GEORGIA DOT RESEARCH PROJECT 18-06

FINAL REPORT

REVIEW OF SPECIAL PROVISIONS AND OTHER CONDITIONS PLACED ON GDOT PROJECTS FOR IMPERILED SPECIES PROTECTION

VOLUME II

Georgia Department of Transportation

OFFICE OF PERFORMANCE-BASED MANAGEMENT AND RESEARCH

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ATLANTA, GA 30308

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7. Author(s):
Jace M. Nelson, Timothy A. Stephens, Robert B. Bringolf, Jon Calabria, Byron J. Freeman, Katie S. Hill, William H. Mattison, Brian P. Melchionni, Jon W. Skaggs, R. Alfie Vick, Brian P. Bledsoe, (https://orcid.org/0000-0002-0779-0127), Seth J. Wenger (https://orcid.org/0000-0001-7858-960X)

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Odum School of Ecology
University of Georgia
140 E. Green Str.
Athens, GA 30602
208-340-7046 or 706-542-2968
swenger@uga.edu

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600 West Peachtree St. NW
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Georgia has numerous protected freshwater species, which means that the Georgia Department of Transportation (GDOT) must frequently consult with federal and state agencies to identify measures to avoid, minimize and mitigate impacts to imperiled aquatic organisms. Some of these measures, such as restrictions on in-water work during the reproductive season, impose substantial costs on GDOT projects, but their efficacy has not been thoroughly evaluated. The current system also provides limited flexibility. The research team has developed a system for assessing the impact of road construction projects on imperiled freshwater species that accounts for project characteristics, site characteristics, and species sensitivity. Called the "Total Effect Score" (TES), it is based on a comprehensive assessment of the tolerances and traits of 111 freshwater species and a thorough review of the literature on the efficacy of construction and post-construction BMPs. It employs a risk-based system to assess construction-phase effects and post-construction effects over a 50-year time horizon, making it possible to identify tradeoffs among alternative management practices. Additionally, the research team developed a template for a programmatic agreement (PA) that uses the TES as the basis for a streamlined system for evaluating projects. The PA is intended to cover both informal and formal consultation under a single system, which should reduce consultation time and increase predictability. To support the adoption of the PA, the research team conducted a biological assessment of all species. Adoption of the PA and the TES system should provide substantial cost savings for GDOT while improving outcomes for federally and state protected freshwater species.

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GDOT Research Project 18-06

Final Report

REVIEW OF SPECIAL PROVISIONS AND OTHER CONDITIONS PLACED ON GDOT PROJECTS FOR IMPERILED AQUATIC SPECIES PROTECTION

VOLUME II

By

Seth J. Wenger, Associate Professor
Brian P. Bledsoe, Professor
Jace M. Nelson, Research Professional
Timothy A. Stephens, Graduate Student
Robert B. Bringolf, Associate Dean
Jon Calabria, Associate Professor
Byron J. Freeman, Senior Public Service Associate
Katie S. Hill, Research Professional
William H. Mattison, Graduate Student
Brian P. Melchionni, Graduate Student
Jon W. Skaggs, Graduate Student
R. Alfie Vick, Professor

University of Georgia Research Foundation, Inc.

Contract with
Georgia Department of Transportation

In cooperation with
U.S. Department of Transportation Federal Highway Administration

January 2021

SI* (MODERN METRIC) CONVERSION FACTORS

APPROXIMATE CONVERSIONS TO SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
in	inches	25.4	millimeters	mm
ft	feet	0.305	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km
		AREA		
in^2	square inches	645.2	square millimeters	mm^2
ft^2	square feet	0.093	square meters	m^2
yd^2	square yard	0.836	square meters	m^2
ac	acres	0.405	hectares	ha
mi^2	square miles	2.59	square kilometers	km^2
		VOLUME		
fl oz	fluid ounces	29.57	milliliters	mL
gal	gallons	3.785	liters	L
ft^3	cubic feet	0.028	cubic meters	m^3
yd^3	cubic yards	0.765	cubic meters	m^3
		NOTE: volumes greater than 1000 L shall be shown in m^3		
		MASS		
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams (or "metric ton")	Mg (or "t")
		TEMPERATURE (exact degrees)		
^oF	Fahrenheit	5 (F-32)/9 or (F-32)/1.8	Celsius	^oC
		ILLUMINATION		
fc	foot-candles	10.76	lux	lx
fl	foot-Lamberts	3.426	candela/m^2	cd/m^2
		FORCE and PRESSURE or STRESS		
lbf	poundforce	4.45	newtons	N
lbf/in^2	poundforce per square inch	6.89	kilopascals	kPa

APPROXIMATE CONVERSIONS FROM SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
mm	millimeters	0.039	inches	in
m	meters	3.28	feet	ft
m	meters	1.09	yards	yd
km	kilometers	0.621	miles	mi
		AREA		
mm^2	square millimeters	0.0016	square inches	in^2
m^2	square meters	10.764	square feet	ft^2
m^2	square meters	1.195	square yards	yd^2
ha	hectares	2.47	acres	ac
km^2	square kilometers	0.386	square miles	mi^2
		VOLUME		
mL	milliliters	0.034	fluid ounces	fl oz
L	liters	0.264	gallons	gal
m^3	cubic meters	35.314	cubic feet	ft^3
m^3	cubic meters	1.307	cubic yards	yd^3
		MASS		
g	grams	0.035	ounces	oz
kg	kilograms	2.202	pounds	lb
Mg (or "t")	megagrams (or "metric ton")	1.103	short tons (2000 lb)	T
		TEMPERATURE (exact degrees)		
^oC	Celsius	1.8C+32	Fahrenheit	^oF
		ILLUMINATION		
lx	lux	0.0929	foot-candles	fc
cd/m^2	candela/m^2	0.2919	foot-Lamberts	fl
		FORCE and PRESSURE or STRESS		
N	newtons	0.225	poundforce	lbf
kPa	kilopascals	0.145	poundforce per square inch	lbf/in^2

* SI is the symbol for the International System of Units. Appropriate rounding should be made to comply with Section 4 of ASTM E380. (Revised March 2003)

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PREFACE/EXECUTIVE SUMMARY

Georgia has well over a hundred protected freshwater species, which means that the Georgia Department of Transportation (GDOT) must frequently consult with federal and state agencies to identify measures to avoid, minimize and mitigate impacts to imperiled aquatic organisms. Some of these measures, such as restrictions on in-water work during the reproductive season, impose substantial costs on GDOT projects. There is a need for an assessment of the efficacy of these and other potential measures, an assessment of the sensitivities of the various imperiled taxa, and a system to provide the flexibility for GDOT to employ the most effective measures for a given project, location and species.

To meet this need, the research team has developed a system for assessing the impact of road construction projects on imperiled freshwater species that accounts for project characteristics, site characteristics, and species sensitivity. Called the "Total Effect Score" (TES), it is based on a comprehensive assessment of the tolerances and traits of 111 freshwater species and a thorough review of the literature on the efficacy of construction and post-construction best management practices. It employs an innovative, risk-based system to assess both direct and indirect construction-phase effects and post-construction effects over a 50-year time horizon, making it possible to identify tradeoffs among alternative management practices. For example, the system allows the user to compare the benefit of timing restrictions versus improved stormwater management practices, providing a great deal of flexibility to identify the most appropriate and cost-effective management tools. The system is implemented with a user-friendly Excel tool designed to use readily available inputs and provide outputs in the form needed to support existing systems.

Additionally, the research team developed a template for a programmatic agreement (PA) that uses the TES as the basis for a streamlined system for evaluating GDOT projects. The programmatic agreement is intended to cover both informal and formal consultation under a single system, which should substantially reduce consultation time and increase predictability. To support the adoption of the PA, the research team has also conducted a biological assessment of all 111 species, which was reviewed by a panel of 13 external experts. The actual PA and supporting biological opinion will need to be drafted by the US Fish and Wildlife Service, in cooperation with GDOT and other state and federal agencies, but the research team has supplied all of the essential information for preparing the official documents. The research team believes that adoption of the PA and the TES system will provide substantial cost savings for GDOT while improving outcomes for federally and state protected freshwater species.

This volume is the second in a series. The other volumes in the series are *Review of Special Provisions and Other Conditions Placed on GDOT Projects for Imperiled Species Protection Volume I, III and IV.*

APPENDIX A: DETAILS OF CONSTRUCTION PHASE BMP LEVEL DETERMINATION

CONSTRUCTION ACTIVITIES AND THEIR POTENTIAL IMPACT TYPES

There are 77 construction activities that were assumed to be representative of the construction activities anticipated for GDOT projects. These construction activities were provided by GDOT. Each activity was reviewed and the potential impact types that might result from that activity were identified. A detailed table of the impacts associated with each construction activity is included below.

Table A1. Potential impact types associated with construction activities.

Activity	Sediment	Contaminants	Altered Hydrology or Connectivity	Physical Contact	Noise
Barges		X		X	X
Barriers					
Bird netting					
Blasting	X	X		X	X
Borrow pits	X	X		X	X
Bridge, bent / pile / footer removal	X		X	X	X
Bridge, cathodic protection		X			
Bridge, co-polymer overlay		X			
Bridge, drilled shafts	X	X		X	X
Bridge, driven piles	X		X	X	X
Bridge, jacking	X			X	

Bridge, joint replacement / modification				X	
Bridge, pile (carbon fiber wraps)	X	X		X	
Bridge, pile encasing	X	X		X	
Bridge, seismic repair				X	
Bridge, steel maintenance		X			
Concrete		X		X	
Construction debris removal	X	X		X	
Containment device	X		X		
Culvert, cleaning / refurbishing	X	X	X	X	
Culvert, construction	X	X	X	X	
De-watering	X	X	X	X	
Ditch, modification	X		X		
Drainage structures, curb and gutter			X		
Drainage structures, installation	X		X		
Drift / debris removal	X	X		X	
Dust control		X			
Earthwork	X		X		
Epoxy injection		X			
Erosion control BMPs, permanent	X	X			
Erosion control BMPs, temporary	X	X			
Falsework	X		X	X	
Fencing					
Gabion baskets / mattresses	X	X	X	X	
Grading	X	X			
Haul road / temporary work road	X	X			
Heavy equipment / vehicle use	X	X		X	??
Herbicide		X			
Hydrodemolition	X	X		X	
In water, coffer dams / porta-dams	X	X	X	X	

In water, jetty	X	X	X	X	
In water, rip rap	X	X	X	X	
Landscaping	X				
Lighting					
Metalizing		X			
Painting		X			
Piping, permanent	X		X		
Piping, temporary	X		X		
Pressure washing		X			
Rip rap / rock		X	X	X	
Road, milling		X		X	
Road, pavement rehab		X			
Road, resurfacing		X			
Road, shoulder maintenance		X			
Sandblasting		X			
Scaffolding					
Sidewalk installation	X				
Sign installation / replacement					
Slash piles, burning					
Spall repair		X		X	
Staging area	X	X			
Stream modification or relocation, permanent	X	X	X	X	
Stream modification or relocation, temporary	X	X	X	X	
Striping and pavement markers					
Structure, construction non-bridge / non-culvert	X	X		X	
Structure, demolition non-bridge / non-culvert	X	X		X	
Surveys					
Trails, pedestrian / bike					
Utilities, above ground	X				

Utilities, below ground	X			X	
Vegetation removal, herbaceous	X				
Vegetation removal, tree branch					
Vegetation removal, trees	X			X	
Walls	X		X	X	
Wetland access mats					
Wetland fill	X	X	X		

BMP LEVEL DECISION TREES

The decision trees developed to determine the level of protection from construction phase BMPs are provided below. The decision trees follow an evaluation which determines the level of protection provided and identifies required BMPs based on responses to project specific characteristics. Decision trees for impacts derived from upland sediment are used to determine the E&S BMP level in the SES calculation. However, the decision trees for instream sediment impacts and non-sediment impacts (e.g. contaminants) identify minimum required BMPs based on applied construction activities and species sensitivity.

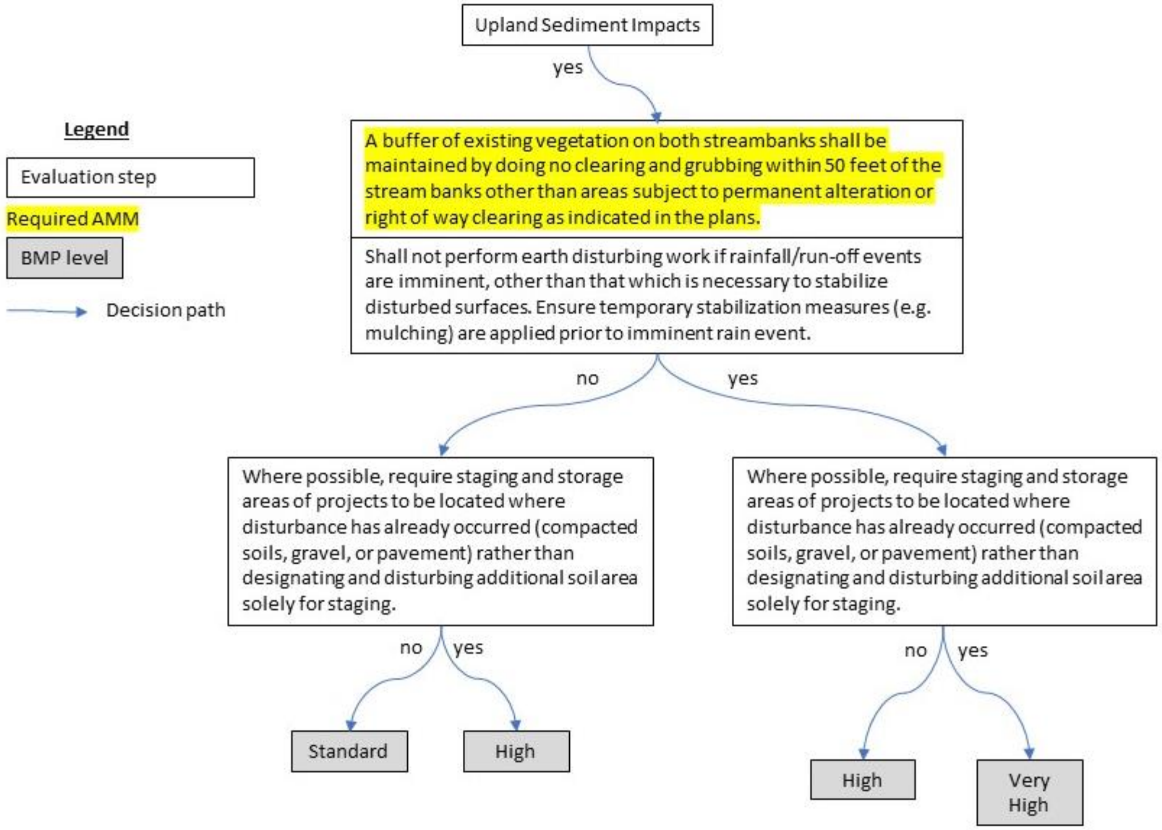


Figure A1 (a). Diagram. Construction phase activity restriction BMPs related to erosion and sediment control.

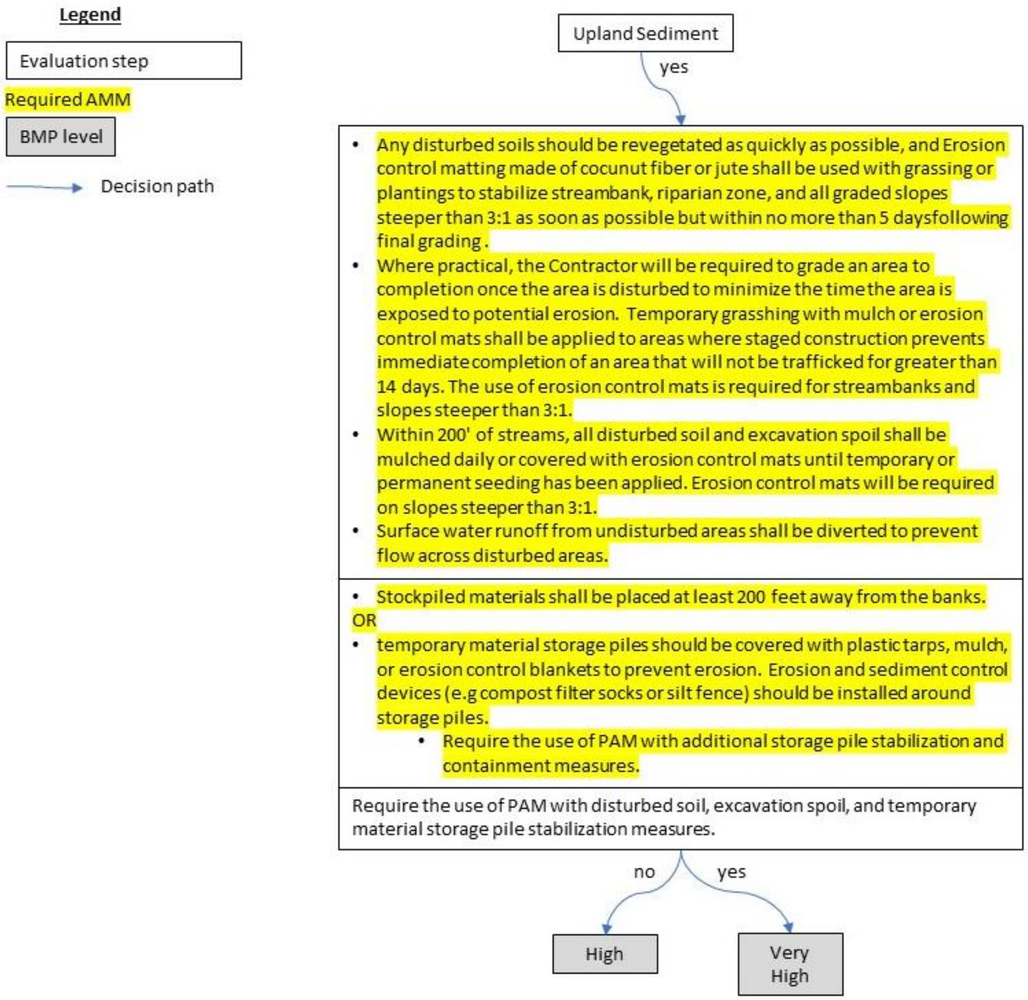


Figure A1 (b). Diagram. Construction phase source prevention BMPs related to erosion and sediment control.

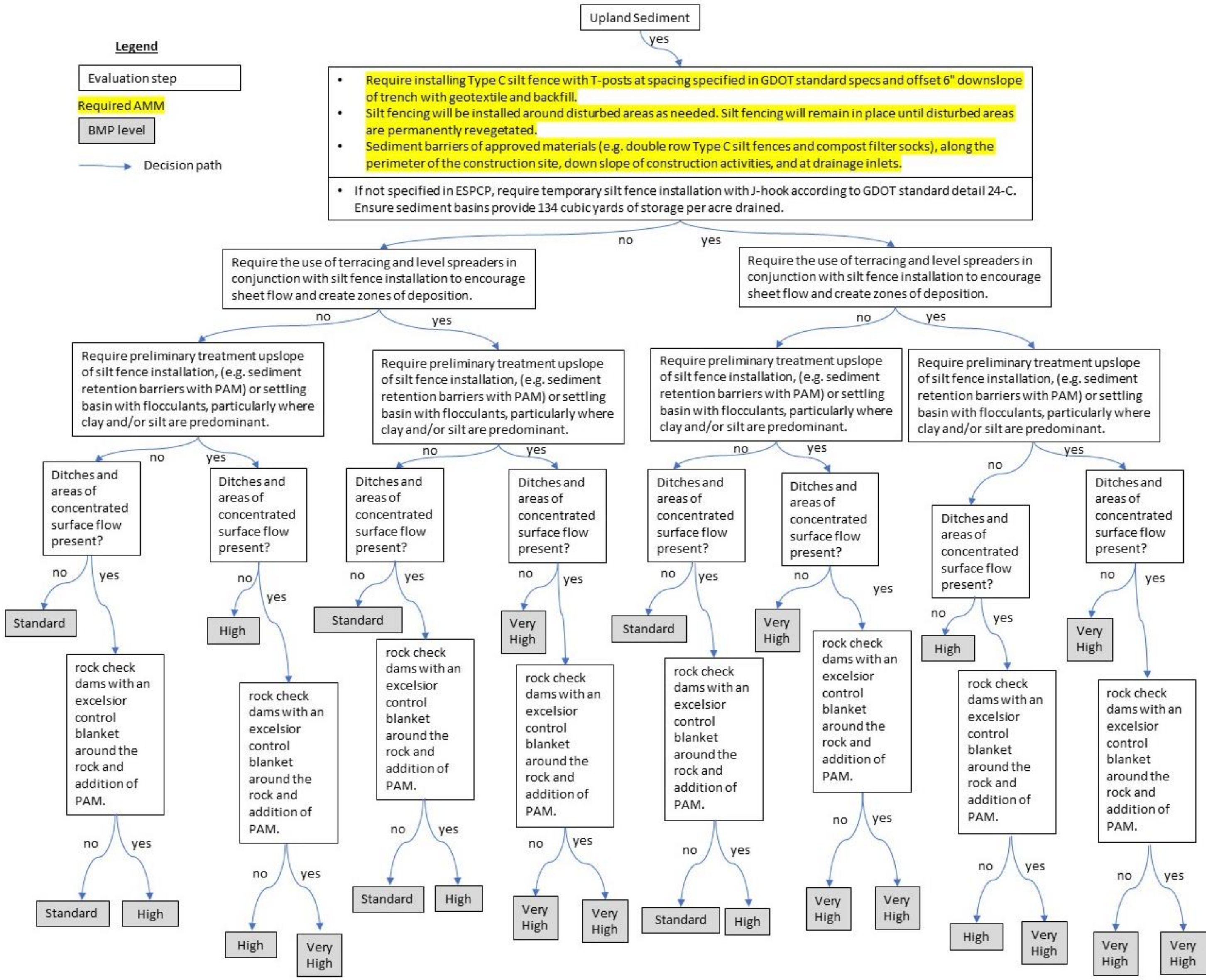


Figure A1 (c). Diagram. Construction phase interception BMPs related to erosion and sediment control.

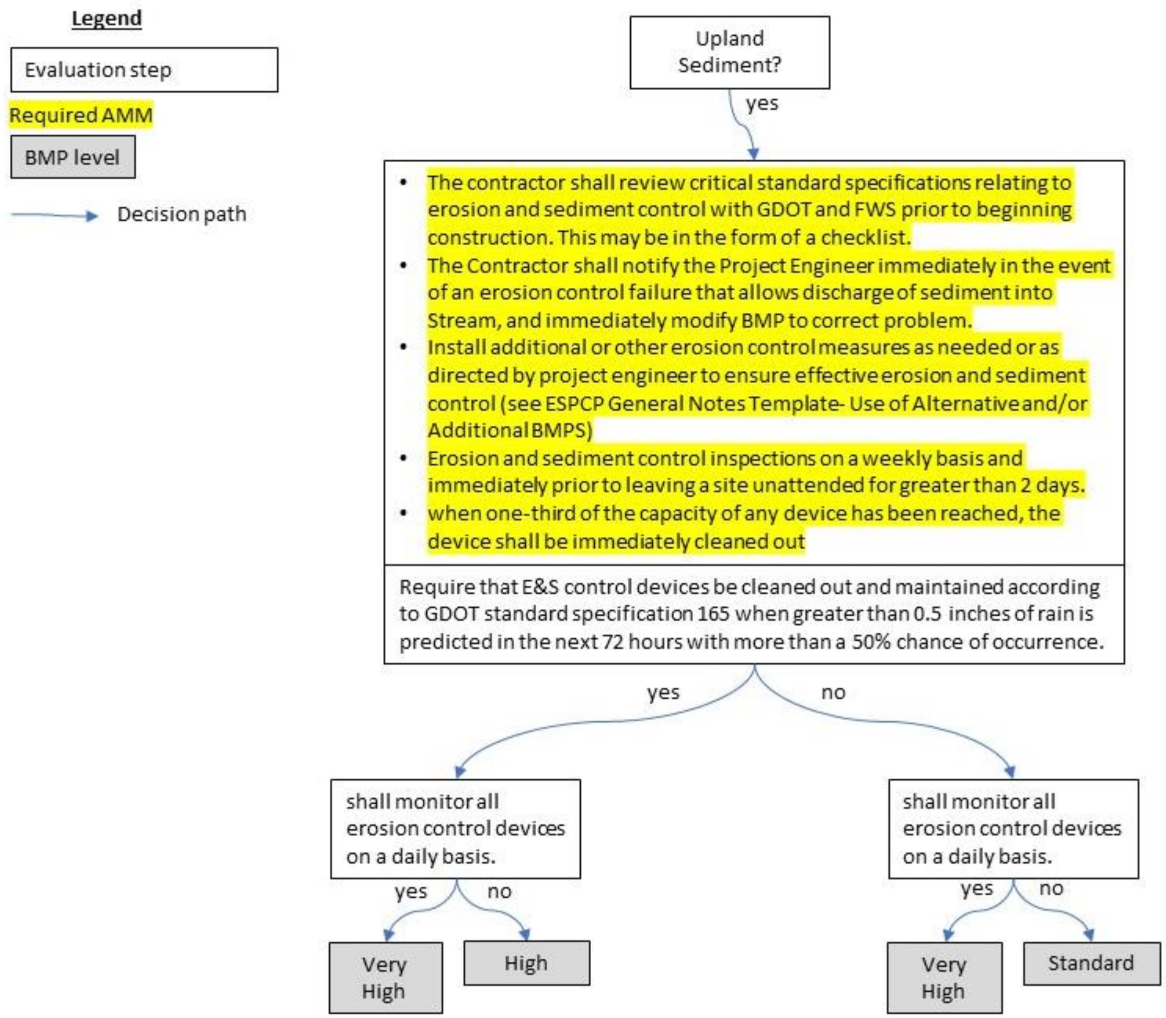


Figure A1 (d). Diagram. Construction phase monitoring and maintenance BMPs related to erosion and sediment control.

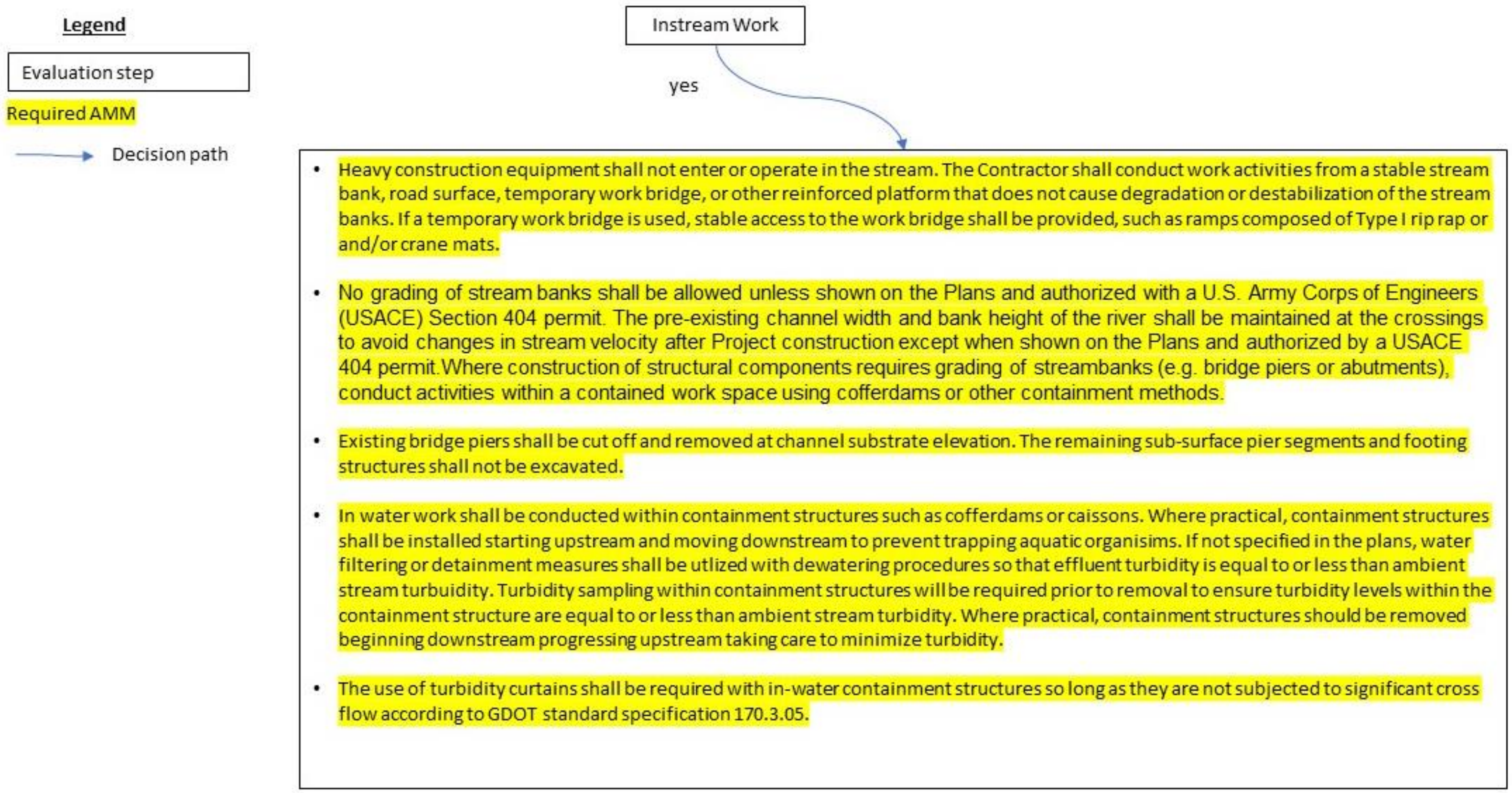


Figure A1 (e). Diagram. Construction phase sediment BMPs related to instream work.

