Use of a Watershed Model to Characterize and Prioritize Bacteria Sources for Mitigation in New Hampshire Coastal Beach Watersheds.

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NEW HAMPSHIRE DEPARTMENT OF Environmental Services

FB environmental

NHDES Beach Inspection Program

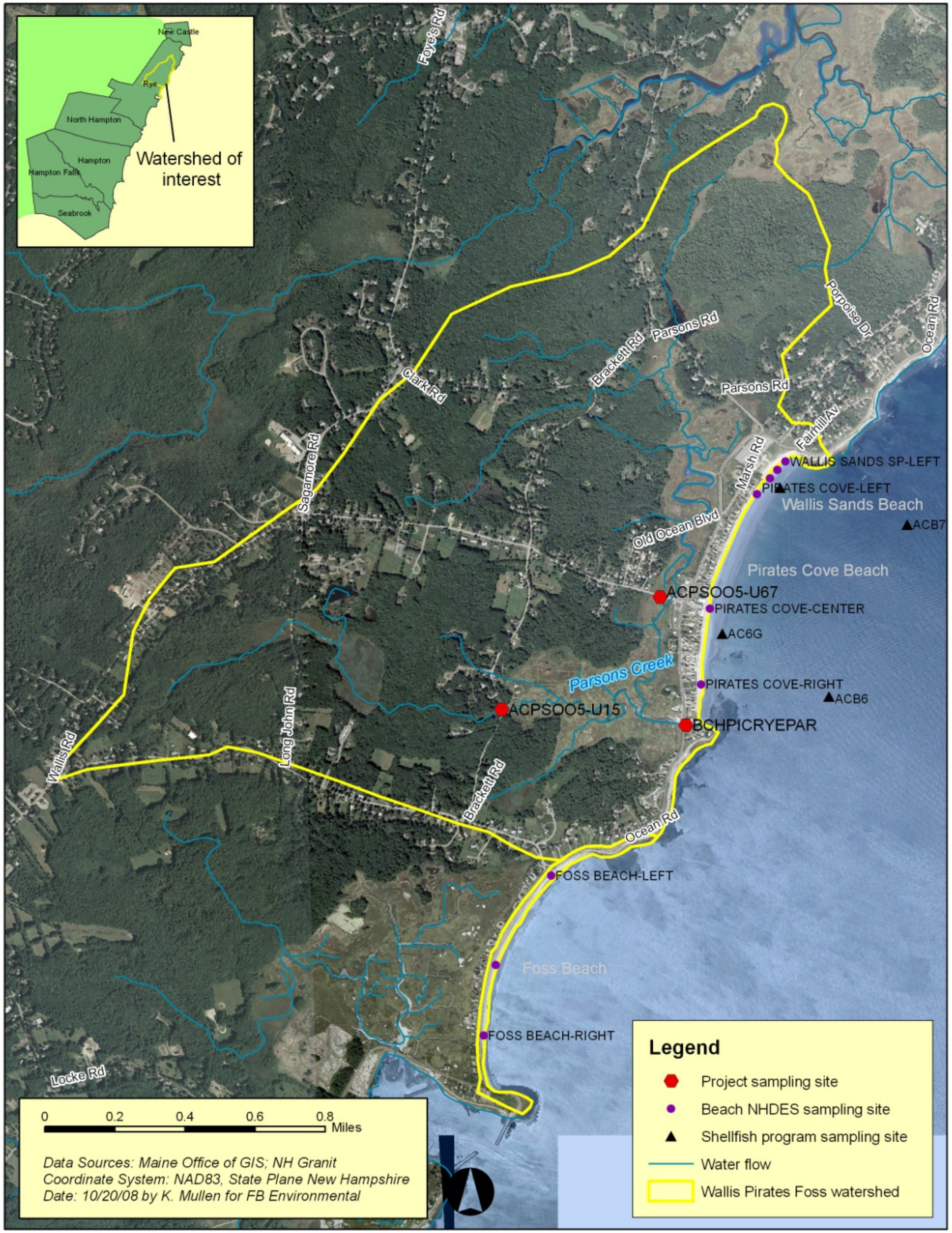
- Monitoring NH beaches for >20 yr
  - Marine & Fresh
- Public Health is our Concern
  - Prevent the spread of water-bourne illness
  - Pathogens (indicator organisms) & Toxic algae
- Hampton Beach, NH
  - Awarded 5 stars for water quality by the NRDC in 2008

Responsibilities of the Beach Program

- Assigning each beach a “Tier” status
- Monitoring water quality
  - λ appropriate to tier status
- Posting Advisories & Warnings
- Inspecting each beach
  - Facilities, waste receptacles, animal presence, signs, emergency equipment
- Report our findings annually
  - General public, Local Beach Managers & EPA

NH Coastal Region

- 16 Coastal Beaches in 2008
- Watersheds outlined in white
- Extending from New Castle Town Beach to Seabrook Town Beach
- Isle of Shoals
  - Star Island Beach 2009



