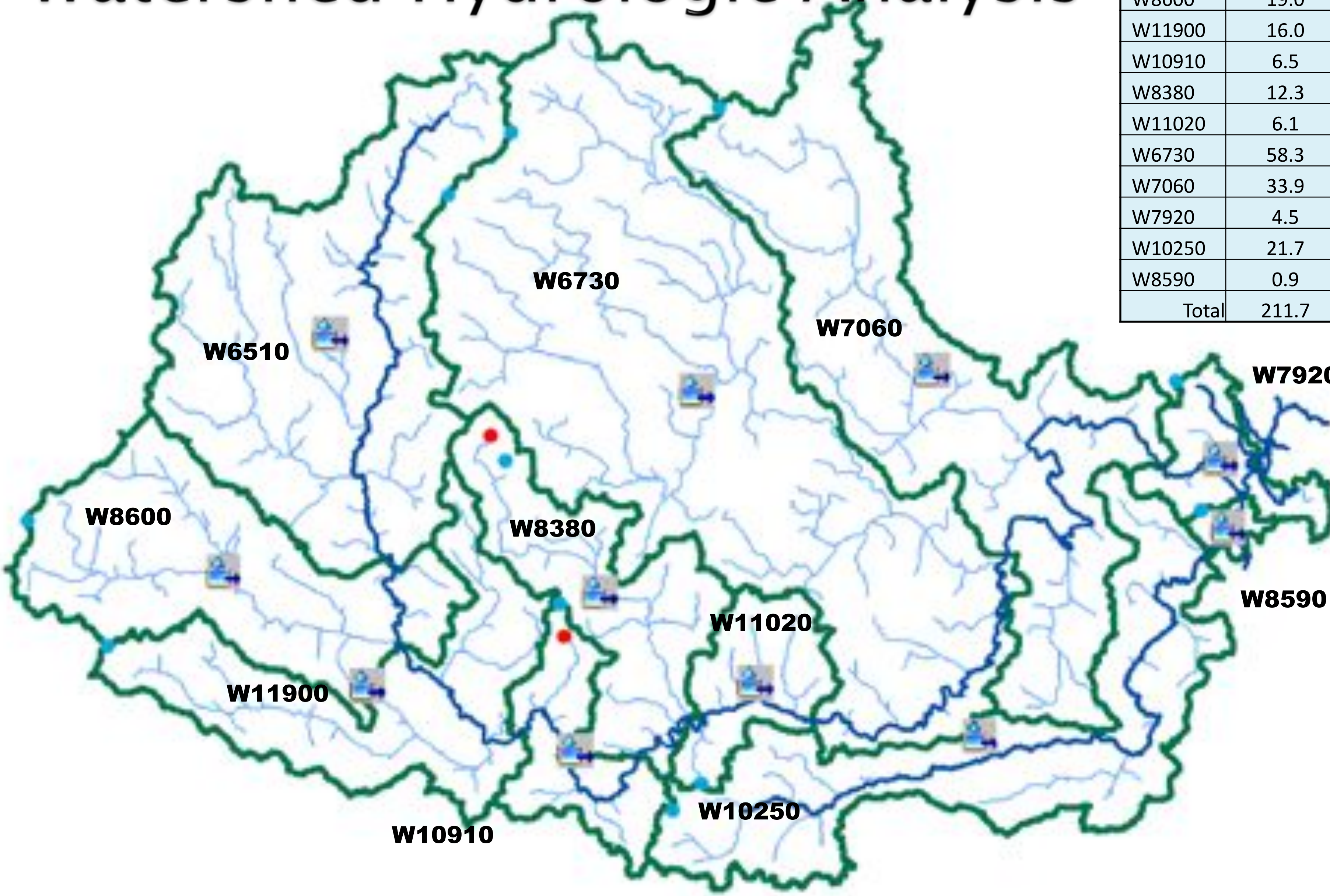
    ➢ 75 yr record – 1935 - 2009

    Q_{100} = 9,411 cfs

    Statistically Significant

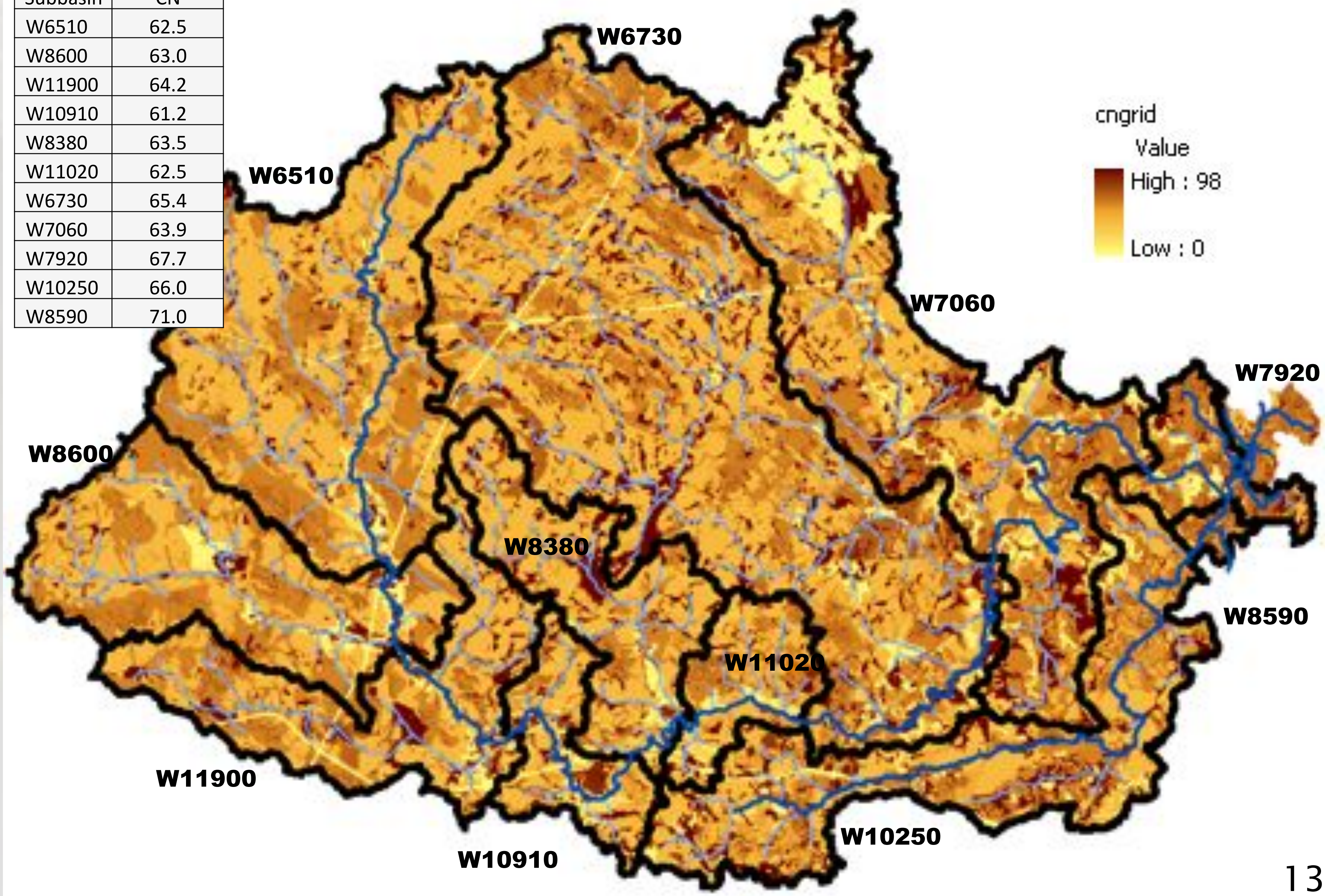
Watershed Hydrologic Analysis

Subbasin	Area (mi2)
W6510	32.2
W8600	19.0
W11900	16.0
W10910	6.5
W8380	12.3