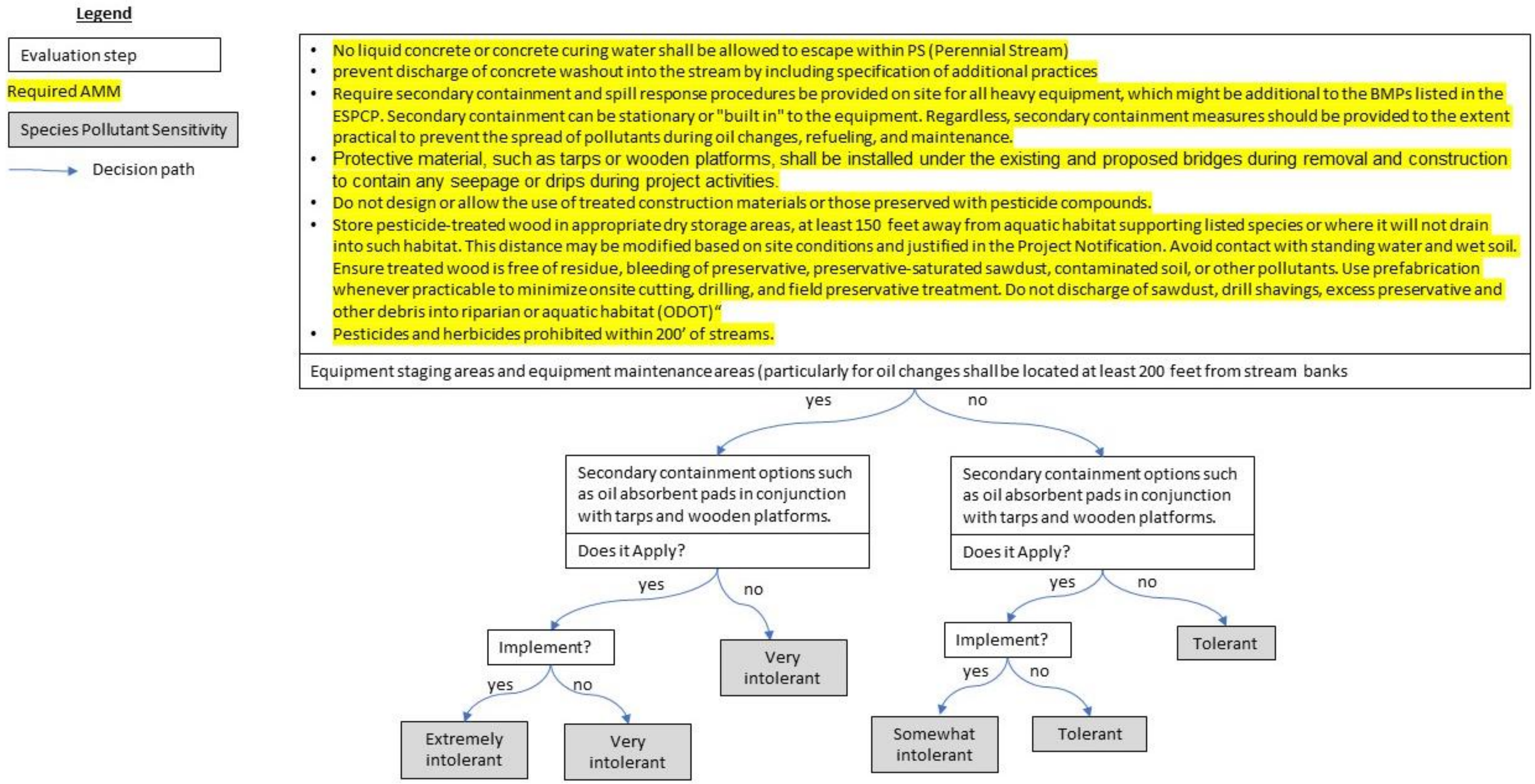


Figure A1 (f). Diagram. Construction phase BMPs related to the control of contaminants. Pollutant sensitivities indicate the most sensitive species allowed to be covered by a particular set of AMMs.

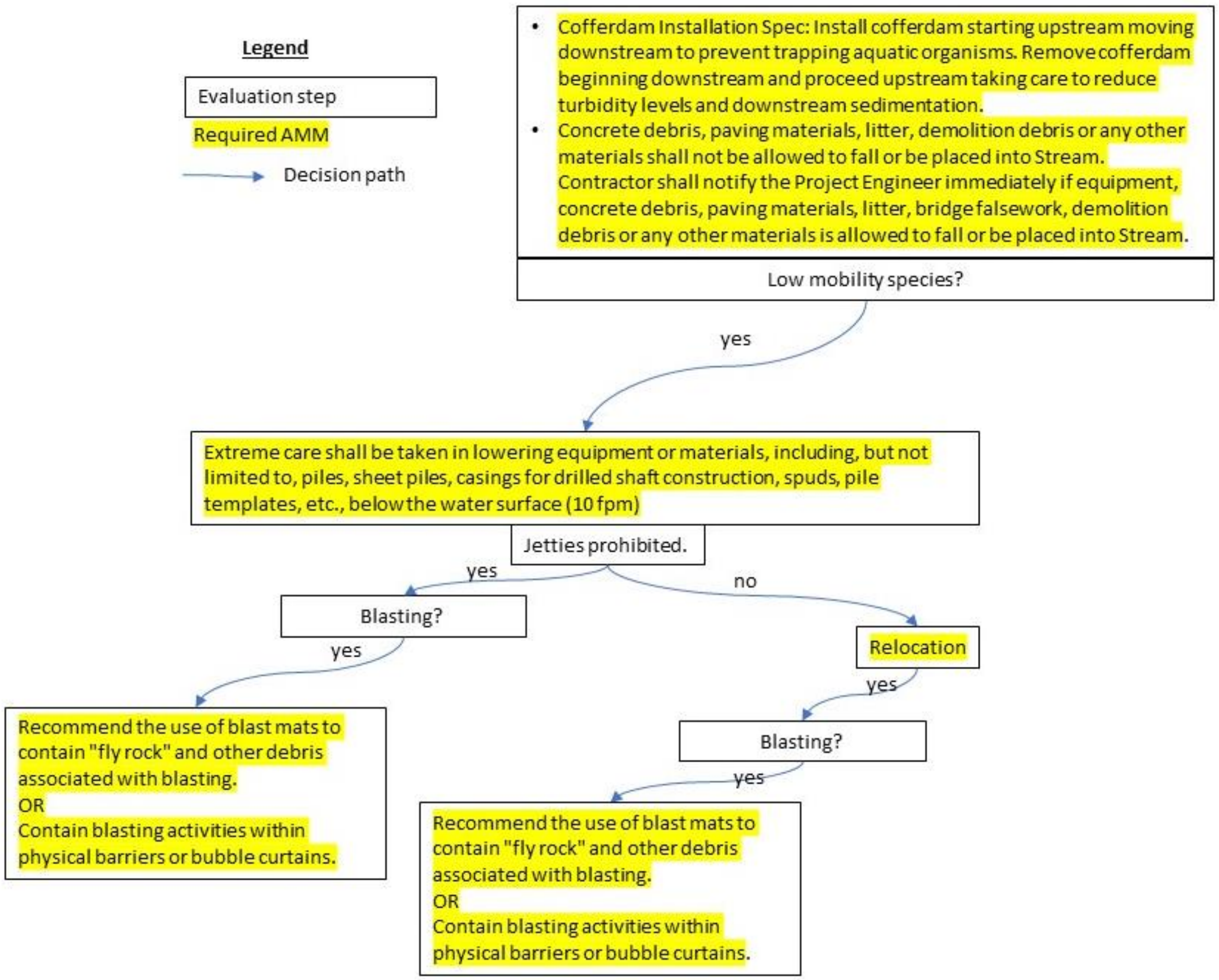


Figure A1 (g). Diagram. Construction phase BMPs to reduce physical contact impacts.

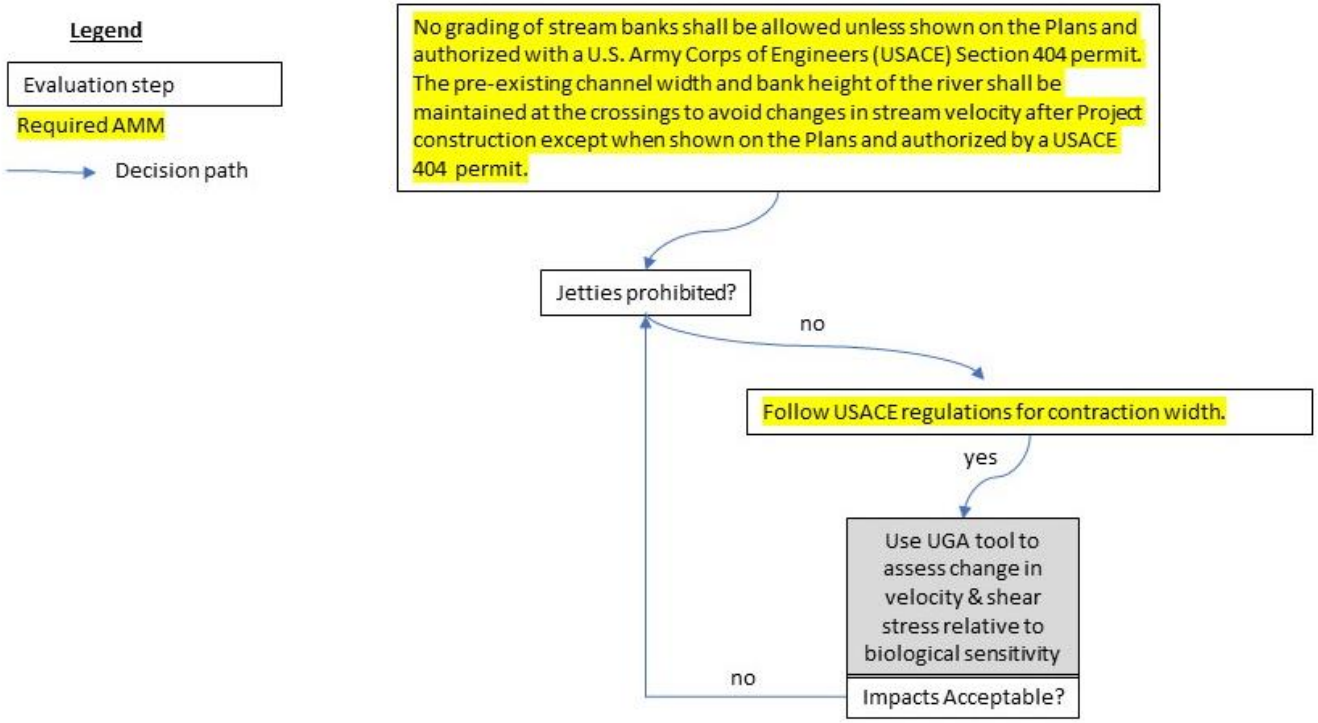


Figure A1 (h). Diagram. Construction phase BMPs to reduce altered hydrology/connectivity impacts.

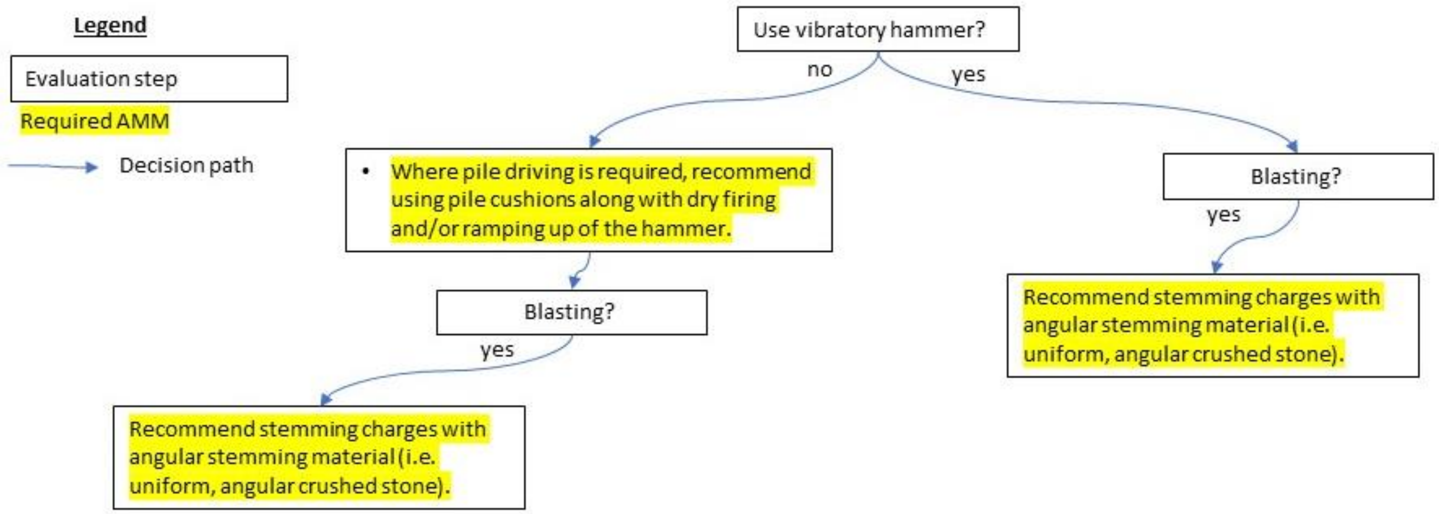


Figure A1 (i). Diagram. Construction phase BMPs to reduce noise impacts.

Table A2. BMP level scores pertaining to combinations of scores from sediment reduction types.

Activity Restriction	Source Prevention	Interception	Monit. & Maint.	Final Score
Standard	Standard	Standard	Standard	Standard
Standard	Standard	Standard	High	Standard
Standard	Standard	Standard	Very High	Advanced
Standard	Standard	High	Standard	Standard
Standard	Standard	High	High	Advanced
Standard	Standard	High	Very High	Advanced
Standard	Standard	Very High	Standard	Advanced
Standard	Standard	Very High	High	Advanced
Standard	Standard	Very High	Very High	Advanced - High
Standard	High	Standard	Standard	Standard
Standard	High	Standard	High	Advanced
Standard	High	Standard	Very High	Advanced
Standard	High	High	Standard	Advanced
Standard	High	High	High	Advanced - High
Standard	High	High	Very High	Advanced - High
Standard	High	Very High	Standard	Advanced - High
Standard	High	Very High	High	Advanced - High
Standard	High	Very High	Very High	Advanced - High
Standard	Very High	Standard	Standard	Advanced
Standard	Very High	Standard	High	Advanced
Standard	Very High	Standard	Very High	Advanced - High
Standard	Very High	High	Standard	Advanced - High
Standard	Very High	High	High	Advanced - High
Standard	Very High	High	Very High	Advanced - High
Standard	Very High	Very High	Standard	Advanced - High
Standard	Very High	Very High	High	Advanced - High
Standard	Very High	Very High	Very High	Very High
High	Standard	Standard	Standard	Standard
High	Standard	Standard	High	Advanced
High	Standard	Standard	Very High	Advanced
High	Standard	High	Standard	Advanced
High	Standard	High	High	Advanced - High
High	Standard	High	Very High	Advanced - High
High	Standard	Very High	Standard	Advanced
High	Standard	Very High	High	Advanced - High
High	Standard	Very High	Very High	High
High	High	Standard	Standard	Advanced

High	High	Standard	High	Advanced - High
High	High	Standard	Very High	High
High	High	High	Standard	Advanced - High
High	High	High	High	Advanced - High
High	High	High	Very High	High
High	High	Very High	Standard	High
High	High	Very High	High	High
High	High	Very High	Very High	High
High	Very High	Standard	Standard	Advanced
High	Very High	Standard	High	Advanced - High
High	Very High	Standard	Very High	High
High	Very High	High	Standard	Advanced - High
High	Very High	High	High	High
High	Very High	High	Very High	High
High	Very High	Very High	Standard	High
High	Very High	Very High	High	High
High	Very High	Very High	Very High	Very High
Very High	Standard	Standard	Standard	Advanced
Very High	Standard	Standard	High	Advanced
Very High	Standard	Standard	Very High	Advanced - High
Very High	Standard	High	Standard	Advanced
Very High	Standard	High	High	Advanced - High
Very High	Standard	High	Very High	High
Very High	Standard	Very High	Standard	Advanced
Very High	Standard	Very High	High	Advanced - High
Very High	Standard	Very High	Very High	High
Very High	High	Standard	Standard	Advanced
Very High	High	Standard	High	Advanced - High
Very High	High	Standard	Very High	Advanced - High
Very High	High	High	Standard	Advanced - High
Very High	High	High	High	High
Very High	High	High	Very High	High
Very High	High	Very High	Standard	Advanced - High
Very High	High	Very High	High	High
Very High	High	Very High	Very High	Very High
Very High	Very High	Standard	Standard	Advanced - High
Very High	Very High	Standard	High	Advanced - High
Very High	Very High	Standard	Very High	High
Very High	Very High	High	Standard	Advanced - High
Very High	Very High	High	High	High
Very High	Very High	High	Very High	Very High

Very High	Very High	Very High	Standard	High
Very High	Very High	Very High	High	Very High
Very High	Very High	Very High	Very High	Very High

RECOMMENDATIONS FOR SPECIAL PROVISIONS

Evaluation and Recommendations for Construction Phase Special Provisions

The research team listed the primary terminology of each special provision, the number of documents in which it was identified (out of 34), the impact it reduces (e.g. sediment), the mitigation type (e.g. source control, interception, etc.), and the project types where it was applied. Information on project type was not available for all special provisions. The Green Book, General NPDES Permit No. GAR100002, and GDOT standard specifications were referred to as standard practice. The special provisions are organized by the impact type they are intended to mitigate: sediment, contaminants, physical contact, altered hydrology/connectivity, and noise.

Table B1. Sediment related special provisions.

<table>
<tr><th>Special Provision</th><th>Number of documents</th><th>Impact</th><th>Mitigation Type</th></tr>
<tr><td>Cofferdam requirement</td><td>5</td><td>Sediment, Contaminants, Physical Contact</td><td>Interception</td></tr>
<tr><td colspan="4">Widening, Bridge Replacement</td></tr>
<tr><td colspan="4">Standard Practice
The use of cofferdams is not mentioned in the Green Book, GDOT Drainage Manual, or NPDES Permit. However, measures to minimize silt migration are required for work in rivers and streams by GDOT Standard Specification 107.23.B - Legal Regulations and Responsibility to the Public (Bridge Construction Over Waterways).
Currently the USACE limits the constriction of stream widths by temporary structures to 33%.
Degree of Benefit
This special provision goes beyond standard practice by specifically stating the method to contain sediment impacts. The use of cofferdams can greatly reduce the risk of spreading pollutants and enhance working conditions by isolating and containing a work area.</td></tr>
</table>

    - However, there is some level of disturbance that occurs due to the installation of cofferdams or containment structures, and some installation techniques require the use of noise generating mechanisms such as impact or vibratory hammers. Further, a reduction in cross-sectional flow area can cause scour.
- Literature
    - Multiple states' AMMs specify procedures for reducing the effects of cofferdams including filtering during de-water procedures, installation techniques, and cofferdam removal techniques.
- Recommendations
    - Recommend special provision in instances where in-water work is required. Further, the research team recommends using terminology inclusive of other debris containment structures in addition to cofferdams to increase flexibility to site conditions and construction activities.
    - If not specified in Erosion, Sediment, and Pollution Control Plan, recommend requiring water treatment or filtering during pumping procedures. The following examples were obtained from the Minnesota DOT:
        - Filter basins use hay bales and filter fabric (to filter out sediment). Sediment will be removed and kept from eroding back into the stream. Silt bags can also be used. Adequate vegetation buffer will separate the sedimentation basin from the stream.
        - Water will be pumped from the work area into the basin before being released. Clean crushed stone should be used around the intake of the pump in the work area to minimize suspended sediments even more.
    - Ensure settling of particulates in water within the cofferdam prior to removal. Conduct turbidity measurements to ensure water turbidity (measured in NTU) within the cofferdam is equal to or less than the adjacent water in the stream.

    - For cofferdams used to construct bridge abutments that are not surrounded on all sides by water (i.e. adjacent to the bank), use silt curtains to reduce downstream turbidity. Silt curtains should be installed predominantly parallel to the main flow of the stream. See GDOT Standard Specification 170. - Silt Curtain - GDOT Standard Specification 170.3.05 (note item A.3).

        - Do not use silt/turbidity curtains with activities that only occur within waterbodies. This will prevent the silt barrier being subjected to crossflow that could induce flow separation and turbulent mixing.

bridge support removal in cofferdams	2	Sediment, Contaminants, Physical Contact	Interception

Bridge Replacement

- Standard Practice
    - See cofferdam requirement

- Degree of Benefit
  - See cofferdam requirement
- Recommendations
  - See cofferdam requirement.

Cofferdam Installation/Removal Spec	2	Sediment, Physical Contact	Interception

Widening

- Standard Practice
  - The special provisions are generally as follows: Coffer dams shall be installed from upstream continuing downstream so as not to trap fish and other aquatic animals. Prior to removal of cofferdam structures, the structures shall be allowed to sit undisturbed for a minimum of 48 hours to allow settlement of suspended materials. Removal of the cofferdam sheeting shall begin on the downstream side and proceed upstream. Care shall be taken to minimize temporary increased downstream turbidity levels and sediment deposition.
  - GDOT standard construction activities list several methods and materials for the installation of cofferdams. However, the direction (upstream to downstream) is not specified - as is by the special provision.
- Degree of benefit
  - This special provision prevents potential mortality of mobile organisms by providing them an opportunity to evacuate.
  - Reduces the impacts from sedimentation. The fall velocity of a particle in suspension is dependent on grain size among other factors such as temperature. The fall velocity for very fine sand at 20 C (68 F) is 3.47 mm/s or 3.8 ft/hr. Very fine clay the other hand has a fall velocity of 5.3 X10^{-5} mm/s or 0.0014 ft/day (noting this does not account for the possibility of flocculation).
- Recommendations
  - See cofferdam requirement above.
  - Recommend keeping special provision due to the potential cost/benefit ratio.

Type "C" silt fence backed with baled straw shall be installed at all designated locations as shown on the Erosion and Sedimentation Control Plans.	4	Sediment	Interception

Culvert Repair, Bridge Replacement

- Standard Practice
  - This special provision simply enforces standard practice - The Erosion and Sedimentation Control Plans.
- Degree of Benefit
  - The degree of benefit added by this special provision is the reinforcement of the design BMP implementation.

- Literature
    - Silt fence backed with baled straw potentially reduces flow through rate causing overtopping of silt fence and BMP failure. Alternative approaches for secondary filtering downstream of silt fence installations suggested.
- Recommendations
    - Recommend alternatives to silt fence backed with baled straw due to the reduction in flow through capacity to increase risk of overtopping failure.

    - Where enhanced levels of protection are needed, require Type C silt fence with t-posts max 5' spacing 1.25lb/ft posts and offset 6" downstream of trench geotextile backfill trench (Whitman et al, 2018) - GDOT detail for silt fence specifies 4' spacing but does not include 6" offset.

    - Do not place silt fences in areas of concentrated flow where chances of failure are more likely (Donald, Zech et al. 2016; EPA). Recommend silt check dams that should be modified by adding excelsior control blankets around the rock or replacing rock check dams with fiber check dams. Polyacrylamide (PAM) can also be added to further reduce turbidity. However, PAM should not be added to standard rock check dams (Kang, McCaleb et al. 2013).

    - Potential alternative to Type to C silt fence is silt-saver belted strand retention fence (SBSR) (Risse et al., 2008).

    - Recommend Type C silt fence with preliminary treatment (Whitman et al., 2019) for enhanced levels of protection, particularly where clay or silt soils are dominant.. Recommend to use in conjunction with flocculants to increase effective particle size of clay and silt particles (i.e. increase settling velocity).

        - Effective preliminary treatment defined in Alabama Soil and Water Conservation Commission Handbook for sediment retention barriers and includes a base of jute netting layered wheat straw and flocculants bound by two rows of polypropylene netting and t-posts.

        - Preliminary treatments (e.g. SBSR) shall be installed upslope of Type C silt fence at a distance that does not reduce silt fence storage capacity.

    - Alternatives to preliminary treatment might include sediment basins with the use of flocculants; however, the research team recognizes that sediment basins are not always feasible due to right of way and topographic constraints. Where practical, ensuring sediment basins provide 134 cy of storage per acre drained (standard is 67 cy/acre) would enhance protection by added redundancy.

    - Recommend evaluating the need for preliminary treatment based on soil type. Require for predominantly clay silt or clay soils.

- Recommend the use of terracing and level spreaders can be used in conjunction with sediment barriers to reduce slopes, encourage sheet flow to sediment barriers, and create zones of deposition (EPA, 1993; 2005).
    - Use non-toxic flocculants - non oil-based anionic PAM. or other
- Where flow paths are predominantly parallel to silt fence installations, require temporary silt fence installation with J-hook according to GDOT Standard Detail D-24C shall be used.

Silt fencing will be installed around disturbed areas as needed. Silt fencing will remain in place until disturbed areas are permanently revegetated.	2	Sediment	Interception

Bridge Replacement

- Standard Practice
    - Standard practice mandates the implementation of perimeter BMPs and correct installation of the Erosion and Sediment Pollution Control Plan (ESPCP). However, this special provision specifies a specific BMP (silt fence). Although, location is subjective by including the language “as needed”.
- Degree of benefit
    - The degree of benefit provided by this special provision depends on the design of the ESPCP and extent and type of perimeter BMPs.
    - It is possible that this special provision ensures the installation of silt fence in addition to what the ESPCP specifies. Although, the NPDES includes language for correcting BMPs (Part IV.C)
- Literature
    - Silt fence has been documented as one of the most effective perimeter BMPs, and adequate permanent vegetation greatly reduces the likelihood and severity of erosion.
- Recommendations
    - Generally, silt fence is one of the most effective perimeter devices, if installed and maintained correctly; however, recommend secondary or preliminary measures where enhanced protection is required.
        - See silt fence recommendations above.
    - Temporary material storage piles should be covered with plastic tarps, mulch, or erosion control blankets to prevent erosion. Erosion and sediment control devices (e.g. compost filter socks or silt fence) should be installed around storage piles. Mulch with tackifiers or soil stabilizers that are anionic, non-oil based (e.g. granular PAM) should be used to reduce turbidity and increase longevity if mulch is necessary.

<table>
<tr><td>Sediment barriers of approved materials (e.g. double row Type C silt fences and compost filter socks), along the perimeter of the construction site, down slope of construction activities, and at drainage inlets.</td><td>1</td><td>Sediment</td><td>Interception</td></tr>
<tr><td colspan="4">Trail Construction</td></tr>
<tr><td colspan="4">● Standard Practice
○ While standard practice mandates perimeter BMPs, this special provision goes beyond standard practice by mandating a specific BMP.
○ The Green Book requires a double row of silt fence in ESAs.
● Degree of benefit
○ The degree of benefit will depend on what was initially specified in the erosion and sediment pollution control plan and on the relative effectiveness of the practices in the special provision to alternative BMPs.
● Recommendations
○ Where predominantly clay/silt soils present, provide preliminary or secondary measures as noted above.</td></tr>
<tr><td>Restricted work zone</td><td>6</td><td>Sediment, Altered Hydrology Connectivity</td><td>Activity Restriction</td></tr>
<tr><td colspan="4">Widening, Bridge Replacement</td></tr>
<tr><td colspan="4">● Standard Practice
○ This special provision goes beyond standard practice by specifying the direction and quantified extents of an area that is allowed to be disturbed. Terminology states that work “shall” be restricted to this designated area. Standard practice in the ESPCP requires estimating the total area of the site that is to be disturbed. Also, the NPDES permit limits site disturbance to less than 25 acres or 50% of the site area, whichever is smaller, at any point in time.
● Degree of benefit provided
○ The degree of benefit provided by this special provision is a reduction in erosion potential from disturbed areas dependent on the ratio of the area allowed to be disturbed by the special provision and the area that would have otherwise been estimated in the ESPCP.
○ Explicitly defining a restricted work area is less subjective and more exact than specifying a percentage of the site. Further, the specification of a specific area is discernible and enforceable.
● Literature
○ Adequate construction phasing can reduce the amount of disturbed soil exposed at any point in time, increase the portion of stabilized surfaces, decrease the</td></tr>
</table>

size and number of BMPs required, and decrease the risk of erosion and sediment pollution.

- Recommendations
  - Maintain existing special provision the following possible additions/edits:
  - Where possible, require staging and storage areas of projects to be located where disturbance is incidental (compacted soils, gravel, or pavement) rather than designating additional disturbed area solely for staging. This will aid in preventing additional and unnecessary disturbances on site.
  - Recommend requiring construction phasing/sequencing that minimizes the amount of area exposed for the shortest amount of time practical to reduce equipment activities, erosion and other potential damages.
  - Consider requiring site fingerprinting (i.e. only clear/grub/grade areas needed to build structures and provide access). This will reduce the amount of earthwork and ESC control devices needed, thus decreasing both erosion and costs.
  - This special provision is very case specific and difficult to implement from a general sense. Using vague language, such as to the extent practical, limits enforcement and provides unintended exemptions. Potentially combine with vegetated buffer or others to only modify areas subject to permanent alteration.

Any disturbed soils should be revegetated as quickly as possible and erosion control matting or other protective measures should be used to stabilize the streambank and riparian zone until a vegetative cover can be established.	1	Sediment	Source Prevention/Interception

Drift Removal

- Standard Practice
  - Standard practice (i.e. Green Book and NPDES permit) establish timing thresholds for temporary and permanent vegetation and suggest revegetation as quickly as possible similar to the special provision.
  - Standard Spec 161.3.05 (Construction) requires "perform permanent grassing, temporary grassing, or mulching on cut and fill slopes weekly (unless shorter period is required by Subsection 107.23) during grading operations".
- Degree of benefit
  - The special provision provides some room for interpretation by applying open ended time limits and reinforces standard practice. Reduces erosion risk from streambanks and upland areas by explicitly requiring erosion control matting for streambanks and riparian zones
- Literature
  - Stabilization of streambanks with woody debris and vegetation can prevent mass movement of soil as well as provide habitat for aquatic organisms.

- Recommendations
    - Maintain special provision as is with the addition of seeding to the requirement of erosion control matting. Further, adjust the language of "should" to "shall". Add a specific minimum time prior to stabilization with protective measures (according to Standard Spec 161.3.05 or prior to leaving the site unattended for 2 days or more).

Immediately after grading any areas to completion, erosion control mats made of coconut fiber or jute shall be placed on all graded slopes and slopes shall be grassed as specified in section 711.3.03.	6	Sediment	Source Prevention

Widening, Trail Construction, Culvert Repair, Bridge Replacement

- Standard Practice
    - NPDES General construction permit places a 14-day limit by which temporary or permanent stabilization must be initiated, but says they **shall** be initiated as soon as practical.
    - GDOT Standard Specification 716
    - GDOT Standard Specification 714 – Jute Mesh Erosion Control

161.3.05 Construction

A. Control Dust Pollution

The contractor shall keep dust pollution to a minimum during any of the activities performed on the project. It may be necessary to apply water or other BMPs to roadways or other areas reduce pollution.

B. Perform Permanent or Temporary Grassing

Perform permanent grassing, temporary grassing, or mulching on cut and fill slopes weekly (unless a shorter period is required by Subsection 107.23) during grading operations. When conditions warrant, the Engineer may require more frequent intervals.

Under no circumstances shall the grading (height of cut) exceed the height operating range of the grassing equipment. It is extremely important to obtain a cover, whether it is mulch, temporary grass or permanent grass. Adequate mulch is a must.

When grading operations or other soil disturbing activities have stopped, perform grassing or erosion control as shown in the Plans, as shown in an approved Plan submitted by the Contractor, or as directed by the Engineer.

- Degree of benefit
    - This special provision goes beyond standard practice by specifying stabilization immediately following completion rather than as soon as practical.
    - The special provision goes beyond standard practice by requiring a specific form of stabilization that is more effective than grassing alone or grass with mulch.
- Literature
    - Erosion control mats should be considered first for soil stabilization before mulching because of increased longevity, higher reduction rates of sediment and turbidity, and cost efficiency (Tyner et al., 2011; EPA, 1993).

