NORMANDEAU ASSOCIATES
Environmental Consultants

Memorandum

To: Northern Pass Transmission LLC

From: Normandeau Associates, Inc.

Date: August 10, 2016

Re: ORAR Stream Crossing Evaluation – Phase I

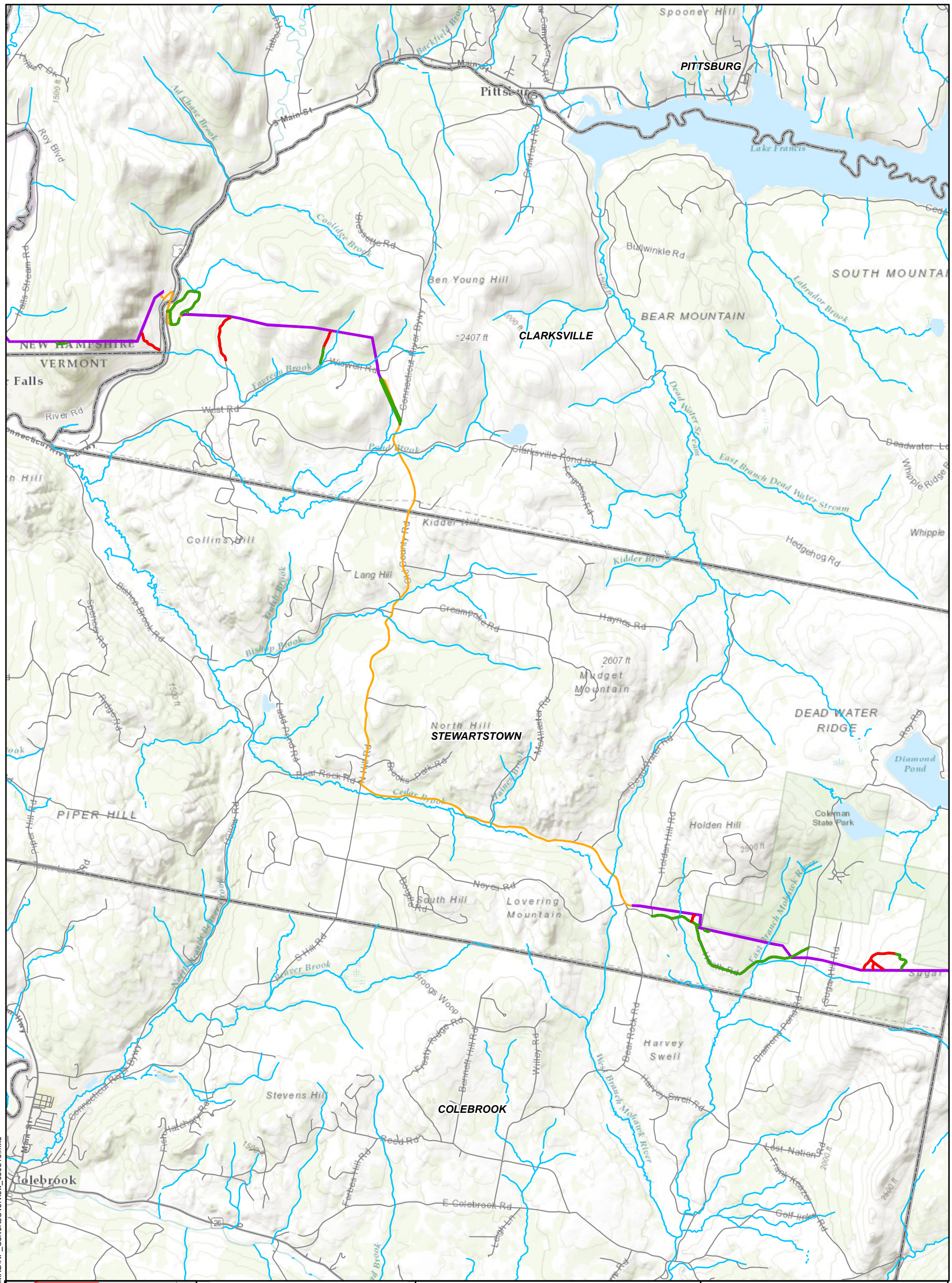
During the weeks of July 26th and August 1st, 2016, a field survey was conducted on the Off Right-of-Way Access Roads (ORARs) that are currently proposed for use during the construction of the Northern Pass Project. The survey evaluated stream crossings occurring on improved roads that appeared to be adequate to support construction vehicles, but were originally constructed for forestry purposes and therefore likely permitted under the Permit by Notification process for forestry activities. The forestry PBN does not require compliance with the stream rules, but using the roads for non-forestry purposes does require stream rule compliance. In response to guidance from the NH Department of Environmental Services (NHDES), this culvert survey was conducted for Northern Pass. The location of the study area and all the crossings surveyed in Phase I are shown on Figure 1 (three maps).

