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Mapping and Legal Implications of Future Flooding in the Lamprey River Watershed of New Hampshire Due to Changes in Land Use and Climate

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2012 NH Water & Watershed Conference

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http://100yearfloods.org

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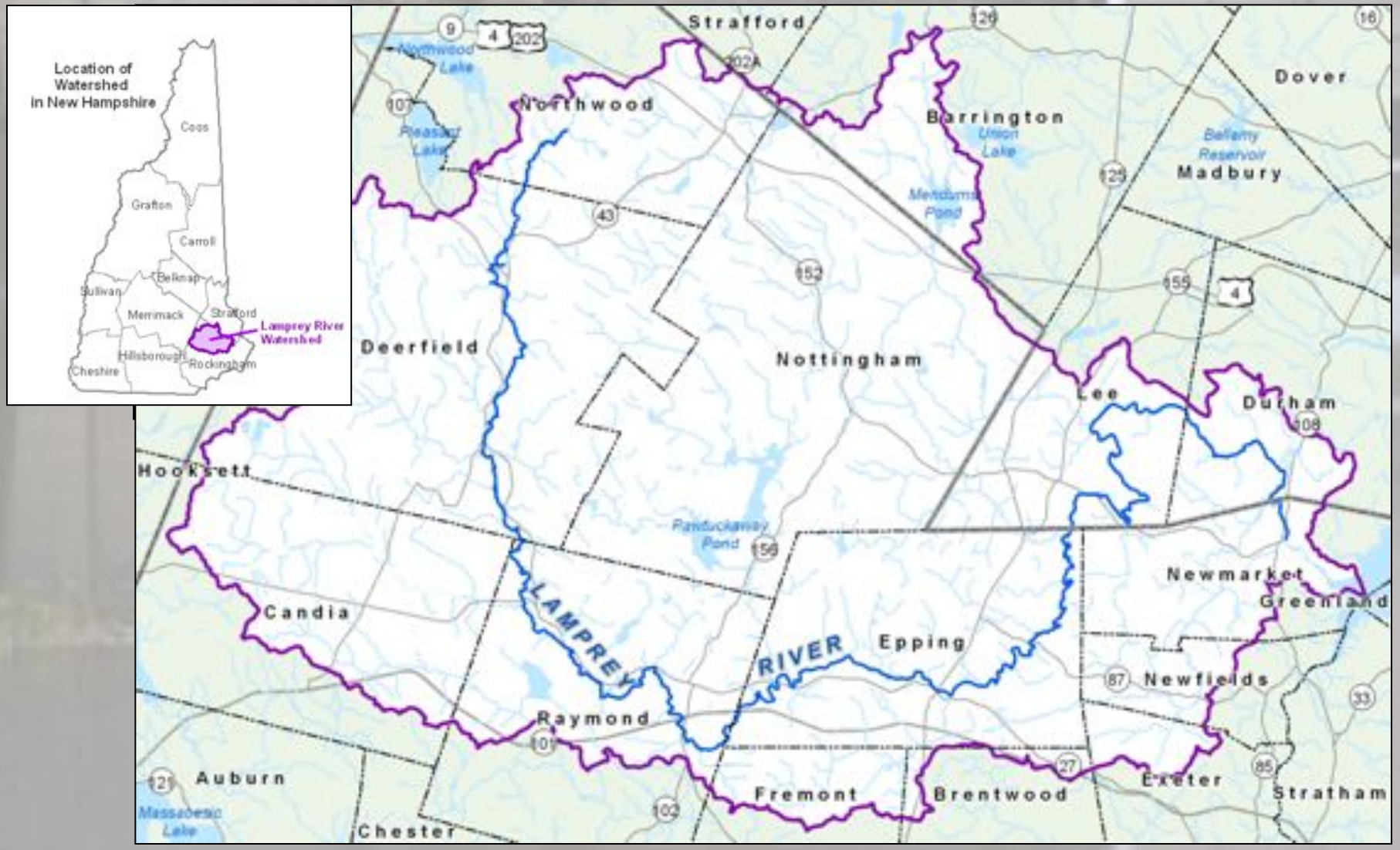
Antioch University New England