- Recommendations
    - Recommended requiring coir fiber matting when soil is exposed but not trafficked for 5 days or more). A random-weave, high mass per area design instead of open- weave, low mass per area design should be used to lower sediment concentrations and outputs from exposed slopes (Sutherland & Ziegler 2007). Mulch with seeding or flocculants permitted on slopes flatter than 3:1. Standard practice limits the application of mulch (2020) without seed to 2:1 slopes.

All disturbed soil and excavation spoil shall be mulched daily or covered with erosion control mats.	19	Sediment	Source Prevention

Widening, Trail Construction, Bridge Replacement,

- Standard Practice
    - NPDES General construction permit places a 14-day limit by which temporary or permanent stabilization must be initiated, but says they **shall** be initiated as soon as practical.
- Degree of Benefit
    - Additional benefit is added by specifying an exact and enhanced frequency of erosion control measures eliminating, particularly in the case of mulch.
- Literature
    - Erosion control mats are more effective than mulch; however, mulch effectiveness generally increases with application rate up to high coverage rates (e.g. > 90%).
- Recommendations
    - Recommend erosion control mats where enhanced levels of protection are needed and soil will remain undisturbed for greater than 5 days on slopes steeper than 3:1.
    - The depth and percent cover maintained by the mulch is more important than the frequency of mulching. However, frequent mulching mulch application might be an effective means to remove the subjectivity of judging an application depth and density that requires additional mulch.
    - Recommend mulch with tackifiers or soil stabilizers that are anionic, non-oil based (e.g. granular PAM) should be used to reduce turbidity and increase longevity (Minnesota Stormwater Manual; Weston et al. 2009).

when one-third of the capacity of any device has been reached, the device shall be immediately cleaned out	12	Sediment	Monitoring/Interception

Widening, Trail Construction, Culvert Repair, Bridge Replacement

- Standard Practice

    - Lack of proper BMP maintenance results in a violation. ESPCP requires maintenance of sediment storage when filled 22 cy per acre drained, they are to be restored to initial design values (67 cy per acre).
    - Inspections are required to occur after rain events or every 2-weeks.
- Degree of benefit
    - This special provision modifies standard practice. In general, this special provision reinforces and slightly modifies standard practice (i.e. NPDES permit) making the capacity unitless by specifying one-third rather than 22 cy per acre, which is approximately one-third of 67 cy.
- Literature
    - Most other states' AMMs specify maintenance when half capacity has been reached.
- Recommendation
    - Maintain special provision with the following additions:
        - Recommend adding language to clean out when a rain event is imminent.
            - An alternative wording is, "Within 200' of streams, clean out when a rain event is imminent or greater than 0.25 inches of rain is predicted by the National Weather Service Quantitative Precipitation Forecasts in the next 24-hours.

shall monitor all erosion control devices on a daily basis.	11	Sediment	Monitoring

Widening, Trail Construction, Culvert Repair, Bridge Replacement

- Standard Practice
    - This special provision increases the frequency of BMP inspection beyond standard practice. According to the NPDES permit, inspections required after rain events or every 2-weeks.
    - Lack of proper BMP maintenance results in a violation. ESPCP requires maintenance of sediment storage when filled 22 cy per acre drained, they are to be restored to initial design values (67 cy per acre).
- Degree of benefit
    - More frequent inspections can aid in reducing the impact or likelihood of BMP failures. Daily inspections within close proximity to environmentally sensitive areas could avoid a failure in between bi-weekly inspections and prior to rain events.
- Literature
    - Improper installation and lack of maintenance have been shown to be significant and common contributors to sediment pollution. Additionally, maintenance and proper installation have been identified as major factors in discrepancies between estimated and actual performance of erosion control devices.

- Other states' AMMs call for regular inspections and immediate corrections to deficiencies. In some instances, regular inspections are classified as daily during prolonged rain events, but typically regular inspections occur at frequencies less than every day.

- Recommendations
  - Recommend erosion and sediment control inspections on a weekly basis and immediately prior to leaving a site unattended for greater than 2 days. by WECS.
    - Potential alternatives for advanced levels of protection might maintain the special provision frequency of daily or adjust the frequency to twice per week since the literature indicates that monitoring and maintenance are areas with the greatest room for improvement and increased efficiency of E&S.

A buffer of existing vegetation on both banks of the creek shall be maintained by doing no clearing and grubbing within 50 feet of the stream banks other than that which is absolutely necessary to construct the Project.	2	Sediment, Contaminants	Activity Restriction/Source Prevention

- Standard practice
  - This special provision is similar to standard practice; however, it does go beyond the requirements of standard practice by specifying that some buffer "shall" be maintained. The clearing and grubbing of what is absolutely necessary is somewhat subjective and open to interpretation.
  - Note, the project type is not listed for this special provision, and it may not be applicable to all project settings and types.
- Degree of benefit added
  - Limiting disturbance in the vicinity of the stream and maintaining a buffer of vegetation can reduce pollution loading from sediment and other contaminants.
  - Additional level of protection added beyond structural BMPs.
- Literature
  - WSDOT - Vegetation will only be grubbed from areas undergoing permanent alteration. No grubbing will occur in areas slated for temporary impacts.
  - Wenger and Fowler (2000) outlined varying widths of buffers with some more conservative than others.
- Recommendations
  - A more definitive criteria in terms of what is "absolutely necessary" might enhance this special provision by increasing clarity of expectations and

reducing subjectivity in interpretation (i.e. per WSDOT - only areas undergoing permanent alteration.)
    - Recommend a conservative buffer (if possible) for perennial and intermittent streams to allow maximum reduction. A buffer with base width of 100 feet plus 2 feet per 1% of average floodplain cross-slope (e.g. 3% floodplain cross-slope results in a buffer width of 100’ + 2*3 = 106’).

Minimize disturbance to streambanks and vegetated buffers. Mechanized clearing shall not be used within 200 feet of stream banks. Vegetation clearing may be performed by hand in these locations.	2	Sediment, Contaminants	Activity Restriction
Drift Removal			

- Standard practice
    - It is important to consider that this special provision was applied to drift removal where mussels were present.
    - The NPDES permit specifies a stream buffer requirement, yet GDOT projects are often exempt. The Green book provides a detail/description for temporary stream crossings including a bridge crossing, and states that clearing of the bed and banks shall be kept to a minimum.
    - This special provision has been included as a standard specification (Section 203.05.F.4) for drift removal.
    - Standard Specification 201.03.D.4. a (Modifications to clearing and grubbing - stream bridges): cut stumps and brush flush with the ground line in the ROW for the full length of the structure.
    - Standard practice requires: 20' of clearance from finished elevation for roadways. Trees marked by the engineer on plans to preserve shall be preserved. Otherwise, clear the entire ROW so that it can be mowed by power mower.
- Degree of benefit added.
    - This practice will reduce disturbance adjacent to the creek, and it is more restrictive than state standards with 25’ vegetative buffer requirements on state designated water courses (50’ for trout waters). Although, the level of disturbance that might result from the use of hand tools is uncertain.
- Recommendations
    - For drift removal projects, this special provision is now standard practice.
    - For other project types - To decrease the impact of disturbance, grubbing, and clearing activities, vegetative rootstock and native materials should/shall only be removed from areas subject to permanent impact. Clipping vegetation at ground level will retain root mass and encourage reestablishment.

<table>
<tr><td>Stockpiled materials shall be placed at least 200 feet away from the banks</td><td>25</td><td>Sediment</td><td>Source Prevention</td></tr>
<tr><td colspan="4">Widening, Trail Construction, Road Construction, Bridge Replacement</td></tr>
<tr><td colspan="4">
Standard Practice
Standard practice and regulations do not specify or regulate the location of stockpiled materials except for restricting placement within environmentally sensitive areas.
Degree of benefit
This practice provides added benefit by increasing the buffer distance between stockpiled materials and stream crossings.
However, in doing so, additional land disturbance might be required by traveling additional distances to place material with equipment.
The distance specified may not be practical in all construction scenarios and exceed the limits of disturbance or ROW.
Literature
Additional states’ AMMs require distances greater than or equal to 200’, and some require perimeter BMPs around stockpile materials.
Recommendations
Recommend only considering the use of this special provision if it does not increase the area of disturbed surface.
Might require vegetative buffer in place.
Recommend that temporary material (i.e. soil) storage piles should be covered with plastic tarps, mulch, or erosion control blankets to prevent erosion. Erosion and sediment control devices (e.g compost filter socks or silt fence) should be installed around storage piles. Mulch with tackifiers or soil stabilizers that are anionic, non-oil based (e.g. granular PAM) should be used to reduce turbidity and increase longevity if mulch is necessary (Minnesota Stormwater Manual; Weston et al. 2009).
Buffer reductions could be appropriate with enhanced erosion prevention and perimeter devices (e.g. erosion control matting, Type C silt fence perimeter control with secondary sediment reduction barrier).
</td></tr>
<tr><td>The Contractor will be required to grade an area to completion once the area is disturbed to minimize the time the area is exposed to potential erosion.</td><td>8</td><td>Sediment</td><td>Source Prevention</td></tr>
<tr><td colspan="4">Bridge Replacement</td></tr>
<tr><td colspan="4">
Standard Practice
Standard practice and regulations specify timing thresholds for requiring various temporary and permanent stabilization measures; however, the special provision goes beyond this by establishing that the area must be graded to completion once disturbed.
</td></tr>
</table>

<table>
<tr><td colspan="4">

Standard practice currently requires mulching if not immediately completed, but allows 60 calendar days before temporary grassing must be applied. (163.3.G)

Degree of benefit

Benefit is provided by potentially reducing the time an area is exposed and thus reducing the probability of a sediment generating rain event.
This special provision might not be entirely possible in all projects where the ROW is minimal requiring concentrated working areas.

Literature

NCDOT calls for grading operations in environmentally sensitive areas to continue work until complete.

Recommendations

Recommend where appropriate. When disturbance occurs and immediate completion is not possible due to phasing, recommend enforcing frequent stabilization measures (i.e. mulch) and enhanced perimeter controls.
Recommended requiring coir fiber matting when soil is exposed but not trafficked for 5 days or more. A random-weave, high mass per area design instead of open- weave, low mass per area design should be used to lower sediment concentrations and outputs from exposed slopes (Sutherland & Ziegler 2007). Mulch with seeding permitted on slopes flatter than 3:1. Standard practice limits the application of mulch without seed to 2:1 slopes.

</td></tr>
<tr><td>Heavy construction equipment shall not enter or operate in stream. Work from temp bridge, bank or road.</td><td>10</td><td>Sediment, Contaminants, Physical Contact</td><td>Activity Restriction</td></tr>
<tr><td colspan="4">Drift Removal, Bridge Replacement</td></tr>
<tr><td colspan="4">

Standard practice

Preventing construction equipment from entering the stream is not regulated by existing standards.

Degree of benefit

Benefit may vary due to it being a function of the area and frequency of disturbance that the stream bed would have been subject to by heavy equipment along with the caliber of substrate.
Reduce mortality of less mobile species (i.e. mussels).

Recommendations

Recommend that heavy equipment operate from temporary construction structures (i.e. bridges, jetties, bulkheads) or stable streambanks.
Recommend adding language that prohibits bank grading and possible vegetation removal in areas not permanently modified.

</td></tr>
<tr><td>The Contractor shall conduct work activities from a stable stream bank or reinforced platform that does not cause</td><td>8</td><td>Sediment, Altered Hydrology</td><td>Source Prevention</td></tr>
</table>

degradation or destabilization of the stream banks		Connectivity, Physical Contact	

Widening, Bridge Replacement

- Standard practice
  - The NPDES permit specifies a stream buffer requirement, yet GDOT projects are often exempt. The Green book provides a detail/description for temporary stream crossings including a bridge crossing, and states that clearing of the bed and banks shall be kept to a minimum.
  - The SP goes beyond standard practice by explicitly restricting any destabilization of the streambanks.
- Degree of benefit
  - Reduce risk of erosion and sediment pollution. The reduction amount will be dependent on the width of the project measured parallel to stream (i.e. the total length of stream bank preserved).
- Recommendations
  - Recommend as is where appropriate.

Rip rap shall be installed as specified in Section 603 "Rip Rap" on all end roll areas beneath the new bridges where revegetation according to Special Provision Section 702 does not occur. Placed Stone Plain Rip Rap, 300 mm, shall be chinked within placed Stone Plain Rip Rap, 600 mm, as specified in Special Provision Sub-Section 805.01B. Placement of these two types of rip rap shall be chinked and accomplished so that space between individual stones is minimized, thereby reducing erosion potential beneath the rip rap. Rip Rap shall not be placed in the stream beds of waterways.	1	Sediment, Physical Contact	Source Prevention/Activity Restriction

- Standard Practice
  - This practice is not addressed in the NPDES permit. However, it is a standard construction activity conducted by GDOT. The Green Book explicitly discourages this practice but where implemented suggests a max slope of 1:2 and more desirable slope of 1:3.
- Degree of benefit
  - Prevention of erosion and streambank destabilization in structurally sensitive areas where vegetation unlikely to grow.
- Recommendations

Maintain special provision where appropriate. Additional consideration could be given to the use filter fabric, and designs should follow the guidelines outlined in the Federal Highway Administration's Hydraulic Engineering Circular 23 *Bridge Scour and Stream Instability Countermeasures: Experience, Selection, and Design Guidance-Third Edition*.			
Instream Timing Restriction	23	Sediment, Physical Contact	Activity Restriction
Widening, Road Construction, Culvert Repair, Bridge Replacement			
- Standard Practice - Timing restrictions are not included standard the Green Book or the NPDES general infrastructure permit - Exceptions are often granted in special provisions as long as work is conducted in isolated areas. - Other states' AMMs - Timing restrictions are included in multiple states' AMMs and are predominantly concerned with the timing of spawning. - Degree of Benefit - Timing restrictions alleviate sediment impacts derived from in-water work - Timing restrictions will be specific to species whose critical life cycle processes (e.g. spawning, migration, incubation, etc.) coincide with the timing of in-stream work. - Recommendations - Timing restrictions should be evaluated based on species sensitivity with the possibility of exceptions for work within containment structures (e.g. cofferdams and caissons).			
Temporary erosion control devices shall be installed before any other work will be allowed to be performed.	3	Sediment	Interception/Source Prevention
Bridge Replacement			
- Standard Practice - This special provision aligns with standard practice. The minor discrepancy is that the NPDES permit states that the erosion control devices "must" be… instead of "shall". - The NPDES permit states that failure to do so will result in a violation. Inspection must occur by the preparer of the ESPCP. - Degree of benefit - The degree of benefit provided by this special provision should be marginal since temporary perimeter erosion control and sediment storage devices should be installed before activities are conducted. However, the special provision			

does add valued benefit by reinforcing the requirement with the language of "shall".

- Literature
  - Other states' AMMs require complete installation of sediment control devices prior to the commencement of any earthwork.
- Recommendations
  - Recommend adding an educational component or checklist to review with the contractor prior to construction to highlight and remind the contractor of critical standard practices.

Live willow stakes shall be planted adjacent to creeks according to Special Provision Section 702 and the Landscaping Plans.	1	Sediment, Contaminants	Source Prevention/Interception

- Standard Practice
  - The Green book has a permanent vegetation measure using live willows (see streambank stabilization pg. 6-59).
  - The NPDES permit does not address willow plantings.
  - Standard specification 702
- Degree of benefit
  - Willow plantings can aid in bank stabilization and reduce the potential for erosion and sediment pollution from upland areas and can serve as part of a vegetated buffer. This special provision is redundant with standard practice since the "Special Provision Section 702" is actually in reference to Standard Spec 702 (I think - I could not find a special provision 702). However, the standard spec 702 calls for clearing and grubbing the area to be planted.
- Recommendations
  - Recommend adding language to minimize vegetation clearing and prohibit grubbing where permanent alteration will not occur

shall not perform earth disturbing work if rainfall/run-off events are imminent	2	Sediment	Activity Restriction

- Standard practice
  - Standard practice does not include this special provision.
- Degree of benefit added
  - This practice prevents the disturbance of additional ground cover when a rain event with a high probability of occurrence is approaching. The degree of benefit is largely dependent on the amount of earth that would have been disturbed prior to the event in the absence of the special provision.
- Recommendations

<table>
<tr><td colspan="4">○ Add language to ensure, at a minimum, temporary stabilization measures (e.g. mulching) are applied prior to imminent rain event and perform maintenance to ensure design capacity of BMPs if a rainfall/run-off event is imminent.</td></tr>
<tr><td>activities may take place during timing restriction from or within cofferdams or socketed caissons, rip rap pads, temporary bulkheads, or temporary work bridges as long as they are installed outside of the restrictive season</td><td>15</td><td>Sediment, Physical Contact</td><td>Source Prevention/Interception</td></tr>
<tr><td colspan="4">Widening, Road Construction, Bridge Replacement,</td></tr>
<tr><td colspan="4">● Standard Practice
○ This practice is not addressed by or mentioned in the NPDES permit. The Green Book refers to some of these practices in the context of streambank stabilization but not in the context of a temporary work platform.
● Degree of benefit
○ This potentially adds benefit by reducing the time of construction when timing restrictions are employed. Stable work platforms and in-stream containment devices decrease the risk of erosion and sediment pollution.
● Recommendations
○ Recommend using containment where in-stream work is required regardless of restrictive season.</td></tr>
<tr><td>The Contractor shall notify the Project Engineer immediately in the event of an erosion control failure that allows discharge of sediment into Stream</td><td>19</td><td>Sediment</td><td>Monitoring</td></tr>
<tr><td colspan="4">Widening, Trail Construction, Bridge Replacement</td></tr>
<tr><td colspan="4">● Standard Practice
○ According to the NPDES observed failures by the permittee are required to be reported to the EPD. The language “shall” is used. Additionally, the BMP is required to be repaired within 2 business days.
● Degree of benefit
○ Notifying the project engineer of an erosion control failure can aid in mitigation and correction of the ESPCP to prevent additional failures. While standard practice requires reporting of any failures by the project engineer, the special provision helps reinforce reporting in between inspections by the contractor. Enforcement might be questionable.
● Recommendations
○ Recommend keeping this special provision and adjust by adding language that requires modifying the BMP to correct the problem.</td></tr>
</table>

required erosion control measures are to be considered minimum erosion control requirements for this area. Install other erosion control measures as needed or directed by the Project Engineer to ensure effective erosion and sedimentation containment control and	2	Sediment	Monitoring/Interception/Source Prevention
Bridge Replacement			

• Standard Practice
  ○ Standard practice requires installation of the erosion control devices per the ESPCP. This special provision goes beyond standard practice by providing written requirement that additional devices must be installed at the request of the project engineer.
• Degree of benefit
  ○ The ESPCP should specify erosion control devices that would minimize erosion and sediment pollution from the site. However, additional measures would further reduce the likelihood of exposure from erosion and sediment pollution. The degree of benefit would be dependent on the efficacy of the original ESPCP and the amount/efficacy of additional measures requested.
• Recommendations
  ○ Recommend revising to reduce redundancy with standard practice: Install additional or other erosion control measures as needed or as directed by the project engineer to ensure effective erosion and sediment control (see ESPCP General Notes Template- Use of Alternative and/or Additional BMPS).			

immediately modify the erosion control plan to correct any circumstances that may cause or allow pollutants from the worksite to enter Stream	3	Sediment, Contaminants	Monitoring
Bridge Replacement			

• Standard Practice
  ○ Standard practice (NPDES permit) allows for 2 business days to correct any BMP failures. The special provision accelerates this timeline by "immediately" and implies that corrections be made before failure occurs if something is identified that "may" cause or allow pollutants to enter the stream.
• Degree of benefit
  ○ This special provision enforces and further enhances the monitoring protocol in standard practice potentially preventing failure before it occurs. However, this special provision might be difficult to enforce.
• Recommendations			

<table>
<tr><td colspan="4">Recommend revising to reduce redundancy with standard practice: Install additional or other erosion control measures as needed or as directed by the project engineer to ensure effective erosion and sediment control.</td></tr>
<tr><td>The Contractor shall schedule his activities to ensure the installation of permanent erosion control features prior to the beginning of major grading activities.</td><td>4</td><td>Sediment</td><td>Interception/Source Prevention</td></tr>
<tr><td colspan="4">Widening, Bridge Replacement</td></tr>
<tr><td colspan="4">
Standard Practice
The NPDES permit addresses the installation of permanent erosion control features by requiring that their timing, location, etc. be specified. However, it does not require them to be installed prior to major grading activities.
Standard Specification 169 requires that post construction stormwater measures be installed after the final grade and stabilization of the area upstream is achieved, but it provides a provision to alter the staging with prior approval.

Degree of benefit
Installing permanent erosion control prior to major grading activities potentially reduces the total amount of disturbance over the course of a project. Rather, than installing temporary devices later to be replaced by permanent devices.
It seems beneficial to stage activities in this order, but this special provision makes it a requirement.
A potential benefit of this special provision is the integration of permanent stormwater controls.

Recommendations
Recommend keeping this special provision where applicable.

</td></tr>
<tr><td>Accumulated drift material shall not be dragged across the streambed. The method of removing drift at locations is attaching lift cables or ropes to the drift and hoisting the materials out of the stream from the top of the bridge deck.</td><td>2</td><td>Sediment, Physical Contact</td><td>Activity Restriction</td></tr>
<tr><td colspan="4">Drift Removal</td></tr>
<tr><td colspan="4">
Standard practice
Note, mussels were the species of concern where this special provision was applied.
Standard practice permits the removal of debris, but it does not restrict or specify a method.

Degree of benefit
Prevent the likelihood of dislodgement or mortality of low mobility mussels.

Recommendations
</td></tr>
</table>

<table>
<tr><td colspan="4">
<li style="list-style:none">
A standard specification for drift removal was added to section 201 to include this special provision.
</td></tr>
<tr><td>No grading of the creek banks shall be allowed. If a temporary work bridge is used, stable access to the work bridge shall be provided by ramps composed of Type I rip rap or and/or crane mats.</td><td>3</td><td>Sediment, Altered Hydrology Connectivity, Physical Contact</td><td>Activity Restriction</td></tr>
<tr><td colspan="4">Bridge Replacement</td></tr>
<tr><td colspan="4">

Standard practice

The NPDES permit specifies a stream buffer requirement, yet GDOT projects are often exempt within a certain area. The Green book provides a detail/description for temporary stream crossings including a bridge crossing, and states that clearing of the bed and banks shall be kept to a minimum.
The SP goes beyond standard practice by explicitly restricting any grading to the stream banks. Although, it seems that disturbance due to the placement of riprap or ramps is unavoidable.

Degree of benefit

Dependent on the amount of disturbed sediment that would have been generated from the banks during or after grading activities - a function of soil type, bank length, height, and exposure to flow. Although the area of disturbance might be small relative to the project site, the slope of stream banks and proximity to the water increases the risk of in-stream sedimentation. Consequently, the benefit provided is significant.

Recommendations

Recommend as is where appropriate.
Where construction of structural components requires grading of streambanks (i.e. bridge deck locations), conduct activities within a contained work space using cofferdams or other containment methods.

</td></tr>
<tr><td>Surface water runoff from undisturbed areas shall be diverted to prevent flow across disturbed areas.</td><td>12</td><td>Sediment</td><td>Source Prevention</td></tr>
<tr><td colspan="4">Widening, Trail Construction, Culvert Repair, Bridge Replacement</td></tr>
<tr><td colspan="4">

Standard Practice

NPDES Permit: States that flows will be diverted or limited from exposed areas "...to the degree attainable."
The special provision goes beyond standard practice by the use of the language "shall" to divert flows from disturbed areas.
Special provision states: accomplished through the use of permanent pipes, temporary pipes, or slope drains. The Contractor may propose alternate methods provided prior approval of the Project Engineer is obtained.

Degree of benefit

</td></tr>
</table>

- This special provision adds benefit by ensuring the practice is installed by use of the language “shall”.
- Literature
  - Additional states’ AMMs require diverting and/or treating flows before discharging into riparian buffers.
- Recommendations
  - Recommend maintaining this special provision.

Table B2. Contaminant related special provisions.

Special Provision	Number of documents	Impact	Mitigation Type
Equipment staging areas and equipment maintenance areas (particularly for oil changes) shall be located at least 200 feet from stream banks	29	Contaminants, Sediment	Source Prevention
Widening, Road Construction, Drift Removal, Bridge Replacement			

- Standard Practice
  - According to the NPDES permit, The ESPCP is to include BMPs for remediating petroleum spills and leaks.
  - The NPDES permit also requires daily inspections where petroleum products are used or vehicles are stored.
- Other States’ AMMs
  - Other states’ buffer distances vary from 150’ - 500’
  - WSDOT calls for the use of vegetable oil or other biodegradable, acceptable hydraulic fluid substitute.
  - In some states, requirements include the use of oil absorbent pads under heavy equipment within a certain buffer distance, secondary containment structures around equipment, spill response materials, and daily equipment inspections.
- Degree of Benefit
  - This special provision decreases the likelihood that pollutants will enter a water body in the event of a spill; however, it does not completely ensure against it since it only pertains to times when equipment is staged. Additionally, 200’ is not practical in all situations and might increase the disturbed area in some instances.
- Literature
  - From an inventory of over 300 plant items, loaders and excavators were the most likely to cause spills. Hydraulic systems were the main contributor to spills. The four major causes of spills were: equipment parts defective (40%), incorrect procedure followed, impact with an object, and design did not anticipate conditions (Guerin 2014).
  - Biodegradable fluids contain high amounts of oxygen in chemical structures, which allows them to be broken down by microbes under aerobic conditions.

Mineral-based hydraulic oil is extremely toxic for aquatic organisms and does not breakdown easily (causing long term impacts after initial spill) (Morledge and Jackson, 2001).

- Recommendations
  - Potential to relax buffer distance based on the following recommendations
  - The research team recommends explicitly requiring secondary containment and spill response procedures be provided on site for all heavy equipment, which might be additional to the BMPs listed in the ESPCP. Secondary containment can be stationary or "built in" to the equipment. Regardless, secondary containment measures should be provided to the extent practical to prevent the spread of pollutants during oil changes, refueling, and maintenance.
    - For example, plastic or wood containment attached to the bottom of the crane between tracks to contain leaks and spills (see examples from Minn DOT at this link: ftp://ftp2.dot.state.mn.us/pub/outbound/erosion/CSM2018b/SecondaryContainmentExamplesV1.pdf.
  - Recommend developing standard specification for equipment staging areas to include spill prevention, containment, and soil stabilization (e.g. rock base) measures.
  - Consider replacing mineral based hydraulic fluids with synthetic biodegradable hydraulic fluid to decrease the severity of impact from spills.
  - Recommend adding special provision to include, at a minimum, a spill containment and response kit for all heavy equipment on a construction site. Recommend ensuring spill response plan is available for all equipment similar to the following provided by WSDOT:
    - i. Site Information: Identify general site information useful in construction planning, recognizing potential sources of spills, and identifying personnel responsible for managing and implementing the plan.
    - ii. Project Site Description: Identify staging, storage, maintenance, and refueling areas and their relationship to drainage pathways, waterways, and other sensitive areas. Specifically address: Contractor's equipment maintenance, refueling, and cleaning activities, the Contractor's on site storage areas for hazardous materials.
    - iii. Spill Prevention and Containment: Identify spill prevention and containment methods to be used at each of the locations identified
    - iv. Spill Response: Outline spill response procedures including assessment of the hazard, securing spill response and personal protective equipment, containing and eliminating the spill source, and mitigation, removal and disposal of the material.
    - v. Standby, On-Site, Material and Equipment: The plan shall identify the equipment and materials the Contractor will maintain on site to carry out the preventive and responsive measures for the items listed.

- vi. Reporting: The plan shall list all federal, state and local agency telephone numbers the Contractor must notify in the event of a spill.
- vii. Program Management: Identify site security measures, inspection procedures and personnel training procedures as they relate to spill prevention, containment, response, management and cleanup.
- viii. Pre-existing Contamination: If pre-existing contamination in the project area is described elsewhere in the plans or specifications, the SPCC plan shall indicate measures the Contractor will take to conduct work without allowing release or further spreading of the materials.
- ix. Attachments
    - Site plan showing the locations identified in (1. B. and 1. 17 C.) noted previously.
    - Spill and Incident Report Forms the Contractor will be using.

No liquid concrete or concrete curing water shall be allowed to escape within stream	1	Contaminants	Activity Restriction

Widening

- Standard Practice
    - No specific activity listed for this special provision (e.g. cofferdams).
    - In general, the NPDES permit requires specification of controls in the ESPCP and measures to reduce the discharge of pollutants. It does not specifically address concrete curing water, and it does not use the language shall not be allowed to escape.
        - “All permittees are required to minimize the discharge of pollutants from dewatering trenches and excavations. Discharges are prohibited unless managed by appropriate controls.”
    - Standard Specification 500 - Concrete Structures: Place Seal Concrete - “Deposit concrete in water only when required by the Plans or when considered necessary by the Engineer.”
- Literature/Other states’ AMMs
    - This special provision is in most states. MinnDOT provides guidance and methods to prevent discharge of concrete washout.
    - The Ashfield Ecological Services Field Office for FWS states the need to prevent wet concrete from contacting waterbodies.
    - USACE 2018 RP 30-35: “Work must be accomplished so that wet (uncured) concrete, concrete curing water, or flowable fill does not contact surface waters.
    - Uncured concrete in a waterway can raise the pH of the surrounding water causing mortality in aquatic organisms.
- Degree of Benefit
    - bicarbonate in concrete can increase pH with negligible to minor impacts.
    - admixtures, curing agents, and fly ash can contain toxic substances.
- Recommendations
    - Recommend adding language to specifically prevent discharge of concrete washout into the stream reinforcing Part IV.D.3.c.(6) of the NPDES permit. This may include the specification of additional practices.

<table>
<tr><td colspan="4">
See examples from the MinnDOT at this link: ftp://ftp2.dot.state.mn.us/pub/outbound/erosion/CSM2018b/Conc%20washoff_out%20guidance.pdf
and the USEPA website (https://www3.epa.gov/npdes/pubs/concretewashout.pdf).
</td></tr>
<tr><td>Protective material, such as tarps or wooden platforms, shall be installed under the existing and proposed bridges during removal and construction to contain any seepage or drips during project activities</td><td>8</td><td>Contaminants, Physical Contact</td><td>Interception</td></tr>
<tr><td colspan="4">Widening, Bridge Replacement</td></tr>
<tr><td colspan="4">

Standard Practice
The NPDES permit regulates stormwater discharges.
It does require the ESPCP to outline spill control and remediation measures.
It does reiterate that projects are subject to Georgia Hazardous Waste Management Act
Degree of Benefit
This special provision goes beyond standard practice by suggesting specific spill control measures and serves as a form of containment to reduce the likelihood of toxic materials incidental to construction from entering the stream directly.
Recommendations
Recommend maintaining existing language of special provision with an addition that includes forms of secondary containment such as oil absorbent pads.

