Fish Passage Barrier Removal on Denson's Creek: *Triple Bottom Line Solution*

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EEE Consulting

Pittman Professional Land Surveying

US Forest Service

JT Russell & Sons, Inc.

Private Landowners

This USFWS Partners for Fish and Wildlife project resulted from collaborating with the Greater Uwharrie Conservation Partnership focusing on watershed restoration to benefit at-risk aquatic species.

5 barriers were removed in 5 years because of willing landowners

Funding (Voluntary Project)

Piedmont Conservation Council

US Fish & Wildlife Service: Partners for Fish and Wildlife Program and Fisheries Program

NFWF

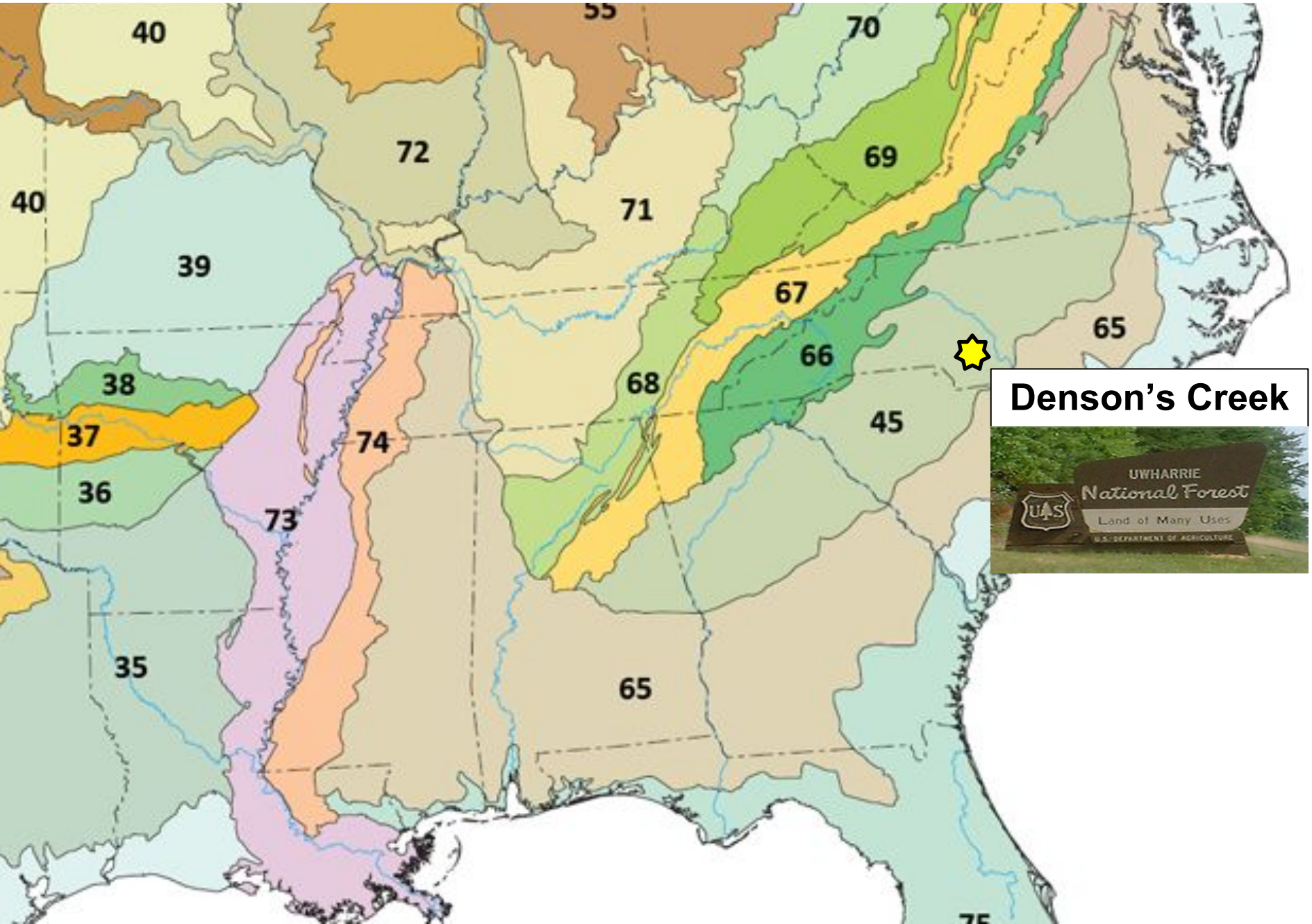
Private Landowners

USFWS Partners for Fish and Wildlife/Fisheries Program &
Piedmont Conservation Council
Densons Creek Wet Ford Replacement Project, Troy, NC

BEFORE

AFTER

Project Location (EPA Level III Ecoregions)



Denson's Creek

- Tributary to Little River in the Yadkin Pee-Dee River Basin
- Drainage Area = 35 square miles