Great Bay National Estuarine Research Reserve

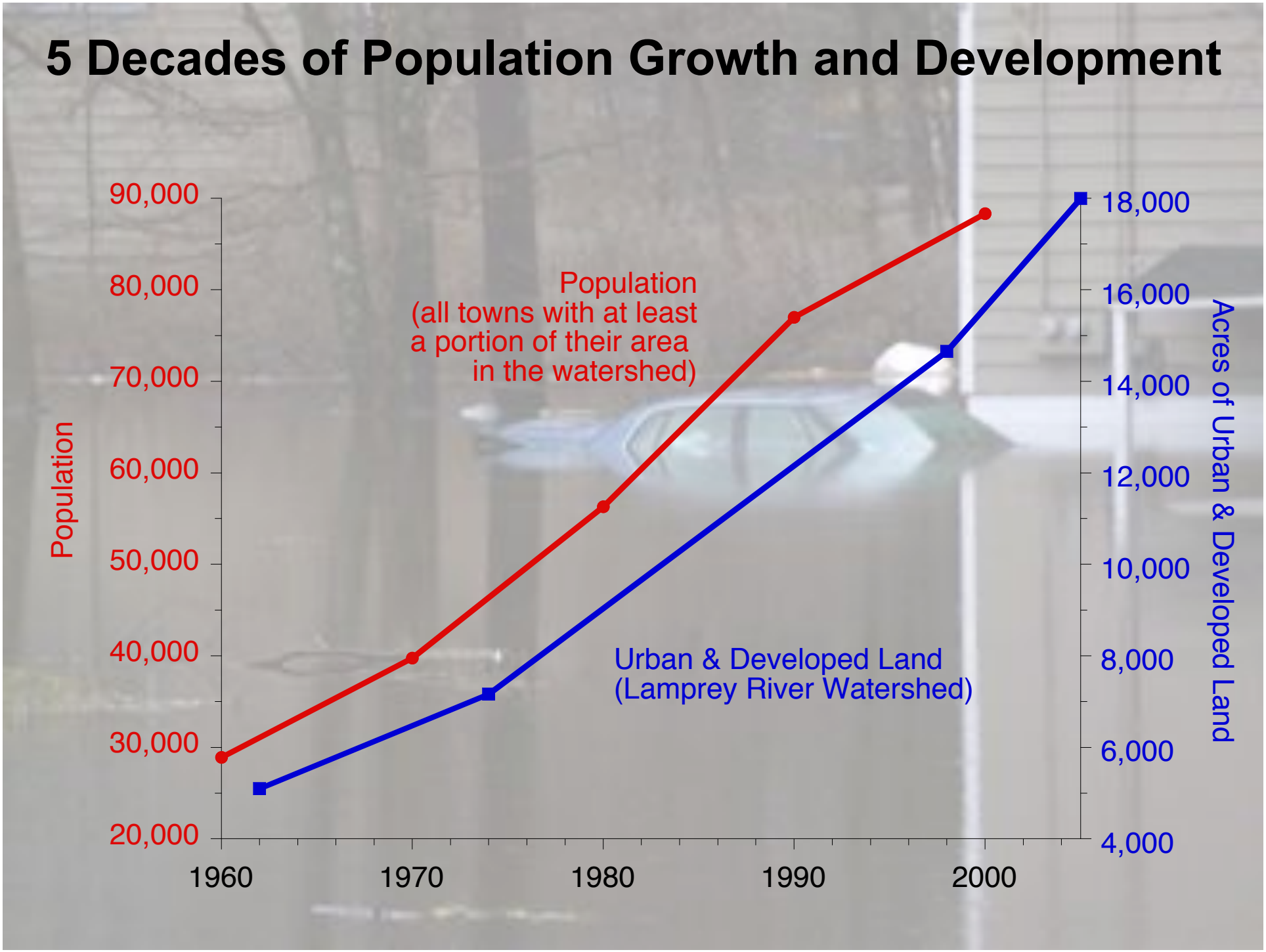
Fish & Game

NOAA

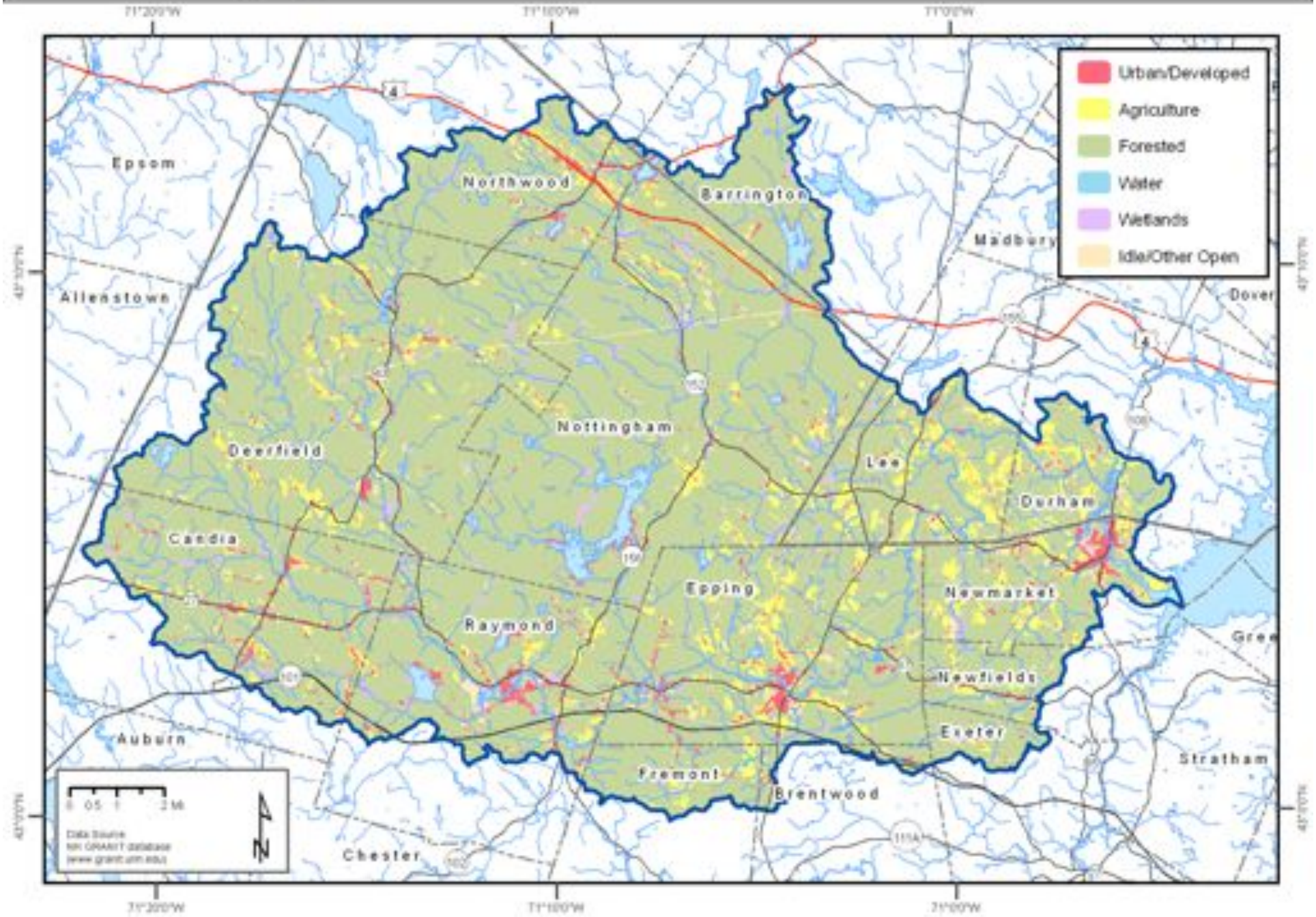
Lamprey River Watershed, New Hampshire



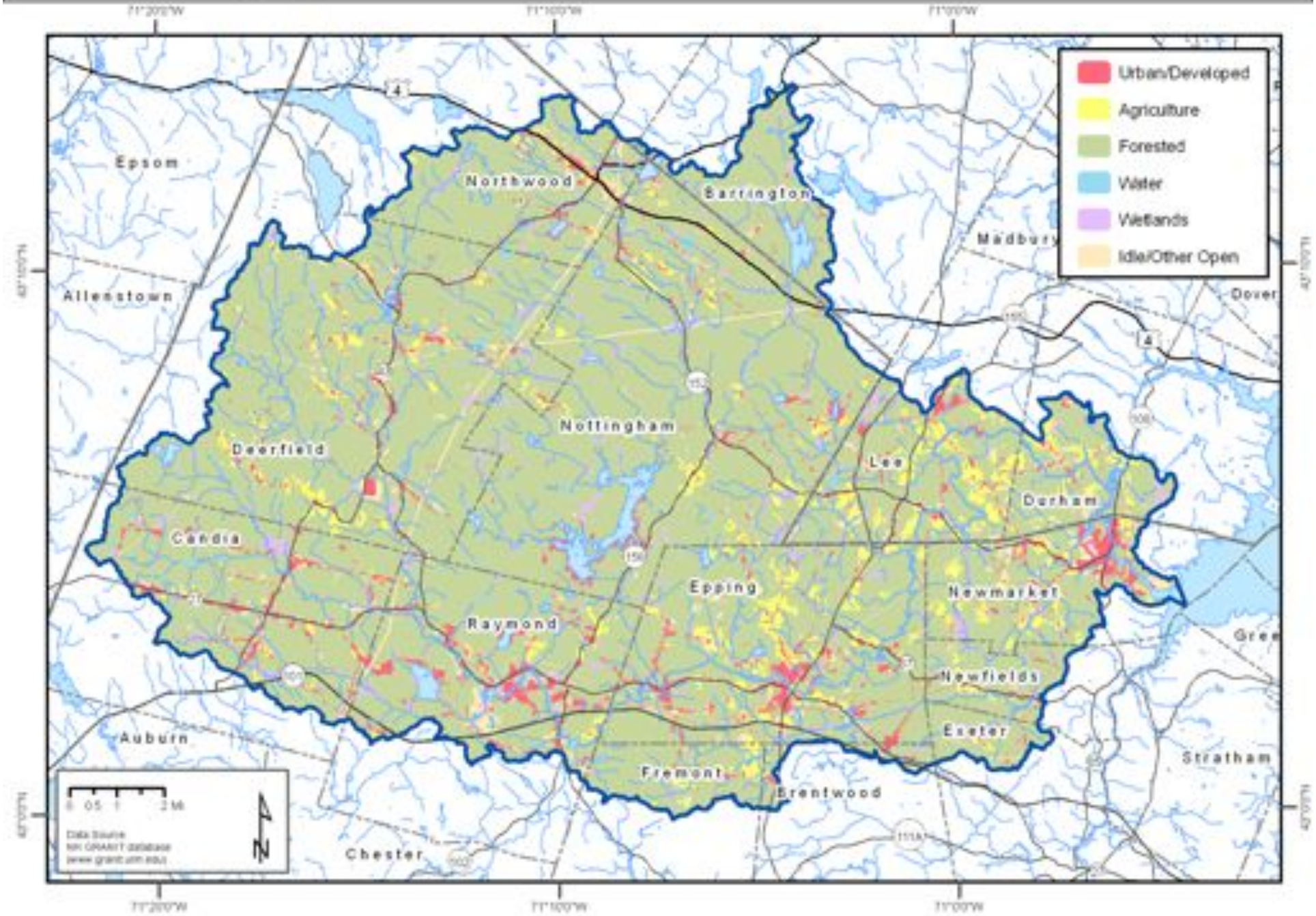
5 Decades of Population Growth and Development



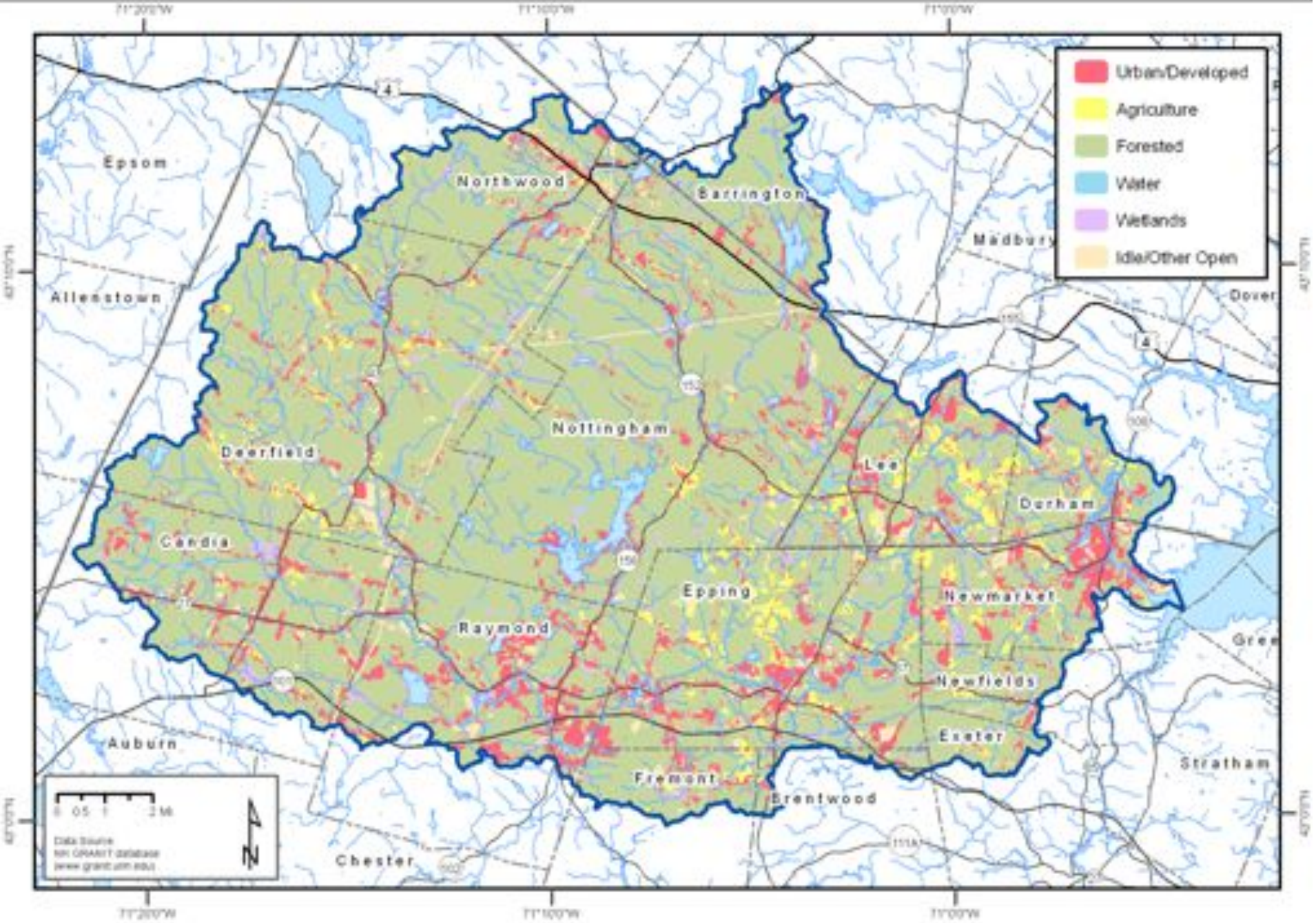
Lamprey River Watershed Generalized Land Use - 1962



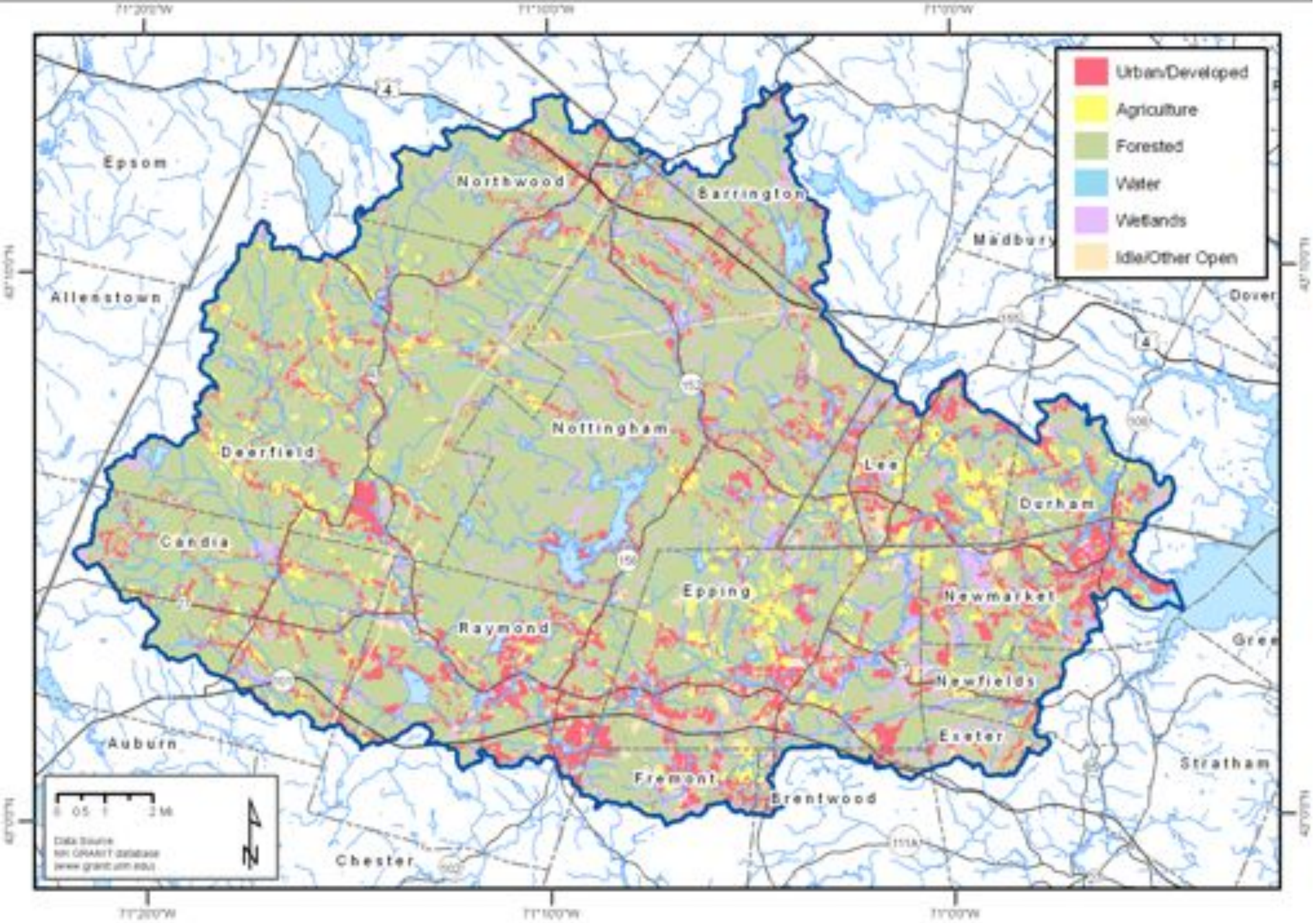
Lamprey River Watershed Generalized Land Use - 1974



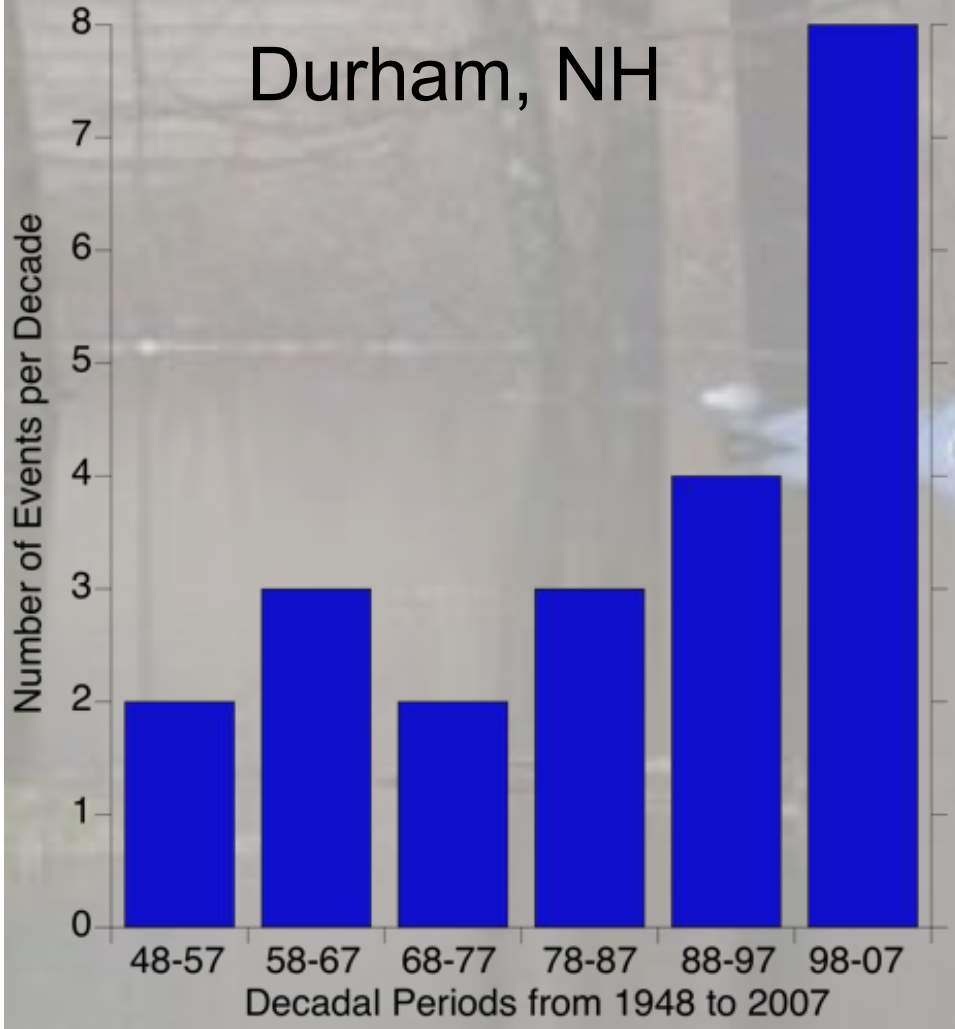
Lamprey River Watershed Generalized Land Use - 1998