</td></tr>
<tr><td>Do not design or allow the use of treated construction materials or those preserved with pesticide compounds unless no alternatives.</td><td>-</td><td>Contaminants, Physical Contact</td><td>Activity Restriction</td></tr>
<tr><td colspan="4">Note: This special provision was not included in example documents and added based on review of other states’ AMMs.</td></tr>
<tr><td colspan="4">Widening, Bridge Replacement,</td></tr>
<tr><td colspan="4">

Standard Practice
This special provision comes from the Oregon Department of Transportation (ODOT).
Degree of Benefit
Prevent the release, leaching, or deposition of toxic chemicals associated with treated materials such as chromium, arsenic, and copper. These pollutants could by-pass any stormwater BMP if they were in direct contact with waterbodies.
Temporary structures and crane mats may use wood that is treated. Standard specifications do not address treated materials that could pose significant harm to aquatic organisms. This special provision sets restrictions and guidelines in place.
Recommendations

</td></tr>
</table>

- Maintain as is when sensitive species are present, but if treated materials are necessary then adhere to the following guidelines to reduce potential impact:
    - Store pesticide-treated wood in appropriate dry storage areas, at least 150 feet away from aquatic habitat supporting listed species or where it will not drain into such habitat. This distance may be modified based on site conditions and justified in the Project Notification.
    - Avoid contact with standing water and wet soil.
    - Ensure treated wood is free of residue, bleeding of preservative, preservative-saturated sawdust, contaminated soil, or other pollutants.
    - Use prefabrication whenever practicable to minimize onsite cutting, drilling, and field preservative treatment.
    - Do not discharge of sawdust, drill shavings, excess preservative and other debris into riparian or aquatic habitat (ODOT)

The Contractor shall not use pesticides or herbicides, within 200 feet	30	Contaminants	Activity Restriction
Widening, Road Construction, Bridge Replacement,			

- Standard Practice
    - NPDES permit simply states that the ESPCP should outline controls to minimize the exposure of pesticides and herbicides to precipitation. Does not prohibit their use.
    - Greenbook suggests to not use topsoil recently treated with herbicides (disturbed area stabilization with sodding).
    - Standard Specification 702 - Vine, Shrub, and Tree Planting:
        - “For stream buffer and marsh restoration areas, pesticides are not to be used unless approved by the department Ecology Manager.”
        - “However, the use of herbicides is prohibited in stream buffer areas unless approved by the Department Ecology Manager.”
- Degree of Benefit
    - There is a large degree of benefit provided since pesticides and herbicides can be highly toxic to aquatic organisms.
- Literature
    - ODOT restricts herbicide use within the most conservative buffer areas and restricts which herbicides can be used elsewhere.
    - US Forest Service prevents boom spraying within aquatic, streamside, and wetland zones. It calls for hand application techniques such as hand-held wand, backpack sprayer, wicking, etc.
    - ADOT Herbicide Treatment Program on Bureau of Land Management Lands in Arizona also prohibits broadcast spraying within designated buffer zones. They recommend using selective herbicides with hand spray application methods.
- Recommendations
    - Maintain 200’ buffer suggested by special provision.
    - Recommend that within 200’ buffer, only certain herbicides and application techniques shall be used. Within the 200’ buffer, only hand-application (e.g. hand-held wand, backpack sprayer, wicking, etc.) is allowed. The following herbicides are recommended to be used :
        - I. aquatic imazapyr (e.g., Habitat)

- II. aquatic glyphosate (e.g., AquaMaster, AquaPro)
- III. aquatic triclopyr-TEA (e.g., Renovate 3)
- IV. chlorsulfuron (e.g., Telar, Glean, Corsair)
- V. clopyralid (e.g., Transline)
- VI. glyphosate (e.g., Rodeo)
- VII. imazapic (e.g., Plateau)
- VIII. imazapyr (e.g., Arsenal, Chopper)
- IX. metsulfuron-methyl (e.g., Escort)
- X. picloram (e.g., Tordon)
  - XI. sethoxydim (e.g., Poast, Vantage)
- XII. sulfometuron-methyl (e.g., Oust, Oust XP)
- XIII. triclopyr (e.g., Garlon 3A, Tahoe 3A)

Table B3. Physical contact related special provisions.

<table>
<tr><th>Special Provision</th><th>Number of documents</th><th>Impact</th><th>Mitigation Type</th></tr>
<tr><td>No incidental debris dropping larger than as specified size</td><td>3</td><td>Physical Contact</td><td>Activity Restriction</td></tr>
<tr><td colspan="4">Bridge Replacement</td></tr>
<tr><td colspan="4">Standard Practice
GDOT Standard Specification 107.23.B - Legal Regulations and Responsibility to the Public (Bridge Construction Over Waterways) states, “Construction waste or debris, from bridge construction or demolition, shall be prevented from being allowed to fall or be placed into wetlands, streams, rivers or lakes.”
Two of the special provisions state 3”. The other does not list a size. They all pertain to projects with Mussels.
Degree of Benefit
Prevents organism mortality from crushing.
Prevents organisms mortality from any introduction of toxic or harmful materials
Enables prompt response, mitigation, and documentation of impact.
Recommendations
Recommend rephrasing to prevent dropping debris regardless of size: “Concrete debris, paving materials, litter, demolition debris or any other materials shall not be allowed to fall or be placed into Stream”
Recommend combining three different special provisions dealing with debris: No incidental debris (e.g. concrete debris, paving materials, litter, demolition debris, or any other materials) dropping larger than___. Contractor shall notify the Project Engineer if any equipment or materials is allowed to fall or be placed into the waterbody.</td></tr>
<tr><td>Blasting Restrictions</td><td>7</td><td>Noise, Physical Contact</td><td>Activity Restriction</td></tr>
<tr><td colspan="4">Widening, Bridge Replacement</td></tr>
<tr><td colspan="4">Standard Practice
The special provision limits explosive poundage per charge - used for calculating blasting radius.
Legal requirements in the GDOT standard specifications requires a blasting plan.
Noise impacts on aquatic organisms from blasting is not discussed in standard practice documents.
Degree of Benefit
Reduces the risk of adverse impacts due to crushing and alleviates the noise/pressure impact on aquatic organisms.
Recommendations
Recommend the use of blast mats to contain “fly rock” and other debris associated with blasting.</td></tr>
<tr><td>Concrete debris, paving materials, litter, demolition debris or any other materials</td><td>8</td><td>Physical Contact</td><td>Activity Restriction</td></tr>
</table>

shall not be allowed to fall or be placed into stream			
Widening, Bridge Replacement,			
- Standard Practice - GDOT Standard Specification 107.23.B - Legal Regulations and Responsibility to the Public (Bridge Construction Over Waterways) states, “Construction waste or debris, from bridge construction or demolition, shall be prevented from being allowed to fall or be placed into wetlands, streams, rivers or lakes.” - Degree of Benefit - Prevents organism mortality from crushing and the introduction of toxic materials. - Recommendations - Maintain as is. - Remove based upon combined special provision above.			
Contractor shall notify the Project Engineer immediately if equipment, concrete debris, paving materials, litter, bridge falsework, demolition debris or any other materials is allowed to fall or be placed into Stream	10	Physical Contact	Monitoring
Widening, Bridge Replacement			
- Standard Practice - Standard practice does not include language that requires notifying the project Engineer. - Degree of Benefit - Enables prompt response, mitigation, and documentation of impact. - Recommendations - Maintain as is - Remove based upon combined special provision above.			

Table B4. Altered hydrology/connectivity related special provisions.

<table>
<tr><th>Special Provision</th><th>Number of documents</th><th>Impact</th><th>Mitigation Type</th></tr>
<tr><td>bridge piers shall be cut off and removed at a depth of two feet below the channel substrate elevation. The remaining sub-surface pier segments and footing structures shall not be excavated.</td><td>2</td><td>Altered hydrology/connectivity, Physical Contact</td><td>Source Prevention</td></tr>
<tr><td colspan="4">Bridge Replacement</td></tr>
<tr><td colspan="4">Standard Practice
GDOT Standard Specification 540 - Removal of Existing Bridge. Remove substructure to streambed or natural ground line unless used as part of a new structure or interferes with excavation for new structure.
Degree of Benefit
Allows for restoration to native or ambient bed material and prevents excessive instream disturbance (i.e. sediment generation).
Recommendations
The research team recommends removing this special provision, as it does not provide any additional benefits compared to the one below. Removing bridge piers two feet below the channel substrate elevation could cause unwanted sediment impacts.</td></tr>
<tr><td>existing bridge piers shall be cut off and removed at channel substrate elevation. The remaining sub-surface pier segments and footing structures shall not be excavated.</td><td>3</td><td>Sediment, Altered Hydrology/Connectivity, Physical Contact</td><td>Source Prevention</td></tr>
<tr><td colspan="4">Bridge Replacement</td></tr>
<tr><td colspan="4">Standard Practice
This special provision coincides with GDOT standard specifications.
GDOT Standard Specification 540 - Removal of Existing Bridge. Remove substructure to streambed or natural ground line unless used as part of a new structure or interferes with excavation for new structure.
Degree of benefit
This special provision adds benefit by eliminating the need to disturb and/or destabilize the stream bed by excavating the pier segments and footing structures.
Recommendations
Keep recommendation as is to prevent erosion of streambed.</td></tr>
<tr><td>Installation of bulkheads, rock jetties, cofferdams/portadams, and water diversions within stream shall only be allowed on one bank at a time in order to reduce stream scour</td><td>2</td><td>Altered hydrology/connectivity, Physical Contact</td><td>Activity Restriction</td></tr>
</table>

Widening			

- Standard Practice
    - USACE RP 30-35: Under Special Condition 17, "For projects that involve the installation of jetties, bulkheads, cofferdams, and other temporary structures that constrict stream/river flow, channel constriction must not exceed 33 percent of total stream/river width at any time."
- Degree of Benefit
    - This special provision prevents altering hydraulics such that they negatively impact aquatic habitat. The degree of benefit will depend on the contraction width, existing substrate, and local flow conditions.
- Recommendations
    - Recommend adhering to USACE regulation. Not all scenarios with temporary construction structures on both banks will result in impactful contraction.

Other Jetti restrictions	2	Altered hydrology/connectivity, Physical Contact	Activity Restriction

- Standard Practice
    - Note "Other restrictions" include the following:
        - Not constructed or removed during breeding season
        - shall not extend past existing piers except where necessary to contain demolition debris.
        - Top shall not exceed x' above mean sea level.
        - Inclusion of culvert through jetti. This is to ensure adequate flow across entire river (downstream).
        - designed to withstand 100 yr storm
        - Meet requirements for Type I rip rap except no material smaller than 0.8 ft^3.
        - area of jetti placement inspected for mussels
        - not to remain in place greater than 16 weeks
    - Jettis are not explicitly addressed by standard practice documents.
    - The example special provisions were applied on the Flint River where mussels were present
- Degree of Benefit
    - These special provisions add benefit by reducing impacts to habitat for species of concern.
- Recommendations
    - Recommend maintaining special provision where appropriate.

Jettis prohibited	2	Altered hydrology/connectivity, Physical Contact	Activity Restriction
Bridge Replacement			

- Standard Practice

<table>
<tr><td colspan="4">

This special provision applied on Ichawaynochaway Creek. Mussels are a species of concern.
Degree of Benefit
The prohibition of jetties in this instance prevents organism mortality from crushing, and it prevents potential habitat alteration from contraction induced scour.
Recommendations
Where mussels are present, recommend maintaining special provision.
Additional recommendations in progress with GDOT research project “Hydraulic effects of temporary bridge construction activities”

</td></tr>
<tr><td>The pre-existing channel width and bank height of the river shall be maintained at the crossings to avoid changes in stream velocity after Project construction.</td><td>6</td><td>Altered hydrology/connectivity</td><td>Activity Restriction</td></tr>
<tr><td colspan="4">Widening, Bridge Replacement</td></tr>
<tr><td colspan="4">

Standard Practice
A stream buffer is required by standard practice, but a variance or exemption is often granted for certain project types such as bridge maintenance or replacement.
Degree of Benefit
This special provision adds benefit by reducing the likelihood of adjusting cross-sectional shape of the channel, the composition of the bed material, and habitat.
Recommendations
Recommend maintaining as is.

</td></tr>
<tr><td>Extreme care shall be taken in lowering equipment or materials, including, but not limited to, piles, sheet piles, casings for drilled shaft construction, spuds, pile templates, etc., below the water surface (10 fpm)</td><td>2</td><td>Altered hydrology/connectivity, Physical Contact</td><td>Activity Restriction</td></tr>
<tr><td colspan="4">Bridge Replacement</td></tr>
<tr><td colspan="4">

Standard Practice
The rate of equipment entry into a waterbody is not addressed in standard regulating documents or standard specifications.
Degree of Benefit
Reduces the risk of mortality to organisms and provides time for organisms to evacuate the construction area.
Recommendations
Maintain as is where appropriate - species dependent.

</td></tr>
<tr><td>Relocation</td><td>9</td><td>Altered hydrology/connectivity, Physical Contact</td><td>Monitoring</td></tr>
</table>

Widening, Bridge Replacement

• Standard Practice
  ○ This special provision is primarily concerned with low mobility organisms (e.g. mussels).
  ○ Relocation is not covered under standard practice.
• Degree of Benefit
  ○ Relocation increases the likelihood of individuals' survival by removing low mobility organisms away from impact areas.
• Recommendations
  ○ The research team recommends maintaining this special provision where appropriate.

Table B5. Noise related special provisions.

Special Provision	Number of documents	Impact	Mitigation Type
Noise Control	3	Noise	Activity Restriction
Bridge Replacement			

- Standard Practice
  - Noise control is not addressed by standard practice documents
  - Control measures include:
    - the use pile cushions for non-timber piles
    - ramping up or dry firing of the hammer
    - “scare charges” for blasting operations
- Degree of Benefit
  - Scare charges, ramping up, and dry firing provide organisms time to evacuate the area prior to blasting or pile driving.
  - Measures that dampen noise reduce or contain detonation pressures that cause injury and/or mortality of aquatic organisms
- Recommendations
  - Recommend stemming charges with angular stemming material (i.e. uniform, angular crushed stone).
  - Recommend containing blasting activities within physical barriers or bubble curtains
  - Where pile driving is required, recommend using pile cushions along with dry firing and/or ramping up of the hammer.
  - Recommend using vibratory hammers to the extent practical.
  - Recommend removing the standard practice of “scare charges”. Repelling or scare charges contribute to fish mortality and are not effective in moving fish away from the potential kill zone of the main blast (Keevin et al. 1998).

RECOMMENDED AMMS

A set of recommended AMMs were developed based on the findings of the literature review, GDOT standard practice, special provisions, and additional states' PBAs. This suite of AMMs includes few new AMMs, special provisions applied on previous GDOT projects, and some modifications to previously applied special provisions. The list of AMMs included below is used to populate the AMMs in the decision tree for determining the E&S BMP level. While the research team aimed to develop a comprehensive and applicable list of special provisions, unique scenarios and innovative technologies may require or result in additional AMMs that provide equal or greater protection than those listed here.

Table B6. Recommended AMMs for use in special provisions and applied in the SES determination.

Index	Special Provision
1	A buffer of existing vegetation on both streambanks shall be maintained by doing no clearing and grubbing within 50 feet of the stream banks other than areas subject to permanent alteration or right of way clearing as indicated in the plans.
2	Heavy construction equipment shall not enter or operate in the stream. The Contractor shall conduct work activities from a stable stream bank, road surface, temporary work bridge, or other reinforced platform that does not cause degradation or destabilization of the stream banks. If a temporary work bridge is used, stable access to the work bridge shall be provided, such as ramps composed of Type I rip rap or and/or crane mats.
3	No grading of stream banks shall be allowed unless shown on the Plans and authorized with a U.S. Army Corps of Engineers (USACE) Section 404 permit. The pre-existing channel width and bank height of the river shall be maintained at the crossings to avoid changes in stream velocity after Project construction except when shown on the Plans and authorized by a USACE 404 permit. Where construction of structural components requires grading of streambanks (e.g. bridge piers or abutments), conduct activities within a contained work space using cofferdams or other containment methods.
4	Within 200' of streams, all disturbed soil and excavation spoil shall be mulched daily or covered with erosion control mats until temporary or permanent seeding has been applied. Erosion control mats will be required on slopes steeper than 3:1.

5	Any disturbed soils should be revegetated as quickly as possible, and Erosion control matting made of coconut fiber or jute shall be used with grassing or plantings to stabilize streambank, riparian zone, and all graded slopes steeper than 3:1 as soon as possible but within no more than 5 days following final grading
6	Where practical, the Contractor will be required to grade an area to completion once the area is disturbed to minimize the time the area is exposed to potential erosion. Temporary grassing with mulch or erosion control mats shall be applied to areas where staged construction prevents immediate completion of an area that will not be trafficked for greater than 14 days. The use of erosion control mats is required for streambanks and slopes steeper than 3:1.
7	Surface water runoff from undisturbed areas shall be diverted to prevent flow across disturbed areas.
8	Stockpiled materials shall be placed at least 200 feet away from the banks
8	Excavation spoil and temporary material storage piles shall be covered with tarps, mulch, or erosion control mats to prevent erosion. Perimeter erosion and sediment control devices (e.g. silt fence) shall be placed around excavation spoil and temporary material storage piles.
9	Require the use of PAM with disturbed soil, excavation spoil, and temporary material storage pile stabilization measures.
10	In water work shall be conducted within containment structures such as cofferdams or caissons. Where practical, containment structures shall be installed starting upstream and moving downstream to prevent trapping aquatic organisms. If not specified in the plans, water filtering or detainment measures shall be utilized with dewatering procedures so that effluent turbidity is equal to or less than ambient stream turbidity. Turbidity sampling within containment structures will be required prior to removal to ensure turbidity levels within the containment structure are equal to or less than ambient stream turbidity. Where practical, containment structures should be removed beginning downstream progressing upstream taking care to minimize turbidity
11	The use of turbidity curtains shall be required with in-water containment structures so long as they are not subjected to significant cross flow according to GDOT standard specification 170.3.05.
12	Temporary erosion control devices shall be installed before any other work will be allowed to be performed. Sediment barriers of approved materials (i.e. double row Type C silt fence) shall be installed along the perimeter of the construction site, down slope of construction activities, and at drainage inlets. Silt fencing will remain in place until disturbed areas are permanently revegetated. Silt fence shall be installed using T-posts at the spacing specified in GDOT standard specifications and details, and T-posts shall be installed at a 6" offset downslope of the geotextile backfill trench.
13	If not specified in ESPCP, require temporary silt fence installation with J-hook according to GDOT standard detail 24-C. Ensure sediment basins provide 134 cubic yards of storage per acre drained.

14	Require preliminary treatment upslope of silt fence installation (e.g. filter socks or other sediment retention barriers with PAM) or settling basins with flocculants, particularly where clay and/or silt are predominant.
15	In ditches and areas of concentrated flow, require rock check dams with an excelsior control blanket around the rock and addition of PAM.
16	Require the use of terracing and level spreaders in conjunction with silt fence installation to encourage sheet flow and create zones of deposition.
17	Erosion and sediment control inspections shall be conducted on a weekly basis, immediately prior to leaving a site unattended for greater than 2 days, and within 24 hours after the end of a rainfall event that is 0.5 inches or greater according to GDOT standard specification 167.3.05.B.
18	The contractor shall review critical standard specifications relating to erosion and sediment control with GDOT and FWS prior to beginning construction. This may be in the form of a checklist or included in the ESPCP. Required erosion control measures are to be considered minimum erosion control requirements for this area. Install other erosion control measures as needed or directed by the Project Engineer to ensure effective erosion and sediment control. If a BMP deficiency or failure is identified by the contractor, the contractor shall contact the Project Engineer immediately to correct the deficiency.
19	When one-third of the capacity of any erosion and sediment control device has been reached, the device shall be immediately cleaned out and maintained according to GDOT standard specification section 165.
20	Require that E&S control devices be cleaned out and maintained according to GDOT standard specification 165 when greater than 0.5 inches of rain is predicted in the next 72 hours with more than a 50% chance of occurrence.
21	The contractor shall monitor all erosion control devices on a daily basis.
22	Do not design or allow the use of treated construction materials or those preserved with pesticide compounds. Unless there are no alternatives and species sensitivity permits, then adhere to the following guidelines to reduce potential impact: Store pesticide-treated wood in appropriate dry storage areas, at least 150 feet away from aquatic habitat supporting listed species or where it will not drain into such habitat. This distance may be modified based on site conditions and justified in the Project Notification. Avoid contact with standing water and wet soil. Ensure treated wood is free of residue, bleeding of preservative, preservative-saturated sawdust, contaminated soil, or other pollutants. Use prefabrication whenever practicable to minimize onsite cutting, drilling, and field preservative treatment. Do not discharge of sawdust, drill shavings, excess preservative and other debris into riparian or aquatic habitat.
23	Equipment staging areas and equipment maintenance areas (particularly for oil changes) shall be located at least 200 feet from stream banks

24	No liquid concrete, concrete curing water, or concrete washout shall be allowed to escape within the stream. Ensure adequate BMPs are implemented to contain, store, and dispose of concrete washout.
25	Protective material, such as tarps or wooden platforms (i.e. containment devices), shall be installed under the existing and proposed bridges during removal and construction to contain any seepage or drips during project activities.
26	Secondary containment measures such oil absorbent pads shall be used with wooden platforms, tarps, or other containment devices installed under bridges to contain any seepage and drips during project activities.
27	Mineral based hydraulic fluids shall be replaced with synthetic biodegradable hydraulic fluid.
28	Require secondary containment and spill response procedures be provided on site for all heavy equipment, which might be additional to the BMPs listed in the ESPCP. Secondary containment can be stationary or "built in" to the equipment. Regardless, secondary containment measures should be provided to the extent practical to prevent the spread of pollutants during oil changes, refueling, and maintenance, and standard activities. For example, plastic or wood containment attached to the bottom of the crane between tracks to contain leaks and spills. In addition, require a spill containment and response kit for all heavy equipment on a construction site.
29	The Contractor shall not use pesticides or herbicides, within 200 feet
30	existing bridge piers shall be cut off and removed at channel substrate elevation. The remaining sub-surface pier segments and footing structures shall not be excavated.
31	Where possible, require staging and storage areas of projects to be located where disturbance has already occurred (compacted soils, gravel, or pavement) rather than designating and disturbing additional soil area solely for staging.
32	Shall not perform earth disturbing work if rainfall/run-off events are imminent, other than that which is necessary to stabilize disturbed surfaces. Ensure temporary stabilization measures (e.g. mulching) are applied prior to imminent rain event.
33	Relocation
34	Extreme care shall be taken in lowering equipment or materials, including, but not limited to, piles, sheet piles, casings for drilled shaft construction, spuds, pile templates, etc., below the water surface (10 fpm)
35	Jetties prohibited
36	Instream Timing Restrictions

37	Rip rap shall be installed as specified in Section 603 “Rip Rap” on all end roll areas beneath the new bridges where revegetation does not occur. Placed Stone Plain Rip Rap, 300 mm, shall be chinked within placed Stone Plain Rip Rap, 600 mm, as specified in Special Provision Sub-Section 805.01B. Placement of these two types of rip rap shall be chinked and accomplished so that space between individual stones is minimized, thereby reducing erosion potential beneath the rip rap. Rip Rap shall not be placed in stream beds.
38	Noise Control: with blasting, require the practice of stemming charges with angular stemming material (e.g. uniform, angular crushed stone).
39	Noise Control: Contain blasting activities within physical barriers or bubble curtains.
40	Noise Control: Where pile driving is required, require the use of pile cushions along with dry firing and/or ramping up of the hammer.
41	Noise Control: Require the use of vibratory hammers to the extent practical.
42	Installation of bulkheads, rock jetties, cofferdams/portadams, and other temporary instream features shall adhere to constriction limits established by the USACE, 33% of total stream/river width shall not be exceeded.
43	Live willow stakes shall be planted adjacent to streams and rivers according to Special Provision Section 702 and the Landscaping Plans.
44	Blasting Restrictions: the use of explosives is strictly prohibited.
45	Blasting Restrictions: No unconfined blasting shall be allowed.
46	The incidental or purposeful dropping of debris (e.g. concrete debris, paving materials, litter, demolition debris, or any other materials) shall not be permitted. Contractor shall notify the Project Engineer if any equipment or materials is allowed to fall or be placed into the waterbody.
47	Minimize disturbance to streambanks and vegetated buffers. Mechanized clearing shall not be used within 200 feet of stream banks. Vegetation clearing may be performed by hand in these locations.
48	Accumulated drift material shall not be dragged across the streambed. The method of removing drift at locations is attaching lift cables or ropes to the drift and hoisting the materials out of the stream from the top of the bridge deck.

Table B7. AMMs Recommended for incorporation into standard practice

Index	Special Provision
1	A buffer of existing vegetation on both streambanks shall be maintained by doing no clearing and grubbing within 50 feet of the stream banks other than areas subject to permanent alteration or right of way clearing as indicated in the plans. *Rationale:* Maintaining a buffer of vegetation along streambanks and riparian zones can significantly reduce the impacts from sediment and contaminant pollution associated with runoff. Except for exemptions, state buffers are either 25 or 50 feet depending on the designation as trout waters. This provision does not eliminate clearing and grubbing along stream banks, but it potentially prevents unnecessary clearing and grubbing.
3	No grading of stream banks shall be allowed unless shown on the Plans and authorized with a U.S. Army Corps of Engineers (USACE) Section 404 permit. The

	pre-existing channel width and bank height of the river shall be maintained at the crossings to avoid changes in stream velocity after Project construction except when shown on the Plans and authorized by a USACE 404 permit. Where construction of structural components requires grading of streambanks (e.g. bridge piers or abutments), conduct activities within a contained work space using cofferdams or other containment methods. *Rationale:* This special provision prevents the risk of geomorphic response due to changes in channel geometry, and it reduces the likelihood of erosion and sediment pollution. It does not strictly prohibit changes in channel geometry since this may be unavoidable in certain situations, but it requires proper permitting in these scenarios.
4	Within 200' of streams, all disturbed soil and excavation spoil shall be mulched daily or covered with erosion control mats until temporary or permanent seeding has been applied. Erosion control mats will be required on slopes steeper than 3:1. *Rationale:* This special provision ensures stabilization measures are in place during a rainfall-runoff event. It reduces subjectivity with estimating proper coverage by specifying a frequency of application. Erosion control mats are more effective than mulching. It is possible that the slope requirement could be modified in a standard specification.
5	Any disturbed soils should be revegetated as quickly as possible, and Erosion control matting made of coconut fiber or jute shall be used with grassing or plantings to stabilize streambank, riparian zone, and all graded slopes steeper than 3:1 as soon as possible but within no more than 5 days following final grading. *Rationale:* This special provision enhances standard practice by ensuring stabilization is more promptly initiated.
7	Surface water runoff from undisturbed areas shall be diverted to prevent flow across disturbed areas. *Rationale:* This is one of the most commonly applied special provisions, and has the potential to prevent a significant amount of erosion by reducing the amount of runoff on disturbed surfaces.
8	Excavation spoil and temporary material storage piles shall be covered with tarps, mulch, or erosion control mats to prevent erosion. Perimeter erosion and sediment control devices (e.g. silt fence) shall be placed around excavation spoil and temporary material storage piles. *Rationale:* This special provision was frequently applied on projects with imperiled aquatic organisms, and it provides an added level of protection for sediment sources that are likely at a higher risk of mobilization compared to surrounding disturbed areas. A potential modification to incorporate this provision into standard practice could be a requirement to use it within a certain distance of streams (e.g. 200 feet).
17	Erosion and sediment control inspections shall be conducted on a weekly basis, immediately prior to leaving a site unattended for greater than 2 days, and within 24 hours after the end of a rainfall event that is 0.5 inches or greater according to GDOT standard specification 167.3.05.B. *Rationale:* The results of the literature review suggest that enhanced monitoring and maintenance can greatly reduce the risk or erosion and sediment pollution with little added cost. This practice greatly increases the effectiveness of BMPs by ensuring they are not deficient due to weathering, changing sight conditions, or cumulative loading.

18	The contractor shall review critical standard specifications relating to erosion and sediment control with GDOT and FWS prior to beginning construction. This may be in the form of a checklist or included in the ESPCP. Required erosion control measures are to be considered minimum erosion control requirements for this area. Install other erosion control measures as needed or directed by the Project Engineer to ensure effective erosion and sediment control. If a BMP deficiency or failure is identified by the contractor, the contractor shall contact the Project Engineer immediately to correct the deficiency. *Rationale:* This provision potentially increases the level of protection by ensuring key measures are correctly identified and understood prior to earth disturbing activities. It enhances communication with contractors enables prompt corrective actions where appropriate. The cost associated with this provision is minimal compared to its potential benefits.
20	Require that E&S control devices be cleaned out and maintained according to GDOT standard specification 165 when greater than 0.5 inches of rain is predicted in the next 72 hours with more than a 50% chance of occurrence. *Rationale:* This ensures that BMPs have the capacity to perform as intended prior to sediment generating rainfall-runoff events; and therefore, reduces the risk of erosion and sediment pollution.
24	No liquid concrete, concrete curing water, or concrete washout shall be allowed to escape within the stream. Ensure adequate BMPs are implemented to contain, store, and dispose of concrete washout. *Rationale:* BMPs pertaining to concrete washout are commonly applied in erosion and sediment control plans. Incorporating this into standard practice can further protect aquatic organisms from contaminant exposure by requiring prevention measures.
28	Require secondary containment and spill response procedures be provided on site for all heavy equipment, which might be additional to the BMPs listed in the ESPCP. Secondary containment can be stationary or "built in" to the equipment. Regardless, secondary containment measures should be provided to the extent practical to prevent the spread of pollutants during oil changes, refueling, and maintenance, and standard activities. For example, plastic or wood containment attached to the bottom of the crane between tracks to contain leaks and spills. In addition, require a spill containment and response kit for all heavy equipment on a construction site. Rationale: These measures can greatly reduce the risk of contaminants from construction equipment entering water bodies. The cost associated with this practice could be minimal as effective protective measures may be “low-tech” and fit to individual applications.
29	The Contractor shall not use pesticides or herbicides, within 200 feet. *Rationale:* This is one of the most commonly applied special provisions. Pesticides and herbicides can be highly toxic to aquatic organisms.
30	Existing bridge piers shall be cut off and removed at channel substrate elevation. The remaining sub-surface pier segments and footing structures shall not be excavated. *Rationale:* This provision currently aligns with standard practice.
31	Where possible, require staging and storage areas of projects to be located where disturbance has already occurred (compacted soils, gravel, or pavement) rather than designating and disturbing additional soil area solely for staging.

	Rationale: This provision provides a low-cost measure to reduce the amount of disturbed area and potential erosion. Although some subjectivity is applied due the language of "where possible", it accounts for those scenarios where this practice is not practical.
42	Installation of bulkheads, rock jetties, cofferdams/portadams, and other temporary instream features shall adhere to constriction limits established by the USACE, 33% of total stream/river width shall not be exceeded. *Rationale:* This provision is currently required by the USACE and prevents geomorphic adjustment and biological habitat impairment due to channel constrictions. This provision could be evaluated on a project specific basis using the tool developed by UGA to assess the impacts of temporary instream construction structures.
47	Minimize disturbance to streambanks and vegetated buffers. Mechanized clearing shall not be used within 200 feet of stream banks. Vegetation clearing may be performed by hand in these locations. *Rationale:* This provision pertains to drift removal and is currently included as a standard specification.
48	Accumulated drift material shall not be dragged across the streambed. The method of removing drift at locations is attaching lift cables or ropes to the drift and hoisting the materials out of the stream from the top of the bridge deck. *Rationale:* This provision pertains to drift removal and is currently included as a standard specification.

