

A photograph of a stream with a stone-lined bank and dense vegetation. The stream is dark and reflects the surrounding greenery. The bank is lined with large, smooth stones. The foreground is filled with lush, green and purple foliage. The background shows a dense forest of tall trees.

Blending Engineering and Environmental Considerations in the Design of Infrastructure Protection and Improvement Projects

Impacts to aquatic and riparian environments have often been overlooked in the design and construction of infrastructure protection and improvement projects.



Riprap bank stabilization on the East Branch of the Pemigewasset River adjacent to municipal sewage lagoons in Lincoln, NH



Concrete-encased oil pipeline across Stag Hollow Brook in Jefferson, NH creating a fish passage barrier

The Prioritization of infrastructure protection is understandable given high project costs, consequences of failure, and potential liability.



Bank erosion on the Mad River in Campton, NH following TS Irene



Landslide along the Souhegan River in Greenville, NH (above and below)



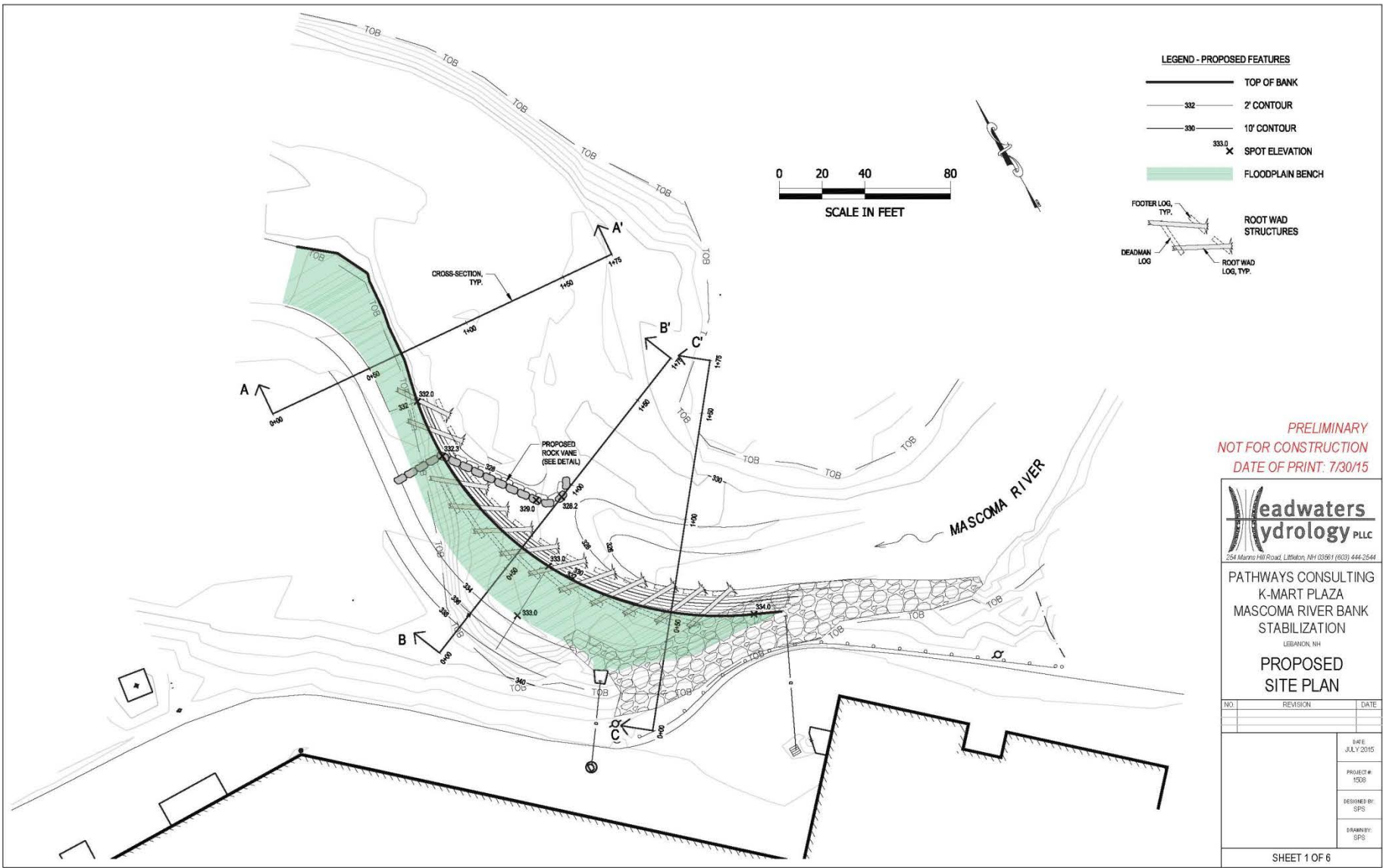
However, in some cases it is possible to utilize or at least incorporate bioengineering into project designs to minimize adverse environmental impacts.

The key is to identify where a completely bio-engineered solution is appropriate, a traditionally engineered solution is needed, or a combination of hard armor and bioengineering can be utilized.

The best designs achieve the multiple objects of improving/protecting infrastructure and enhancing riparian and aquatic environments.

Several examples of project designs follow.