Denson's Creek: State *Endangered Mussel*

Savannah Liliput (*Toxolasma pullus)*

Petitioned for federal listing, 90 day finding was not substantial

Savannah Lilliput
Toxolasma pullus
Contributor: Jennifer Price

DESCRIPTION

Taxonomy and Basic Description

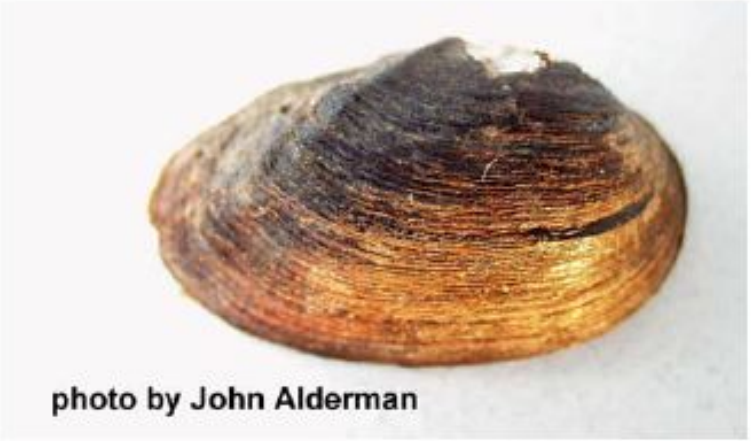


photo by John Alderman

The Savannah lilliput is a small mussel with an oval or elliptical shell and a double posterior ridge. This ridge is usually angular, but is sometimes broadly rounded. Females have a broader, more truncated posterior end; males have a narrower, rounded posterior end. The outer surface of the shell is usually blackish, but sometimes brownish, greenish or olive with very fine, obscure green rays. The inner surface of the shell is bluish white with pink to purplish iridescence at the posterior end. Large specimens range from 30 to 35 mm (1.2 to 1.4 inches) in length (Bogan and Alderman 2004).

http://www.dnr.sc.gov/cwcs/pdf/SavannahLilliput.pdf

Denson's Creek: State *Endangered Mussel*

Brook floater (*Alasmidonta varicosa*)

Jay Mays, USFWS, from Denson's Cr.

NCWRC

https://www.ncwildlife.org/Learning/Species/Mollusks/Brook-Floater#3029854-description

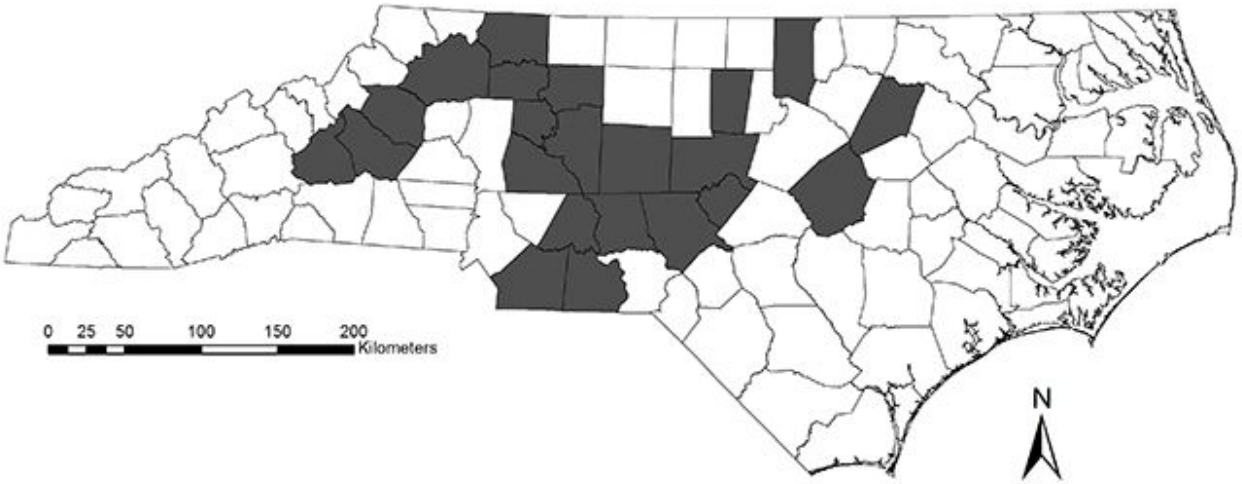
Brook floater (*Alasmidonta varicosa*) Facts:

- Currently NC State endangered; USFWS “At-risk species”
- Petitioned for federal listing in 2011; 90 day finding substantial

https://ecos.fws.gov/ecp0/profile/speciesProfile?spcode=F03D

Currently listing status- Under Review-USFWS species status assessment, lead Asheville FO.

- One population has the potential to be a distinct species in the Uwharries
- Description: NCWRC- kidney –shaped, shell orange to brown with green rays, but can vary to include green and blue. Foot is bright orange.
- Habitat: swift current in run-riffle complexes with clean gravel/sand/cobble substrates.
- Life history: host fish species include the margined madtom, pumpkinseed, golden shiner, and yellow perch.
- NC Distribution:



Brook floater (*Alasmidonta varicosa*)

Brook Floater
Alasmidonta varicosa

Freshwater Mussel Species of Concern

State Rank: S2 (imperiled), Global Rank: G3 (vulnerable)

Identification

The brook floater (*Alasmidonta varicosa*) is a small mussel, usually less than 70 mm in length. The shell is thinner towards the posterior margin and the mussel has a subovate or subtrapezoidal shape (Strayer and Jirka 1997). The ventral margin is slightly indented and the anterior end is abruptly curved. The valves are laterally inflated, giving the mussel a swollen appearance in cross section (Connecticut DEP 2003; Bogan 2002; Nedeau 2000). The posterior ridge is broad and rounded with well-defined ridges crossing the growth lines on the posterior slope. The periostracum (outer covering) is commonly yellowish-green (juveniles) to greenish-brown (adults) and usually has radiating dark green rays across the surface. This species possesses a cantaloupe colored foot (Bogan 2002; Connecticut DEP 2003; Nedeau 2000; Strayer and Jirka 1997).