Sampling Protocol

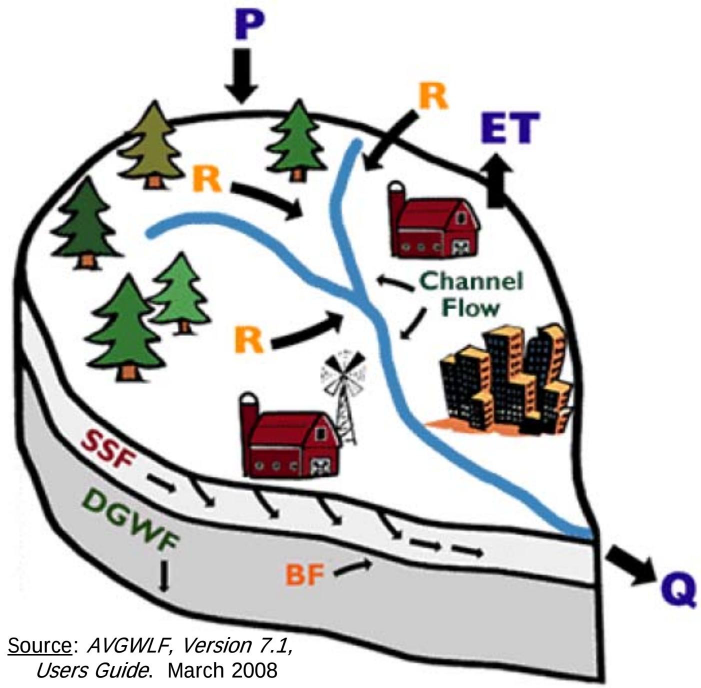
- 3 Beaches shown here
- Purple Dots indicate Beach Sampling Stations
  - Wade out to knee depth
  - Collect water
  - 8 hr holding time
- We've been doing this since 1989…

Overview of bacteria data 2004-2007

		Geomean Standard of 35 col/ 100 ml		Single Sample Standard of 105 col/100 ml		
Beach	n	n above	% above	n above	% above	Adjacent Creeks or Outfalls
New Castle Town	273	42	15%	13	5%	Pipe
Pirates Cove	172	12	7%	5	3%	Parsons Creek
Wallis Sands	173	6	3%	0	0%	Parsons Creek
Foss	108	2	2%	1	1%	Parsons Creek
Jenness	174	12	7%	3	2%	
Cable	249	10	4%	4	2%	
Sawyer	246	20	8%	8	3%	Eel Pond
Bass	225	15	7%	4	2%	Chapel Brook
Northside Park	147	4	3%	2	1%	Little River
State	255	31	12%	10	4%	Little River
North	276	5	2%	0	0%	

Bacterial Source Identification

- Develop a better understanding
- To identify and prioritize bacteria sources for mitigation
- To create a modeling tool that can be used over time to simulate sources & support removal of bacteria sources Prioritize remediation efforts



Source: *AVGWLF, Version 7.1, Users Guide*. March 2008

Overview: What is a watershed model?

A simplified mathematical representation of a complex, real watershed system.

Three primary components:

- Physical characteristics
- Hydrologic budget
- Pollutant transport

AVGWLF – Arc View Generalized Watershed Loading Function

- Screening level watershed loading model
- Applied in New England as part of NEIWPCC project
- Simulates water and pollutant loading from a watershed
- Monthly time scale
- No in-stream dynamics
- Established for nutrient and suspended solids simulation
- Recently added bacteria simulation

Beach Bacteria Source Investigation
Obtain data and set up model

- <u>Collaborate with diverse group of investigators</u>
  - NHDES Beach Program, Shellfish Program, Subsurface Section, IDDE, NPDES and TMDL programs

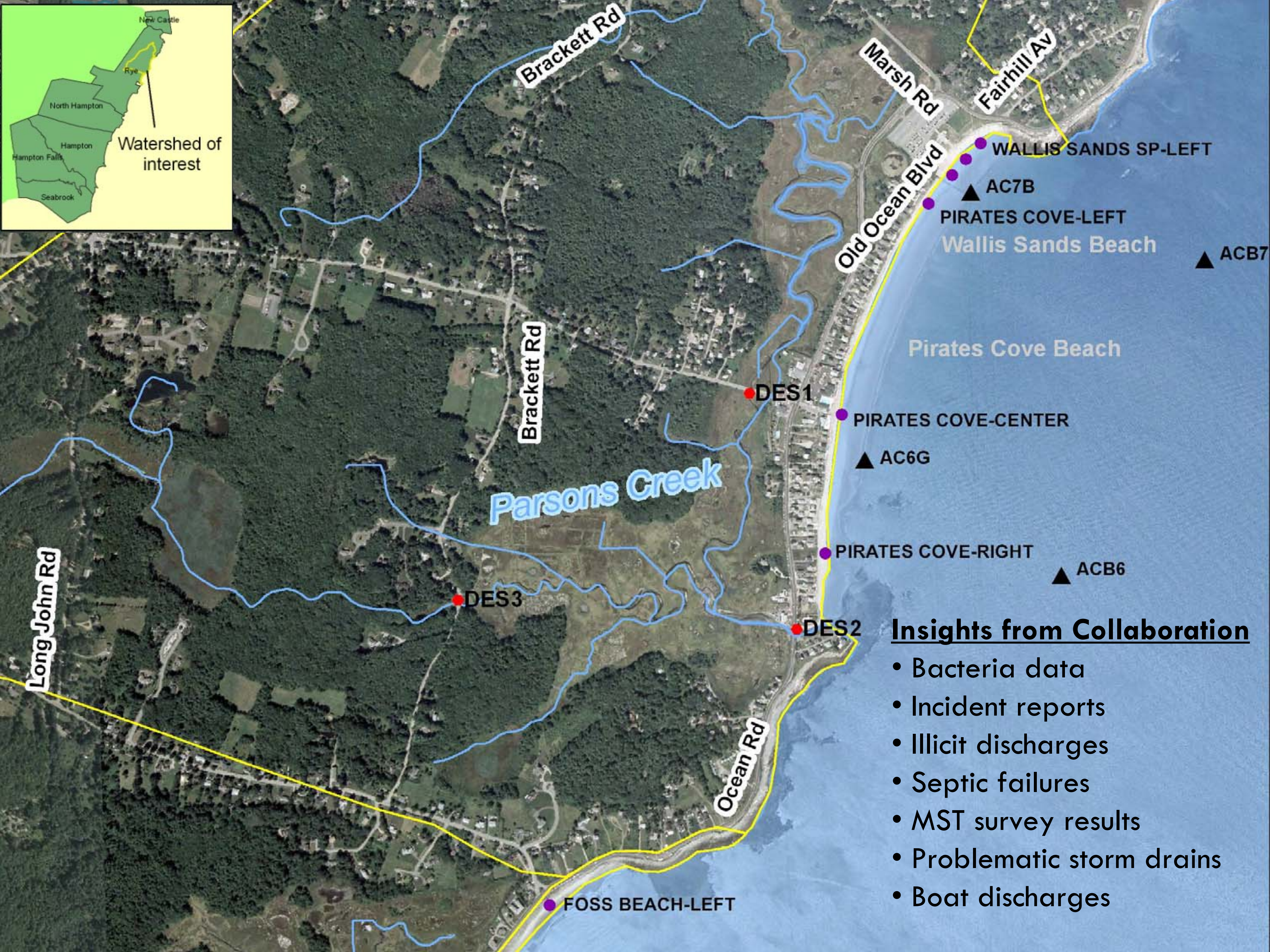
- <u>Conduct field reconnaissance surveys</u>
  - ID sources,
  - refine land cover

