Avoiding the impacts of river management through river corridor and floodplain protection

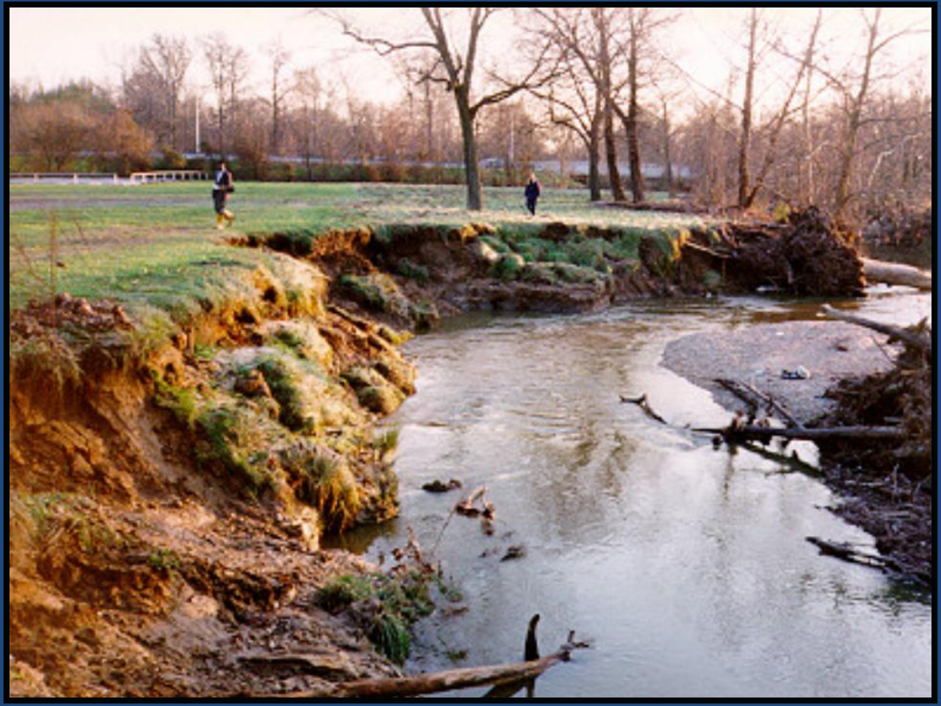
Mike Kline
Vermont ANR

Rivers Program

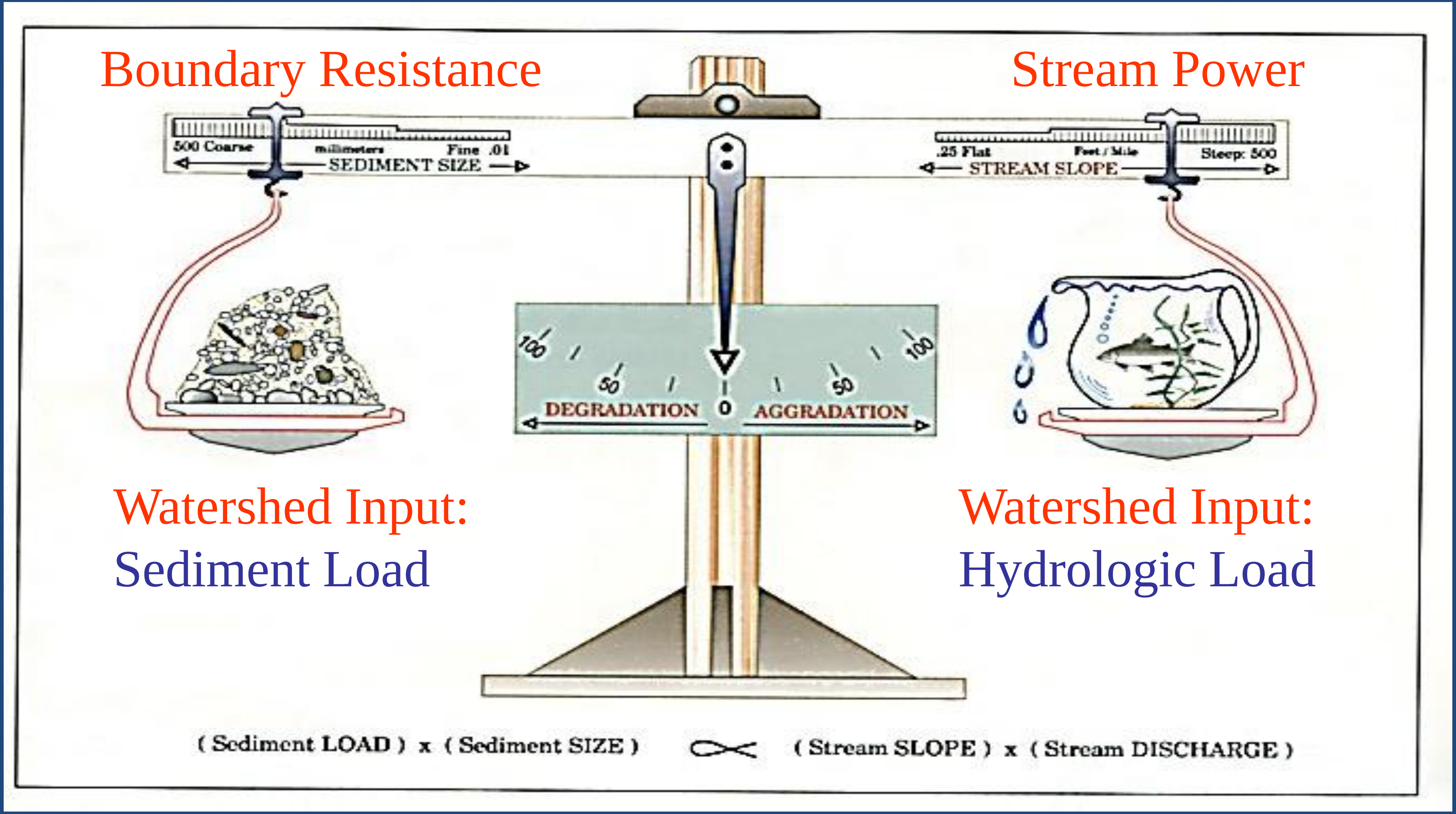
Program Goal: achieve an economically and ecologically sustainable relationship between human investments and the dynamics of rivers.

Working with (not against) fluvial processes and using avoidance strategies, to maximize:

- property protection
- water quality
- ecosystem integrity

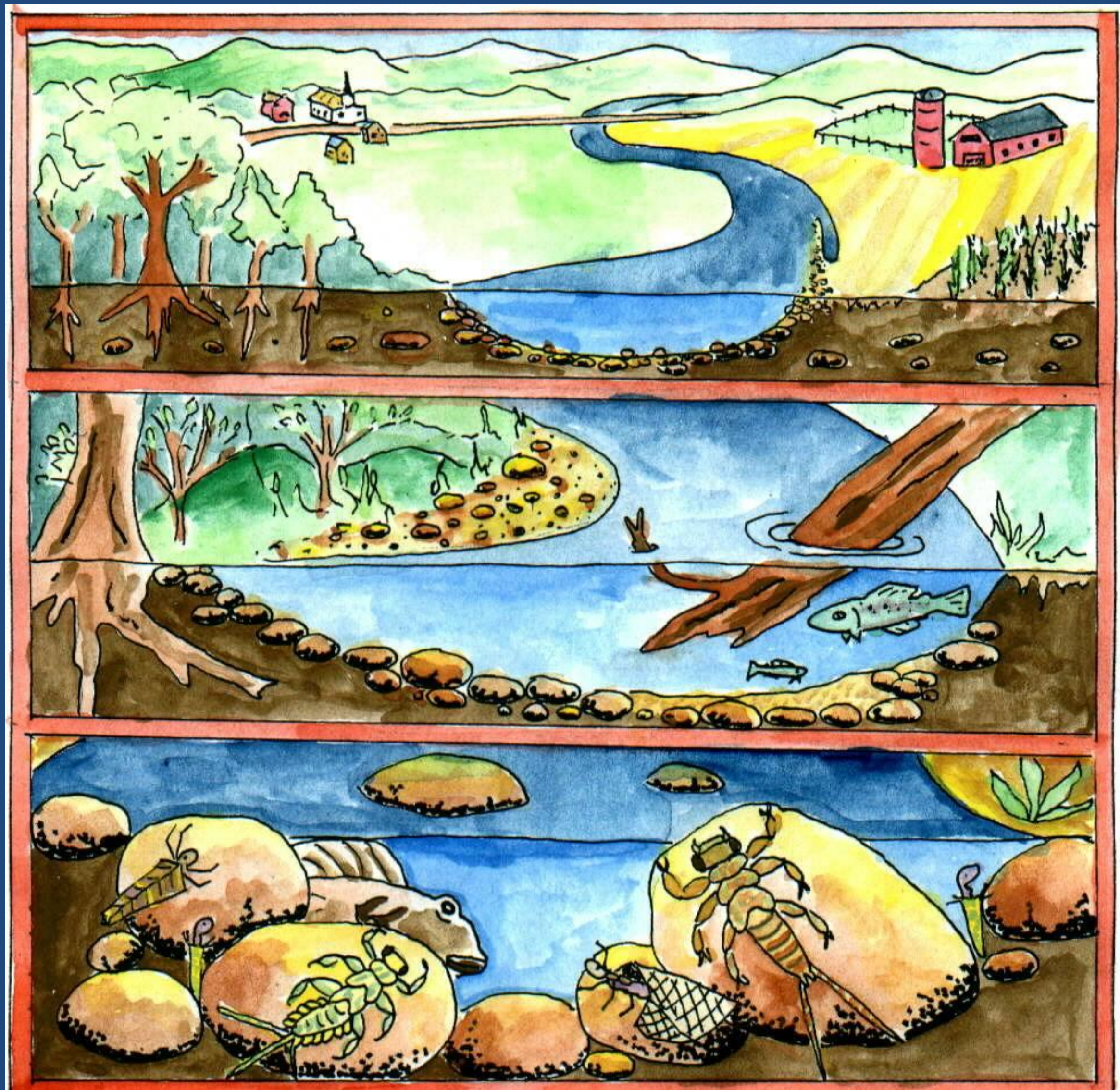


Managing Toward Equilibrium



Analyze stream sensitivity and departures from equilibrium & consequences of an uneven stream energy / sediment distribution