W11020	6.1
W6730	58.3
W7060	33.9
W7920	4.5
W10250	21.7
W8590	0.9
Total	211.7

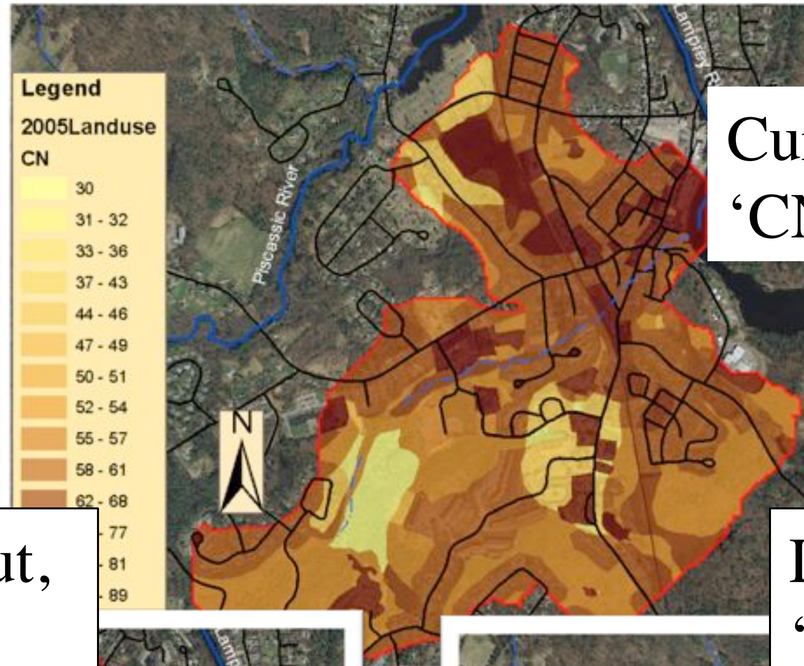


Land Use Within the Watershed

Subbasin	CN
W6510	62.5
W8600	63.0
W11900	64.2
W10910	61.2
W8380	63.5
W11020	62.5
W6730	65.4
W7060	63.9
W7920	67.7
W10250	66.0
W8590	71.0

