STATE GOVERNMENT MUNICIPAL DAY

Rivers in the Design and Construction of Municipal Road Infrastructure

Vermont Rivers and Habitat Programs

October 25, 2019 Montpelier, VT

Presentation Outline

- Introduction to some river processes
- How infrastructure impacts those processes and tends to fail during floods
- Overview of VT aquatic resources
- Importance of habitat and clean water, functioning streams
- New permitting requirements/mindset

Types of Rivers and Streams

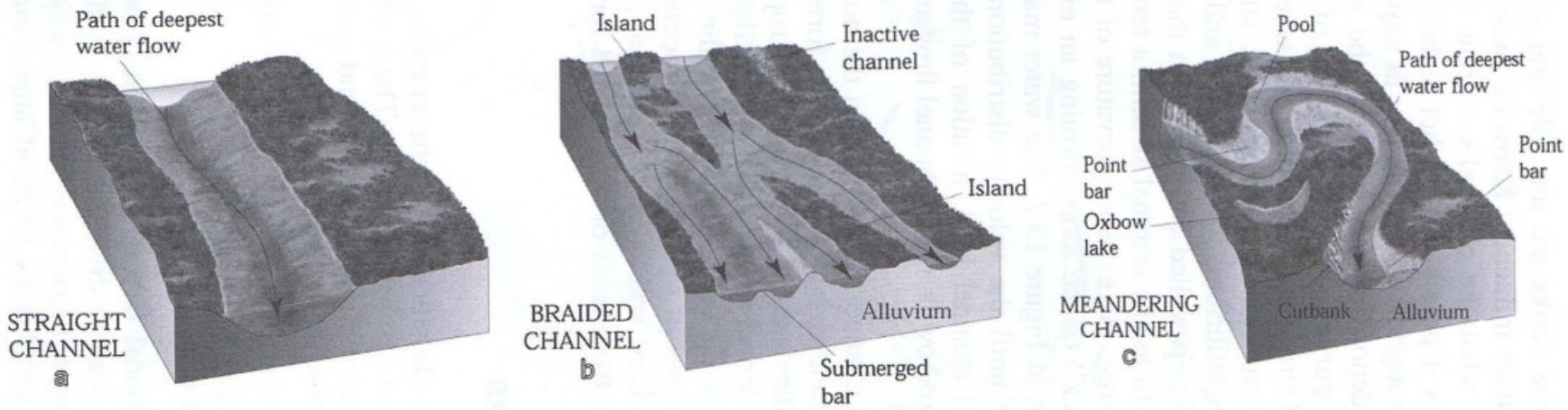


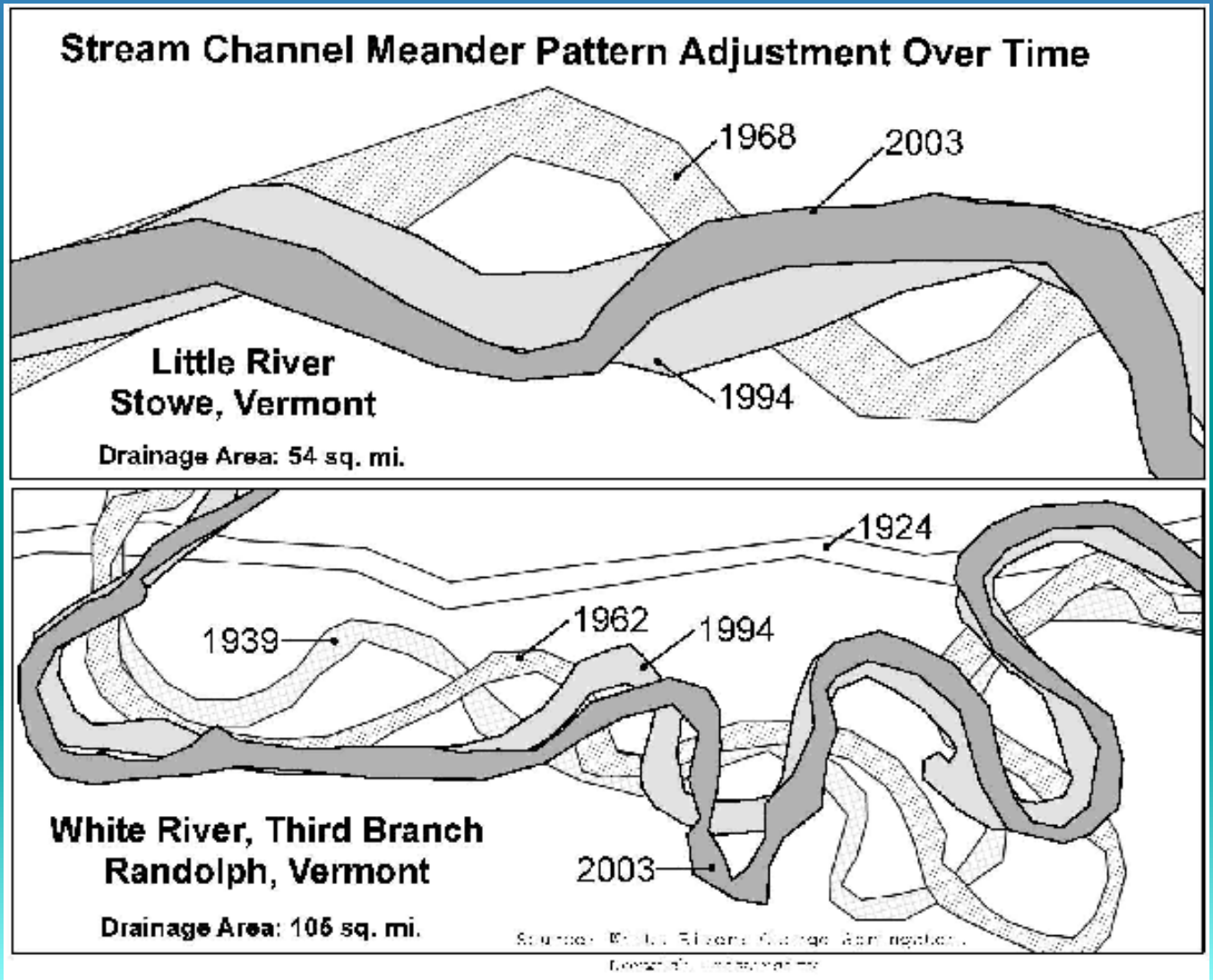
Figure 13.1 Straight, braided, and meandering streams with associated features (Murck and Skinner, 1998).

Source: page 363 of DeBarry, P. 2004 Watersheds: Processes, Assessment and Management. John Wiley & sons, Inc., Hoboken, NJ.