VT ANR Stream Geomorphic Assessment Program



Watershed – Phase 1

Land use, Riparian, Channel and Floodplain Modifications

Reaches – Phase 2

Condition - Departure
Adjustments - Evolution
Sensitivity - Rate

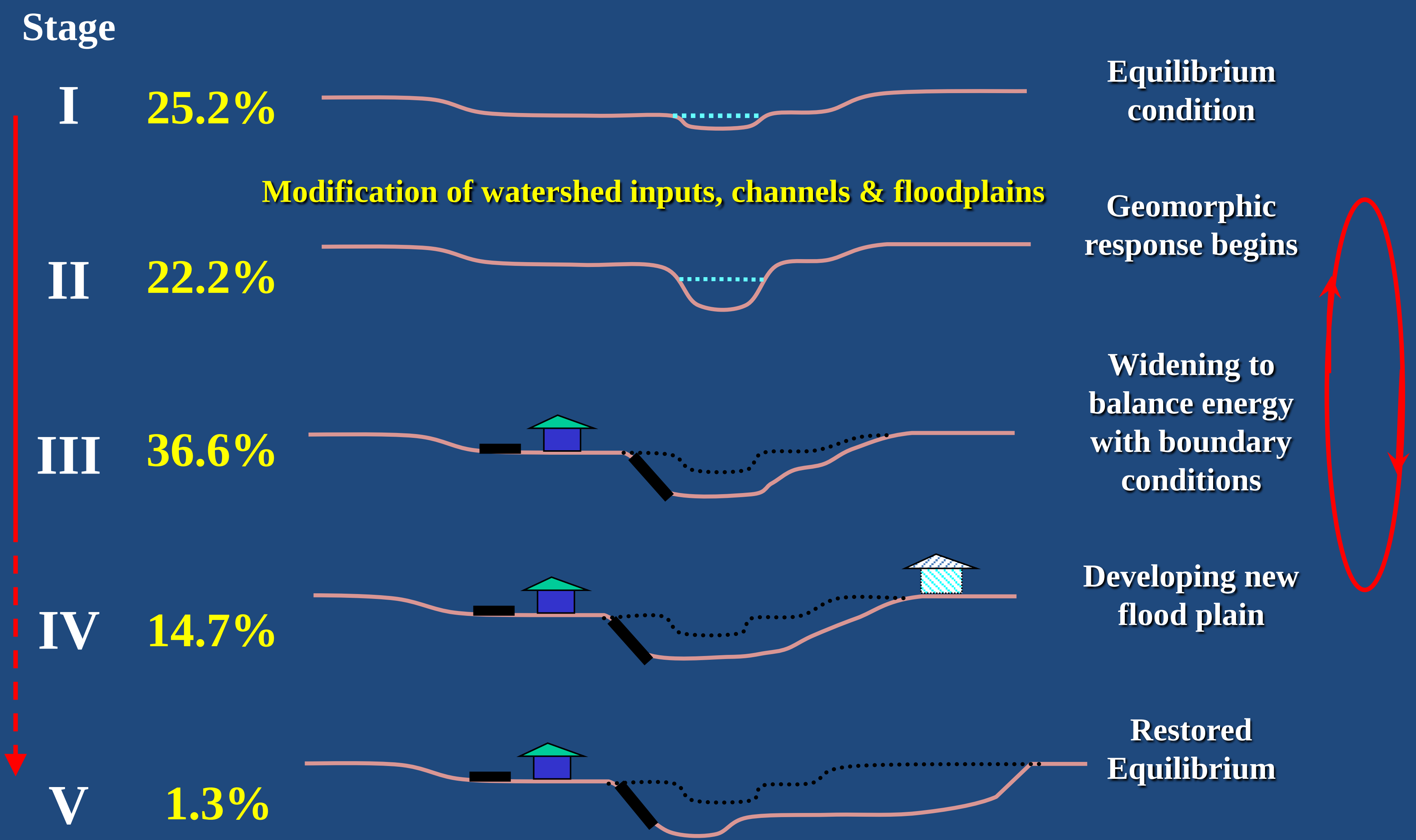
Sites – Phase 3

Hydraulics
Sediment Transport

Habitat Assessment

Bridge/Culvert/Dam

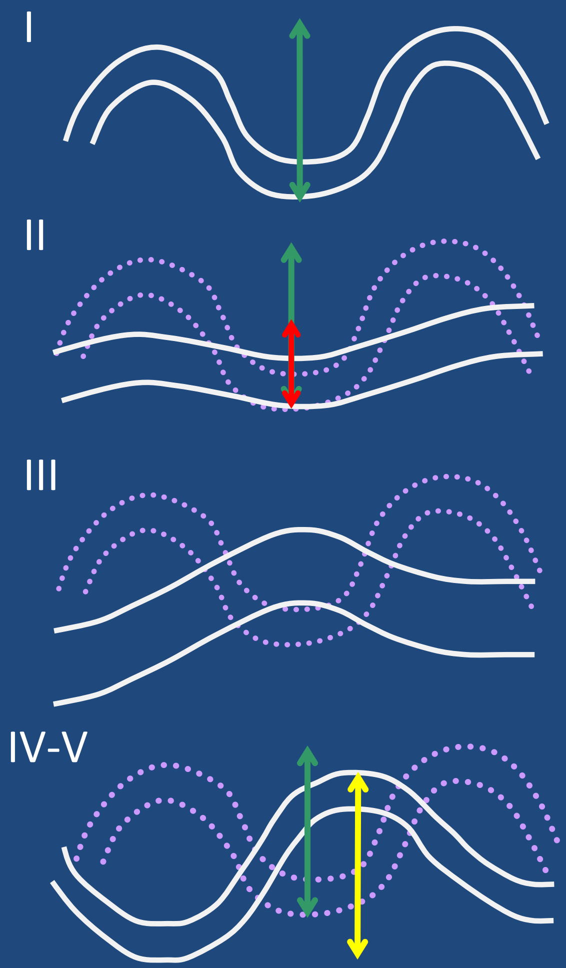
73.5% Assessed Streams in Disequilibrium Lacking Access to a Floodplain

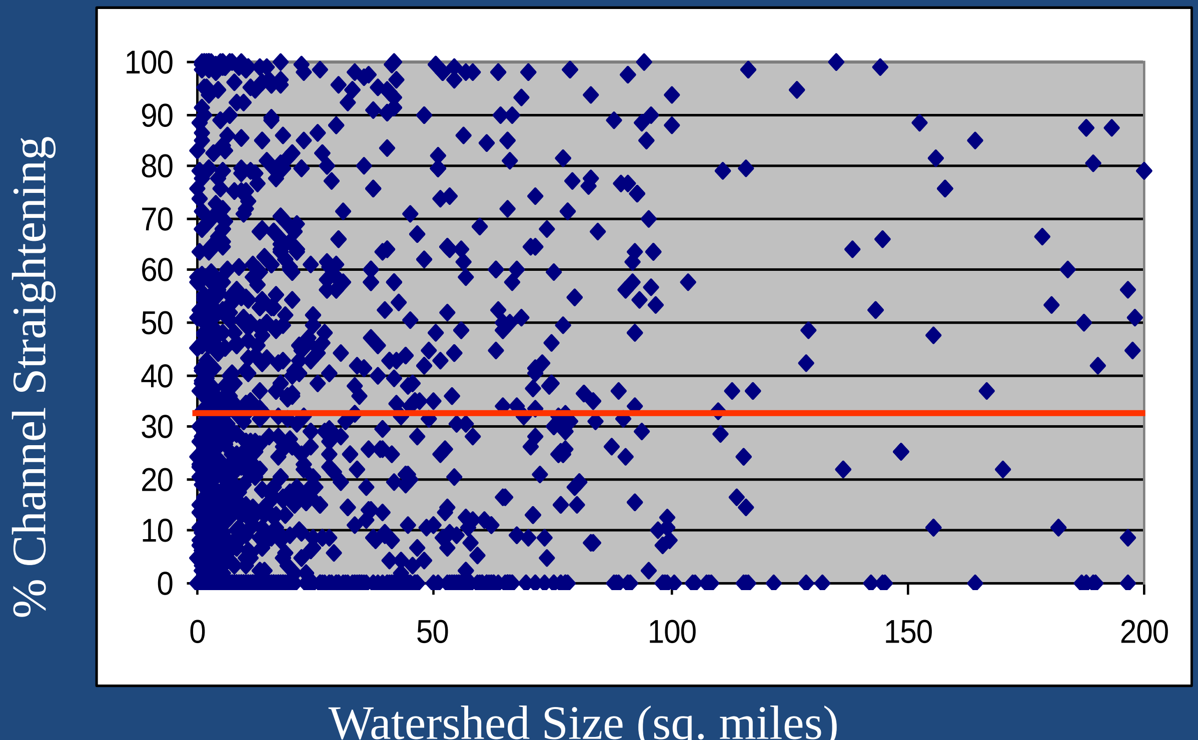


After Schumm, et.al.

On average **31.4%** of Vermont assessed streams have been historically straightened and channelization.

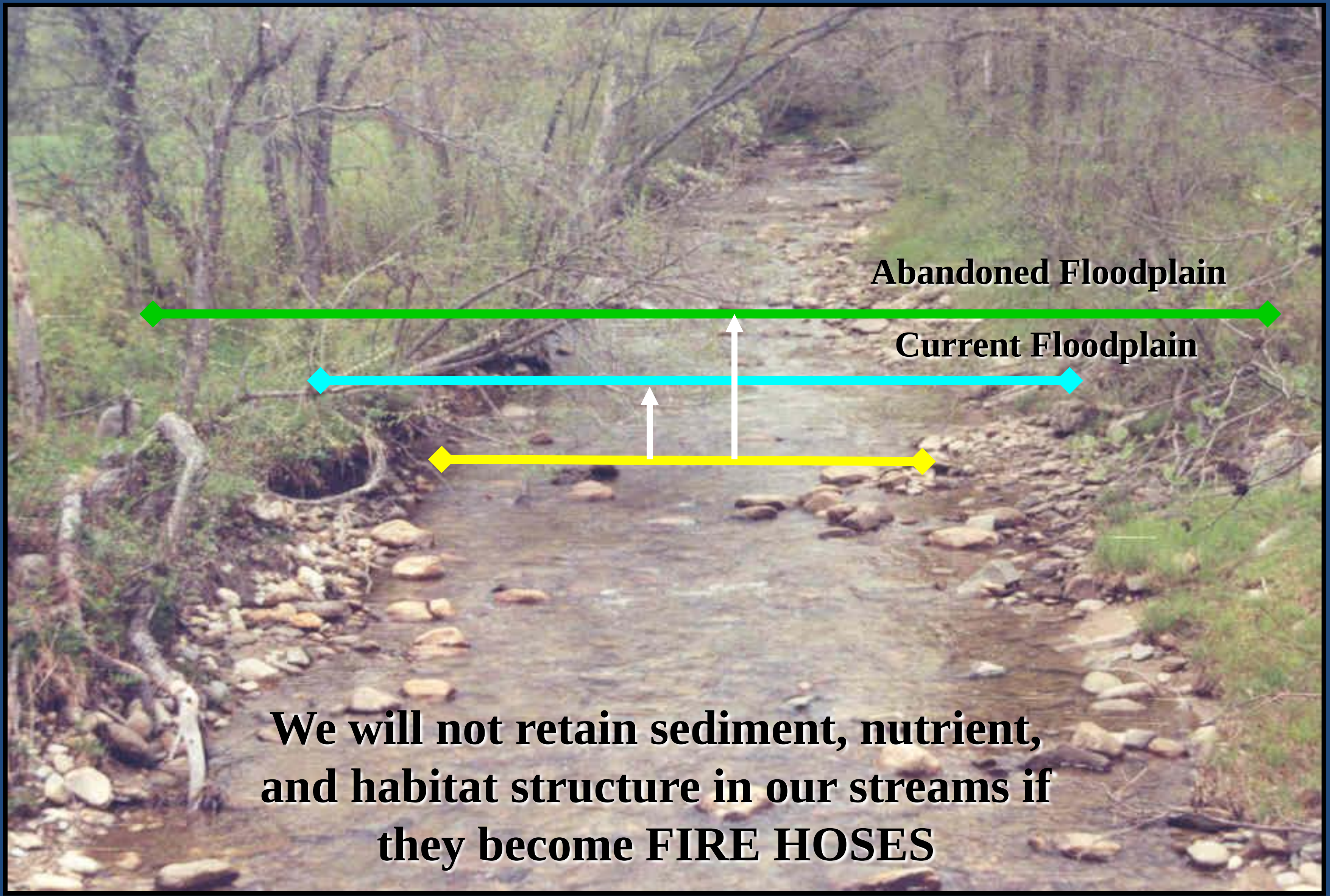
Stages II and III of planform evolution



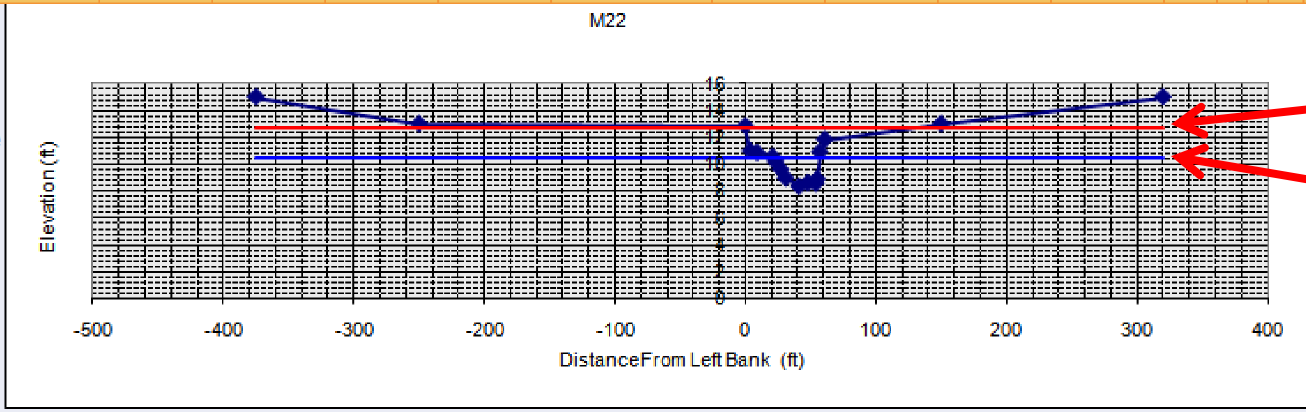


Alteration of Hydrologic, Sediment and Large Wood Regimes

Departures in the size, quantity, sorting, and storage of materials



A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P



Abandoned Floodplain

Annual Flood Stage

Stream Name: Lewis Creek
Reach # M22
Segment D
XS #: 4

Date: see notes
Town: STARKSBORO
Observers: see notes
Riffle

Flodplain Edits	Notes	Distance (ft)	Elevation (ft.)
Rt116, GIS	LVW	-375	15
StP notes	LFPW	-250	13
	LPIN-LTOB	0	12.85
	(LBF?)	4	10.98
	(LBF?)	9	10.86
	LBF	21	10.55
		23	10.2
		27	9.63
	LEW	31	8.96
	TW	41	8.36
		48	8.63
		54	8.57
	REW	55	8.9
		57	10.91
	RTOB-RPI	61	11.83
StP notes	RFPW	150	13
GIS est	RVW	320	15

Notes: StP, ShH(P), Fenns; 10/8/2002. Head riffle. Identified as XS-1 in Ph3 at Long Prof site M22B completed by RMS. KU added VW and FPW values in 2007 based on StP notes & Ph3 cross section from 2002.