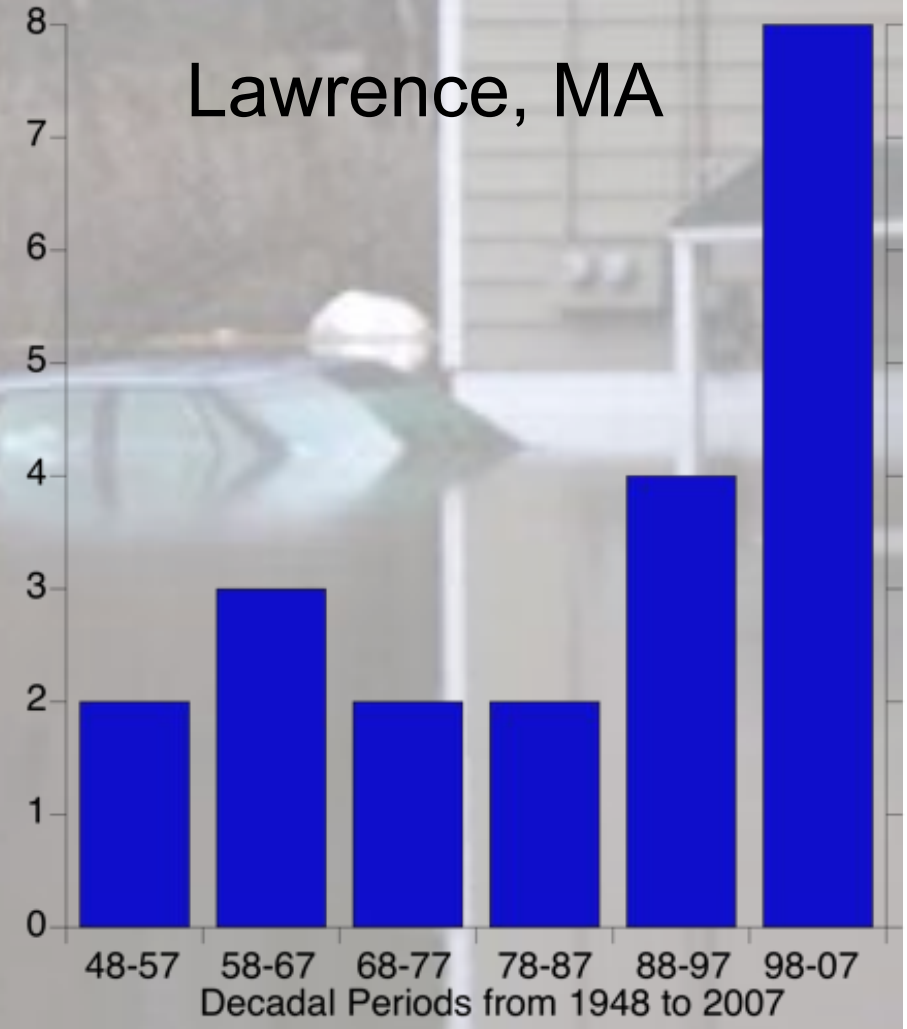


Lamprey River Watershed Generalized Land Use - 2005



4 Inch Precipitation Events by Decade 1948 - 2007

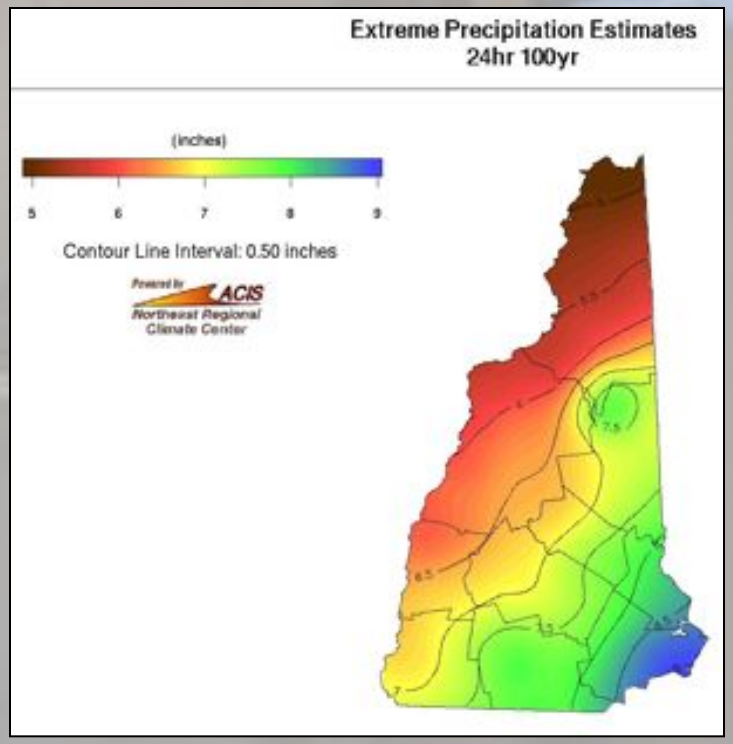




100-year Rainfall Estimates

TP-40 Rainfall Frequency Atlas used for effective conditions = 6.3”

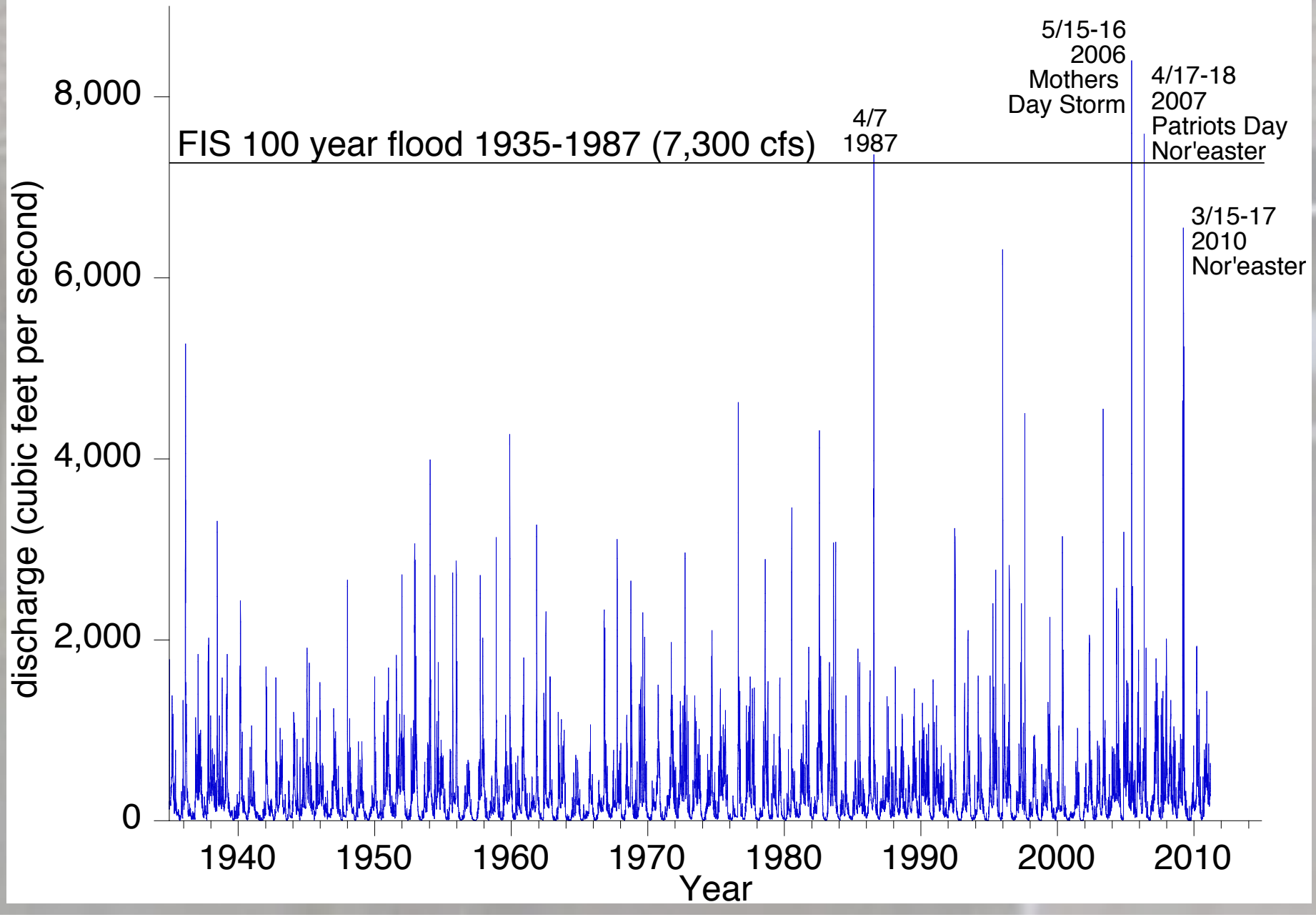
(1938-1957)



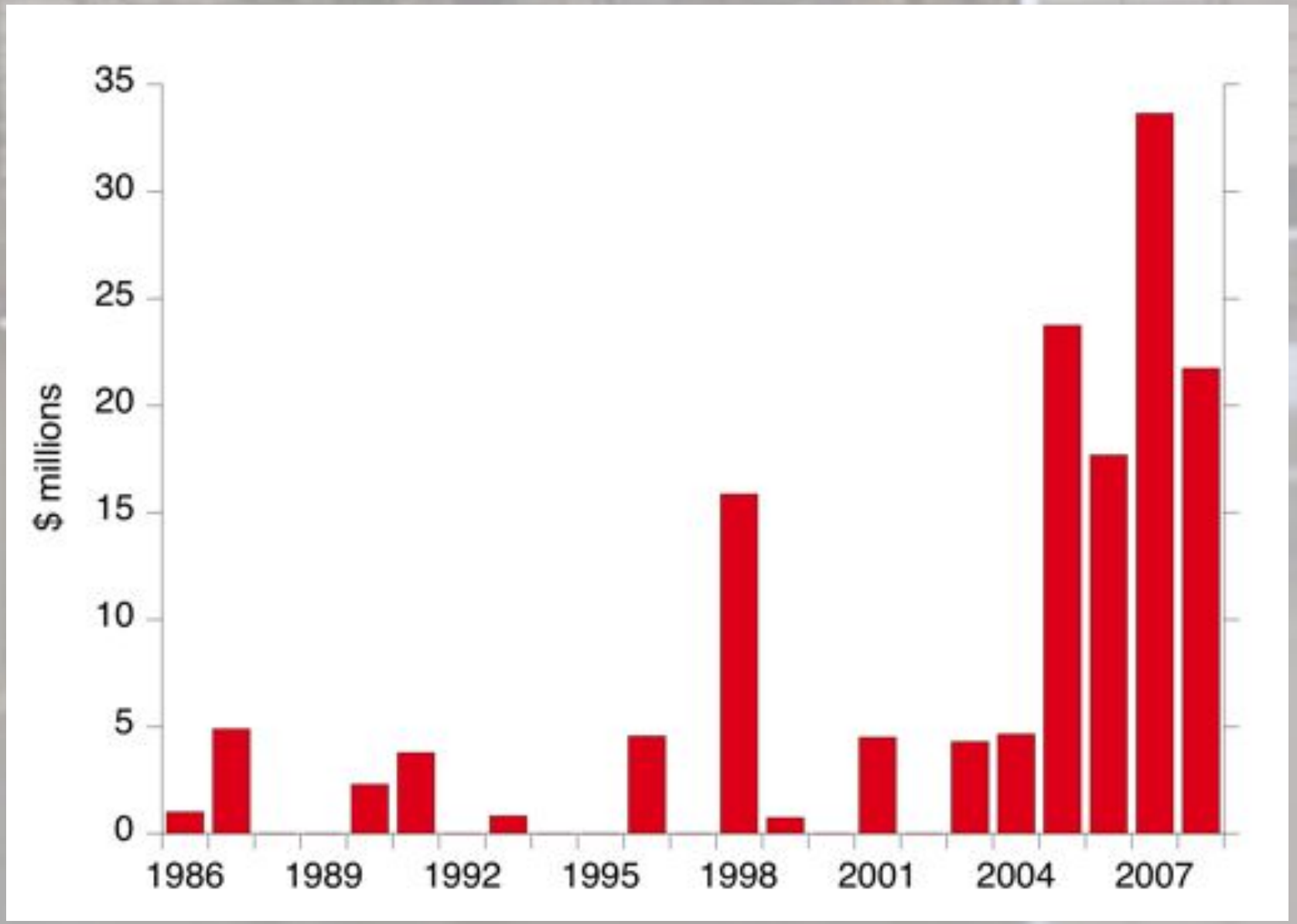
Northeast Regional Climate Center Atlas for Extreme Precipitation for current conditions = 8.5”