Photo:
http://www.mass.gov/dfwele/dfw/nhesp/images/al_varicosa.jpg

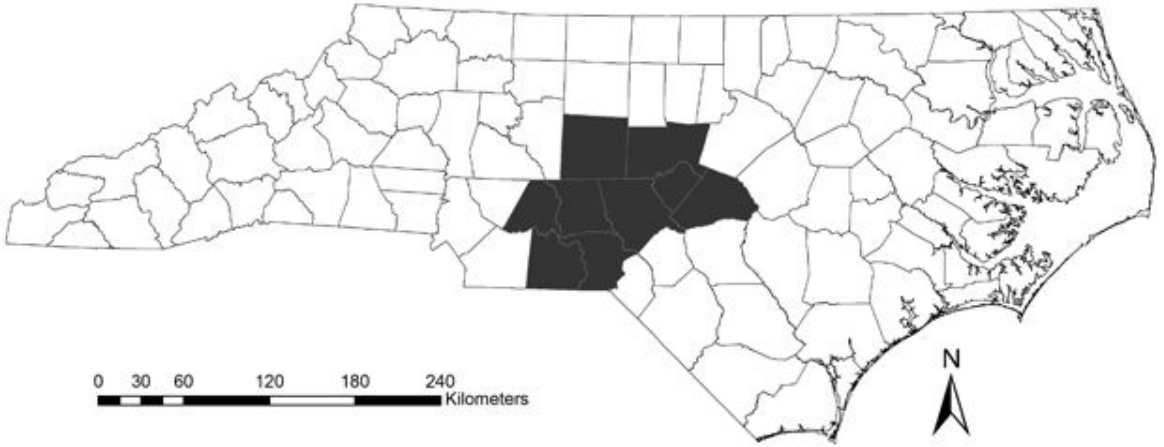
http://www.naturalheritage.state.pa.us/factsheets/12195.pdf

Carolina redhorse (Moxostoma sp. ‘Carolina’) State Threatened

https://www.ncwildlife.org/Learning/Species/Fish/Carolina-Redhorse

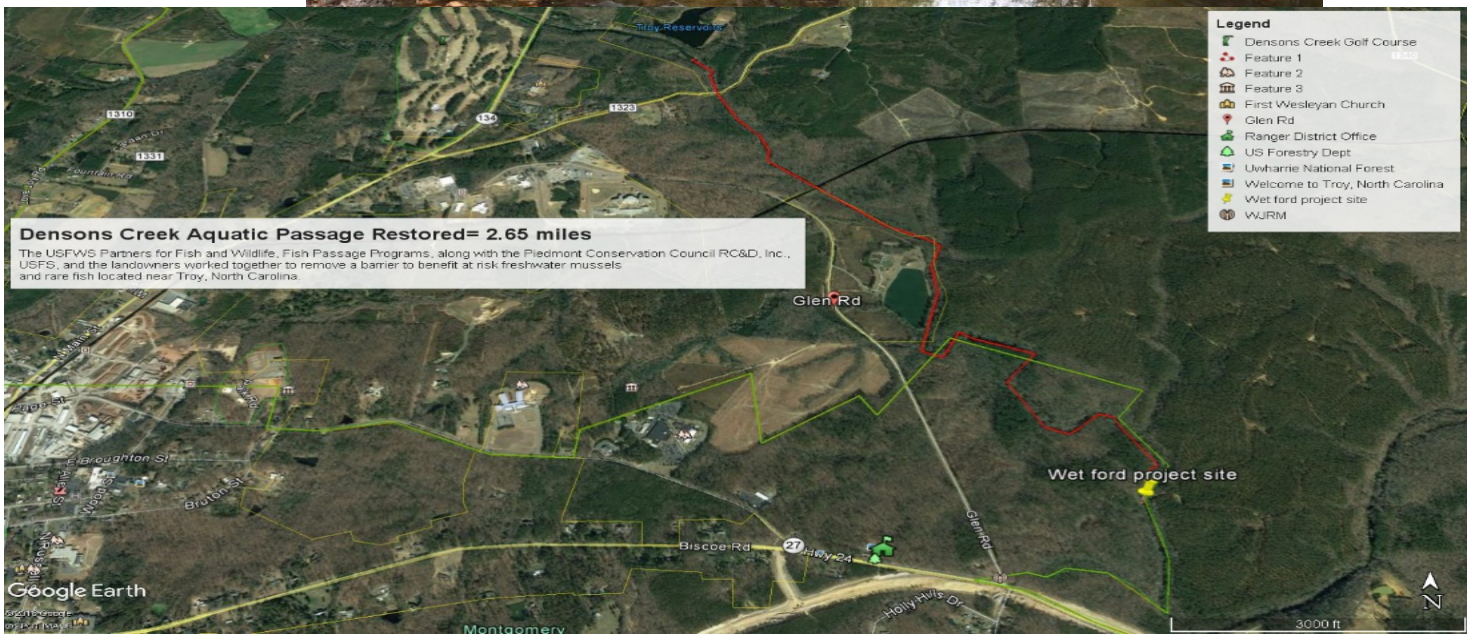
NCWRC

Distribution



Denson's Creek: *Problems*

- Barrier to Fish Passage: Vented Ford Crossing
- Obsolete bridge, unsafe for timber extraction



