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Introduction

The Wood-Pawcatuck Watershed, located in Southern Rhode Island and Eastern Connecticut, is subject to periodic floods, but little data exists on the hydrological effects of the dams, culverts, and bridges it contains. Many of these structures are in disrepair or were never suitable for moving the amount of water they face during increased flow periods. Developing a flood resiliency management plan for the watershed will help to improve this infrastructure, reduce property damage, and maintain ecosystem balances in the event of storm events that bring heavy rains and flooding. With the help of a federal grant from Hurricane Sandy Coastal Resiliency Grant Program, the Wood-Pawcatuck Watershed Association engaged the engineering firm of Fuss and O'Neill to develop a Flood Resiliency Management Plan. As part of this plan a data set of accessible bridge, culvert, and dams will be created to rank their effectiveness and hydraulic capacity. Each site was surveyed to collect both qualitative data of the location, and quantitative measurements of the hydraulic capacities of the structures. This data, along with instream geomorphic data, will be used to develop recommended actions, such as green infrastructure and land use management. The plan will be made available to each town in the watershed, RIDEM, CT DEEP, and RIEMA and other interested parties.

Objective

Collect qualitative and quantitative data for each bridge, culvert and dam within the Wood-Pawcatuck Watershed to develop recommendations for infrastructure improvements that would most effectively improve flood resiliency within the watershed.

Methods

Field Data Acquisition

Vermont Geomorphic Assessment worksheets were used for each bridge and culvert inspected.

ID					Struct_Num	
Observer(s) / Organization(s)					Date	
Town					Phase 1 Project	
Location					Longitude (E/W)	
Reach VTID					Latitude (N/S)	
Road Name					Road Type	paved gravel trai railroad
Stream Name					High Flow Stage	yes no
Channel Width curve measured	(ft.)	ial	concrete plastic corrug		Structure skewed to roadway	yes no
Culvert Length	(ft.)	Culvert Material	plastic smooth tank steel corrugate		Culvert Height	(ft.
Culvert Width	(ft.)	lvert	stone aluminum cor		# of culverts at crossing	
	(11.)	Ũ	other mixed	8	Overflow pipe(s)	yes no
Geomorphic and	Fish Passage Data					
Culvert slope as o Upstream Is structure open Steep riffle prese If channel avulse	ce avulsion would follow	y (cin of s	crele all that apply): tructure:	higher debris s wood debris s yes n cross road fo (feet)	o bllow road unsu	nation none
	flow approaching structur					
	flow approaching structur					
Angle of stream Downstream Water depth in c Culvert outlet inv Backwater Lengt Outlet drop (inver Pool present imr Pool depth at po Maximum pool	ulvert (at outlet): yert: partially backw h (measured from outlet) t to water surface): mediately downstream of a int of streamflow entry:	ater : strue .0 fe	(0.0 fee (0.0 feet) (0.0 feet) (0.0 (0.0 (0.0 (0.0 (0.0 (0.0) (0.0)	et) 10 feet)	free fall yes no	

1 2 3 4 5 UK bedrock present: ves no			1 2 3 4 5 bedrock present: y		
none o				delta mid-cha	
yes	no		yes	no	
high lov	v nor	ie	high lo	ow no	
intact none		0	intact none	faili unkno	
none footer			none footer	culver wing w	
yes distance:	no	_ft.	yes distance:	ne	
LEFT	RIG	нт	LEFT	RI	
yes no	yes	no	yes no	yes	
species: none	1		I	1	
Outside Structure					
species (no	one)		sign	spe	
Comments:					
Comments.					
Description	of Featu	res in	Photo		
	bedrock press none of point r yes high low intact none footer yes distance: LEFT yes no species: none O species (no	bedrock present: yes none delta point mid-cha yes no high low nor intact failin none unknow none culvert footer wing wa yes no distance:	bedrock present: yes no none delta side point mid-channel yes no high low none intact failing none unknown none culvert footer wing walls yes no distance: ft. LEFT RIGHT yes no species: none outside Structure species (none)	bedrock present: yes no bedrock present: yes no none delta side none point mid-channel yes no high low none high intact failing intact failing intact failing none unknown none culvert none culvert footer wing walls footer yes yes no yes yes yes no yes yes yes yes yes yes yes yes yes no yes no	

March, 2009

Figure 2: Geomorphic Assessment (page 2)

Data Assessment

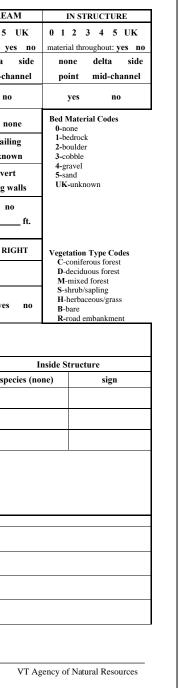
could be determined

Figure 1: Culvert

Assessment (page 1)