- <u>Conduct targeted bacteria sampling</u>

- <u>Review and select optimal parameter values</u>

Purpose of Modeling Application

- Estimate bacteria loads by source in each watershed.
- Develop watershed based plans
- Prioritize and mitigate bacteria sources



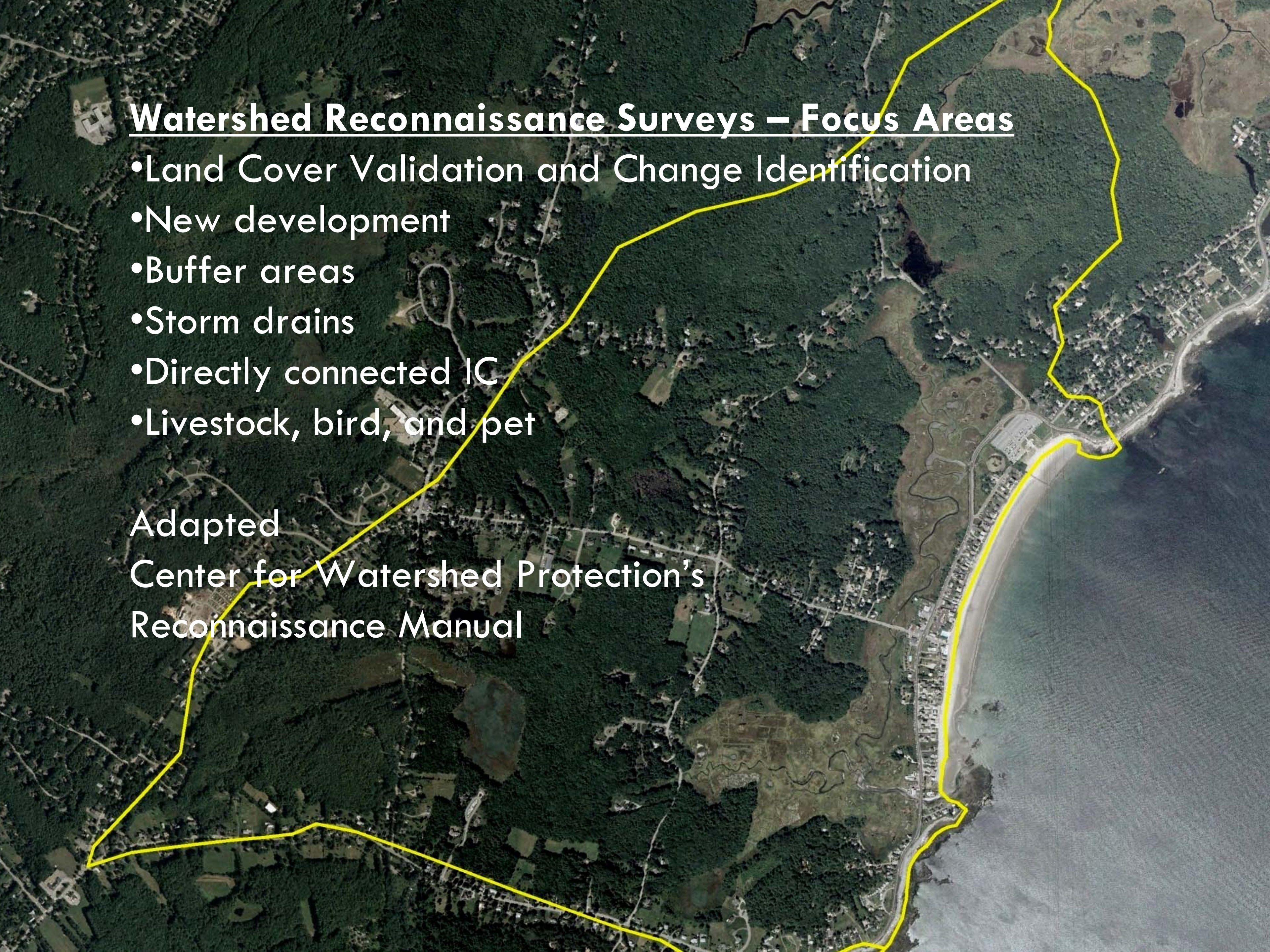