Straighter Braided Meandering

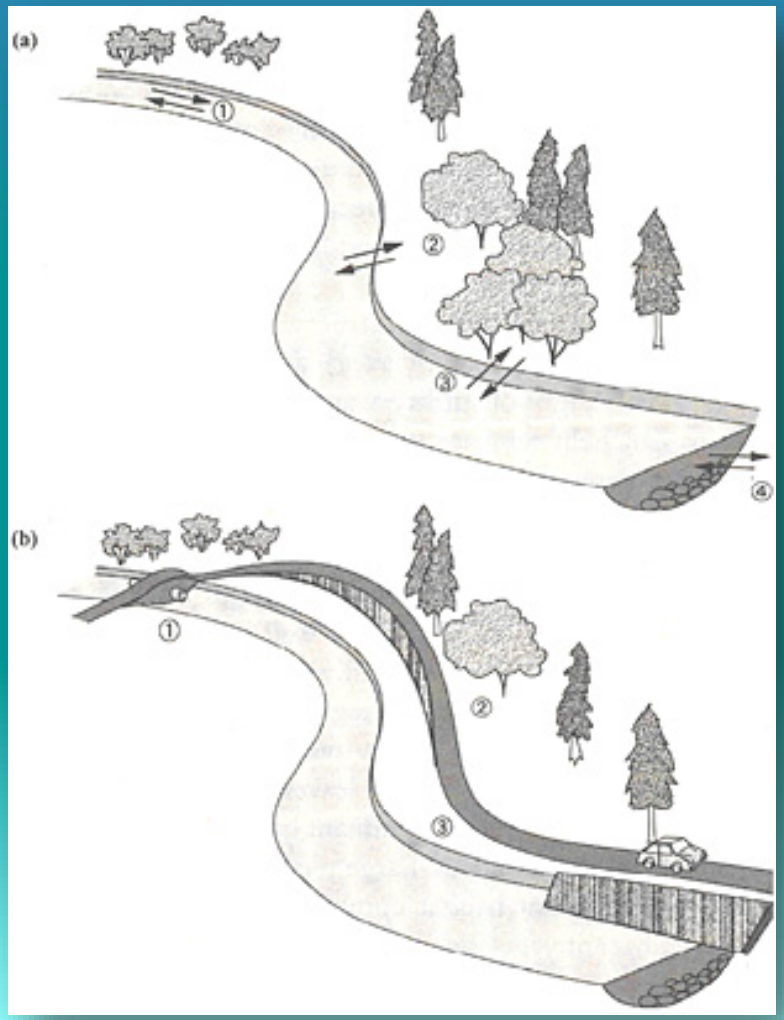
Drives Selected Crossing Structure Type

Rivers Meander Over Time



Bad Locations for Road Crossings

Impacts of Roads on Riverine Processes



Forman et al. 2003

Disrupted movement

- Upstream/downstream, beds/banks

Sediment, chemical (road salt) and available oxygen, etc