- Use USGS Streamstats to define watershed delineations and peak flow data • Use Culvert Master application to estimate hydraulic capacities and efficiencies of each
- structure • Inputting data into Excel so that each structure could later be ranked and deficient structures

Fluvial geomorphic and flood hazard assessment for the Wood-Pawcatuck Watershed Zack Valerio¹, Nate Lukas¹, Erik Mas², Denise Poyer³; 1: Coastal Fellow; 2: Project Coordinator of the Wood-Pawcatuck Watershed Association



Materials Used

- Modified Vermont Geomorphic Assessment Sheets
- Dam Assessment forms
- Survey Equipment (scope, tripod, measurement rod)
- Laser measure & Tape measure
- Camera



Figure 3: Maren, Zack and Rachel inspecting a culvert



Figure 4: Zack holding a survey rod

Results

442 out 594 structures were assessed and organized into a table comparing capacities and discharges at different sites (figure 6), and then were ranked according to their potential impact on public safety (figure 7).

Structure Name	Capacity (cfs)	Discharge (10-year)	Discharge (25-year)	19 14 10 DP 17 P.M.	Discharge (100-year)	25- Year Capacity Ratio	Future 25- Year Capacity Ratio
UWR-WOR-18-4	604.88	155	216	267	322	0.36	0.54
UWR-WOR-18-4-1	45.51	415	637	844	1030	14.00	21.14
UWR-WOR-18-5	122.55	41.2	56.6	69.3	84.1	0.46	0.70
UWR-WOR-19-2	7.47	78	112	142	172	14.99	22.64
UWR-WOR-19-3	36.50	53.5	76.6	96.6	118	2.10	3.17
UWR-WOR-22-2	126.96	16.1	22	26.8	32.6	0.17	0.26
UWR-WOR-24-2	23.12	10.7	13.9	16.4	18.6	0.60	0.91
UWR-WOR-25-2	4.22	18.4	23.9	28.3	32.2	5.66	8.55
WPB-FOUND-20150812	207.78	410	550	666	786	2.65	4.00
WPB-HET-0-2	93.52	144	190	228	265	2.03	3.07

Impact Rating	Upstream and Downstream Development ¹	In FEMA Flood Zone?	Type of Road	Figure 6 (above): example of capacities table Figure 7 (left): ranking scheme for potential impact				
1	Little to no development, mostly forested land	No	Trail					
2	Mostly open farm land, very low density residential area		Driveway		High	Medium	Low	Total # of Structures
3	Low to moderate density residential area, little commercial/industrial development		Town Road	Arched Conduit	50%	38%	13%	8
4	Moderate to high density residential area, some commercial/industrial development		State Road	Box Culvert	16%	49%	35%	68
5	High density residential area, significant commercial/industrial development	Yes	Highway or Railroad	Bridge Circular Conduit	52% 12%	30% 40%	17% 48%	128 218
	•			Circular Conduit	12%	40%	48%	218

Figure 8 (above right): summary of all structures and their potential impact rating, organized by structure type

Figure 9 (below): example of table ranking structures based on their potential impact