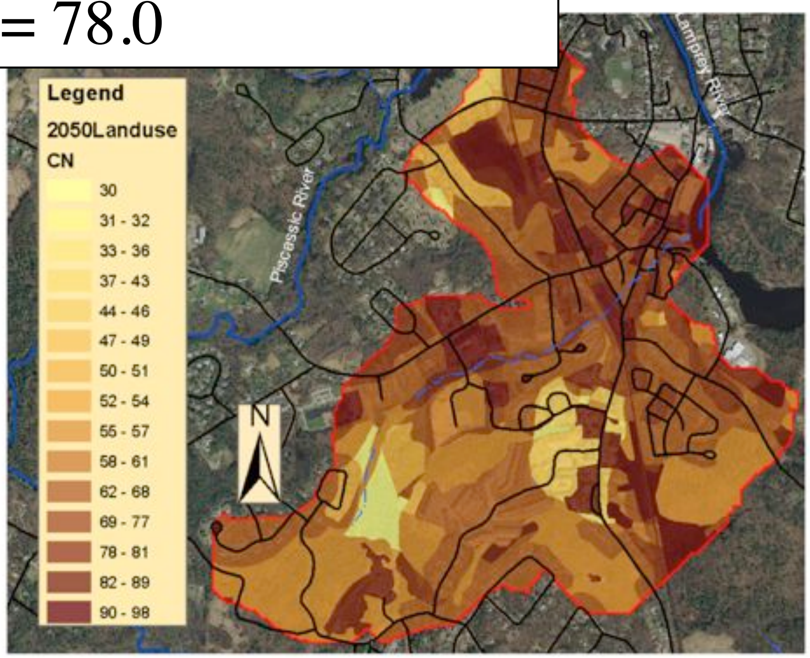


2050 Build-Out, Moonlight Brook, Newmarket

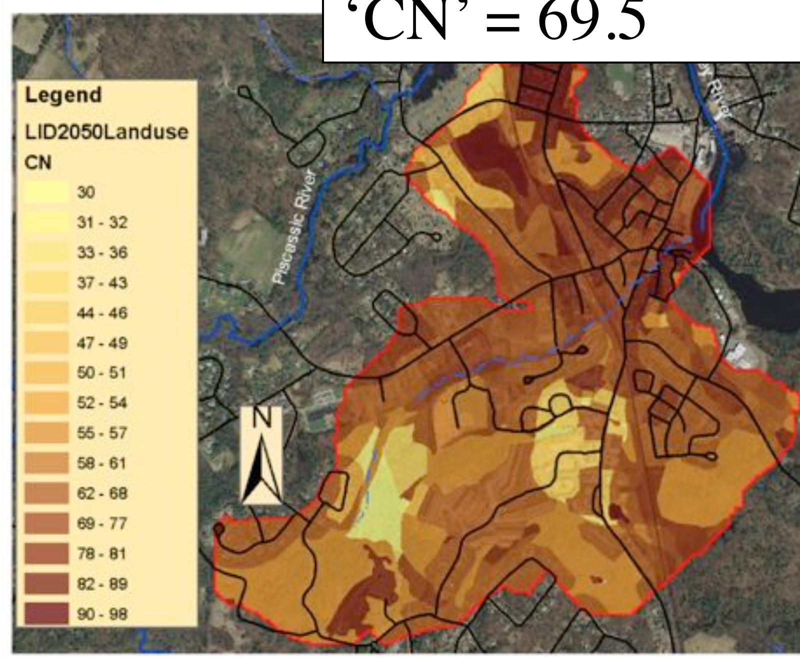


Current Conditions, 'CN' = 66.8

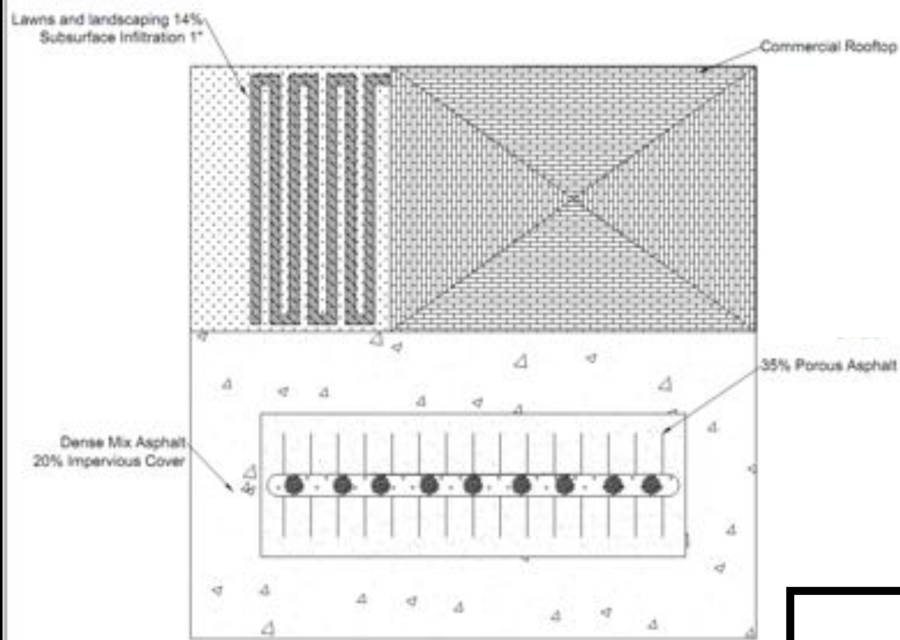
Conventional Build-Out, 'CN' = 78.0



LID Build-Out 'CN' = 69.5



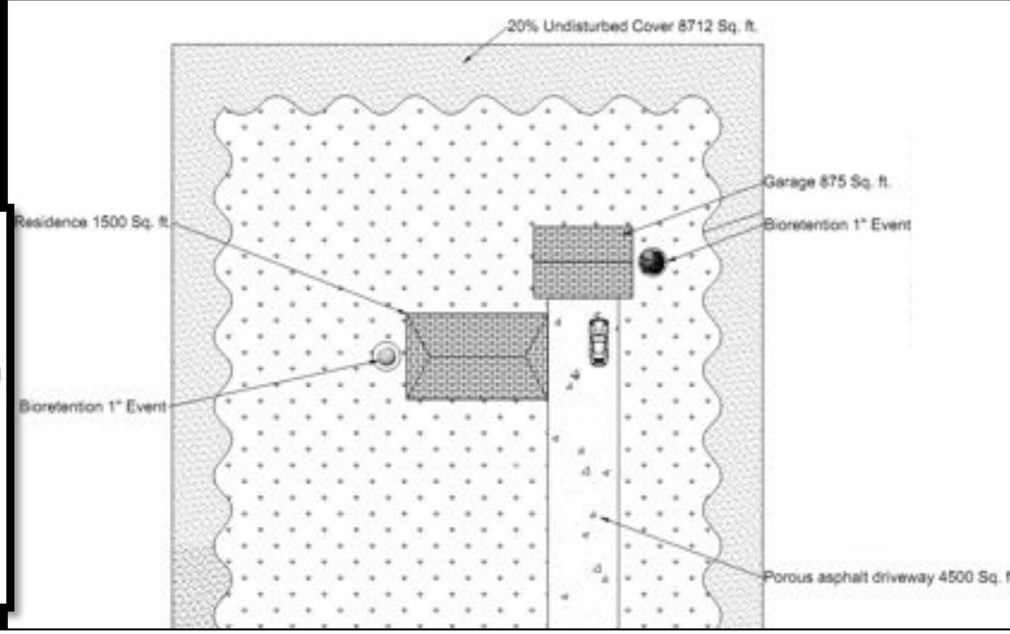
LID Buildout Scenarios



Commercial Zoning

Notes:
85% IC 0% EIC
WQV = 1"
Rooftop Infiltration
Porous asphalt for parking only
Bioretention for drive lanes of standard asphalt

Type	A	B	C	D
CN Predevelopment	38	55	70	77