Observed stream crossings were evaluated for habitat connectivity and sediment transport function as outlined in Chapter Env-Wt 900. A total of 56 crossings were evaluated and 27 were found to be culverts with connectivity issues (i.e., hanging at one or both ends) and/or with stability issues (i.e., erosion in and around the crossing). These culverts would likely need to be replaced or reinstalled if those ORARs are selected for use for Northern Pass construction. They are highlighted in yellow on Table 1. Five culverted crossings, highlighted in blue, have issues with connectivity that may be temporary due to the low water levels in the region. These should be discussed with NHDES personnel if the sizing evaluation, based on watershed size, does not indicate a need for replacement (see further explanation below).

Seventeen of the crossings were spanned by bridges. All bridged crossings appear to have been sized based on bank full width as span openings were at least 85% of the measured bank full widths, up and downstream. Some undermining of footers was noted on a subset of bridges and these should be evaluated by a structural engineer. The remaining eight stream crossings involved culverts made of various materials and one open bottom arch, with no obvious connectivity or stability issues.

All culverted crossings are recommended to be evaluated for size by calculating the watershed size and corresponding 50 year storm volume. Based on the results of this assessment, additional crossings currently not recommended for any action may be identified as needing replacement. We are assessing all the stream crossings on the assumption that they were originally permitted for forestry use only, although many of these ORARs are used for other purposes and may have been permitted for such uses. The results of this Phase I survey and the watershed evaluation will be used to finalize the selection of ORARs for use on the Northern Pass Project. Once the list of those ORARs

and culvert replacements determined to be necessary are finalized, detailed field measurements and channel analysis will then be conducted to support the design of new crossings that meet the requirements of Env-Wt 900. The watershed analysis will begin immediately, and the detailed field survey (Phase 2) will take place in August and September of 2016, with permit applications submitted as soon as possible thereafter.