Denson's Creek: *Vented Ford Crossing*

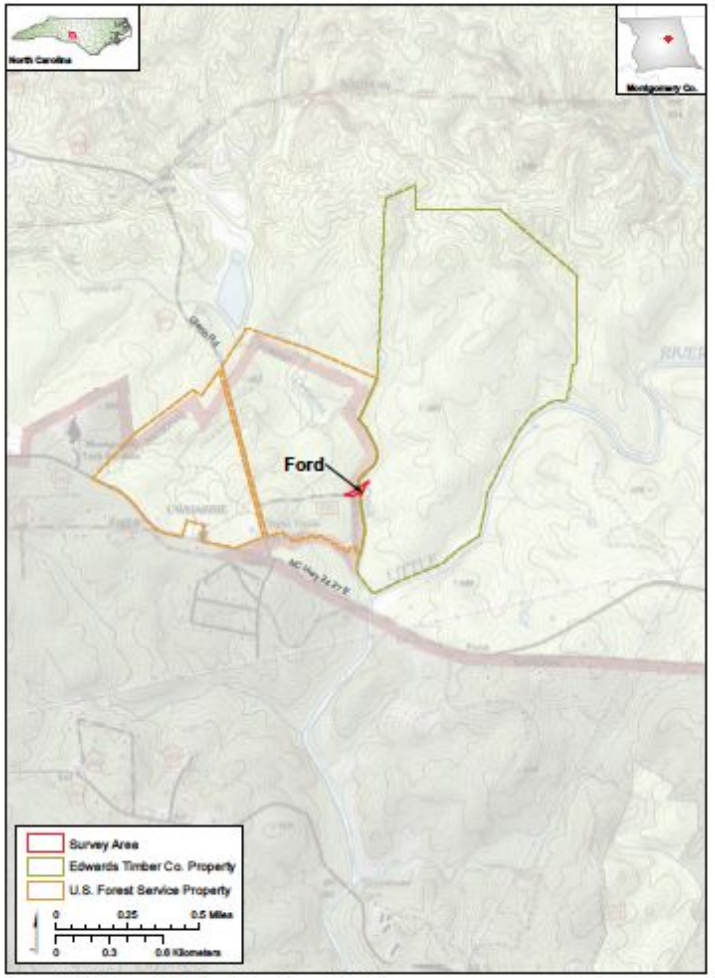
Denson's Creek: *Vented Ford Crossing*

- 65-ft long low-water bridge for logging trucks and hunters
- Decaying foundation with 13 culverts (20-inch openings)

Denson's Creek: *Vented Ford Crossing*

- Built between 1956 and 1961
- Architectural evaluation determined structure was not eligible for NRHP
- No effect on significant archaeological resources- Sect. 106 National Historic Preservation Act

Location Map Showing USFS Parcel No. U-798 and Location of Densons Creek Vented Ford



Source: USGS Topographic Quadrangle Map, Biscoe, NC (1984)

Denson's Creek: *Permitting*

- NEPA (USFWS In-house)
- Forest road crossing exemption 404 (f)
- Fish enhancement structures - NWP 27
- NCDWR 401 Water Quality Certification
- Intra-Service Section 7 and State clearing house review
- USFS Decision Memo
- Sect 106 NHPA and NRHP

Project Objectives: *Triple Bottom Line*

1. Restore aquatic organism passage, re-open historical habitat by removing total barrier (physical & velocity)
2. Facilitate crossing for silvicultural practices for timber extraction
3. Provide educational opportunities for the community

Evaluating Alternative Solutions

- **MCDA:** ***Multiple-Criteria Decision Analysis***
- Consider stakeholder input & implementation factors (constraints, cost, timing, practicality)
- Evaluate alternatives based on **Objectives**:
    - *Risk Management* (Safety, Infrastructure, Flooding)
    - *Ecosystem Functions* (Habitats, Water Quality, Floodplains, Buffer)
    - *Stream Stability* (Streambanks, Equilibrium, Sed Trans)
    - *Community* (Stormwater, Aesthetics, Access & Education)

International Society on MCDM

Multiple Criteria Decision Making

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Results of the Elections in 2017

