Programmatic Biological Assessment for Transportation Projects for the Gulf of Maine Distinct Population Segment of Atlantic Salmon and Designated Critical Habitat

U.S. Fish and Wildlife Service Jurisdiction

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Submitted by:

Maine Department of Transportation

Federal Highway Administration

US Army Corps of Engineers

and

Maine Turnpike Authority

Table of Contents

List of Tables

List of Figures

List of Acronyms and Abbreviations

Action Agencies	Federal Highway Administration and U.S. Army Corps of Engineers
AMM	avoidance and minimization measure
AOP	aquatic habitat connectivity
ASRCP	Atlantic Salmon Recovery and Conservation Program
ASF	Atlantic Salmon Fisheries
ATS	Atlantic salmon
BFW	bankfull width
BMP	best management practices
CH	Atlantic salmon designated critical habitat
CM	conservation measure
CMP	corrugated metal pipe
cSEL	cumulative sound exposure level
CSE	conservation spawning escapement
CWA	Clean Water Act
dB	decibel
DPS	distinct population segment
ESA	Endangered Species Act
ESM	engineered streambed material
FHWA	Federal Highway Administration
FHWG	Fisheries Hydroacoustic Working Group
FRP	fiberglass reinforced polymer
GLNFH	Green Lake National Fish Hatchery
GOM DPS	Gulf of Maine Distinct Population Segment
HDPE	high-density polyethylene
HUC	hydrologic unit code
ILF	in lieu fee
ISPG	Integrated Stream Bank Protection Guidelines
LAA	likely to adversely affect
MaineDOT	Maine Department of Transportation
MDEP	Maine Department of Environmental Protection
MDMR	Maine Department of Marine Resources
MSW	multi-sea winter
MTA	Maine Turnpike Authority
NE	no effect
NEPA	National Environmental Policy Act
NLAA	not likely to adversely affect
NMFS	National Oceanic and Atmospheric Administration's Marine Fisheries Service
NTU	nephelometric turbidity units
OHWM	ordinary high water mark
PAH	polycyclic aromatic hydrocarbons

PBA	Programmatic Biological Assessment
PCE	primary constituent element
Proponents	Maine Department of Transportation and Maine Turnpike Authority
RMS	root mean squared
SE	severity of ill-effects
SEL	sound exposure level
Services	U.S. Fish and Wildlife Service and National Marine Fisheries Service
SE	severity of ill-effect
SEWPCP	Soil Erosion and Water Pollution Control Plan
SHRU	salmon habitat recovery unit
SPCCP	Spill Prevention, Control and Countermeasures Plan
SW	sea-winter
TSS	total suspended solids
USACE	U.S. Army Corps of Engineers
USFWS	U.S. Fish and Wildlife Service
YOY	young-of-the-year

Executive Summary

The Maine Department of Transportation (MaineDOT) has prepared this programmatic biological assessment (PBA) on behalf of the Federal Highway Administration (FHWA), U.S. Army Corps of Engineers (USACE), and Maine Turnpike Authority (MTA) to cover routine state transportation activities over the next 5 years. The FHWA and USACE are co-action agencies, (herein Action Agencies) in submitting this PBA. MaineDOT and MTA (herein Proponents) will be the users of the PBA.

The Gulf of Maine Distinct Population Segment (GOM DPS) and Critical Habitat of Atlantic salmon span portions of all five of MaineDOT's regions (Figure 1-1). Through this assessment, the Action Agencies and Proponents commit to aid in the recovery of Atlantic salmon by responsibly implementing specified avoidance and minimization measures (AMMs) and conservation measures during covered activities. These AMMs and conservation measures range from items being implemented in the planning phase of projects (e.g. aquatic connectivity design) to construction specific activities such as spill prevention plans.

This PBA captures routine state transportation activities with the understanding that not all activities affecting Atlantic salmon will go through programmatic consultation. Within the GOM DPS and designated critical habitat, MaineDOT predicts roughly 200 projects will occur over the 5-year term of the PBA, while MTA anticipates less than 20 projects. This assessment allows for timely processing of consultations, predictable design standards, and minimized effects on the species and their habitat.

This PBA and subsequent Programmatic Biological Opinion will streamline the Endangered Species Act (ESA) Section 7 consultation process so that routine transportation projects can be executed in a timelier manner. This will allow the U.S. Fish and Wildlife Service (USFWS), Action Agencies, and Proponents to focus resources on more complicated projects with less predictable effects.

The administration and implementation of this agreement will follow guidance in a Users' Guide that the Proponents will develop in cooperation with the USFWS as the Programmatic Biological Opinion is being finalized.

This PBA does not address other ESA-listed species or critical habitat; separate consultation is necessary to document effects on those species and their critical habitat.

Chapter 1 Introduction

This programmatic biological assessment (PBA) covers Maine Department of Transportation (MaineDOT) and Maine Turnpike Authority (MTA) routine activities associated with preserving, improving, and maintaining the state's transportation system. The transportation system includes federal and state highways and routes as well as crossing structures on local roads that fall under the state's responsibility. For the remainder of this document, MaineDOT and MTA are referred to as the "Proponents." Most of these routine activities will have funds from the Federal Highway Administration (FHWA) and/or require permitting through the U.S. Army Corps of Engineers (USACE). For the remainder of this document, FHWA and USACE will be referred to as the "Action Agencies". Pursuant to Section 7 of the Endangered Species Act (ESA) of 1973, as amended, federal agencies must ensure their actions are not likely to jeopardize the continued existence of any endangered or threatened species or result in the destruction or adverse modification of designated critical habitat.

Sections 7(a) (1) and 7(a) (2) of the ESA play important roles in achieving the species conservation purposes of the Endangered Species Act. Section 7(a) (1) provides a clear conservation mandate that directs each federal agency to proactively develop programs for the conservation of each endangered species that it can affect within its authorities. Section 7(a) (2) prohibits federal agencies from authorizing, funding or carrying out actions that are likely to jeopardize the continued existence of listed species. It also requires that agency actions are consistent with recovery of the species they affect. Without this conservation mandate, Section 7 would operate as a permitting program.

This PBA addresses the Gulf of Maine (GOM) distinct population segment (DPS) of Atlantic salmon (*Salmo salar*), a federally endangered species with designated critical habitat in Maine, within the jurisdiction of the U.S. Fish and Wildlife Service (USFWS) for the 5-year period following the issuance of the Biological opinion. This PBA includes project activities that may affect, are not likely to adversely affect (NLAA), and may affect, are likely to adversely affect (LAA) GOM DPS Atlantic salmon and critical habitat. The use of this PBA is limited to Proponent or consulting biologists working on projects in the range of the GOM DPS Atlantic salmon and critical habitat under jurisdiction of the USFWS. The Proponents will enter project specific information into the standard reporting form, to be developed as part of the Users' Guide, and submit it to USFWS. The form will incorporate relevant information from this PBA and the USFWS's subsequent Programmatic Biological Opinion.

This PBA was organized to present proposed actions and effect determinations in a clear manner. Often, this required a repetitive approach to activity descriptions and effect determinations. The intent was to ensure that sections of the PBA could 'stand-alone' for the reader and minimize the amount of referencing on important items.

1.1 Intent

MaineDOT has prepared this PBA to satisfy the programmatic authorization in accordance with legal requirements found in the ESA. Currently, the Proponents prepare an individual biological assessment and obtain individual and separate USFWS authorization for each routine activity that is funded or approved by the FHWA and/or triggers a Section 404 of the federal Clean Water Act (CWA) or Section 10 of the Rivers and Harbors Act permit from the USACE. This practice is repetitive, time-consuming (up to 1 year or longer) and expensive for MaineDOT, MTA, and the federal agencies (i.e., USFWS, and Action Agencies). The intent of the PBA is to streamline the ESA Section 7 consultation process so that routine transportation projects can be executed in a timely manner, and the Proponents and Action Agencies, together with the USFWS, can focus on implementing conservation measures to aid in species recovery, while still fulfilling the requirements for compliance with the ESA.

1.2 Species Need

The mission of the U.S. Fish and Wildlife Service is working with others to conserve, protect, and enhance fish, wildlife, plants, and their habitats for the continuing benefit of the American people. MaineDOT, USACE and FHWA acknowledge that USFWS is putting together a new Atlantic salmon recovery plan that is built on a foundation of an agreement on the biological needs of the species, identification of objectives or a shared goal, and actions to achieve that goal. Although this Recovery Plan has not been officially published, we are in support of the efforts for species recovery.

https://www.fws.gov/northeast/atlanticsalmon/PDF/FrameworkWorkingDraft031211MC.pdf

To ensure that the USFWS Transportation Program supports the Service's mission and goals, the Program is structured around six goal categories, which together, embody the mission of the USFWS as expressed through its transportation system and are consistent with U.S. Department of Transportation goals. The following goals serve to guide transportation decisions and policies over the long term in ways that not only benefit the transportation system, but also help the agency achieve its overall mission: environmental and resource protection; safety; transportation asset management; access, mobility, and connectivity; visitor experience; and coordinated opportunities and partnerships.

1.3 Transportation Need

MaineDOT maintains 7,472 miles of pavement and 2,190 bridges in the state; MTA maintains 303 miles of pavement and associated bridges. The programmatic approach is applicable because of the large volume of similar types of projects that MaineDOT and MTA combined conduct each year that may affect Atlantic salmon and their critical habitat. Because MaineDOT has prepared this PBA, further discussion will focus on work undertaken by this agency, with the understanding that MTA typically undertakes a lower volume of similar activities on an annual basis.

Table 1-1 provides the best estimate of future projects available and shows that roughly 200 scheduled projects from 2017 to 2022 are anticipated during the 5-year term of the PBA across MaineDOT's five regions (Figure 1-1). These estimates were developed by extrapolating project numbers using the average number of projects per year from MaineDOT's 2016-2018 work plan.

Table 1-1 indicates those activities occurring frequently in the state. [Note: Some of these projects may not qualify for analysis under terms of this PBA or will not affect the species.]

Table 1-1. MaineDOT projects predicted to be within the range of the GOM DPS that may meet the terms of the Atlantic salmon PBA in the 5-year period after the biological opinion is issued.

Project Activity	Number
Stream Crossing Replacements:	--
Culverts (Spans ≤20 feet)	50
Bridges (Spans > 20 feet)	45
Bridge and Culvert Removal	3
Scour Countermeasures	15
Culvert End Resets and Extensions	50
Bridge Maintenance	16
Temporary Work Access and Temporary Bridges	15*
Invert Line and Slipline Culvert Rehabilitation	15
Pre-project Geotechnical Drilling	15*
ESTIMATED TOTAL	194*

*Both the temporary work access and temporary bridges activity and the pre-project geotechnical drilling activity have been broken out into their own separate activities to further detail their effects, but note that these activities are part of other activities as well and therefore do not contribute to the total estimated projects to be processed under this programmatic.

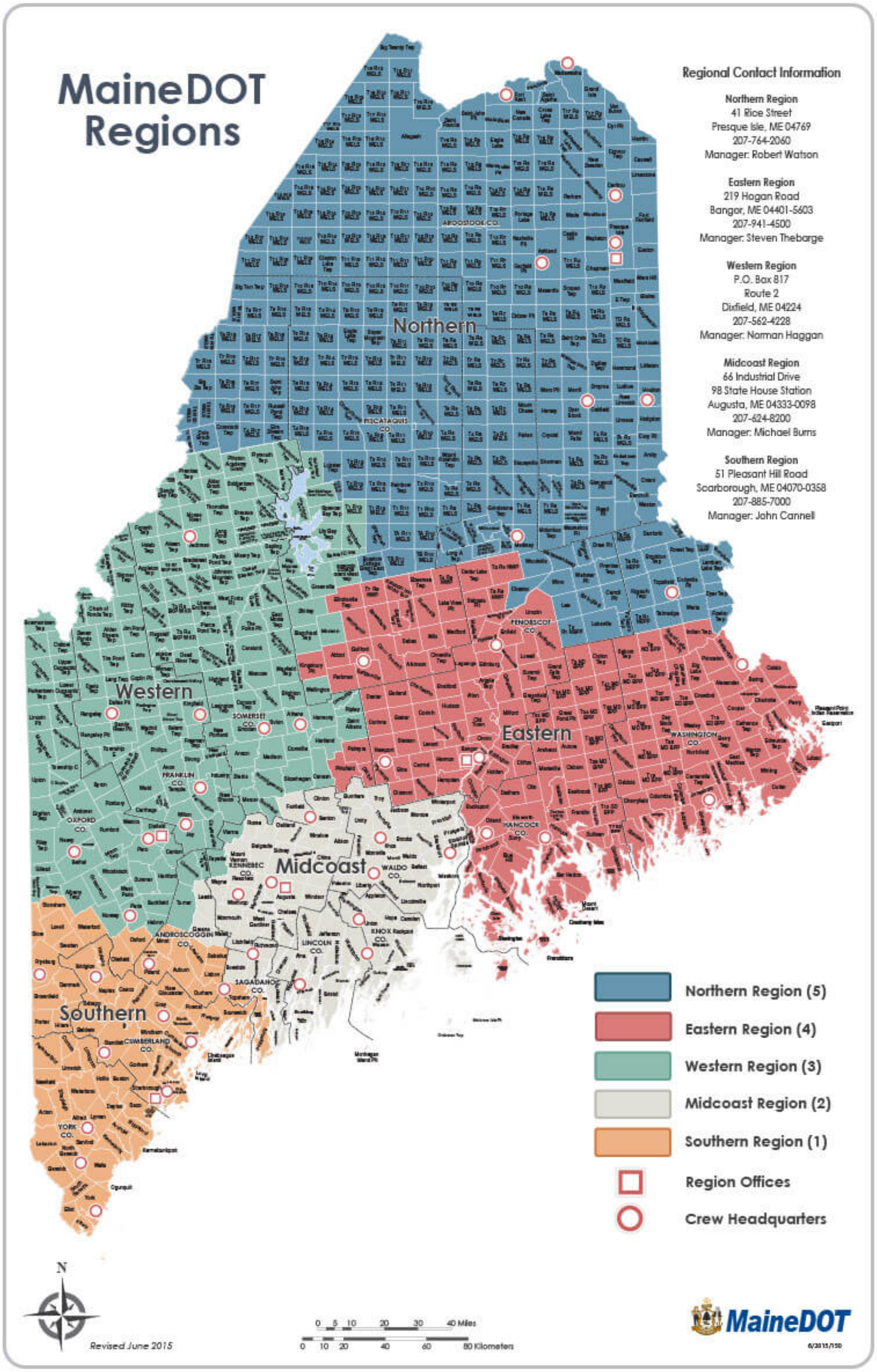

Figure 1-1. MaineDOT's five maintenance regions.

MaineDOT used the projects listed in Table 1-1 to estimate effects to Atlantic salmon habitat per project and the overall amount of habitat affected during the 5-year term of this PBA. Effects to Atlantic salmon and critical habitat are discussed in Chapter 5.

The Proponents and FHWA's mission is to responsibly provide our customers the safest and most reliable transportation system possible, given available resources. Over time, responsible production has been reflected in how the Proponents have changed work practices to comply with more stringent regulatory requirements, resulting in reduced environmental impacts, but at higher project costs.

In recent years, two substantial environmental issues have contributed to increased costs in construction. First, the timeframe allowed has become more restricted for in-water work. Second, due to growing concerns for fish passage and stream connectivity, the size of stream crossing structure openings has increased.

In MaineDOT's 2014-2015-2016 work plan, available financial resources were approximately $2.02 billion over the course of this period, funding 1,600 separate work items. In 2014 alone, MaineDOT proposed over 800 work items, with 425 of those funded as capital projects totaling $455 million. Even at what might appear to be healthy funding levels, work needed to maintain and replace Maine's existing state transportation system is still 30 percent, or approximately $100 million annually, underfunded. This persistent funding shortfall requires that MaineDOT stretch every available dollar as much as prudently possible. This PBA is intended to facilitate a more streamlined consultation process for the majority of the transportation program and establish consistent and practicable avoidance and minimization measures (AMMs) and conservation measures that make sense for transportation goals and for promoting Atlantic salmon recovery.

1.4 Reinitiation of Consultation

As provided in 50 CFR 402.16, "reinitiation of consultation is required and shall be requested by the Federal agency or by the Service, where discretionary Federal involvement or control over the action has been retained or is authorized by law and:

(a) If the amount or extent of taking specified in the incidental take statement is exceeded;

(b) If new information reveals effects of the action that may affect listed species or critical habitat in a manner or to an extent not previously considered;

(c) If the identified action is subsequently modified in a manner that causes an effect to the listed species or critical habitat that was not considered in the biological opinion; or

(d) If a new species is listed or critical habitat designated that may be affected by the identified action."

