TO: Noelle MacKay, Commissioner, Department of Housing & Community Development
FR: Joe Segale. Policy and Planning Manager, Vermont Agency of Transportation
DA: 10.20.14
RE: State and Local Highway Unmet Needs

There is a total unmet need of approximately $9 million to upgrade culverts on the state highway system in Washington, Windham and Windsor Counties. In order to restore access to the towns that were cut-off by Tropical Storm Irene in August 2011 and to provide a basic level of mobility to support all other disaster response and recovery efforts, the Vermont Agency of Transportation and municipalities worked quickly to repair damaged road segments, bridges and culverts. It was also imperative that state and local roads were repaired before the start of winter. Many of these locations were repaired to their original pre-disaster condition and therefore remain vulnerable, even three years latter, to destruction from future events. In the spring of 2012, VTrans conducted a scan tour of locations with emergency repairs and identified approximately 55 larger culverts that required reconstruction and upsizing to satisfy the state's hydraulic and river geomorphology standards. Over the last few years, VTrans was able to reconstruct and upsize culverts at about 10 locations using available FHWA funding. There are approximately 45 locations remaining that still require upgrades but FHWA-ER funding is no longer available. Like all state DOTs, VTrans is also faced with a significant funding gap in all programs (estimated at $240 million per year relative to annual budget of approximately that ranges from $650 million) and does not have the resources to address these highly vulnerable culverts. VTrans has conducted preliminary engineering to identify the type, size and cost of the appropriate structure for the location listed in Table 1. The remaining locations are listed in Table 2 with cost estimates based on the typical average for a 4' x 4' box culvert.

Table 1: Vermont State Highway Culverts Damaged During Irene. (Emergency Repairs Made, but Upgrades Still Required. Locations with Preliminary Designs and Cost Estimates)

County	Town	Route	Mile Marker	Recommended Design	Total Cost
WINDHAM COUNTY	BRATTLEBORO	US 9	0.8	4'x4' box	$205,000
WINDHAM COUNTY	WILMINGTON	VT 100	4.15	4'x4' box	$205,000
WINDSOR COUNTY	LUDLOW	VT 100	1.34	4'x4' box	$205,000
WINDSOR COUNTY	LUDLOW	VT 100	0.99	4'x4' box	$205,000
WINDSOR COUNTY	LUDLOW	VT 100	1.14	4'x4' box	$205,000
WINDSOR COUNTY	PLYMOUTH	VT 100	8.41	4'x3' box	$205,000
WINDSOR COUNTY	LUDLOW	VT 100	1.14	6'x4' box	$230,000
WINDSOR COUNTY	ROCHESTER	VT 73	2.0 TO 3.4	5'x4' box	$230,000
WINDSOR COUNTY	PLYMOUTH	VT 100A	4.39	5'x4' box	$230,000
WINDSOR COUNTY	STOCKBRIDGE	VT 107	4.42	5'x4' box	$230,000
WINDSOR COUNTY	BARNARD	VT 12	9.52	5'x4' box	$255,000
WINDSOR COUNTY	PLYMOUTH	VT 100A	4.39	6'x5' box	$280,000
WINDSOR COUNTY	STOCKBRIDGE	VT 107	2.5	6'x4' box	$280,000
WINDSOR COUNTY	LUDLOW	VT 103	0.95	10'x5' box	$405,000
WINDSOR COUNTY	LUDLOW	V 100	8.42	14'x7' bridge	$430,000
WINDSOR COUNTY	WOODSTOCK	US 4	9.5	22'x8' bridge	$1,000,000
WINDSOR COUNTY	STOCKBRIDGE	VT 107		6'x4' box	$280,000
				Total	**$5,080,000**

Table 2: Vermont State Highway Culverts Damaged During Irene with Emergency Repairs and Upgrades Still Required (Locations without Preliminary Designs and Cost Estimates)