http://precip.eas.cornell.edu/

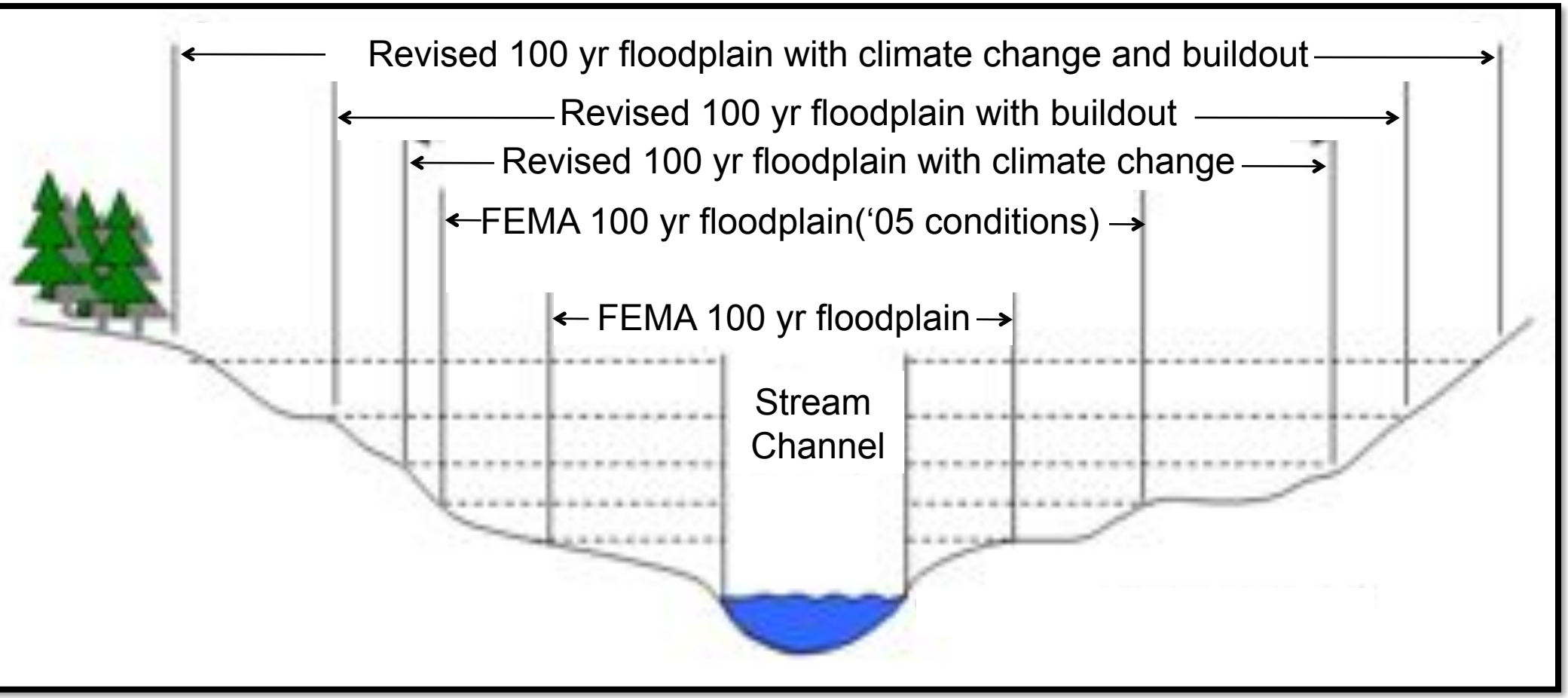
Daily Discharge, Lamprey River 1934 - 2012



Costs from Presidentially Declared Disasters in NH



Changing Floodplains with Changing Climate & Land Use

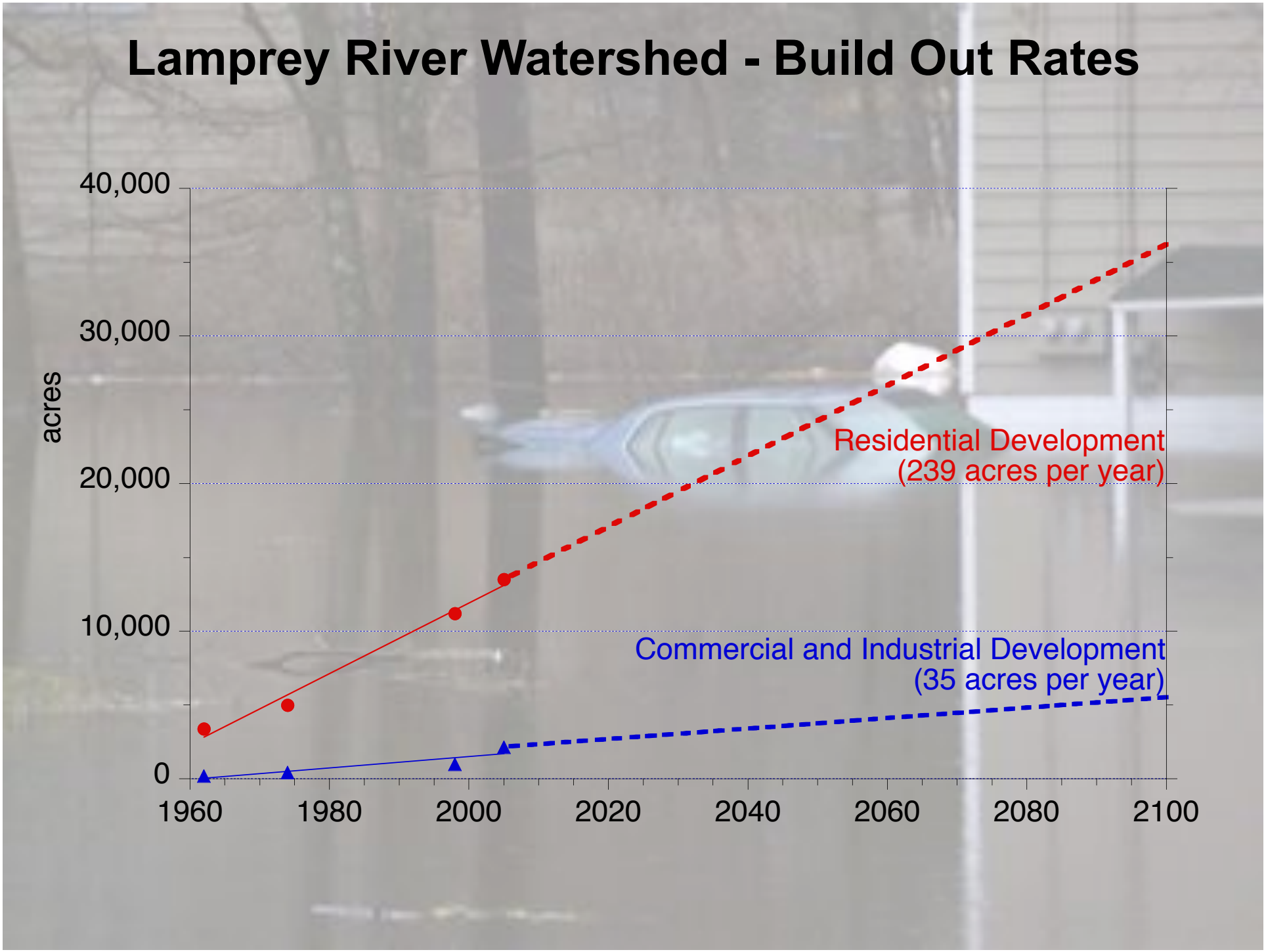


Land Use & Climate Scenarios

Land Use Conditions	Max Daily Precipitation (inches)			
	FIS Conditions	Current Climate	2050*	2100*
FIS	6.3			
2005		8.5		
Build-out			8.5, 11.4	8.5, 11.4
Build-out with LID			8.5, 11.4	8.5, 11.4

* high value for future precipitation represent maximum value from downscaling output from four GCM (CCSM, GFDL, HADCM3, PCM) for a high emissions scenario (A1Fi)

Lamprey River Watershed - Build Out Rates



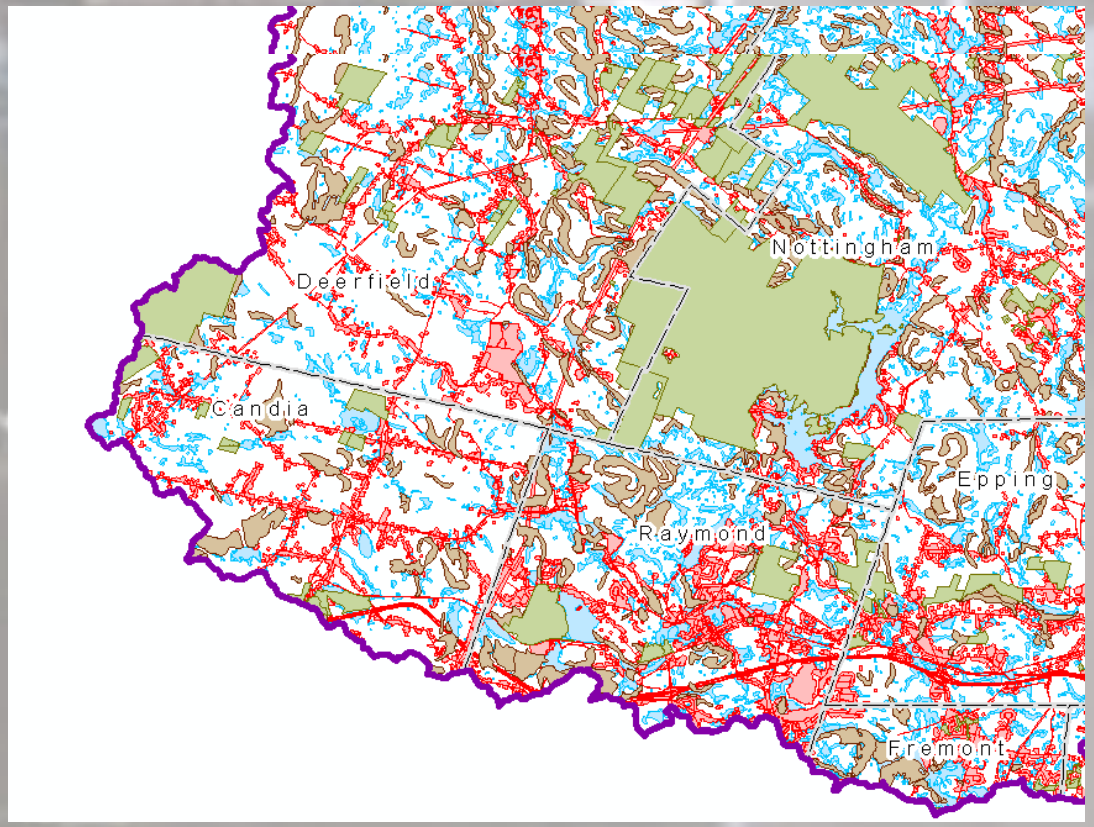
Mapping Buildout

Starting with total watershed acreage, eliminate:

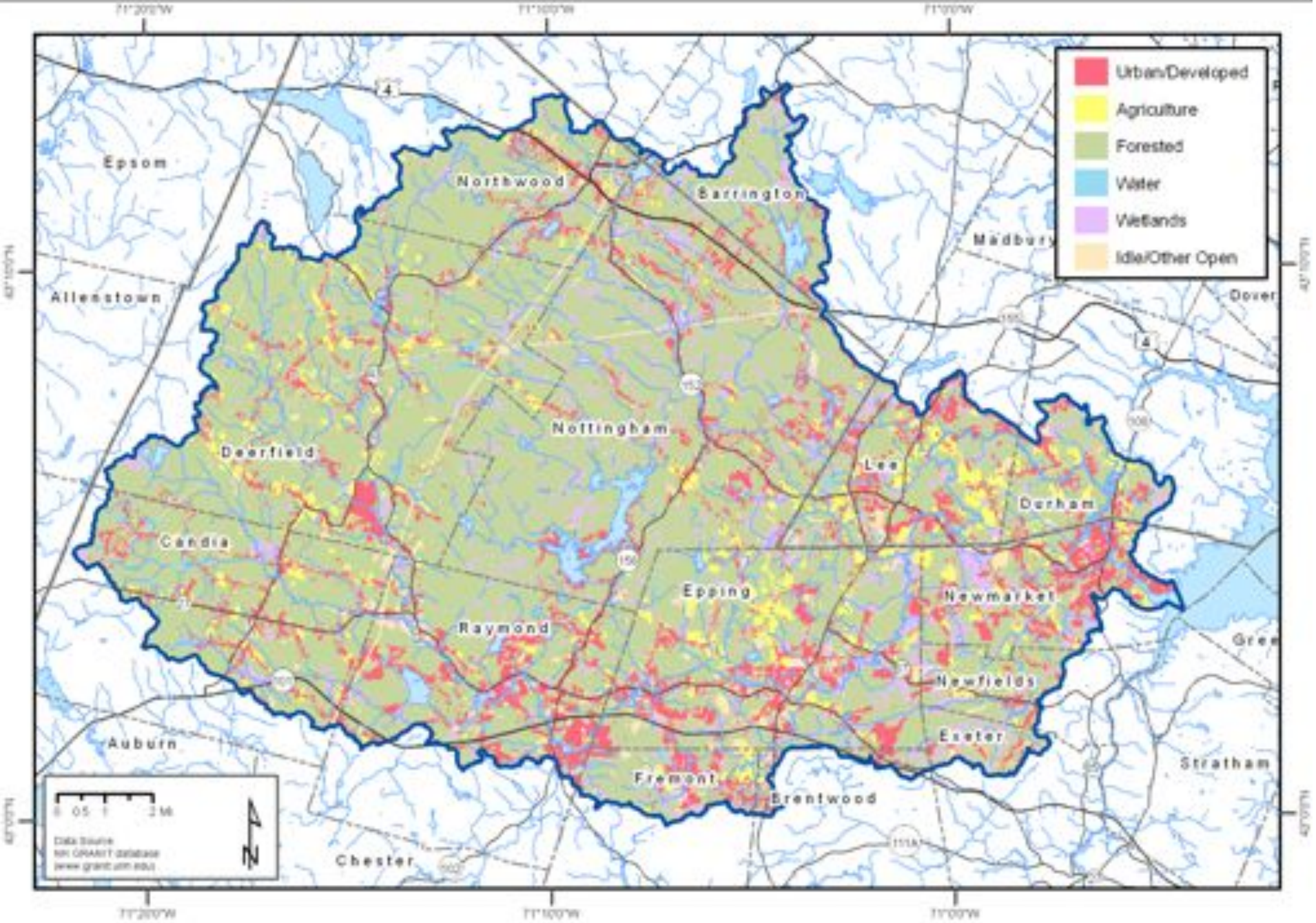
- Developed land
- Hydric soils/wetlands/surface water
- Steep slopes (> 15%, based on soils)
- Conservation lands; public water supply protection areas

Build out flat terrains first, moving incrementally to steeper slopes

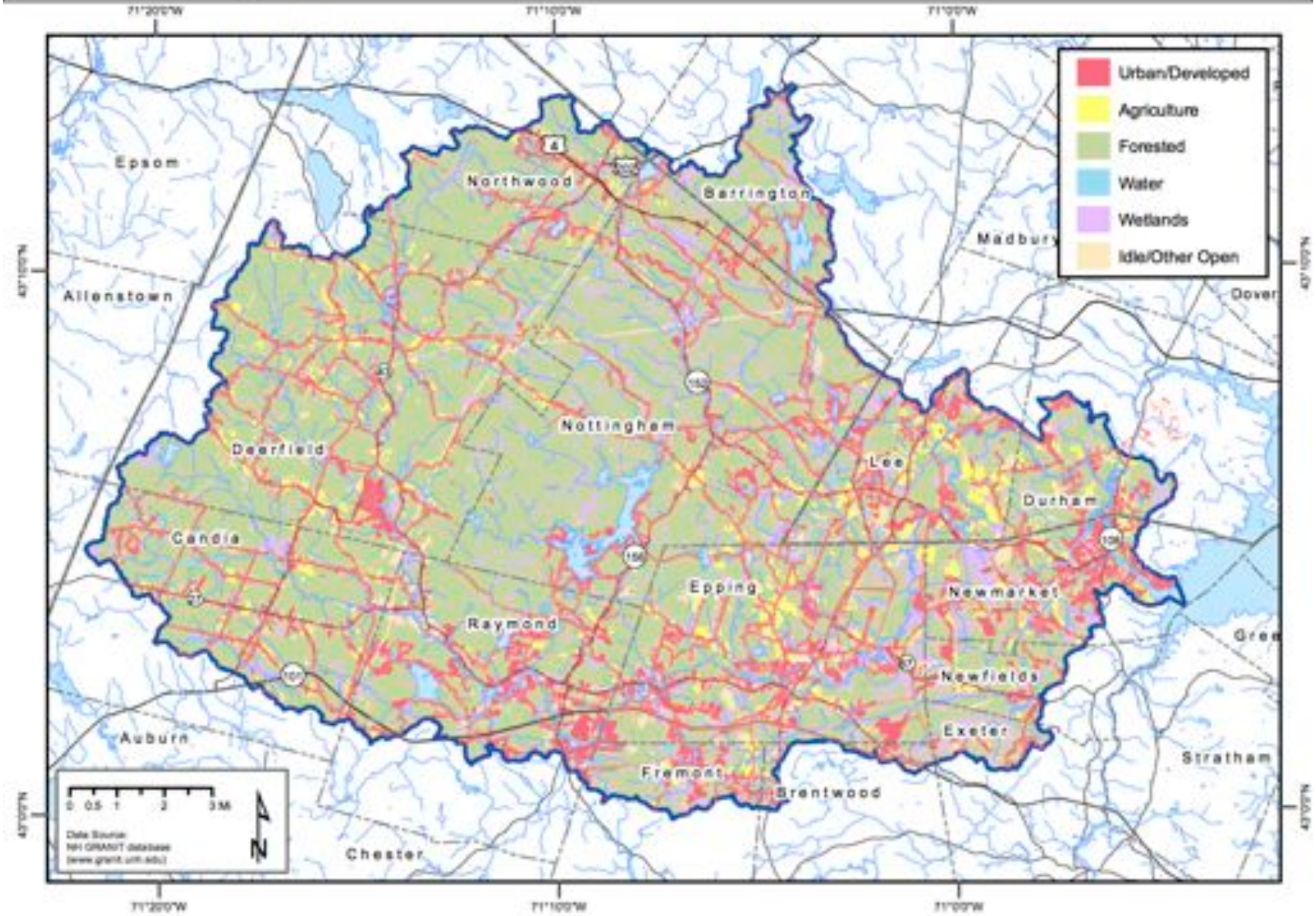
Within a slope category, build out areas closest to roads first



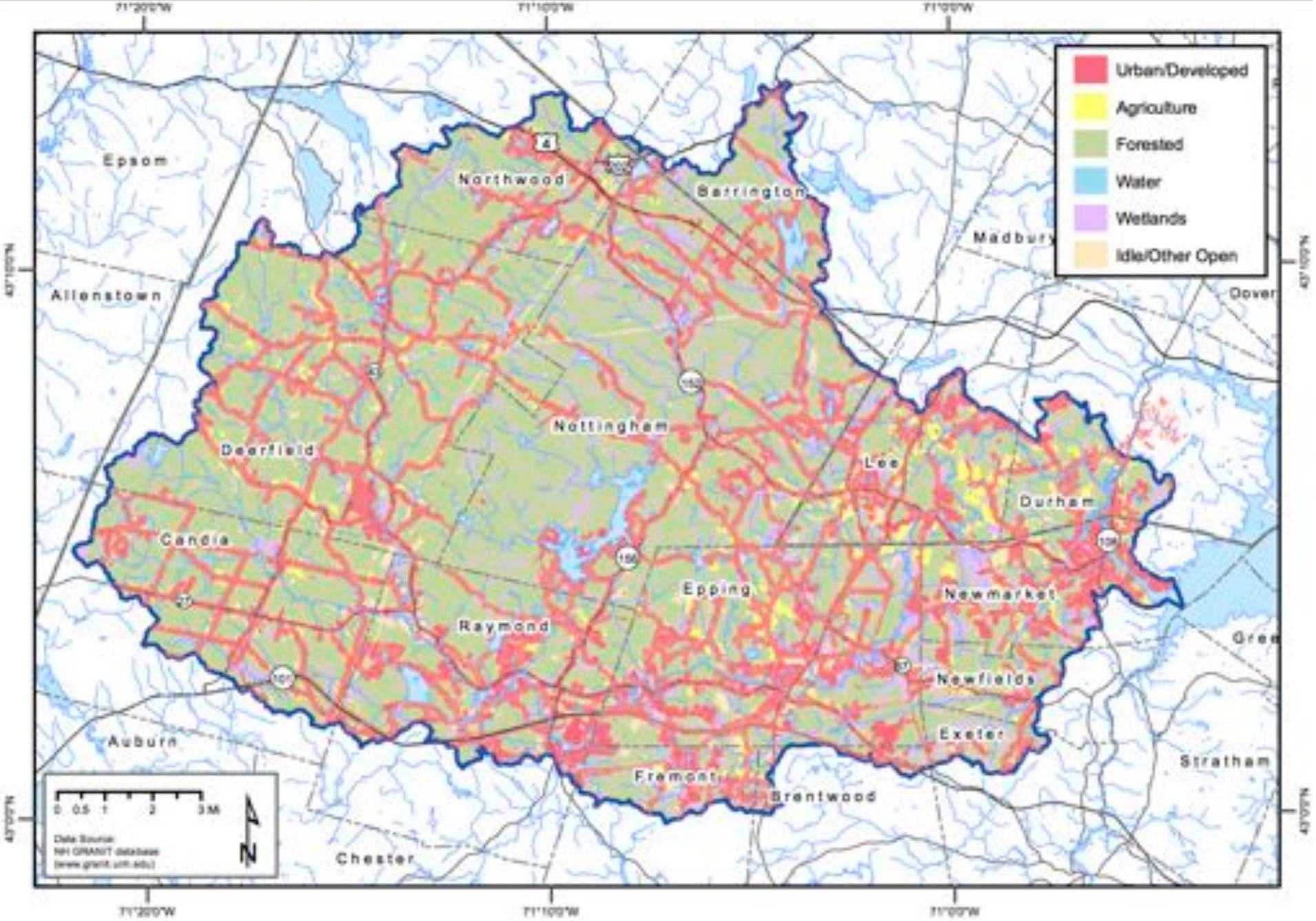
Lamprey River Watershed Generalized Land Use - 2005



Lamprey River Watershed Generalized Land Use - 2050



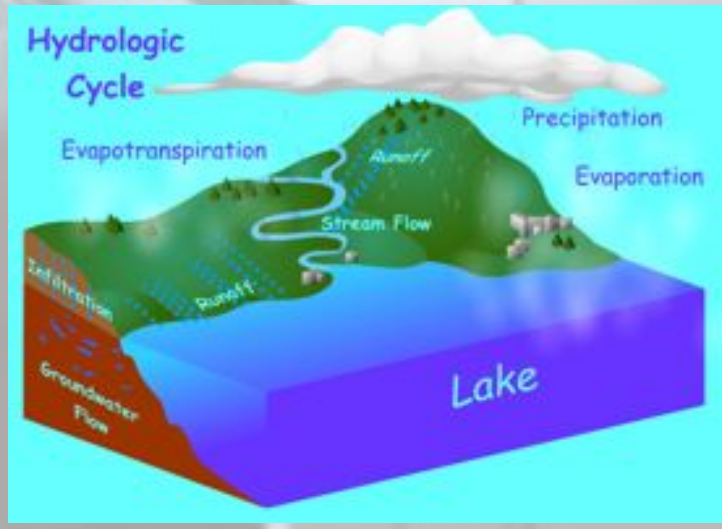
Lamprey River Watershed Generalized Land Use - 2100



Hydrologic Methodology

- **FIS: Annual peak flow frequency analysis**
  - peak annual stream flow
  - standard deviation
  - weighted coefficient of skewness
- **Lamprey River Project:**