Elevation Bankfull	Elevation top of bank	W fpa (ft)	Channel Slope (%)	Manning's "n"
10.5	11.87	400	0.87	0.042

Dimensions			
54.29	x-section area	1.54	d mean
35.31	width	36.17	wet P
2.14	d max	1.50	hyd radi
3.51	bank ht	22.96	w/d ratio
400.00	W flood prone area	11.33	ent ratio

Hydraulics	
4.32	velocity (ft/sec)
234.30	Q Manning's (cfs)
0.81	shear stress ((lbs/ft sq)
0.65	shear velocity (ft/sec)
0.10	stream power (lbs/ft/sec)
6.68	friction factor u/u*
121.03	threshold grain size (mm)

Segment Slopes | Segment Pebble Counts | Segment A XS | Segment B XS | Segment C XS | **Segment D XS** | Dimension Data Converter

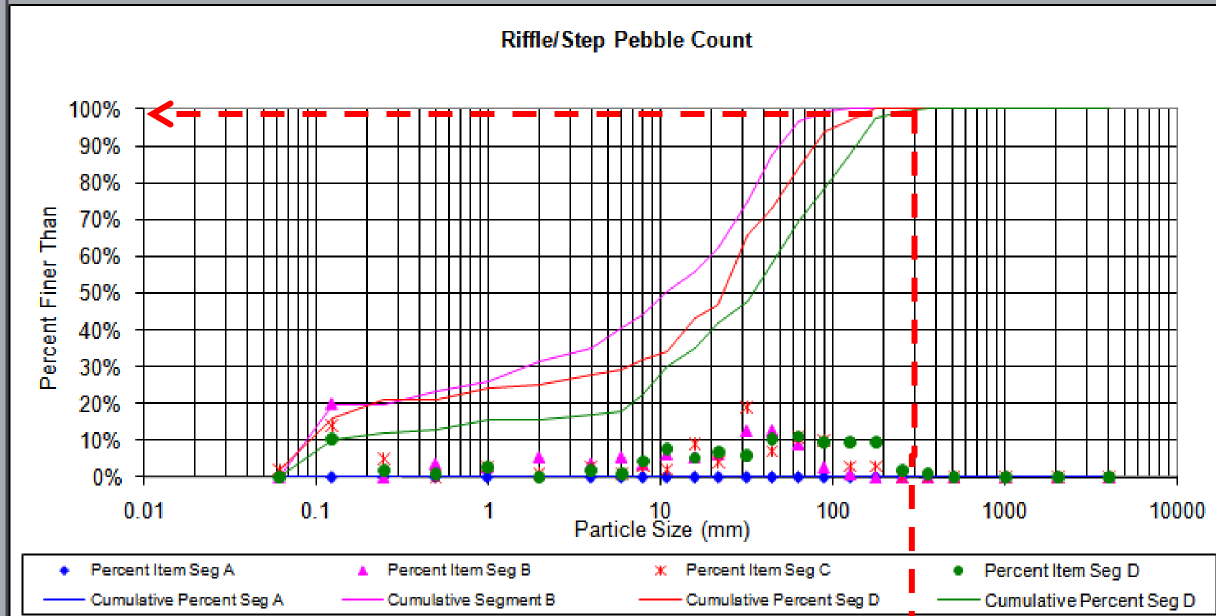
B C D E F G H I U V W X Y Z AA AB AC AD AE AF AG

Pebble Count Worksheet

Stream Name: Lewis Creek **Date:** see notes
Reach #: M22 **Town:** STARKSBORO

Material	Size Range (mm)		Seg A	Seg B	Seg C	Seg D
silt/clay	0	0.062			2	
very fine sand	0.062	0.125		22	14	12
fine sand	0.125	0.25			5	2
medium sand	0.25	0.5		4		1
coarse sand	0.5	1		3	3	3
very coarse sand	1	2		6	1	
very fine gravel	2	4		4	3	2
fine gravel	4	6		6	1	1
fine gravel	6	8		4	3	5
medium gravel	8	11		7	2	9
medium gravel	11	16		6	9	6
coarse gravel	16	22		7	4	8
coarse gravel	22	32		14	19	7
very coarse gravel	32	45		14	7	12
very coarse gravel	45	64		10	11	13
small cobble	64	90		3	10	11
medium cobble	90	128		1	3	11
large cobble	128	180			3	11
very large cobble	180	256				2
small boulder	256	362				1
small boulder	362	512				
medium boulder	512	1024				
large boulder	1024	2048				
very large boulder	2048	4096				
bedrock						
		Total Particles:	0	111	100	117

Notes: Pebble counts transferred from Ph3 worksheets.

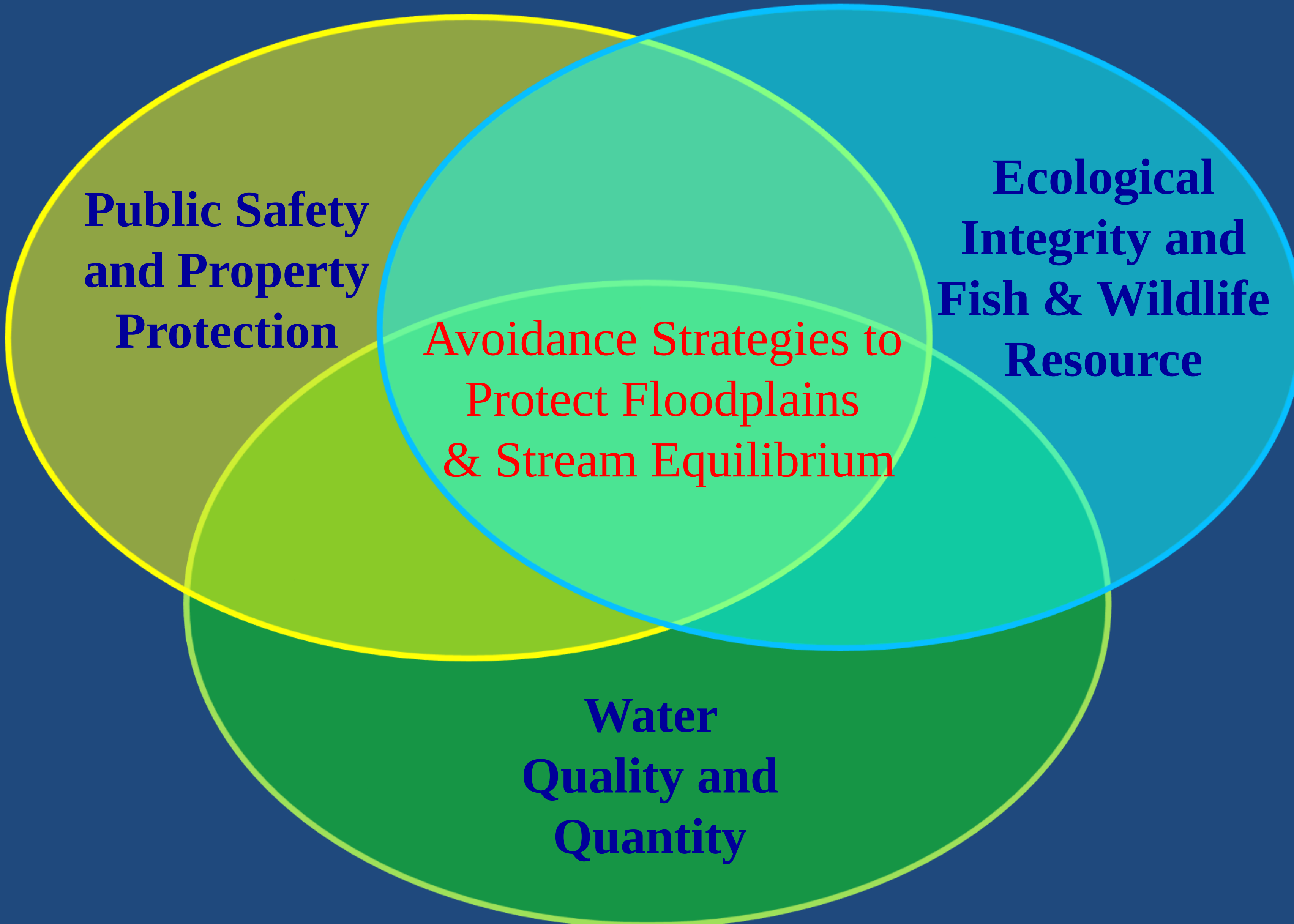


	Size percent less than (mm)					Percent by substrate type					
	D16	D35	D50	D84	D95	silt/clay	sand	gravel	cobble	boulder	bedrock
Segment A											
Segment B	0.109	3.897	10.753	41.063	60.600	0%	32%	65%	4%	0%	0%
Segment C	0.125	11.468	23.341	64.000	101.212	2%	23%	59%	16%	0%	0%
Segment D	2.567	15.950	34.356	110.046	164.782	0%	15%	54%	30%	1%	0%

Reach Incision converts dominate process from depositional to sediment transport

Threshold Grain Size = 121mm
(Phase 3 verification)

Functioning floodplains and river corridors create an intersection for the protection of public values



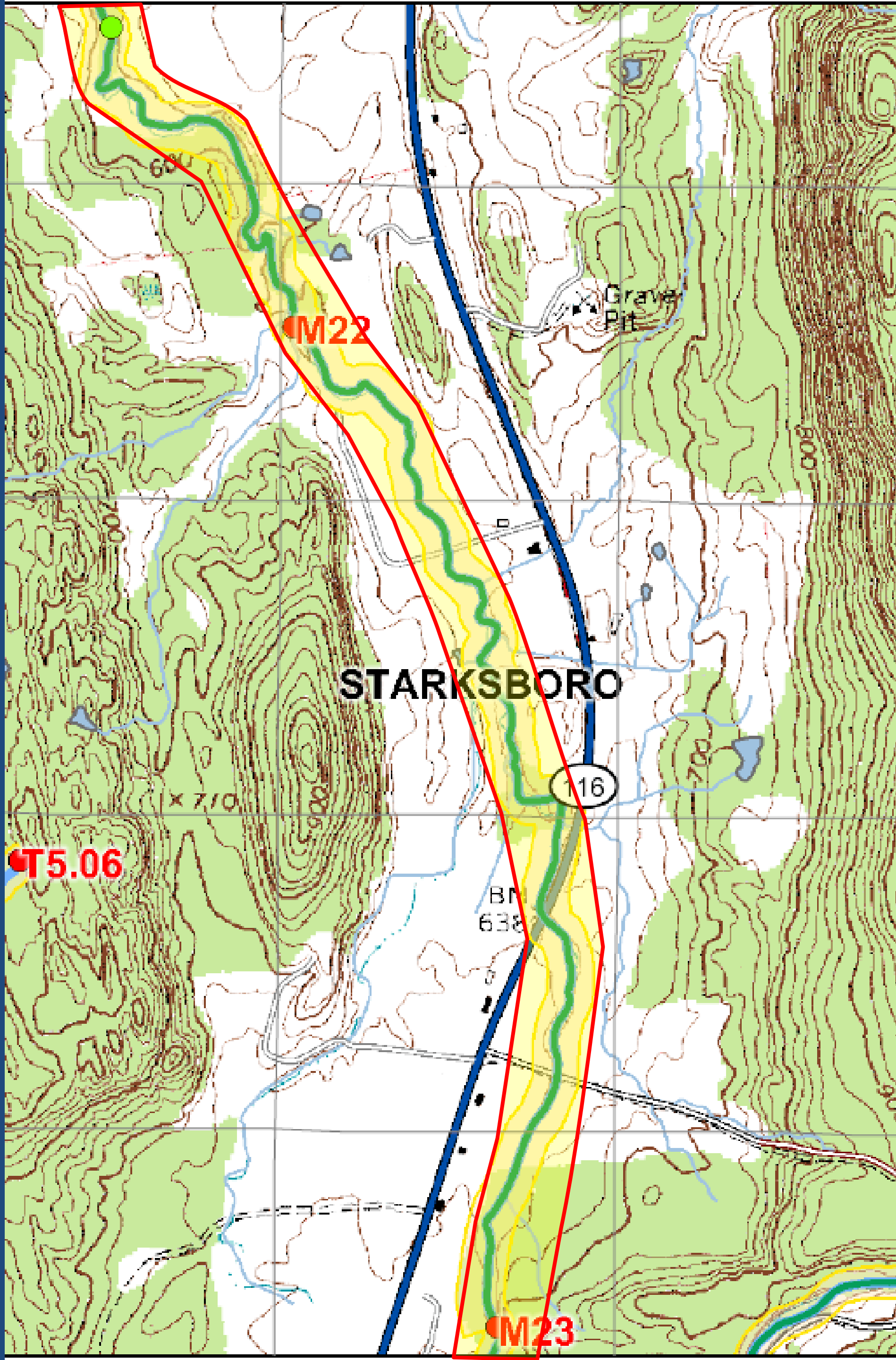
River Corridor Planning

Watershed Strategies:

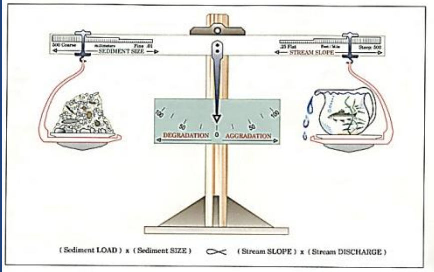
Drainage and Stormwater Management
Gully and Erosion Control
Floodplain / River Corridor Protection
Buffer Establishment and protection
Road-Stream Crossing Retrofits / Replacements
Reach-scale River Corridor Easements
Reach-scale River Corridor Restoration Projects

Reach-specific Protection and Restoration Projects:

Protect River Corridors
Plant Stream Buffer
Stabilize Stream Bank
Arrest head cuts and nick points
Remove Berms and other constraints to flood and sediment load attenuation
Remove/Replace Structures (e.g. undersized culverts, constrictions, low dams)
Restore Incised Reach
Restore Aggraded Reach



River Corridor Planning Maps



Watershed Scale Stressors

Hydrologic - **Land use, stormwater, divisions, flow regulation, dams**

Sediment Load - **Land Use, depositional features, bank erosion, mass failures & gullies, upstream incision, and tributary rejuvenation**

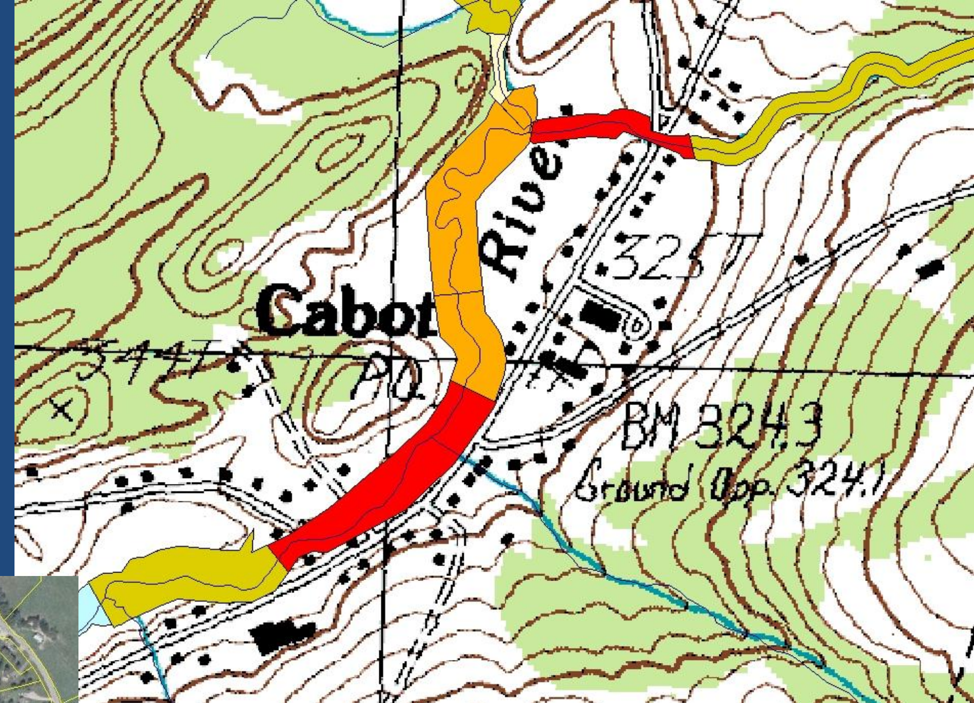
Reach Scale Stressors

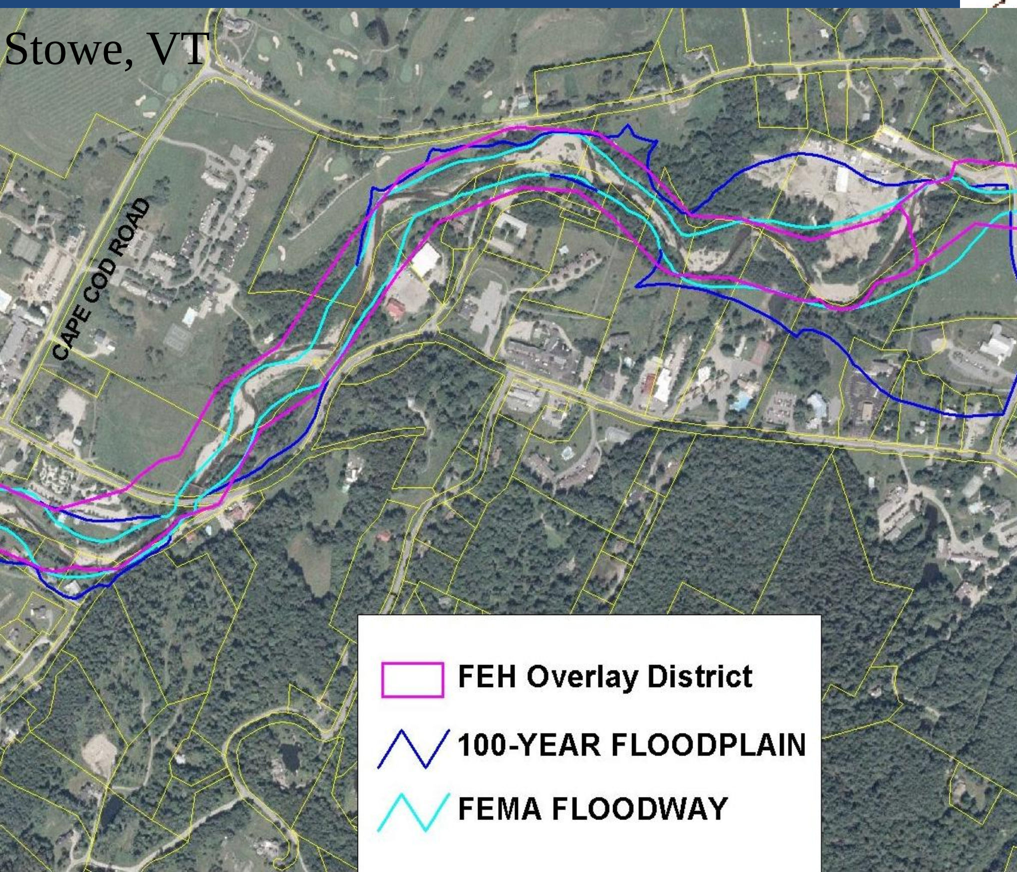
Stream Power - **Channelization, berms, dredging, grade controls, encroachments, head cuts, beaver dams**

Boundary Condition - **Buffers, grade controls, erosion, bed/bank materials, snagging, windrowing**

SGAT – Stream Geomorphic Assessment Tool

ArcGIS program to index features and draw belt width-based river corridors

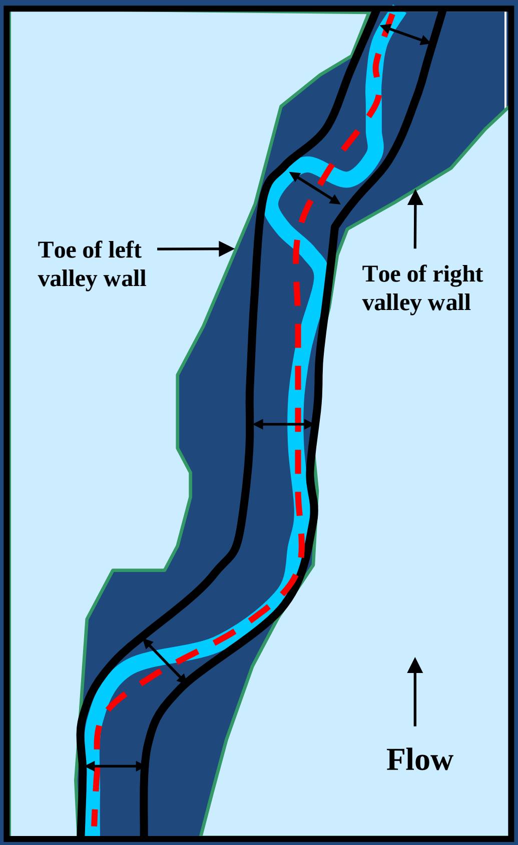




River Corridors are designed to assist in managing toward, protecting, and restoring the fluvial geomorphic equilibrium condition of Vermont rivers; and to avoid conflicts between human investments and river dynamics in an economically and ecologically sustainable manner.

Belt Width

$B = 3.7W^{1.12}$ **Williams, 1986**



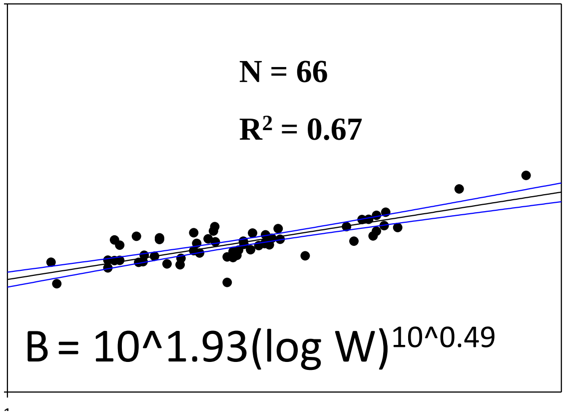
Using Williams Regression

Meander width ratio

B/W = 5 to 6 channel widths

Vermont Meander Width Ratios

Low gradient, unconfined alluvial streams



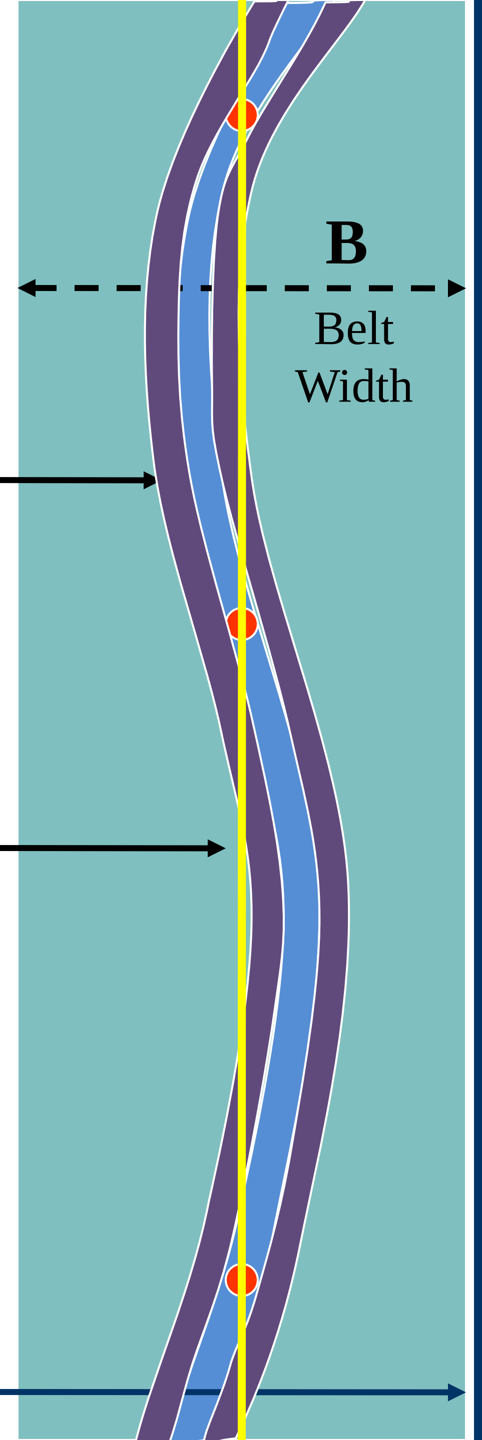
B/W = 6 to 8.5

For a 50 foot wide stream

B/W = 6.7

Belt Widths are a function of

- drainage area = D
- stream width = W
- valley slope & width
- stream sensitivity



Channel Evolution Stage used to help interpret sediment/ wood storage and transport