County	Town	Route	Mile Marker	Total Cost
WASHINGTON COUNTY	BERLIN	VT 12	6.06	$200,000
WASHINGTON COUNTY	FAYSTON	VT 17	4.30	$200,000
WINDHAM COUNTY	DOVER	VT 100	0.05	$200,000
WINDHAM COUNTY	HALIFAX	VT 112	5.6	$200,000
WINDSOR COUNTY	BETHEL	VT 107	0.2 TO 6.5	$200,000
WINDSOR COUNTY	BROWNSVILLE	VT 44	0.5	$200,000
WINDSOR COUNTY	BROWNSVILLE	VT 44	3.3 TO 3.6	$200,000
WINDSOR COUNTY	HARTFORD	VT 14	6.98	$200,000
WINDSOR COUNTY	HARTFORD	US 4	0.6 TO 1.2	$200,000
WINDSOR COUNTY	LUDLOW	VT 100	0.99	$200,000
WINDSOR COUNTY	ROCHESTER	VT 73	2.0 TO 3.4	$200,000
WINDSOR COUNTY	ROCHESTER	VT 73	2.0 TO 3.4	$200,000
WINDSOR COUNTY	ROCHESTER	VT 73	2.0 TO 3.4	$200,000
WINDSOR COUNTY	ROCHESTER	VT 73	2.0 TO 3.4	$200,000
WINDSOR COUNTY	ROCHESTER	VT 100	0.6	$200,000
WINDSOR COUNTY	SHARON	VT 14	2.3	$200,000
WINDSOR COUNTY	STOCKBRIDGE	VT 107	0.2	$200,000
WINDSOR COUNTY	WEATHERSFIELD	VT 131	2.02	$200,000
WINDSOR COUNTY	WEATHERSFIELD	VT 106	3.7	$200,000
WINDSOR COUNTY	WOODSTOCK	US 4	9.5	$200,000
			Total	**$4,000,000**

There is an unmet need of at least $3 million to upgrade culverts and bridges on the town highway systems in Washington, Windham and Windsor Counties. With assistance from the regional planning commissions that serve these three counties, VTrans has developed a partial list of culverts and bridges on town highways that were damaged by Tropical Storm Irene. These locations were repaired quickly to their original pre-disaster condition and therefore remain vulnerable to damage from future events. To date, we have heard back from 13 of the approximately 70 towns in the three counties regarding their unmet needs. Therefore Table 3 presents only a partial list of unmet needs on the town highway network.

Table 3: Town Highway Culverts Damaged During Irene with Emergency Repairs and Upgrades Still Required
(Partial List)

County	Town	Location	Comments	Preliminary Cost Estimate
WASHINGTON	East Montpelier	Quaker Rd, Culvert #6	0.48 miles north of US Rte. 2; subject of 09/09/2011 VTrans hydraulic study. Culvert directs a mapped brook under Quaker Road from north to south; culvert operated at maximum capacity during 2011 events, but could not handle flow; road served as a dam, creating a large lake on north side that overtopped and damaged Quaker Road (FEMA funded repairs); hydraulic study revealed a need to upsize culvert to 6x current capacity	$63,300[1]
WASHINGTON	Moretown	Bridge Rd, Bridge #41	Bridge was lost during Tropical Storm Irene DR4022. In order to meet State ANR Standards Moretown's Codes & Standards for bridges, we increased the length of the bridge about 18' in order to get the abutments out of the Mad River per our permit from Patrick Ross. Once we learned of the permit requirement, were told to request to FEMA that the project be changed to an "Improved Project". FEMA approved our request. We were under the understanding that as long as the costs were justified, and line items in the contract, that FEMA would pay the overrun. Now FEMA is baulking about paying the $143,497.07 costs associated with lengthening the bridge to meet State and Local standards.	$143,497[2]
WINDHAM	DOVER	Holland Road	3 foot culvert on Holland Rd. that washed out in 2011 and every time it rains hard it runs over	$85,000[3]
WINDHAM	WILMINGTON	Bridge #52 Coldbrook Rd	A Hydraulics Study was done in March of 2012 by Leslie Russell. Town has applied for funding on this but so far has not been successful.	$338,250[4]
WINDSOR	Andover	Steigers Rd, Simonds Rd & Hilltop Rd	multiple undersized culverts on extremely steep roads	$200,000[5]
WINDSOR	Bethel	Spooner Rd	large culvert on Spooner Road, which is a class 4 TH. ANR would have preferred that it be up sized rather than putting the original one back in place, but FEMA wouldn't cover it.	$85,0003