<u>Insights from Collaboration</u>

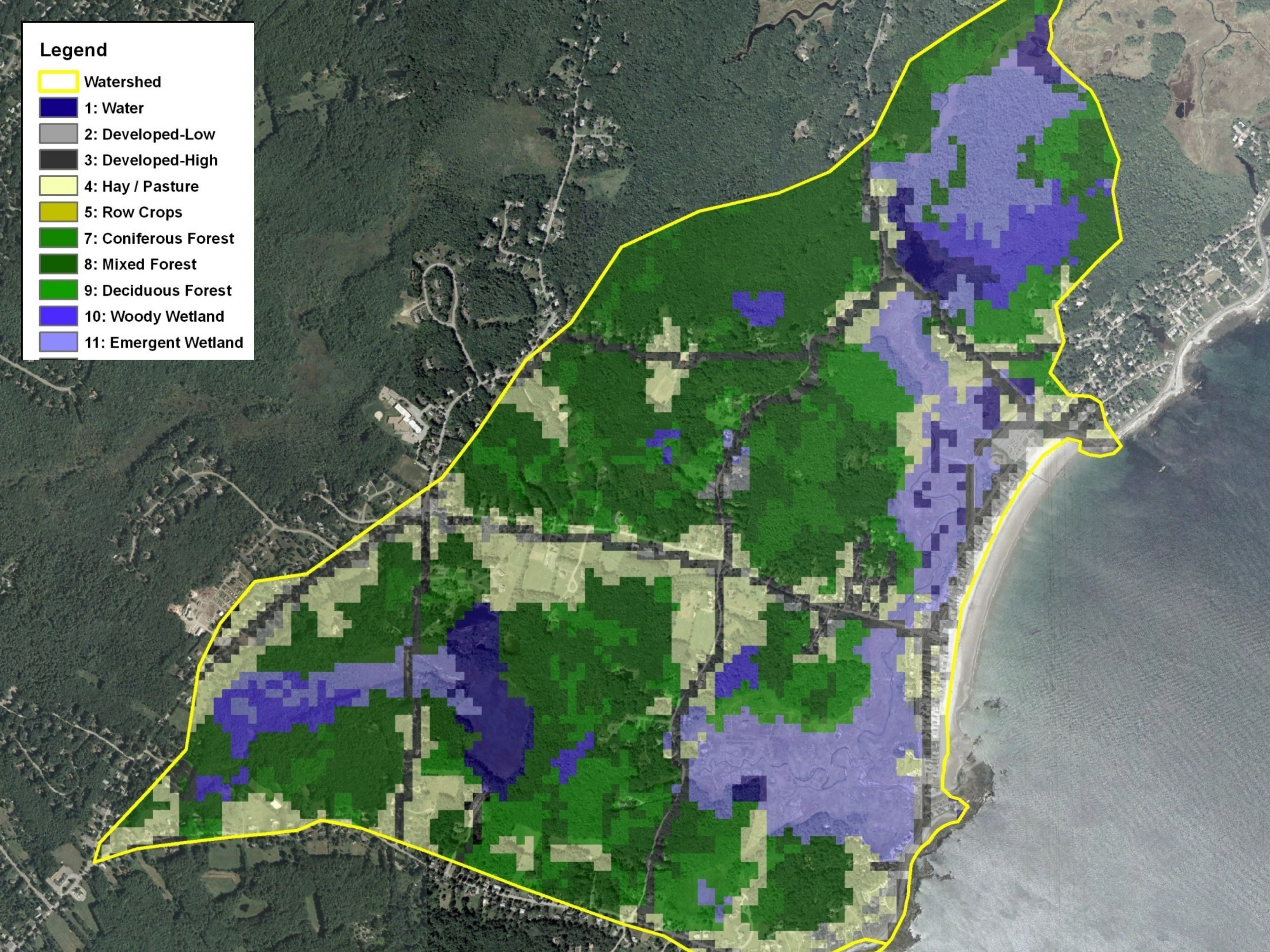
- Bacteria data
- Incident reports
- Illicit discharges
- Septic failures
- MST survey results
- Problematic storm drains
- Boat discharges

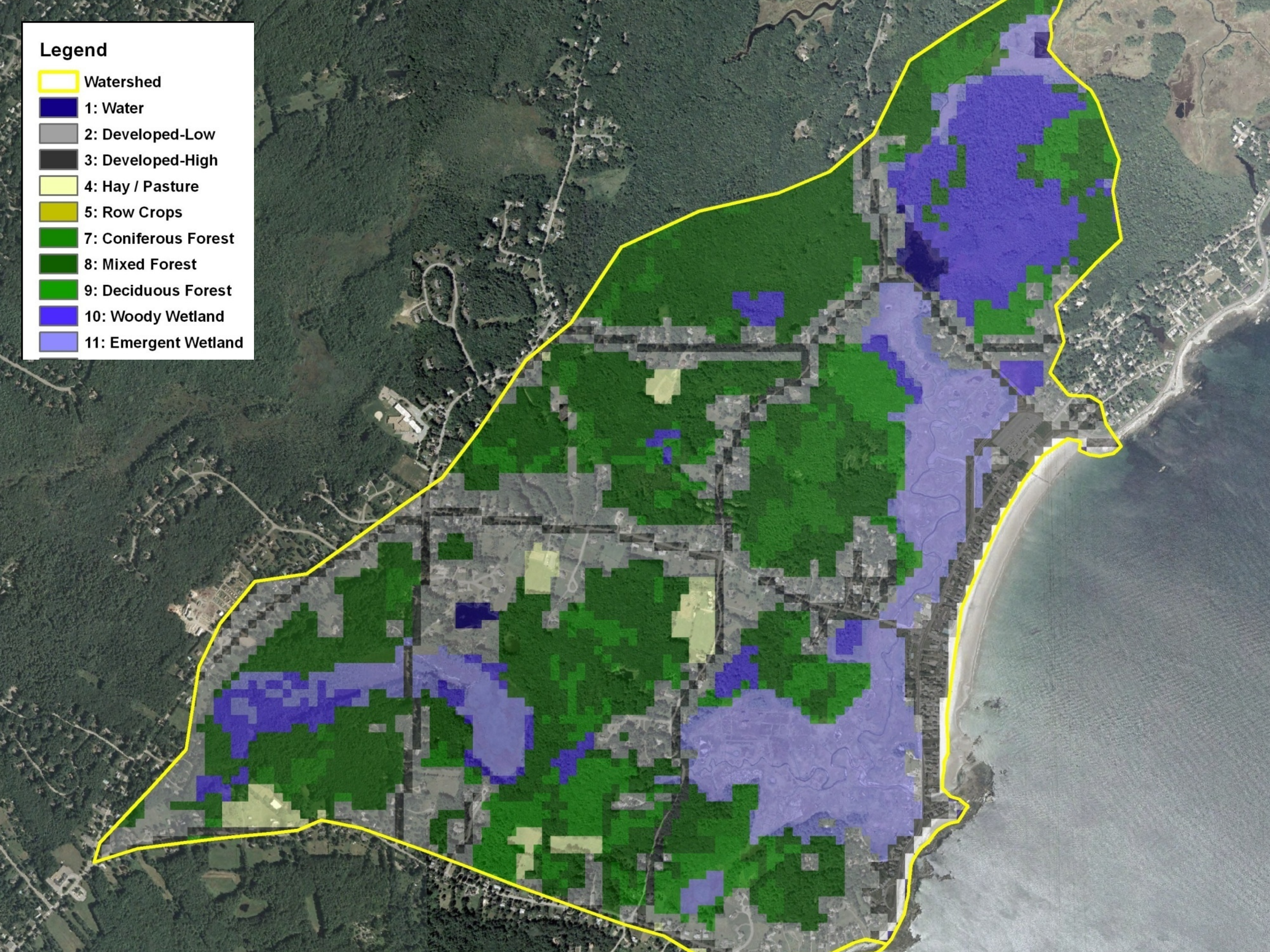
Watershed Reconnaissance Surveys – Focus Areas