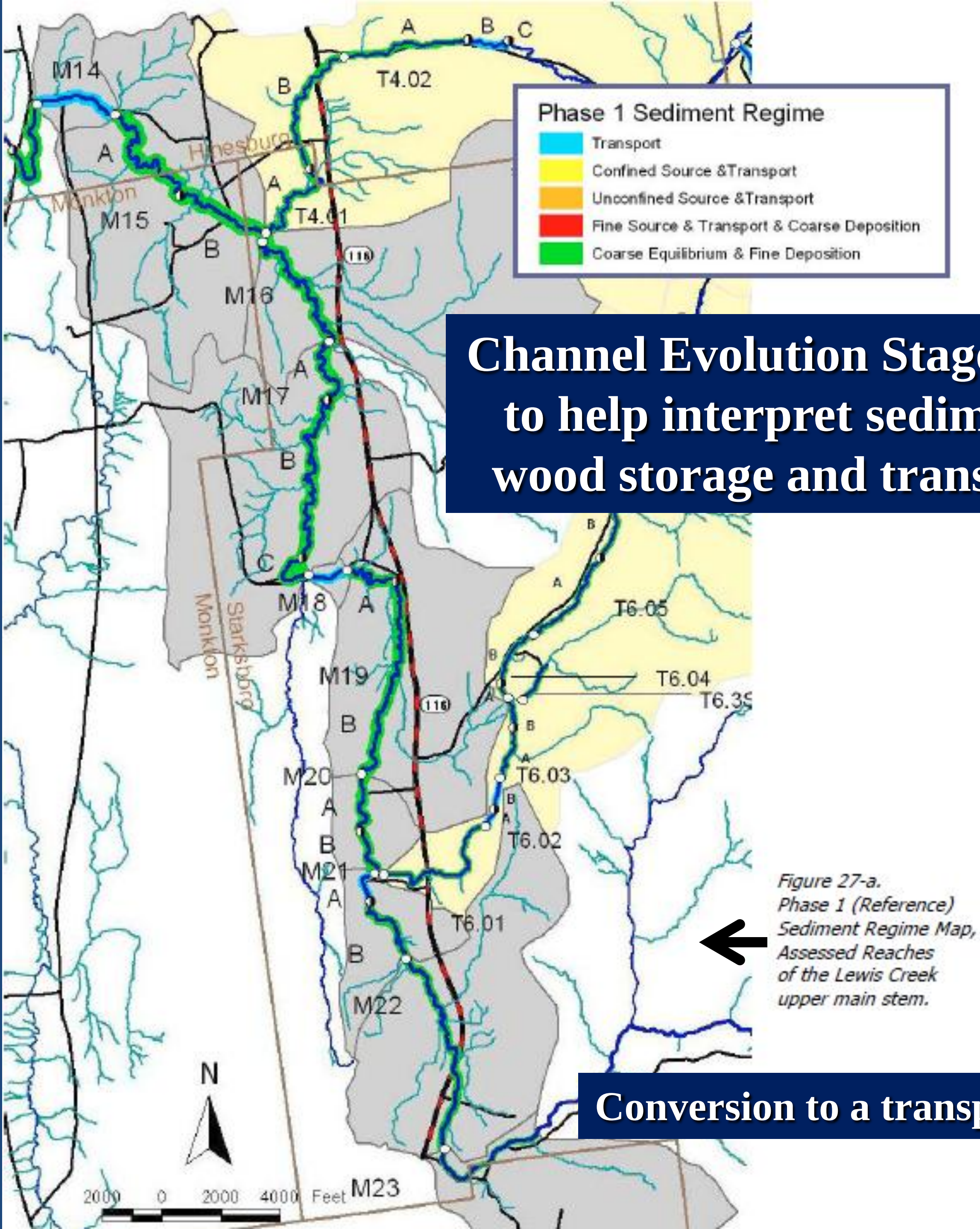


Figure 27-a.
Phase 1 (Reference)
Sediment Regime Map,
Assessed Reaches
of the Lewis Creek
upper main stem.

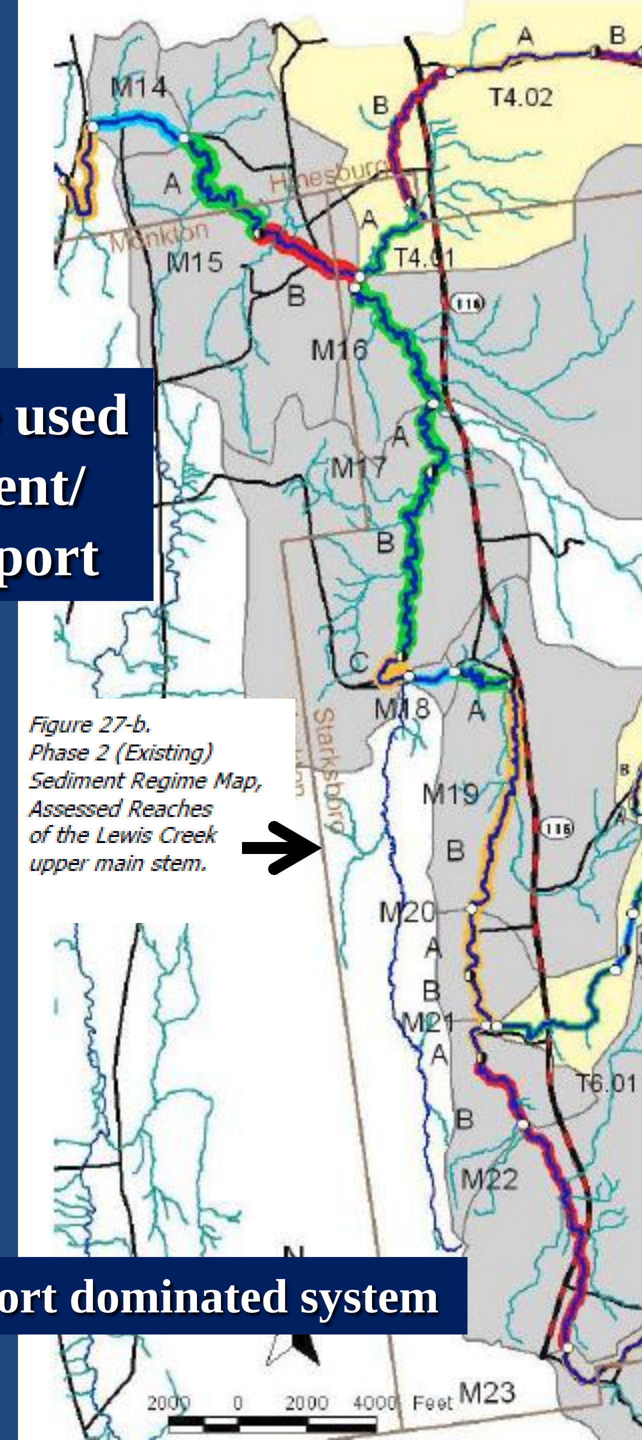


Figure 27-b.
Phase 2 (Existing)
Sediment Regime Map,
Assessed Reaches
of the Lewis Creek
upper main stem.

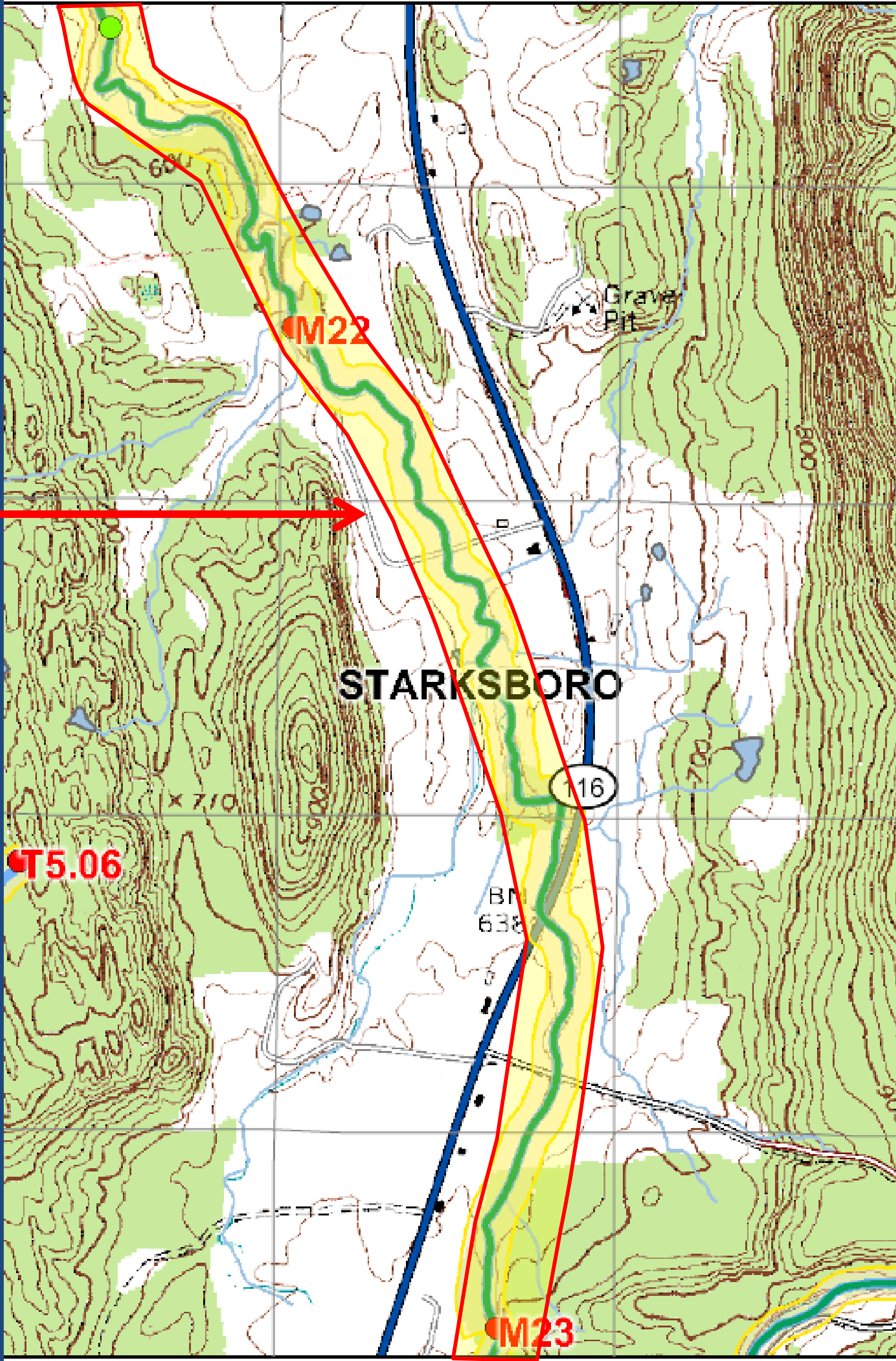
Conversion to a transport dominated system

River Corridor Protection

Fluvial Erosion Hazard (FEH) Area developed for municipality for their use in land use planning & regulation

- FEH Overlay District
- Model FEH bylaws
- Pre-Disaster Mitigation Plan
- Municipal Incentives

Communities w/ river corridor plans	**170**
FEH projects underway or completed	**60**
Draft FEH maps completed	**81**
FEH maps adopted as an ordinance	**15**