Channel/Riparian encroachment

Debris flows, catastrophic failure

Changes to flow characteristics

Channelization = more flooding

There are cumulative effects too…

Flow Constriction Schematic

Bad Size

Good Size

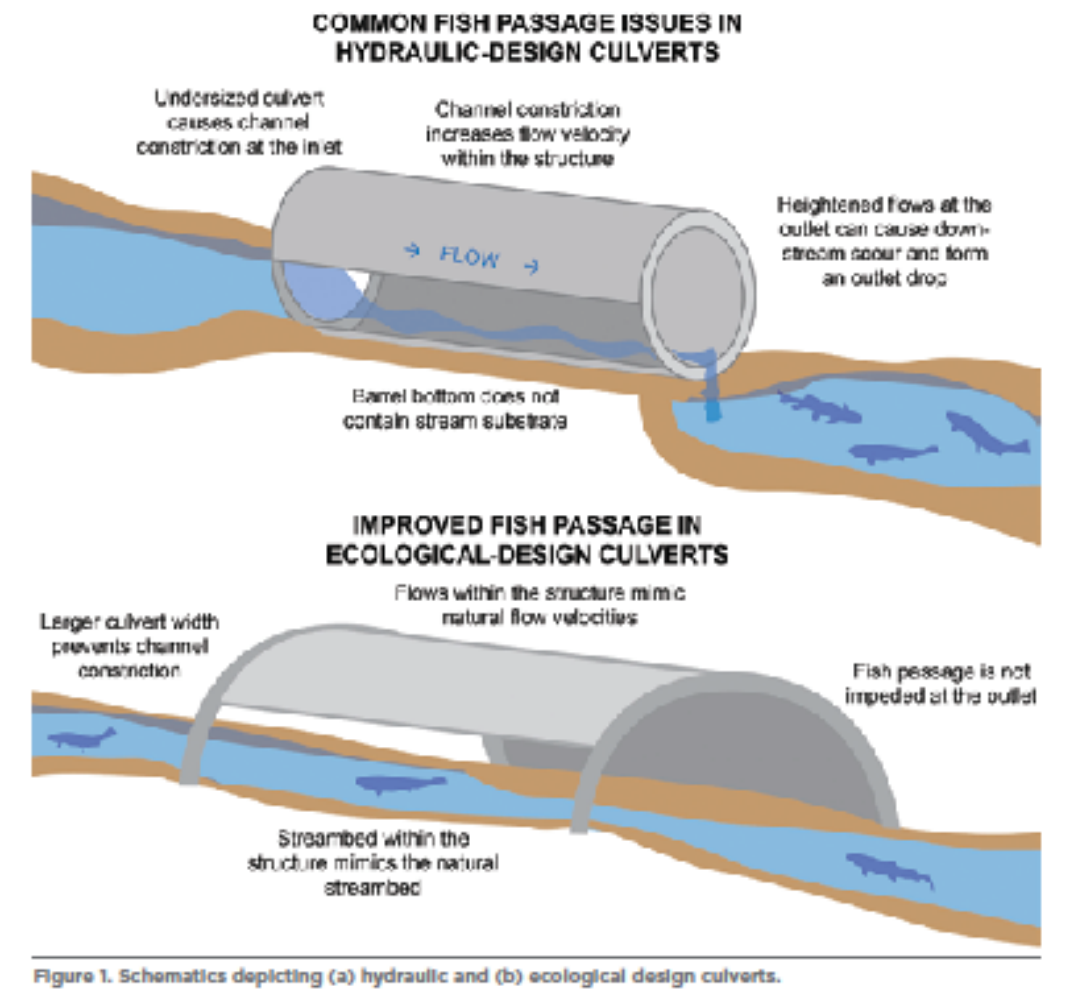


Figure 1. Schematics depicting (a) hydraulic and (b) ecological design culverts.