- Land Cover Validation and Change Identification
- New development
- Buffer areas
- Storm drains
- Directly connected IC
- Livestock, bird, and pet

Adapted
Center for Watershed Protection's
Reconnaissance Manual




Legend
Watershed
1: Water
2: Developed-Low
3: Developed-High
4: Hay / Pasture
5: Row Crops
7: Coniferous Forest
8: Mixed Forest
9: Deciduous Forest
10: Woody Wetland
11: Emergent Wetland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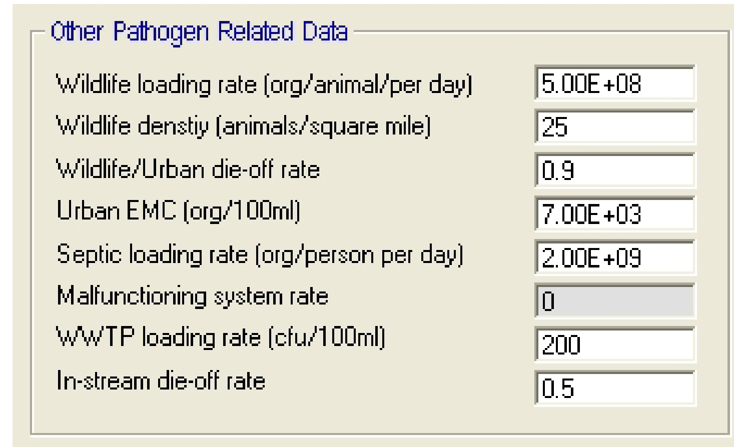
Watershed Bacteria Model Setup
Specifying Key Parameter Values

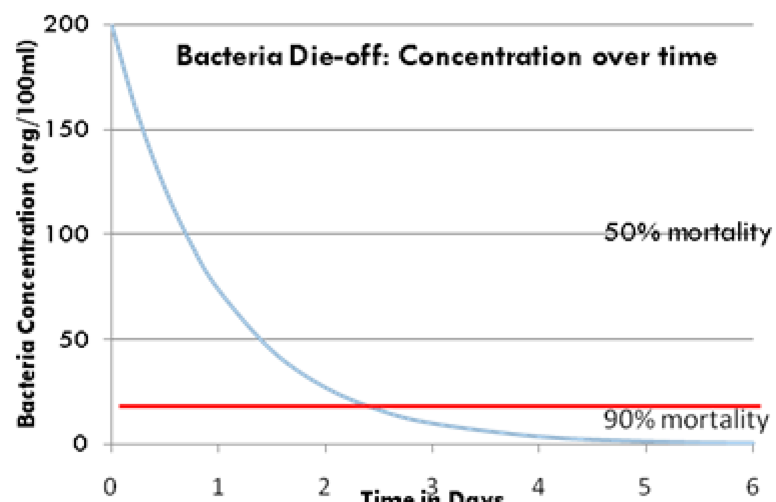
<u>Bacteria source loading rates by type</u>

- Urban runoff
- Failing Septic systems
- WWTP and other PS
- Livestock
- Wildlife



<u>Bacteria fate and transport terms</u>

- Overland die off rate
- In-stream die off rate



Simulating Urban Runoff

<u>Steps:</u>

1. Specify land cover type
2. Assign Event Mean Concentration (EMC) value
3. Bacteria load is a product of EMC and flow volume

Urban runoff bacteria load = EMC (org/100ml) x Volumetric flow rate(volume/day)