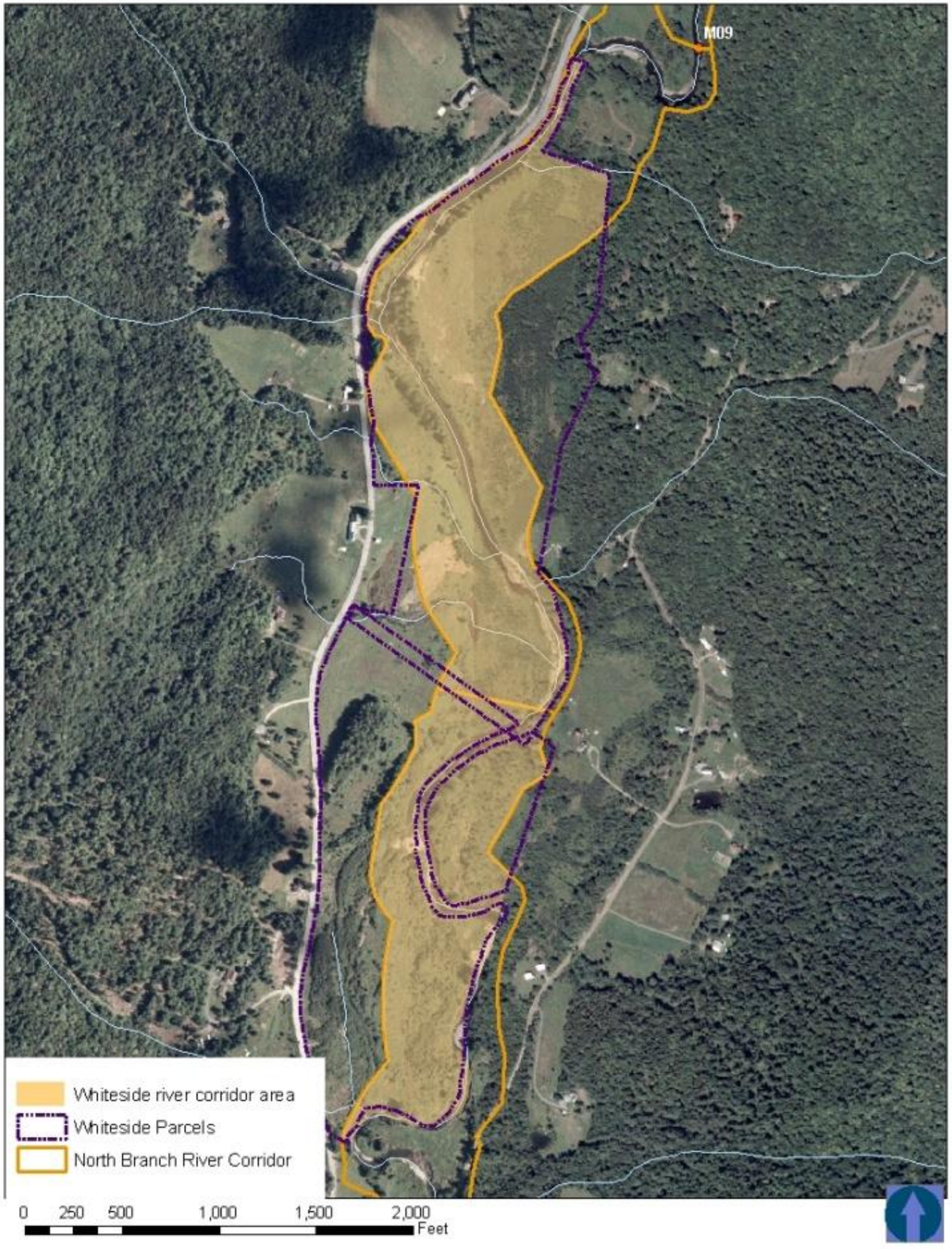
River Corridor Easement used to secure:

- ➢Channel Management Rights
- ➢Riparian Buffer
- ➢Corridor Development Rights

31 easements with 722 acres
closing on another
10 easements with 170 acres

Protecting
Key Attenuation Assets

Cessation of channelization to increase/allow for sediment storage at key watershed locations



Culvert Failure Modes Report Geomorphic Incompatibility

Town Name : CAMBRIDGE

Structure#:	Road Name:	Stream Name:	Concern for structure due to: Fluvial condition or process	Potential Failure Mode due to structure / geomorphic incompatibility: Out-flanking	Scour	Ice or Debris Jam	Structure Related Damage: Flooding of Adjacent Property	Erosion of Adjacent Property	Existing Problems 1	2	3	4	5	% bankfull width
VT07-06-03	HOGBACK RD	Judevine Brook	-	X	X	X	X	X	X	X	-	X	-	55.56%

Existing Problems:
1. Upstream sediment deposit present
2. Scour and/or erosion present
3. Inlet obstruction present
4. Poor location or alignment
5. Beaver Activity

Judevine Brook Culvert

Geomorphically Incompatible

Blocks Aquatic Organism Passage

Culvert Aquatic Organism and Wildlife Passage Report - Potential Barriers to Movement and Migration

Town Name: CAMBRIDGE

Structure#:	RoadName:	StreamName:	Aquatic Organisms: Culvert Blocks Aquatic Organism Passage (AOP): All Fish and stream salamanders (except resident adult salmonids)	Culvert Blocks AOP: All Fish and stream salamanders	Culvert Potentially Blocks AOP: All Fish and stream salamanders	Culvert Does Not Block AOP: All Fish and stream salamanders	Terrestrial Wildlife: Structure Potentially Blocks Terrestrial Wildlife Movement: Small Wildlife (herps, small mammals)	Medium Wildlife (fisher, otter, coyote, fox)	Large Wildlife (deer, moose, bear)	Potential for / or Evidence of Wildlife Crossing at / near Structure	Species Observed via Roadkill or Wildlife signs
VT07-06-03	HOGBACK RD	Judevine Brook	-	X	X	-	X	X	X	-	none,none,none,none

Gully Brook, Traverse Farm
Marginal pasture converted to Flood Attenuation Area

Mix of Passive and Active Restoration Techniques

How DYNAMITE streamlines streams

Practically every farm in the heavy crop-producing areas of the United States needs some ditching, and there is hardly a stream in the entire boundary of the Union that does not need to be corrected to give better service in discharging the large amounts of waste water from heavy rains, and to protect low lands.

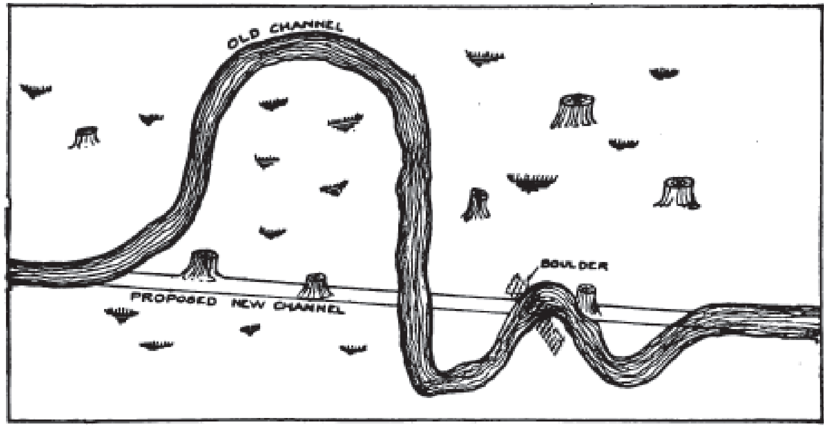
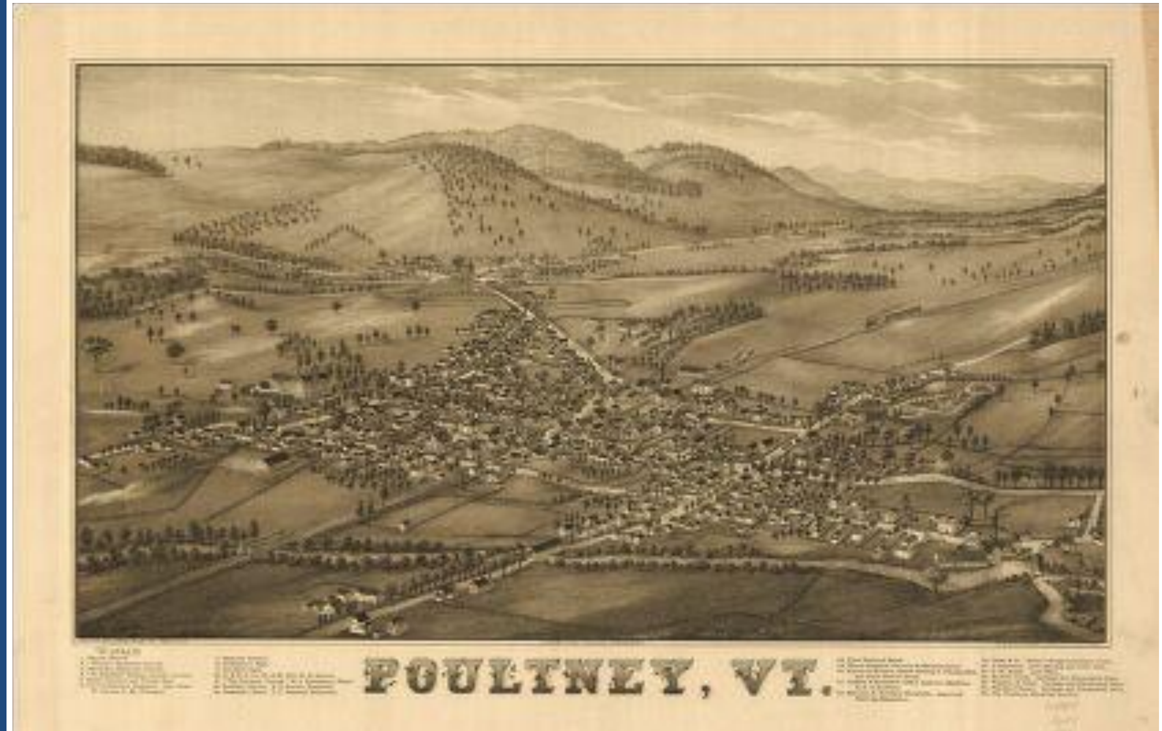


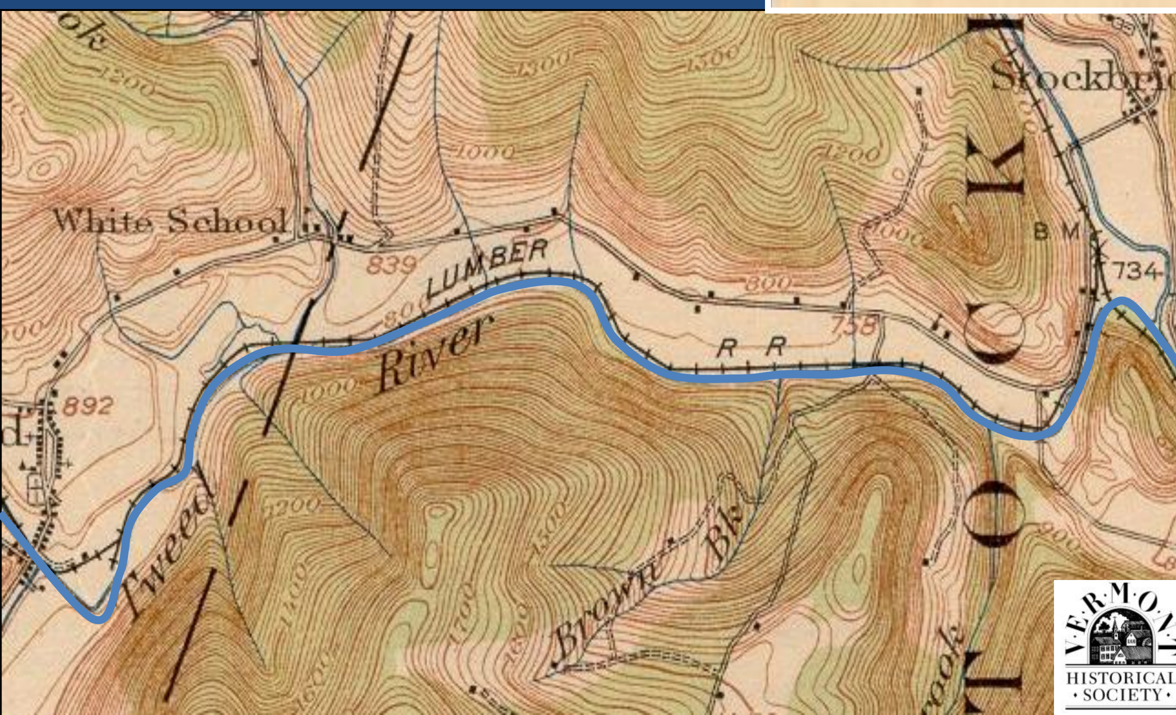
FIG. 54. DIAGRAM OF STREAM TROUBLES THAT MAY BE CORRECTED BY BLASTING.

CROOKED STREAMS are a menace to life and crops in the areas bordering on their banks. The twisting and turning of the channel retards the flow and reduces the capacity of the stream to handle large volumes of water. Floods result. Crops are ruined. Lives are lost. Banks are undermined, causing cave-ins that steal valuable acreage.