Call for Papers: European Journal for Decision Processes

Call for Papers: IJITDM

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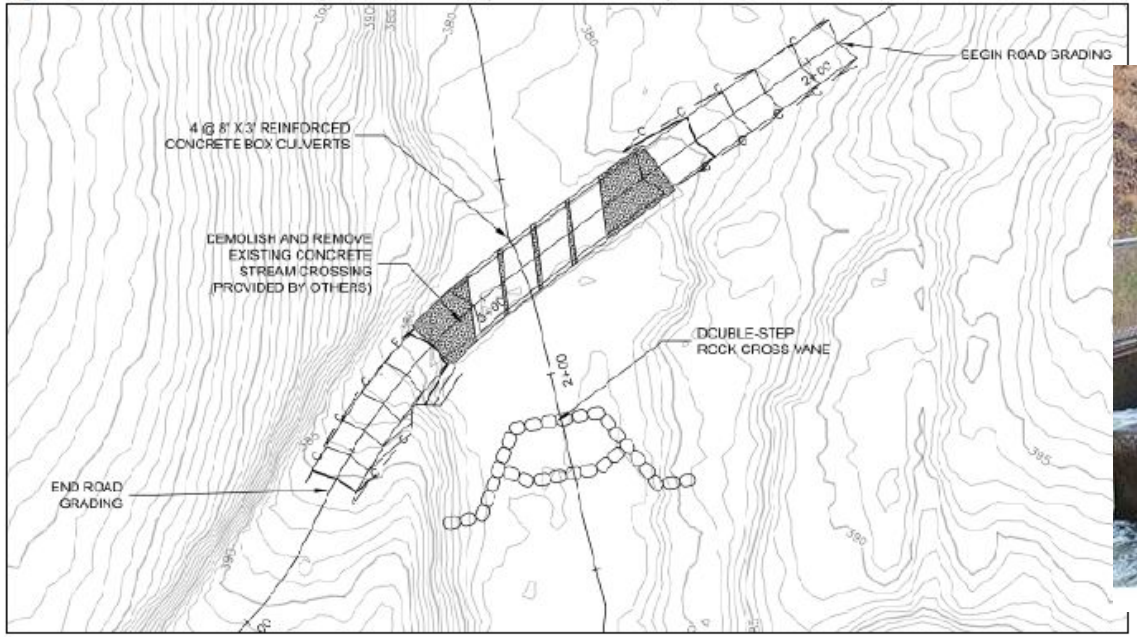
Evaluating Alternative Solutions

- **Alternative 1** - Removing existing concrete structure and replacing with low-profile reinforced concrete box culvert and installing in-stream rock grade-control structures to raise the stream profile.
- **Alternative 2** - Removing existing concrete structure and replacing with a wet rock ford crossing using in-stream rock grade-control structure to raise the stream profile.
- **Alternative 3** - Retrofit of the existing concrete structure
- **Alternative 4** - Spanning Denson Creek with a bridge structure

Figure 1: Alternative 1 Culvert Replacement Concept Plan View Excerpt



www.alamy.com - C4366D

Multiple-Criteria Decision Analysis (MCDA)

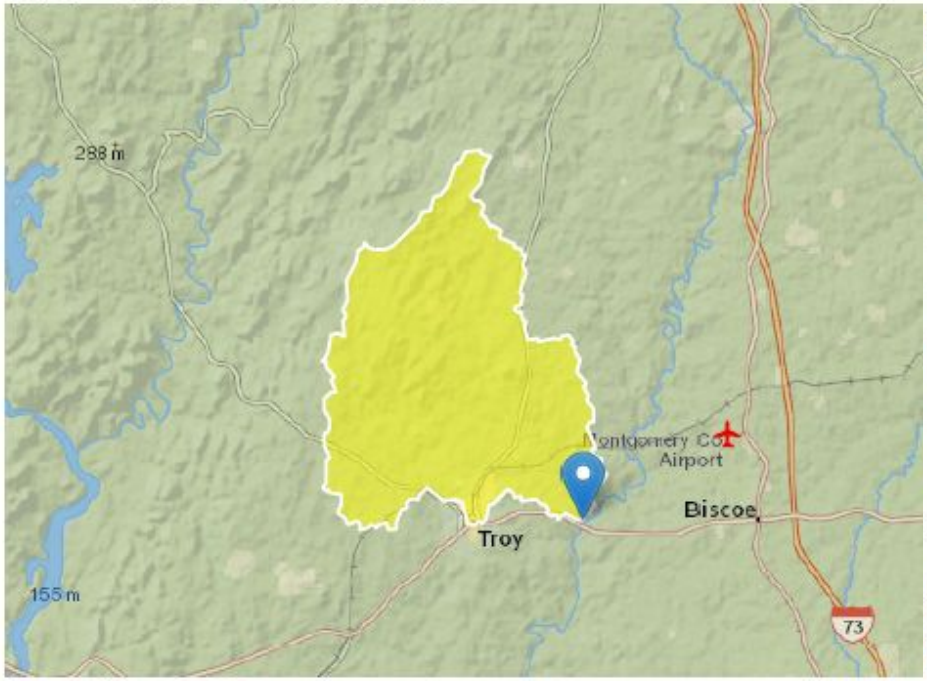
Multi-Criteria Decision Analysis (MCDA): Densons Creek Fish Passage Barrier Removal, Troy, NC	Risk Management Objectives			Ecosystem Function Objectives				Stream Stability Objectives			Community Objectives			For each objective, enter its weighting factor from 0 to 3; For each option, enter the score reflecting its potential to achieve each objective from 0 to 5; Do not enter values into shaded cells.					
	Safety	Infrastructure Protection	Flooding	Aquatic Habitats	Water Quality	Floodplain Functions	Native Riparian Buffer	Streambank Stability	Natural Equilbrium Channel	Balanced Shear Stresses	Watershed Protection	Aesthetics	Access and Education					
Objective Weighting Factor (0 to 3)	3	3	3	3	2	2	2	2	2	2	2	2	2	Length of Project (ft)	Cost Estimate ($)	Unit Cost ($/ft)	MCDA Matrix Score	MCDA Score per $	MCDA Rank
Option 1. Concrete Box Culvert	5	5	3	4	4	3	3	3	2	2	4	1	3	80	$ 190,000	$ 2,375	101	0.04	4
Option 2. Wet Ford Crossing	5	5	3	5	4	5	4	4	4	4	5	4	3	80	$ 80,000	$ 1,000	128	0.13	1
Option 3. Retrofit Existing Structure	5	5	3	3	4	3	5	3	2	2	3	1	3	80	$ 100,000	$ 1,250	100	0.08	2
Option 4. Bridge	5	5	1	5	4	4	5	3	3	3	3	2	3	80	$ 150,000	$ 1,875	108	0.06	3