[1] 10/20/2014 email from Tom Anderson, VTrans District 6 Project Manager, summary of information from Town of East Montpelier
[2] Verbal from Cheryl Brown, Moretown Treasurer
[3] Based on average replacement cost for culverts replaced by VTrans on state system
[4] Email from Scott Murphy, Wilmington Town Manager to Chris Taft, VTrans, Oct 16, 2014
[5] Information provided by Todd Menees, ANR and supplemented with cost information from Southern Windsor RPC

County	Town	Location	Comments	Preliminary Cost Estimate
WINDSOR	Bethel	Camp Brook Rd, over Camp Brook just west of Sugar Hill Road and between Watershed and Sugar Hill Rd	2 Town culverts were overtopped and road destroyed. Repairs were made quickly to reopen Camp Brook Road to restore access to the towns of Rochester and Stockbridge because VT route 107 was closed. VT 107 was not fully re-open until December 2011, 4 months later. Both culverts should be replaced with bridges.	$500,000[6]
WINDSOR	Bethel	Watershed Rd just south of Camp Brook Rd.	Town bridge over-topped and approaches damaged and repaired quickly to provide open access. Should be replaced with new bridge with appropriate span	$250,000[7]
WINDSOR	Bethel	Sugar Hill Road just north of Camp Brook Road	Town culvert overtopped and road destroyed. Repairs were made quickly, should be replaced with bridges.	$250,0007
WINDSOR	Bridgewater	Hale Hollow Rd, south of VT 100A, over Phinney Hollow Brook	15 ft brook overtopped and south abutment destroyed during Irene. Was not upsized, reused deck only, replaced south abutment. Requires new bridge to be consistent with latest standards	$100,0007
WINDSOR	Cavendish	Greenbush Rd TH #20	culvert, should be bridge	$160,000[8]
WINDSOR	Cavendish	Pratt Hill Rd	sewer crossing	$30,0008
WINDSOR	Chester	Blue Hill Rd	undersized bridge replacement	$150,0008
WINDSOR	Chester	Potash Brook Rd/Lovers Lane	multiple culverts and homes	$175,0008
WINDSOR	Chester	Reservoir Rd	dam failure and downstream stone box culvert	$200,0007
WINDSOR	Plymouth	Hale Hollow Rd	4' round Culvert Overtopped during Irene Not upsized due to integrated concrete header Outlet is failing back to road and to adjacent barn	$20,000
WINDSOR	Plymouth	Hale Hollow Rd	4' ellipse Culvert Overtopped during Irene. Not upsized	$15,000
WINDSOR	Reading	Tyson Rd	bridge replacement	$145,0008
WINDSOR	Reading	Tyson Rd	road embankment stabilization	$74,0008
WINDSOR	Sharon	Downer Rd, Culverts #29 and 30	TH Grant Application to replace undersized existing steel culverts with concrete box culverts with wing walls. Total cost $222,640.	$47,6408

[6] Information provided by Two Rivers Ottauquechee Regional Commission

[7] Information provided by Two Rivers Ottauquechee Regional Commission

[8] Information provided by Todd Menees, ANR and supplemented with cost information from Southern Windsor RPC

County	Town	Location	Comments	Preliminary Cost Estimate
			TH Grant of $175,000. $47,640 funding gap. Town has not yet built project.	
WINDSOR	West Windsor	Bible Hill Rd	3 undersized culverts	$65,0008
			Total	$3,096,687

Developing a Risk-Based Resilience Improvement Plan

The tables above identify culverts and bridges that were damaged by Tropical Storm Irene, were repaired quickly but remain vulnerable to future events. To systematically improve the resilience of the transportation system we must also look beyond roads and bridges that were damaged during that one notably large event and identify infrastructure that is vulnerable to damage from future extreme weather and the resulting consequences if the failure occurs. Understanding the probability that a piece of infrastructure will fail and the resulting consequences can be the basis for quantifying risk so that limited funding can be targeted where it will make the most difference.