= (bacterial organisms)/day

Urban Runoff

Urban Event Mean Concentration

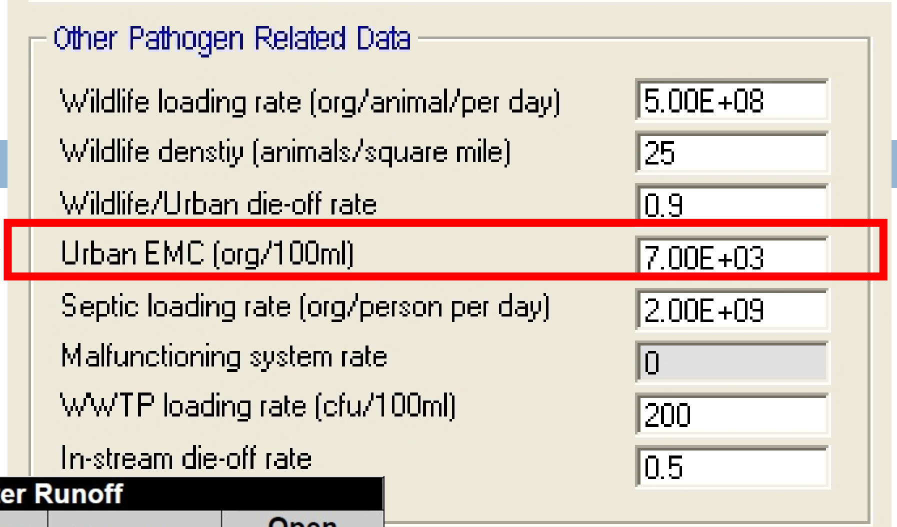
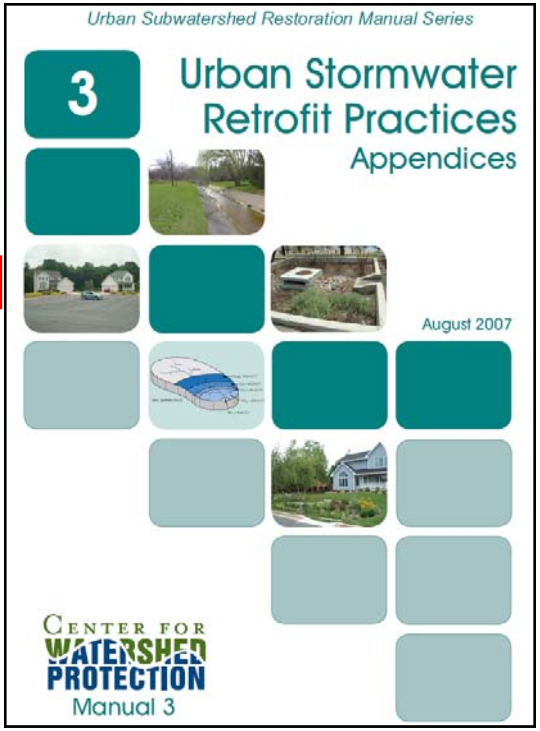


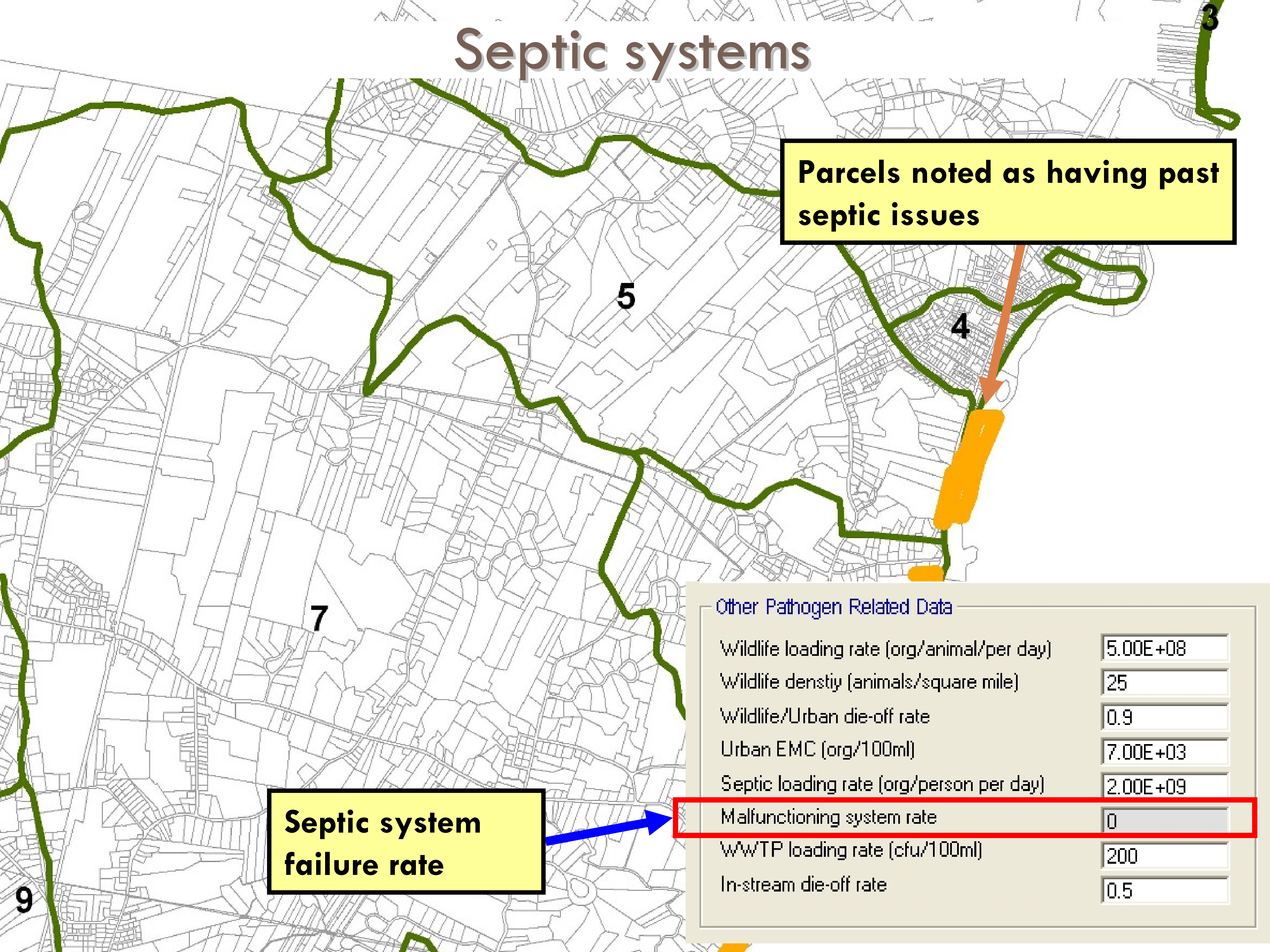
Table B.4: Summary of Pollutant EMCs in Stormwater Runoff