200+ years of
Channel, Floodplain and Watershed Modifications:

- Deforestation
- Snagging and ditching
- Encroachments, i.e., villages, farms, roads and rails





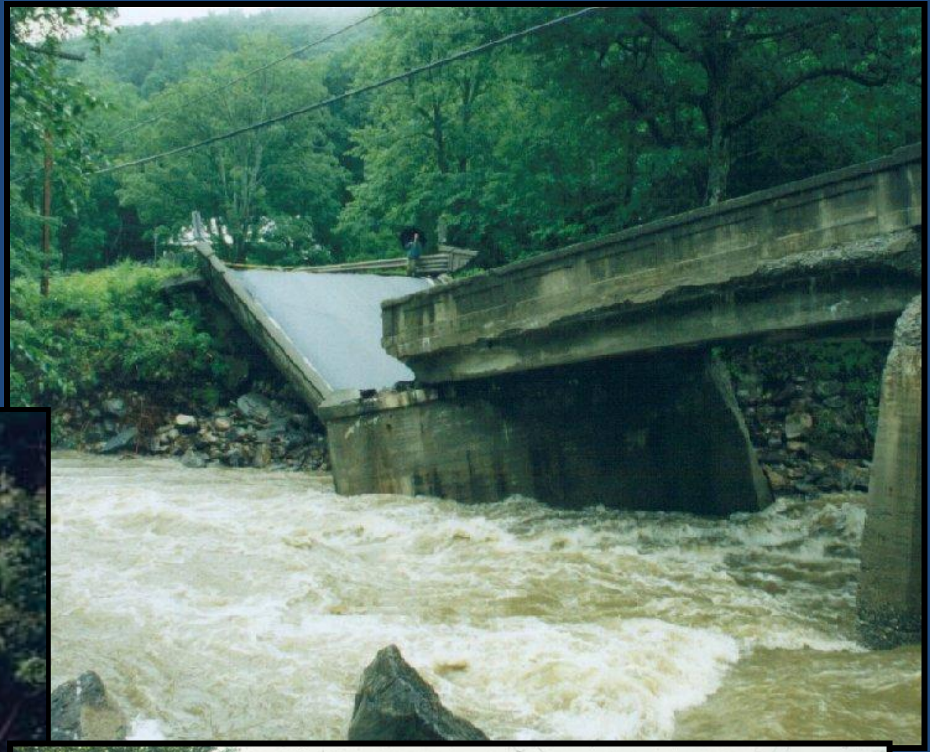
- Dams and diversions
- Gravel removal
- Channeling - berming
- Undersized Culverts
- Stormwater

Traditional Approach to River Management:
Contain flows within the straightened channel



Lesson in VT

Trying to stop floods



Is a recipe for erosion.

Escalating Costs, Risks, and Ecosystem Degradation

Floods and Property Damage

Encroachment

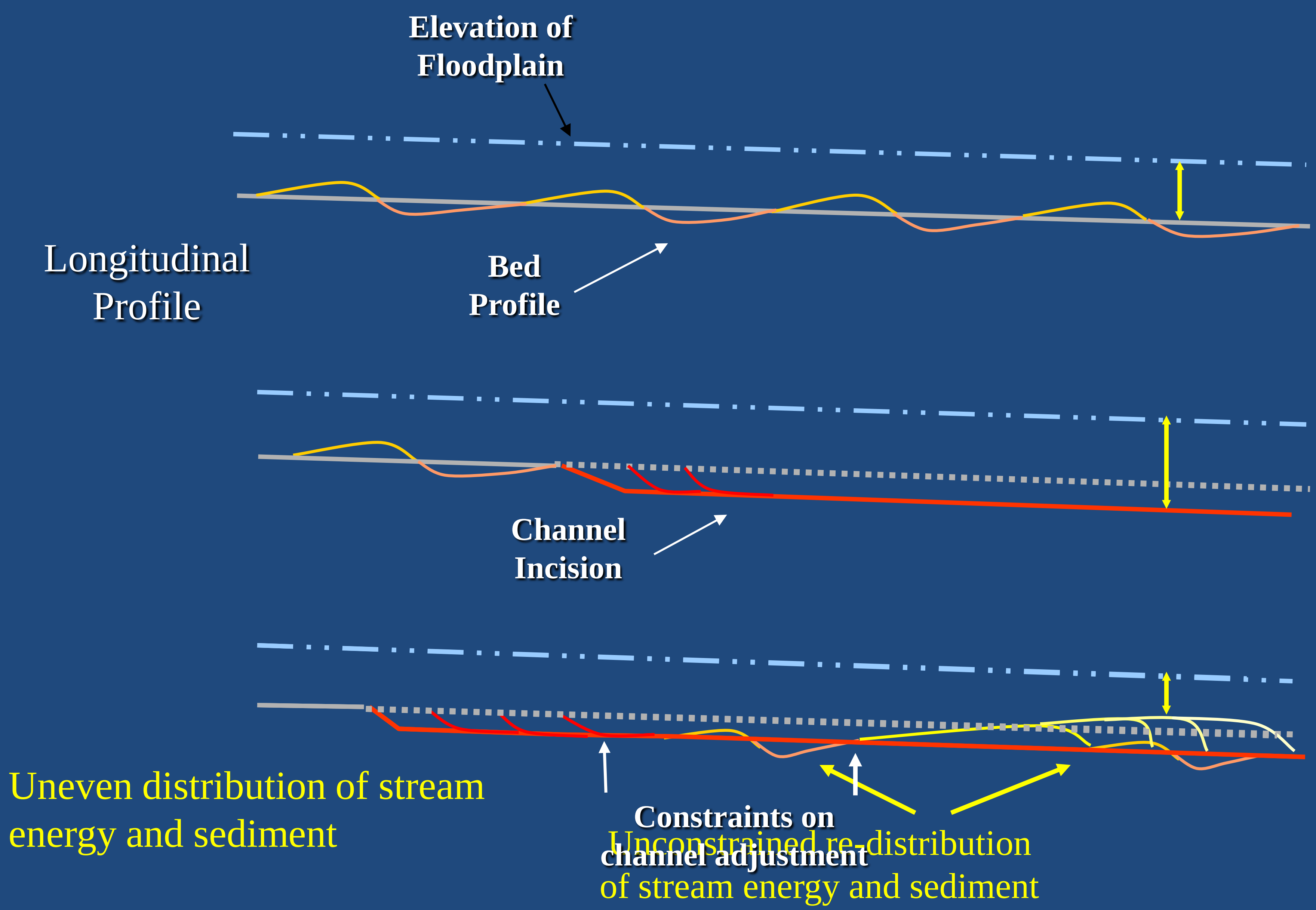
Dredge, Berm and Armor

Vermont River Management:

Moving away from the concept that rivers are static systems.

Repeated and costly efforts to control long lengths of rivers as static channels is proof that channelization with structural measures at a large scale is an unsustainable public policy.

Understand constraints at larger temporal and spatial scales

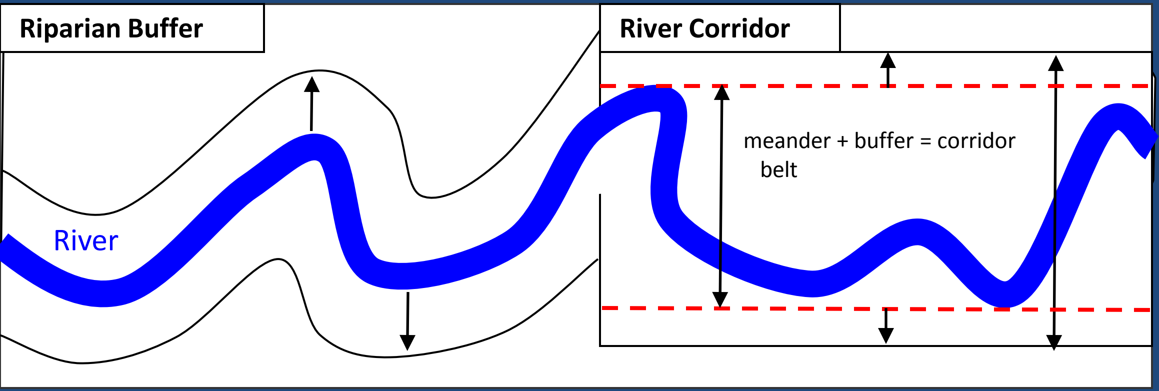


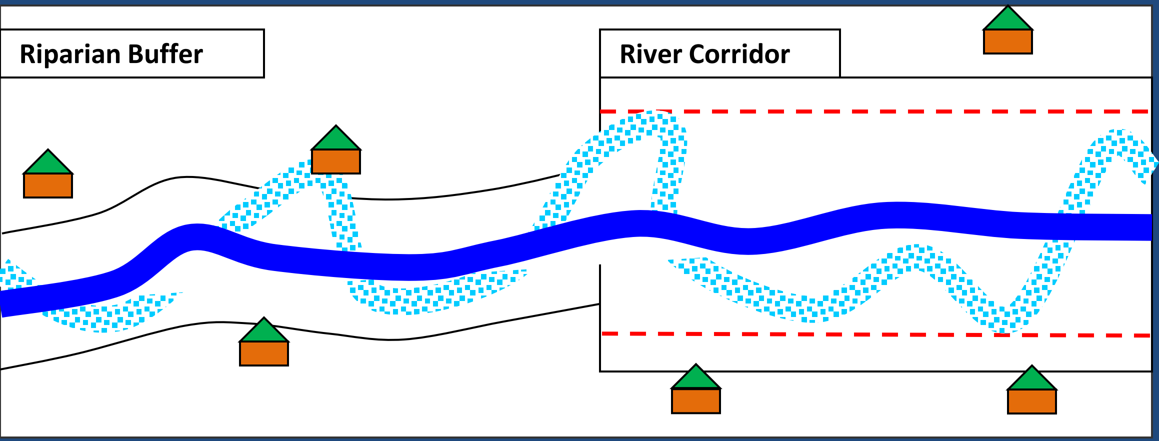
Rip-rap failing after seven years – ongoing maintenance costs

Attenuation asset lost forever?

Message to Towns

Encroachments on straightened and incised channels equals property loss, high and ongoing costs of managing rivers, and a loss of recovery options ($$$).





Go beyond the concept of riparian buffers.

Protect river corridors and floodplains to accommodate floods and fluvial processes; distribute and dissipate energy; store sediment and woody debris; and create and maintain habitat.

Vermont Rivers and River Corridor Management After Irene

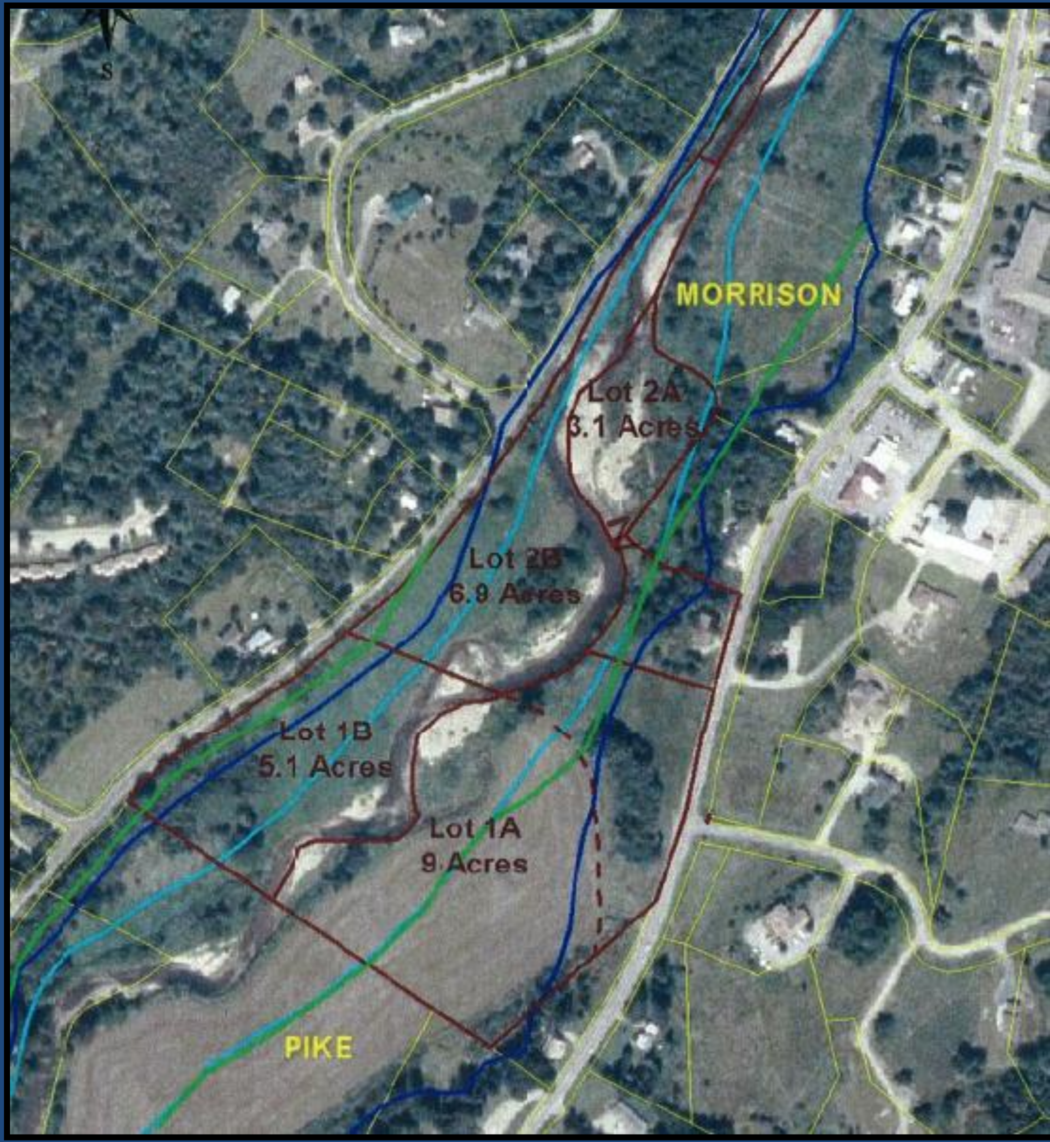

CAT
CAT
320D L
JEROME CONST.
802-442-5525

Channelized reaches in traditional downtowns and village districts will continue be managed.