Wing Wall Scour

Limits Bank Scour

Properly Size Crossing Structures

Undersized Crossing Risks

Risk of Catastrophic Failure is a Common Failure Mode in All Flood Sizes and Increases Road Risks

Undersized Stream Crossings

Increased Risks and More Maintenance and Costs

Flow Constriction at a Bridge

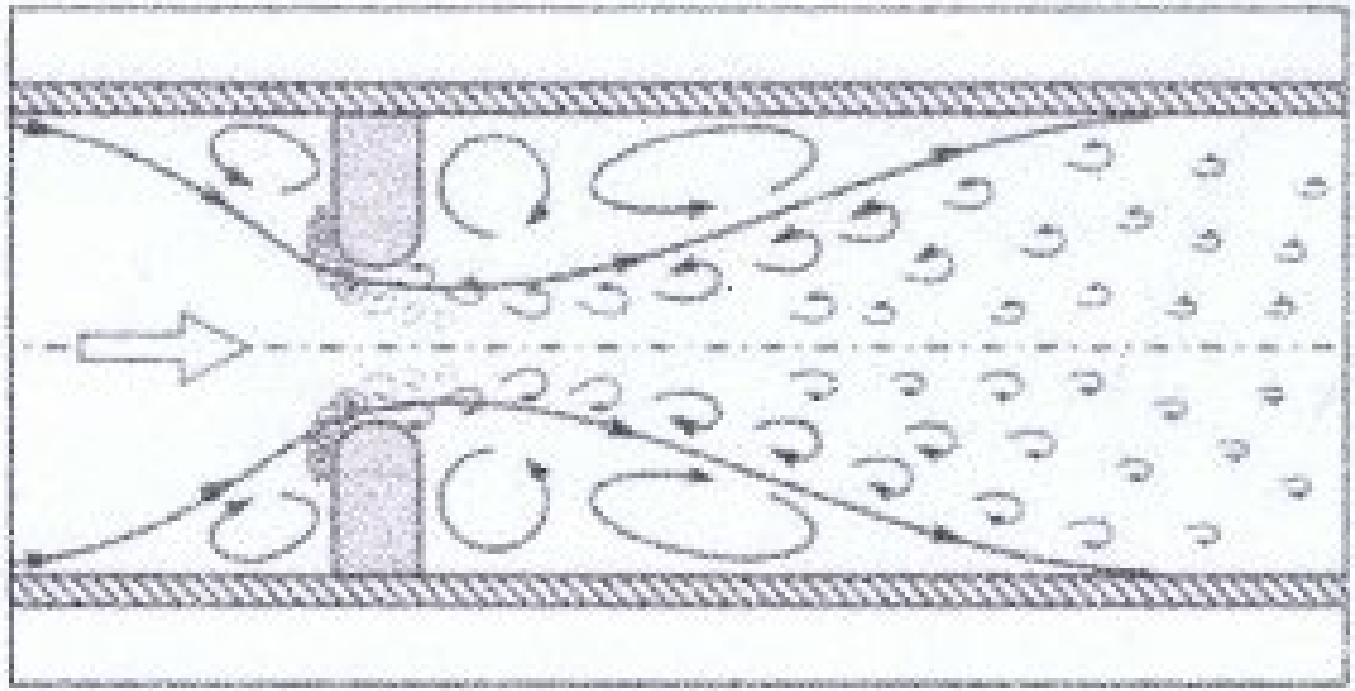


Figure 1.1: Schematic of flow constriction at a bridge (Arneson et al., 2012).