CN Conventional	84	89	92	94
CN LID	64	73	80	83



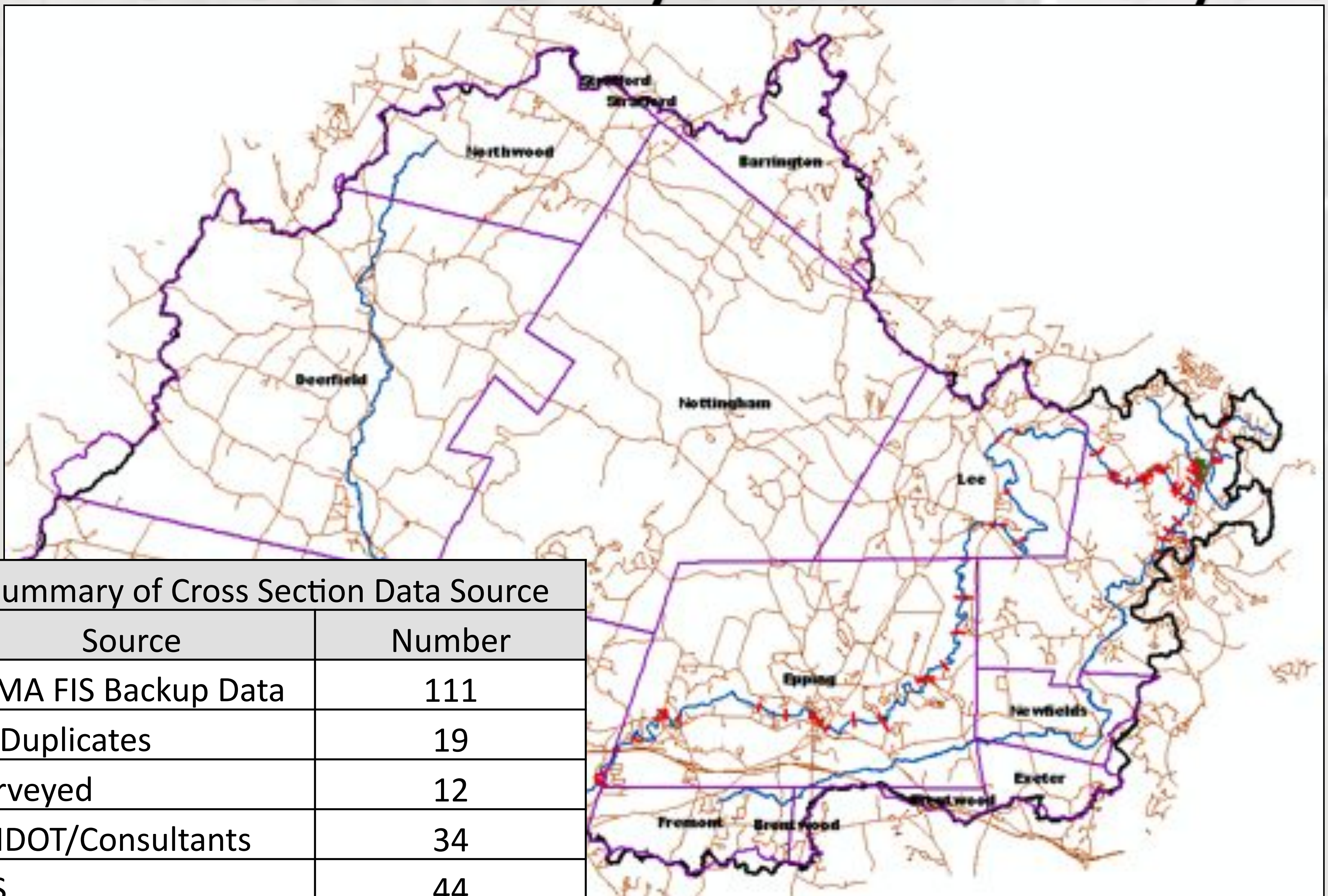
One Acre Residential

Notes:
19% IC 0% EIC
WQV = 1"
Rooftop and garage bioretention
Associated impervious surface biorentention
Porous asphalt driveway

Type	A	B	C	D
CN Predevelopment	38	55	70	77
CN Conventional	51	68	79	84
CN LID	43	62	74	80

Runoff Curve Number Reduction Method from : 1. McCuen, R. and M. D. E. (1983). Changes in Runoff Curve Number Method; 2. Maryland Department of Environment (2008). Maryland Stormwater Design Manual, Supplement No. 1.