Northern Pass Figure 1
ORARs Stream Crossings
Map 1 of 3

Northern New Hampshire, USA

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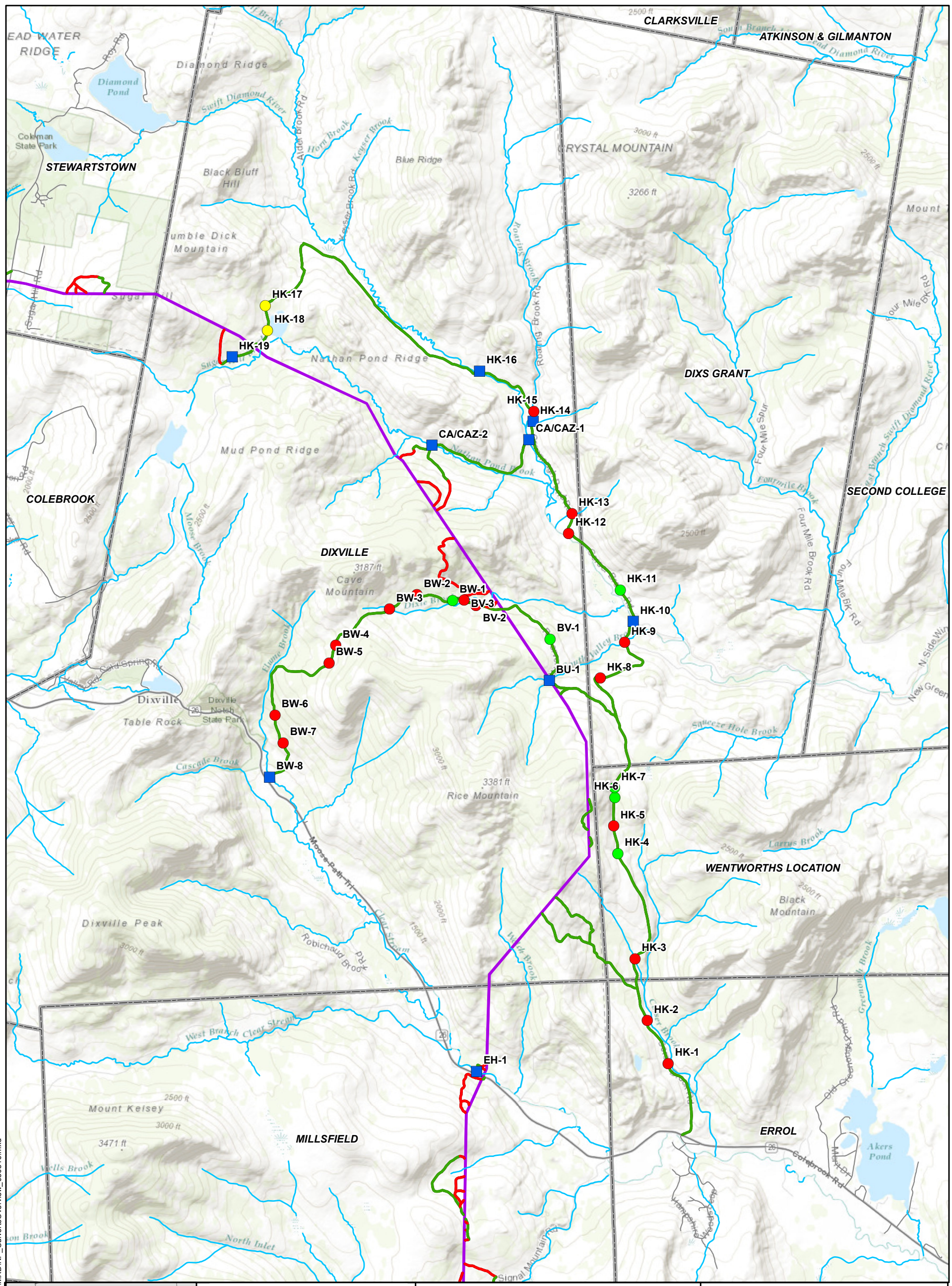

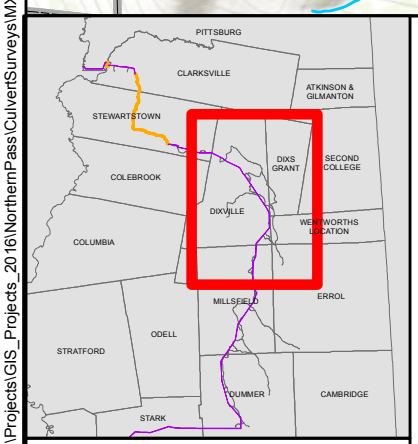

Index Map

- Bridge - No Action
- Culvert - No Action
- Culvert - Pending
- Culvert - Upgrade
- Road surveyed
- Road not surveyed; or not improved
- Access Routes
- Proposed OH ROW
- Proposed UG ROW
- Municipal Border