The language above is taken directly from the CFR and is specific to formal consultations. The Proponents recognize that reinitiation applies to the entire PBA and not just those activities resulting in adverse effects. This PBA analyzes effects to Atlantic salmon and Atlantic salmon critical habitat only. Effects on other species are to be addressed under separate consultation. Therefore, item (d) in the reinitiation language above does not apply unless through regulation, reinitiation may be required if there are changes are made to the status of Atlantic salmon or their designated critical habitat during the 5-year term of this PBA.

Chapter 2 Gulf of Maine Distinct Population Segment of Atlantic Salmon

In 2000, the National Marine Fisheries Service (NMFS) and USFWS (collectively, the Services) listed the GOM DPS of Atlantic salmon as an endangered species (USFWS and NMFS 2000; 65 Federal Register [FR] 69465-69483). The 2000 GOM DPS listing included all naturally reproducing wild populations and hatchery populations having historical river specific characteristics found north of the Kennebec River. On June 19, 2009 the Services published the Final Rule determination of endangered status for the GOM DPS of Atlantic salmon (NMFS and USFWS 2009; 74 FR 29300-29341). The Services' subsequent listing of Atlantic salmon as an endangered species included an expanded range for the GOM DPS. This listing included populations from the Androscoggin River north to the Dennys River.

The decision to expand the geographic range of the GOM DPS was largely based on the results of a Status Review (Fay et al. 2006) completed by a Biological Review Team consisting of federal and state agencies and Tribal interests. Fay et al. (2006) concluded that the DPS delineation in the 2000 listing designation was largely appropriate, except in the case of large rivers that were excluded in the 2000 listing determination. Fay et al. (2006) concluded that the Atlantic salmon currently inhabiting Maine's larger rivers (Androscoggin, Kennebec, and Penobscot) are genetically similar to the rivers included in the GOM DPS as listed in 2000, have similar life history characteristics, and/or occur in the same zoogeographic region. Further, the Atlantic salmon populations inhabiting the large and small rivers from the Androscoggin River northward to the Dennys River differ genetically and in important life history characteristics from Atlantic salmon in adjacent portions of Canada (Spidle et al. 2003, Fay et al. 2006). Thus, Fay et al. (2006) concluded that this group of populations (a "distinct population segment") met both the discreteness and significance criteria of the Services' DPS Policy (USFWS and NMFS 1996; 61 FR 4722-4725), and therefore, recommended the geographic range included in the new expanded GOM DPS. The final rule expanding the GOM DPS agreed with the conclusions of the Biological Review Team regarding the DPS delineation of Maine Atlantic salmon. The GOM DPS was separated into three Salmon Habitat Recovery Units (SHRUs). The SHRUs include the Downeast Coastal, Penobscot Bay, and Merrymeeting Bay (NOAA 2009, NMFS and USFWS 2009; 74 FR 29300-29341).

2.1 Species Description

Atlantic salmon are an anadromous fish that use freshwater rivers and streams for spawning and nursery, and saline ocean environments for periods of rapid growth. The June 19, 2009, Final Rule notices provide thorough descriptions of the species (USFWS and NMFS 2009; 74 FR 29344-29387) and designation of critical habitat (NMFS 2009a; 74 FR 29300-29341) for the recovery of the species.

The Atlantic salmon is native to the basin of the North Atlantic Ocean, from the Arctic Circle to Portugal in the eastern Atlantic, from Iceland and southern Greenland, and from the Ungava region of northern Quebec south to the Connecticut River (Scott and Crossman 1973). In the United States, Atlantic salmon historically ranged from Maine south to Long Island Sound. However, the Central New England DPS and Long Island Sound DPS are both extirpated (USFWS and NMFS 2000).

The GOM DPS includes all anadromous Atlantic salmon whose freshwater range occurs in the watersheds from the Androscoggin River northward along the Maine coast to the Dennys River, and wherever these fish occur in the estuarine and marine environment. Table 2-1 lists the impassable falls that delimit the upstream extent of the freshwater range of Atlantic salmon. The marine range of the GOM

DPS extends from the Gulf of Maine, throughout the Northwest Atlantic Ocean, to the coast of Greenland (Figure 2-1).

Table 2-1. Impassable falls that delimit the upstream extent of the freshwater range of Atlantic salmon.

Impassable Falls	Town	Waterbody
Rumford Falls	Rumford	Androscoggin
Snow Falls	West Paris	Little Androscoggin
Grand Falls	Township 3 Range 4 BKP WKRWKR[1]	Dead River (Kennebec Basin)
Unnamed Falls / Indian Pond Dam	Indian Stream Township	Kennebec River
Big Niagara Falls	Township 3 Range 10 WELS[1]	Nesowadnehunk Stream (Penobscot Basin)
Grand Pitch	Trout Brook Township	Webster Brook (Penobscot Basin)

[1] Abbreviations for land grant designations in minor civil divisions: BKP = Bingham's Kennebec Purchase
WKR = West of the Kennebec River
WELS = West of the Easterly Line of the State

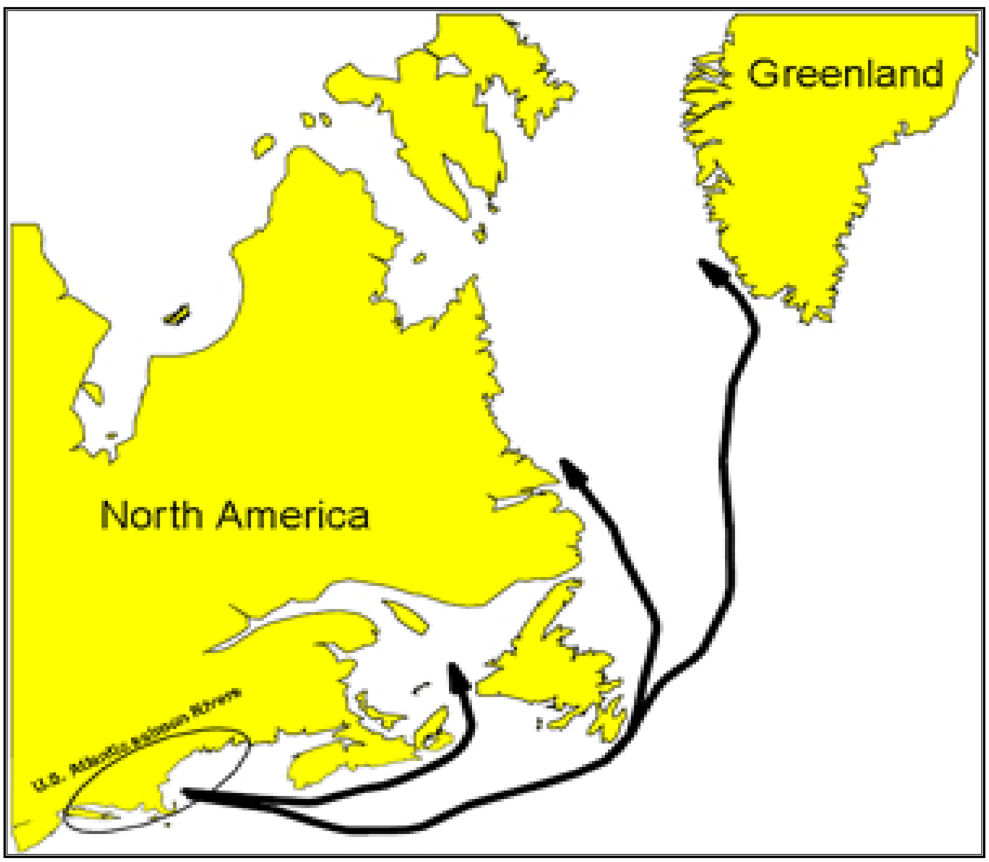

Figure 2-1. GOM DPS of Atlantic salmon migratory route.

Included in the GOM DPS are all associated conservation hatchery populations used to supplement these natural populations. Currently, such conservation hatchery populations are maintained at Green Lake and Craig Brook National Fish Hatcheries, both operated by the USFWS. Excluded from the GOM DPS are landlocked Atlantic salmon and those salmon raised in commercial hatcheries for the aquaculture industry (NMFS and USFWS 2009).

Atlantic salmon have a complex life history that includes territorial rearing in rivers to extensive feeding migrations on the high seas. During their life cycle, Atlantic salmon go through several distinct phases that are identified by specific changes in behavior, physiology, morphology, and habitat requirements.

Adult Atlantic salmon return to rivers from the ocean and migrate to their natal streams to spawn. Adults ascend their natal rivers beginning in the spring. The ascent of adult salmon continues into the fall. Although spawning does not occur until late-fall, the majority of Atlantic salmon in Maine enters freshwater between May and mid-July (Meister 1958, Baum 1997).

Early migration is an adaptive trait that ensures adults have sufficient time to effectively reach spawning areas despite the unfavorable conditions that naturally occur within rivers (Bjornn and Reiser 1991). Salmon that return in early spring spend nearly five months in the river before spawning, often seeking cool water refuge (e.g., deep pools, springs, and mouths of smaller tributaries) during the summer months.

In the fall, female Atlantic salmon select sites for spawning. Spawning sites are positioned within flowing water, particularly where upwelling of groundwater occurs, allowing for percolation of water through the gravel (Danie et al. 1984). These sites are most often positioned at the head of a riffle (Beland et al. 1982), the tail of a pool, or the upstream edge of a gravel bar where water depth is decreasing, water velocity is increasing (White 1942; McLaughlin and Knight 1987), and hydraulic head allows for permeation of water through the redd (a gravel depression where eggs are deposited). Female salmon use their caudal fin to scour or dig redds. The digging behavior also serves to clean the substrate of fine sediments that can embed the cobble/gravel substrate needed for spawning and consequently reduce egg survival (Gibson 1993). As the female deposits eggs in the redd, one or more males fertilize the eggs (Jordan and Beland 1981). The female then continues digging upstream of the last deposition site, burying the fertilized eggs with clean gravel.

A single female may create several redds before depositing all of her eggs. Female anadromous Atlantic salmon produce 1,500 to 1,800 eggs per kilogram of body weight, yielding an average of 7,500 eggs per 2 sea-winter (SW) female (an adult female that has spent two winters at sea before returning to spawn) (Baum and Meister 1971). After spawning, Atlantic salmon may either return to sea immediately or remain in freshwater until the following spring before returning to the sea (Fay et al. 2006). From 1967 to 2003, approximately 3% of the wild and naturally reared adults that returned to rivers where adult returns are monitored (mainly the Penobscot River) were repeat spawners (USASAC 2004).

Embryos develop in the redd for a period of 175 to 195 days then hatch in late-March or April (Danie et al. 1984)., Newly hatched salmon (referred to as larval fry, alevin, or sac fry) remain in the redd for approximately 6 weeks after hatching and are nourished by their yolk sac (Gustafson-Greenwood and Moring 1991). Survival from the egg to fry stage in Maine is estimated to range from 15% to 35% (Jordan and Beland 1981). Survival rates of eggs and larvae are a function of stream gradient, overwinter temperatures, interstitial flow, predation, disease, and competition (Bley and Moring 1988). Once larval fry emerge from the gravel and begin active feeding they are referred to as fry. The majority of fry (>95%) emerge from redds at night (Gustafson-Marjanen and Dowse 1983).

When fry reach approximately 4 centimeters (cm; 1.6 inches) in length, the young salmon are termed parr (Danie et al. 1984). Parr have eight to eleven pigmented vertical bands on their sides that are believed to serve as camouflage (Baum 1997). A territorial behavior, first apparent during the fry stage, grows more pronounced during the parr stage, as the parr actively defend territories (Allen 1940, Kalleberg 1958, Danie et al. 1984).

First year parr are often characterized as being small parr or 0+ parr (4 to 7 cm [1.5 to 2.8 inches] long), whereas second and third year parr are characterized as large parr (>7 cm [2.8 inches] long) (Haines 1992). Parr growth is a function of water temperature (Elliott 1991); parr density (Randall 1982); photoperiod (Lundqvist 1980); interaction with other fish, birds, and mammals (Bjornn and Reiser 1991); and food supply (Swansburg et al. 2002). Parr movement may be quite limited in the winter (Cunjak 1988, Heggenes 1990); however, movement in the winter does occur (Hiscock et al. 2002) and is often necessary, as ice formation reduces total habitat availability (Whalen et al. 1999). Parr have been documented using riverine, lake, and estuarine habitats; incorporating opportunistic and active feeding strategies; defending territories from competitors including other parr; and working together in small schools to actively pursue prey (Pepper 1976, Pepper et al. 1984, Hutchings 1986, Gibson 1993, O'Connell and Ash 1993, Erkinaro et al.1995, Dempson et al. 1996, Erkinaro et al. 1998, Marschall et al. 1998, Halvorsen and Svenning 2000, Klemetsen et al. 2003).

In a parr's second or third spring (age 1 or age 2, respectively), when it has grown to 12.5 to 15 cm (5 to 6 inches) in length, a series of physiological, morphological, and behavioral changes occur (Schaffer and Elson 1975). This process, called "smoltification," prepares the parr for migration to the ocean and life in salt water. Most parr remain in the river for two to three years before undergoing smoltification. Some male parr may not go through smoltification and will become sexually mature and participate in spawning with sea-run adult females. These males are referred to as "precocious parr." In Maine, 90% or more of naturally reared parr remain in freshwater for 2 years with the balance remaining for either 1 or 3 years (USASAC 2005). For parr to undergo smoltification, they must reach a critical size of 10 cm total length at the end of the previous growing season (Hoar 1988). During the smoltification process, parr markings fade and the body becomes streamlined and silvery with a pronounced fork in the tail. Naturally reared smolts in Maine range in size from 13 to 17 cm (5 to 6.7 inches), and most smolts enter the sea during May to begin their first ocean migration (USASAC 2004). During this migration, smolts must contend with changes in salinity, water temperature, pH, dissolved oxygen, pollution levels, and predator assemblages. The physiological changes that occur during smoltification prepare the fish for the dramatic change in osmoregulatory needs that come with the transition from a fresh to a salt water habitat (Ruggles 1980, Bley 1987, McCormick and Saunders 1987, McCormick et al. 1998). The transition of smolts into seawater is usually gradual as they pass through a zone of fresh and saltwater mixing that typically occurs in a river's estuary. Given that smolts undergo smoltification while they are still in the river, they are pre-adapted to make a direct entry into seawater with minimal acclimation (McCormick et al. 1998). This pre-adaptation to seawater is necessary under some circumstances where there is very little transition zone between freshwater and the marine environment.

The spring migration of post-smolts out of the coastal environment is generally rapid, within several tidal cycles, and follows a direct route (Lacroix and McCurdy 1996, Lacroix et al. 2004, Lacroix and Knox 2005, Hyvarinen et al. 2006). Kocik et al. (2009) documented smolt migrating with the tides primarily at night. Post-smolts generally travel out of coastal systems on the ebb tide and may be delayed by flood tides (Lacroix and McCurdy 1996, Lacroix et al. 2004, Lacroix and Knox 2005, Hyvarinen et al. 2006). Lacroix and McCurdy (1996), however, found that post-smolts exhibit active, directed swimming in areas with strong tidal currents. Studies in the Bay of Fundy and Passamaquoddy Bay suggest that post-smolts aggregate together and move near the coast in "common corridors" and that post-smolt movement is closely related to surface currents in the Bay (Lacroix and McCurdy 1996, Lacroix et al. 2004, Hyvarinen et al. 2006). European post-smolts tend to use the open ocean for a nursery zone, while North American post-smolts appear to have a more near-shore distribution (Friedland et al. 2003). Post-smolt distribution may reflect water temperatures (Reddin and Shearer 1987) and/or the major surface-current vectors

(Lacroix and Knox 2005). Post-smolts live mainly on the surface of the water column and form shoals, possibly of fish from the same river (Shelton et al. 1997).