Mascoma River Bank Stabilization K-Mart Plaza, Lebanon, NH



PRELIMINARY
NOT FOR CONSTRUCTION
DATE OF PRINT: 7/30/15

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PATHWAYS CONSULTING
K-MART PLAZA
MASCOMA RIVER BANK
STABILIZATION
LEBANON, NH

**PROPOSED
SITE PLAN**

NO.	REVISION	DATE

DATE: JULY 2015
PROJECT #: 1508
DESIGNED BY: SPS
DRAWN BY: SPS

Mascoma River Bank Stabilization K-Mart Plaza, Lebanon, NH



Construction: November/December 2015
Photos captured: March 2016



Breezy Hill Road Bridge Replacement Warner River, Bradford, NH



Roadway inundation during 2006
Mother's Day Flood



Pre-existing bridge (33' span)



New bridge (80' span)

Breezy Hill Road Bridge Replacement Warner River, Bradford, NH



Construction: 2016

Photos captured: November 2016

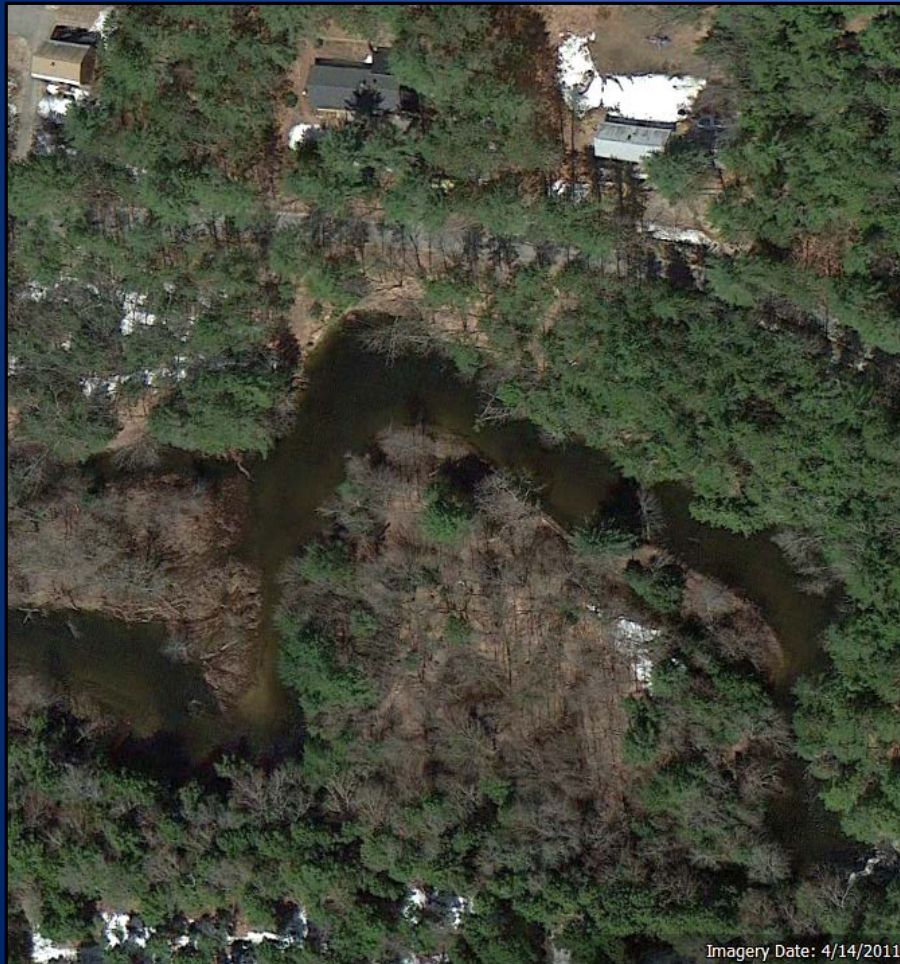


View downstream

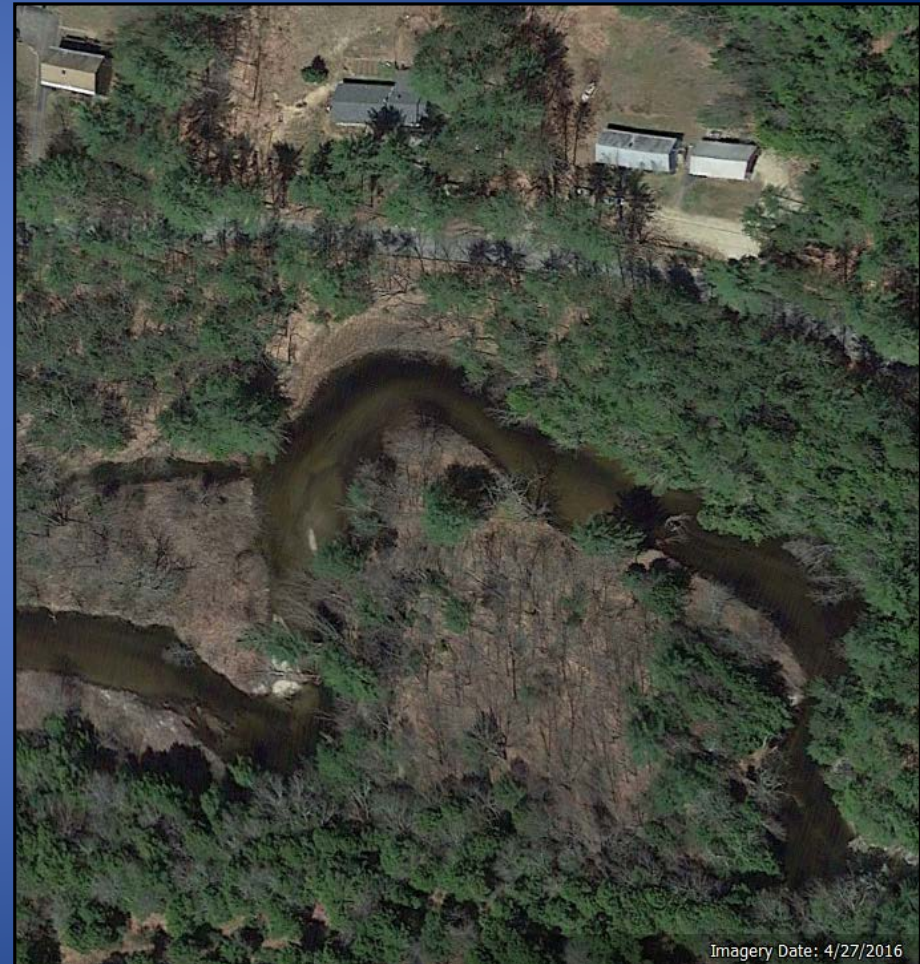


View upstream

Smith River Bank Stabilization Bristol, NH



April 2011 (pre-construction)



April 2016 (post-construction)

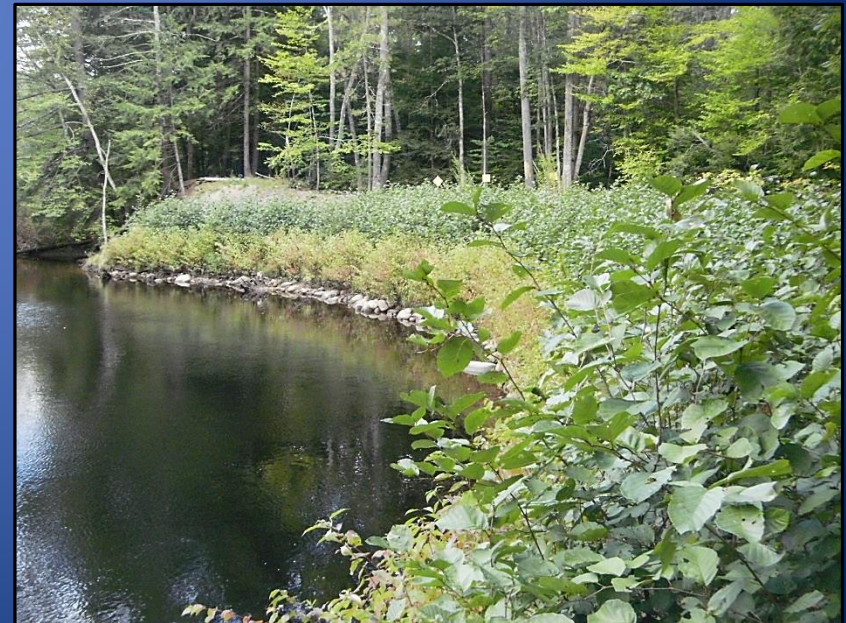
Smith River Bank Stabilization, Bristol, NH



Construction: October/November 2011
Photo above captured: November 2011
Photos right captured: September 2013