Data provided by: NH GRANIT & ESRI

N

0 2,500 5,000 10,000 Feet

Northern Pass Figure 1
ORARs Stream Crossings
Map 2 of 3

Northern New Hampshire, USA

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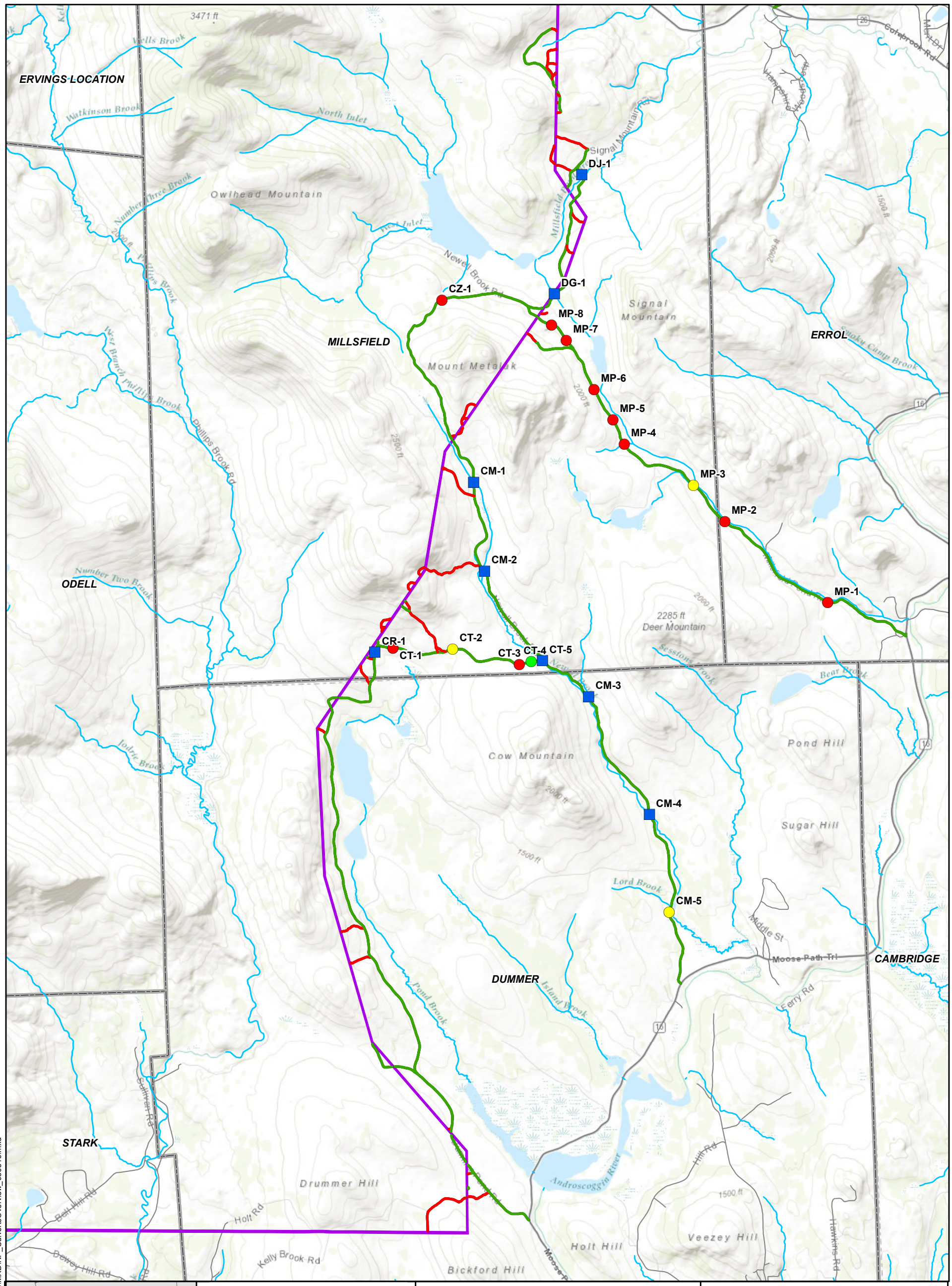

Northern Pass Figure 1
ORARs Stream Crossings
Map 3 of 3

Northern New Hampshire, USA

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Table 1 Summary of ORARs Stream Crossings
Northern Pass