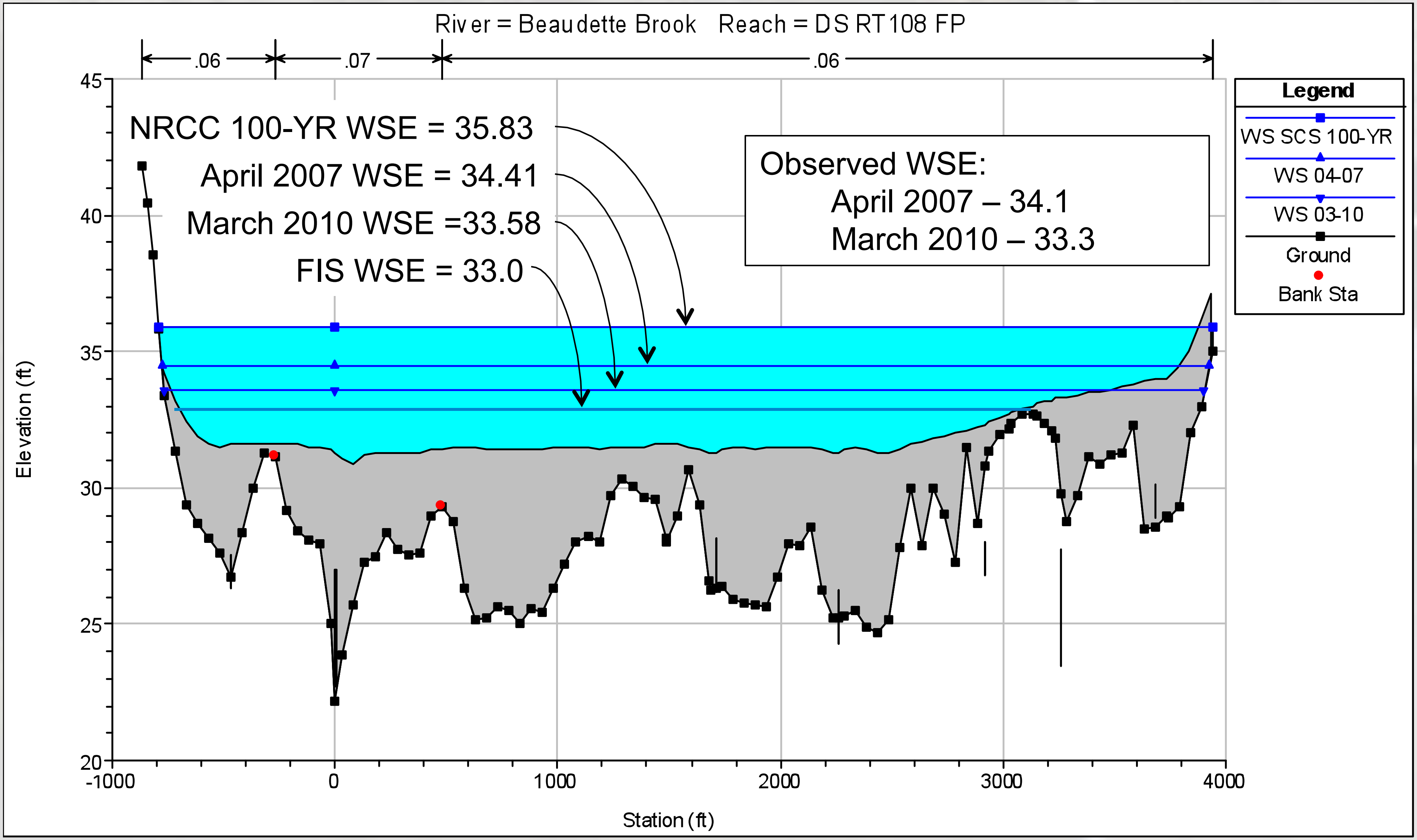
HEC-GeoRAS Hydraulic Analysis



Summary of Cross Section Data Source	
Source	Number
FEMA FIS Backup Data	111
Duplicates	19
Surveyed	12
NHDOT/Consultants	34
GIS	44
Total	220

Hydraulics Model – Results for RT108

Hydraulics Model – Results and Calibration for RT108



Results from 2010 Climate and Land Use Updates

- Model updates indicated a 45% increase in the 100-year flood flow from
  - USGS gage: 7,300 cfs (FIS) to 10,649 cfs (NRCC)

- An increase in the base flood elevations by an average of 2.7 feet along the 36 mile study reach.

  - NRCC elevation almost two feet higher than April 2007 event

2050 Build-out at the Watershed Scale and Subwatershed Scale

Watershed Scale Build-Out

- Conventional development resulted in an increase 0.3 feet in base flood elevation and a 4.3% flood flow increase and only a 2.8% increase with the LID scenario.