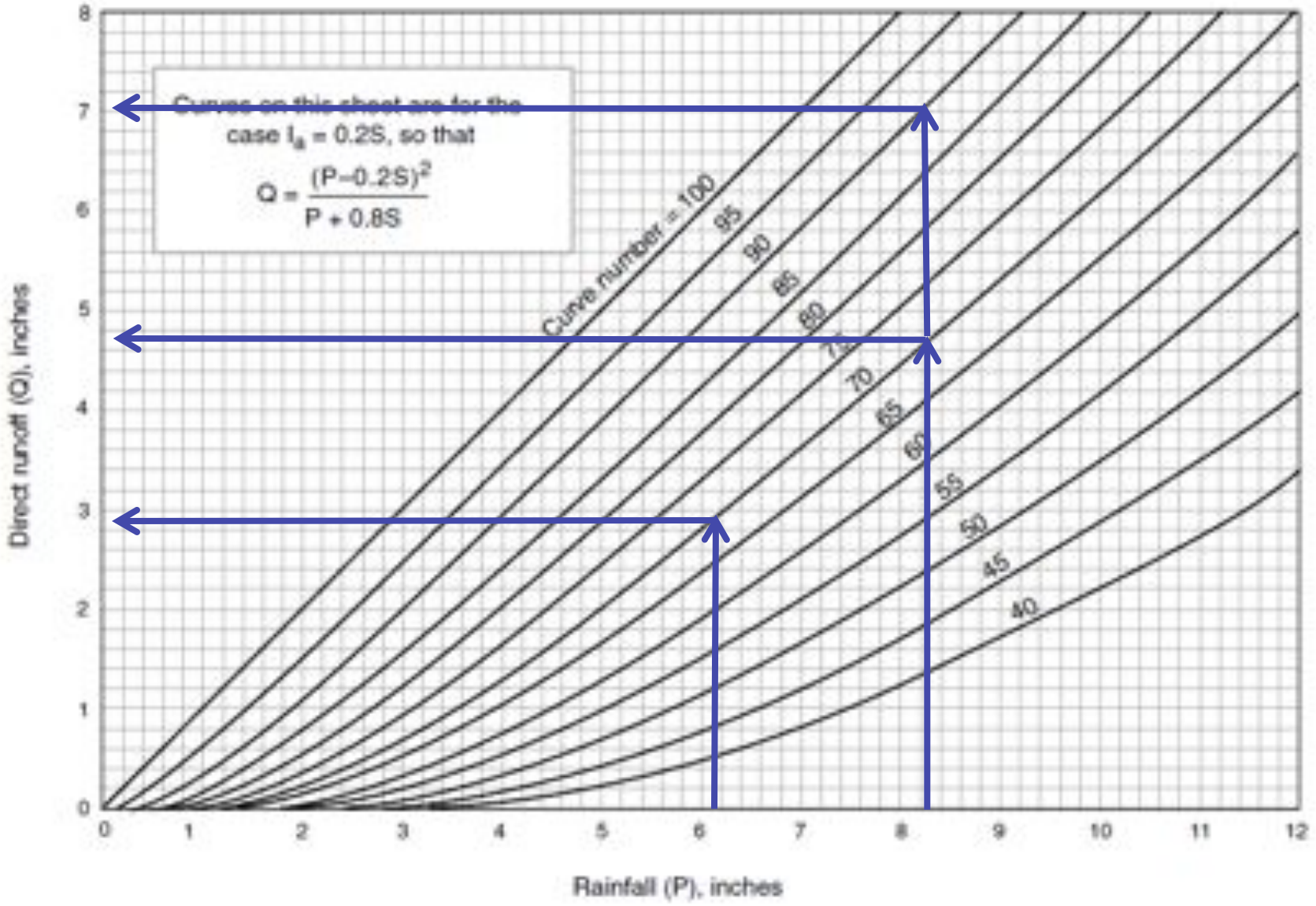
  Rainfall-Runoff Model
  - Watershed area
  - Time of concentration
  - Runoff curve number (CN)



Hydrologic Modeling: HEC-GeoHMS & HEC-HMS

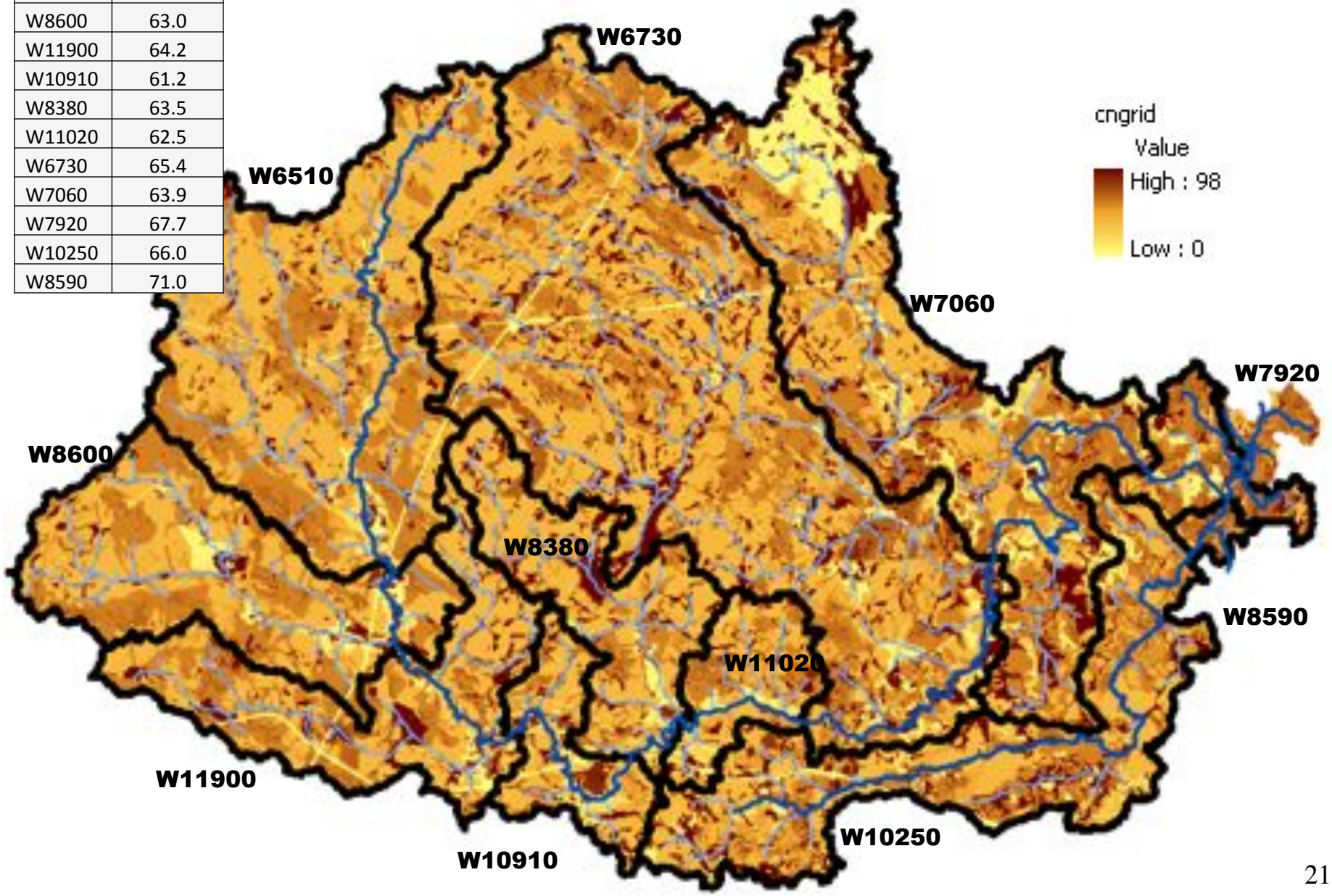
Hydraulic Modeling: HED-GeoRAS & HEC-RAS

Curve Number: Rainfall – Runoff Equation



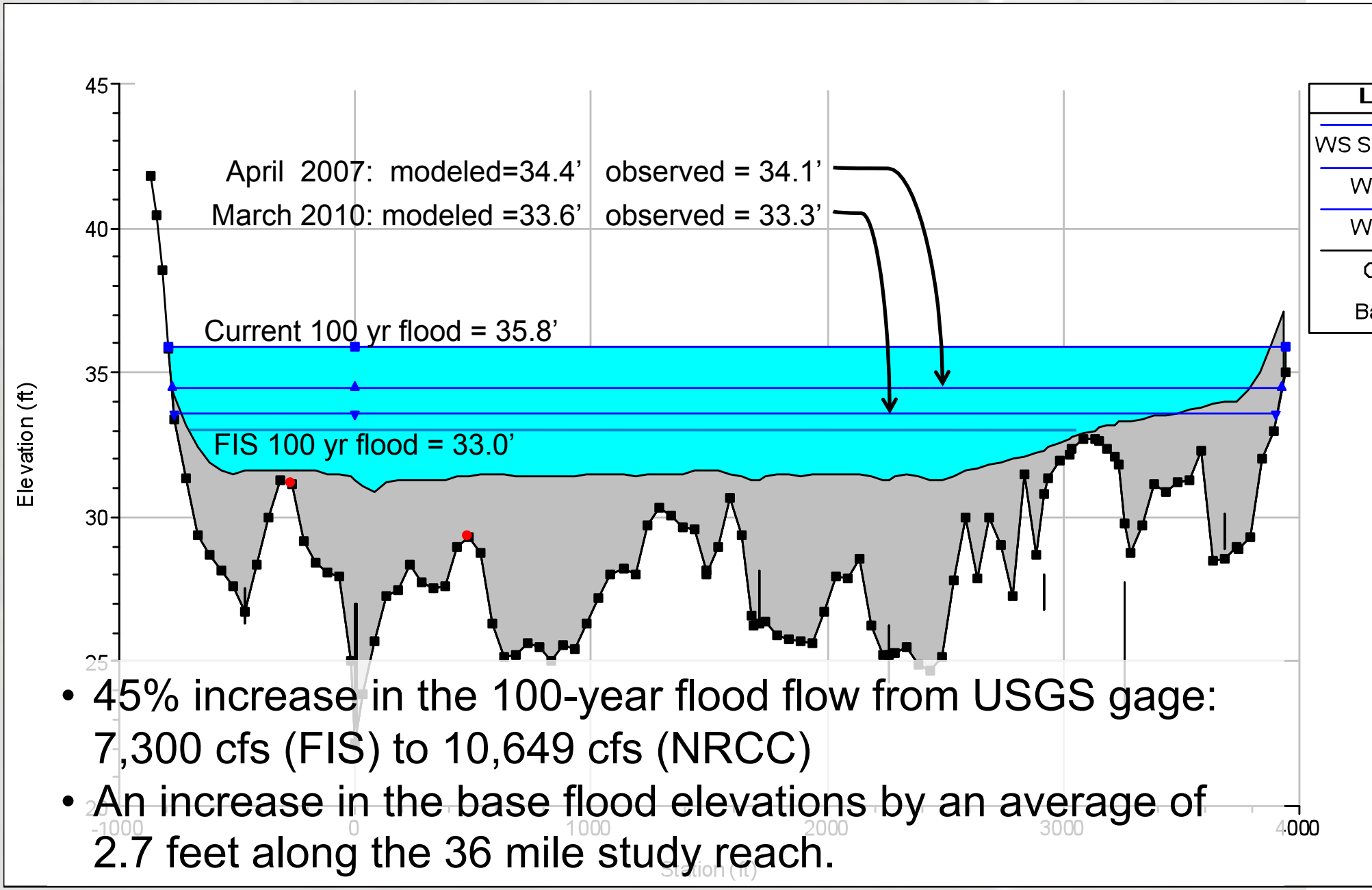
Curve Number based on Land Use and Soil Type

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



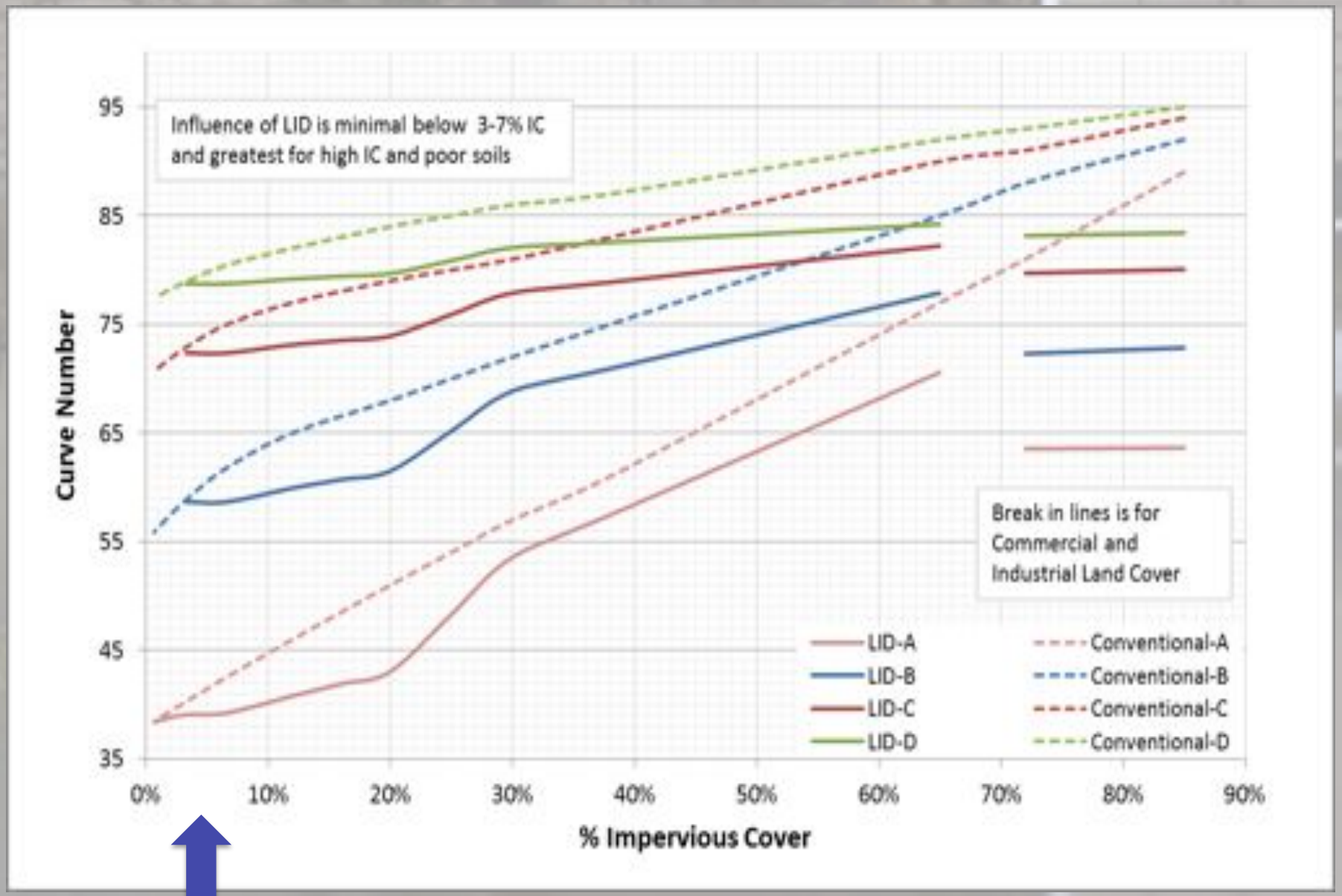
Hydraulic Calibration – Results for RT108

UNH Hydraulics Model – Calibration & Results – RT108



- 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.