ID	Type	Area	Size	Material	Condition of Material	Short Circuiting?	Hanging? Drop and side	Recommendation	Connectivity?	Watershed Area (ac)	50 Year Storm Volume	Bkfull US (ft)	Bkfull DS (ft)	Size OK?	Comments
BU-1	B	RR	24' opening	Steel/Conc	OK	NA	NA	No Action	Yes			18.6	16	Opening > than Bkfull up and down	10.5' wide wetted surface
BV-1	C	RR	18"	AC	Damaged at top	NN	No	No Action	Yes			4.9	9.5	Opening >1/3 of Bkfull Up	1/3 of culvert contained sediment on DS side
BV-2	C	RR	48"	AC	OK	NN	Yes (0.5' DS)	Upgrade	**No**			5.5	8.4	Opening >1/3 of Bkfull Up and Dn	
BV-3	C	RR	7'	FGS	OK	NN	Yes (0.5' DS)	Upgrade	**No**			19.5	19	Opening >1/3 of Bkfull Up and Dn	
BW-1	OA	RR	40" open arch	FGS	OK	NA	NA	No Action	Yes			7.4	8.9	Opening >1/3 of Bkfull Up and Dn	Dry on DS side
BW-2	C	RR	2-36"	AC	OK	**Yes**	Yes (0.1'/0.4' DS)	Upgrade	**No**			8.3	9.5	Opening >1/3 of Bkfull Up and Dn	Inlet 2" above sediment surface
BW-3	C	RR	36"	PC	OK	NN	Yes (0.3' DS)	Upgrade	**No**			10.5	11.1	**No, <1/3 Bkfull up and Dn**	Erosion of road on top of culvert up and down stream
BW-4	C	RR	36"	AC	OK	NN	Yes (0.7' DS)	Upgrade	**No**			7.6	10.1	**No, <1/3 Bkfull up and Dn**	Erosion of road on top of culvert up and down stream
BW-5	C	RR	48"	AC	OK	NN	Yes (0.6' DS)	Upgrade	**No**			9.1	8.2	Opening >1/3 of Bkfull Up and Dn	Erosion of road on top of culvert up and down stream
BW-6	C	RR	2-26"x 21" elliptical	AC	OK	NN	Yes (1.8'/1.0' DS)	Upgrade	**No**			6.2	9.9	Openings >1/3 of Bkfull Up and Dn	Erosion of road on top of culvert up and down stream
BW-7	C	RR	26"x 18" elliptical	AC	OK	NN	Yes (0.4' DS)	Upgrade	**No**			9.1	9.5	**No, <1/3 Bkfull up and Dn**	Erosion of road on top of culvert up and down stream
BW-8	B	RR	27' opening	Steel/Conc	OK	NA	NA	No Action	Yes			24.5	20.5	Opening > than Bkfull up and down	11' wide wetted surface
CA/CAZ-1	B	CBR	43' opening	Steel/Conc	OK	NA	NA	No Action	Yes			44	39.7	Opening > 85% of Bkfull up and down	
CA/CAZ-2	B	CBR	24' opening	Steel/Conc	OK	NA	NA	No Action	Yes			25.1	28	Opening > 85% of Bkfull up and down	
CM-1	B	NBR	11.8' opening	Wood	OK	NA	NA	No Action	Yes			11.7	13.6	Opening > than Bkfull up	
CM-2	B	NBR	16.0' opening	Steel/Rock	OK	NA	NA	No Action	Yes			17.1	13.5	Opening > than Bkfull down	
CM-3	B	NBR	17.8' opening	Steel/wood	OK	NA	NA	No Action	Yes			12.5	11.8	Opening > than Bkfull up and down	
CM-4	B	NBR	19.5' opening	Steel/wood	OK	NA	NA	No Action	Yes			22	21.9	Opening close to Bkfull up and down	
CM-5	C	NBR	1-28"North; 1-24" South	AC	South culvert is deformed	NN	Yes (0.3'/0.2' DS)	Pending	**No**			7.6	NA	Openings > than 1/3 Bkfull up	28" north culvert is functioning and passing water; south culvert inlet is about 4" higher than water level. Discharges into larger stream system.