LITERATURE REVIEW OF CONSTRUCTION PHASE AMMS

SEDIMENT RELATED AMMS

Soil erosion on construction sites typically occurs from splash erosion and rill/interrill erosion. Splash erosion occurs as the energy produced from a raindrop impacting the soil surface detaches and erodes the soil particles. Rill (concentrated flow within rills) and interrill (shall sheet flow) erosion occurs as the force of flowing water exceeds the resistive force the soil and mobilizes particles. Consequently, rainfall is a primary driver influencing erosion on construction sites, and rainfall intensity is more strongly correlated with soil erosion than total rainfall depth meaning short duration high intensity storms can produce more soil erosion than a longer, less intense storm of equal rainfall depth. Other pertinent factors that describe or influence the ratio of erosive forces relative to resistive forces, and thus erosion, are the soil type (i.e. its erodibility), topography that influences the erosive force of water, and BMPs that modify soil erodibility and/or hydraulic forces.

Early studies investigating sediment production from areas undergoing construction revealed in-stream sediment concentrations of 3000 to 150,000 ppm; whereas the highest observed concentrations from natural and agricultural land use types were 2000 ppm (Wolman and Schick, 1967). Stringent regulation and implementation of erosion control practices in recent decades have greatly reduced, but not eliminated, elevated sediment concentrations as a result of construction activities. Modern field evaluations of erosion control effectiveness have shown a wide range of efficiencies due to variation in site characteristics, monitoring and maintenance, individual BMP practices, and correct installation of those practices.

Erosion control devices can be generally classified by two types: those that prevent or reduce erosion at the source (i.e. source prevention), and those that attempt to capture and store eroded sediment before it is transported off site (i.e. interception).

A questionnaire and field evaluation of Tennessee Department of Transportation (TDOT) construction sites indicated that silt fence (with and without wire backing), rock check dams, enhanced rock check dams, and sediment tubes (i.e. wattles), catch basin protections, mulching/seeding, sediment filter bags, and temporary slope drains were the most commonly applied erosion control devices. A bulk of the 42 erosion control devices listed in the TDOT drainage manual were never applied (Schwartz and Hathaway, 2018).

Sediment barriers are an intercepting practice installed along the perimeter and within a construction site. They operate by ponding water long enough for suspended sediment to fall out of suspension and remain trapped behind the device. However, this requires a balance of providing enough capacity and flow through rate to prevent overtopping while ponding water long enough for suspended particles to settle. Higher removal efficiency has been documented with increased settling times (Barret et al., 1995), while overtopping has also been observed as a primary failure mechanism (Whitman et al., 2019).

Common sediment barriers include but are not limited to silt fence, straw wattles (i.e. sediment tubes), compost filter socks, mulch berms, and others. Many of these practices and their standard details are listed in the Manual for Erosion and Sediment Control in Georgia (2016). Silt fence is the most commonly applied and studied sediment barrier ranging from field investigations, experimental studies, and small-scale materials testing in a laboratory setting (Cooke et al., 2015). Burns and Troxel (2015) reviewed the relative frequency interception practices occurred in E&S control manuals across states, and silt fence was identified in 49 manuals with the next most frequent, straw or hay bales, identified in 22 manuals.

Silt fence is manufactured by a variety of woven and non-woven synthetic fabrics with variable apparent opening sizes. Apart from impacts on flow through rate, this is typically not an issue where soil particles are relatively large, such as sand. However, the efficiency of silt fence is greatly reduced as the representative grain diameter of soil decreases relative to silt fence apparent opening size (Fisher and Jarret, 1984, EPA, 1993), and there are disparities between the efficiency of lab and field testing (Barret et al., 1995; Chapman et al., 2014). For instance, GDOT standard specification 881.2.07 specifies Type A, B and C silt fence have an apparent opening size of 600 μm. While the diameter of a typical clay particle is 6 μm and smaller. It is important to consider the effective grain diameter of particles since some tend to coagulate producing a larger diameter particle.

In a full-scale experimental study Whitman et al. (2019) found that turbidity measurements immediately downstream of various sediment barrier installations was greater than the upstream ponded water even though sediment retention rates were greater than 90% in some instances. Only one practice in their study decreased downstream turbidity, and it was an innovative approach that utilized flocculants in conjunction with layered wheat straw. While they did not specify the soil type, the high retention rates and increased turbidity for the silt fence practices suggests smaller particles were allowed to pass through. In contrast, Burns and Troxel (2015) observed up to a 92.8% reduction in turbidity downstream of silt fence installation, but their sampling locations are not clearly defined and they simulate a 10-year, 6-hour event compared to the 2-year, 24-hour event by Whitman et al. (2019). A field test of silt-saver belted strand retention fence, which has a smaller apparent opening size and higher flow through rate than Type C silt fence, showed higher performance at reducing downstream TSS and turbidity than the Type C silt fence (Risse et al., 2008).

The results of several experimental studies report variable performance rates of silt fence compared to alternative practices, such as compost filter socks and mulch berms. This is likely a result of the various testing methodologies, site conditions, and soils. The results of several experimental studies report variable performance rates of silt fence compared to alternative practices, such as compost filter socks and mulch berms. This is likely a result of variation among experimental designs where soils, slopes, plot area, rainfall application and other factors are controlled. An evaluation of multiple sediment barriers using ASTM D351 indicated that Type A and Type C silt fence resulted in higher reductions in turbidity and TSS compared to mulch berms, compost socks, and straw bales (Burns and Troxel, 2015). Straw bales had the lowest performance with a 91.2% reduction in TSS and a 49.2% reduction in turbidity.

In contrast, Faucette et al. (2009) document a number of studies that report greater TSS and turbidity reductions using mulch filter berms and compost filter socks compared to silt fence (Demars et al., 2000; Faucette et al., 2005; Sadeghi et al., 2006). However, Faucette et al. (2009) evaluated TSS and turbidity reductions of straw bales, mulch filter berms, and compost filter socks under simulated rainfall, and reported removal efficiencies that are typically lower than those reported for silt fence under experimental conditions in additional studies (e.g. >90% TSS removal efficiency for Burns and Troxel, 2015; Risse et al., 2008; Whitman et al., 2018; 2019). There is a general consensus that straw bales should be avoided if other practices are available. The variation in results among studies highlights the need to consider site specific conditions when selecting and installing erosion control practices (Cooke et al., 2015).

The experimental study of Whitman et al. (2019) observed failure mechanisms in each device tested for a simulated 2-year, 24-hour storm. Three primary mechanisms were observed: overtopping of the device, undercutting of the device, and structural failure due to hydrostatic loading. Overtopping occurs when the capacity of the device is exceeded. For wattles and compost filter socks, this can occur simply due to the height of the device. For silt fence, clogging of the fabric pores can reduce the flow through rate causing excess water to pond behind the device and eventually overtop the structure. Undercutting of devices typically occurred due to installation method and the stability of the interface between the installation and the soil. Structural failure due to hydrostatic loading could be caused by inadequate materials or reduced flow through rates that cause water to pond at depths greater than intended. For instance, structural failure of silt fence installed with hardwood stakes occurred in scenarios where a hardwood stake contained defects.

Field evaluations of silt fence and other sediment barriers have indicated variable and quite low efficiencies of sediment removal in contrast those reported in experimental studies (Barret et al., 1998), which have been largely attributed to improper installation and maintenance neglect

(Cooke et al., 1995). Therefore, critical components of adequately controlling sediment is the proper installation and maintenance of sediment barriers.

The Manual for Erosion and Sediment Control in Georgia endorses the use of a static-slicing method to install silt fencing, based on an EPA-supported study in which the method performed as well as the highest-performing of three trenching methods tested, which typically required triple the time and effort (ASCE 2001). However, Bugg et al. (2017), in a study for the Alabama Department of Transportation, demonstrated that one layer of trenched silt fencing method was less prone to failure than other methods that included slicing. A more recent experiment evaluated 8 configurations of the the Alabama Department of Transportation (ALDOT) standard wire-backed, nonwoven silt fence including the suggested method of Bugg et al. (2017) (Whitman et al., 2018). They find that altering the installation method to offset silt fence stakes 6" downslope of the backfill trench reduces the likelihood of undermining while increasing t-post weight and decreasing spacing reduces the likelihood of structural failure.

There is a general consensus that silt fence should not be placed in areas of concentrated flow, and this practice was removed from GDOT erosion control measures in 2014. However, a study found that, if maintained properly, silt fence could operate as intended in areas of concentrated flow. The research team does not recommend this due to the frequent maintenance this would require and elevated likelihood of failure.

While the majority of these indicate that silt fence is one of the more effective interception practices, the variation highlights the need to consider site specific conditions when selecting and installing erosion control practices (Cooke et al., 2015).

Sediment basins have been frequently applied at transportation construction sites; however, this practice is infeasible in a number of scenarios due to topographic and spatial constraints. A number of studies have investigated the effectiveness of sediment basins (Chapman et al. 2014; Kalainsan et al. 2009; Line and White 2001), and similar to silt fence effectiveness is variable depending on sediment texture (i.e. clay vs. sand). Since sediment basins rely on particles settling out of suspension, clay particles that have very slow settling velocities are not effectively retained by sediment basins. Enhancements to sediment basins include the use of flocculants to increase particle settling velocities, baffles to increase retention times, and skimmers so that water is drained from the surface. It is imperative to provide outlet protection for sediment basins to ensure that concentrated flow in these locations is not a source of sediment erosion.

Mulch is commonly applied stabilization measure to reduce soil erosion by reducing runoff rates and the energy associated with splash erosion. Experimental field studies have found that mulch can reduce erosion by greater than 90% compared to bare soil (McLaughlin 2002; Sidhu 2015). Coverage rates and depths are the primary factors governing the effectiveness of mulch, and most guidance suggests 90% coverage rates to a depth of greater than 2 inch (Prosdocimi et al. 2016; Smets et al. 2008; Tyner et al. 2011). The addition of PAM with mulch can further enhance the effectiveness to reduce soil loss.

While mulch has proven to be an effective measure to reduce erosion, erosion control mats have been found to more effective. Specifically, a random-weave, high mass per area design instead of open- weave, low mass per area design provided the highest efficiency to reduce soil loss (Álvarez-Mozos et al. 2014; Sutherland and Ziegler 2007).

The research team was unable to identify relevant peer reviewed literature or reports regarding the effectiveness of cofferdams to reduce soil erosion. Therefore, the research team relied on guidance from other state DOTs. Cofferdams or containment measures may be constructed from a variety of materials, methods, and configurations. However, their implementation is generally regarded as providing a significant protection to sediment pollution where instream work is required. Primary guidance regarding cofferdams and containment measures is related to dewatering procedures and ensuring discharge turbidity is equal to or less than ambient turbidity levels of the receiving water body.

EFFECTIVENESS OF NON-SEDIMENT RELATED AMMS

Heavy machinery and equipment used in close proximity to streams during construction increases the likelihood of spills and leaks releasing into waterbodies (Wheeler et al., 2015). A study was done that inventoried over 300 plant items to identify common factors behind spills. They found that equipment under the most stress, such as loaders and excavators, were most likely to experience failures. The failures usually occurred within the hydraulic systems of the equipment (Guerin 2014). Morledge and Jackson (2001) stated that mineral-based hydraulic oil was extremely toxic to aquatic organisms and did not break down as well as biodegradable fluids, which contain high amounts of oxygen in their chemical structures and allow microbes and other organisms to break them down easily under aerobic conditions. Colorado Department of Transportation (CDOT) identified methods to deal with spills and leaks in their Erosion Control and Stormwater Quality Guide (2002). They called for an "ample supply of cleanup materials" to be present in maintenance areas and the use of absorbent materials to contain spills of hydraulic fluids, oils, gasoline, etc. Likewise, GDOT also requires spill kits in maintenance areas. Another recommendation that CDOT made was the use of less hazardous and non-toxic petroleum products whenever possible.

Liquid concrete can be hazardous to aquatic organisms if released into nearby waterbodies. Admixtures contain chemicals that can be acutely and chronically toxic. Calcium and bicarbonate, found in concrete, have the potential to raise the pH of streams that have come in contact with uncured concrete (Andersson and Stromvall, 2001; Kurda et al., 2018). In their HIP III Handbook, the Bonneville Power Administration outlines that uncured concrete can be accidentally discharged into streams or riparian zones when work is done nearby.

Treated materials such as treated wood can pose a significant hazard to aquatic organisms. Treated wood can leach toxic chemicals such as chromium, arsenic, and copper that bypass stormwater BMPs designed to capture toxicants like them. Cleaning and maintenance practices (e.g. power washing) can remove particles of treated materials and deposit them in the soil or water beneath a structure (Lebow et al.,2004). Lebow and Tippie (2001) presented guidelines to minimize any release of contaminants from wood treated with preservatives. They recommended reducing the amount of field fabrication of treated materials to prevent discharge of sawdust, drill shavings, and other construction debris. Materials that are observed having oily surfaces and/or "bleeding" after treatment should not be used in environmentally sensitive areas. They also stated that treated materials should not be stored in areas of standing water or wet soils to prevent contaminants from easily entering adjacent waterbodies or soils.

Certain pesticides and herbicides can be toxic to aquatic environments. Pesticides and herbicides can enter waterbodies through sorption to soil particles and subsequent transport or by aqueous transport in stormwater (Syversen and Bechmann, 2004). With an experimental plot, Sybervsen and Bechmann (2004) found that vegetated buffer zones reduce the delivery of pesticides to streams. A review of mitigation effectiveness was done for pesticides from agriculture areas which found that surface runoff and erosion of particles, that pesticides adsorb to, were the two most prominent sources. The review also identified how the USDA (2000) suggests a 30 meter buffer width to trap soluble particles such as pesticides (Reichenberger et al., 2007). Arizona Department of Transportation outlined methods to reduce the amount of pesticides and herbicides that reach buffer zones or waterbodies. In their Herbicide Treatment Program on Bureau of Land Management Lands in Arizona manual, they prohibit broadcast spraying within designated buffer zones, call for the use of selective herbicides (labeled for use to the edge of bodies of water or with aquatic labelling) only, and allow only hand spray application.

Physical contact effects can cause injury or mortality to aquatic organisms. The installation of piers, piles, jetties, and other in-stream structures can cause direct impacts such as crushing less or immobile benthic organisms (e.g. mussels) (Cocchiglia et al., 2012). Equipment and machinery operating in-stream can also have direct impacts on aquatic organisms and their habitat.

Altering the hydrology and connectivity of waterbodies has been identified to cause adverse effects on aquatic biota. Poor bridge construction or placement can lead to habitat fragmentation. Piers that are incorrectly placed can cause scouring, bed instability, debris accumulation, and habitat fragmentation. Clear span bridges, that do not use piers or piles as supports, have been recommended to leave the natural bed and bank intact (Cocchiglia et al., 2012). Rip rap placement must also be considered to avoid unnecessary impacts. Incorrect placement of rip rap has been shown to inhibit natural inputs of sediment that is crucial for channel morphology. Channel incision could begin occurring with increased water velocities that scour both upstream and downstream banks (Reid and Church, 2015).

Blasting and the pressure waves associated with it have been linked to the mortality of aquatic organisms such as fish. Techniques used by many DOTs and contractors that are aimed at reducing the overall mortality from these practices have been found ineffective. Repelling (or scare) charges, which are used to "scare" fish and other aquatic organisms away from blast sites, were observed by multiple agencies to contribute to fish mortality. A telemetry study was conducted and showed that the charges also did not move fish far enough away from the main detonation zone to prevent mortality (Keevin et al., 1997). Bubble curtains reduce the explosive wave pressure from underwater blasting, but still have been observed having fish mortality occurring outside of the curtains (Keevin, 1998). The FWS, in a Florida Blasting Guidelines (2006) document, recommended stemming charges and using physical barriers to contain underwater blasting. Keevin (1998) found that physical barriers helped reduce the wave pressures. He also stated that stemming charges, which uses angular material such as crushed rock to fill drill holes of charges, can significantly decrease the amount of blast energy leaving the hole.

Pile driving activities are the main contributor to acute, anthropogenic sound disturbances associated with construction projects. They can cause fish mortality, damage to internal organs (e.g. swim bladders), and behavioral changes. Some studies have even show that aquatic species can exhibit both temporary and permanent hearing loss from these activities (Popper and Hastings, 2009). Pile driving also causes fish to become overstimulated and thus more susceptible to predation (NOAA, 2006; Popper and Hastings, 2009). NOAA (2006) found that using vibratory hammers on piles, opposed to traditional driven piles, does not impact fish as much by operating at different sound frequencies. Pile cushions can also reduce peak acoustic effects of driving piles while maintaining driving efficiency (Deng et al. 2016).

APPENDIX B. COVERED PROJECT TYPES

BRIDGE/CULVERT MAINTENANCE

Bridge repair, retrofit, and maintenance activities are implemented to prolong the use and function of bridges, ensure motorist safety, and protect the environment. Whether a bridge is repaired, rehabilitated, or replaced depends on the age of a bridge and damage that may occur to a bridge (e.g., from a storm event, earthquake, or vehicle or boat collision). The length of stream and/or wetland potentially affected by bridge repair and maintenance depends upon the scale of the bridge project and the required actions.

Bridge maintenance activities may include washing, painting, debris (or drift) removal from bridge piers, scour repair, guardrail repairs, joint replacement, lighting and signage repairs, pile encasement, and structural rehabilitation. Such activities generally include work such as repairing damage or deterioration in various bridge components; cleaning out drains; repairing or replacing expansion joints; cleaning and repairing structural steel; sealing concrete surfaces; concrete patching; and sanding and painting.

Bridge maintenance projects can be long-term, lasting more than one construction season. Seismic retrofit activities are not temperature and/or time sensitive and may occur anytime throughout the year, while joint replacement, bridge deck replacement, and bridge deck rehabilitation are temperature dependent activities, limited to the warmer months. Bridge scour repair work tends to occur during low-water times of year, and bridge painting may only occur late spring through fall when temperatures are high enough to allow the paint to dry properly.

Bridge painting involves washing the bridge with highly pressurized water, abrasive sand blasting to remove all corrosion, and then applying a minimum number of coats of paint. Depending on the type of paint utilized, paint must be applied when temperatures are above 35°F, 40°F, and 50°F and it is not raining. Containment devices must be installed on the bridge to prevent debris from falling below. Before beginning work, the design of all proposed containment systems (including drawings) must be submitted to the GDOT District Engineer for review and approval per GDOT Standard Specification (2013) Section 535. Steel bridges also require rivet replacement and crack stabilization. These activities are often added to a bridge painting contract.

Metalizing is another process that can be used to protect the steel structure of a bridge, as an alternative to painting. Metal coatings are created by using a heat source to melt the metal, and then an airstream sprays the molten metal onto the steel surface in a thin film. Once the metal strikes the steel, it re-solidifies quickly to become a solid coating.

Debris (or drift) removal can be accomplished in a variety of ways depending on the type and quantity of debris, and the size and configuration of the bridge. Hand removal is possible in some instances, although the use of mechanical aids, such as chainsaws, winches, boats, and heavy equipment, are often necessary. Work may be done from the stream banks, bridge deck, or a boat.

Scour at bridge piers can become a major safety issue for some bridges. Repair of scoured bridge piers can include construction of temporary cofferdams around affected piers to isolate work areas; concrete or gabion repair to footing, columns or abutments; placement of rip-rap at scour locations; placement of concrete mattresses along bridge piers; use of liquid concrete ('flowable' fill); or installation of concrete armor tetrapods (four-legged, interlocking concrete structures). A-JACKS are also used for direct bridge scour repair, especially where there is a low bridge with a limited hydraulic opening and when hauling rock is cost prohibitive.

Concrete mattresses consist of flat, continuous blocks of cured concrete (closed cell) or concrete with voids in which stream gravel can be placed (open cell). The concrete blocks are linked together with steel or synthetic cable. To install a concrete mattress, the streambed must be excavated at the leading and trailing edges to avoid undermining of the device. The mattress is placed on geotextile or filter fabric with an excavator, and earth anchors are often used to secure it. Rip-rap is loose stone used to stabilize banks and prevent scour and erosion. Rip-rap can be placed by hand or with machinery, depending on the size of stone and amount needed. The A-JACKS system is composed of cured concrete pieces resembling "jacks" that are assembled into a continuous, interlocking, yet flexible matrix. This matrix provides protection against high-velocity flow. The use of A-JACKS is an alternative to rip-rap placement and may avoid the need for streambed excavation. A-JACKS are typically secured together with steel cable. Placement typically requires an excavator which is operated from the stream bank whenever possible. Concrete armor tetrapods are similar in function but differ in shape. Flowable fill is a mixture of cement, sand, fly ash, water, and/or foam admixtures. It is used as a substitute for compacted gravel. It can set under water and is therefore sometimes used in scour repair/bank stabilization.

Construction of temporary access fills may be required to provide a working platform for machinery. Working platforms are usually constructed of light, loose rip-rap matched to the material necessary for the repair. The platform material is then repositioned as the machinery backs away from the work site. Installation methods vary on a site-specific basis. In navigable waters, access from a barge may be required. Whenever possible, equipment, such as excavators, will operate from stream banks, bridges, or temporary work platforms to avoid in-channel operation. If in-channel equipment operation is necessary, aquatic spider excavators are often used, especially if access to the site is difficult, as they are small, relatively light, and have rubber tires to minimize substrate disturbance. Aquatic spiders are typically used in small streams, because the size of rock they can pick up is limited. Sometimes materials can be placed directly on the streambed with little to no excavation; in other instances, excavation is necessary to key in materials. Often, stream flow and anticipated erosion will determine specific aspects of design such as anchoring.

Other methods for temporary access may include the construction of temporary haul roads or the placement of wetland access mats for wetland access. These wetland access mats may be made of geotextile fabric or wood and are placed over emergent vegetation in wetlands to provide stability and access for construction equipment in areas that may be otherwise inaccessible to heavy machinery. The construction of temporary roads is discussed further in New Road

Construction. Bridge or culvert maintenance may also include activities in the neighboring areas and include guard rail repairs or replacement and lighting or sign installation or replacement.

Structural rehabilitation may include replacement or repair of degraded steel superstructure, jacking of the bridge, rehabilitation of the bridge deck, repair to bridge approaches, or repair or replacement of bridge rail. Work is typically conducted in a stepwise fashion, moving from one section of the structure to the next, rather than on the entire structure at once. Rehabilitation of the bridge deck can include preparation of the deck surface using a machine to blast the surface of the deck. This can either be done using steel shot or hydrodemolition, which consists of a combination of sand and water, to score the surface of the deck. Another machine is used to vacuum up debris and water to control runoff. If applicable, all bridge drains are sealed during this process to prevent material from leaving the bridge deck. This prepares the bridge deck for the application of a two-part co-polymer or latex-modified concrete overlay. The co-polymer material is sprayed over the existing surface of the bridge and spread out evenly. This provides a protection on the bridge. Existing bridge drains would be plugged during the process to prevent material from leaving the bridge deck. Overlay must be applied when temperatures are over 40°F. During this process, bridge joints are also replaced by removing the existing joint, replacing with a new joint and filling and sealing. Bridge jacking is the process of increasing the vertical clearance of a bridge and adjusting the roadway to match. Roadway shoulder and slope work will be included to adjust the toe of slopes.

Protection of piles, piers, or bents include pile encasing or jacketing, using carbon fiber wraps, and cathodic protection. Pile encasing or jacketing is the process of placing a protective shell around a bridge pile to protect and expand the life of the pile. Jackets may be made of fabric or concrete and reinforced with steel. According to GDOT Standard Specification (2013) Section 547, pile encasements extend from two feet below the existing streambed to the top elevation for pile encasement, as shown on the construction plans.

Culverts require maintenance when at least 25 percent of their capacity is restricted by debris, sediment, or vegetation. Maintenance may also occur for damage to the structure, such as spalls. Culvert maintenance activities may include temporary stream diversion, debris removal, epoxy injections, patch repair, repair of the headwall, outfall, or wing walls, shotcrete lining, scour repair and rip-rap installation, washing, sandblasting, and repainting. Temporary stream diversion includes relocating the stream during the maintenance activity. The stream may be relocated to a ditch or pipe and returned to its existing channel following the completion of maintenance activity. Debris removal may be done by hand or with machines. Epoxy injections are used to repair cracks in concrete. Repair of headwall, outfall, or wing walls may include rebuilding of the structures or patches of the existing concrete. Shotcrete is concrete conveyed through a hose and pneumatically projected at high velocity onto a surface. Scour repair and rip-rap installation were described above.

If maintenance activities are to be performed during migratory bird nesting season (March 15 – August 31) and have the potential to impact migratory birds nesting on a structure, then bird exclusionary devices may be installed prior to the start of nesting season. For bridges, exclusionary barriers may be made of plastic, canvas, or other materials proposed by the Contractor and approved by the State Environmental Administrator prior to installation.

Typically netting is used. For box culverts, exclusionary barrier may be overlapping strips of flexible plastic (also called “PVC Strop Doors” or “Strip Curtains”) or an alternate material proposed by the Contractor and approved by the State Environmental Administrator prior to installation. Once installed, all exclusionary barriers shall be inspected daily for holes or other defects that impair the ability to exclude migratory birds from nesting beneath the bridge, and any holes or defects shall be repaired immediately.

Equipment

Commonly used equipment for bridge repair and maintenance includes backhoes, bulldozers, excavators, barges, dump trucks, front-end loaders, scaffolding, drapes, generators, cranes, impact and vibratory pile drivers, drilling rigs, concrete saws, traffic control devices, compressors, and other heavy equipment. The equipment operates most frequently from the bridge deck, a work barge in navigable waters, or temporary false work hung beneath the bridge deck, although in rare instances equipment may be required to operate from the bank to remove debris or repair bridge abutments and supports.

Post-construction

Post-construction activities will depend on the maintenance activity performed. These may include bank stabilization through the placement of rip-rap or re-seeding with vegetation.

ROAD MAINTENANCE

Road maintenance includes pavement preservation, shoulder work, curb cuts, and striping. Pavement preservation consists of patching, repairing, and replacing roadway surfaces and pavement. These include three types of pavement: (1) asphalt, (2) chip seal, and (3) concrete. If the existing pavement is in good condition, it may be covered over with a new layer of asphalt. Repair of badly deteriorated pavement could require grinding of existing pavement or replacement of the road foundation material prior to repaving. This typically involves grinding off and replacing the existing asphalt pavement.

Most paving occurs during May through September. Activities may occur seven days a week, taking place during daylight hours, night hours, or both, depending on traffic volumes. Project duration depends on the size of the area being paved and could take from 1 to 120 working days to complete. Pavement preservation through chip sealing (alternately termed bituminous surface treatment or BST) involves the application of hot liquid asphalt and a layer of crushed rock on an existing asphalt surface. The application of BST is a temperature- and weather-sensitive activity. These projects may include a rock crushing operation to produce the necessary aggregate.

Hotmix Asphalt (HMA) paving is also a temperature- and weather-sensitive activity. Typically, the existing pavement is ground down (cold-milling) and replaced, or simply overlaid with new asphalt. Cold milling creates dry pavement grounds that are hauled to a dumpsite, spread along the road shoulders, or recycled into new pavement. Profile grinding is another optional method of removing the pavement surface. All asphalt paving projects involve the use of an asphalt plant area where asphalt is mixed with crushed rock to produce the new HMA, as well as occasionally crushing of rock for the pavement materials.

Preservation of existing Portland Cement Concrete Pavement (PCCP) is typically accomplished by removal and replacement of the existing PCCP, the placement of additional dowel bars into the existing pavement, or grinding of the existing surface. The removal results in concrete rubble that is typically hauled to a dumpsite. This is often accompanied by profile grinding as is the placement of additional dowel bars. Profile-grinding employs a series of diamond saws cooled by water that cut away the pavement. This creates pavement slurry that requires disposal at a dumpsite. Since paving may result in a slightly higher road surface, manholes, inlets, and guardrail etc. may need to be raised or replaced.

Guardrail raising involves the removal of existing guardrail, installation of taller posts, and reinstallation or replacement (depending on condition) of the rail.

Installation or replacement of roadside signs, guide posts, and raised pavement markers; guardrail improvements, fence installation and repair; and paint striping may also be included in a paving project. For most projects, installation of road signs, guideposts, and fencing involves minor amounts of excavation and vegetation removal. However, installation of very large signs, including concrete footings and steel supports, can potentially disturb substantial areas. Trenching may also be required to run utilities from existing sources to lighted signs. Paint striping may be completed with oil-based or latex-based paints, self- adhesive strips, or inset durable lane strips. Painting must be conducted in dry weather.

Equipment

Commonly used equipment for pavement preservation includes heavy trucks, asphalt grinders, pavers, chip spreaders, rock crushing operations, asphalt plants, front end loaders, compaction rollers or tampers (both vibrating and static), guardrail post drivers, small trucks and backhoes, and traffic control devices.

Post Construction Actions

Post-construction activities will depend on the maintenance activity performed. These may include bank stabilization through the placement of rip-rap or re-seeding with vegetation.

OTHER MAINTENANCE

This category includes routine right-of-way maintenance and guard rail maintenance. Routine right-of-way maintenance includes mowing, tree trimming, shoulder/slope maintenance, and vegetation removal. Right-of-way maintenance is performed by each district. Other maintenance activities performed by each district include the removal of vegetation and snow from roads and the preparation of roads for winter weather.

Equipment

Commonly used equipment for this activity includes mowers, trucks, trailers, brush hog, dump trucks, graders, seeders, and various hand tools.

Post Construction Actions

Post-construction activities will depend on the maintenance activity performed. These may include bank stabilization through the placement of hay or mulch and re-seeding or planting.

DRAINAGE SYSTEM MAINTENANCE

Drainage System Repair and Maintenance activities include all work necessary to maintain roadside ditches and channels, cross culverts and pipes, catch basins and inlets, and detention/retention basins. Drainage features function to keep the highway free from excess water that could create an unsafe condition. Thus, drainage facilities are cleaned periodically to permit free flow and to avoid erosion and damage to roads and other infrastructure. The extent of the area to be affected by drainage system repair and maintenance activities depends upon the size of the drainage channel or ditch and the specific actions required.

Drainage system repair and maintenance work may occur throughout the year depending on the weather and the specific project; however, most work is scheduled to occur during the summer, during low-water flow or dry conditions. Work may occur at any time of day or night, seven days a week. Most activities are completed within a few hours in any given location. However, some projects may take from one to five working days to complete. Roadside ditches are impacted by the accumulation of sediments and debris, vehicles that leave the roadway, and slides. Regular maintenance is required to remove built up sediments, debris or blockages, re-slope the sides, and maintain capacity. Material that is removed is recycled when possible or placed at suitable disposal sites.