Subwatershed Scale Build-Out

- Urban sub basins had substantial runoff reductions using LID build-out scenarios and in one instance actually reduced beyond current conditions.
- Conventional build-out had increases in runoff from 29-36% whereas LID build-out had a range of -2-7%.

This last finding is substantial illustrates that LID in a redevelopment scenario can serve to reduce runoff from current conditions.

Funding

Funding is provided by the Cooperative Institute for Coastal and Estuarine Environmental Technology (CICEET) whose mission is to support the scientific development of innovative technologies for understanding and reversing the impacts of coastal and estuarine contamination and degradation.


Thank you for your time.
Questions?

Hydraulics Model – Cross Sections

Summary of Cross Section Data Source	
Source	Number
FEMA FIS Backup Data	111
Duplicates	19
Surveyed	12
NHDOT/Consultants	34
GIS	44
Total	**220**

- FIS sections were duplicated as needed to provide immediate sections up and downstream of bridges
- No backup data available for Lee
- Projects included additional sections supplementing FIS sections
- Improved modeling in RT108 corridor and tributaries

Hydraulics Model – Structural Data

Summary of Bridge Structure Source for the Lamprey River			
Community	Station	Road Name	Data Source
Raymond	181300	Dudley Road	Electronic WSP2 files from Roald Haestad, Inc. March 1993
	180964	Raymond Road (RT 27)	
	167900	Langford Road	
	160746	Main Street	
	155060	Epping Street	
	154106	B&M Railroad	
	147643	Freetown Road (RT 107)	
	141372	Prescott Road	
Epping	136759	State Route 101	
	127937	Epping Road (RT 27)	Electronic HEC-RAS files from NHDOT, 2010
	123964	Blake Road	As-built drawings from NHDOT, dates vary
	107459	Main Street (Plummer)	
	106269	Mill Street	Electronic HEC-RAS files from NHDOT, 2000
	105560	Calef Hwy (RT 125)	
	88171	Hedding Road (RT 87)	WSPRO print out and As-built from NHDOT, 2000
Lee	61457	Wadleigh Falls Road	As-built drawings from NHDOT, dates vary
	35683	Lee Hook Road	
Durham	20082	Wiswall Road	Electronic HEC-RAS files from CLD Consulting, 2009
	16028	Packer's Falls Road	FEMA FIS Backup Data
Newmarket	1602	RT 108	

Summary of Bridge Structure Source for the RT108 Corridor			
Watercourse	Station	Road Name	Data Source
Floodplain	71	Newmarket Road (RT 108)	Survey drawings from NHDOT, 2010
Hamil Brook	1040	Newmarket Road (RT 108)	FEMA FIS Backup Data
Longmarsh Brook	4182	Bedard Road	
Longmarsh Brook	1703	Longmarsh Road	
Longmarsh Brook	275	Tote Road	

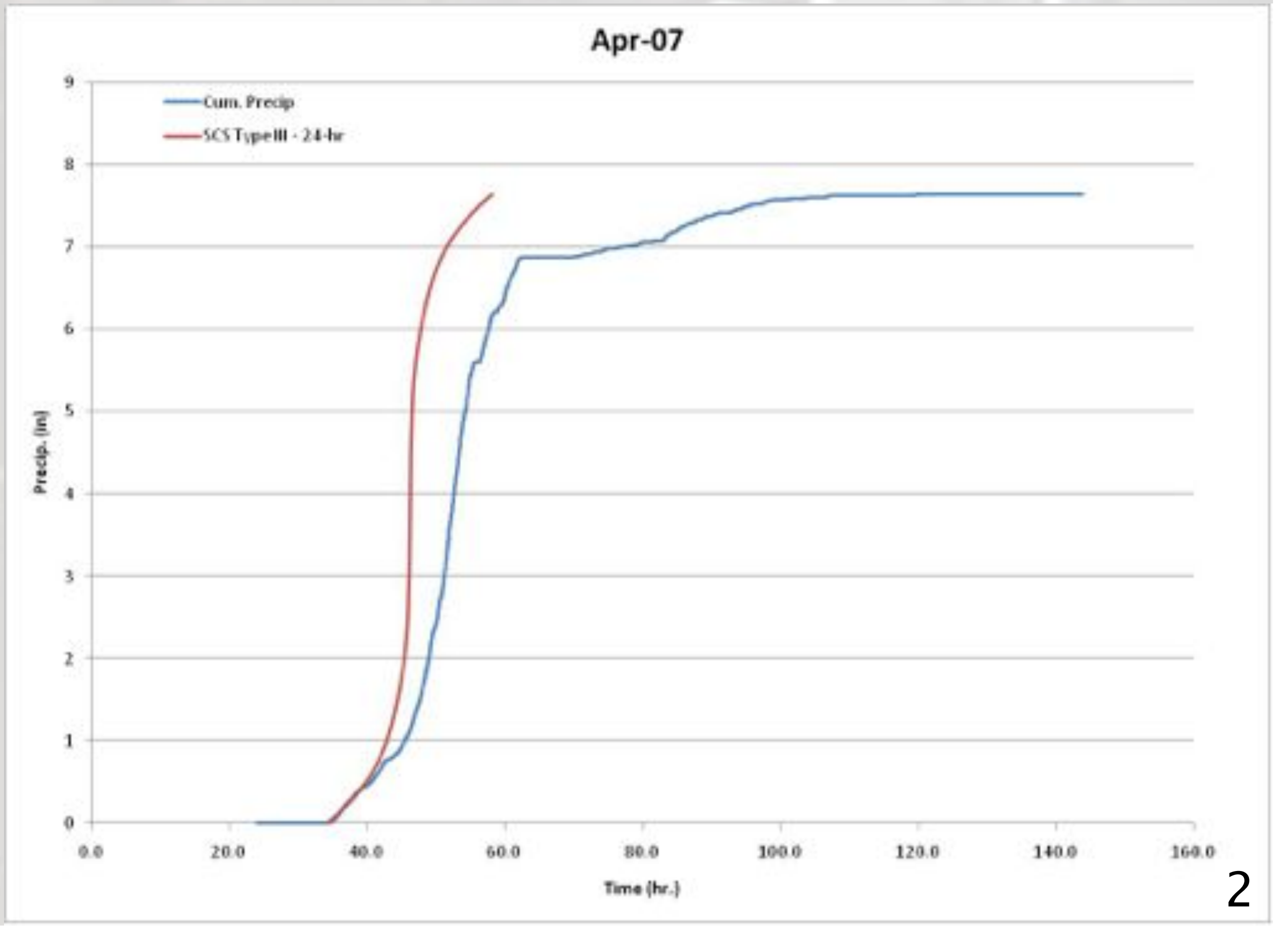
Hydraulics Model – Dam and In-line Structural Data