View downstream



View upstream

Lower Warren Brook Restoration Alstead, NH

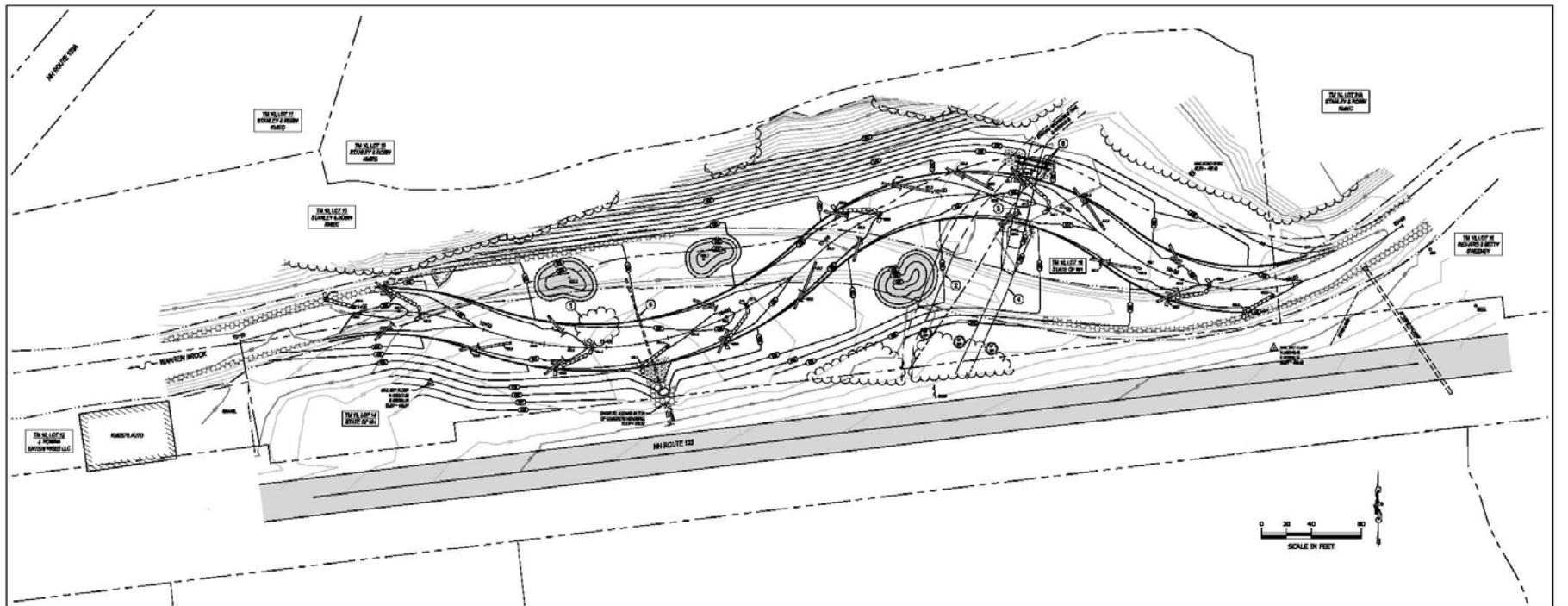


Post 2005 Flood



Pre-Restoration (Dec. 2011)

Lower Warren Brook Restoration, Alstead, NH



KEY NOTE

1. SALVAGE TREES WHO ROOT WOUNDS EXIST FOR USE IN LOW WINDS AND ROOT WOUND STRUCTURES.
2. REMOVE AND RE-LOCATE BRIDGE AND FOUNDATION BUILT ON ROCKS (SEE GENERAL NOTE 6).
3. APPROXIMATE NEW LOCATION OF BRIDGEABLE BRIDGE. COORDINATE RELOCATION WITH TOWN ENGINEERS (SEE GENERAL NOTE 6).
4. APPROXIMATE NEW LOCATION OF BRIDGEABLE TRAIL. COORDINATE RELOCATION WITH TOWN ENGINEERS (SEE GENERAL NOTE 6).
5. REMOVE CHANNELS OF CULVERTS AND BRUSH BUNDLES TO BE RELOCATED TO THE RE-LOCATED BRIDGE.
6. INSTALL TWO (2) FT. LONG 18" CONCRETE HOLES OR WITH SALVAGED FROM ON-SITE BRUSH BRIDGE APPROXIMATE 18" SPACED WITHIN BRUSH FLOOR AN AREA ON BOTH SIDES OF TRAIL WITH BRUSH COLLECTIBLES. COLLECTIBLES SHALL BE SALVAGED FROM BRUSH AND PLANT OUTLETS AND RE-INSTALLMENTS.

GENERAL NOTES

1. WHERE ROOT WOUNDS ARE SPECIFIED, THEY SHALL BE IN ACCORDANCE WITH THE NEW HAMPSHIRE DEPARTMENT OF TRANSPORTATION STANDARD SPECIFICATIONS FOR ROAD AND BRIDGE CONSTRUCTION 2014.
2. THE CONTRACTOR SHALL ADHERE TO ALL CONDITIONS OF THE ENVIRONMENTAL PERMITS ISSUED FOR THE PROJECT.
3. NO EXISTING MONUMENTS, PROPERTY MARKS, OR BENCHMARKS SHALL BE DISTURBED WITHOUT FIRST MAKING PROVISIONS FOR THEIR LOCATION.
4. ALL WORK SHALL BE PERFORMED WITH-IN TAX MAP 10, LOTS 10, 11, 14, 15, AND 18 OR EASEMENTS SECURED BY THE OWNER AND/OR CONTRACTOR.
5. COORDINATE RELOCATION OF THE BRIDGEABLE BRIDGE AND TRAIL WITH TOWN ENGINEERS. CONTACT: CHRIS PORTER (803) 313-3444.
6. SURPLUS EXCAVATED MATERIAL SHALL BE DEPOSITED OFF-SITE IN AN UPLAND AREA AND IN COMPLIANCE WITH LOCAL, STATE, AND FEDERAL REGULATIONS.
7. NATURAL SAND, GRAVEL, CORALS, AND Boulders ON THE BED OF THOSE PORTIONS OF THE EXISTING STREAM CHANNEL TO BE ABANDONED SHALL BE SALVAGED AND USED TO LINE THE BED OF THE RELOCATED STREAM CHANNEL. THE DEPTH OF MATERIAL TO BE SALVAGED SHALL BE APPROXIMATELY 18 INCHES.