Flow Arrows of Bed & Bank Scour at Wingwalls

Vermont Flood History Recorded 1973 - 2011

Small, Medium and State-Wide

19 Floods in 38 Years

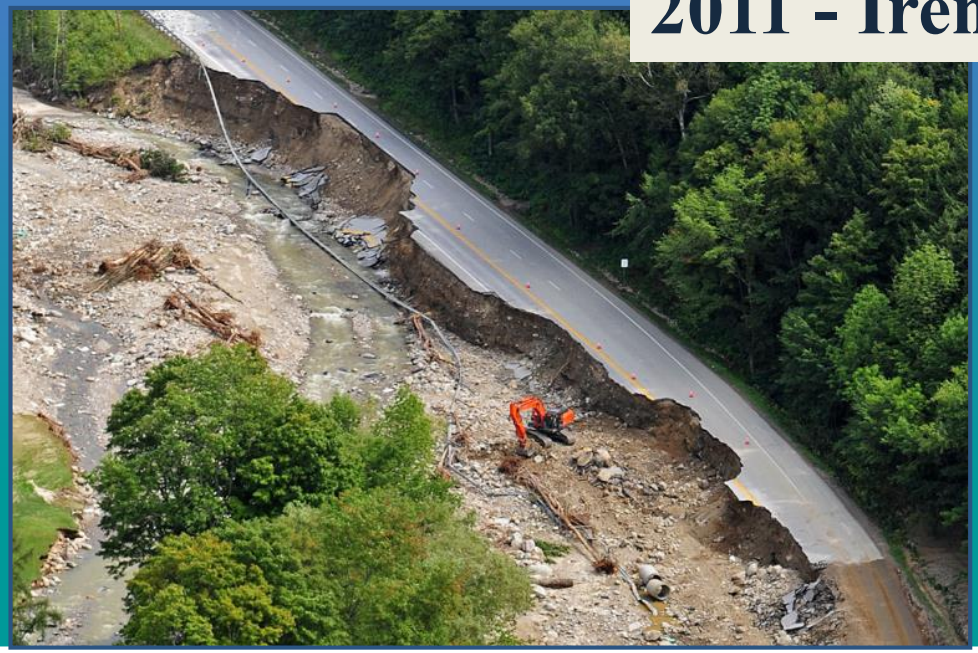
Averages **1 flood every 2 Years**

Since <u>1927 Flood-of-Record</u>

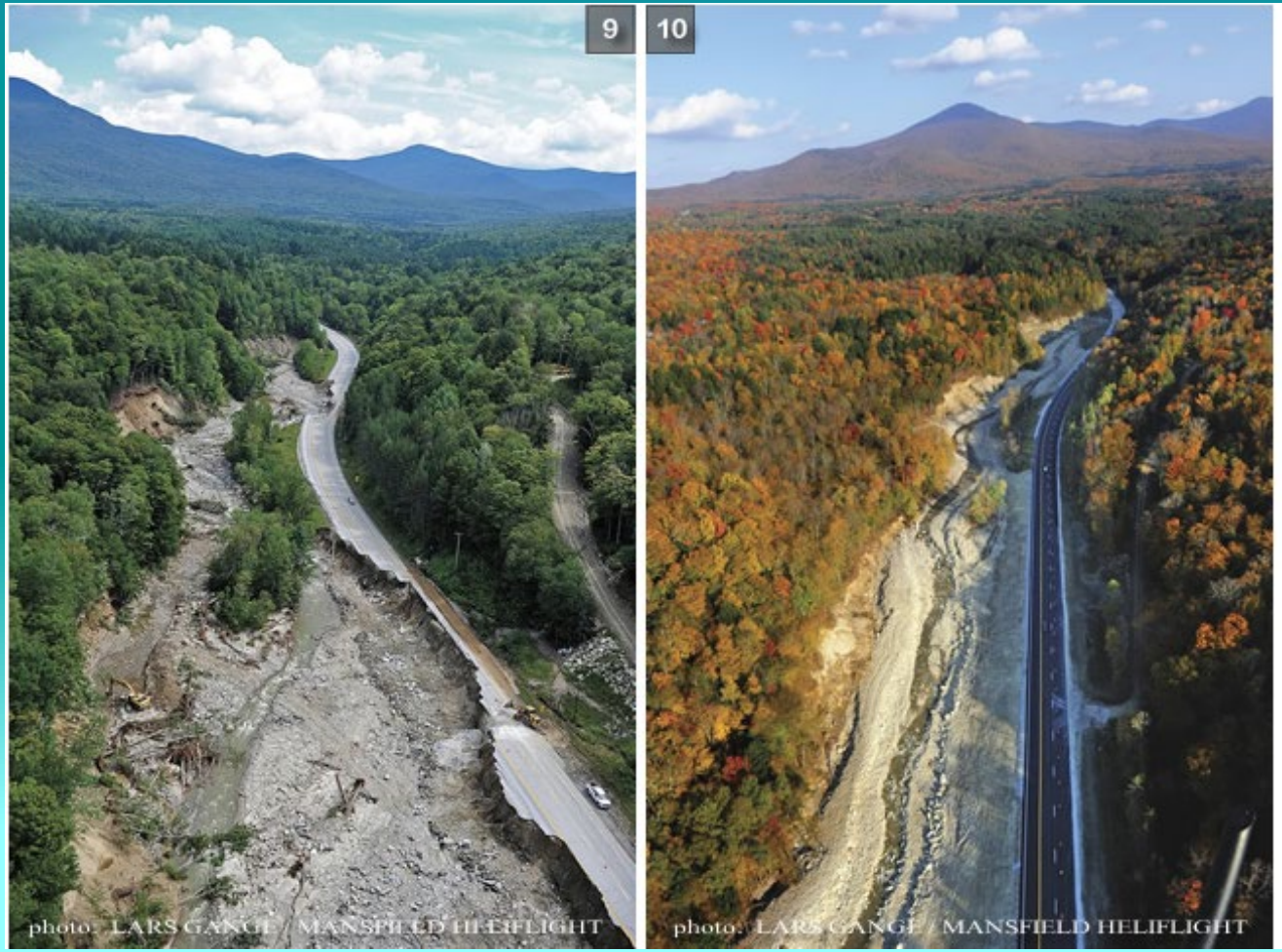
State-Wide every 13.5 Years

Selected flood disasters - Areas of greatest damage

2011 - Irene



Urgency of Recovery Overshadows the Opportunity to Reduce Vulnerability to Future Floods



3 IRENE LESSONS LEARNED

1. Demonstrated vulnerability to flood damage

2. Recovery demonstrated dependence on channelization

3. Channelization may be the greatest cause of flood damage to these same land uses

FEATURE Gillespie et al. 2014, *Fisheries*

Flood Effects on Road–Stream Crossing Infrastructure: Economic and Ecological Benefits of Stream Simulation Designs

More costly at construction stage…

Table 1. Cost comparison of traditional hydraulic design vs. AOP stream simulation design in the Green Mountain National Forest.

Estimated costs from damage survey reports					
Road no./name	Traditional culvert/replace in kind ($)	Betterment/AOP stream simulation replacement ($)	Anticipated % cost increase for AOP stream simulation design	Actual construction cost ($)	Actual % cost increase for AOP stream simulation design