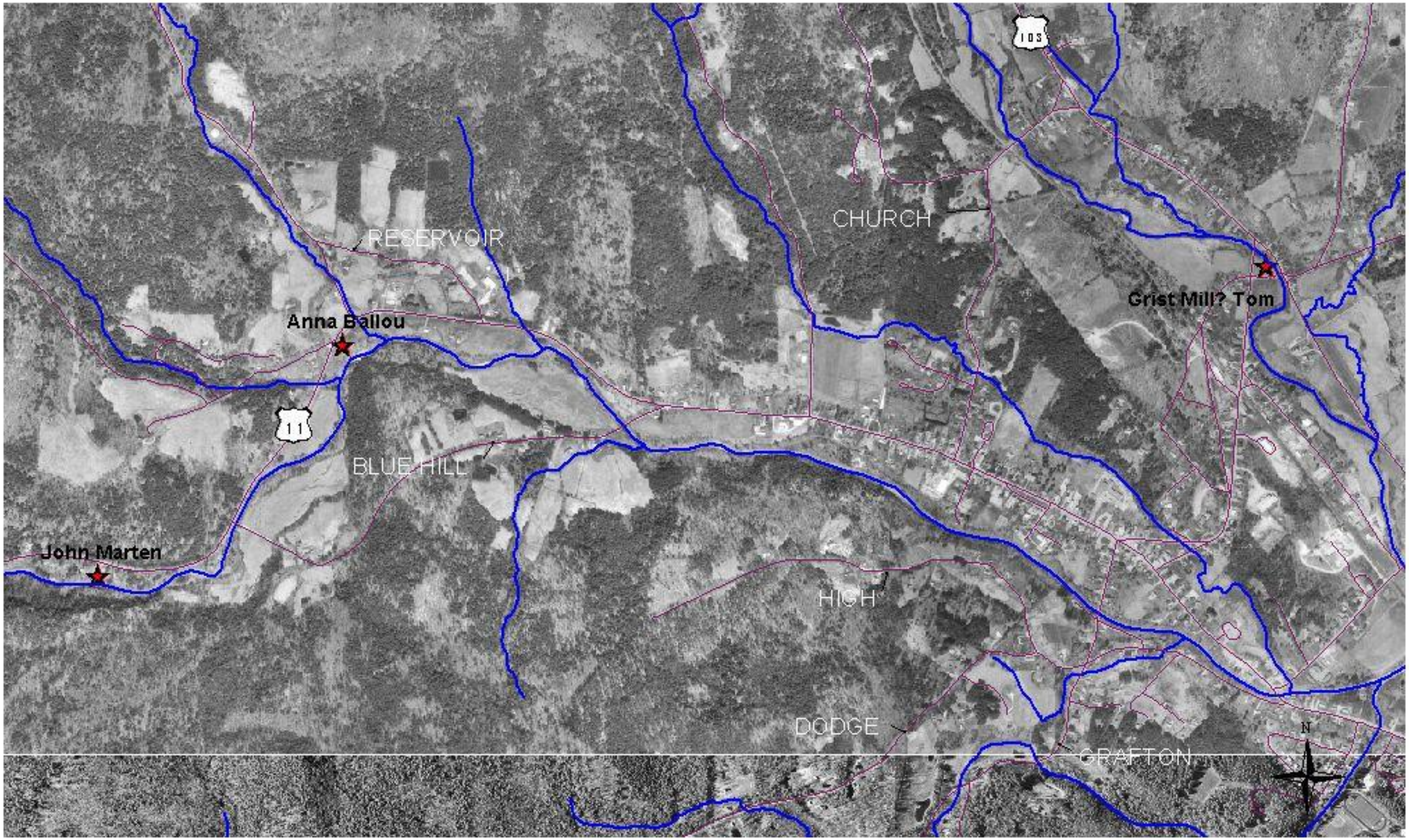
Phase 1 of the
Roaring Branch Floodplain
Restoration Project, Bennington

Management of some river reaches should be discontinued

Which river corridors and floodplains should be protected and restored?

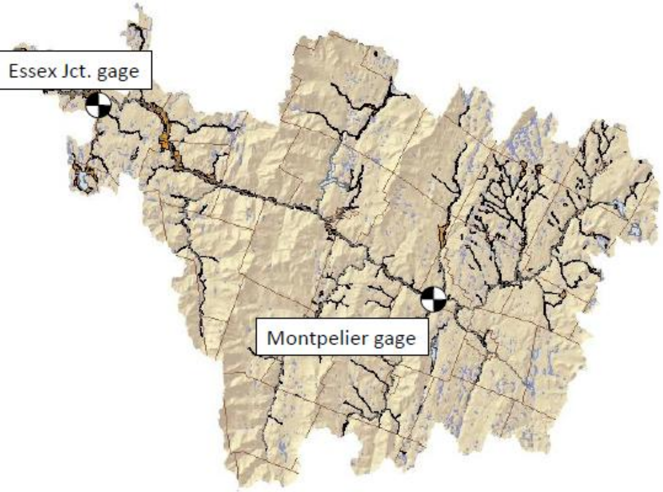


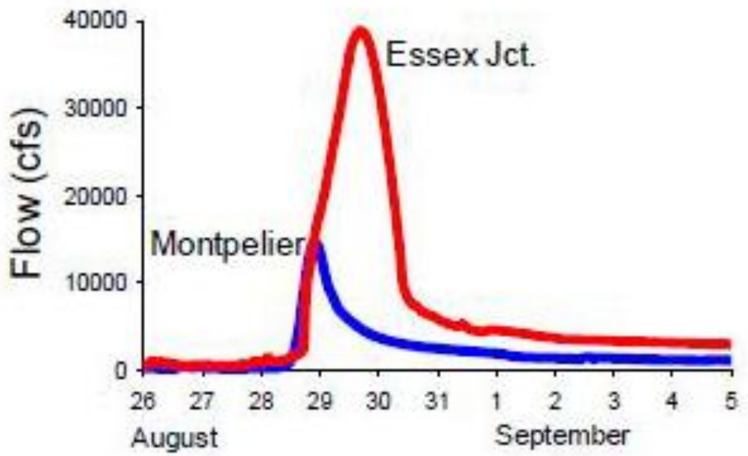
Easement on
Key Sediment Attenuation Area
in Stowe, VT



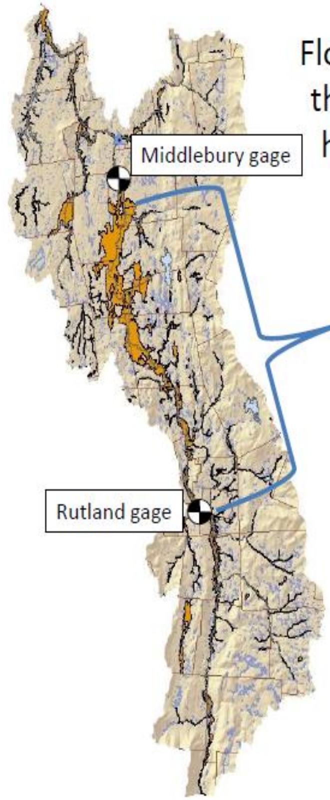
Success in limiting stream alterations and protecting river ecology, in post flood situations, will depend on the State's ability to reduce and further limit river corridor encroachments

Floodplains (orange) and wetlands (blue) in the Winooski River watershed, and flow gage hydrographs during Tropical Storm Irene

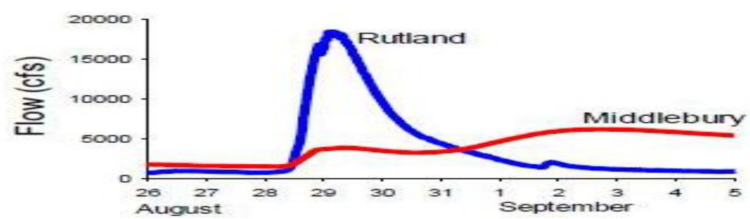




Floodplains (orange) and wetlands (blue) in the Otter Creek watershed, and flow gage hydrographs during Tropical Storm Irene



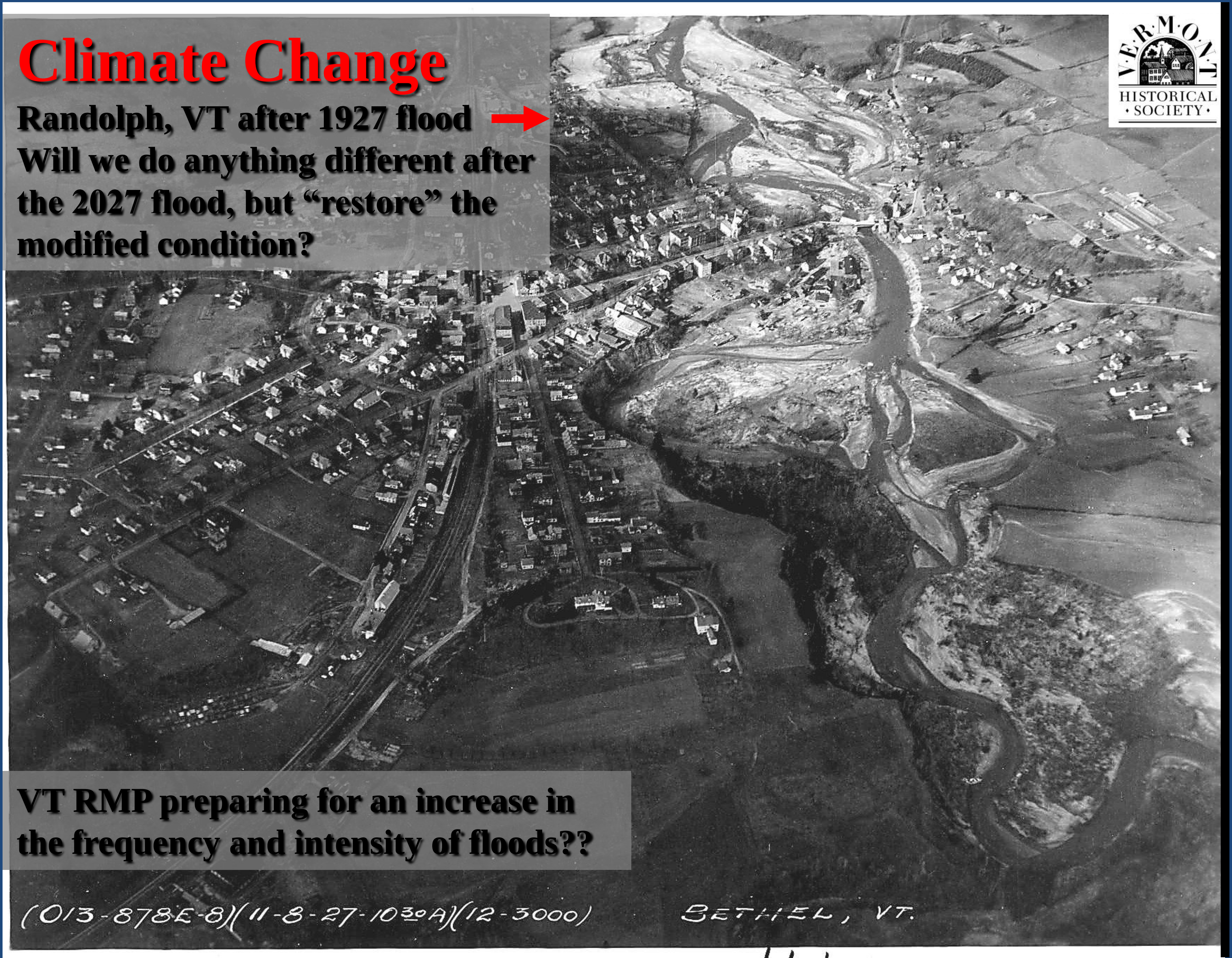
Extensive riparian wetlands and floodplain downstream of Rutland attenuated the flood peak in Otter Creek at Middlebury during Tropical Storm Irene.



Irene flood flow data showing the protection of downstream communities when attenuation assets are in place and functioning.

Climate Change

Randolph, VT after 1927 flood →
Will we do anything different after the 2027 flood, but "restore" the modified condition?



VT RMP preparing for an increase in the frequency and intensity of floods??