During the late-summer and autumn of the first year, North American post-smolts are concentrated in the Labrador Sea and off of the west coast of Greenland, with the highest concentrations between 56° N and 58° N (Reddin 1985, Reddin and Short 1991, Reddin and Friedland 1993). The salmon located off Greenland are composed of both 1SW fish and fish that have spent multiple years at sea (multi-sea winter fish, or MSW) and includes immature salmon from both North American and European stocks (Reddin 1988, Reddin et al. 1988). The first winter at sea regulates annual recruitment, and the distribution of winter habitat in the Labrador Sea and Denmark Strait may be critical for North American populations (Friedland et al. 1993). In the spring, North American post-smolts are generally located in the Gulf of St. Lawrence, off the coast of Newfoundland, and on the east coast of the Grand Banks (Reddin 1985, Dutil and Coutu 1988, Ritter 1989, Reddin and Friedland 1993, Friedland et al. 1999).

Some salmon may remain at sea for another year or more before maturing. After their second winter at sea, the salmon over-winter in the area of the Grand Banks before returning to their natal rivers to spawn (Reddin and Shearer 1987). Reddin and Friedland (1993) found non-maturing adults located along the coasts of Newfoundland, Labrador, and Greenland, and in the Labrador and Irminger Sea in the later summer and autumn.

Figure 2-2 shows the Atlantic salmon's life-cycle, and Table 2-2 explains the distribution of age classes of Atlantic salmon in Maine rivers over a calendar year.

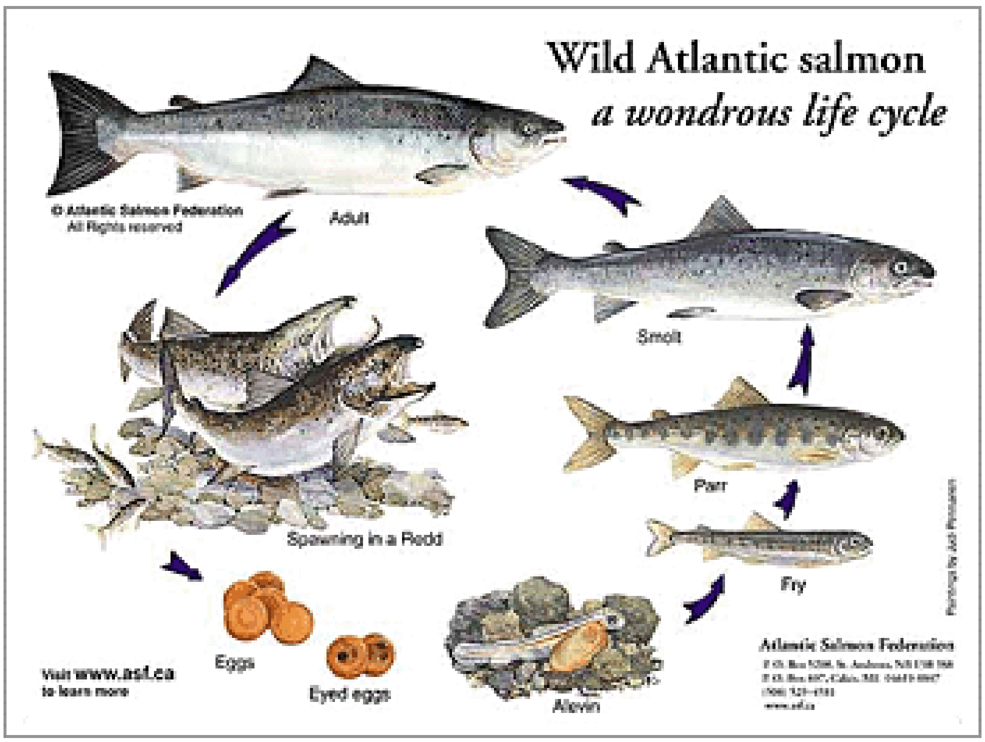

Figure 2-2. Atlantic salmon life cycle (courtesy of ASF 2012). It illustrates a typical occupied watershed in Maine, although locations in the watershed may dictate the presence of certain life stages present. So, one would not expect all watersheds in under this PBA to exhibit these characteristic life stages.

Table 2-2. Atlantic salmon life cycle and expected ATS presence distribution in Maine rivers by age-class.

Atlantic Salmon Life Cycle Monthly Gantt Chart												
	January	February	March	April	May	June	July	August	September	October	November	December
Adults	OVERWINTER				MIGRATION (ocean to rivers)			HOLDING		SPAWNING		OVERWINTER
										MIGRATION (river to ocean)		
Smolts					MIGRATION (river to ocean)							
Parr/Fry	REARING											
Alevins			HATCH									
Eggs	DEVELOPMENT IN REDDS									DEVELOPMENT IN REDDS		

2.2 Status and Trends of Atlantic Salmon Range wide

Atlantic salmon populations have been declining in the GOM DPS since the early 1800s and the present population estimates are a great deal lower than the historic run numbers (Fay et al 2006). The returning adults records show that numbers have somewhat stabilized at very low numbers since the late 1990s (Fay et al 2006). Data sets tracking adult abundance are not available throughout this entire time period. However, Fay et al. (2006) present a comprehensive time series of adult returns to the GOM DPS dating from 1967 to 2004. We supplement these data with adult returns in 2007 through 2011. Adult salmon returns over 14 years from 2001 through 2014 are shown in Figure 2-4. It is important to note that contemporary abundance levels of Atlantic salmon within the GOM DPS are several orders of magnitude lower than historical abundance estimates. For example, Atkins and Foster (1867 as cited in Schmitt and Anderson 2012) estimated that roughly 100,000 adult salmon returned to the Penobscot River alone before the river was dammed, whereas contemporary estimates of abundance for the entire GOM DPS have never exceeded 5,000 individuals in any given year since 1967 (Fay et al. 2006).

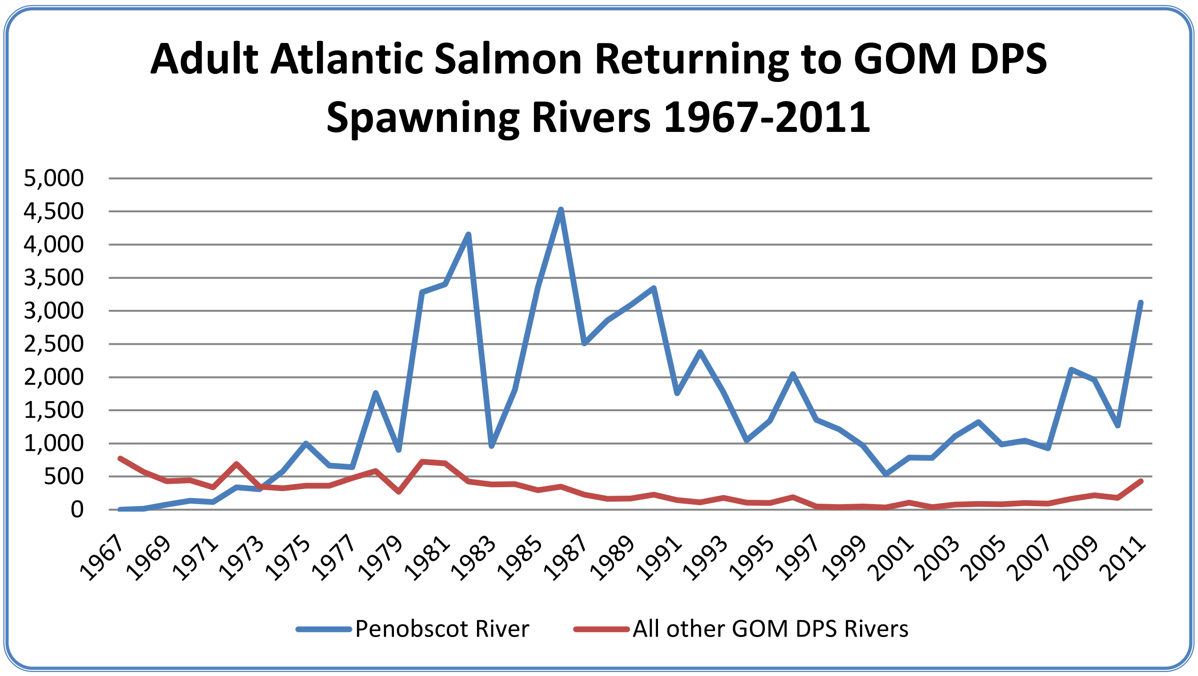

Figure 2-3. Adult Atlantic salmon returns to GOM DPS Rivers 1967-2011.

Data source: MDMR, unpublished data.

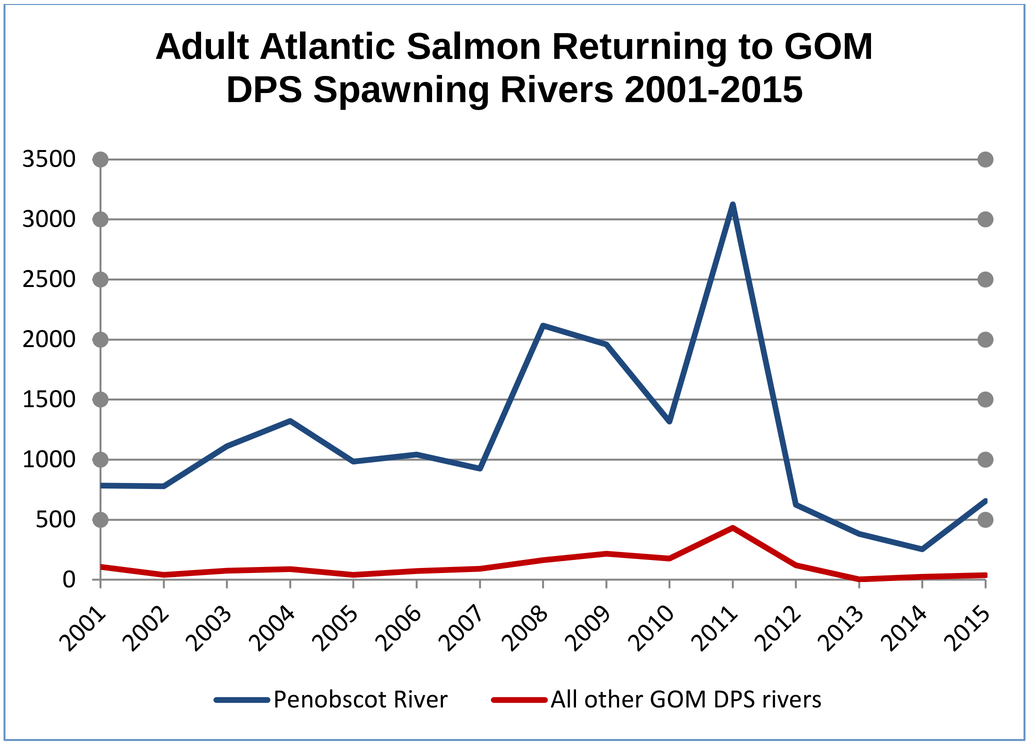

Figure 2-4. Adult Atlantic salmon returns to GOM DPS Rivers 2001-2014.

Data source: MDMR, unpublished data.

Contemporary abundance estimates help to describe the status of the GOM DPS today. After a period of population growth in the 1970s, adult returns of salmon in the GOM DPS have been steadily declining since the early 1980s and appear to have stabilized at very low levels since 2000 (Figure 2-3). The population growth observed in the 1970s is likely attributable to favorable marine survival and increases in hatchery capacity, particularly from GLNFH which was constructed in 1974. Marine survival remained relatively high throughout the 1980s, and salmon populations in the GOM DPS remained relatively stable until the early 1990s. In the early 1990s marine survival rates decreased, leading to the declining trend in adult abundance observed throughout the remainder of the decade. Poor marine survival of Atlantic salmon persists in the GOM DPS to date.

Adult returns to the GOM DPS have been very low for many years and remain extremely low in terms of adult abundance in the wild. Further, the majority of all adults in the GOM DPS return to a single river, the Penobscot, which accounted for 91% of all adult returns to the GOM DPS in 2007. Of the 1044 adult returns to the Penobscot in 2006, 996 of these were the result of smolt stocking and only the remaining 48 were naturally reared. In 2007 and 2008, salmon returns in the Penobscot River were 916 and 2,117 adults, respectively. Most of these returns were also of hatchery origin (USASAC 2008). The term naturally-reared includes fish originating from natural spawning and from hatchery fry (USASAC 2008). Hatchery fry are included as naturally-reared because hatchery fry are not marked; therefore, they cannot be distinguished from fish produced through natural spawning. Because of the extensive amount of fry stocking that takes place in an effort to recover the GOM DPS, it is possible that a substantial number of fish counted as naturally-reared were actually stocked as fry.

According to a Maine Department of Marine Resources (MDMR) correspondence (MDMR 2011), Atlantic salmon counts from the Veazie trap on the Penobscot River exceeded 3,100 in 2011. The counts are more than double 2010's totals, and represent the eighth highest run since the counting program began in 1978 and the highest since 1986. Conversely, counts in 2013 and 2014 were <500, the lowest in 40 years.

Low abundances of both hatchery-origin and naturally-reared adult salmon returns to Maine demonstrate continued poor marine survival. Declines in hatchery-origin adult returns are less sharp because of the ongoing effects of hatcheries. In short, hatchery production over this time period has been relatively constant, generally fluctuating around 550,000 smolts per year (USASAC 2008).

In contrast, the number of naturally reared smolts emigrating each year is likely to decline following poor returns of adults (three years prior). Thus, wild smolt production will suffer three years after a year with low adult returns, because the progeny of adult returns typically emigrate three years after their parents return. The relatively constant inputs from smolt stocking, coupled with the declining trend of naturally reared adults, result in the apparent stabilization of hatchery-origin salmon and the continuing decline of naturally reared components of the GOM DPS observed over the last 2 decades.

Adult returns for the GOM DPS remain well below conservation spawning escapement (CSE) goals that are widely used to describe the status of individual Atlantic salmon populations (ICES 2005). When CSE goals are met, Atlantic salmon populations are generally self-sustaining. When CSE goals are not met (i.e., <100%), populations are not reaching full potential which can be indicative of a population decline. For all GOM DPS rivers in Maine, current Atlantic salmon populations (including hatchery contributions) are well below CSE levels required to sustain themselves (Fay et al. 2006), a further indication of their poor population status.

In conclusion, the abundance of Atlantic salmon in the GOM DPS has been low and either stable or declining over the past several decades. The proportion of fish that are of natural origin is very small (below 10%) and is continuing to decline. The conservation hatchery program has assisted in slowing the decline and helping to stabilize populations at low levels, but has not contributed to an increase in the overall abundance of salmon and has not been able to halt the decline of the naturally reared component of the GOM DPS.

2.3 Summary of Factors Affecting Recovery of Atlantic Salmon

As part of the final rule listing, factors leading to the five statutory ESA listing factors were identified. The five factors are: (1) present or threatened destruction, modification, or curtailment of its habitat or range; (2) overutilization for commercial, recreational, scientific, or educational purposes; (3) predation or disease; (4) inadequacy of existing regulatory mechanisms; or (5) other natural or manmade factors affecting their continued existence. The 2005 Atlantic salmon recovery plan (NMFS and USFWS 2005) included a threat assessment that addresses factors fitting into the five categories used in the ESA listing. These threats include avian predation, low marine survival, invasive fish species that predate on Atlantic salmon, climate change, water quality, and depleted cover species communities.

2.4 Designated Critical Habitat for Atlantic Salmon

Coincident with the June 19, 2009 endangered listing, NMFS designated critical habitat for the GOM DPS of Atlantic salmon (NMFS 2009a; 74 FR 29300-29341). On August 10, 2009, the NMFS revised the limits of critical habitat to exclude all trust and fee holdings of the Penobscot Indian Nation (NMFS 2009b; 74 FR 39903-39907). NMFS separated the GOM DPS into three Salmon Habitat Recovery Units

(SHRUs), the Downeast Coastal, Penobscot Bay, and Merrymeeting Bay SHRUs (NMFS 2009a; Figure 2-5).