	All Data	Residential	Commercial	Industrial	Freeways	Open Space
# of Storms Sampled	*3,765*	*1,042*	*527*	*566*	*185*	*49*
Median Event Mean Concentrations (mg/L or ppm, except where noted)						
TDS	80	72	72	86	77.5	125
TSS	59	49	43	81	99	48.5
BOD_5	8.6	9.0	11.0	9.0	8.0	5.4
COD	53	54.5	58	58.6	100	42.1
Fecal Coliform[1]	5,091	7,000	4,600	2,400	1,700	7,200
NO2 + NO3	0.60	0.60	0.6	0.69	0.28	0.59
TKN	1.4	1.5	1.5	1.4	2.0	0.74
Total N	2.0	2.1	2.1	2.09	2.28	1.33
Dissolved P	0.13	0.18	0.11	0.10	0.20	0.13
Total P	0.27	0.31	0.22	0.25	0.25	0.31
Dissolved Cu[2]	8.0	7.0	7.57	8.0	10.9	--
Total Cu[2]	16	12	17	20.8	34.7	10
Dissolved Zn[2]	52	31.5	59	112	51	--
Total Zn[2]	116	73	150	199	200	40

Source: Pitt *et al.*, 2004.
[1] MPN/100 mL, which represents the most probable number (MPN) of bacteria that would be found in 100 mL of water
[2] Cu and Zn values are shown in μg/l



Septic systems



Simulating Failing Septic Systems

Failing septic system bacteria load =

= (# of failing systems) x (# people/system) x (bacteria load/person)

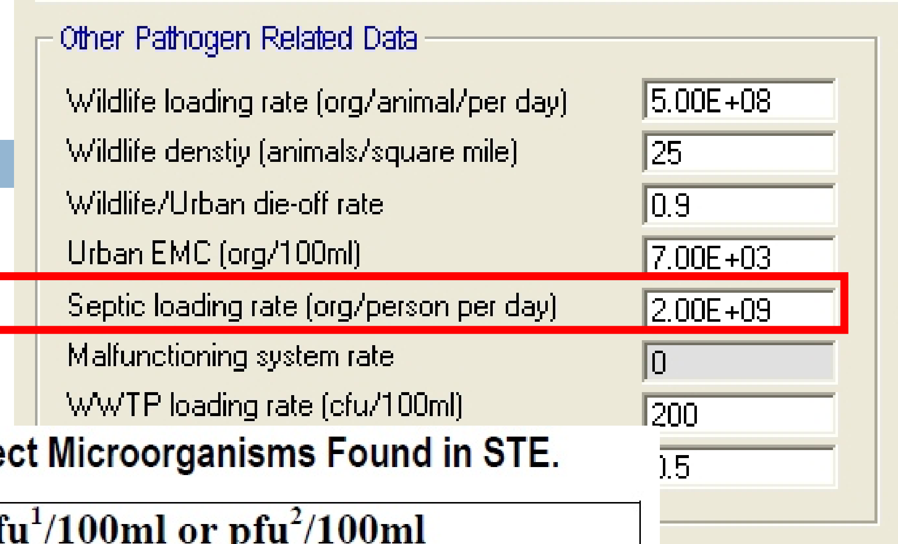
<u>Assumptions:</u>

1. Assume all parcels >30 m from sewer are on septic
2. 1 structure/parcel and 2 people/structure
3. 1% of septic systems are failing

Bacteria load/person/day obtained from available literature

Selecting and adding septic systems data

Septic Loading Rate



Lowe, K.S., N. Rothe, J. Tomaras, K. DeJong, M Tucholke, J. Drewes, J. McCray, and J. Munakata-Marr. 2007. Influent Constituent Characteristics of the Modern Waste Stream from Single Sources: Literature Review. Water Environment Research Foundation.

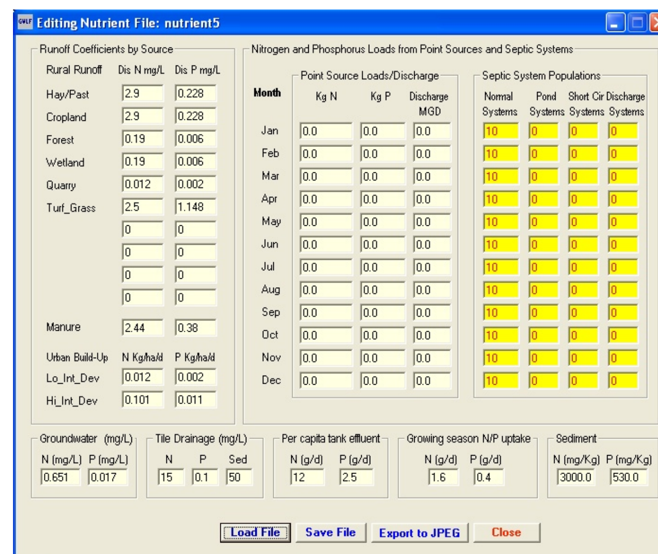
Table 3-8. Literature Values for Concentration of Select Microorganisms Found in STE.