8. EXISTING RIPRAP IS TO BE REMOVED EXCEPT WHERE SHOWN TO REMAIN. RIPRAP TO REMAIN IN FILL AREAS SHALL BE LEFT IN PLACE AND FILLED OVER. RIPRAP TO REMAIN IN CUT AREAS SHALL BE REMOVED TO ALLOW THE ESTABLISHMENT OF SUBGRADES AND REPLACED TO ESTABLISH FIRM GRADERS. NEW RIPRAP IN THE VICINITY OF THE RELOCATED BRIDGE ABUTMENTS AND EXISTING 18" HOPE CULVERT (STA 13+56.4) SHALL BE SALVAGED FROM AREA WHERE RIPRAP IS TO BE REMOVED.
9. 200 TONS OF Boulders FOR ROCK WADERS AND J-HOOK WADERS WILL BE DONATED BY COLD SPRING MATERIALS IN HALIFORD, NH. THIS IS EXPECTED TO BE A SUFFICIENT QUANTITY OF ROCK TO CONSTRUCT ALL OF THE WADERS STRUCTURES CALLED FOR ON THE PLAN. THE CONTRACTOR SHALL ENSURE THAT THE DONATED ROCK MEETS THE SIZE, SHAPE, AND DENSITY SPECIFICATIONS AND SHALL TRANSPORT THE ROCK FROM THEIR QUARRY IN WIND POLIF TO THE JOB SITE. CONTACT SUSAN STACY, COLD SPRING MATERIALS PLANT MANAGER, AT (802) 444-2003 TO ARRANGE FORING, SORTING, AND LOADING OF MATERIALS.
10. THE PROJECT ENGINEER SHALL IDENTIFY (TAG) EXISTING TREES AND BRUSH PLANTED IN THE PROJECT AREA IN OR ABOUT 2007 WHICH ARE TO BE SALVAGED. THE CONTRACTOR SHALL ESTABLISH A TEMPORARY ON-SITE HARDWAY FOR HANDING, SALVAGING AND STORING THE SALVAGED TREES AND BRUSH IN THE HARDWAY, AND TRANSPORT THE SALVAGED TREES AND BRUSH TO THE BRUSH CRACKS WHERE SALVAGED. THE CONTRACTOR SHALL CAREFULLY SALVAGE THE PLANT MATERIALS WITH THE ENTIRE ROOT MASS INTACT. WHILE STORED IN THE HARDWAY, THE CONTRACTOR SHALL COVER THE ROOTS OF THE SALVAGED TREES AND BRUSH WITH SOIL OR BANK MULCH AND WATER REGULARLY TO MINIMIZE PLANT MORTALITY. THE PROJECT ENGINEER SHALL PROVIDE PLANTING LAYOUT.
11. THE CONTRACTOR IS SOLELY RESPONSIBLE FOR CONTROLLING EROSION IN ALL AREAS DISTURBED BY HIS ACTIONS. COSTS FOR REQUIRED EROSION CONTROL, REGARDLESS OF WHETHER OR NOT SUCH MEASURES ARE SHOWN ON THE DRAWINGS, SHALL BE BORNE BY THE FIRM.