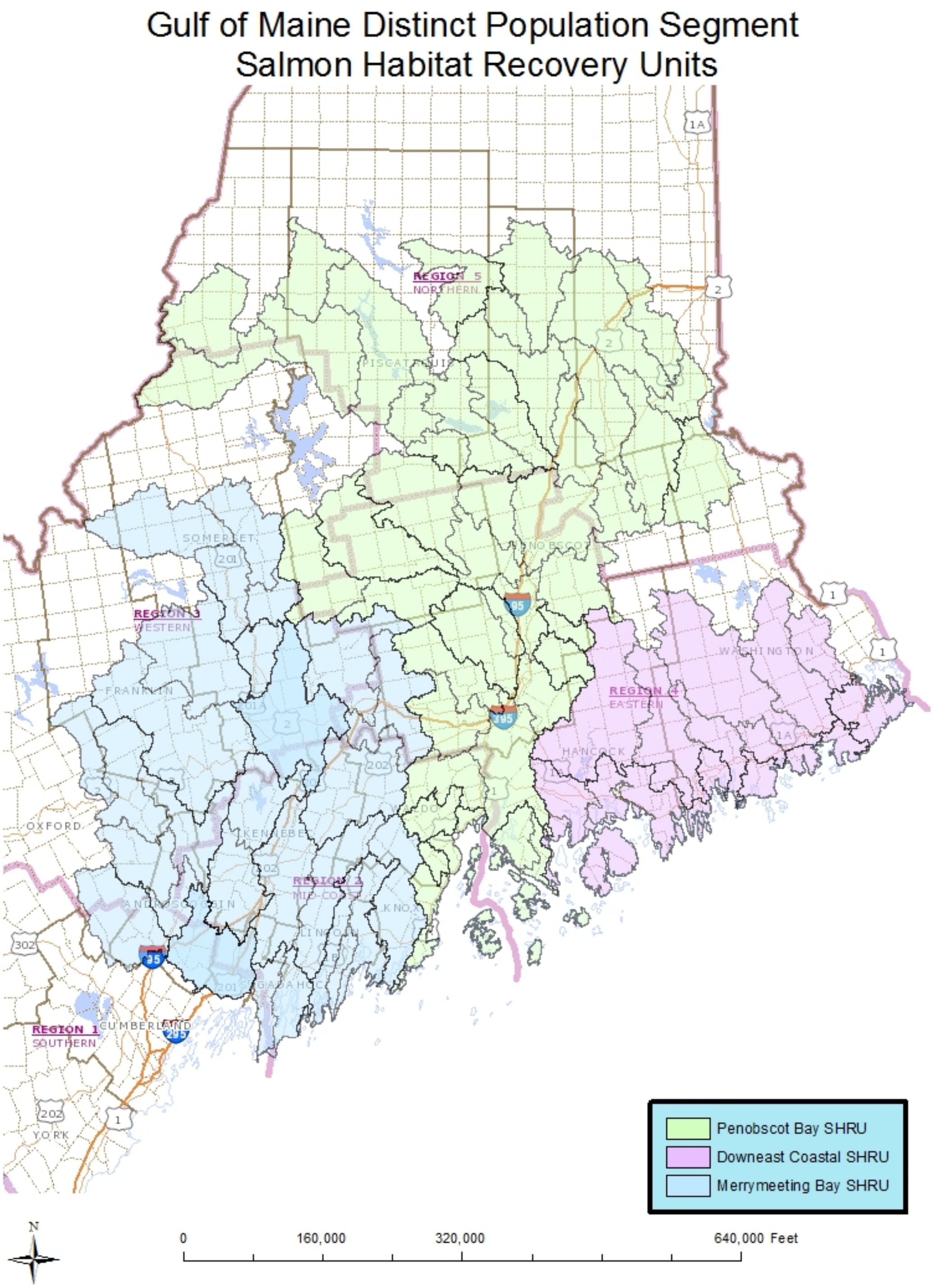

Figure 2-5. Salmon habitat recovery units (SHRUs) for GOM DPS of Atlantic salmon and limits of HUC 10 watersheds.

NMFS (2009a) best describes the reasoning for developing SHRUs as such,

> *"Dividing the GOM DPS into subsets represented as SHRU's provides the best management tool for establishing recovery goals in which the species is well represented over its entire range. The SHRU delineation fits well as either management units or recovery units as described above. However, Recovery Units are more appropriate given that maintaining a population in all three SHRU's is necessary in order to preserve the genetic variability of the DPS, which in turn is necessary in ensuring that the population is capable of adapting to and surviving natural environmental and demographic variation that all populations are subjected to over time."*

The three SHRUs resemble, with some differences, the hydrologic unit code (HUC) 10[1] basin divisions for the GOM DPS (Figure 2-5). The Merrymeeting Bay SHRU incorporates two large basins, the Androscoggin and Kennebec, and extends east to include the St. George watershed. The Penobscot Bay SHRU includes the entire Penobscot basin and extends west to include the Ducktrap watershed and extends east to include the Bagaduce watershed. The Downeast Coastal SHRU includes all the small- to medium-sized coastal watersheds extending east of the Penobscot SHRU to include the Dennys River watershed.

Figure 2-6 illustrates the extent of designated critical habitat for the GOM DPS. The status of Atlantic salmon critical habitat in the GOM DPS is important for two reasons: a) because it affects the viability of the listed species within the action area at the time of the consultation; and b) because those habitat areas designated "critical" provide primary constituent elements (PCEs) essential for the conservation (i.e., recovery) of the species. The complex life cycles exhibited by Atlantic salmon give rise to complex habitat needs, particularly during the freshwater phase (Fay et al. 2006). Spawning gravels must be a certain size and free of sediment to allow successful incubation of the eggs. Eggs also require cool, clean, and well-oxygenated waters for proper development. Juveniles need abundant food sources, including insects, crustaceans, and other small fish. They need places to hide from predators (mostly birds and larger fish), such as under logs, root wads, and boulders in the stream, as well as beneath overhanging vegetation. They also need places to seek refuge from periodic high flows (side channels and off-channel areas) and from warm summer water temperatures (coldwater springs and deep pools). Returning adults generally do not feed in fresh water but instead rely on limited energy stores to migrate, mature, and spawn. Like juveniles, they also require cool water and places to rest and hide from predators. During all life stages, Atlantic salmon require cool water that is free of contaminants. They also need migratory corridors with adequate passage conditions (timing, water quality, and water quantity) to allow access to the various habitats required to complete their life cycle.

[1] The U.S. Geological Survey and Water Resource Council developed the Hydrologic Unit Code (HUC) system to facilitate the geographic classification of surface water drainages based on topography and surface flow. The system divides drainages in the U.S. into six nested levels. Drainages are assigned a numbered code that reflects the level of classification. At level 4 is HUC 8, which represents a sub-basin, and level 5 is HUC 10, which represents a watershed. The numbers 8 and 10 reflect the number of digits in the code. As the drainage becomes smaller, the length of code gets longer.

Atlantic Salmon Gulf of Maine Distinct Population Segment

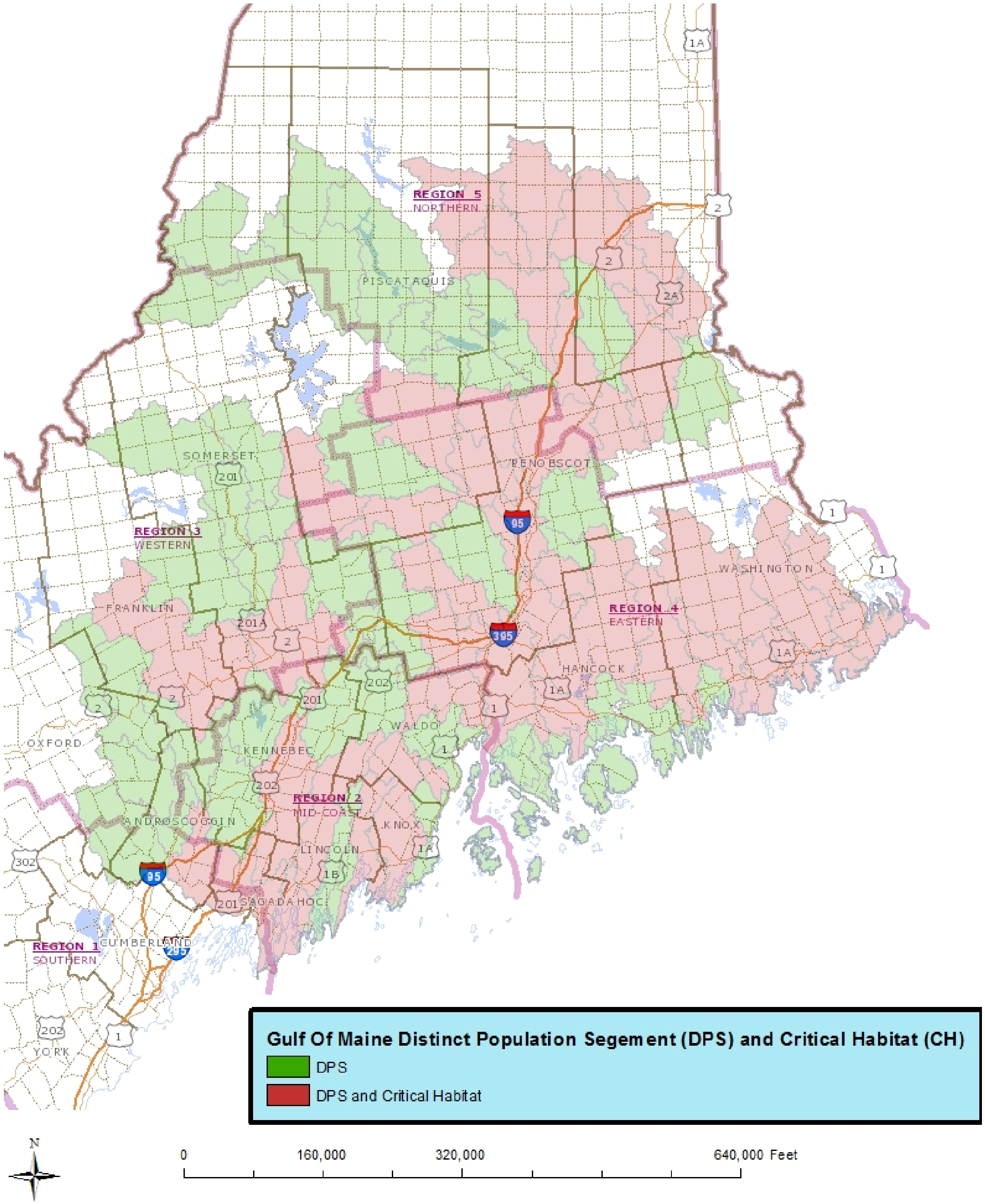

Figure 2-6. Atlantic salmon critical habitat within the GOM DPS.

The Atlantic salmon critical habitat PCEs are explained below, and Table 2-3 lists descriptions of functioning and necessary habitat features.

The physical and biological features of the two PCEs for Atlantic salmon critical habitat are as follows:

Physical and biological features of the spawning and rearing (SR) PCEs

- SR 1. Deep, oxygenated pools and cover (e.g., boulders, woody debris, vegetation, etc.), near freshwater spawning sites, necessary to support adult migrants during the summer while they await spawning in the fall.
- SR 2. Freshwater spawning sites that contain clean, permeable gravel and cobble substrate with oxygenated water and cool water temperatures to support spawning activity, egg incubation, and larval development.
- SR 3. Freshwater spawning and rearing sites with clean, permeable gravel and cobble substrate with oxygenated water and cool water temperatures to support emergence, territorial development and feeding activities of Atlantic salmon fry.
- SR 4. Freshwater rearing sites with space to accommodate growth and survival of Atlantic salmon parr.
- SR 5. Freshwater rearing sites with a combination of river, stream, and lake habitats that accommodate parrs' ability to occupy many niches and maximize parr production.
- SR 6. Freshwater rearing sites with cool, oxygenated water to support growth and survival of Atlantic salmon parr.
- SR 7. Freshwater rearing sites with diverse food resources to support growth and survival of Atlantic salmon parr.

Physical and biological features of the migration PCE

- M 1. Freshwater and estuary migratory sites free from physical and biological barriers that delay or prevent access of adult salmon seeking spawning grounds needed to support recovered populations.
- M 2. Freshwater and estuary migration sites with pool, lake, and in-stream habitat that provide cool, oxygenated water and cover items (e.g., boulders, woody debris, and vegetation) to serve as temporary holding and resting areas during upstream migration of adult salmon.
- M 3. Freshwater and estuary migration sites with abundant, diverse native fish communities to serve as a protective buffer against predation.
- M 4. Freshwater and estuary migration sites free from physical and biological barriers that delay or prevent emigration of smolts to the marine environment.
- M 5. Freshwater and estuary migration sites with sufficiently cool water temperatures and water flows that coincide with diurnal cues to stimulate smolt migration
- M 6. Freshwater migration sites with water chemistry needed to support sea water adaptation of smolts.

Habitat areas designated as critical habitat must contain one or more PCEs within the acceptable range of values required to support the biological processes for which the species uses that habitat. Critical habitat has only been designated in areas considered currently occupied by the species. Critical habitat includes the stream channels within the designated stream reach and includes a lateral extent as defined by the ordinary high water mark (OHWM) or the bankfull elevation in the absence of a defined high-water line. In estuaries, critical habitat is defined by the perimeter of the water body as displayed on standard 1:24,000 scale topographic maps or the elevation of extreme high water, whichever is greater.

For an area containing PCEs to meet the definition of critical habitat, the ESA also requires that the physical and biological features essential to the conservation of Atlantic salmon in that area "may require special management considerations or protections." Activities within the GOM DPS that were identified as potentially affecting the physical and biological features and therefore requiring special management considerations or protections include agriculture, forestry, changing land-use and development, hatcheries and stocking, roads and road crossings, mining, dams, dredging, and aquaculture.

Table 2-3. Matrix of Primary Constituent Elements (PCEs) and essential features for assessing the environmental baseline of the action area.

	Conservation Status Baseline		
PCE Essential Features	Fully Functioning	Limited Function	Not Properly Functioning
A) Adult Spawning (October 1 – December 14)			
Substrate	Highly permeable course gravel and cobble between 1.2 - 10 cm dia.	40- 60% cobble (22.5-256 mm dia.) 40 - 50% gravel (2.2 – 22.2 mm dia.); 10-15% course sand (0.5 - 2.2 mm dia.), and <3% fine sand (0.06 - 0.05mm dia.)	More than 20% sand (particle size 0.06 - 2.2 mm), no gravel or cobble
Depth	17 - 30 cm	30 - 76 cm	<17 cm or >76 cm
Velocity	31 - 46 cm/sec	8 - 31cm/sec or 46 - 83 cm/sec	<5 - 8 cm/sec or >83cm/sec
Temperature	7°C to 10°C	often between 7°C - 10°C	always <7° or >10°C
pH	> 5.5	between 5.0 and 5.5	< 5.0
Cover	Abundance of pools 1.8-3.6 m deep (McLaughlin and Knight 1987). Large boulders or rocks, over hanging trees, logs, woody debris, submerged vegetation or undercut banks	Limited availability of pools 1.8 - 3.6 m deep (McLaughlin and Knight 1987). Large boulders or rocks, over hanging trees, logs, woody debris, submerged vegetation or undercut banks	Absence of pools 1.8 - 3.6 m deep (McLaughlin and Knight 1987). Large boulders or rocks, over hanging trees, logs, woody debris, submerged vegetation or undercut banks
Fisheries Interactions	Abundant diverse populations of indigenous fish species	Abundant diverse populations of indigenous fish species, low quantities of non-native species present	Limited abundance and diversity of indigenous fish species, abundant populations of non-native species
B) Embryo and Fry Development (October 1 – April 14)			
Temperature	0.5°C and 7.2°C, averages nearly 6°C from fertilization to eye pigmentation	averages <4°C or 8°C to 10°C from fertilization to eye pigmentation	>10°C from fertilization to eye pigmentation
D.O.	at saturation	7-8 mg/L	<7 mg/L
pH	>6.0	6 - 4.5	<4.5
Depth	5.3 - 15cm	NA	<5.3 or >15cm
Velocity	4 – 15cm/sec.	NA	<4 or >15cm/sec.

Table 2-3. Matrix of Primary Constituent Elements (PCEs) and essential features for assessing the environmental baseline of the action area.