CR-1	B	CBR	16.6' opening	Wood	OK	NA	NA	No Action	Yes			10.9	14.8	Opening > than Bkfull up and down	
CT-1	C	DPR	24"	AC	OK	**Yes**	No	Upgrade	Partial			5.5	7.5	**No, <1/3 Bkfull down**	Slightly hung inlet
CT-2	C	DPR	52"	AC	OK, dented on outlet side	NN	Yes (0.1' DS)	Pending	**No**			See note	9.4	Openings >1/3 of Bkfull Dn	Upstream channel modified by logging activities and presence of large wetland
CT-3	C	DPR	18"	AC	OK	NN	No	Upgrade	Yes			4.8	See comment	**No, <1/3 Bkfull up**	New crossing. Downstream stream channel straightened recently, likely when culvert was installed. Crossing was dry during inventory. Inlet 1/3 buried due to wide basin at inlet.
CT-4	C	DPR	18"	AC	OK	NN	No	No Action	Yes			4.1	See comment	Openings > than 1/3 Bkfull up	New crossing. Downstream stream channel straightened recently, likely when culvert was installed. Crossing had very low flow during inventory. Inlet and outlet 1/3 embedded due to wide basin at inlet.
CT-5	B	DPR	22.7' opening	Steel/Rock	OK	NA	NA	No Action	Yes			26	25.37	Opening > 85% of Bkfull up and down	10.8' wetted surface
CZ-1	C	MBR	18"	AC	OK, dented on outlet side	**Yes**	Yes (0.6' DS)	Upgrade	**No**			6.5	7.8	**No, <1/3 Bkfull up and down**	
DG-1	B	SMR	13.8' opening	Wood	OK	NA	NA	No Action	Yes			12.1	15.5	Opening > 85% of Bkfull up and down	5.0' wetted surface; some undercutting of wood abutments
DJ-1	B	SMR	30' opening	Steel/Rock	OK	NA	NA	No Action	Yes			27	24.1	Opening > than Bkfull up and down	20' wetted surface
EH-1	B	SMR	45.5' opening	Steel/wood	OK	NA	NA	No Action	Yes			39.1	39.5	Opening > than Bkfull up and down	
HK-1	C	CBR	28"x 41"	AC	OK	NN	Yes (1' DS)	Upgrade	**No**			9.7	8.4	Opening >1/3 of Bkfull Up and Dn	Eroding from road runoff around culvert on downstream side
HK-2	C	CBR	40"	SS	OK	NN	Yes (>3' DS)	Upgrade	**No**			9.1	14.5	Opening >1/3 of Bkfull Up and Dn	Eroding from road runoff around culvert on downstream side
HK-3	C	CBR	39"	AC	OK	NN	Yes (>3' DS)	Upgrade	**No**			14	15	**No, <1/3 Bkfull up and Dn**	
HK-4	C	CBR	2-42" x 26"	AC	OK	NN	No	No Action	Yes			6.5	13	Openings >1/3 of Bkfull Up and Dn	North culvert blocked at outlet
HK-5	C	CBR	24"inlet; 28" outlet	Conc/AC	OK	NN	Yes (0.5' DS)	Upgrade	**No**			8	12	Opening >1/3 of Bkfull Up and Dn	
HK-6	C	CBR	36"	AC	OK	NN	No	No Action	Yes			7.5	8.1	Opening >1/3 of Bkfull Up and Dn	
HK-7	C	CBR	36"	AC	OK	NN	No	No Action	Yes			5.9	5.5	Opening >1/3 of Bkfull Up and Dn	Erosion of road on top of culvert up and down stream
HK-8	C	CBR	36"	AC	OK	NN	Yes (2.5' DS)	Upgrade	**No**			9	11.1	**No, 1/3 Bkfull up, < 1/3 of Bkfull down**	Erosion of road on top of culvert up and down stream