FR42.05.0 over Bingo Road	92.950.00	142,050.00	53	113,738.00	22
FR42B.00.0 over Bingo Brook	112,175.00	156,775.00	40	Never constructed, road decommissioned	NA
FR49.00.5 over Boyden Brook	93,800.00	140,700.00	50	Never constructed, Irene damaged site access road	NA
FR92.00.0 Over Goshen Brook	106,635.00	172,200.00	61	119,835.00	12
FR92A.00.0 over Hale Brook	104,700.00	130,250.00	24	113,725.00	9

Economic & Community Benefits from Stream Barrier Removal Projects in Massachusetts Mass. Dept. F&G, 2015

On average, upgrade of the 3 culverts in the study was 38% less expensive than in-kind replacement and maintenance over 30 years.

King 2017, MI Upper Peninsula study

Site	Total Planned Cost of Replacement	Total Failure Cost of Replacement
UNGOLD	$137,519	$163,648
GOLD02	$205,979	$245,115
GOLD03	$137,519	$163,648
HOLM02	$137,519	$163,648
HOLM03	$205,979	$245,115
MITITRIB01	$14,968	$17,811
MITITRIB02	$28,527	$33,947
SILK02	$137,519	$163,648
NBPR10	$137,519	$163,648
Average	$127,005	$151,136

Work with Rivers, Don't Fight the Power of Water!

What's Good For Public Safety

What's Good for Our Budget

Is Good for Our Environment!

A <u>Win-Win-Win</u> Outcome!