	Conservation Status Baseline		
PCE Essential Features	Fully Functioning	Limited Function	Not Properly Functioning
Fisheries Interactions	Abundant diverse populations of indigenous fish species	Abundant diverse populations of indigenous fish species, low quantities of non-native species present	Limited abundance and diversity of indigenous fish species, abundant populations of non-native species
C) Parr Development (All Year)			
Substrate	Gravel between 1.6 and 6.4 cm dia. and boulders between 30 and 51.2 cm dia. May contain rooted aquatic macrophytes	Gravel <1.2cm dia. and/or boulders >51.2 cm dia. May contain rooted aquatic macrophytes	No gravel, boulders, or rooted aquatic macrophytes present
Depth	10 - 30cm	NA	<10 cm or >30cm
Velocity	7 to 20 cm/sec.	<7cm/sec. or >20 cm/sec.	Velocity exceeds 120 cm/sec.
Temperature	15°C to 19°C	generally between 7°C - 22.5°C, but does not exceed 29°C at any time	stream temperatures are continuously <7°C or known to exceed 29°C
D.O.	>6 mg/l	2.9 - 6 mg/l	<2.9 mg/l
Food	Abundance of larvae of mayflies, stoneflies, chironomids, caddisflies, blackflies, aquatic annelids, and mollusks as well as numerous terrestrial invertebrates and small fish such as alewives, dace or minnows	Presence of larvae of mayflies, stoneflies, chironomids, caddisflies, blackflies, aquatic annelids, and mollusks as well as numerous terrestrial invertebrates and small fish such as alewives, dace or minnows	Absence of larvae of mayflies, stoneflies, chironomids, caddisflies, blackflies, aquatic annelids, and mollusks as well as numerous terrestrial invertebrates and small fish such as alewives, dace or minnows
Passage	No anthropogenic causes that inhibit or delay movement	Presence of anthropogenic causes that result in limited inhibition of movement	Barriers to migration known to cause direct inhibition of movement
Fisheries Interactions	Abundant diverse populations of indigenous fish species	Abundant diverse populations of indigenous fish species, low quantities of non-native species present	Limited abundance and diversity of indigenous fish species, abundant populations of non-native species
D) Adult Migration (April 15 – December 14)			
Velocity	30 cm/sec - 125 cm/sec	In areas where water velocity exceeds 125 cm/sec adult salmon require resting areas with a velocity of < 61 cm/s	Sustained speeds >61 cm/sec and maximum speed >667 cm/sec
D.O.	> 5mg/L	4.5 - 5.0 mg/l	< 4.5mg/L
Temperature	14°C – 20°C	Temperatures sometimes exceed 20°C but remain below 23°C	>23°C
Passage	No anthropogenic causes that delay migration	Presence of anthropogenic causes that result in limited delays in migration	Barriers to migration known to cause direct or indirect mortality of adults

Table 2-3. Matrix of Primary Constituent Elements (PCEs) and essential features for assessing the environmental baseline of the action area.

	Conservation Status Baseline		
PCE Essential Features	Fully Functioning	Limited Function	Not Properly Functioning
Fisheries Interactions	Abundant diverse populations of indigenous fish species	Abundant diverse populations of indigenous fish species, low quantities of non-native species present	Limited abundance and diversity of indigenous fish species, abundant populations of non-native species
E) Juvenile Migration April 15 – June 14			
Temperature	8°C - 11°C	5°C - 11°C.	<5°C or >11°C
pH	>6	5.5 - 6.0	<5.5
Passage	No anthropogenic causes that delay migration	Presence of anthropogenic causes that result in limited delays in migration	Barriers to migration known to cause direct or indirect mortality of smolts

2.5 Priority Areas

There are many different factors that can define the priority of a watershed for restoration. The process described below represents qualifiers that make a watershed a priority area for the purpose of this PBA.

MaineDOT, FHWA, NMFS, MDMR, and USFWS met on April 14, 2015 to discuss creating priority watersheds for Atlantic salmon recovery. The parties discussed the active restoration programs and the current distribution of Atlantic salmon in the GOM DPS. The discussions led to the idea for arranging in tiers the priority areas in all of the hydrologic unit code (HUC) 10 watersheds within the GOM DPS. The rationale for each of the tier priority areas is explained in the sections below. Table 2-4, Table 2-5 and Table 2-6 below list each watershed and its corresponding tier priority within a SHRU. Figure 2-7, Figure 2-8, and Figure 2-9 illustrate the geographic locations of the tier watersheds in each SHRU.

The purpose of defining priority areas was to focus efforts of project design and construction AMMs to areas that are priorities for Atlantic salmon recovery or may be occupied by Atlantic salmon. This will maximize the conservation efforts and efficient use of project funding in areas that have both agency and Atlantic salmon priorities. If recovery programs and species distribution change in the 5-year term of this PBA, the Proponents and Action Agencies will adopt any new scheme developed by the Services. This document is intended to be dynamic throughout its term and mirror Atlantic salmon recovery priorities.

2.5.1 Tier 1 Priority Areas

Tier 1 priority areas are the highest priority recovery watersheds. These watersheds contain active recovery programs and have known salmon occurrences. Generally, these watersheds contain the highest quality salmon habitat. A total of 41 watersheds were determined to be within Tier 1 priority areas (approximately 46.6% of the HUC-10 watersheds within the GOM DPS). Of the 41 watersheds listed within the Tier 1 priority areas, 37 are within Atlantic salmon designated critical habitat.

For the purposes of analysis, it is assumed that all Tier 1 areas are potentially occupied by a life stage of ATS. Site specific presence expectations will be refined when the projects are submitted for review.

2.5.2 Tier 2 Priority Areas

Tier 2 priority areas are those watersheds where recovery actions are not active, but may be related to proximal recovery programs located in Tier 1 priority areas. These watersheds may also contain important populations of cover species that are important for Atlantic salmon recovery. These watersheds are not expected to have substantial numbers of Atlantic salmon in any life stage. Species use in these areas varies depending on the watershed. These watersheds are currently of lower recovery importance as compared to Tier 1 priority areas. A total of 19 watersheds were determined to be within Tier 2 priority areas (approximately 21.6% of the HUC-10 watersheds within the GOM DPS). Of the 19 watersheds listed within the Tier 2 priority areas, 9 are within Atlantic salmon designated critical habitat.

2.5.3 Tier 3 Priority Areas

Tier 3 priority areas are those watersheds not meeting the definition of Tier 1 or Tier 2, but within the range of the GOM DPS of Atlantic salmon. These 28 areas, representing approximately 31.8% of the HUC-10 watersheds within the GOM DPS, are not within Atlantic salmon designated critical habitat. For the 5-year duration covered by this PBA, activities that occur in Tier 3 priority areas will result in No Effect to the species.

If recovery programs or species distribution change during the 5 year term of this PBA, these priority area designations may change and the change may require reinitiation of the consultation. If recovery programs and species distribution change in the 5-year term of this PBA, the Proponents and Action Agencies will adopt any new scheme developed by the Services.

Table 2-4. HUC 10 Watersheds within the Downeast Coastal Salmon Habitat Recovery Unit.

HUC 10 CODES	Watersheds	Critical Habitat	Tier Priority
105000201	Dennys River	Yes	1
105000204	East Machias River	Yes	1
105000205	Machias River	Yes	1
105000208	Pleasant River	Yes	1
105000209	Narraguagus River	Yes	1
105000212	Graham Lake	Yes	1
105000207	Chandler River	Yes	1
105000210	Tunk Stream	Yes	2
105000203	Grand Manan Channel	Yes	2
105000213	Union River Bay	Yes	2
105000206	Roque Bluffs Coastal	Yes	2
105000211	Bois Bubert Coastal	No	3
105000214	Lamoine Coastal	No	3
105000215	Mt. Desert Coastal	No	3

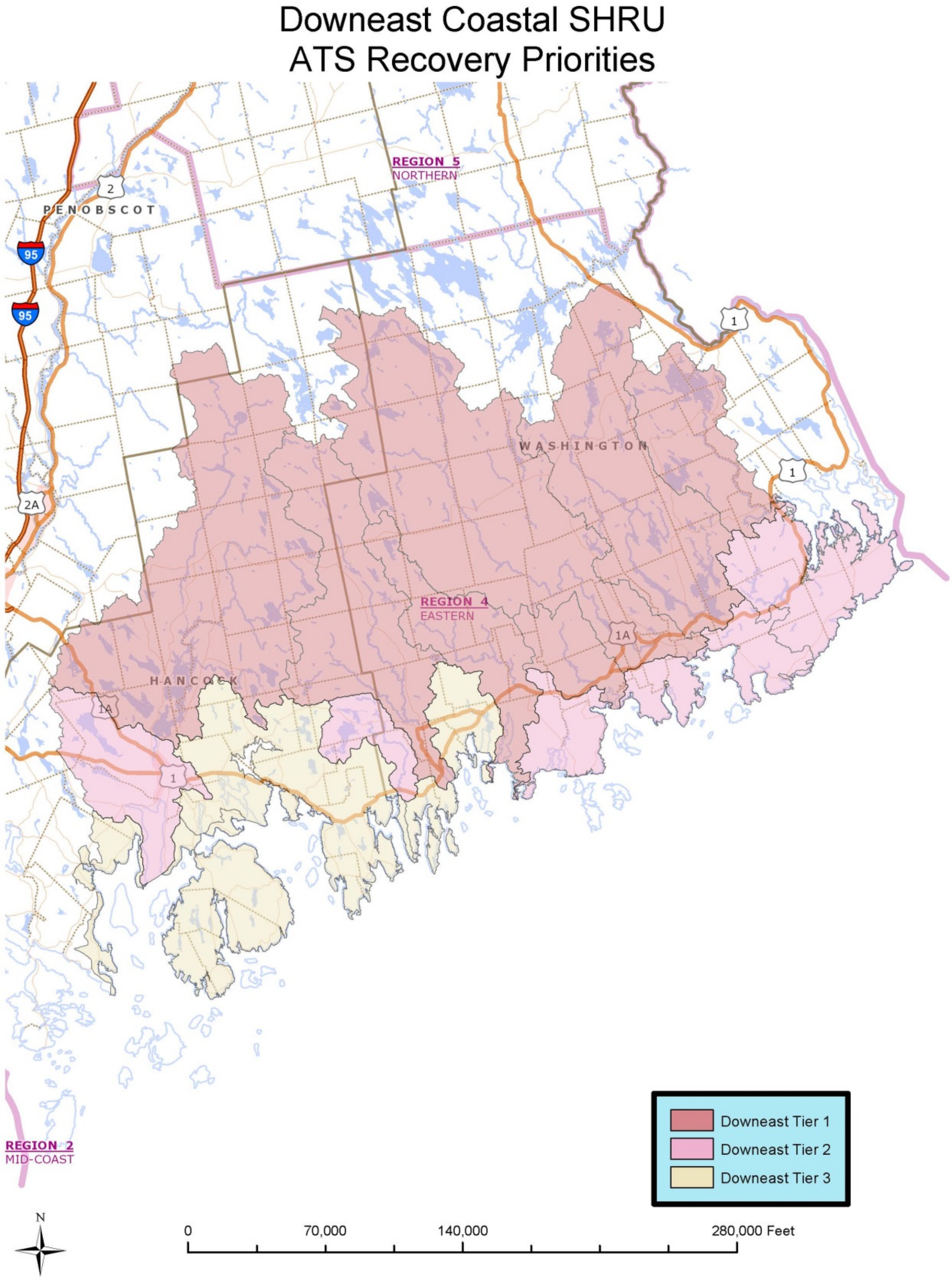

Figure 2-7. Classified Atlantic salmon priority areas within the Downeast Coastal Salmon Habitat Recovery Unit.

Table 2-5. HUC 10 watersheds within the Merrymeeting Bay Salmon Habitat Recovery Unit.

HUC_10 CODES	Watershed	Critical Habitat	Priority Tier
103000304	Carrabassett River	No	1
103000305	Sandy River	Yes	1
103000306	Kennebec River at Waterville Dam	Yes	1
103000312	Kennebec River at Merrymeeting Bay[2]	Yes	1
104000210	Little Androscoggin River	Yes	1
105000301	St. George River	Yes	1
105000305	Sheepscot River	Yes	1
103000306	Kennebec River at Waterville Dam	Yes	1
104000209	Androscoggin River (6) above Little Androscoggin River	No	2
103000303	Kennebec River (6)	No	2
103000307	Sebasticook River at Pittsfield	No	2
103000308	Sebasticook River (3) at Burnham	No	2
103000309	Sebasticook River (4) at Winslow	No	2
103000310	Messalonskee Stream	No	2
103000311	Cobbosseecontee Stream	No	2
105000306	Sheepscot Bay	Yes	2
105000307	Kennebec River Estuary	Yes	2
105000302	Medomak River	Yes	2
103000204	Dead River	No	3
104000204	Ellis River	No	3
103000106	Kennebec River (2) above The Forks	No	3
103000301	Kennebec River (4) at Wyman Dam	No	3
103000302	Austin Stream	No	3
104000205	Androscoggin River (3) above Webb River	No	3
104000206	Androscoggin River (4) at Riley Dam	No	3
104000207	Androscoggin River (5) at Nezinscot River	No	3
104000208	Nezinscot River	No	3
105000303	Johns Bay	No	3
105000304	Damariscotta River	No	3

[2] Tier 1 priority areas Togus Stream and Bond Brook

Merrymeeting Bay
ATS Recovery Priorities

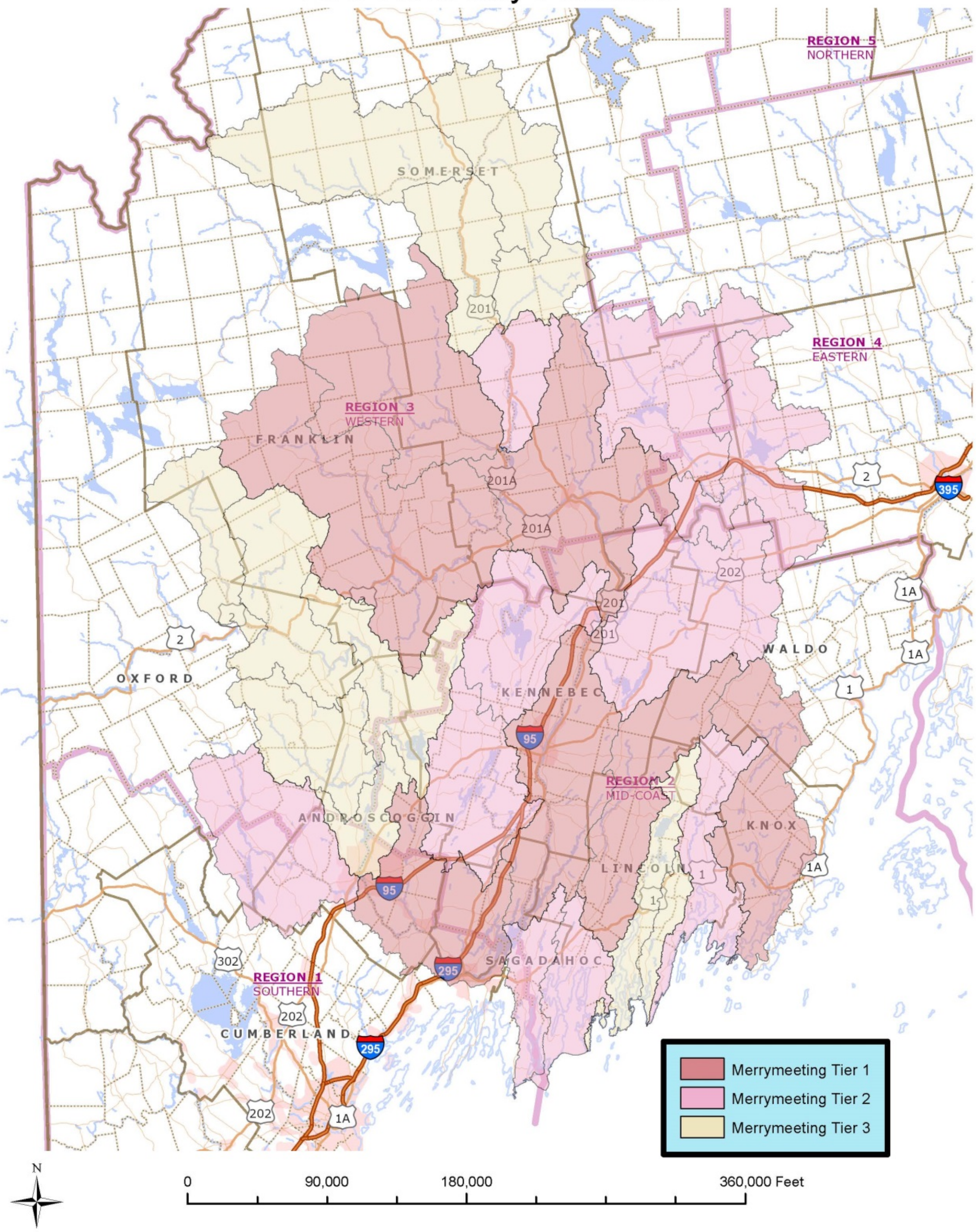

Figure 2-8. Classified Atlantic salmon priority areas within the Merrymeeting Bay Salmon Habitat Recovery Unit.