Cross culverts convey water from one side of the highway to the other. These can become blocked by debris, sediment, vegetation, beaver-deposited materials, or slide materials. Occasionally, scour within the system can result in blocking of the culvert with rock or gravel. Blocked culverts can result in flooding over the roadway, or in severe cases, the culvert and the roadway can blow out. Regular removal of debris, sediment, and vegetation can help eliminate those situations. All of these obstructions must be removed regularly. Sometimes temporary diversions, such as sandbag berms, are installed to allow for culvert cleaning in a dewatered environment.

Catch basins and inlets are part of the highway storm drain system. Sediment accumulates within these structures, necessitating regular cleaning. Material is removed by manual clearing methods or by using a vacuum truck. Solids are tested, and disposed of at an approved disposal facility. Solids may be recycled as fill material when suitable. Otherwise, they will be disposed of at an approved disposal facility. Liquids may be decanted at an approved decant facility. Regular cleaning improves water quality and minimizes sediments that enter the natural stream systems. Retention/detention facilities are used to contain runoff and remove sediments. Over time, sediments build up and must be removed to maintain capacity and filtration. Backhoes or other equipment remove the sediment buildup, normally during dry conditions.

Other typical activities include excavation of debris and sediment from ditches and detention/retention basins, minor grading and reshaping along ditches and at storm drain outfalls and inlets, and repair of damaged culverts. Removal of newly constructed beaver dams is often necessary when the dams impact the effectiveness of storm drainage facilities.

Equipment

Commonly used equipment includes dump trucks, front-end loaders, backhoes, bulldozers, double drum dragline, vacuum truck, culvert rodder (trailer-mounted high-pressure water system), water tank truck, truck- mounted attenuator, other heavy equipment, and hand tools such as shovels and rakes. The equipment generally operates from the road prism, although in rare instances equipment may be required to operate outside of the developed road prism.

Post Construction Actions

Post-construction activities will depend on the maintenance activity performed. These may include bank stabilization through the placement of hay or mulch, re-seeding or planting, and addition of rip rap.

BRIDGE CONSTRUCTION/REPLACEMENT

Bridge construction may be a component of a larger roadway construction project or a stand-alone project. There are multiple types of bridges including but not limited to concrete slab, concrete arch, concrete box girder, concrete T beam, steel beam, pre-tensioned concrete beam, post-tensioned concrete beam, steel truss, and timber trestle. Bridges can span wetlands, streams, and other water bodies as well as roadway and other transportation infrastructure.

Some bridges span the stream systems they are crossing, while others have piers in the channel. The number of piers in the channel varies by bridge. Most new bridges are designed to span as much of the river as possible, and to provide the least amount of constriction that is practicable on the system. Many bridge piers are now drilled shafts, eliminating shallow footings that are susceptible to scour.

Bridge replacements tend to be long-term projects requiring one or more years to complete. Installation of new bridges may require construction of a detour bridge. Occasionally, half of the new bridge is constructed adjacent to the old bridge and acts as the detour bridge while the original is removed and replaced. Most bridge replacements use the same alignment or are constructed near the old alignment. Temporary bridges may be built as construction platforms. Often, in-water work is timed to minimize impacts to sensitive aquatic species. Some sedimentation of the waterway may occur during pile driving and removal. Bridge removal can also result in sediment and small concrete chunks entering the water.

Major bridge replacement construction activities often include:

- Clearing and grading for road widening
- Clearing and grubbing of existing streamside vegetation
- Construction of stormwater facilities
- Excavation for new bridge abutments
- Construction of bridge columns/piers/abutments
- Concrete pouring
- Pile installation and removal

- Bridge demolition
- Rip-rap placement (described in **Bridge/Culvert Maintenance**)
- Paving with asphalt or concrete
- Relocation of above or below ground utilities (described in **New Road Construction**)

Piles are installed using several different methods. Pile driving involves the use of an impact pile driving hammer, which is a large piston-like device that is usually attached to a crane. The power source for impact hammers may be mechanical, “air steam,” diesel, or hydraulic. In most impact drivers, a vertical support holds the pile in place while a heavy weight or ram moves up and down, striking an anvil which transmits the blow of the ram to the pile. In hydraulic hammers, the ram is lifted by fluid, and gravity alone acts on the down stroke. A diesel hammer, or internal combustion hammer, carries its own power source, and can be open-end or closed-end. An open-end diesel hammer falls just under the action of gravity. A closed-end diesel hammer (double acting) compresses air on its upward stroke and can therefore run faster than open-end hammers. Impact hammers can drive at a rate of approximately 40 strikes per minute.

Vibratory hammers can also be used to both install and remove piling. A vibratory hammer is a large, mechanical device, mostly constructed of steel (weighing 5 to 16 tons) that is suspended from a crane by a cable. A vibratory pile driving hammer has a set of jaws that clamp onto the top of the pile. The pile is held steady while the hammer vibrates the pile to the desired depth. Because vibratory hammers are not impact tools, noise levels are not as high as with impact pile drivers. However, piles that are installed with a vibratory hammer must often be "proofed." Proofing involves striking the pile with an impact hammer to determine the load bearing capacity of the pile and may involve multiple impacts. If this is the case, noise will be elevated to that associated with impact pile driving. To remove piles, the hammer is engaged and slowly lifted with the aid of a crane, extracting the piling from the sediment.

Contrary to pile driving, drilled shafts may be used to establish the foundation of a bridge by using a drilled hole into the substrate that is stabilized to allow for controlled placement of reinforcements and concrete.

Cofferdams are often installed to create an isolated work area which can be dewatered for bridge and culvert installations or improvements. Cofferdams may consist of large casings (hollow cylinders) or structures created out of sheet piles. The majority of these cofferdam installations are completed with vibratory hammers. The exception to the use of vibratory hammers is when the substrate consists of very hard material, such as bedrock. In such cases, impact pile driving may be necessary. In some cases, other construction methods are used, such as stacked Jersey barriers with an impermeable liner, sand bag/impermeable liner barriers, etc. These are accomplished typically by using a crane or excavator (Jersey barrier) or placed by hand (sand bags).

Bridges can be removed using several methods, including: (1) dismantled over water from adjacent bridge deck or approach; (2) dismantled over the water and lowered onto a barge and barged out to a dismantling site; (3) dismantled over water and sections removed by crane; and

(4) falsework (temporary structures) can be built under and around the bridge, and the bridge dismantled by sections. Bridge removal methods are selected based on a number of factors, including the structure of the bridge, the size of the bridge and river, the location within the system, the topography, the substrate of the stream, and the amount of access to the bridge and the banks. Falsework includes temporary work bridges and rock jetties.

Since many older bridges have bridge piers in the system, these also need to be removed. Concrete piers can be removed by demolition using a hoe ram (as long as pieces do not enter the water), or removed by a vibratory hammer; they can be cut off two ft. below the ground level, or a temporary cofferdam can be constructed and the material can be hydraulically removed (Table B1). The bridge demolition method will be determined by site and project-specific conditions. The bridge deck may be removed by hydrodemolition or other methods. Containment systems are installed to prevent debris from falling into streams or existing roadways.

Isolation of the work area and stream (or de-watering) is often required on bridge replacement projects and may require the use of cofferdams, sandbag berms, temporary culverts or flumes depending on site conditions. Bridge replacement projects often require column construction within stream channels which typically involves the isolation of the column location through the use of a large diameter steel sleeve that is driven into the stream substrate. All work, including excavation for the footing, placement of forms, and pouring of the concrete, would then be completed within the sleeve at each column location. This technique helps minimize construction impacts by isolating the work from the stream.

Bridge demolition and replacement may also require the temporary or permanent relocation of utilities. Utilities may be located above or below ground and may even be attached to the existing bridge. Utility work may include excavation to install new utility poles or trench excavation to install underground utilities. This work is accounted for in the GDOT Ecology Assessment of Effects Report when utility relocation is a part of the GDOT contract; otherwise, environmental clearance is the responsibility of the utility company.

New bridge construction may use many of the same access and de-watering methods as listed above for bridge demolition. Bridge replacements may require more than one construction season, due to multiple factors such as project complexity or if the in-water work may be limited to certain periods to minimize impacts to sensitive aquatic species. Often, work on the out-of-water portions or behind cofferdams will occur year round.

Equipment

General equipment associated with bridge construction and demolition includes, but is not limited to, dump trucks, front-end loaders, cranes, asphalt grinders, paving machines, compaction rollers, bulldozers, chainsaws, vibratory and impact pile drivers, barges, explosives, excavators, rock crusher (if blasting is used for on-site fill) track or pneumatic drill, graders, jack hammers, stingers, wire saws, air compressors, traffic control devices, generators, and other heavy equipment.

Post Construction Actions

Following bridge construction, the site(s) are stabilized and restored using a variety of techniques. All exposed areas are typically mulched and seeded with an approved herbaceous seed mix and/or planted with woody shrub vegetation and trees (if appropriate) during the first available planting season. Temporary access road material is removed and the area is restored to a more natural grade and stabilized through seeding and planting. GDOT Standard Specifications (2013) Sections 700 – Grassing, 701 – Wildflower Seeding, and 702 – Wine, Shrub, and Tree Planting and Root Protection provide specifications for planting and specify appropriate seed mixes.

Table B1. Bridge Removal Technique Examples

Type of Structure	Construction Method	Access Method
Steel or Timber	(a) Remove structure in segments with or without dropping pieces into water.	(a) Work from shore via crane arm or other heavy equipment; (b) Work from adjacent bridge deck or bridge approach; (c) Work from temporary platform or false work erected within the water; and (d) Lower structure or segments onto barge. Barge material to shore.
Concrete	(a) Remove structure in segments without dropping in water. Frequently, concrete slabs may be removed via saw cutting.	(a) Work from shore via crane arm or other heavy equipment; (b) Work from adjacent bridge deck or bridge approach; (c) Work from temporary platform or false work erected within the water; and (d) Lower structure or segments onto barge. Barge material to shore.
Piers	(a) Leave the piers in place	N/A

	(b) Piers located out of water – cut at ground level and remove.	(a) Work from shore via heavy equipment.
	(c) Piers located out of water – removed with hoe ram.	(a) Work from shore via heavy equipment.
Type of Structure	**Construction Method**	**Access Method**
	(d) Piers located in water – construct cofferdam around and remove pier.	(a) Work from shore via crane arm or other heavy equipment; b) Work from adjacent bridge deck or bridge approach; (c) Work from temporary platform or false work erected within the water. (d) Lower structure or segments onto barge. Barge material to shore.
	(e) Piers located in water – use vibratory hammer to lift and remove.	(a) Work from shore via crane arm or other heavy equipment; b) Work from adjacent bridge deck or bridge approach; (c) Work from temporary platform or false work erected within the water. (d) Lower structure or segments onto barge. Barge material to shore.
	(f) Piers located in water – cut or break off at or below surface level (dependent upon substrate).	(a) Work from shore via crane arm or other heavy equipment; b) Work from adjacent bridge deck or bridge approach; (c) Work from temporary platform or false work erected within the water. (d) Lower structure or segments onto barge. Barge material to shore.

CULVERT CONSTRUCTION/MODIFICATION

Culverts include small concrete and box girders that do not qualify as bridges due to their size. Typically bridges less than 20 ft. wide are referred to as either culverts or structures. Conventional culverts include, but are not limited to, concrete, corrugated metal, timber, and PVC piping. Culvert installation may occur independently or as part of a larger road improvement project. Proper culvert sizing is determined by consulting hydraulics manuals and fish passage guidance. Culvert lengths range between 18 and 200 ft.

Culvert replacements and extensions are typically short duration activities requiring less than one month to complete. Typical culvert replacements and extensions involve removing vegetation at the outlet and inlet area, removing existing pavement and roadbed to extract the existing culvert, placing the new culvert, backfilling and replacing the pavement, installing armoring and headwalls, re-vegetating if necessary, and if flow is present, dewatering the work area and establishing a flow bypass prior to initiating work. In-water construction typically occurs during low-flow months or during dry periods.

Equipment

General equipment associated with roadway construction includes, but is not limited to, dump trucks, front-end loaders, cranes, asphalt grinders, paving machines, compaction rollers, bulldozers, chainsaws, vibratory and impact pile drivers, barges, explosives, excavators, rock crusher (if blasting is used for on-site fill) track or pneumatic drill, graders, jack hammers, stingers, wire saws, air compressors, traffic control devices, generators, and other heavy equipment.

Post Construction Actions

Following culvert installation or replacement, the site(s) are stabilized and restored using a variety of techniques. All exposed areas are typically mulched and seeded with an approved herbaceous seed mix and/or planted with woody shrub vegetation and trees (if appropriate) during the first available planting season. If necessary, rip-rap may be placed at the outlet of the culvert to dissipate the velocity of the water exiting the structure. Rip-rap installation is further described in **Bridge/Culvert Maintenance**. If necessary, permanent erosion control BMPs will be installed.

ROAD CONSTRUCTION

Road construction activities include those related to traffic flow and capacity increasing projects. Primary project objectives may include mobility and/or safety improvements. These projects include new road alignment, high-occupancy toll lanes, high-occupancy vehicle (HOV) lanes, intersection improvements, passing lanes, managed lanes, road realignment (including sharp curve treatments), frontage roads, and road widening. Intersection improvement projects include interchange alignments, new interchanges, roundabouts, median crossovers, and turn lanes. Widening or replacing aging bridges could occur for these projects (see **Bridge Construction/Replacement**). Constructing new or extending / replacing culverts could also occur for these projects (see **Culvert Construction / Modification**).

Several activities and components of transportation are described within the new roadway construction category, such as staging area establishment, offsite use areas, site preparation, roadway construction, and drainage system installation and enhancements.

Unique components of highway construction include stormwater treatment facility construction, paving, painting, illumination, and signing. New highway interchange construction could occur in areas that are highly developed or within areas that are becoming increasingly developed, but do not typically occur in rural areas.

Some new road construction is designed to improve the safety of the highway system. These projects include installation of sidewalks, slope flattening (which often require culvert extensions), and alignment modifications. Slope flattening and clear zone maintenance reduces hazards for automobiles that inadvertently leave the roadway. The clear zone is the total roadside border area that is available for safe, unobstructed use by errant vehicles. Slope flattening typically involves the placement and removal of fill material on existing cut slopes. Slopes are flattened to make them more traversable and improve site distance. Slope and ditch repair involves re-grading ditches and slopes to the current safety standards and design slopes. It may also include filling in or repairing sides of the ditches where necessary. Alignment modifications may include adding auxiliary lanes (e.g., truck climbing and acceleration lanes), channelization (new turn lanes), on- and off-ramp extensions, or realigning an intersection to improve the sight distance. If a new lane is added, an alignment modification of the adjacent road may be necessary to maintain continuity of the roadway.

Road realignment may also straighten curves or approaches to bridges. Alignment modifications could range in length from a few hundred ft. to a couple thousand ft. for curve realignments, or up to a few miles for realigning a major section of roadway. Truck lanes, turn lanes, and acceleration lanes typically average between 10 and 12 ft. wide. Sidewalk widths vary from 5 to 10 ft. wide, depending on jurisdiction and intended use. Road realignments and widenings often range between 0.25 and 5.0 miles in length. New interchanges and interchange improvements, such as roundabouts and median crossovers, are also common safety projects.

High-occupancy toll lanes and high-occupancy vehicle lanes are lanes constructed to increase the available capacity of roadways. These lanes require a toll or minimum vehicle occupancy for use of the lanes. These are typically constructed on existing interstates to increase their capacity and may be reversible depending on traffic flow.

Drainage systems on new road construction may include the installation of curb and gutter to drain water from the roadway. Additional features may be necessary to convey water, including the installation of culverts, ditches, vegetative swales, and similar structures.

Staging areas are used for delivery and storage of construction materials and equipment, contractor office and storage trailers, and employee parking. These areas are typically contractor-selected and permitted. These areas are often fenced and located in close proximity to project construction. Temporary fencing prevents machinery and equipment, materials storage, and construction activity from intruding into adjacent properties, wetland and stream buffers, and shoreline areas. Office trailers, placed on temporary foundations, are often connected to available utilities including power, telephone, water, and sewer as needed. Connecting to these utilities may include installing poles for power lines and excavating trenches to place water and sewer pipelines. After construction is complete, staging areas are restored, if appropriate, and disconnected from any utilities.

Depending on site conditions, construction staging areas vary in size and may require vegetation clearing, grubbing, and grading or excavation to level the site and install drainage improvements. Extensive alterations to establish a staging area, such as blasting, are extremely unlikely. Cleared vegetation is often hauled offsite, mulched and redistributed, or less commonly piled and burned onsite (i.e.: slash piles). Excess material (e.g., soil, rock, and debris) is disposed of at offsite facilities or reused as appropriate in construction. Conveyance systems for the movement of stormwater from a collection point to an outfall can consist of drainage pipes and stormwater facilities (such as ponds, vaults, and catch basins), using gravity or pumps to move the stormwater. Temporary driveways and access roads may be established from staging areas to the existing roadway network. Some staging areas may also be equipped with wheel washes that clean truck tires to reduce tracking dirt and dust offsite. Additional dust control is provided via water trucks and street sweepers.

Staging, fueling, and storage areas are typically located in areas that minimize potential effects to sensitive areas. Specialized best management practices (BMPs) are employed around concrete-handling areas to prevent water contamination from uncured cement entering water bodies or stormwater facilities. Temporary erosion and sediment control measures are implemented prior to ground disturbance on these sites. Examples include marking clearing limits, establishing construction access, controlling runoff flow rates (sediment ponds, check dams, etc.), installing sediment controls and soil stabilization (silt fence, coir blankets, temporary seeding), protecting slopes, protecting drain inlets, and preventing/containing contaminant spills.

OFFSITE USE AREAS

Offsite use areas are necessary for rail and roadway projects and mainly consist of borrow material and waste disposal sites. Depending on the project, they can be owned by GDOT or another public or private entity. Borrow sites are contractor-selected and undergo a separate environmental analysis from the rest of the project. Sites that would require a 404 permit or coordination under the Endangered Species Act are dismissed, thus only sites with negligible environmental impact are chosen. Common activities associated with material sites include vegetation removal, excavation, rock crushing, and blasting.

Project specific locations include such areas as staging areas, access roads, borrow sites, and waste disposal areas for project-related activities. These types of project-related activities may or may not occur within the project limits of construction and are often carried out by State DOT contractors.

SITE PREPARATION

Site preparation begins with vegetation removal, which may be permanent or temporary. Permanent conversion of a vegetated area into a developed area includes clearing vegetation then grubbing out the roots. Temporary vegetative clearing includes cutting vegetation but maintaining the root mass to allow for regrowth. Removed vegetation is disposed of similarly to staging area vegetation clearing. Preliminary earthwork consists of stripping topsoil from an area and either removing earth or placing and compacting earth for roadway prism construction or slope construction. The earth may be moved from or to another section on the same project, or it may come from or be disposed off-site. Completed cut or fill prisms may then be covered by any number of treatments, such as rock base and pavement, rock stabilization and rip-rap, or mulch and seeding.

Blasting may also be required when expanding the road. The scale of blasting operations can vary from breaking up a boulder or trimming an unstable overhang, to large-scale removal operations that involve thousands of cubic yards of material. The size and spacing of charges are largely dependent on the work objectives and the geologic structure of the rock. There are two general types of blasting: production and controlled. Production blasting uses widely-spaced, large explosive charges that are designed to fragment a large amount of burden (the rock that lies between the existing slope face and blasthole). Controlled blasting uses more tightly spaced and smaller explosive charges to remove smaller amounts of burden. This technique can remove material along the final slope face or it can be used prior to production blasting to create an artificial fracture along the final cut slope.

Holes are drilled into the rock to set explosives. Drilling may be done with hand equipment by workers suspended on ropes to crane-supported drill platforms. In some cases, drill access may require establishing small access roads to position a track-mounted drill rig. Soil and unconsolidated rock on top of the blasting surface is removed prior to blasting. Blasting mats may be required to contain flying rock, especially when blasting occurs adjacent to sensitive areas such as aquatic systems. Containment can also include installing anchored wire mesh.

Temporary earthen or rock berms that function as heightened ditches or proprietary rockfall protection fences located close to the blasting area are also commonly used to contain rolling debris or minimize movement of blasted material. These structures are typically placed at the toe of landslides and are located to avoid impacts to stream or wetlands and designed to keep debris out of sensitive areas. Rock berms can also be permanent structures. Berms or fences are typically within the road prism; therefore, impacts to vegetation are minimal.

Drainage and utility work often accompany excavation and embankment. Impacts to wetlands and other sensitive areas are first avoided and minimized as much as possible, then mitigated when unavoidable. Utility work includes excavation to install new utility poles or trench excavation to install underground utilities. This work can be completed in forested areas. This work is accounted for in the GDOT Ecology Assessment of Effects Report when utility relocation is a part of the GDOT contract; otherwise, environmental clearance is the responsibility of the utility company.

Temporary road construction is often necessary for equipment access and involves similar site preparation activities as conducted for permanent roads. However, these roads are often unpaved, either constructed by grading, laying fabric and quarry spalls, or construction mats. Compaction is minimized so the materials can be removed and the site restored and replanted following construction. A variety of temporary construction BMPs are used for site preparation, including silt fences, berms, fiber wattles, storm drain inlet protection, straw bale barriers, check dams, and detention or siltation ponds. Erosion control measures are installed and operational before commencement of ground- disturbing activities. Areas where vegetation should be preserved are clearly marked or fenced. If work is conducted at night, temporary lighting is utilized.

Roadway Construction

Roadway construction activities generally include installation of the roadway itself, and associated facilities such as retaining walls, noise walls, and stormwater treatment.

A roadway embankment is a raised area of fill often used in roadway approaches. The construction of roadway embankment consists of building up soil or rock to create a new ground surface at the elevation needed for the new roadway or structure. Roadway embankments slope outward; therefore, the higher the embankment, the wider the surface area needed at the base. To avoid future settlement, rollers and hauling equipment thoroughly compact each layer of soil or rock. Retaining walls are used to support the embankment fill area where other constraints may exist along the alignment. Once final grading is achieved, the roadway is paved, striped, and signed. Guardrails may also be installed if applicable. More detail on paving is provided in **Road Maintenance**.

Retaining walls are used to minimize the footprint width of the roadway cut or fill. Because retaining walls can be nearly vertical, they allow for a much smaller footprint than an earth slope. They can be used to support the roadway when the roadway is higher than the surrounding ground and can also be used in situations where the road is lower than the surrounding ground. In this case, the retaining wall supports the adjacent soil and prevents soil from slumping onto the roadway. Retaining walls are also used in areas where there is a high possibility of erosion such as near a bridge abutment or water. The walls must have an area of free drainage between the retained soil and the back of the retaining wall to prevent water pressure from developing and adding to the soil loads. The drainage is usually provided by placing a layer of clean gravel and drainage pipes against the back of the retaining wall. There are a variety of wall types (soldier pile, mechanically stabilized earth [MSE], soil nail, etc.); the type used depends on the structure it supports, the ground slope being retained, and available area.

Noise walls are mitigation measures designed to reduce noise impacts on sensitive receivers. They are typically precast panels or cast-in-place walls. They can be cast in a wide variety of patterns to improve their aesthetics. On bridges, noise walls may be cast into the traffic barrier. Noise walls are constructed to withstand the forces of wind and seismic loads.

Stormwater facilities are typically constructed to collect and treat stormwater runoff from impervious surfaces such as roads and bridges. The type of facility constructed will depend on the topography, profile of the road or bridge segment, availability of land, and availability and proximity of an outfall site for collected and treated water. A variety of approaches are utilized, such as bioswales, constructed stormwater wetlands and ponds, vaults, and where possible, infiltration and dispersion.

Equipment

General equipment associated with roadway construction includes, but is not limited to, dump trucks, front-end loaders, cranes, asphalt grinders, paving machines, compaction rollers, bulldozers, chainsaws, vibratory and impact pile drivers, barges, explosives, excavators, rock crusher (if blasting is used for on-site fill) track or pneumatic drill, graders, jack hammers, stingers, wire saws, air compressors, traffic control devices, generators, and other heavy equipment.

Post Construction Actions

Following road construction, the site(s) are stabilized and restored using a variety of techniques. All exposed areas are typically mulched and seeded with an approved herbaceous seed mix and/or planted with woody shrub vegetation and trees (if appropriate) during the first available planting season. Temporary access road material is removed and the area is restored to a more natural grade and stabilized through seeding and planting. If necessary, permanent erosion control BMPs will be installed.

SAFETY IMPROVEMENTS

Safety and mobility projects may occur within both rural and urban environments. Projects in this category are designed to improve safety, traffic flow, and operations on existing road corridors. Work described in this section is intended to focus on those safety and mobility improvements that typically, by themselves, do not require new significant road construction as described in **Road Construction**.

Advanced Traffic Management System and Intelligent Transportation System highway projects typically include installing or repair/replacement of fiber-optic cables, traffic cameras, variable message signs, traffic information signs, weather stations, and highway advisory radio systems.

Highway safety projects may also include installation or repair of sidewalks, guard rail and curbing, concrete jersey barriers, and impact attenuators. Additional safety projects include signal and illumination improvements, raised (island) or painted channelization, tree removal from the clear zone, shrub cutting from the road prism when encroaching on sight distance, and rumble strip grinding. Channelization is the separation of conflicting traffic movements with the use of new turn lanes, traffic islands, or pavement markings.

Additionally, safety improvements include lighting and signal installation or replacement. These projects are typically performed within existing right-of-way with minimal ground disturbance.

Equipment

General equipment associated with Safety Improvements typically includes, but is not limited to, dump trucks, front-end loaders, cranes, asphalt grinders, paving machines, compaction rollers, bulldozers, chainsaws, vibratory and impact pile drivers, graders, jack hammers, wire saws, air compressors, traffic control devices, generators, and other heavy equipment.

Post Construction Actions

Post construction methods will be similar to **Road Construction**. All exposed areas are typically mulched and seeded with an approved herbaceous seed mix and/or planted with woody shrub vegetation and trees (if appropriate) during the first available planting season. Temporary access road material is removed and the area is restored to a more natural grade and stabilized through seeding and planting. If necessary, permanent erosion control BMPs will be installed.

PUBLIC USE

Public Use activities include multi-use trails, park and ride facilities, parking areas, rest areas, sidewalks, waystations, scales, and welcome center facilities.

Multi-use paths are typically concrete or asphalt paths for pedestrian and non-motor vehicle use. These paths may go through wetland areas and may be associated with an existing roadway or constructed separately. In wet or environmentally sensitive areas, wood boardwalks are used. Construction of multi-use paths is similar to **Road Construction**.

Other public use activities can include the construction of facilities, such as parking areas, rest areas, waystations, scales, and welcome centers. Site preparation of these facilities is similar to **Road Construction** and can be found detailed in that section. Project construction may include the laying of asphalt or concrete and the construction of a physical building.

Equipment

General equipment associated with roadway construction includes, but is not limited to, dump trucks, front-end loaders, cranes, asphalt grinders, paving machines, compaction rollers, bulldozers, chainsaws, vibratory and impact pile drivers, barges, explosives, excavators, rock crusher (if blasting is used for on-site fill) track or pneumatic drill, graders, jack hammers, stingers, wire saws, air compressors, traffic control devices, generators, and other heavy equipment.

Post Construction Actions

Post construction methods will be similar to **Road Construction**. All exposed areas are typically mulched and seeded with an approved herbaceous seed mix and/or planted with woody shrub vegetation and trees (if appropriate) during the first available planting season. Temporary access road material is removed and the area is restored to a more natural grade and stabilized through seeding and planting. If necessary, permanent erosion control BMPs will be installed.

APPENDIX C. TOTAL EFFECT SCORE SPREADSHEET TOOL USER'S GUIDE

This document is intended to provide guidance and assist with questions when implementing the Total Effect Score spreadsheet tool, TES_v9.6.xlsx. The spreadsheet tool was developed by the Institute for Resilient Infrastructure Systems and River Basin Center at the University of Georgia in collaboration with the Georgia Department of Transportation and U.S. Fish and Wildlife Service. The spreadsheet tool calculates the Total Effect Score and Maximum Effect Score according to the methods outlined in Chapters 2 – 4 of this report for project stream reaches and species. Consequently, the tool can aid in selection of appropriate construction phase Avoidance and Minimization Measures (AMMs) and post construction stormwater BMPs.

The document is organized by worksheets and steps required to implement the tool. The procedures outlined here can serve as a step-by-step guide to properly implement the tool. However, numerically labeled instructions are available in the tool itself. This guide does not provide detailed descriptions of inputs to the tool as they are provided by comments in the tool itself and in Chapters 2 – 4 of this report.

CAUTION: It is important to only modify cells or text where prompted within the tool. Modifying existing sheet labels or cells that are not intended for user input could result in an error due improper referencing/indexing of built-in functions.

Project Description Sheet

The Project description sheet appears upon opening an empty version of the tool (Figure C1). This page must be filled out to populate the rest of the tool with the appropriate reach labels.

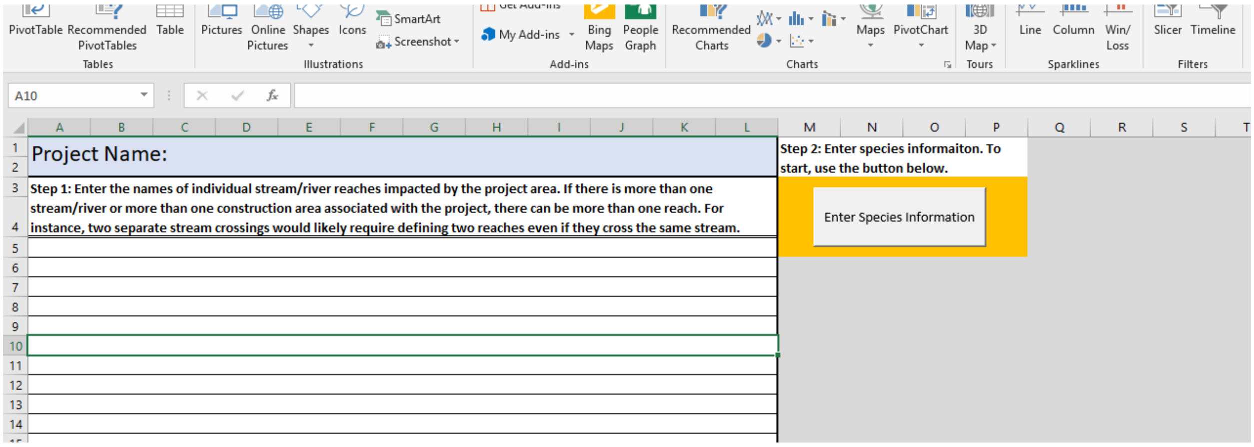


Figure C1. Image. Display upon opening an empty version of the tool.

Step 1. Enter the name of the project beginning and cell A1 and individual stream/river reaches beginning in cell A5 (Figure C2). As indicated in the tool, stream or river reaches are those impacted by the project. Separate reaches may be entered to delineate between locations along the same stream/river that are separated by different project impact areas. For instance, two separate reaches along the same stream may be required where different project areas are located in separate sub-basins, such as two bridge crossings located some distance apart.

Once all streams/river reaches have been entered, click the gray button labeled “Enter Species Information” to continue (Step 2).