Medway Road New Bridge

Rebuilt wider and higher after Irene

UMass Amherst 2016 River Smart Communities

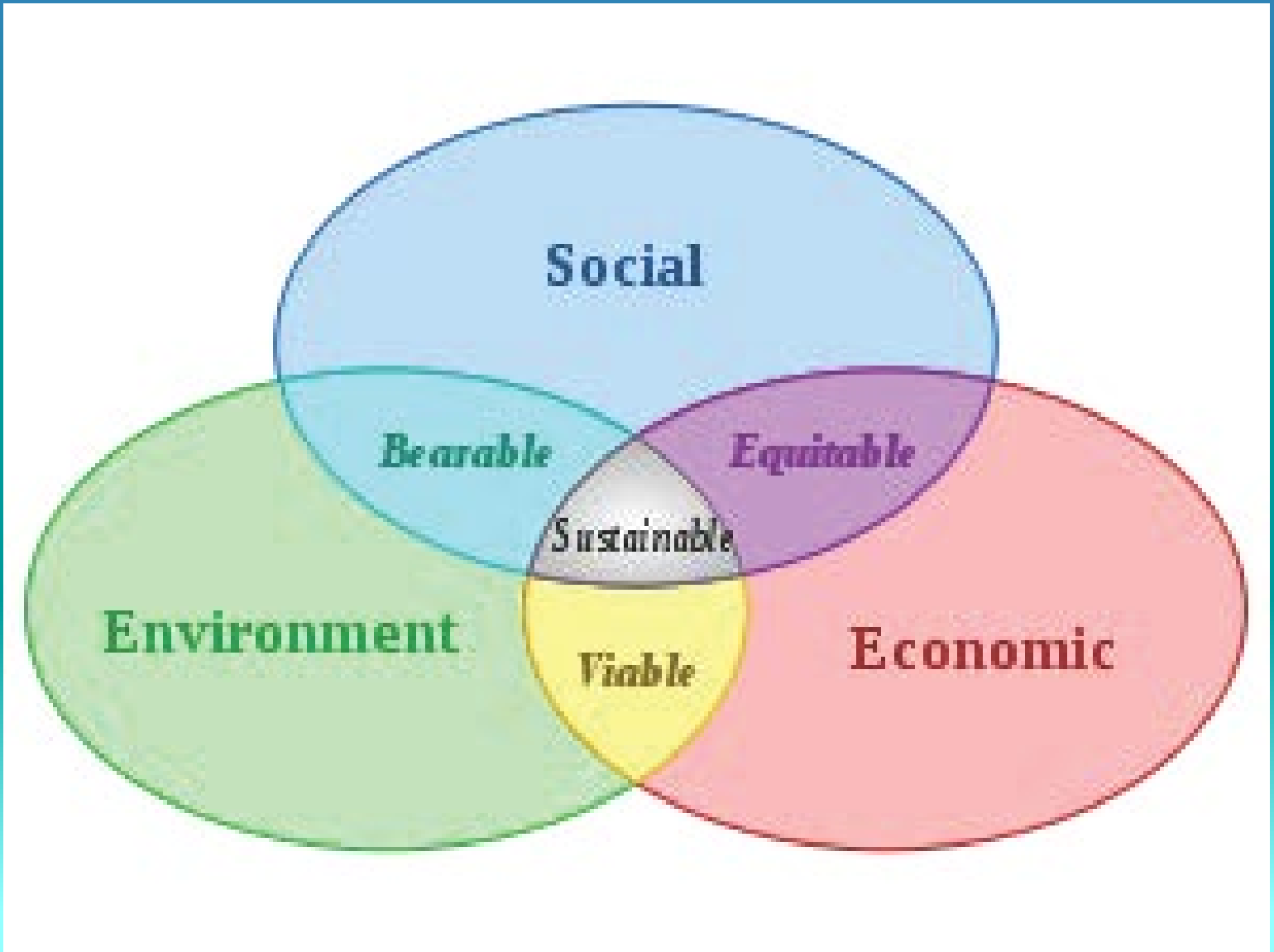
PDF Available River Smart Communities

State and Army Corps Programs

- Same Goals and Objectives
- Different Permit Thresholds
- Different Permit Applications