Table 2-6. HUC 10 watersheds within the Penobscot Bay Salmon Habitat Recovery Unit.

HUC 10 CODES	Watersheds	Critical Habitat	Tier Priority
102000203	East Branch Penobscot River (2)	Yes	1
102000204	Seboeis River	Yes	1
102000205	East Branch Penobscot River (3)	Yes	1
102000301	West Branch Mattawamkeag River	Yes	1
102000302	East Branch Mattawamkeag River	Yes	1
102000303	Mattawamkeag River (1)	Yes	1
102000305	Mattawamkeag River (2)	Yes	1
102000306	Molunkus Stream	No	1
102000307	Mattawamkeag River (3)	Yes	1
102000401	Piscataquis River (1)	Yes	1
102000402	Piscataquis River (3)	Yes	1
102000404	Pleasant River	Yes	1
102000405	Seboeis Stream	Yes	1
102000406	Piscataquis River (4)	Yes	1
102000501	Penobscot River (1) at Mattawamkeag	Yes	1
102000502	Penobscot River (2) at West Enfield[3]	Yes	1
102000506	Penobscot River (3) at Orson Island	Yes	1
102000509	Penobscot River (4) at Veazie Dam	Yes	1
102000510	Kenduskeag Stream	Yes	1
102000511	Souadabscook Stream[4]	Yes	1
102000512	Marsh River	Yes	1
102000513	Penobscot River (6)[5]	Yes	1
105000219	Ducktrap River	Yes	1
102000503	Passadumkeag River	No	1
102000403	Sebec River[6]	No	1
102000202	Grand Lake Matagamon	Yes	1
102000304	Baskahegan Stream	No	2
102000505	Sunkhaze Stream	Yes	2
102000507	Birch Stream	Yes	2
102000508	Pushaw Stream	No	2
105000218	Belfast Bay	No	2
102000106	Nesowadnehunk Stream	No	3
102000101	North Branch Penobscot River	No	3

[3] Tier 1 priority area Main Stem Penobscot
[4] Tier 1 priority area Main Stem Souadabscook
[5] Tier 1 priority areas Sedgeunkedunk and Cove Brook
[6] Tier 1 priority area Sebec River below most-downstream dam

HUC 10 CODES	Watersheds	Critical Habitat	Tier Priority
102000102	Seeboomook Lake	No	3
102000103	West Branch Penobscot River at Chesuncook Lake	No	3
102000104	Caucomgomok Lake	No	3
102000105	Chesuncook Lake	No	3
102000107	Nahamakanta Stream	No	3
102000108	Jo-Mary Lake	No	3
102000109	West Branch Penobscot River (3)	No	3
102000110	West Branch Penobscot River (4)	No	3
105000216	Bagaduce River	No	3
105000217	Stonington Coastal	No	3
105000220	West Penobscot Bay Coastal	No	3
102000504	Olamon Stream	No	3

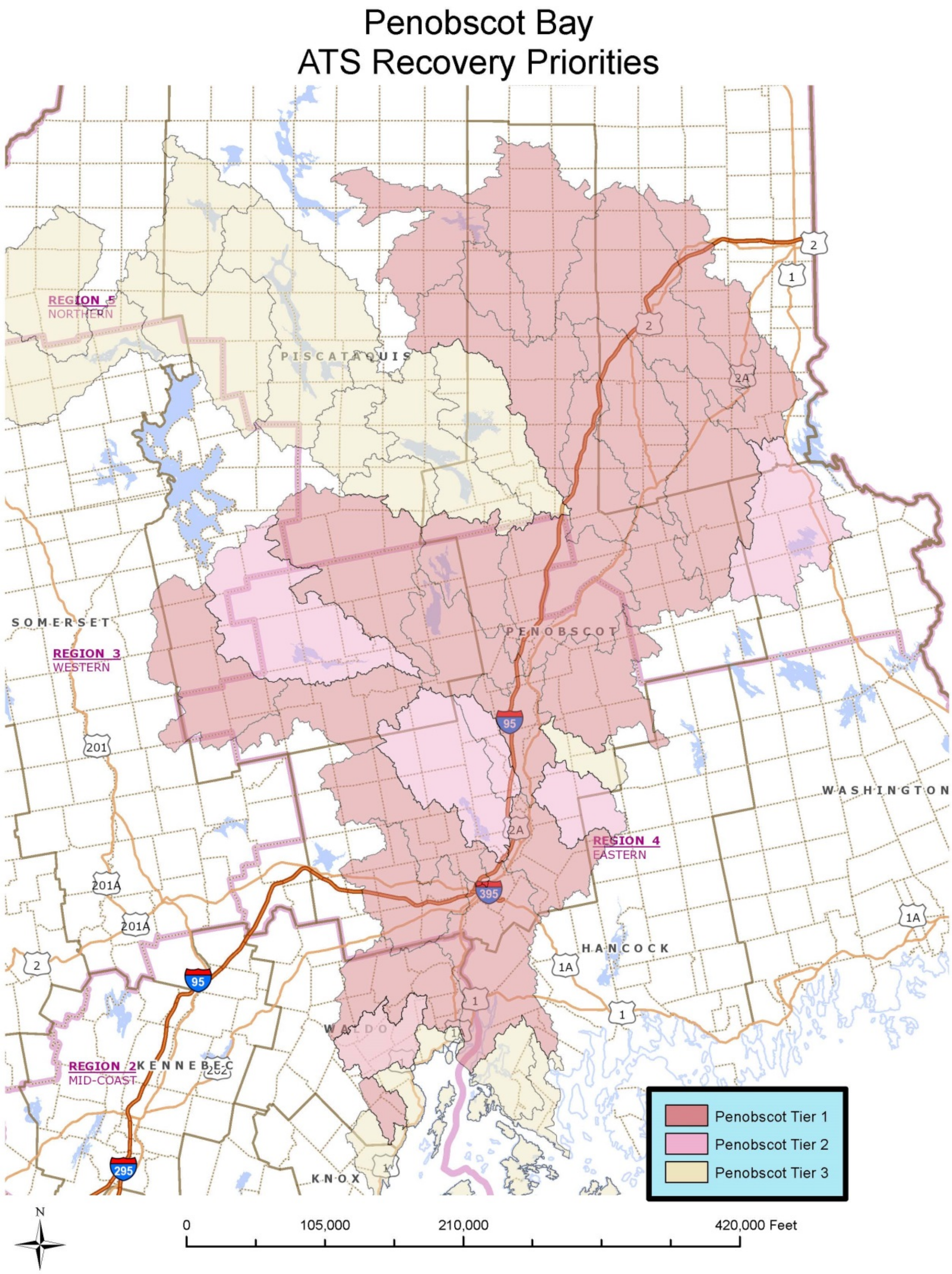

Figure 2-9. Classified Atlantic salmon priority areas within the Penobscot Bay Salmon Habitat Recovery Unit.

2.6 Environmental Baseline

According to the ESA Section 7 Consultation Handbook (USFWS and NMFS 1998), the Biological Opinion includes an environmental baseline section. This is "an analysis of the effects of past and ongoing human and natural factors leading to the current status of the species, its habitat (including designated critical habitat), and ecosystem, within the action area. The environmental baseline is a "snapshot" of a species' health at a specified point in time. It does not include the effects of the action under review in the consultation" (USFWS and NMFS1998).

To facilitate the USFWS's preparation of the Programmatic Biological Opinion, the Proponents define the environmental baseline for this PBA as the range of the GOM DPS of Atlantic salmon because the range is wholly contained within the action area. Hence, the discussion of the range-wide status provides the environmental baseline description for the proposed action.

Chapter 3 Proposed Action

The Proponents conduct several kinds of routine and similarly-designed projects that result in predictable temporary and/or permanent impacts to Atlantic salmon and Atlantic salmon designated critical habitat for certain activities. These projects include maintenance, repairs, and upgrades to existing structures, replacement of existing structures, and removal of existing structures. This PBA focuses on 8 project activities that may have effects to Atlantic salmon and/or critical habitat that are easily analyzed, relatively small in extent and magnitude, where potential effects can be avoided and/or minimized with standard measures.

3.1 Avoidance and Minimization Measures (AMMs)

Each of the activities includes implementation of best management practices (BMPs) and AMMs. BMPs are methods, facilities, built elements, and techniques implemented or installed during project construction to prevent or reduce project impacts on natural resources, such as water quality, soil, and animal habitats. AMMs are measures that prevent or reduce the impact of a project on listed species or habitats. AMMs can be precautionary, avoidance, or protection procedures, such as timing restrictions or buffers around sensitive habitats and habitat features that are important to listed species. For the purposes of this PBA, AMMs include all BMPs and apply to all project activities. AMMs and BMPs are measures that are considered part of the proposed activity that will be implemented. They are not recommendations, guidelines, or suggestions.

The proposed activities (Section 3.4 through Section 3.11) include the implementation of relevant and appropriate AMMs. The expected outcomes from AMM implementation are identified and explained as part of each activity description. General AMMs (or a summary of applicable AMMs) are listed and summarized in Section 3.12. The AMMs are also later emphasized in Chapter 5 when discussing the potential effects associated with implementation of the activities. If any of the AMMs cannot be implemented for a specific project, then that project cannot be covered under this PBA.

3.2 Conservation Measures

Conservation measures are activities or techniques that contribute towards the recovery of listed species. They may include design features to improve or maintain habitat connectivity in a crossing structure or enhance shoreline habitat along with bank stabilization. Conservation measures can also include mitigation actions that restore habitat connectivity elsewhere within the GOM DPS through individual actions or under a comprehensive effort, such as an in-lieu fee program. Conservation measures #1 and #2 below only apply to certain projects while conservation measure #3 is a program that will be implemented and reported on. These conservation measures are listed separately from the more specific AMMs. It is important to note that there is intentional overlap between the overall conservation measures and the specific AMMs that implement them.

3.2.1 Conservation Measure #1 – Habitat Connectivity Design

Of any of the proposed activity outcomes, stream habitat connectivity will have the largest effect on long-term recovery for Atlantic salmon. The Proponents have committed to designing stream crossing replacement projects in Tier 1 priority areas in a way that restores and maintains habitat connectivity and is therefore consistent with USFWS recovery goals.

3.2.2 Conservation Measure #2 - Development and Implementation of a Fee-based Mitigation Program

Compensating for adverse effects on critical habitat is an integral part of the Atlantic Salmon Recovery and Conservation Program, a regulatory program administered by the Services to compensate for impacts to Atlantic salmon habitat loss through the ESA (ESA; 7 U.S.C. § 136, 16 U.S.C. § 1531 et seq.). ESA further grants the Services an option to establish a compensation fund, or ILF, for the purpose of receiving compensation fees, grants and other related income or entering into an enforceable, written agreement with a public, quasi-public or municipal organization or a private, nonprofit organization for the administration of an in lieu fee program. Compensation provides an off-set for an adversely affected resource function with a function of equal or greater value. In general, mitigation is a sequential process of avoiding adverse impacts, minimizing impacts that cannot be practicably avoided, and then compensating for those impacts that cannot be further minimized. The ESA authorizes the Services to establish a program providing for compensation of unavoidable losses to protected natural resources from proposed development activities. Compensatory mitigation can be included in an ESA consultation that has been determined to have an adverse effect on Atlantic salmon critical habitat as a result of a project.

In Maine, an Atlantic salmon-specific in lieu fee program, primarily led by the USACE, is under development concurrent with this agreement for the express purpose of providing a vehicle for targeted species restoration and conservation on a statewide basis. Compensation ratios, habitat values, service areas, documentation requirements, and administrative provisions for the Atlantic salmon in lieu fee program will be determined via collaborative establishment of the mitigation instrument. The Proponents will participate in this program once it is established as a means to offset residual adverse effects associated with specific activities included in this programmatic consultation.

The goals and objectives of an established in lieu fee compensation program are as follows:

a) Provide an alternative to permittee-responsible compensatory mitigation that will effectively increase the DPS population and/or restore Atlantic salmon habitat functions and values lost through permitted impacts;
b) Substantially increase the extent and quality of restoration, enhancement, and protection of protected Atlantic salmon natural resources over that typically achieved by permittee-responsible mitigation for activities that impact Atlantic salmon and their habitat;
c) Reduce the extent of cumulative adverse impacts to aquatic resources that are considered protected Atlantic salmon habitat under the ESA;
d) Provide project applicants greater flexibility in compensating for adverse impacts to Atlantic salmon; and
e) Achieve ecological success on a biophysical region basis by directing in lieu fees to federally protected Atlantic salmon and their habitat that are appropriate to the geographic service area, and by integrating in lieu fee projects with other conservation activities whenever possible.

The Proponents may choose to provide compensation for adverse effects through design, implementation and maintenance of a permittee-responsible mitigation project or, in lieu of such a project, may pay an in lieu compensation according to a subsequent agreement between the Parties.

Consistent with the goals and objectives stated above, the Proponents will provide mitigation for four activities that are proposed as a part of this PBA:

1. Stream crossing replacements with widths less than 1.2 bankfull width (BFW) but ≥ 1.0 BFW in Tier 2 priority areas (note: stream crossing replacements less than 1.0 BFW are not allowed in Tier 2 priority areas under this PBA);
2. Culvert end resets and extensions in Tier 1 and 2 priority areas;
3. Bridge scour countermeasures in Tier 1 and 2 priority areas; and
4. Invert line and slip line culvert rehabilitations in Tier 2 priority areas (note: Invert line and slip line culvert rehabilitations are not allowed in Tier 1 priority areas).

The levels of mitigation required will be determined based on the provisions established during the in lieu fee program development.

3.2.3 Conservation Measure #3 - Turbidity Monitoring Program

The Proponents and the USFWS recognize a data gap in understanding turbidity effects from transportation projects in Maine. The Proponents have committed to developing a monitoring protocol and conduct monitoring on a subset of all of the proposed activities. The proponents are working with the USFWS to develop a suitable monitoring protocol. It is anticipated that this protocol will be complete prior to the issuance of the BO and will be part of the User's Guide.

This data collection is meant to inform future individual consultations and programmatic updates and is a component of the PBA’s adaptive management. The collection of this data is not meant to be a compliance check on these projects. The information from this monitoring will be compared against the assumptions made for quantifying adverse effects. The Proponents and the USFWS will discuss the findings and make a decision about re-initiation of consultation.

Table – Summary of Activities, Tiers and Conservation Measures Proposed in PBA

Activity	**Tier 1**	**Tier 2**	**Tier 3**
1. Stream Crossing Replacements:			
*Culvert (spans ≤ 20') Replacements	CM#1 *[designed to meet 1.2BFW standard w/ ESM]*	CM#1 *[designed to a structure diameter of at least 1.0BFW w/ ESM]* CM#2 *w/ caveat**	
*Bridge (spans > 20') Replacements	CM#1 *[designed to meet 1.2BFW standard w/ ESM]* *(AMM #2: In-water work July 15-April 15)*	CM#1 *[designed to a structure width of at least 1.0BFW]* CM#2 *w/ caveat** *(AMM #2: In-water work July 15-April 15)*	
2. Bridge or Culvert Removal	CM#1		
3. Culvert End Resets and Extensions	CM#2	CM#2	
4. Bridge Scour Countermeasures	CM#2	CM#2	
5. Bridge Maintenance:			
*Grout Bag Installation			
*Concrete Repair			
6. Temporary Work Access and Temporary Bridges			
7. Invert Line and Slipline Culvert Rehabilitation	Invert line and sliplne culvert rehabilitation projects **are not allowed in Tier 1 priority areas.**	CM#2	
8. Pre-project Geotechnical Drilling/Sampling	No in-water work window requirement, UNLESS drilling/sampling requires temporary access. Then, standard work window applies.	No in-water work window requirement, UNLESS drilling/sampling requires temporary access. Then, standard work window applies.	
Urgency Projects	No in-water work window requirement	No in-water work window requirement	

*****if proposed replacement is less than 1.2 BFW, mitigation will be provided. If replacement is 1.2 BFW or greater, no mitigation will be provided)

3.3 Urgency Projects

USACE, FHWA, USFWS and MaineDOT have identified an expedited process for approving projects that are threatened by imminent failure and those that require emergency repair or replacement following a failure. Activities that meet those criteria will implement the procedures for emergency consultation under the ESA (50 CFR 402.05; USFWS and NMFS 1998) and the USACE's emergency situation procedures (33 CFR 325.2(e)(4)).