We have taken the first steps towards understanding risk by identifying culverts, short and long bridges that are vulnerable to damage from future extreme precipitation events. Table 4 quantifies the number of culverts, short structures and bridges in each county with span widths that are less than 80% of the bank-full width of the river channel. To be resilient to flooding a structure's span should be equal to or greater than the bank full with of the river it crosses. A bank full width of 80% was selected as the cut-off point for this analysis to avoid overstating the challenge and to account for the resolution of a hydraulic analysis conducted at a large scale on over 10,000 structures. The analysis is based on field inventories and inspections conducted by VTrans, the RPCs and towns that gathered information on location, type, general condition and size of each structure. The percent bank full width is equal to (1) the actual span or width of each structure as measured in the field divided by (2) the required bank full width based on the watershed served by each structure estimated using a GIS application recently developed by the Central Vermont Regional Planning Commission. The results are conservatively low because inventories have not been completed in three towns (Bethel, Athens and Stratton) and the analysis has yet to be conducted on VTrans culverts.

As shown in Table 4, there are a large number of structures that are undersized and vulnerable to future damage, and these structures impact a large percentage of the network. The cost to address these locations is $400-$800 Million.

Table 4. Structures Vulnerable to Flood Damage (spans less than 80% of bank full width)

	Town Culverts *(1.5 to 6 ft)*		**State & Town Short Bridges** *(6 to 20 ft span)*		**State & Town Long Bridges** *(Greater than 20 ft span)*	
County	Number	% of Total	Number	% of Total	Number	% of Total
Washington	887	42%	87	49%	7	3%
Windham	1,083	35%	75	26%	3	1%

Windsor	1,371	38%	157	22%	9	2%
Total	3,341	38%	319	27%	19	2%

Road segments proximate to rivers and streams are also vulnerable to damage from future events even. The statewide river corridor GIS layer was combined with the statewide road coverage to identify approximately 300 miles of local and state roads in the three counties that are within the estimated inundation and fluvial erosion hazard boundaries of nearby rivers and streams. The river corridor layer was developed by the ANR River Program and categorizes river reaches as low, moderate and high sensitivity. A high sensitivity reach is the most unstable and likely to leave its channel causing nearby erosion and deposition of sediment and debris downstream during high precipitation events.

One approach to mitigating potential damage along these roadways is to stabilize the roadway slope adjacent to the river with rip rap and other similar armoring. The cost to implement this strategy is approximately $1.7 million per mile[9], which results in a total of cost of almost $500 million to address vulnerable road segments in the three counties.

Table 5: Road Miles within High Sensitive River Corridor Reaches

System	Washington	Windham	Windsor	Totals
State Highways	19.1	24.3	63.3	106.7
Town Highways	40.6	52.6	92.9	186.1
State Forest	0.4	0.4	0.0	0.8
National Forest	0.0	0.1	0.1	0.1
Total Mileage	60.1	77.3	156.2	293.7

The total cost to address vulnerable transportation infrastructure just within these three counties ranges between $900 million and $1.3 Billion. To put the impact of this need in perspective, Vermont's annual capital program for transportation capital projects, operating and administration has been approximately $650 million for the last two years[10]. As noted previously, Vermont faces an annual shortfall of $240 million per year when comparing basic system preservation and operation needs to revenue. We also face similar resiliency needs in all other areas of the state which are not quantified here but must also be addressed. We don't expect, nor is it necessary, to address every undersized culvert or road segment that may be damaged by an adjacent river. We do expect to invest wisely using a risk based approach have made significant progress in that direction by been actively collecting information, and developing the supporting methods and tools to integrate land use, transportation and river science.

[9] Per Mile Cost of Roadway Slope\Stream Bank Armoring (October 23, 2014 memo Chris Bump) based on actual costs of DDIR work along VT 14 in Hartford and Randolph.

[10] This budget is inflated as it includes some lingering earmarks, ARRA funding and FHWA-ER funds from Irene and other recent disasters. The historic budget is closer to $500 million per year.