Same **Win-Win-Win** Outcomes

Sustainability Diagram



Importance of Habitat Protection

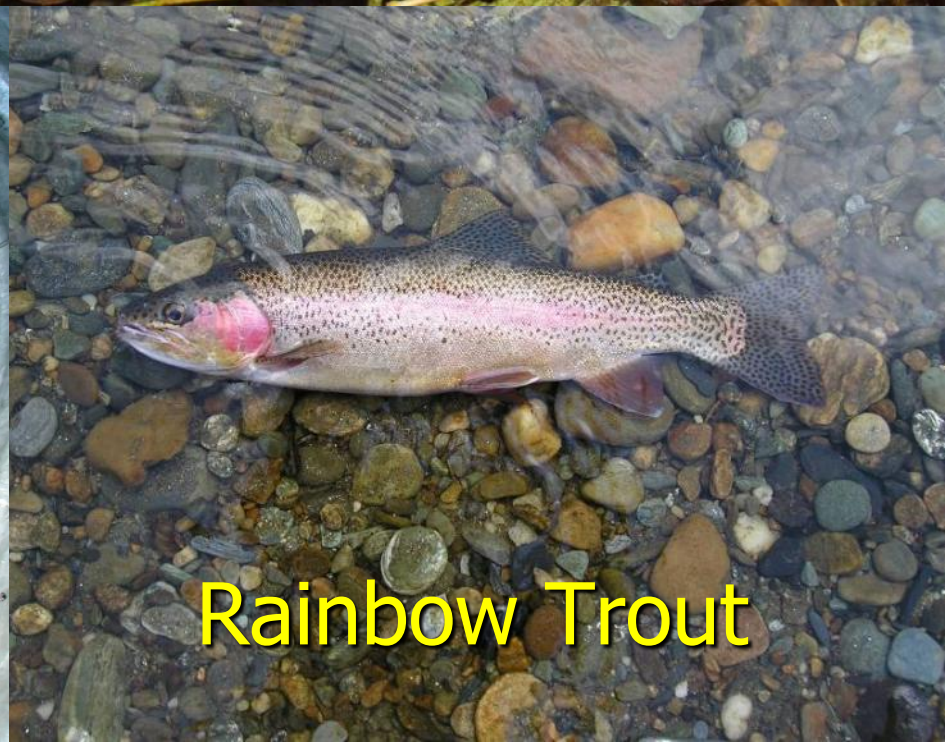
Healthy rivers support many uses (recreation, water supply, aesthetics [tourism])

Angling and hunting = important cultural and economic activities

Transportation infrastructure affects terrestrial wildlife populations, habitat

Fishes of Vermont

- 77 native
- 15 introduced



Burbot

Rainbow Smelt

White Sucker

Slimy Sculpin

Migratory species (sea- & lake-run)

Atlantic salmon

American eel

Sea lamprey

Other Aquatic Species

Spring salamander

Two-lined salamander

Wood turtle

Aquatic Habitat

- Water Quality – temperature, pH, D.O., alkalinity, etc….
- Water Quantity – hydrology, flow regulation
- Physical Habitat – 3-dimensional
  - streambed, banks, riparian zone

What does 'good habitat' look like?
It is structurally complex, diverse

What does ‘good habitat’ look like?

It is often ‘messy’

What does ‘good habitat’ look like?

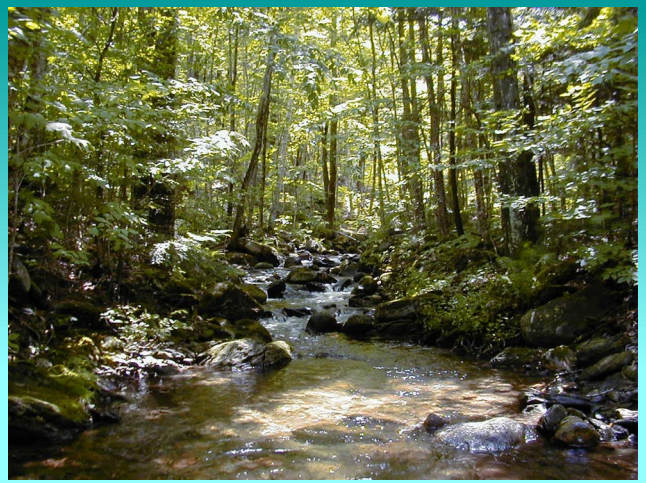
It is well connected

Deer Crossing Through Culvert

Bear Crossing Under Bridge

Summary

- Work with Rivers, Don’t Fight the Water
- Promote Healthy ecosystems by designing structures that are compatible with natural stream processes
- New Permitting requirements due to improved knowledge



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Questions and/or Comments?

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