PROPOSED FEATURES LEGEND

- 1" CONTOUR
- 2" CONTOUR
- SPOT ELEVATION
- 18" HOPE
- J-HOOK WADERS
- ROCK WADERS
- LOG WADERS
- ROOT WADERS
- RIPRAP (shown in existing)
- DRY RIPRAP
- 18" HOPE
- WADERS POOL
- 18" HOPE CULVERT

EXISTING FEATURES LEGEND

- 12" CONTOUR
- 2" CONTOUR
- ATYPICALS PRIORITY LINE
- TOP OF BANK
- WETLAND BOUNDARY
- EDGE OF 18" HOPE CULVERT
- EXPOSED BRICKWORK
- TRAILLINE
- PAVED SURFACE
- ELEVATION CONTROL POINT
- ELEVATION BENCHMARK

Proposed Site Plan

PERFORMED BY HEADWATERS HYDROLOGY, PLLC IN DECEMBER 2011 AND MARCH 2012. HORIZONTAL AND VERTICAL DATUMS ARE ASSUMED.

IDENTIFIED 10/11, DECEMBER 2011 AND MARCH 2012.

DATE OF PRINT: 3-11-13

SHEET 3 OF 8

Headwaters Hydrology, PLLC

200 North 100 Street, Liberty, NH 03083, 603.442.8800

LOWER WARREN BROOK STREAM RESTORATION

ALSTEAD, NEW HAMPSHIRE

SITE PLAN AND GENERAL NOTES

NO.	REVISION	DATE

DATE: NOV 2012
 DRAWN: TSB
 CHECKED: JSP
 DESIGNED: JSP
 SCALE: 8/16

Lower Warren Brook Restoration, Alstead, NH



Construction: July-October 2016
All photos looking downstream
November 2016



Bissell Brook Bank Stabilization, Stratford, NH

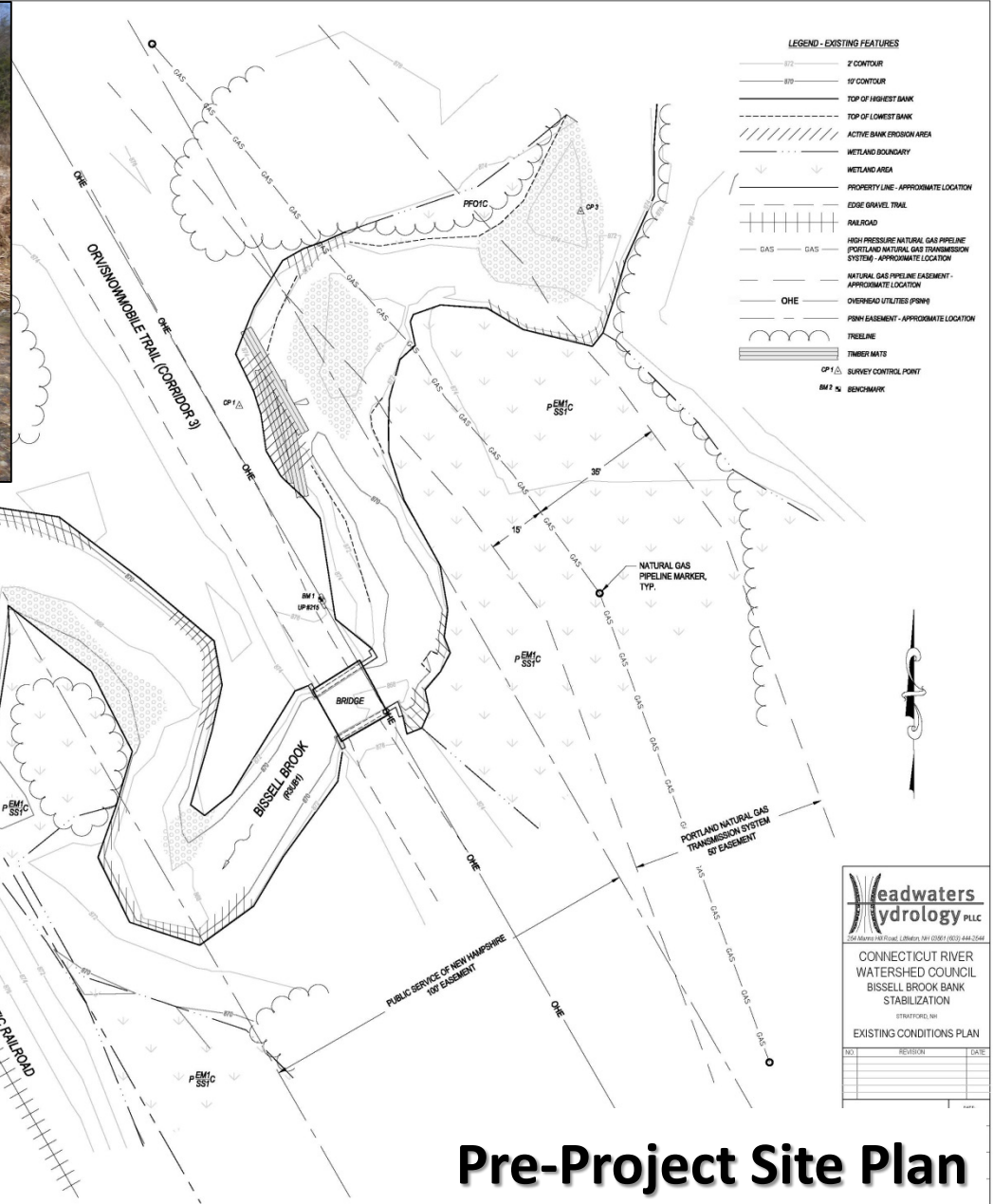


8. WETLAND BOUNDARIES SHOWN ON THIS PLAN WERE DELINEATED BY SEAN SWEENEY (CWS #216) ON SEPTEMBER 28, 2014. THE WETLAND DELINEATION WAS PERFORMED IN ACCORDANCE WITH THE U.S. ARMY CORPS OF ENGINEERS WETLAND DELINEATION MANUAL, TECHNICAL REPORT Y-81-1, JANUARY 1987 AND NH CODE OF ADMINISTRATIVE RULES, CHAPTER ENV-WT 300, PART ENV-WT 301, SECTION ENV-WT 301.01.

9. TOP OF BANK ALSO REPRESENTS THE LIMITS OF STATE WETLAND JURISDICTION WHERE WETLANDS DO NOT BORDER THE STREAM CHANNEL.

10. DELINEATED WETLANDS HAVE BEEN CLASSIFIED IN ACCORDANCE WITH U.S. FISH AND WILDLIFE SERVICE MANUAL FW5035-7091 CLASSIFICATION OF WETLANDS AND DEEPWATER HABITATS OF THE UNITED STATES, COWARD ET AL, 1979 PER NH CODE OF ADMINISTRATIVE RULES, CHAPTER ENV-WT 300, PART ENV-WT 301, SECTION ENV-WT 301.02.

NOTE: TOPOGRAPHIC AND WETLAND MAPPING NOT COMPLETED DOWNSTREAM FROM RAILROAD



LEGEND - EXISTING FEATURES

- 10' CONTOUR
- 2' CONTOUR
- TOP OF HIGHEST BANK
- TOP OF LOWEST BANK
- ACTIVE BANK EROSION AREA
- WETLAND BOUNDARY
- WETLAND AREA
- PROPERTY LINE - APPROXIMATE LOCATION
- EDGE GRAVEL TRAIL
- RAILROAD
- HIGH PRESSURE NATURAL GAS PIPELINE - APPROXIMATE LOCATION
- NATURAL GAS PIPELINE EASEMENT - APPROXIMATE LOCATION
- OHE - OVERHEAD UTILITIES (P/NH)
- P/NH EASEMENT - APPROXIMATE LOCATION
- TREELINE
- TIMBER MATS
- CP 1 Δ SURVEY CONTROL POINT
- BM 1 □ BENCHMARK

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CONNECTICUT RIVER WATERSHED COUNCIL
 BISSELL BROOK BANK STABILIZATION
 STRATFORD, NH