Summary of In-line Structure Source for the Lamprey River			
Community	Station	Road Name	Data Source
Epping	127265	Bunker Pond Dam	Electronic HEC-RAS files from NHDOT
Lee	61266	Wadleigh Falls Dam	Land Records
Durham	19859	Wiswall Dam	Electronic HEC-RAS files from CLD Consulting Engineers
Newmarket	1286	Coffee Sluice	Electronic HEC-RAS files from Wright-Pierce
Newmarket	1164	Macallen Dam	

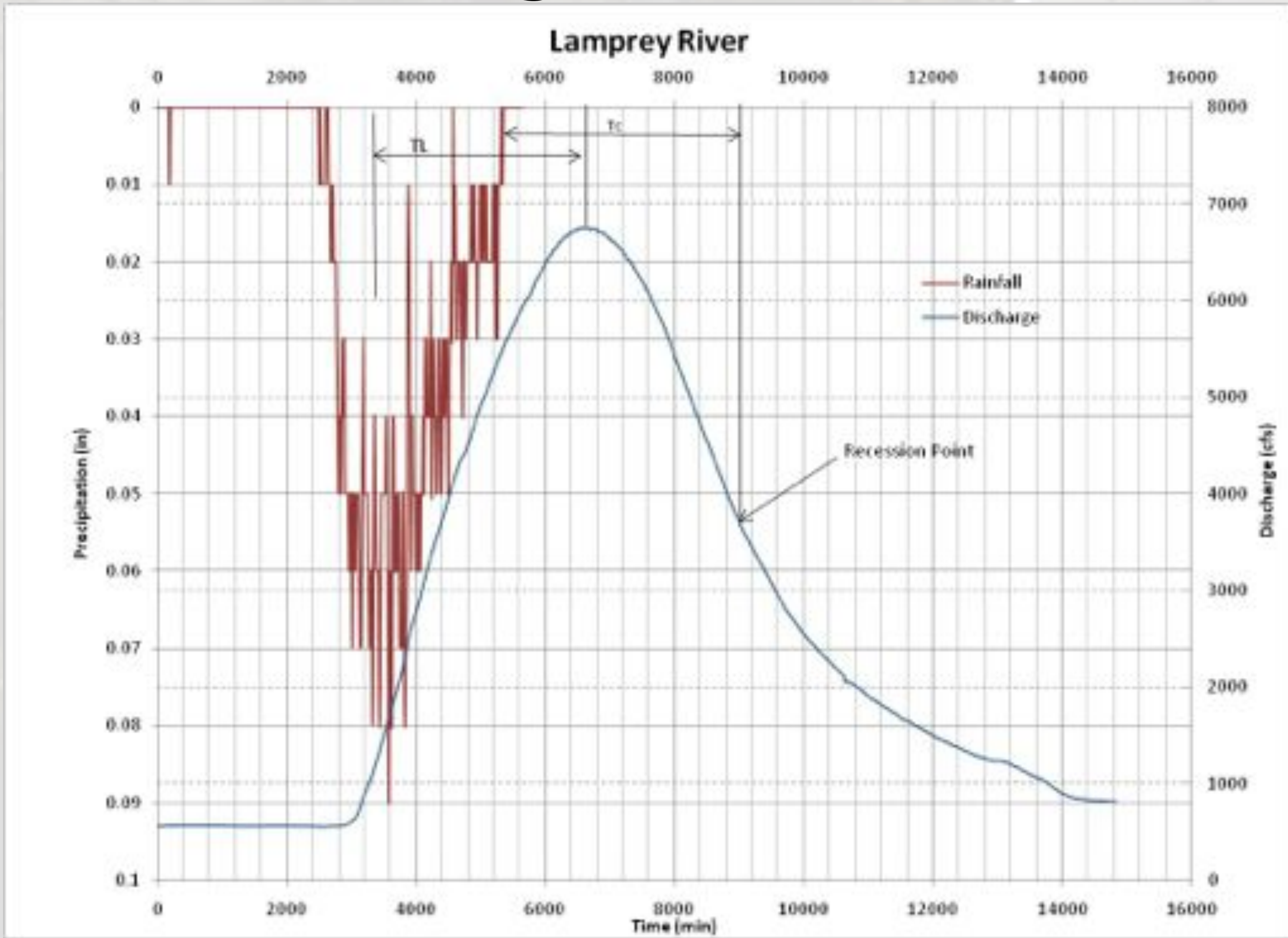
- NHDES Dam Management studying removal of Bunker Pond dam
- Wiswall bridge has been replaced and downstream dam replacement in near future
- Macallen Dam recently inspected per NHDES request
- Spillway dimensions and layout, elevation field verified