The USACE Maine General Permit (GP), "33 CFR 325.2(e)4 states that an 'emergency' is a situation which would result in an unacceptable hazard to life, a significant loss of property, or an immediate, unforeseen, and significant economic hardship if corrective action requiring a permit is not undertaken within a time period less than the normal time needed to process the application under standard procedures."

Emergency work is subject to the same terms and conditions of the USACE Maine GP, as is non-emergency work, and similarly, must qualify for authorization under the GP; otherwise an Individual Permit is required. USACE will work with all applicable agencies to expedite verification according to established procedures in a truly defined emergency. This applies to situations involving acts of nature, disasters, casualties, national defense or security emergencies, etc., and includes response activities that must occur to prevent imminent loss of human life or property. The ESA Section 7 Consultation Handbook (USFWS and NMFS 1998) provides a full explanation of the emergency consultation process. The following sections provide a summary of the process.

There are situations when projects are of great urgency to MaineDOT, but do not qualify as an emergency under either the ESA or USACE regulations. For example, a road crossing could fail, and there is a detour nearby, considered reasonable by USACE or USFWS and use of the detour may relieve the immediate emergency, but addressing the failure is still an urgent matter for MaineDOT to avoid further damage to infrastructure and ensure the safety of the traveling public. MaineDOT has developed a protocol for declaring a project as "urgent" that includes review by engineers.

3.3.1.1 Urgency project determination

MaineDOT has established a protocol to determine whether a situation is urgent and secondarily to determine if a set of circumstances fall under programmatic consultation. A project defined as urgent and an urgency-type situation must meet the following criteria: a situation which would result in an unacceptable hazard to life, a significant loss of property, or an immediate, unforeseen, and economic hardship if corrective action requiring a permit is not undertaken within a time period less than that to process and receive an environmental permit (i.e., Section 404 of the CWA permit or Section 10 of the Rivers and Harbors Act permit) under standard procedures. The final determination of an urgency situation will be made by the MaineDOT Chief Engineer or Director of Maintenance and Operations, as appropriate. To be covered under this Programmatic Biological Assessment, the urgent activity must be conducted in accordance with terms and conditions herein. Any activities not described within this PBA are not eligible for programmatic coverage.

This process is specific to MaineDOT; if MTA wishes to implement the urgency process it must implement a similar strategy that is approved by the USFWS.

3.3.1.2 Procedure

Action Agencies' Initial Contact

For this PBA, MaineDOT, FHWA or USACE will contact the USFWS by telephone or e-mail to notify the USFWS that an urgency declaration has been made. MaineDOT, FHWA or USACE, as appropriate, will subsequently submit the reporting form that will be developed as part of the User's Guide. The USFWS will respond in writing via e-mail within 2 business days of the receipt of the request to proceed. Due to the timely response needed to carry-out urgency projects, the standard in-water work window (AMM #1) will not apply to urgency projects. However, whenever practicable, urgency projects will try to meet the goal of working within the standard in-water work window as much as possible. In summary, urgency projects will meet the activity requirements for this PBA except for any timing restrictions (unless practicable), and the USFWS will conduct an expedited review as compared to other activities covered under the PBA.

Following completion of the urgency project, MaineDOT will submit a report detailing the construction. The report will include photographs, report of any 'take', and a summary of how the AMMs were applied.

3.4 Activity 1- Stream Crossing Structure Replacements

MaineDOT completes regular inventory inspections of stream crossing structures. Condition ratings are developed from these inspections. These condition ratings along with corridor priorities help the proponents make decisions on when a crossing structure needs to be replaced or repaired. This same procedure is completed for entire highway sections. When a highway project is programmed as part of a work plan, it often serves as an opportunity to proactively replace a crossing structure along that section of road

The term *stream crossing* is generic and includes two types of crossing structures. The Proponents have distinguished crossing replacements that are 20 feet in width as a different activity than crossing replacements that are >20 feet in width. The construction of these two sized structures is substantially different (as explained below). Crossings ≤ 20 feet wide are typically closed-bottomed structures (i.e. round and box culverts). Stream crossings > 20 feet wide are bridges, which are open-bottomed structures that allow the natural streambed to remain. These two types of crossing replacement also differ in duration of construction. MaineDOT has successfully completed 20-foot-wide concrete box culverts within the period of the standard in-water construction period (July 15 to October 1). More often than not, construction of crossings >20 feet in width requires a longer duration of in-water construction than allowed through the standard in-water construction period.

However, this size distinction is not in line with MaineDOT crossing structure definitions. MaineDOT defines a culvert that is 5 to10 feet in width as a **large culvert**, while a diameter of 10 feet or larger is a **bridge.** There is effectively no difference in stream crossing design function, construction, and effects between an 8-foot-wide and a 12-foot-wide crossing structure. Therefore, the Proponents have adopted 20 feet is the most logical split for documenting these two activities, considering need to adequately explain construction techniques and effect determinations in this PBA. For the remainder of this document, structures that are ≤ 20 feet in width will be referred to as **culvert replacements** and structures >20 feet in width will be referred to as **bridge replacements**.

3.4.1 Design and Planning of Stream Crossing Replacements

Many AMMs are employed during project design and planning. These AMMs are not traditional BMPs employed during project construction. Design and planning may also include conservation measures. The project proponents propose the following measures be implemented during project design and planning of stream crossing replacements to avoid and minimize effects to Atlantic salmon and Atlantic salmon critical habitat and, in some cases, promote salmon recovery.

3.4.1.1 Habitat Connectivity Design

The Proponents propose to design culvert replacement projects in Tier 1 priority areas (as defined in Section 2.5.1) to meet the 1.2 BFW standard and install substrate material and stream banks inside the crossing structures to promote habitat connectivity for a variety of aquatic organisms. The substrate and stream bank material will be designed to mimic natural stream conditions. The design techniques are explained in more detail in Appendix B.

For projects in Tier 2 priority areas (as described in Section 2.5.2), the Proponents propose to design culvert replacement projects (section 2.5 above) to a structure diameter of at least 1.0 BFW of the stream and include appropriate stream substrate where feasible. Habitat connectivity in Tier 2 priority areas will also be designed following the process outlined in Appendix B.

3.4.1.2 Engineered Streambed Material (ESM)

Engineered streambed material (ESM) will be designed according to the guidance in Appendix B. Though the design approach is more ‘engineered’ than a stream simulation approach, the material that will be placed in/under the replacement structures will be similar. In natural streams, the substrate is a function of stream gradient, width, and flows, all of which affect velocity. The Proponents’ approach will use these same factors to estimate the streambed material given those conditions instead of relying on a survey of a reference reach of the stream. The Proponents believe that this streambed material will be stable under the design flows, but as with natural substrate may become mobile under high flow situations.

3.4.1.2 In-water Construction Period

As an AMM, in-water work associated with all proposed activities, except bridge replacements and urgency projects, will be conducted during the low stream flow period (July 15 to October 1). This work window has long been in place in Maine to avoid and minimize impacts to resident salmonid species. It is the period when there is no Atlantic salmon spawning. It also represents a period of lower mobility among Atlantic salmon parr and adults due to the warmer water conditions. Lower water levels make downstream flow maintenance, cofferdam installation, and in-water construction generally less challenging and minimize the chance that salmon will be encountered in the project-specific action area during an activity.

As discussed above, the construction duration of large stream crossings (i.e., bridges) is longer than the 2.5 months that the standard in-water work window allows for. These projects can take anywhere from 2.5 to 8 months and beyond to complete. The Proponents propose a July 15 to April 15 in-water work window for these projects to avoid the smolt seaward migration period for Atlantic salmon, which occurs from mid-April through mid-June (Baum 1997). Atlantic salmon smolts are very sensitive to disrupted migration. Effects expected from utilizing this in-water work window are discussed in Chapter 5.

3.4.1.3 Soil Erosion and Water Pollution Control Plan (SEWPCP) Review

All stream crossing projects will require the contractor to complete and submit a Soil Erosion and Water Pollution Control Plan (SEWPCP). The contractor will develop and submit the SEWPCP to the Proponents’ resident engineer in charge of the project. The resident engineer will rely on support from the environmental office field representatives, from MaineDOT or MTA, to review and approve the SEWPCP. Review of the SEWPCP and planning the use of each BMP is a critical point of construction planning. The SEWPCP contains the contractors proposed cofferdam locations, cofferdam materials, dirty water treatment design and location, downstream flow maintenance plan, temporary soil erosions control methods, and Spill Prevention, Control and Countermeasures Plan (SPCC Plan).

After receiving the MaineDOT contractor’s SEWPCP, the MaineDOT resident engineer will send it to the MaineDOT environmental field representative, who verifies that planned construction components are in compliance with the contract stipulations and the AMMs that are a part of this PBA.

3.4.1.4 Cofferdam Use

Sandbags

Cofferdams could potentially include, but are not limited to, the following types: sandbag, industrial sandbag, plastic sheeting, and sheet piles. Sandbag cofferdams are a more cost effective and turbidity limiting method of isolating an in-water work site compared to other cofferdam options, but are generally limited to water depths less than 6 feet. If a project requires excavation of more than ~2 feet (for bridge abutment removal or forming of a spread footing, sheet piles can be driven into the substrate to cut water inflow off a deeper level and result in a more structurally sound/safer work area. From past construction experience, MaineDOT estimates that for crossing replacements ≤20 feet in width, sandbags are used 95 percent of the time and sheet piles are used 5 percent of the time. For crossing replacements that are >20 feet sheet piles are used 60 percent of the time and sandbags are used 40 percent of the time. The increase in use of sheet piles for large bridges is due to the increases in water depths (greater than 6 feet) at larger crossings.

The contractor may choose to create portions of the cofferdam out of industrial sandbags (see Figure 3-1 and Figure 3-2). These are large bags made of a heavy poly material that can be filled with sand and are effective at stopping water flow. Each bag is filled with sand and then lowered in place with heavy equipment. A sheet of plastic is sometimes incorporated under and in front of the sandbag enclosure to aid in sealing of water flow (Figure 3-3). The contractor may choose to create portions of the cofferdam out of small sandbags (Figure 3-4 and Figure 3-5) or jersey barriers (Figure 3-6). Water depths may dictate that multiple sandbags are stacked on top of one another.

Typically, the entire disturbed area will be within the cofferdam. This cofferdam could be a continuation of the wet road system (a.k.a. temporary stone access road, temporary stone causeway) or other method that accomplishes the goal of isolating the work area. The downstream portion of the cofferdam provides a safeguard against a failure of the upstream portion. If the water control system leaks, a pump will be placed within the work area to create negative pressure to minimize dirty water flow out of the cofferdam, which will then be pumped into the "dirty water" treatment system described in Section 3.4.1.3.

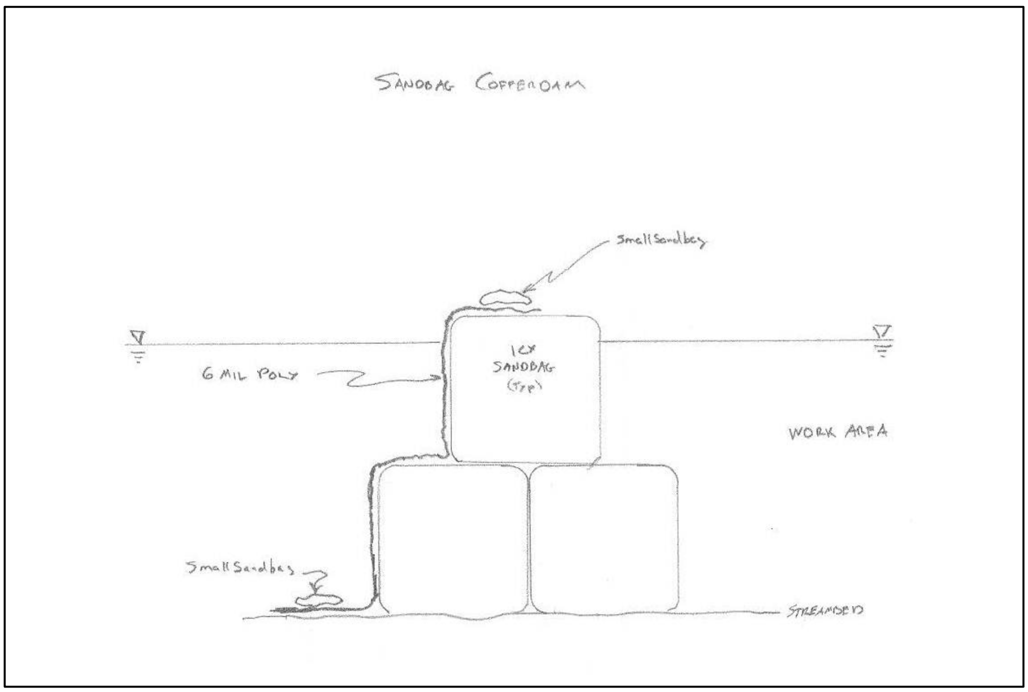

Figure 3-1. Detail of typical sandbag cofferdam using industrial-sized sandbags. Water flow is moving left to right in the drawing above. The area labeled 'Work Area' will be dewatered.

Figure 3-2. Cofferdam made of industrial sandbags. Bypass pump intake upstream of the cofferdam.

Figure 3-3. Placement of plastic sheeting under sandbag cofferdam.

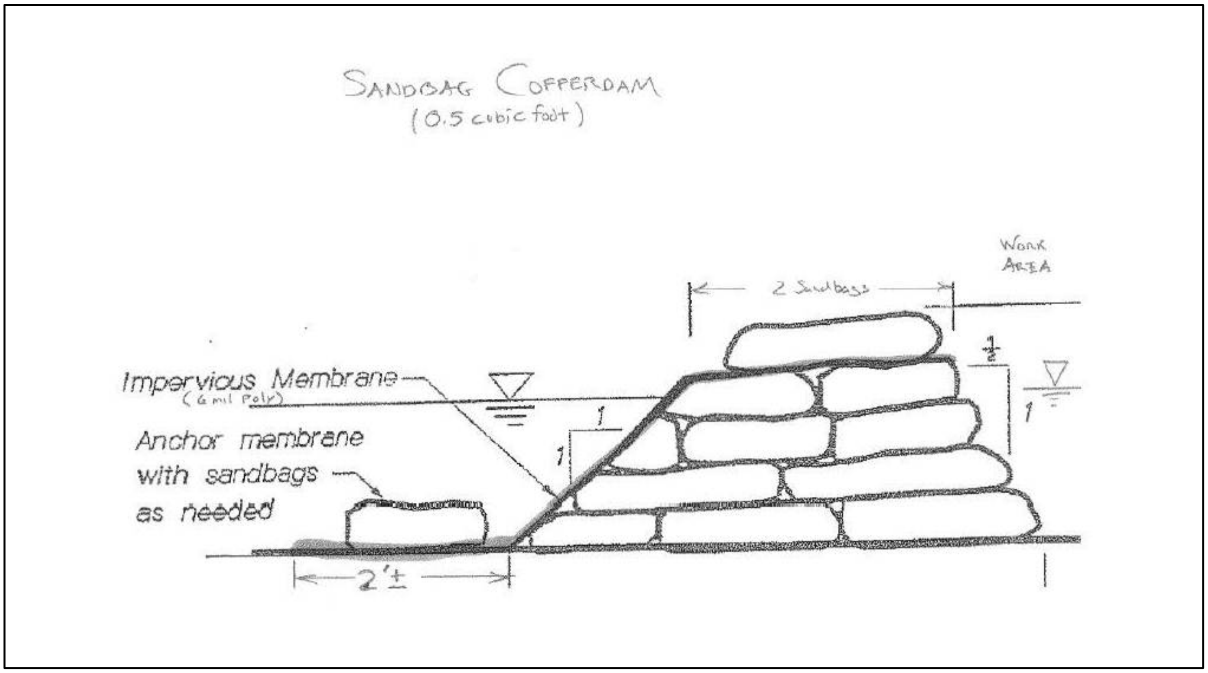

Figure 3-4. Detail of sandbag cofferdam using small sandbags. Water flow is moving left to right in the drawing above. The area labeled 'Work Area' will be dewatered.

Figure 3-5. Example of a cofferdam constructed of small sandbags.