Denson's Creek: *Design Parameters*

- Bankfull Q = 800 cfs
- Bankfull A = 160 sq ft

Densons Creek StreamStats Report

Region ID: NC
Workspace ID: NC20180810181816259000
Clicked Point (Latitude, Longitude): 35.35939, -79.85222
Time: 2018-08-10 14:18:31 -0400



Peak-Flow Statistics Parameters [Peak Southeast US over 1 sqmi 2009 5158]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	34.8	square miles	1	9000
PCTREG1	Percent Area in Region 1	100	percent	0	100
PCTREG2	Percent Area in Region 2	0	percent	0	100
PCTREG3	Percent Area in Region 3	0	percent	0	100
PCTREG4	Percent Area in Region 4	0	percent	0	100
PCTREG5	Percent Area in Region 5	0	percent	0	100

Peak-Flow Statistics Flow Report [Peak Southeast US over 1 sqmi 2009 5158]

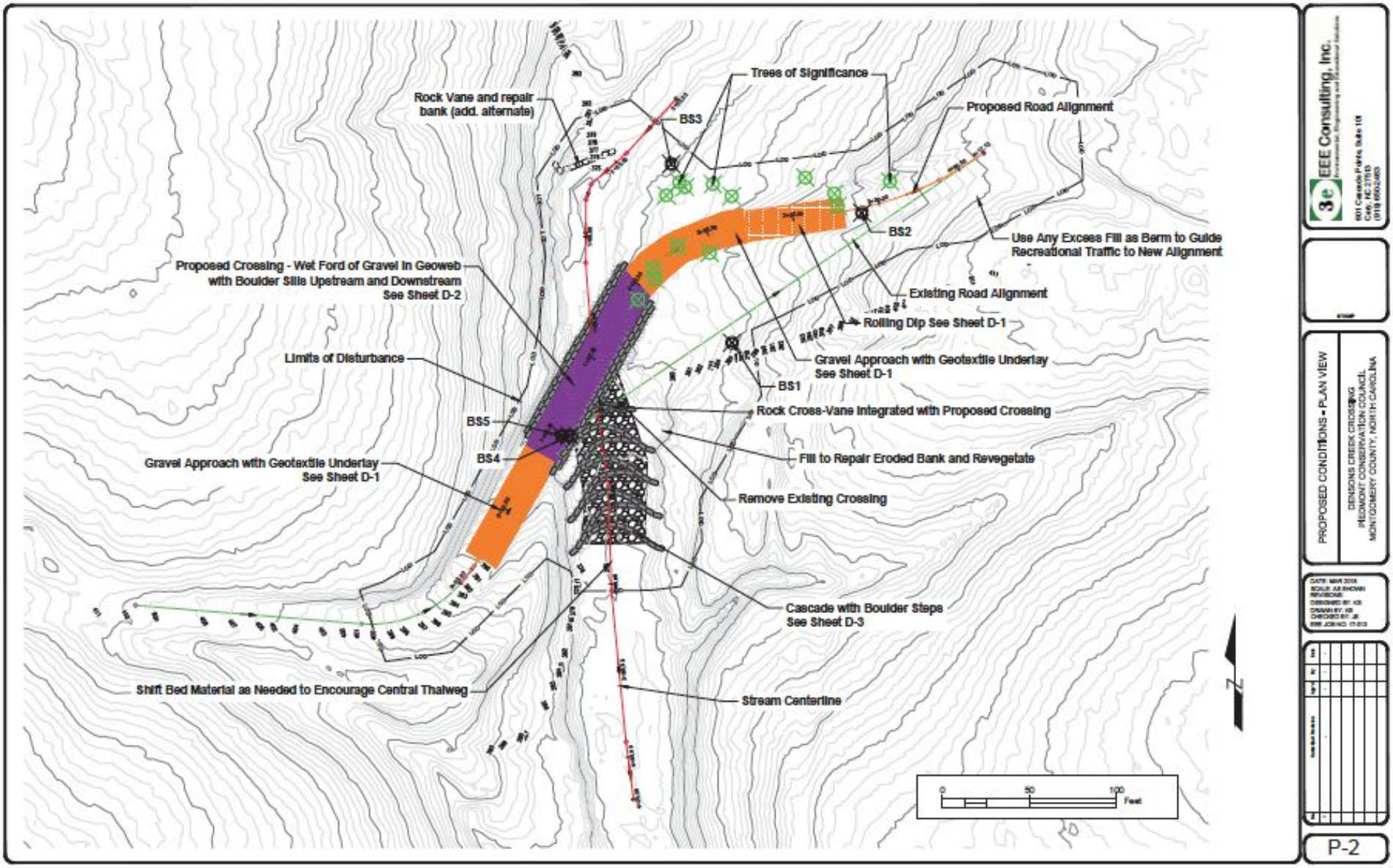
PII: Prediction Interval-Lower, Plu: Prediction Interval-Upper, SEp: Standard Error of Prediction, SE: Standard Error (other -- see report)