EXISTING CONDITIONS PLAN

NO.	REVISION	DATE

Pre-Project Site Plan

Bissell Brook Bank Stabilization, Stratford, NH

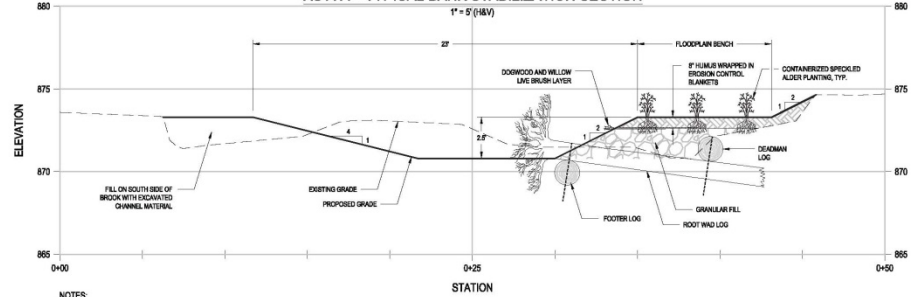
LEGEND - PROPOSED FEATURES

- 872 — 2' CONTOUR
- 870 — 10' CONTOUR
- TOP OF BANK
- 873.3 x — SPOT ELEVATION
- FLOODPLAIN BENCH
- WILLOW TRANSPLANT
- ROOT WAD STRUCTURES
- FOOTER LOG, TYP.
- DEADMAN LOG
- ROOT WAD LOG, TYP.

GENERAL NOTES

1. NO CONSTRUCTION SHALL OCCUR WITHIN THE NATURAL GAS PIPELINE EASEMENT WITHOUT THE APPROVAL OF PORTLAND NATURAL GAS TRANSMISSION SYSTEM (PNCTS). THE CONTRACTOR SHALL CONTACT PNCTS AT (603) 788-6296 PRIOR TO CONSTRUCTION TO OBTAIN APPROVAL, COORDINATE CONSTRUCTION SCHEDULE, AND DETERMINE IF ANY LIMITATIONS ON THE WORK OR SPECIAL CONDITIONS ARE REQUIRED.
2. THE CONTRACTOR SHALL ADHERE TO ALL CONDITIONS OF THE ENVIRONMENTAL PERMITS ISSUED FOR THE PROJECT.
3. NO EXISTING MONUMENTS, PROPERTY BOUNDS, OR BENCHMARKS SHALL BE DISTURBED WITHOUT FIRST MAKING PROVISIONS FOR RELOCATION.
4. ALL WORK SHALL BE PERFORMED WITHIN THE PROJECT PROPERTY OR EASEMENTS SECURED BY THE OWNER AND/OR CONTRACTOR.
5. THE CONTRACTOR IS SOLELY RESPONSIBLE FOR CONTROLLING EROSION IN ALL AREAS DISTURBED BY HIS ACTIONS. COSTS FOR REQUIRED EROSION CONTROL, REGARDLESS OF WHETHER OR NOT SUCH MEASURES ARE SHOWN ON THE DRAWINGS, SHALL BE BORNE BY HIM.
6. THE CONTRACTOR SHALL COORDINATE SITE ACCESS VIA THE EXISTING OR VISIBLE TRAIL WITH THE STRATFORD TOWN ENGINEERS. CONTACT TED BURTON (TRAIL MASTER) AT (603) 922-3360. CONSTRUCTION SHALL BE STAGED AND EXECUTED SO AS NOT TO IMPEDE OR OTHERWISE DISRUPT TRAVEL ALONG THE TRAIL.
7. THE CONTRACTOR IS RESPONSIBLE FOR LOCATING AND PROTECTING EXISTING UTILITIES. THE CONTRACTOR SHALL CONTACT DIG SAFE (811) AT LEAST 3 BUSINESS DAYS PRIOR TO STARTING CONSTRUCTION TO VERIFY UTILITY LOCATIONS.
8. EXISTING TOPOGRAPHY AND PLANIMETRY ARE FROM A FIELD SURVEY BY HEADWATERS HYDROLOGY, PLLC COMPLETED ON SEPTEMBER 28, 2014 AND OCTOBER 6, 2014. HORIZONTAL GRID IS ASSUMED APPROXIMATE NH STATE PLANE; VERTICAL DATUM IS NAVD83.
9. WETLAND DELINEATION BY SEAN SWEENEY, NH CERTIFIED WETLAND SCIENTIST #216, SEPTEMBER 28, 2014.