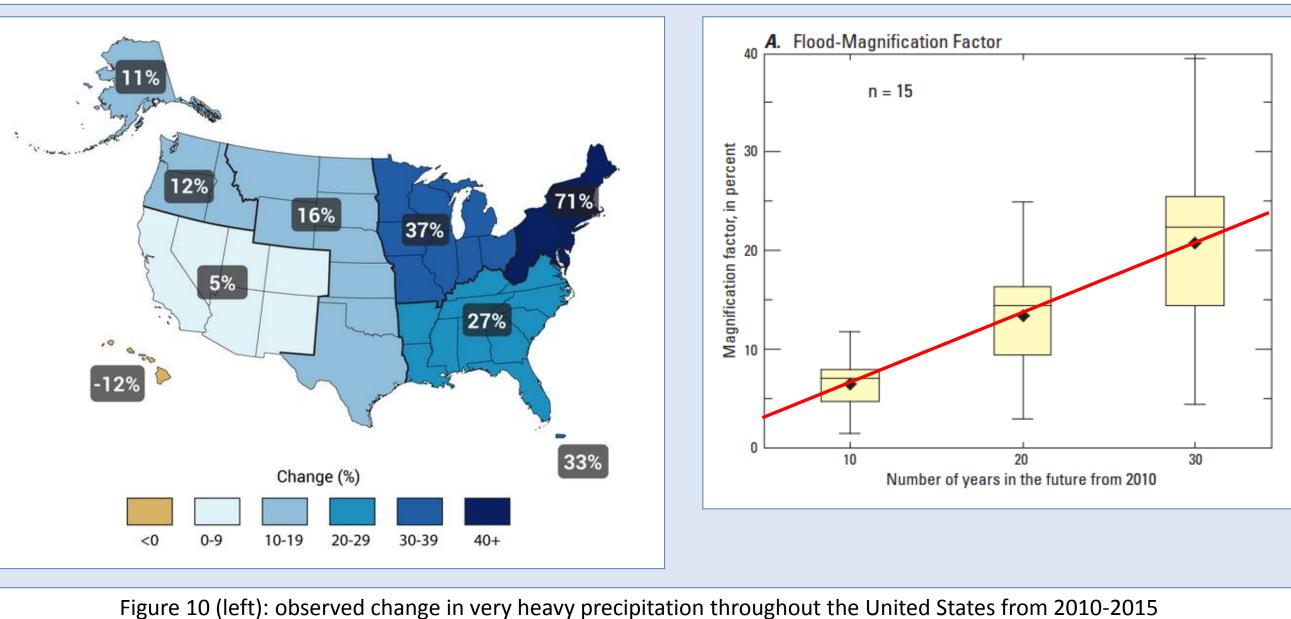
Structure Name	Surrounding Area	FEMA Flood Zone?	Type of Road	Overall Ranking
AWR-GRE-0-6	Little Development/Forested	No	Town	Low
AWR-GRE-10-1-1	Little Development/Forested	Yes	Town	Medium
AWR-GRE-10-2-1	Little Development/Forested	No	Town	Low
AWR-GRE-1-2	Little Development/Forested	No	Town	Low
AWR-GRE-3-1	Low to Moderate Density Residential/Commercial	No	State	Medium
AWR-GRE-4-1	Little Development/Forested	No	Town	Low
AWR-GRE-5-1	Low Density Residential/No Commercial	No	Town	Low
AWR-GRE-5-2	Low Density Residential/No Commercial	No	Town	Low
AWR-GRE-6-1	Little Development/Forested	Yes	Town	Medium
AWR-GRE-7-1	Little Development/Forested	No	Town	Low
AWR-GRE-8-2-1	Little Development/Forested	No	Town	Low
AWR-GRE-8-2-2	Little Development/Forested	No	Town	Low



Figure 5: Nate using survey equipment

Discussion

Considering the effects of increased precipitation patterns in the New England area, and human urbanization influences, the impact for flooding is predicted to increase in magnitude into the near future. Applying the USGS flood magnification factor to our collected data, we can estimate that this factor of increased magnitude will result in greater discharges, therefore causing structures to be under greater stress.



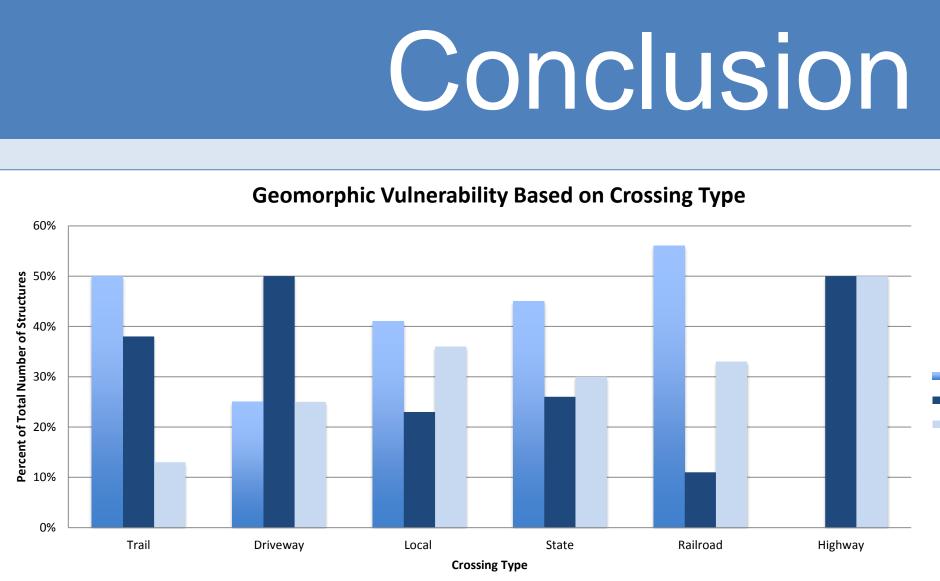


Figure 12 (left): percent of structures vulnerable to increased flooding, and the ranking of this impact, which can be the basis for determining which structures may be modified. Local crossing types are of the most concern, as there are a relatively high number of local crossing types, and nearly half are rated as being highly vulnerable to adverse flooding impacts. Figure 13 (right): total number of structures assessed within each crossing type



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Figure 11 (right): the magnification of flooding impacts over years in the future from 2010

	Total # of
Crossing Type	Structures
Trail	16
Driveway	8
Local	255
State	132
Railroad	9
Highway	2

References

Acknowledgements