Statistic	Value	Unit	PII	Plu	SEp
2 Year Peak Flood	1590	ft^3/s	915	2750	34.5
5 Year Peak Flood	2730	ft^3/s	1590	4700	34
10 Year Peak Flood	3560	ft^3/s	2030	6220	35.1
25 Year Peak Flood	4620	ft^3/s	2550	8360	37.5
50 Year Peak Flood	5560	ft^3/s	2970	10400	39.6
100 Year Peak Flood	6390	ft^3/s	3310	12400	41.9
200 Year Peak Flood	7210	ft^3/s	3600	14400	44.3
500 Year Peak Flood	8490	ft^3/s	4040	17800	47.7

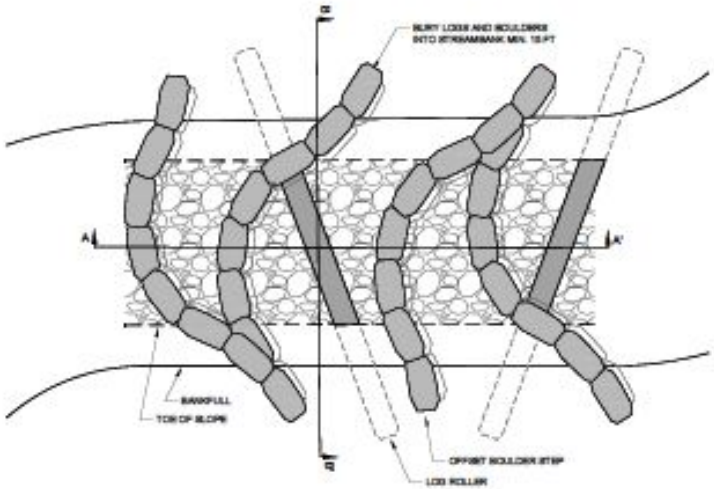
Peak-Flow Statistics Citations

Weaver, J.C., Feaster, T.D., and Gotvald, A.J.,2009, Magnitude and frequency of rural floods in the Southeastern United States, through 2006—Volume 2, North Carolina: U.S. Geological Survey Scientific Investigations Report 2009–5158, 111 p. (http://pubs.usgs.gov/sir/2009/5158/)

Design Plan: *EEE Consulting*



Constructed Cascade Riffle with Drops < 0.4 ft



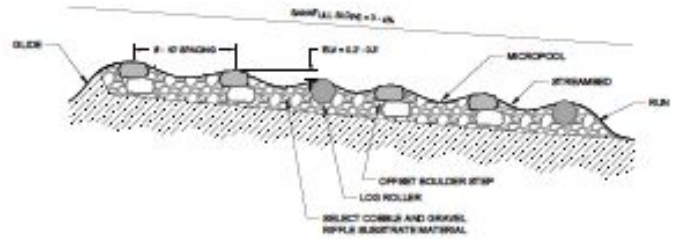
CASCADE WITH BOULDER STEPS AND LOGS NOT TO SCALE