XS A-A' - TYPICAL BANK STABILIZATION SECTION

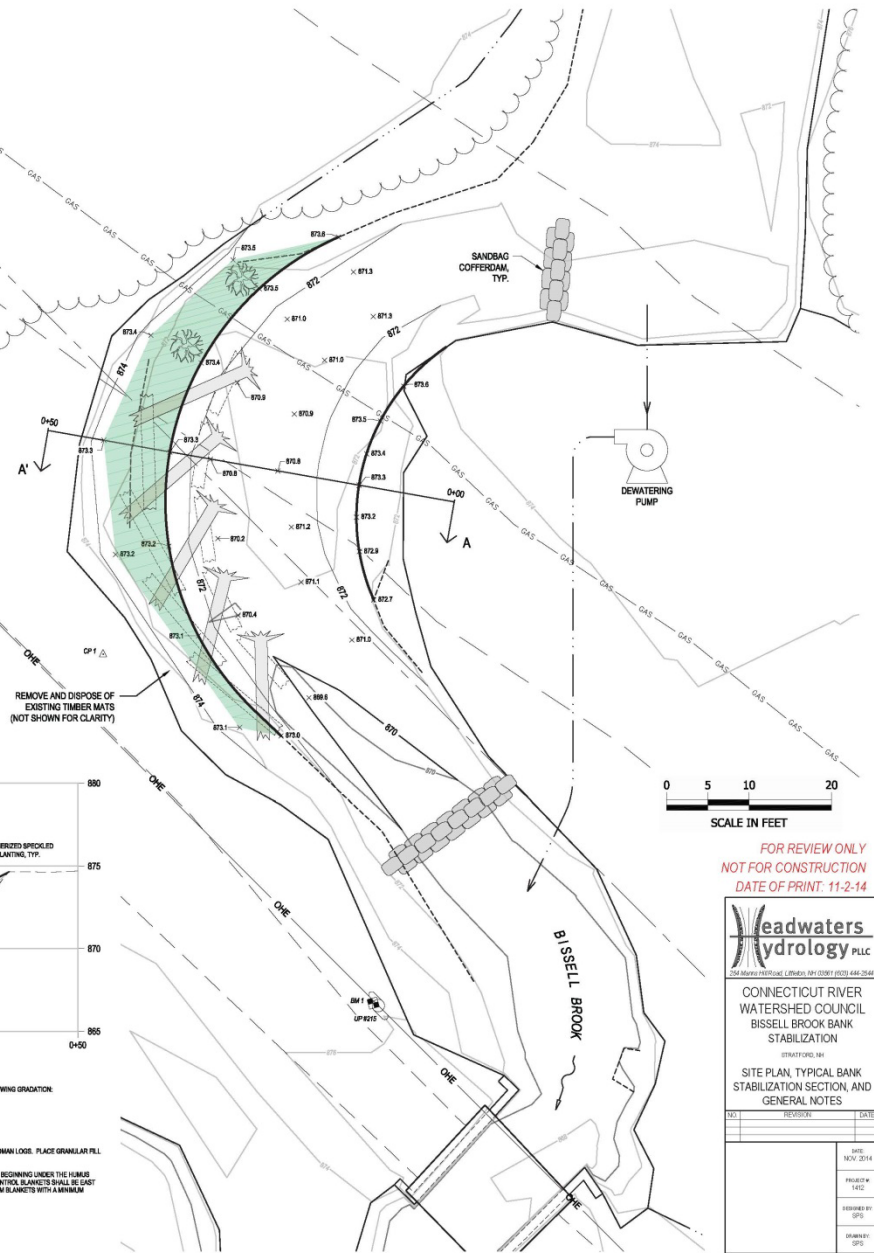


- NOTES:
1. FILL PLACED TO CONSTRUCT THE FLOODPLAIN BENCH AND NORTH STREAMBANK UP TO 1" BELOW FINISH GRADE SHALL BE GRANULAR FILL. GRANULAR FILL SHALL BE A MIX OF NATURALLY OCCURRING SAND, GRAVEL, COBBLE, AND BOULDER HAVING THE FOLLOWING GRADATION:

GRADE	% PASSING BY WEIGHT
24 IN	100
30 IN	100
48 IN	20-30
60 IN	10-15

2. GRANULAR FILL SHALL BE USED TO FILL BETWEEN ROOTWAD, FOOTER, AND DEADMAN LOGS. PLACE GRANULAR FILL INSTALLED IN CONTINUOUS STRIPS ORIENTED PERPENDICULAR TO THE STREAM FLOW BEGINNING UNDER THE HILMS NO 10 IN THE ADJACENT BULK BAGS THAT THERE IS NO EXPOSED HILMS. EROSION CONTROL BLANKETS SHALL BE LAPPED PER SINGLE STYLE SUCH THAT THE UPSTREAM BLANKETS OVERLAP THE DOWNSTREAM BLANKETS WITH A MINIMUM 1" MANUFACTURER'S RECOMMENDED STAPLING PATTERN.

Proposed Site Plan



FOR REVIEW ONLY
 NOT FOR CONSTRUCTION
 DATE OF PRINT: 11-2-14

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CONNECTICUT RIVER WATERSHED COUNCIL
 BISSELL BROOK BANK STABILIZATION
 03/2015/05/16
 SITE PLAN, TYPICAL BANK STABILIZATION SECTION, AND GENERAL NOTES

NO.	REVISION	DATE

DATE:	NOV. 2014
PROJECT:	1412
DESIGNED BY:	SPD
DRAWN BY:	SPD

SHEET 3 OF 4

Bissell Brook Bank Stabilization Stratford, NH



Construction: October 2016
All photos captured October 2016

Bissell Brook Bank Stabilization Stratford, NH



All photos captured October 2016

Bissell Brook Bank Stabilization Stratford, NH



View downstream



View upstream



Shrub plantings

All photos captured October 2016

Ainsworth Pond Dam Removal, Jaffrey, NH



Ainsworth Pond Dam Removal, Jaffrey, NH



Ainsworth Pond Dam Removal, Jaffrey, NH



May 2015 (pre-constuction)



April 2016 (post-constuction)

Ainsworth Pond Dam Removal, Jaffrey, NH



5/10/16



9/27/16