Calibrating the Watershed

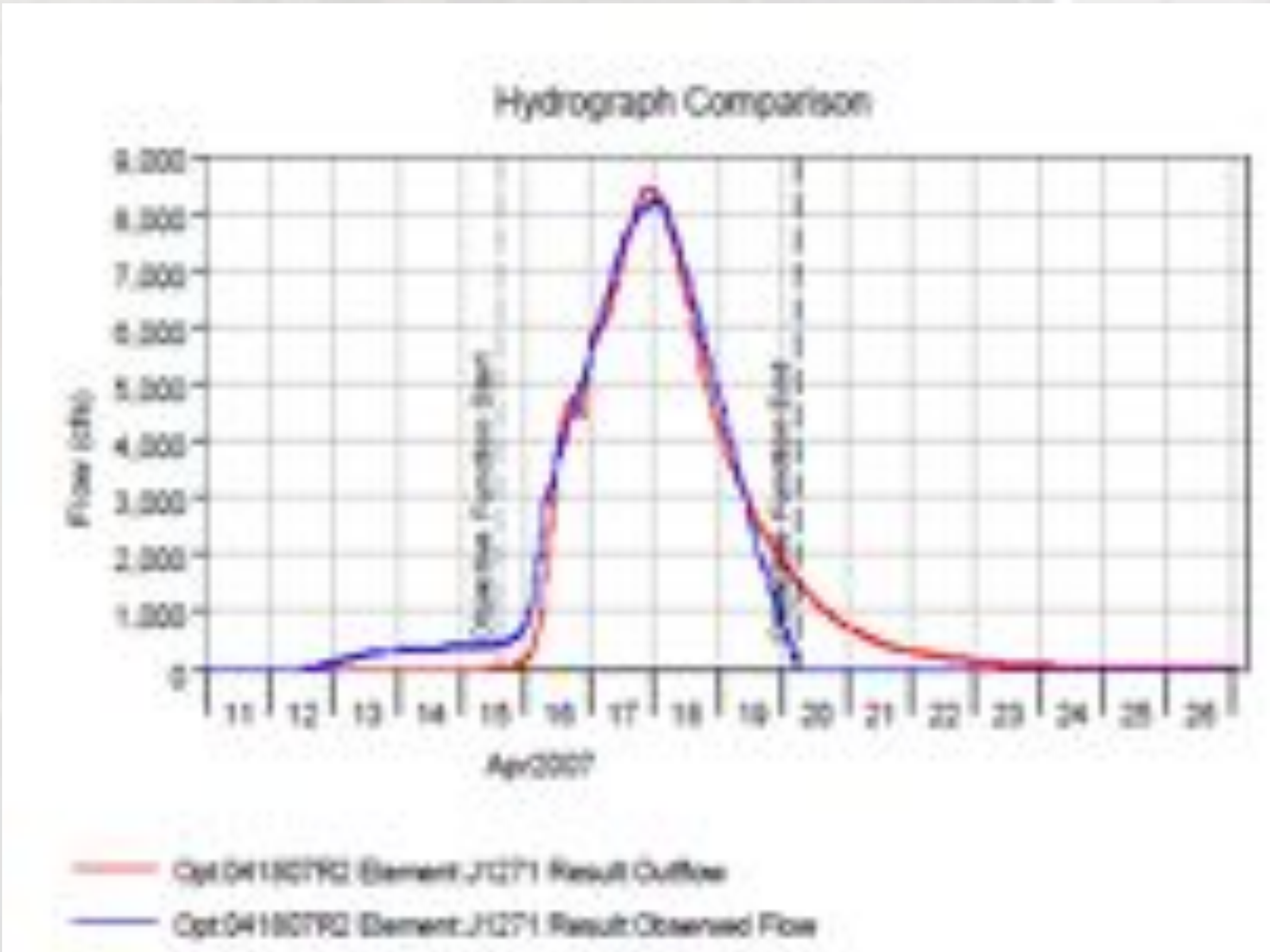
- Calibration:
  - April 2007 – 7,590 cfs, Precipitation – 7.65 in
  - March 2010 – 6,550 cfs, Precipitation – 7.02 in
- Optimization parameters:
  - Manning's 'n'
  - Lag Time
  - Tc
- Simulated for
  - Time to peak
  - Runoff volume
  - Peak flow



Calibrating the Watershed



Calibrating the Watershed



Calibrating the Watershed

<u>Hydrology Model</u> – Calculated flood flow for the gaged 183 sq.mi. watershed

- Results of calibrated model run for current land use (2005) using TP-40 rainfall. $Q_{100,\ TP\text{-}40}$ = 7,580 cfs vs. $Q_{100,\ FIS}$ = 7,300 cfs
- Results of calibrated model run for current land use (2005) using NRCC Atlas rainfall. $Q_{100,\ CA}$ = 10,649 cfs
- 68-percent confidence interval of gaging station estimate for data from 1935-2009, $Q_{100,\ LP3}$ = 9,411 cfs
  $L_{0.01,0.68}$ = 8,862 cfs $H_{0.01,0.68}$ = 10,040 cfs