DETAILED PLAN

CASCADE WITH BOULDER STEPS AND LOGS

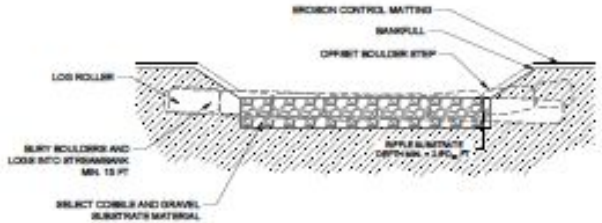
NOTES

1. THE CASCADE STRUCTURE WITH OFFSET BOULDER STEPS AND LOG ROLLERS IS A STREAM AND RIVER RESTORATION DESIGN FEATURE THAT INCORPORATES COARSE MATERIAL SUBSTRATE MATERIAL, BOULDERS AND LARGE WOOD (LOGS) IN THE CHANNEL BOTTOM THAT WILL NOT BE MOBILIZED UNDER DEFINED FLOW CONDITIONS. REPLACING (OR ADDING TO) THE NATIVE CHANNEL BED MATERIAL WITH LARGER DIAMETER ROCK AND LARGE WOOD CREATES A RIFFLE THAT FUNCTIONS AS A RIGID GRADE CONTROL AND HABITAT FEATURE. LARGER ROCK MATERIAL AND WOOD ENHANCES FLOW DIVERSITY AND TURBULENCE UNDER BASE FLOW CONDITIONS, WHICH PROMOTES AQUATIC HABITAT, NUTRIENT PROCESSING AND RE-AERATION OF STREAM FLOW BENEFITING WATER QUALITY. THE D_{84}, D_{95}, D_{96} OR D_{100} PARTICLES OF THE CONSTRUCTED MAY BE DESIGNED TO RESIST I_{bkf} WHILE ALLOWING SMALLER SUBSTRATE PARTICLES TO BE MOBILIZED AND REPLACED BY UPSTREAM SEDIMENT SEDIMENT SUPPLY. THIS STRUCTURE MAY BE USED IN RIFFLES WITH STEEPER SLOPES AS A GRADE CONTROL.
2. ALL SELECT RIFFLE MATERIAL SHALL BE QUARRIED STONE UNLESS NATIVE MATERIAL OF SIMILAR SIZE IS AVAILABLE ONSITE AND MEETS THE CONSTRUCTED RIFFLE SIZE SPECIFICATIONS. THE ENGINEER MUST APPROVE THE USE OF ALL ONSITE NATIVE MATERIAL.
3. THE GRAVEL AND COBBLE SUBSTRATE USED FOR THIS DESIGN FEATURE SHOULD BE PREFERENTIALLY HARVESTED FROM THE EXISTING CHANNEL AND OTHER DESIGNATED MINING AREAS ONSITE.
4. SORTING AND SIEVING OF THE HARVESTED RIFFLE SUBSTRATE IS INCIDENTAL TO THE CONSTRUCTION OF THIS STRUCTURE.
5. LOGS SHALL HAVE MINIMUM DIAMETER OF 2.0 FT. LOGS SHALL HAVE A MINIMUM LENGTH OF W_{bkf} + 30 FEET.
6. ALL LOGS SHALL BE RELATIVELY STRAIGHT AND LIMBS AND BRANCHES SHALL BE TRIMMED FLUSH.
7. FOR INSTALLATION, THE CONTRACTOR SHALL OVER EXCAVATE THE LENGTH OF THE CASCADE, INSTALL 700 GRAM COIR FIBER EROSION CONTROL MATTING, KEY MATTING INTO THE RIFFLE TRENCH AND BACKFILL WITH THE SPECIFIED SELECT RIFFLE MATERIAL TO THE ELEVATIONS SHOWN ON THE PROPOSED PROFILE.
8. CONSTRUCTED RIFFLE MATERIAL SHALL EXTEND A MINIMUM OF 15 FT U/S OF THE P.T. INTO THE GLIDE AND D/S TO THE P.C.
9. P.T. AND P.C. STATIONS AND ELEVATIONS ARE INCLUDED IN THE PROPOSED PLAN AND PROFILE SHEETS. SET RIFFLE INVERTS AT ELEVATION SHOWN ON THE PLAN AND PROFILE SHEETS. NO ELEVATIONS OF THE CONSTRUCTED RIFFLE WITH LOG ROLLERS MAY VARY FROM THE PLAN SHEETS WITHOUT DIRECTION FROM THE ENGINEER.
10. THE VERTICAL SLOPE OF EACH LOG AND BOULDER ARM SHALL NOT EXCEED 2% UNLESS OTHERWISE DIRECTED BY THE ENGINEER. THE SLOPES WILL BE DICTATED BY THE WIDTH TO DEPTH RATIO OF THE REACH, TYPICAL RIFFLE INNER BERM CHANNEL, AND THE VERTICAL DROP OVER THE LOG AND LOG DIAMETER.
11. THE MAXIMUM DISTANCE BETWEEN LOG AND BOULDER SHALL BE 8 - 10 FT. MAXIMUM ELEVATION DROP BETWEEN LOGS SHALL BE 0.2 - 0.3 FT OF THE LOG DIAMETER.
12. SELECT RIFFLE MATERIAL SHALL BE USED AS BACKFILL MATERIAL AROUND THE STRUCTURE.
13. SECURE ALL GEOTEXTILE FABRIC ON TOP OF FOOTER LOG USING 3 IN 10D GALVANIZED COMMON NAIL ON 12 IN SPACING ALONG LOG. NAIL NON-WOVEN GEOTEXTILE TO EDGE OF HEADER LOG AND BACKFILL.
14. SELECT RIFFLE MATERIAL DEPTH SHALL BE AT LEAST 2.5 TIMES THE D_{84} (MM) SPECIFIED BY THE ENGINEER.
15. SELECT RIFFLE MATERIAL WILL BE PLACED AT A UNIFORM THICKNESS.
16. THE SELECT RIFFLE MATERIAL WILL BE PLACED SUCH THAT, IN CROSS-SECTION, ITS LOWEST ELEVATION OCCURS IN THE CENTER OF THE CHANNEL AS PER THE DETAIL.
17. SELECT RIFFLE MATERIAL SHALL BE COMPACTED USING TRACK EQUIPMENT OR AN EXCAVATOR BUCKET SUCH THAT FUTURE SETTLEMENT OF THE MATERIAL IS KEPT TO A MINIMUM.
18. THE SURFACE OF THIS STRUCTURE SHALL BE FINISHED TO A SMOOTH AND COMPACT SURFACE IN ACCORDANCE WITH THE LINES, GRADES, AND CROSS-SECTIONS OR ELEVATIONS SHOWN ON THE DRAWINGS. THE DEGREE OF FINISH FOR INVERT ELEVATIONS SHALL BE WITHIN 0.1 FT OF THE GRADES AND ELEVATIONS INDICATED.
19. RE-GRESSING OF CHANNEL AND BANKFULL BENCH/FLOODPLAIN WILL LIKELY BE REQUIRED FOLLOWING INSTALLATION OF IN-STREAM STRUCTURES AND SHALL BE CONSIDERED INCIDENTAL TO CONSTRUCTION.



CASCADE WITH BOULDER STEPS AND LOGS NOT TO SCALE

DETAILED CROSS-SECTION A - A'



CASCADE WITH BOULDER STEPS AND LOGS NOT TO SCALE

DETAILED CROSS-SECTION B - B'

Implementation:
April - *May, 2018*

1. Demolition of existing structure by USFWS SE Aquatic Restoration Team
2. Installation of wet ford and rock cascade by NSE

Wet Ford Construction: *North State Environmental*

1. 5 days working in base flow
2. 400 tons rock to create ford and downstream cascade

Final Product:

Safe wet ford crossing that supports fish passage

Lessons Learned

- Stakeholder engagement requires buy-in from all involved parties
- Working within constraints requires creativity and thoughtful analysis
- Communication is essential throughout planning and implementation

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