Implementing LID



Watershed Scale CN and Runoff

Sub Basin	Current 2005 CN	2050 Conventional Build-out CN	2050 LID Build-out CN	ΔRunoff Depth (in) Conv-LID
RT27, Raymond	62.5	64.9	64.2	0.08
Langford Rd, Raymond	63.0	66.4	65.2	0.14
Downstream Raymond	64.2	68.3	67.5	0.10
West limit, Epping	**61.2**	**67.3**	**65.3**	**0.24**
Blake Road, Epping	63.5	65.4	64.9	0.06
RT 101, Epping	62.5	65.8	65.0	0.09
Northern limit, Epping	65.4	68.3	67.4	0.11
USGS Gage 01073500	63.9	66.2	65.0	0.14
Durham & Newmarket	67.7	70.2	69.5	0.08
Pisscassic River	66.0	70.4	68.7	0.20
Macallen Dam	71.0	75.3	74.9	0.05

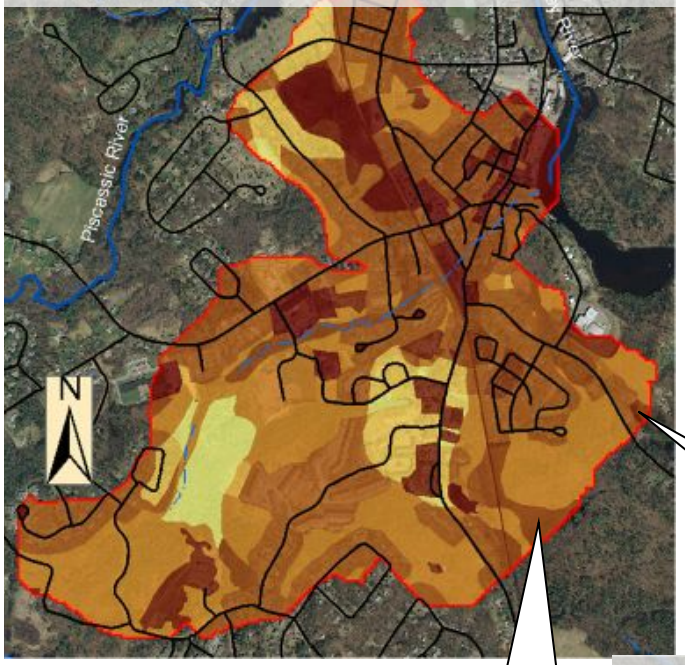
Conventional build-out increases flood flow by 4.3% (0.3’ BFE)
LID build increases flood flow by 2.8% increase

Urban Scale CN, Runoff, and Discharge

Sub-Basin	Current 2005 CN	2050 Conventional Build-out CN	2050 LID Build-out CN	Δ Conv-LID
Moonlight Brook (0.9 sq. miles)				
CN	66.8	78.0	69.5	8.5
Runoff Depth (in)	4.5	5.9	4.8	1.1
Disharge (cfs)	655	852	704	148
Intermittent Stream, Epping (1.2 sq. miles)				
CN	70	81.7	69.4	12.3
Runoff Depth (in)	4.9	6.3	4.8	1.5
Disharge (cfs)	1,031	1,320	1,016	304
Intermittent Stream, Raymond (0.9 sq. miles)				
CN	65.8	79	66.6	12.4
Runoff Depth (in)	4.4	6	4.5	1.5
Disharge (cfs)	508	696	520	176

Moonlight Brook, Newmarket

Current Conditions CN=66.8

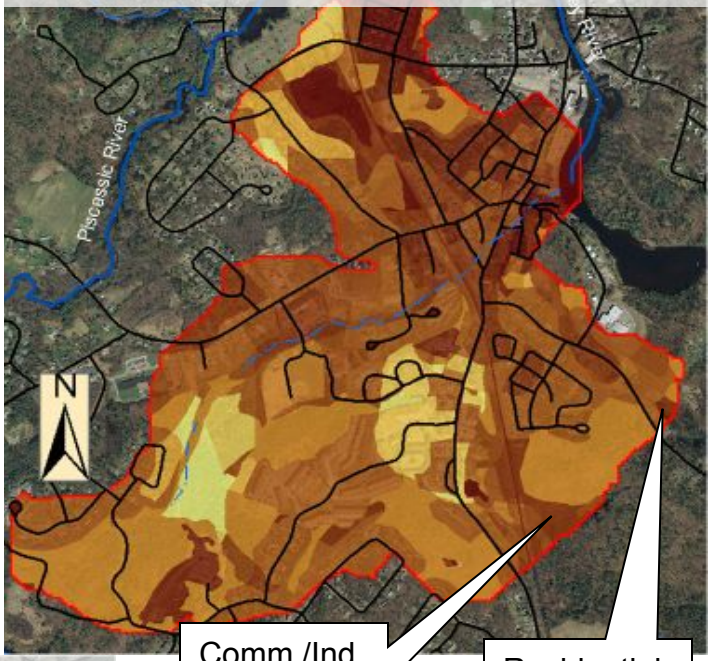


Forested
Type D soil
CN = 77

Forested
Type C soil
CN = 70

CN
30
31 - 32
33 - 36
37 - 43
44 - 46
47 - 49
50 - 51
52 - 54
55 - 57
58 - 61
62 - 68
69 - 77
78 - 81
82 - 89
90 - 98

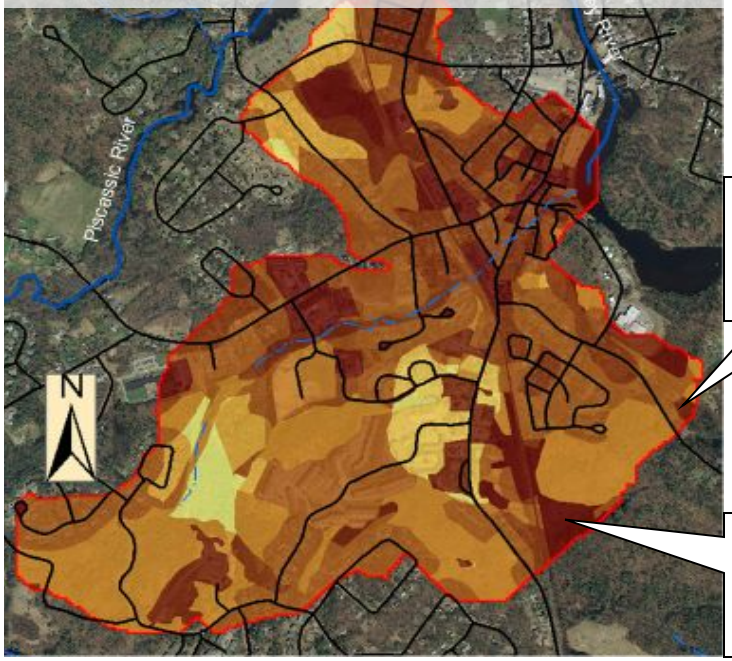
LID Build-Out CN=69.5



Comm./Ind.
Type D soil
CN = 80

Residential
Type D soil
CN = 80

Conventional Build-Out CN=78.0



Residential
Type D soil
CN = 84

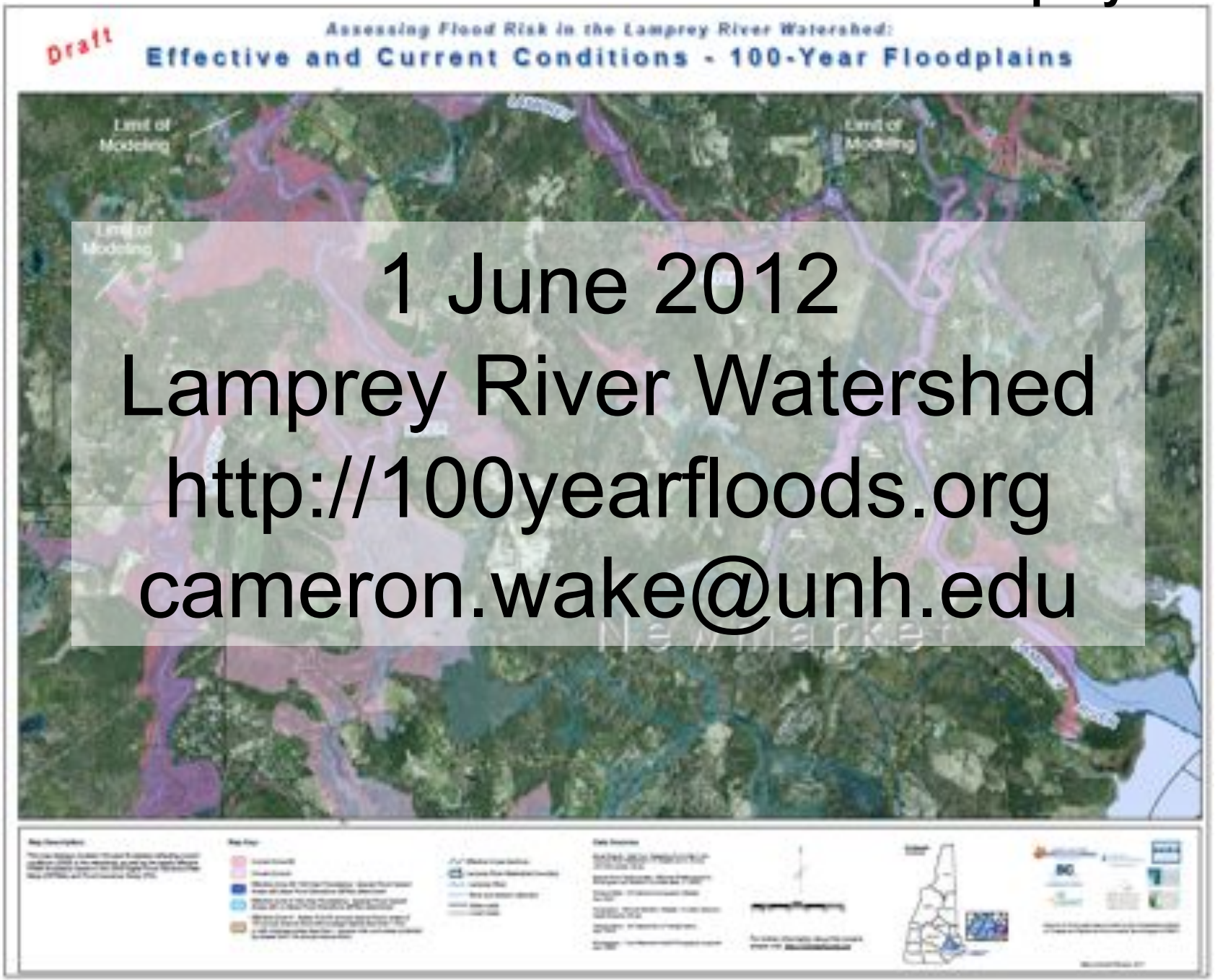
Comm./Ind.
Type D soil
CN = 94

New Flood Plain Maps and Questions of Legal Authority, Measures and Consequences

In Collaboration with Vermont Law School

1. What is the potential liability of government if they fail to reduce vulnerability to flood risk based on UNH's information?
2. What legal and policy approaches may communities adopt to reduce flood risks in the expanded flood hazard area?
3. Do NH communities have the legal authority under state legislation to design and implement regulatory controls based on current and projected flooding levels?
4. What legal standard of scientific and technical reliability must be met to support regulatory measures based on current and future environmental conditions?
5. What is the potential regulatory takings exposure of communities if they impose regulatory controls that are designed to address anticipated future environmental conditions?