Table 1 Summary of ORARs Stream Crossings
Northern Pass

ID	Type	Area	Size	Material	Condition of Material	Short Circuiting?	Hanging? Drop and side	Recommendation	Connectivity?	Watershed Area (ac)	50 Year Storm Volume	Bkfull US (ft)	Bkfull DS (ft)	Size OK?	Comments
HK-9	C	CBR	120"x78"	AC	OK	NN	Yes (0.8 DS)	Upgrade	**No**			18.2	19	Opening >1/3 of Bkfull Up and Dn	Arch with bottom; reset lower?
HK-10	B	CBR	34' opening	Conc/Wood	OK	NA	NA	No Action	Yes			39	40.4	Opening >1/3 of Bkfull Up and Dn	
HK-11	C	CBR	21"	AC	OK	NN	No	No Action	Yes			4.8	5.4	Opening >1/3 of Bkfull Up and Dn	Dry
HK-12	C	CBR	36"	AC	OK	NN	Yes (0.9 DS)	Upgrade	**No**			9.1	12.1	**No, <1/3 Bkfull up and Dn**	
HK-13	C	CBR	2-30"; 1-34" x 23"	AC	OK	NN	Yes, south(1.5' DS)	Upgrade	**No**			18.1	14.1	Openings >1/3 of Bkfull Up and Dn	North culvert plugged with sediment, wood
HK-14	B	CBR	12.9' opening	Wood	OK	NN	No	No Action	**Yes**			15.4	15.2	Opening >1/3 of Bkfull Up and Dn	
HK-15	C	CBR	16.5' x 8.5'	AC	OK	NN	Yes, (0.6' DS)	Upgrade	**No**			29.2	31.1	Opening >1/3 of Bkfull Up and Dn	Arch with bottom; reset lower?
HK-16	B	CBR	25.2' opening	Conc/Wood	OK	NA	No	No Action	**Yes**			30.5	41.5	Opening >1/3 of Bkfull Up and Dn	
HK-17	C	CBR	24"	AC	OK	NN	Yes, (0.2' DS)	Pending	**No**			4.7	8.1	Opening >1/3 of Bkfull Up	
HK-18	C	CBR	24"	AC	OK	NN	Yes, (0.2' DS)	Pending	**No**			5.4	6.5	Opening >1/3 of Bkfull Up	
HK-19	B	CBR	10'	S	OK	NA	No	No Action	Yes			5.5+17.5	11.5	Opening >1/3 of Bkfull Up and Dn	
MP-1	C	MPR	15"	AC	Corroding	NN	Yes (0.9' DS)	Upgrade	**No**			8.3	7.6	**No, <1/3 Bkfull up and Dn**	
MP-2	C	MPR	36"	AC	OK	NN	Yes (0.5' DS)	Upgrade	**No**			6.1	6.7	Openings >1/3 of Bkfull Up and Dn	
MP-3	C	MPR	2-42"	AC	OK	NN	Yes (0.5' DS south culvert)	Pending	Partial			12.5	17	Openings >1/3 of Bkfull Up and Dn	North culvert is at grade at outlet
MP-4	C	MPR	24"	Conc	OK	NN	No	Upgrade	Yes			7.4	8.5	**No, <1/3 Bkfull up and Dn**	**Erosion of road on top of culvert up and down stream. Otherwise, culvert appears functional with simulation in culvert. Dominant particles sand upstream, in culvert and down stream.**
MP-5	C	MPR	30"	Conc	OK	NN	Yes (0.1' DS)	Upgrade	**No**			11.5	6.5	**No, <1/3 Bkfull up**	**Cobbles aggrading at inlet**
MP-6	C	MPR	24"	AC	Deformed	**Yes**	Yes (0.2' DS)	Upgrade	**No**			5	4.5	Openings >1/3 of Bkfull Up and Dn	Cracks in soil in road above culvert; may be compromised
MP-7	C	MPR	30"	Conc	OK	**Yes**	Yes (0.2' DS)	Upgrade	**No**			4.5	6.7	Openings >1/3 of Bkfull Up and Dn	
MP-8	C	MPR	36"	AC	OK	NN	Yes (0.6' DS)	Upgrade	**No**			11.5	10	**No, <1/3 Bkfull up and down**	

Notes:

	Crossing recommended for upgrade
	Crossing condition indicate a functional crossing with some connectivity issues associated with low water conditions
	Crossing not recommended for action based on Chapter Env-Wt 900.

C=culvert
B=bridge
PC=plastic corrugated
AC= aluminum corrugated
SS=smooth steel
OA=open-bottom arch
Bkfull=bankfull

NN=none noted
NA=not applicable

RR=Reservoir Road
CBR=Coarser Brook Road
SMR=Signal Mountain Road
MPR=Millsfield Pond Road
NBR=Newell Brook Road
DPR=Dummer Pond Road

DS=downstream
US=Upstream