Organism/Organism Type	Mean cfu[1]/100ml or pfu[2]/100ml
Fecal Coliforms	1.1×10^6 (Brown *et al.*, 1980) 4.2×10^5 (Ziebell *et al.*, 1977) 1.9×10^6 (Ziebell *et al.*, 1977) 4.2×10^5 (McCoy and Ziebell, 1975)
Coliphages/Viruses	6.4×10^1 (Brown, *et al.*, 1980)
Total Coliforms	3.4×10^6 (Ziebell *et al.*, 1977) 5.7×10^6 (Ziebell *et al.*, 1977)
Fecal Streptococci	3.8×10^3 (Ziebell *et al.*, 1977) 1.6×10^5(Ziebell *et al.*, 1977) 3.8×10^3 (McCoy and Ziebell, 1975)
Total Bacteria	3.4×10^6 (Ziebell *et al.*, 1977) 3.0×10^7 (Ziebell *et al.*, 1977) 3.4×10^8 (McCoy and Ziebell, 1975)

[1] cfu, colony forming units; refers to bacterial counts
[2] pfu, plaque forming units; refers to viral counts

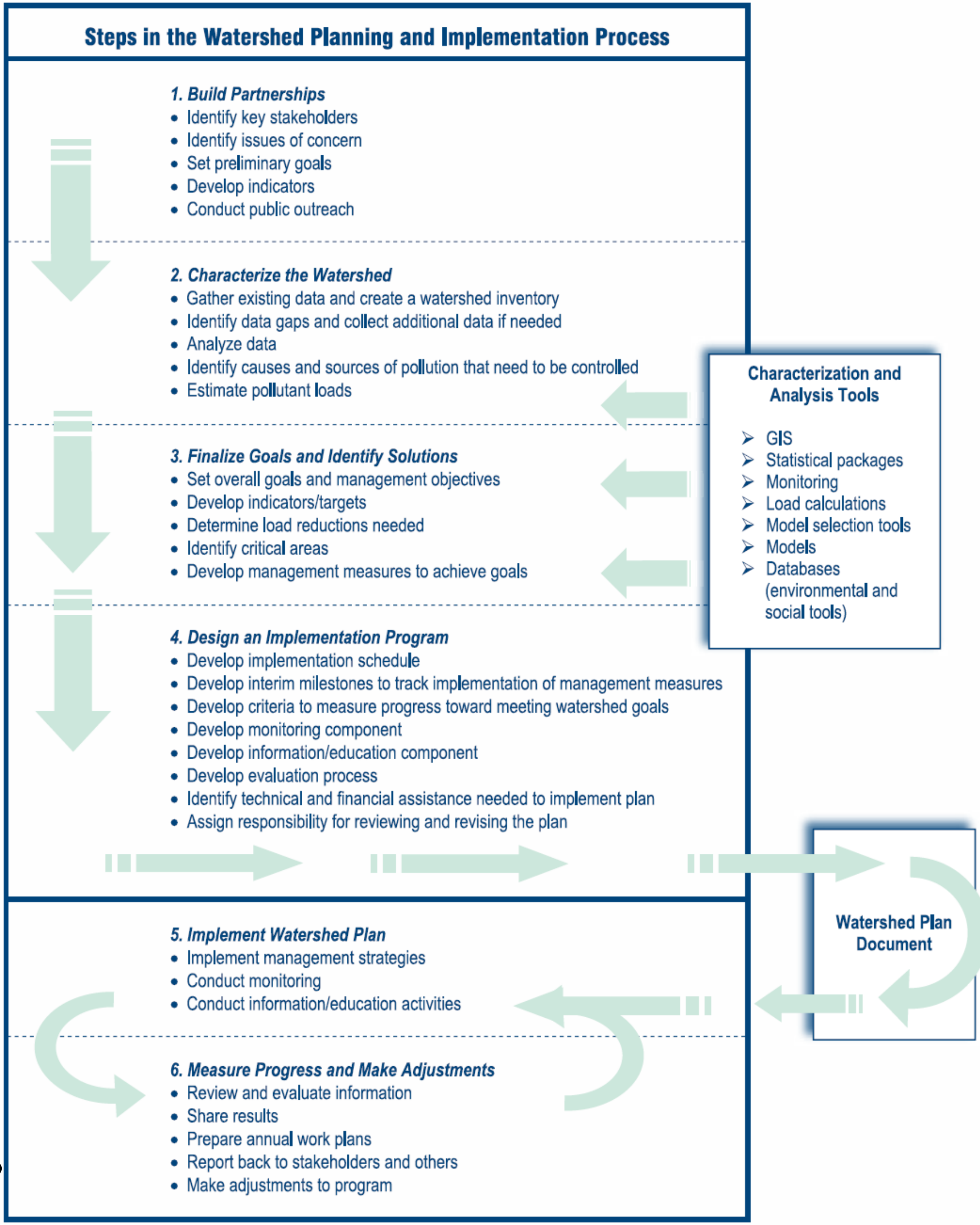
Watershed Modeling Workshops

- Shared decision making
- Collaboration in setting up the model
- Training to enable DES staff to model independently
- Identify and address challenges early on



Watershed Based Plans

Characterization and analysis of watersheds supports development of Watershed Plans and implementation of mitigative actions.



Source: U.S. EPA. 2008. Handbook for Developing Watershed Based Plans to Restore and Protect our Waters.

Project Accomplishments

- Project Goals
  - ID greatest contributing watersheds
  - Propose watershed restoration based on modeling
- Created Framework for watershed based planning
  - Includes septic system management plans
  - Set-up to apply for 319 Funds
- Blazing a trail with AVGWLF-E

Project Team
thank you to…

- Sonya Carlson, Teresa Ptak, and others, NHDES Beach Program
- Jody Connor, NHDES Limnology Section
- Chris Nash and Matt Wood, NHDES Shellfish Program
- Andy Chapman, NHDES Watershed Program
- Rob Livingston, NHDES IDDE Investigator
- Jay Baas, NHDES Subsurface Section
- Andrew Cornwell, NHDES Database Manager
- Dr. Steve Jones, UNH Microbial Source Tracking Investigator
- Dr. Pete Shanahan, Senior Modeling Advisor
- Dr. Barry Evans, AVGWLF developer and advisor
- Cayce Dalton, Lead modeler

And, Thank You all for Coming.

Questions anyone?

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