FEMA and Current Conditions – Lower Lamprey



Newmarket Effective 100 Year Floodplain

Assessing Flood Risk - Lamprey River Watershed

Advisory Committee

municipal, regional, state, federal and non-profit representation

Cliff Sinnott, Rockingham Planning Commission (Chair)
Joanne Cassulo, NH Office of Energy and Planning
David Cedarholm, Durham Public Works
Cynthia Copeland, Strafford Regional Planning Commission
Michael Goetz, FEMA Region 1
Diane Hardy, Newmarket Planning Department
Sharon Meeker, Lamprey River Advisory Committee
Jack Munn, Southern New Hampshire Planning Commission
Jennifer Perry, Exeter Public Works
Ron Poltak & Becky Weidman, NEIWPC
Keith Robinson, USGS
Carl Spang/Dawn Genes, Lamprey River Watershed Association
Eric Williams, NH Department of Environmental Services

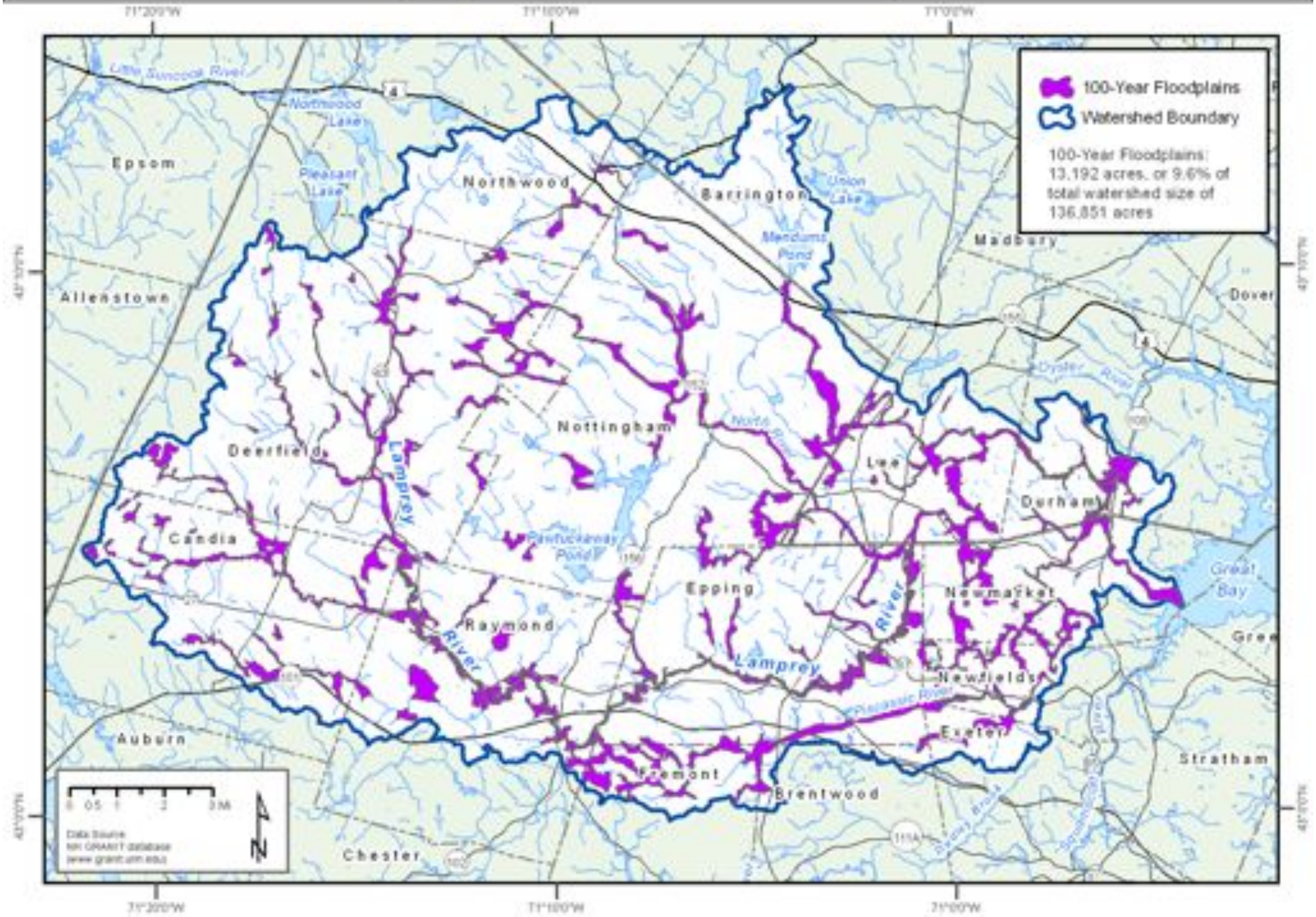
Assessing Flood Risk - Lamprey River Watershed

Technical Analysis
- Construct hydrologic and hydraulic model
- Develop land use and climate change scenarios
- Run model; plot cross-sections; map results

Dissemination
- Advisory Group & Focus Groups
- Community Workshops
- Municipal & Regional Planners
- NH GRANIT website

Evaluation and Feedback

Lamprey River Watershed Floodplains

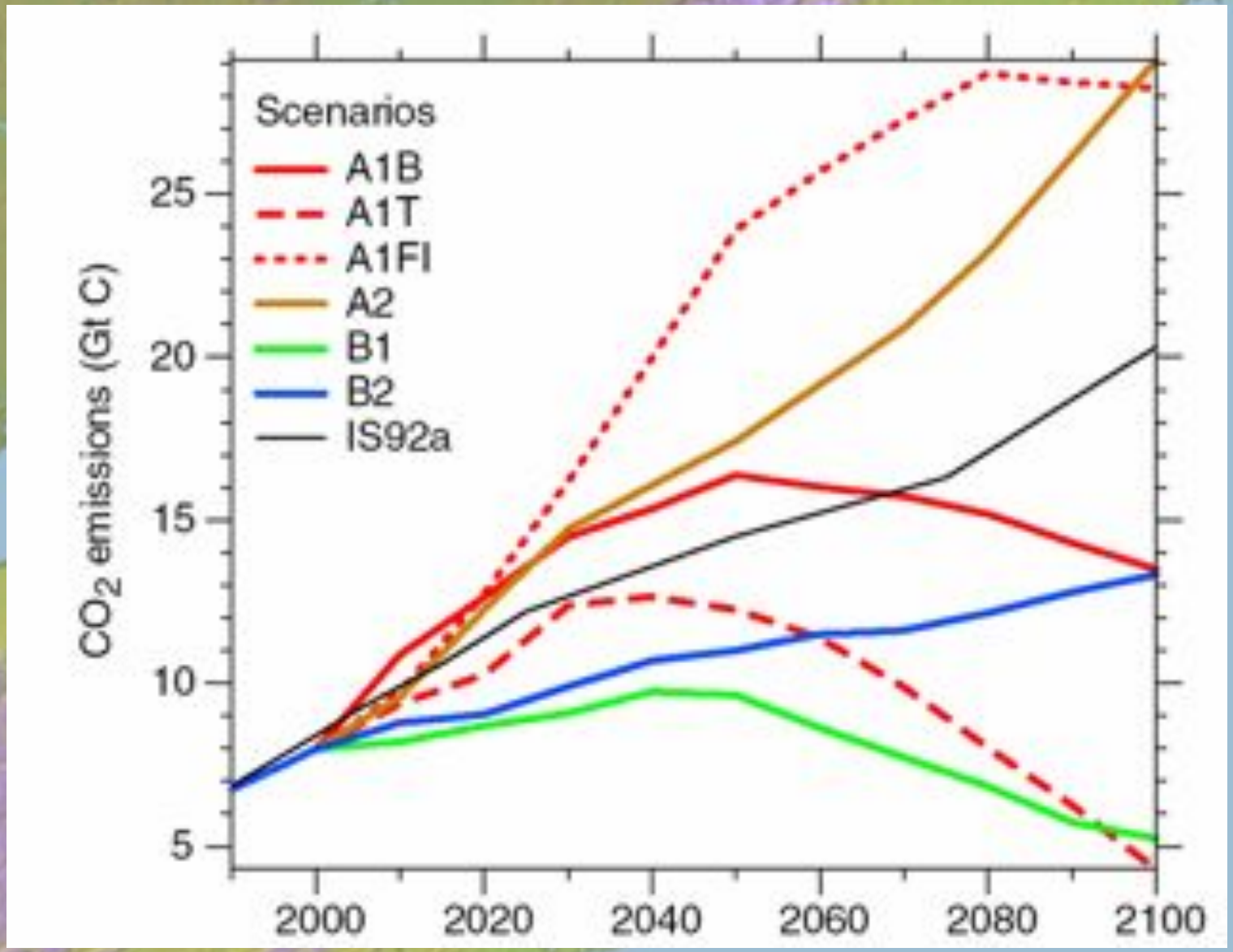


Assessing Flood Risk - Lamprey River Watershed

Project Objectives:

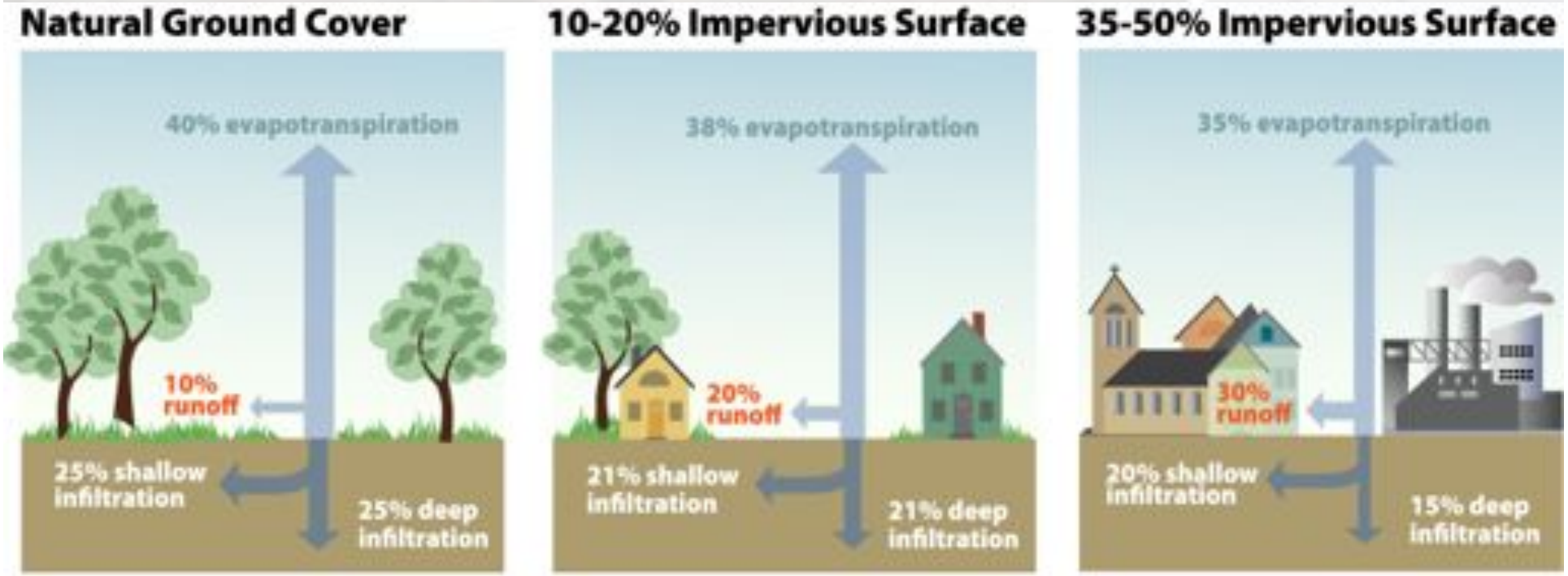
- Assess flood risk associated with combined land use and climate change scenarios out to 2100
- Produce maps of the 100-year flood risk boundaries and river discharge at specific locations
- Demonstrate the use of our products to support land use decision-making in coastal communities
- Serve as a model for other New England watersheds
- Address legal issues of using projected flood information

Projecting Future Climate Change for the Northeast: Greenhouse Gas Emission Scenarios



Projecting Future Climate Change for the Northeast: Downscale Global Projections to Regional Level

GCM	Max Daily Precip - A1Fi	
	Durham, NH	Lawrence MA
CCSM	6.3"	11.4"
GFDL	6.5"	6.7"
HADCM3	7.8"	9.0"
PCM	7.5"	10.0"


Natural Ground Cover
40% evapotranspiration
10% runoff
25% shallow infiltration
25% deep infiltration
10-20% Impervious Surface
38% evapotranspiration
20% runoff
21% shallow infiltration
21% deep infiltration
35-50% Impervious Surface
35% evapotranspiration
30% runoff
20% shallow infiltration
15% deep infiltration