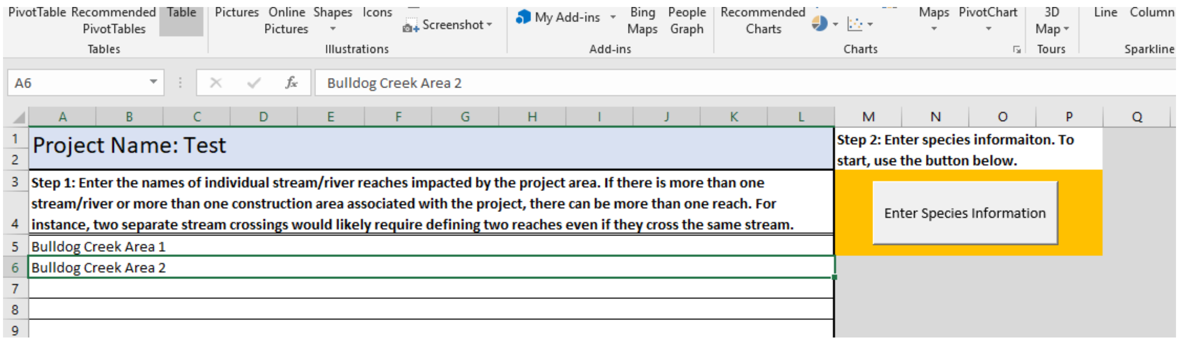


Figure C2. Image. Display of Project Description with project name and stream/river reaches filled out.

Species

Step 2. The species tab includes a list of state and federally listed threatened and endangered freshwater aquatic species. A column label is added for each stream/river reach entered on the Project Description sheet (Figure C3).

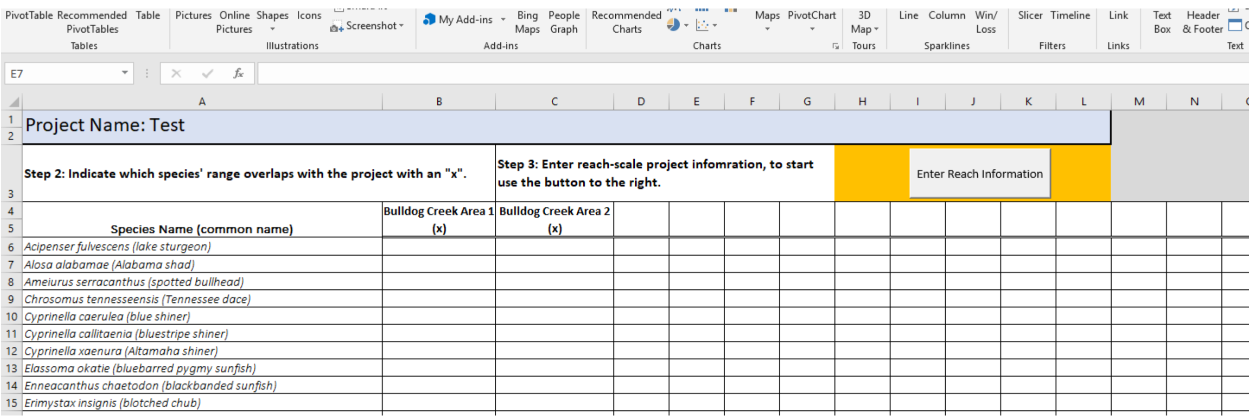
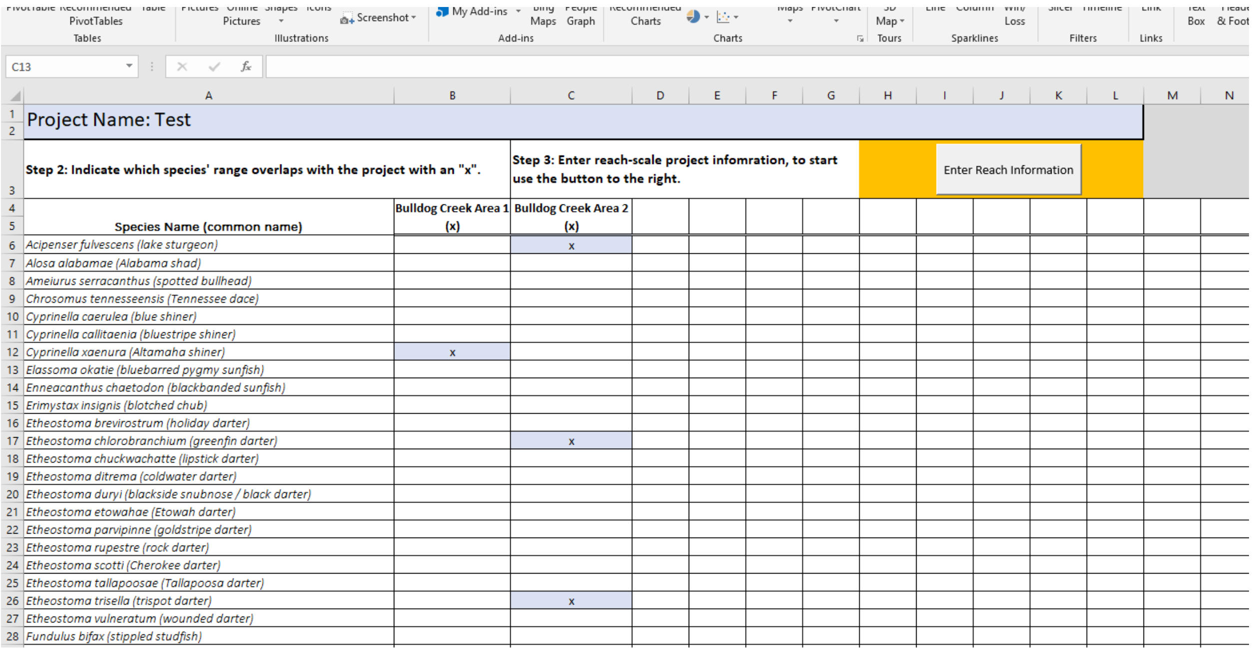


Figure C3. Image. Species information sheet.

For each stream/river reach, select the appropriate species by entering a lower case "x" in the corresponding row for that species (Figure C4). More than one species can be selected for each stream/river reach. Once all species have been selected proceed to Step 3 by clicking the gray box labeled "Enter Reach Information".



Project Name: Test

Step 2: Indicate which species' range overlaps with the project with an "x".

Step 3: Enter reach-scale project infomration, to start use the button to the right.

Enter Reach Information

Species Name (common name)	Bulldog Creek Area 1 (x)	Bulldog Creek Area 2 (x)
Acipenser fulvescens (lake sturgeon)		x
Alosa alabamae (Alabama shad)		
Ameiurus serracanthus (spotted bullhead)		
Chrosomus tennesseensis (Tennessee dace)		
Cyprinella caerulea (blue shiner)		
Cyprinella callitaenia (bluestripe shiner)		
Cyprinella xaenura (Altamaha shiner)	x	
Elassoma okatie (bluebarred pygmy sunfish)		
Enneacanthus chaetodon (blackbanded sunfish)		
Erimystax insignis (blotched chub)		
Etheostoma brevirostrum (holiday darter)		
Etheostoma chlorobranchium (greenfin darter)		x
Etheostoma chuckwachatte (lipstick darter)		
Etheostoma ditrema (coldwater darter)		
Etheostoma duryi (blackside snubnose / black darter)		
Etheostoma etowahae (Etowah darter)		
Etheostoma parvipinne (goldstripe darter)		
Etheostoma rupestre (rock darter)		
Etheostoma scotti (Cherokee darter)		
Etheostoma tallapoosae (Tallapoosa darter)		
Etheostoma trisella (trispot darter)		x
Etheostoma vulneratum (wounded darter)		
Fundulus bifax (stippled studfish)		

Figure C4. Image. Species information sheet with species for each reach selected.

Upon clicking the "Enter Reach Information" button, a number of worksheets will be created. Proceed in the order in which they are listed at the bottom of the screen: 1) ES Inputs, 2) PCES, 3) each stream/river reach name.

ES Inputs

Step 3. This sheet corresponds to direct impact effects to species such as physical contact, reproduction, and lost habitat. Values should be entered according to the column headings for each species and each reach (

Figure C5).

Project Name: Test

Step 3: Enter reach-scale information for the direct impact effect score.

Reach	Species	Direct effects do not apply for a species? (x = not applicable, blank= applicable)	Number of reproductive seasons during in-water work	Migratory species timing restrictions applied? (x = yes, blank for no)	Area of permitted impact (Acres)	Area of permitted impact + downstream impacts (Acres)	Lost habitat (Acres)	Area of reconnected habitat (% of existing)	Critical Population Adjustment (0.8, 0.9,1, or 1.1)
Bulldog Creek Area 1	Cyprinella xaenura (Altamaha shiner)		1		0.05	0.06	0.0030		1
Bulldog Creek Area 2	Acipenser fulvescens (lake sturgeon)	x	1		0.05	0.06	0.004		1
Bulldog Creek Area 2	Etheostoma chlorobranchium (greenfin darter)		1		0.05	0.06	0.004		1
Bulldog Creek Area 2	Etheostoma trisella (trispot darter)		1		0.05	0.06	0.004		1

Figure C5. Image. ES Inputs sheet.

Guidance for each input is provided in the tool through comments as indicated by red triangles in the top right-hand corner of the column heading cells. Comments can be viewed by hovering the cursor over the red triangle (Figure C6). Full definitions of each input and how they are incorporated into the Direct Effect Score are outlined in Chapters 2 - 4 this report.

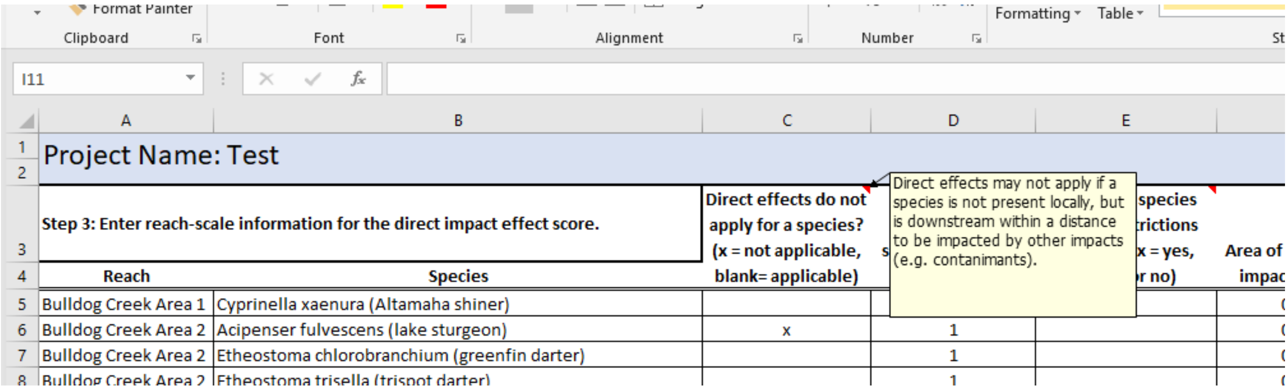


Figure C6. Image. Comment displaying guidance for input indicated by column heading.

Once the inputs have been entered for each stream/river reach and species, proceed to Step 4 by selecting the "PCES" worksheet tab at the bottom of the page.

PCES

Step 4. This sheet is intended for inputs relating to the Post Construction Effect Score, and it can be used in an iterative fashion to select the appropriate BMPs required to modify the Total Effect Score as desired. For instance, some BMPs have a higher efficacy and will reduce the TES more than others with a lower efficacy. Locations for input will be expanded as pre-requisite information is provided.

The first pieces of required information are the "Number of subregions" and "Total Proposed Project IA (acres)" which are input at cells B4 and B5, respectively (Figure C7). As noted on the ES Inputs, guidance for specific input information is available through comments in the tool (indicated by a red triangle at the top right corner of a cell).

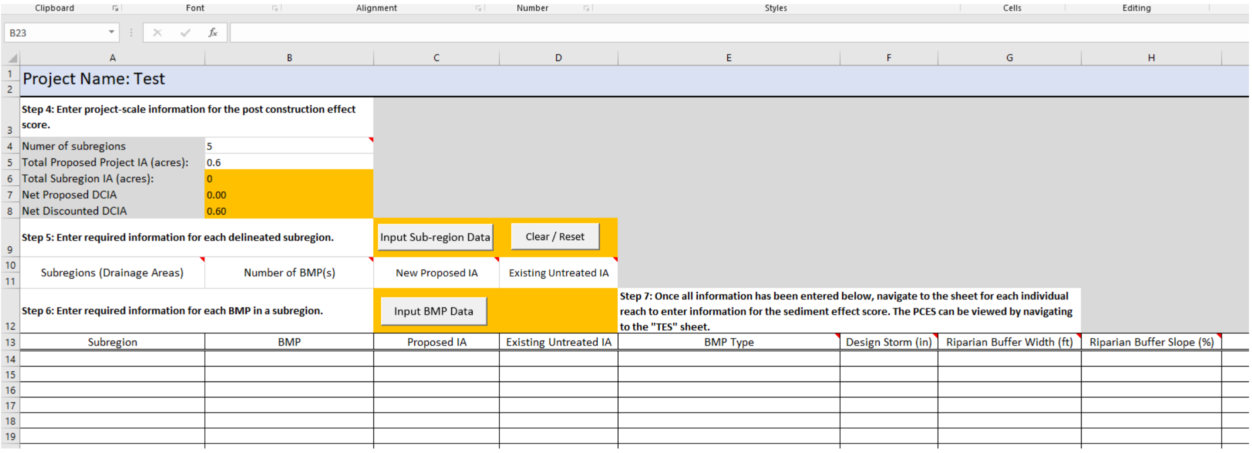


Figure C7. Image. PCES inputs upon arriving at the sheet.

Step 5. Once the inputs required by Step 4 have been provided click the button labeled “Input Sub-region Data”. This will provide a space to enter information for the number of sub-regions input in Step 4 at cell B4 (Figure C8). If the number of subregions changes, and more or less rows are required, use the “clear/reset” button to start over and go back to Step 4. Note: Both the “New Proposed IA” and the “Existing Untreated IA” do not need to be filled out. Input is only required for one of them for each subregion. However, it may be appropriate to enter values for both, and the tool will perform calculations accordingly. The definitions for these two inputs are available through comments in the tool as indicated by the red triangles at the top right-hand corner of cells.

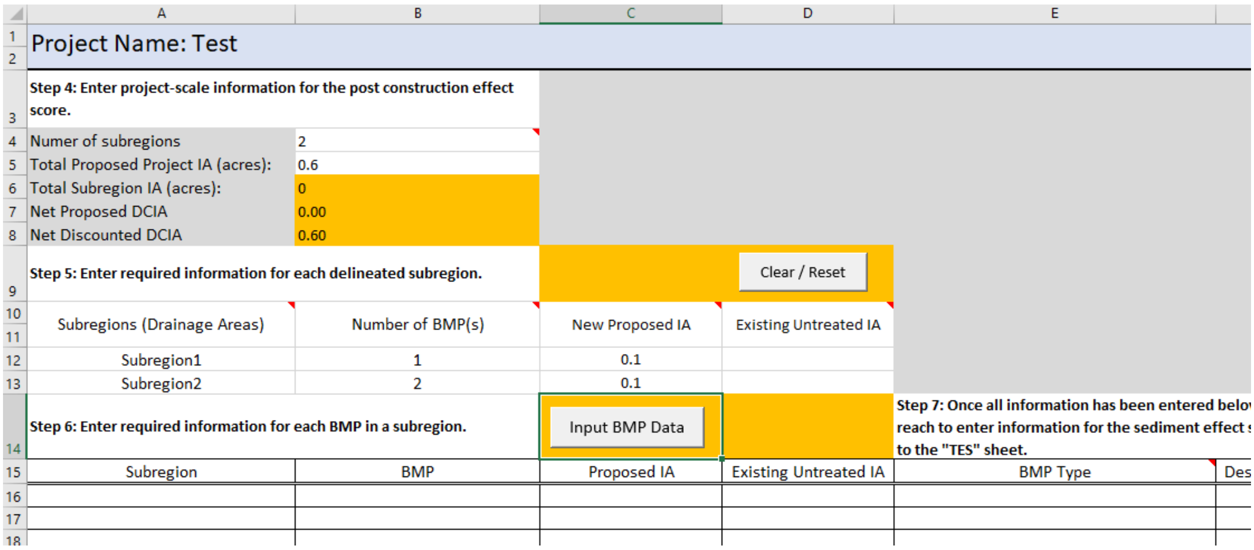
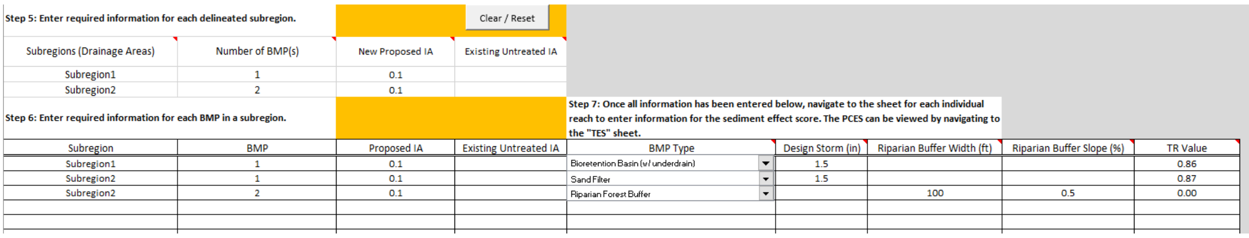


Figure C8. Image. Display of area to enter specific information for each subregion.

Step 6. Click the button labeled “Input BMP Data” to enter BMP specific information for each subregion (Figure C9). This will populate BMP and subregion data according to information provided in Step 5. This is the primary iterative component of the PCES sheet. Once the rest of the steps are completed and the TES is correctly calculated, the user can return to the PCES sheet and modify BMP selection to evaluate its impacts on the TES. Only information for BMP Type, Design Storm, Riparian Buffer Width, and Riparian Buffer Slope should be entered in this section. According to the BMP type, only design storm or riparian buffer information should be provided (Figure C9). Riparian buffer information only applies to the Riparian Forest Buffer BMP. The BMP type and design storm/riparian buffer information are used in background calculations to determine BMP efficacy which impact the post construction effect score.



Step 5: Enter required information for each delineated subregion.

Clear / Reset

Subregions (Drainage Areas)	Number of BMP(s)	New Proposed IA	Existing Untreated IA
Subregion1	1	0.1	
Subregion2	2	0.1	

Step 6: Enter required information for each BMP in a subregion.

Step 7: Once all information has been entered below, navigate to the sheet for each individual reach to enter information for the sediment effect score. The PCES can be viewed by navigating to the "TES" sheet.

Subregion	BMP	Proposed IA	Existing Untreated IA	BMP Type	Design Storm (in)	Riparian Buffer Width (ft)	Riparian Buffer Slope (%)	TR Value
Subregion1	1	0.1		Bioretention Basin (w/ underdrain)	1.5			0.86
Subregion2	1	0.1		Sand Filter	1.5			0.87
Subregion2	2	0.1		Riparian Forest Buffer		100	0.5	0.00

Figure C9. Image. Display of input for BMP specific information. Notice that design storm is used for non-riparian buffer BMP types and riparian buffer width and slope are input for the Riparian Forest Buffer BMP.

Once the information of the PCES is filled out, proceed to Step 7 by navigating to the worksheet labeled with one of the stream/river reach names.

Stream/River Reach Name

Step 7. Enter the project characteristics required to calculate the sediment effect score for each specific stream/river reach (Figure C10). Each stream/river reach has an identical page specified by its name on the Project Description sheet. Definitions for each input are listed to the right of each input. Some of the inputs required directly providing a value; while others enable selection from a dropdown menu. The project reach information is used to estimate expected soil loss for use in the sediment effect score calculation.

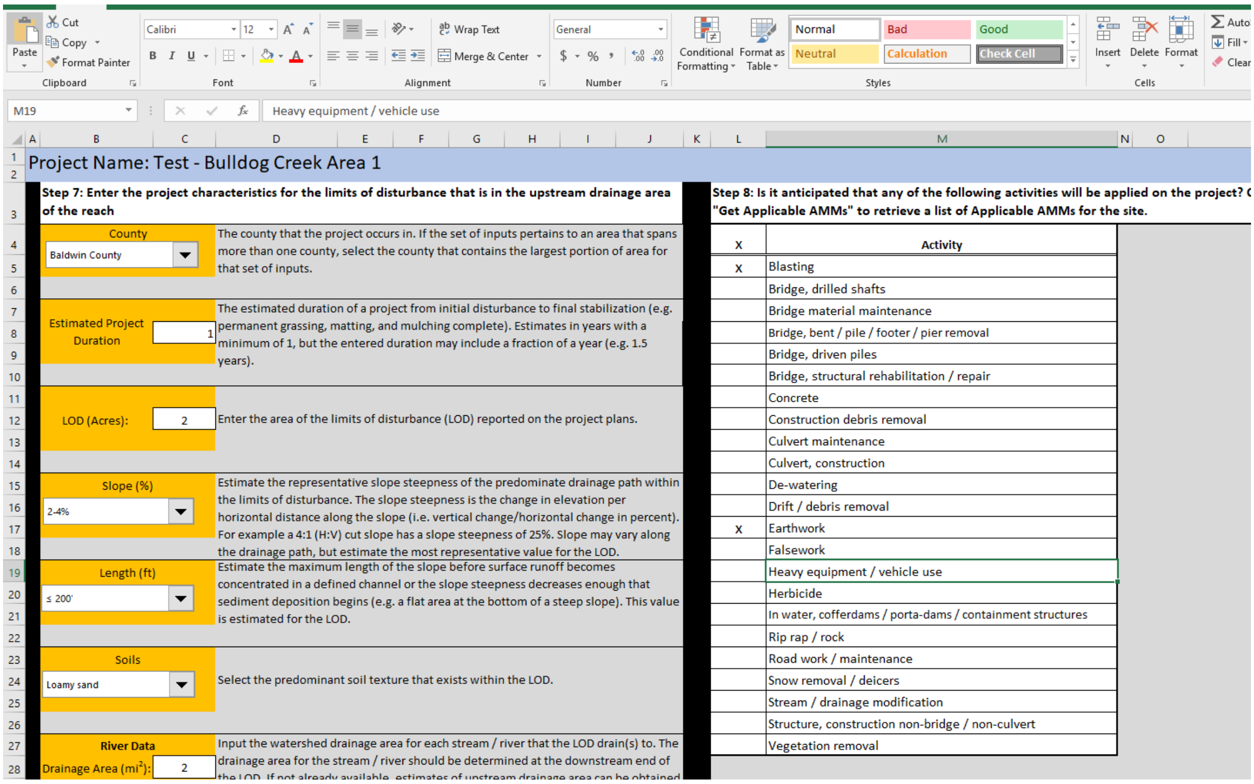


Figure C10. Image. Display of required project reach characteristics and anticipated activities for calculating the sediment effect score.

Step 8. Once the project reach characteristics have been entered, identify the anticipated activities that will be employed at the project (Figure C10). Selected activities are used to determine the applicable AMMs for a particular project reach.

Step 9. Once the activities have been selected, scroll down to find Step 9, where the user must indicate additional detail about the nature of project activities (Figure C11). This section is required to ensure populated AMMs are applicable and the sediment effect score is not biased by evaluating AMMs that do not apply to a particular scenario. Responses are indicated by an “x” or leaving the cells blank if they do not apply. Once this is complete, click the gray button labeled “Get Applicable AMMs”, which will automatically search a database to populate applicable AMMs for the project reach. Upon selecting the button, a message box will ask for verification to proceed since it will clear any previously selected

AMMs since this sheet can be used iteratively to evaluate the selection of different AMMs on the TES.

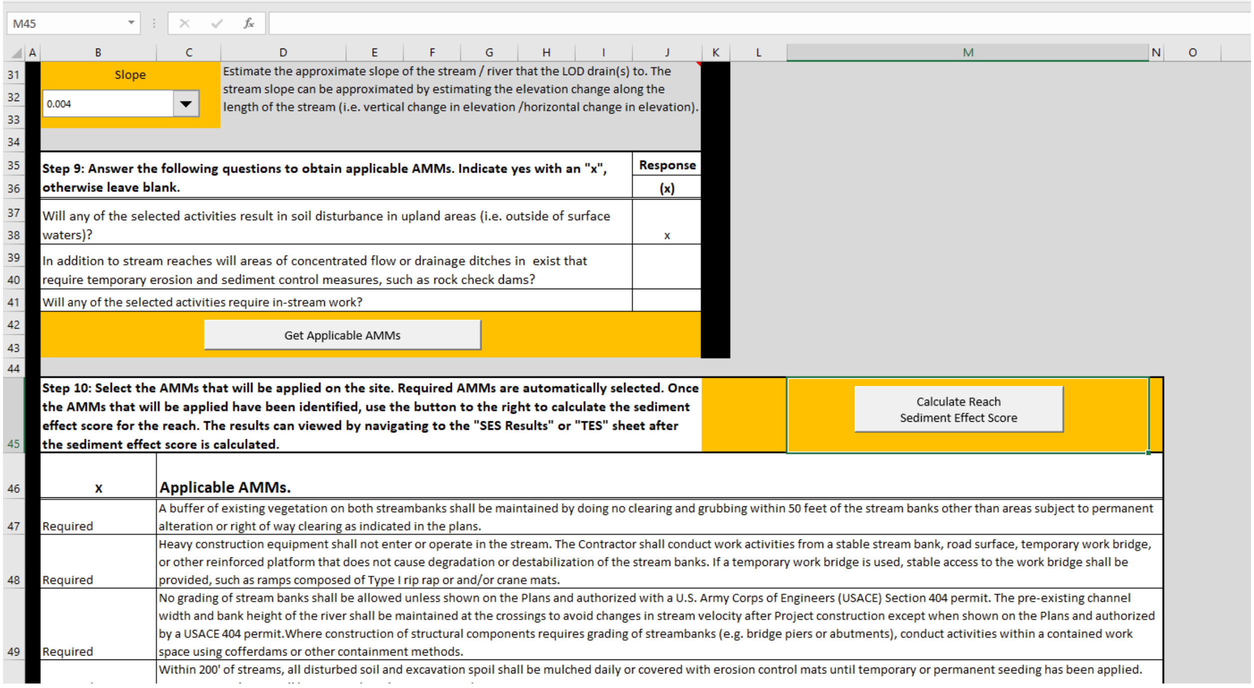


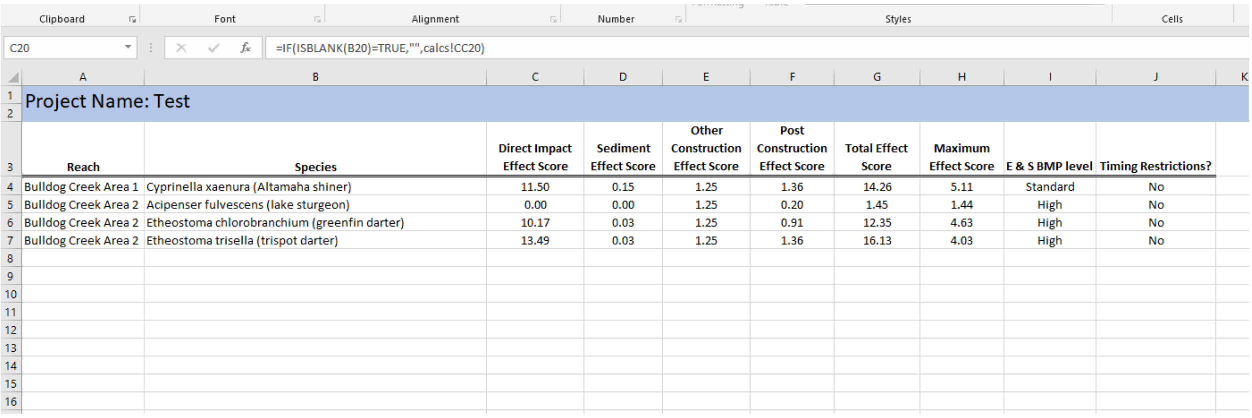
Figure C11. Image. Display of required information in Step 9 and applicable AMMs returned by clicking the button "Get Applicable AMMs"

Step 10. Once the applicable AMMs have been populated the user must select which to apply by indicating them with an “x” in the cells to the left of the AMM. Certain AMMs are required and will be indicated as such (Figure C11). The required and optional AMMs are grouped together for ease of viewing. The required AMMs are displayed before the optional AMMs. Once the optional AMMs to be applied have been selected, click the gray button labeled “Calculate Reach Sediment Effect Score”. This will calculate the sediment effect score for each species at that reach and is based on the project reach characteristics, employed activities, and applied AMMs.

Steps 7 – 10 must be repeated for each stream/river reach listed on the Project Description sheet. Once this is complete the user can navigate to the TES sheet to view the results.

TES

This sheet displays the results of each effect score due to the inputs required in steps 1 – 10 (Figure C12). Information will be incomplete if all steps have not been completed prior to navigating to this page. The user may view the results and iteratively modify inputs provided in prior steps. Particularly, this feature is intended to aid in selection of post construction BMPs (Steps 4 - 6) and construction phase AMMs (Steps 7 – 10).



Reach	Species	Direct Impact Effect Score	Sediment Effect Score	Other Construction Effect Score	Post Construction Effect Score	Total Effect Score	Maximum Effect Score	E & S BMP level	Timing Restrictions?
Bulldog Creek Area 1	Cyprinella xaenura (Altamaha shiner)	11.50	0.15	1.25	1.36	14.26	5.11	Standard	No
Bulldog Creek Area 2	Acipenser fulvescens (lake sturgeon)	0.00	0.00	1.25	0.20	1.45	1.44	High	No
Bulldog Creek Area 2	Etheostoma chlorobranchium (greenfin darter)	10.17	0.03	1.25	0.91	12.35	4.63	High	No
Bulldog Creek Area 2	Etheostoma trisella (trispot darter)	13.49	0.03	1.25	1.36	16.13	4.03	High	No

Figure C12. Image. Display of the calculation results that quantify effect scores on the TES sheet.

SES Results

This sheet is intended for ease of viewing and reporting. By clicking the gray button labeled "Show or Refresh Results", the tool will write out the species, project reaches, results of the sediment effect score, activities, and applied AMMs so that the sheet can be easily printed or copied into reports (Figure C13). If changes are made to other portions of the sheet after displaying the results, they will not automatically update. The user must select the gray button to reflect any changes.

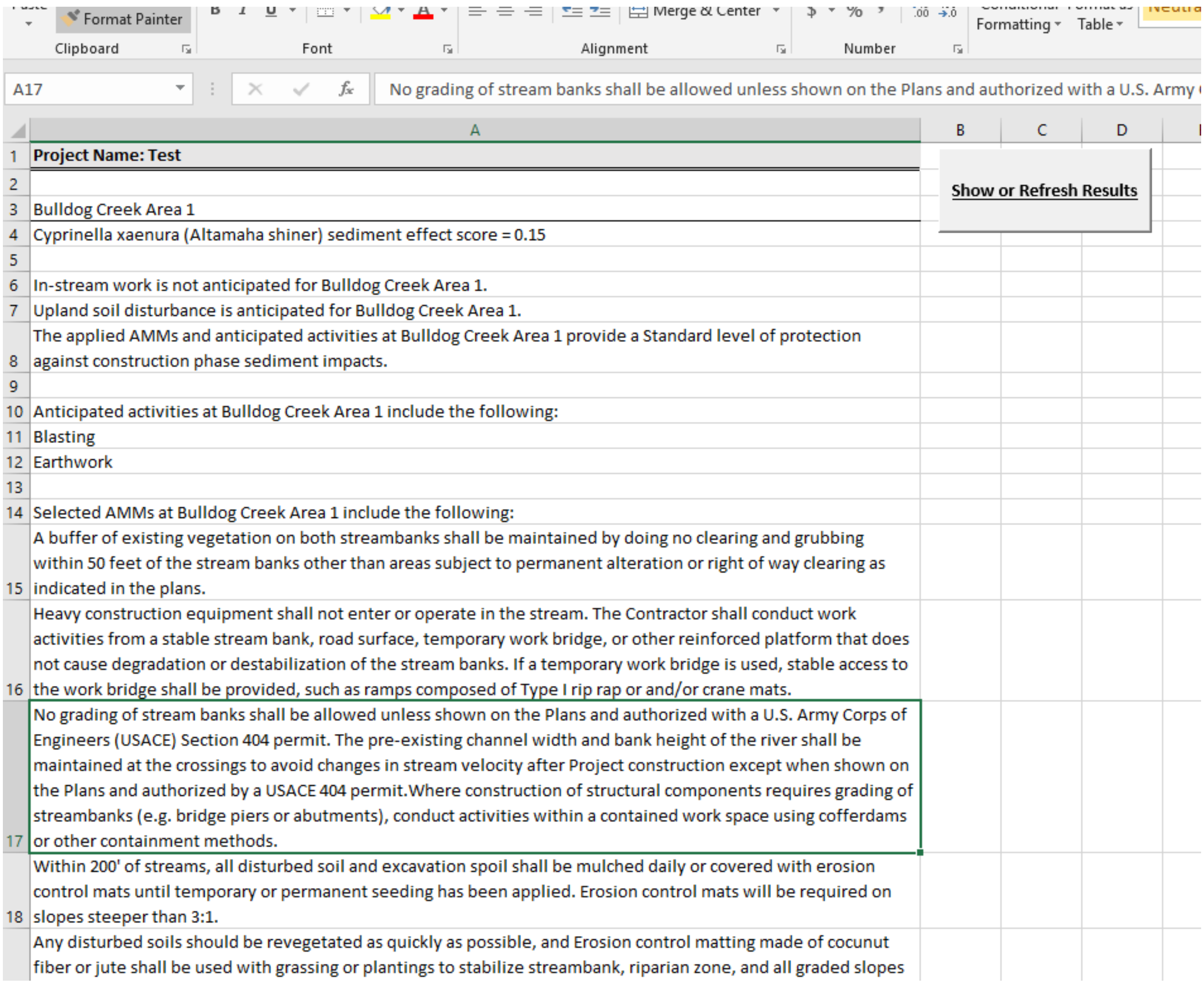
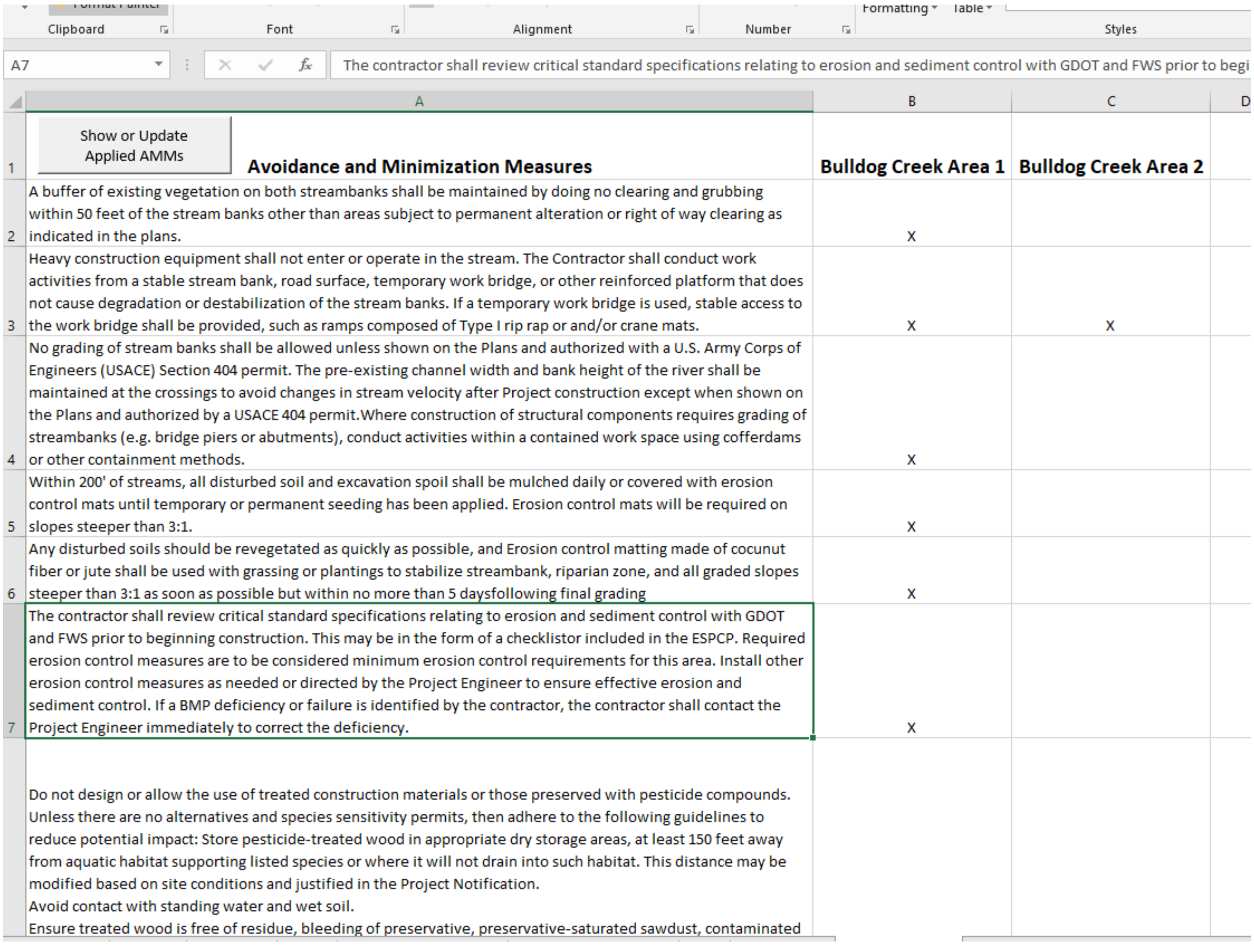


Figure C13. Image. Results of the sediment effect score indicated on the SES Results page.

Applied AMMs

This sheet is intended for ease of viewing and reporting. By clicking the gray button labeled "Show or Update Applied AMMs", the tool will write all applied AMMs and indicate which reach they are applied at (Figure C14). Similar to the SES Results sheet, any changes made after displaying the results will not automatically update. The gray button must be clicked to reflect any changes made.



	A	B	C	D
1	Avoidance and Minimization Measures	Bulldog Creek Area 1	Bulldog Creek Area 2	
2	A buffer of existing vegetation on both streambanks shall be maintained by doing no clearing and grubbing within 50 feet of the stream banks other than areas subject to permanent alteration or right of way clearing as indicated in the plans.	X		
3	Heavy construction equipment shall not enter or operate in the stream. The Contractor shall conduct work activities from a stable stream bank, road surface, temporary work bridge, or other reinforced platform that does not cause degradation or destabilization of the stream banks. If a temporary work bridge is used, stable access to the work bridge shall be provided, such as ramps composed of Type I rip rap or and/or crane mats.	X	X	
4	No grading of stream banks shall be allowed unless shown on the Plans and authorized with a U.S. Army Corps of Engineers (USACE) Section 404 permit. The pre-existing channel width and bank height of the river shall be maintained at the crossings to avoid changes in stream velocity after Project construction except when shown on the Plans and authorized by a USACE 404 permit.Where construction of structural components requires grading of streambanks (e.g. bridge piers or abutments), conduct activities within a contained work space using cofferdams or other containment methods.	X		
5	Within 200' of streams, all disturbed soil and excavation spoil shall be mulched daily or covered with erosion control mats until temporary or permanent seeding has been applied. Erosion control mats will be required on slopes steeper than 3:1.	X		
6	Any disturbed soils should be revegetated as quickly as possible, and Erosion control matting made of cocunut fiber or jute shall be used with grassing or plantings to stabilize streambank, riparian zone, and all graded slopes steeper than 3:1 as soon as possible but within no more than 5 daysfollowing final grading	X		
7	The contractor shall review critical standard specifications relating to erosion and sediment control with GDOT and FWS prior to beginning construction. This may be in the form of a checklistor included in the ESPCP. Required erosion control measures are to be considered minimum erosion control requirements for this area. Install other erosion control measures as needed or directed by the Project Engineer to ensure effective erosion and sediment control. If a BMP deficiency or failure is identified by the contractor, the contractor shall contact the Project Engineer immediately to correct the deficiency.	X		
	Do not design or allow the use of treated construction materials or those preserved with pesticide compounds. Unless there are no alternatives and species sensitivity permits, then adhere to the following guidelines to reduce potential impact: Store pesticide-treated wood in appropriate dry storage areas, at least 150 feet away from aquatic habitat supporting listed species or where it will not drain into such habitat. This distance may be modified based on site conditions and justified in the Project Notification. Avoid contact with standing water and wet soil. Ensure treated wood is free of residue, bleeding of preservative, preservative-saturated sawdust, contaminated			

Figure C14. Image. Display of results on the Applied AMMs sheet.

Tool Modification

There are numerous hidden sheets within the tool where background calculations are performed and databases are referenced. Visual Basics for Applications macros within the tool call upon these sheets as well. It is not recommended to unhide or modify the tool without substantial QA/QC and background knowledge since modifications could unintentionally alter linked data.

Some of the cells within the tool are locked to since altering them disrupt tool performance or result in calculation errors. The cells may be unlocked by entering the correct password: ***uga***.

There are several databases containing critical information that might be updated as new information becomes available:

- SpeciesTraits – contains the list of species and their specific traits such as pollutant sensitivity, overall imperilment, etc.
- PCES_dbase – contains a list of post construction stormwater controls, their efficacies, and calculations to determine toxicity reduction.
- Activities_AMMs – is a database containing all AMMs cross-referenced to all construction activities. Each row has an index that indicates the unique AMM. This database is referenced to generate a list of applicable AMMs and used in the determination of the SES based on user selection of applied AMMs.

Most calculations occur directly on the calcs sheet (hidden). This sheet also contains some indexing cells that adjust values when certain inputs are selected or changed. The main portion of the TES calculation occurs in columns BH through CP.

There are additional hidden sheets in the tool, but these serve the primary function reading and writing data for output in visible sheets in an organized format.

For tool inquiries please contact:

Dr. Seth Wenger: swenger@uga.edu

Dr. Brian Bledsoe: bbledsoe@uga.edu

Tim Stephens: tas48127@uga.

REFERENCES

ADOT Herbicide Treatment Program on Bureau of Land Management Lands in Arizona. 2015. edited by Bureau of Land Management.

Álvarez-Mozos, J., E. Abad, M. Goñi, R. Giménez, M. A. Campo, J. Díez, J. Casalí, M. Arive, and I. Diego. 2014. "Evaluation of erosion control geotextiles on steep slopes. Part 2: Influence on the establishment and growth of vegetation." Catena 121: 195-203. https://doi.org/10.1016/j.catena.2014.05.015.

Álvarez-Mozos, Jesús, Eguzki Abad, Rafael Giménez, Miguel A. Campo, Mikel Goñi, Maider Arive, Javier Casalí, Javier Díez, and Ignacio Diego. 2014. "Evaluation of erosion control geotextiles on steep slopes. Part 1: Effects on runoff and soil loss." Catena 118: 168-178.

Andersson, Å C., and A. M. Stromvall. 2001. "Leaching of Concrete Admixtures Containing Thiocyanate and Resin Acids." *Environmental Science and Technology* 35 (4): 788–93. https://doi.org/10.1021/es000138h.

Barett, M., Kearfott, P., Malina Jr, J., Landphair, H., Li, M., Olivera, F., and Rammohan, P. 2005. Pollutant Removal on Vegetated Highway Shoulders. Texas Department of Transportation, Texas Transportation Institute.

Barrett, Michael E, John Edmund Kearney, Terry Glen McCoy, and Joseph F Malina. 1995. "An Evaluation of the Use and Effectiveness of Temporary Sediment Controls."

Barrett, Michael E., Joseph F. Malina, and Randall J. Charbeneau. 1998. "An Evaluation of Geotextiles for Temporary Sediment Control." *Water Environment Research* 70 (3): 283–90. https://doi.org/10.2175/106143098x124902.

Barrett, Michael, Pam Kearfott, Joseph Malina Jr, Harlow Landphair, Ming-Han Li, Francisco Olivera, and Pavitra Rammohan. 2006. “Pollutant Removal on Vegetated Highway Shoulders.” https://trid.trb.org/view/782693.

Belayutham, Sheila, Vicente A. González, and Tak Wing Yiu. 2016. "A cleaner production-pollution prevention based framework for construction site induced water pollution." Journal of Cleaner Production 135: 1363-1378. https://doi.org/10.1016/j.jclepro.2016.07.003.

Best Management Practices for Projects Affecting Rivers, Streams, Tributaries. 2007. edited by Oklahoma Ecological Services Field Office U.S. Fish and Wildlife Service: U.S. Fish and Wildlife Service.

Brown, W. 2000. “Muddy Water In - Muddy Water Out?” *Watershed Protection Techniques* 2 (3): 393–403. https://owl.cwp.org/mdocs-posts/elc_pwp52/.

Burns, Susan E, Cameron F Troxel,. 2015. “Life Cycle Cost Assessment And Performance Evaluation Of Sediment Control Technologies,” 187p.

Chapman, Jacqueline M., Catherine L. Proulx, Maxime A.N. Veilleux, Caroline Levert, Shireen Bliss, Marie Ève André, Nicolas W.R. Lapointe, and Steven J. Cooke. 2014. “Clear as Mud: A Meta-Analysis on the Effects of Sedimentation on Freshwater Fish and the Effectiveness of Sediment-Control Measures.” *Water Research* 56: 190–202. https://doi.org/10.1016/j.watres.2014.02.047.

Cocchiglia, Letizia, Patrick J. Purcell, and Mary Kelly-Quinn. 2012. "A Critical Review of the Effects of Motorway River-Crossing Construction on the Aquatic Environment." Freshwater Reviews 5 (2): 141-168. https://doi.org/10.1608/frj-5.2.489.

Cooke, S. J., J. M. Chapman, and J. C. Vermaire. 2015. “On the Apparent Failure of Silt Fences to Protect Freshwater Ecosystems from Sedimentation: A Call for Improvements in Science, Technology, Training and Compliance Monitoring.”

Journal of Environmental Management 164: 67–73. https://doi.org/10.1016/j.jenvman.2015.08.033.

Deng, Qingpeng, Weikang Jiang, and Wenzheng Zhang. 2016. “Theoretical Investigation of the Effects of the Cushion on Reducing Underwater Noise from Offshore Pile Driving.” *The Journal of the Acoustical Society of America* 140 (4): 2780–93. https://doi.org/10.1121/1.4963901.

Donald, W. N., W. C. Zech, M. A. Perez, and X. Fang. 2016. "Evaluation and Modification of Wire-Backed Nonwoven Geotextile Silt Fence for Use As a Ditch Check." Journal of Irrigation and Drainage Engineering 142 (2): 04015050. https://doi.org/10.1061/(asce)ir.1943-4774.0000959.

Ehrhart, B. J., R. D. Shannon, and A. R. Jarrett. 2002. "Effects of Construction Site Sedimentation Basins on Receiving Stream Ecosystems." Transactions of the ASAE 45 (3). https://doi.org/10.13031/2013.8833.

"Endangered Species Act (ESA) Section 7(a)(2) Biological Opinion City and Borough of Sitka Gary Paxton Industrial Park Multipurpose Dock Project Sawmill Cove, Sitka, Alaska." 2017. https://repository.library.noaa.gov/view/noaa/17590.

Erosion Control and Stormwater Quality Guide. 2002. edited by Colorado Department of Transportation.

"Erosion prevention practices- tackifiers and soil stabilizers." 2019. Minnesota Stormwater Manual. MediaWiki. https://stormwater.pca.state.mn.us/index.php/Erosion_prevention_practices_-_tackifiers_and_soil_stabilizers.

Faucette, L. B., J. Governo, R. Tyler, G. Gigley, C. F. Jordan, and B. G. Lockaby. 2009. "Performance of compost filter socks and conventional sediment control barriers used for perimeter control on construction sites." Journal of Soil and Water Conservation 64 (1): 81-88. https://doi.org/10.2489/jswc.64.1.81.

Fisher, L S, and A R Jarrett. 1984. “Sediment Retention Efficiency of Synthetic Filter Fabrics.” *Transactions of the ASAE* 2 (27): 429–36. https://doi.org/10.13031/2013.32805.

Flores, Alejandro N., Brian P. Bledsoe, Christopher O. Cuhaciyan, and Ellen E. Wohl. 2006. “Channel-Reach Morphology Dependence on Energy, Scale, and Hydroclimatic Processes with Implications for Prediction Using Geospatial Data.” *Water Resources Research* 42 (6): 1–15. https://doi.org/10.1029/2005WR004226.

Gibson, R. John, Richard L. Haedrich, and C. Michael Wernerheim. 2005. "Loss of Fish Habitat as a Consequence of Inappropriately Constructed Stream Crossings." Fisheries 30 (1): 10-17. https://doi.org/10.1577/1548-8446(2005)30[10:lofhaa]2.0.co;2.

Guerin, T. 2014a. "Understanding Causes of Leaking Plant and Equipment on Construction Sites That Can Lead to Soil and Groundwater Contamination." Remediation-the Journal of Environmental Cleanup Costs Technologies & Techniques 25 (1): 115-131. https://doi.org/10.1002/rem.21418. <Go to ISI>://WOS:000216053700009.

Guerin, Turlough. 2014b. "Root causes of fluid spills from earthmoving plant and equipment: Implications for reducing environmental and safety impacts." Engineering Failure Analysis 45: 128-141. https://doi.org/10.1016/j.engfailanal.2014.06.011.

Gyssels, G., and J. Poesen. 2003. "The importance of plant root characteristics in controlling concentrated flow erosion rates." Earth Surface Processes and Landforms 28 (4): 371-384. https://doi.org/DOI 10.1002/esp.447. <Go to ISI>://WOS:000182434400003.

Hanson, J., Helvey, M., and Strach, R. . 2003. Non-Fishing Impacts to Essential Fish Habitat and Recommend Conservation Measures. edited by National Oceanic and Atmospheric Administration.

Harbor, Jon. 1999. "Engineering Geomorphology at the Cutting Edge of Land Disturbance: Erosion and Sediment Control on Construction Sites." *Geomorphology* 31 (1–4): 247–63. https://doi.org/10.1016/S0169-555X(99)00107-5.

Hartanto, Herlina, Ravi Prabhu, Anggoro S. E. Widayat, and Chay Asdak. 2003. "Factors affecting runoff and soil erosion: plot-level soil loss monitoring for assessing sustainability of forest management." Forest Ecology and Management 180 (1-3): 361-374. https://doi.org/10.1016/s0378-1127(02)00656-4.

HIP III Handbook: Unabbreviated Guidance of Biological Opinion Requirements and RRT Process. 2016. edited by Bonneville Power Administration.

Kang, J., M. M. McCaleb, and R. A. McLaughlin. 2013. "Check dam and polyacrylamide performance under simulated stormwater runoff." J Environ Manage 129: 593-8. https://doi.org/10.1016/j.jenvman.2013.08.023. https://www.ncbi.nlm.nih.gov/pubmed/24036092.

Katopodis, Christos. 2010. "Developing a toolkit for fish passage, ecological flow management and fish habitat works." Journal of Hydraulic Research 43 (5): 451-467. https://doi.org/10.1080/00221680509500144.

Keevin, Thomas M. 1998. "A Review of Natural Resource Agency Recommendations for Mitigating the Impacts of Underwater Blasting." Reviews in Fisheries Science 6 (4): 281-313. https://doi.org/10.1080/10641269891314302.

Krenitsky, E. C., M. J. Carroll, R. L. Hill, and J. M. Krouse. 1998. "Runoff and Sediment Losses from Natural and Man-Made Erosion Control Materials." Crop Science 38 (4): 1042. https://doi.org/10.2135/cropsci1998.0011183X003800040026x.\

Kurda, Rawaz, José D. Silvestre, and Jorge de Brito. 2018. “Toxicity and Environmental and Economic Performance of Fly Ash and Recycled Concrete Aggregates Use in Concrete: A Review.” *Heliyon* 4 (4). https://doi.org/10.1016/j.heliyon.2018.e00611.

Lammers, Roderick W., and Brian P. Bledsoe. 2018. “Parsimonious Sediment Transport Equations Based on Bagnold’s Stream Power Approach.” *Earth Surface Processes and Landforms* 43 (1): 242–58. https://doi.org/10.1002/esp.4237.

Lebow, Stan T., Paul Cooper, and Patricia K. Lebow. 2004. "Variability in Evaluating Environmental Impacts of Treated Wood." Department of Agriculture, Forest Service, Forest Products Laboratory: 1-10. https://doi.org/10.2737/fpl-rp-620.

Lebow, Stan T., and Michael Tippie. 2001. "Guide for Minimizing the Effect of Preservative-Treated Wood on Sensitive Environments." U.S. Department of Agriculture, Forest Service, Forest Products Laboratory: 18. https://doi.org/10.2737/fpl-gtr-122.

Li, Ming-Han, and Karen E. Eddleman. 2002. "Biotechnical engineering as an alternative to traditional engineering methods." Landscape and Urban Planning 60 (4): 225-242. https://doi.org/10.1016/s0169-2046(02)00057-9.

Menashe, E. 2001. "Incorporating Vegetation in Engineering Designs to Protect Pudget Sound Shorelines." Pudget Sound Research 2001, Bellevue, WA.

Meyer, L.D., W.H., Wischmeier, and G.R. Foster. 1970. “Mulch Rates Required for Erosion Control in Steep Slopes.” *Soil Science Society of America Journal* 34 (6): 928–31. https://doi.org/10.2136/sssaj1970.03615995003400060031x.

Mol, Jan H., and Paul E. Ouboter. 2004. "Downstream Effects of Erosion from Small-Scale Gold Mining on the Instream Habitat and Fish Community of a Small Neotropical Rainforest Stream." Conservation Biology 18 (1): 201-214. https://doi.org/10.1111/j.1523-1739.2004.00080.x.

Montgomery, David R, and Lee H Macdonald. 2002. "In the Channel Network , Channel Type , Temporal Dure to Guide the Assessment and Monitoring of Ly Do Not Fully Recognize the Extent to Which the Nels . In the Absence of a Better Understanding Of." *Journal Of The American Water Resources Association* 38 (1).

Montgomery, David R., and John M. Buffington. 1997. "Channel-Reach Morphology in Mountain Drainage Basins." *Bulletin of the Geological Society of America* 109 (5): 596–611. https://doi.org/10.1130/0016-7606(1997)109<0596:CRMIMD>2.3.CO;2.

Morledge, Roy, and Frank Jackson. 2001. "Reducing environmental pollution caused by construction plant." Environmental Management and Health 12 (2): 191-206. https://doi.org/10.1108/09566160110389933.

Paterson, Robert G. 1994. "Construction practices: The good, the bad, and the ugly." Watershed Protection Techniques 1 (3): 44-48.

Pillard, David A., Jeffrey S. Cornell, Doree L. DuFresne, and Mark T. Hernandez. 2001. "Toxicity of Benzotriazole and Benzotriazole Derivatives to Three Aquatic Species." *Water Research* 35 (2): 557–60. https://doi.org/10.1016/S0043-1354(00)00268-2.

Popper, A. N., and M. C. Hastings. 2009. "The effects of anthropogenic sources of sound on fishes." J Fish Biol 75 (3): 455-89. https://doi.org/10.1111/j.1095-8649.2009.02319.x. https://www.ncbi.nlm.nih.gov/pubmed/20738551.

Prosdocimi, Massimo, Paolo Tarolli, and Artemi Cerdà. 2016. "Mulching Practices for Reducing Soil Water Erosion: A Review." *Earth-Science Reviews* 161: 191–203. https://doi.org/10.1016/j.earscirev.2016.08.006.

Price, David M., Timothy Quinn, and Robert J. Barnard. 2010. "Fish Passage Effectiveness of Recently Constructed Road Crossing Culverts in the Puget Sound Region of Washington State." North American Journal of Fisheries Management 30 (5): 1110-1125. https://doi.org/10.1577/m10-004.1.

Radermacher, Max, Lynyrd de Wit, Johan C. Winterwerp, and Wim S. J. Uijttewaal. 2016. "Efficiency of Hanging Silt Curtains in Crossflow." Journal of Waterway, Port, Coastal, and Ocean Engineering 142 (1): 04015008. https://doi.org/10.1061/(asce)ww.1943-5460.0000315.

Reichenberger, Stefan, Martin Bach, Adrian Skitschak, and Hans Georg Frede. 2007. “Mitigation Strategies to Reduce Pesticide Inputs into Ground- and Surface Water and Their Effectiveness; A Review.” *Science of the Total Environment* 384 (1–3): 1–35. https://doi.org/10.1016/j.scitotenv.2007.04.046.

Reid, David, and Michael Church. 2015. "Geomorphic and Ecological Consequences of Riprap Placement in River Systems." JAWRA Journal of the American Water Resources Association 51 (4): 1043-1059. https://doi.org/10.1111/jawr.12279.

Risse, L. M., S. A. Thompson, J. Governo, and K. Harris. 2008. “Testing of New Silt Fence Materials: A Case Study of a Belted Strand Retention Fence.” *Journal of Soil and Water Conservation* 63 (5): 265–73. https://doi.org/10.2489/jswc.63.5.265.

Schueler, Thomas R. 1995. “Site Planning for Urban Stream Protection.” Metropolitan Washington Council of Governments.

Schueler, T, C Lane, and CS Network. 2014. “Recommendations of the Expert Panel to Define Removal Rates for Erosion and Sediment Control Practices.” *Cbweb.Aws.Chesapeakebay.Net*. https://cbweb.aws.chesapeakebay.net/documents/WQGIT_APPROVED_ESC_EXPERT_PANEL_REPORT_LONG_04142014.pdf.

Schwartz, John S, and Jon M Hathaway. 2018. “In-Service Performance Evaluation of Erosion Prevention and Sediment Control (EPSC) Devices.”

Sholtes, Joel S., Steven E. Yochum, Julian A. Scott, and Brian P. Bledsoe. 2018. “Longitudinal Variability of Geomorphic Response to Floods.” *Earth Surface Processes and Landforms* 43 (15): 3099–3113. https://doi.org/10.1002/esp.4472.

Singh Sidhu, Ramandeep. 2015. “Effectiveness of Selected Erosion Control Covers during Vegetation Establishment under Simulated Rainfall.”

Smets, T., J. Poesen, and A. Knapen. 2008. “Spatial Scale Effects on the Effectiveness of Organic Mulches in Reducing Soil Erosion by Water.” *Earth-Science Reviews* 89 (1–2): 1–12. https://doi.org/10.1016/j.earscirev.2008.04.001.

Stein, Eric D., Matthew R. Cover, A. Elizabeth Fetscher, Clare O'Reilly, Roxana Guardado, and Christopher W. Solek. 2013. "Reach-Scale Geomorphic and Biological Effects of Localized Streambank Armoring." JAWRA Journal of the American Water Resources Association 49 (4): 780-792. https://doi.org/10.1111/jawr.12035.

Stevens, E, BJ Barfield, SL Britton, and JS Hayes. 2004. “Filter Fence Design Aid for Sediment Control at Construction Sites.” https://www.ars.usda.gov/research/publications/publication/?seqNo115=182944.

Sutherland, Ross A., and Alan D. Ziegler. 2007. "Effectiveness of coir-based rolled erosion control systems in reducing sediment transport from hillslopes." Applied Geography 27 (3-4): 150-164. https://doi.org/10.1016/j.apgeog.2007.07.011.

Syversen, Nina, and Marianne Bechmann. 2004. “Vegetative Buffer Zones as Pesticide Filters for Simulated Surface Runoff.” *Ecological Engineering* 22 (3): 175–84. https://doi.org/10.1016/j.ecoleng.2004.05.002.

U.S. Environmental Protection Agency. 2009. “Development Document for Final Effluent Guidelines and Standards for the Construction & Development Category.” Washington, DC.

Wachal, David J., Kenneth E. Banks, Paul F. Hudak, and R. Daren Harmel. 2009. “Modeling Erosion and Sediment Control Practices with RUSLE 2.0: A Management Approach for Natural Gas Well Sites in Denton County, TX, USA.” *Environmental Geology* 56 (8): 1615–27. https://doi.org/10.1007/s00254-008-1259-3.

Water Quality Fact Sheet: Non-Petroleum Hydraulic Fluids and Biodiesel Fuel for Construction Equipment. 2012. edited by California Coastal Nonpoint Source Program.

Wenger, S. and Fowler, L. . 2000. Protecting Stream and River Corridors: Creating Effective Local Riparian Buffer Ordinances. Carl Vinson Institute of Government (The University of Georgia).

Wheeler, Andrew P., Paul L. Angermeier, and Amanda E. Rosenberger. 2005. “Impacts of New Highways and Subsequent Landscape Urbanization on Stream Habitat and Biota.” *Reviews in Fisheries Science* 13 (3): 141–64. https://doi.org/10.1080/10641260590964449.

Whitman, J. Blake, Wesley C. Zech, Wesley N. Donald, and Jeffrey J. LaMondia. 2018. “Full-Scale Performance Evaluations of Various Wire-Backed Nonwoven Silt Fence Installation Configurations.” *Transportation Research Record* 2672 (39): 68–78.

Whitman, J. Blake, Wesley C. Zech, and Wesley N. Donald. 2019. “Full-Scale Performance Evaluations of Innovative and Manufactured Sediment Barrier Practices.” *Transportation Research Record* 2673 (8): 284–97.

Zech, W. C., C. P. Logan, and X. Fang. 2014. “State of the Practice: Evaluation of Sediment Basin Design, Construction, Maintenance, and Inspection Procedures.” *Practice Periodical on Structural Design and Construction* 19 (2): 1–8.

Zech, W. C., J. S. Mcdonald, and T. P. Clement. 2009. “Field Evaluation of Silt Fence Tieback Systems at a Highway Construction Site.” *Practice Periodical on Structural*

Design and Construction 14 (3): 105–12. https://doi.org/10.1061/(ASCE)1084-0680(2009)14:3(105).