Figure 3-6. Cofferdam made of sandbags and jersey barriers draped with plastic sheeting. Pump intake in the photo is maintaining water levels in the work area.

Sheet Piles

Sheet piling is an earth retention and excavation support technique that retains soil and reduces groundwater inflow using steel sheet sections with interlocking edges (Figure 3-7 and Figure 3-8). Sheet pile retaining walls are usually used in soft soils and tight spaces. Sheet pile walls are made out of steel, vinyl or wood planks which are driven into the ground. For a quick estimate, the material is usually driven 1/3 above ground and 2/3 below ground, but this may be altered depending on the environment and substrate. Sheet piles are particularly challenging to drive under low bridge decks as clearance for heavy machinery needed to lift and drive the piles is limited.

Figure 3-7. Sheet pile used as a cofferdam (upstream of work area).

Figure 3-8. Sheet pile used as a cofferdam (upstream of work area).

Portable Cofferdam

A Portadam® is a temporary, portable cofferdam for use in open water up to 12 feet deep (Figure 3-9). The Portadam® uses a free-standing steel support system and impervious fabric membrane (Figure 3-10) to create a work area within which water levels can be controlled during construction without excavation or fill. Just as with standard cofferdams, the working area inside can never be totally 'dry', but pumps can ensure the area is largely dry and water is flowing into the cofferdam (not out). The structure rests on the channel bed, eliminating the need for pile driving equipment, cross-bracing, or anchorage.

Figure 3-9. Work behind a Portadam® cofferdam.

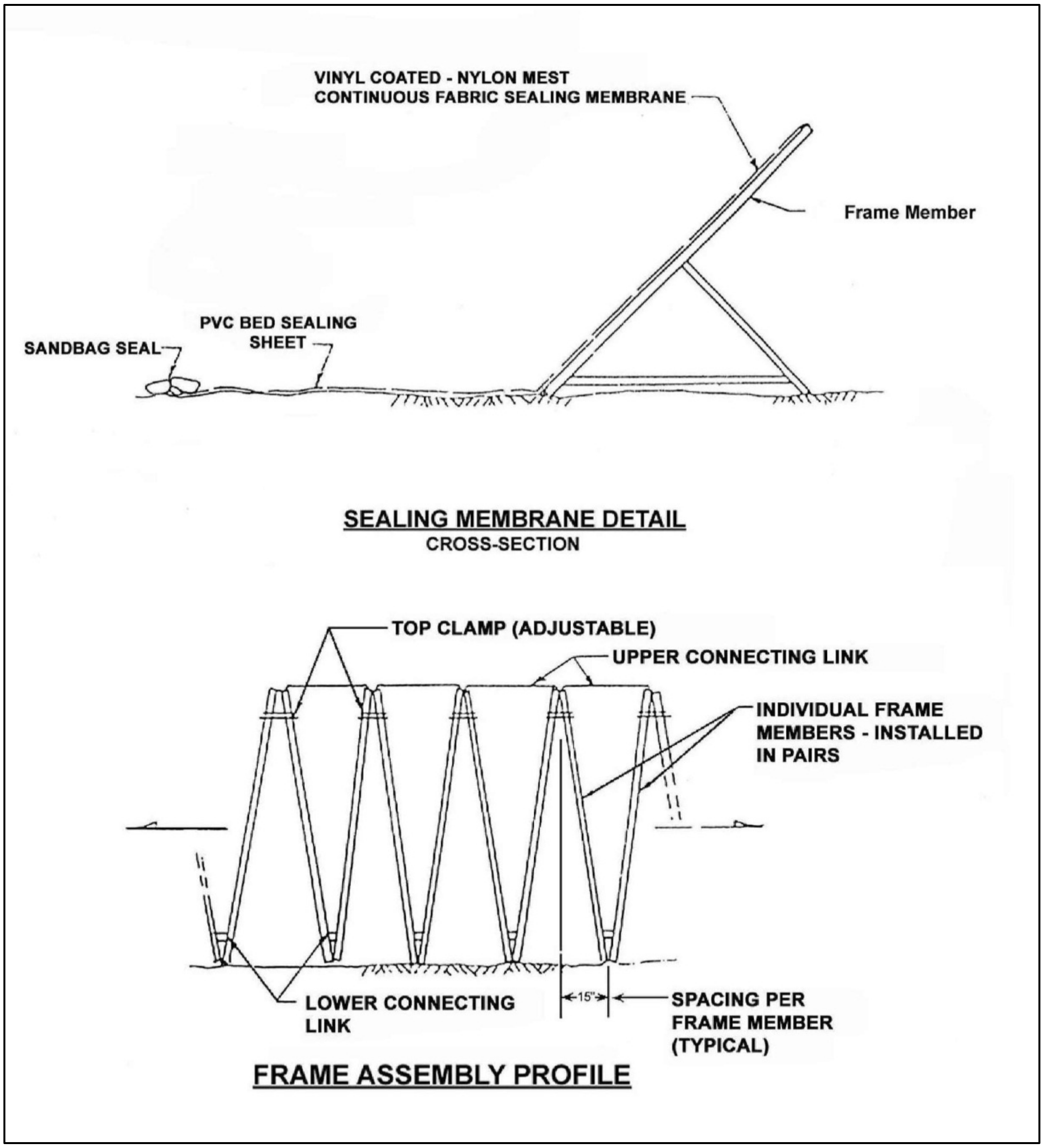

Figure 3-10. Standard Portadam® system design.

3.4.2 Cofferdam Installation for Culvert Replacement

The installation of cofferdam systems is a typical practice for in-water work. Cofferdam systems enclose a work area and reduce sediment pollution generated from construction work. Typical cofferdams are placed to keep water out of the work area by blocking flow both upstream and downstream (typical shown in Figure 3-1 and Figure 3-4). Cofferdams can also be used to divert flow away from one side of a flowing waterbody (typical shown in Figure 3-11). The area inside of the cofferdams is 'dewatered'. All cofferdams have small leaks. As long as the water levels inside of the cofferdam are kept low, the water pressure from the outside of the cofferdam will ensure that dirty water does not leak out of the cofferdam into the affected resource. Cofferdams will not be used to enclose pile driving activities.

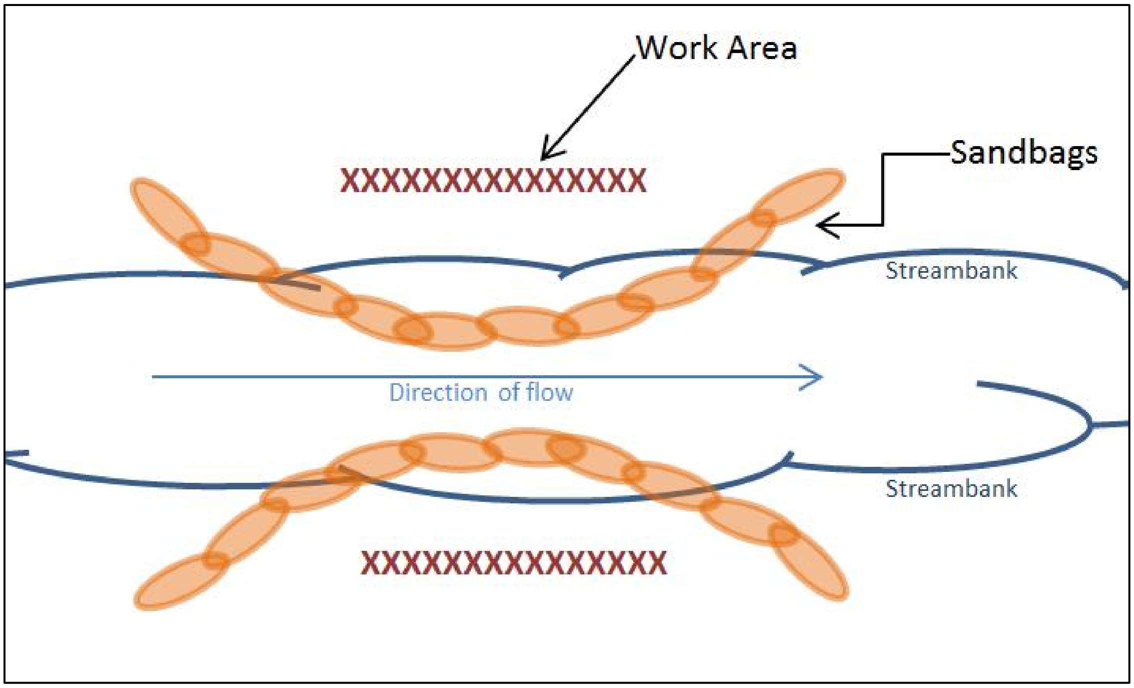

Figure 3-11. A diagram of sandbag cofferdams used to create work areas around bridge abutments.

Cofferdams could potentially include, but are not limited to, the types described in Section 3.4.1.4. Sandbag cofferdams are a more cost effective solution, compared to other options, but are limited to sites with water depths <6 feet. Sandbag cofferdams are also laid on the substrate of the stream. If a project requires >2 feet of excavation (e.g., for bridge abutment removal or forming of a spread footing), sheet piles can be driven into the substrate to cut water inflow off at a deeper level and result in a more structurally sound and safer work area. From past construction experience, MaineDOT estimates from past culvert replacements (crossings that are ≤ 20 feet in width), sandbags are used 95% of the time and sheet piles are used 5% of the time. For crossing replacements that are >20 feet wide sheet piles are used 60% of the time and sandbags are used 40% of the time. The increase in use of sheet piles for large bridges is due to the increases water depths (>6 feet) at larger crossings.

The following list explains a typical cofferdam installation process when stream flow is totally blocked by an upstream sandbag cofferdam and water flow is maintained by a bypass pump or a diversion channel.

1. The upstream cofferdam will be installed first. Heavy-duty plastic sheeting is laid along the bottom of the stream where the sandbags will be placed.
2. The excess plastic will then be folded over the dam in the upstream direction and another layer of sandbags will be laid on the plastic to help seal the dam from infiltration. The plastic will be extended along the stream bottom as far upstream as practicable.
3. When large, industrial sandbags are used, additional small sandbags may be placed in between the large industrial bags to help seal the work area from water flow.
4. The contractor will then begin pumping upstream water flow around the cofferdammed area (Figure 3-12). This water will be pumped directly into the stream downstream of the planned downstream cofferdam location. At the outlet of the pumps, high velocity (>5 feet per second) water will be returned to the stream. This water has the potential to disturb the stream substrate and cause a turbidity release. The Proponents will implement scour prevention

measures (AMM #18) to reduce energy at the point of discharge and prevent elevating turbidity levels.

Figure 3-12. A pump sending upstream water around a cofferdam.

5. The downstream cofferdam will then be installed in the same manner as the upstream cofferdam. This second cofferdam is a safeguard against a failure of the upstream cofferdam.
6. Once both cofferdams have been installed, the contractor will begin to dewater the area between the cofferdams. If the water still appears turbid from the installation activities, it will be pumped to a dirty water treatment system (see Section 3.3.3.1). If the water inside of the cofferdam visually appears to be as turbid as the water flowing into the upstream cofferdam, it will be pumped to downstream of the downstream cofferdam.
7. The inside of the cofferdam is then dewatered using pumps to create a "dry" work area (Figure 3-13). This process is explained in detail in Section 3.3.3.1.

Figure 3-13. A dewatered work area with a small pump to maintain the dry work area.

8. Most cofferdams leak to a small degree, so a pump will be placed within the work area to catch accumulating water, which will then be pumped into the “Dirty Water” Treatment System (Figure 3-14).

For crossing replacements with deep pools on the downstream side, the cofferdam will likely be placed at the downstream extent of the “scour pool” to ensure the water can be properly controlled on the site. Attempting to install a cofferdam in deep water in a scour pool can be problematic due to cofferdam leakage and increased water pressure due to increased depth. The downstream pool will be dewatered to a depth that allows fish evacuation (see section 3.4.2.2 and Appendix A for evacuation method).

If the contractor chooses to use sheet piles in a cofferdam system that impedes water flow, sheets will be driven in pairs across the stream to act as a cofferdam. Each sheet is approximately 24 inches wide, and the sheets will be driven into the substrate adjacent to the shoreline to ensure the flow of water is sealed off from the construction site. The length of the sheet piles will vary based on soil conditions, but they will need to be driven deep enough to cut off water flow while still being tall enough to isolate the work area. These piles will normally be installed with a vibratory hammer. The process of cofferdam installation and water control with sheet pile mirrors the process described for sandbags, the only difference being plastic sheeting is not placed on the stream bottom for a seal. Small sandbags may still be placed outside of the sheet piles to help seal water flow from entering the work area.

3.4.2.1 Dewatering

As discussed above, the work area will be largely dewatered to allow for ‘dry’ conditions to complete the crossing replacement work. Water inside of a newly constructed cofferdam is often turbid. Because water flow is cut off by the cofferdams and being pumped around the work site, the suspended sediments tend to stay in suspension for periods of time >4 hours. To dewater the work area, this turbid water is pumped to a sediment basin/filter basin that will filter much of the suspended sediments out of the water and allow the water to flow through a vegetated buffer prior to entering the stream.

“Dirty Water” Treatment System

After the cofferdams have been installed, it is necessary to dewater the work area itself. This water is then pumped into a sediment basin for filtration. The contractor will implement the following steps for the dewatering and filtering process.

1. The system will be installed according to MaineDOT’s Best Management Practices (BMP) Manual.
2. The filter basin may be composed of hay bales and filter fabric (Figure 3-14). Filter fabric is placed inside of the hay bale barrier to filter sediment. These sediments will be disposed of away from the stream in a manner that they cannot erode back into the stream.
3. Proprietary products, such as ‘dirt bags,’ can also be used. A ‘dirt bag’ is a large bag built with filter fabric that will filter turbid water similar to the basin technique described above.
4. The sedimentation basin will be located close to the project location with adequate vegetation between it and the stream to act as a filter.
5. Pumping
    a. Hoses will be setup between the treatment basin and the work area to be dewatered.
    b. The “dirty water” pump(s) will then be started in the water will be pumped to the treatment area.
6. The work area will then be pumped as dry as possible.
7. If there is leakage around the cofferdam, or upwelling in the work area, pockets will be excavated in the work area to collect the water. This water will be pumped into the “dirty water” system for treatment, prior to its release back into the stream. (See Figure 3-13 for a pump intake used for maintenance pumping.) Clean crushed stone is often placed around this pump intake to minimize further suspended sediments from being pumped in the treatment basin.

Figure 3-14. Hay bales and geotextile fabric used as part of a dirty water treatment system.

3.4.2.2 Fish Evacuation

Fish evacuations are conducted by qualified MaineDOT personnel after a cofferdam is installed to minimize the potential of fish becoming trapped within the excluded work area. If water depths within the cofferdam are <2 feet, the fish evacuation will take place prior to dewatering and in-water work; this depth represents a safe water level for those operating the electro-fishing system as well as a maximum depth that a comprehensive evacuation can be completed. A seine will first be used to ‘herd’ fish out of the work area. Though the seine presents a smaller chance of injury to any fish in the work area, it is not efficient as fish can hide in the substrate as the seine passes. Following seining, an electro-fishing system is used to stun any fish still left in the work area, collect them, and move them into adjacent habitat. Fish are moved primarily upstream of the project area to remove them from any potential turbidity releases during construction. MaineDOT’s Atlantic Salmon Evacuation Plan and Disinfection Procedures are provided in Appendix A.

If stream depths are >2 feet, the cofferdams must be installed and the dewatered prior to the fish evacuation effort. The contractor will bring the water level down to <2 feet deep then the fish evacuation will begin as described above.

The Proponents propose to complete a comprehensive evacuation on any project where Atlantic salmon presence is likely. When presence is not likely, a case-by-case determination will be made with USFWS about whether a comprehensive fish evacuation is an appropriate AMM for the project. This discussion will occur when the project is submitted for USFWS review.

3.4.2.3 Maintenance of water flow

Stream flow must be maintained downstream of the project. Not only is this important to downstream aquatic biota, but it is necessary for construction as water flow that is blocked will eventually over top cofferdams and cause damage to the work area and surrounding property. A bypass pump and a diversion channel are the two different systems that MaineDOT uses to maintain water flow. Pump diversions are the most common method used to maintain downstream flow and are utilized on approximately 90% of the Proponents' small stream crossing replacements. The use of a diversion channel is limited by the topography of the site. If the channel has steeply sloping banks and surrounding topography, it is challenging to dig a channel down to an elevation to match the existing stream elevation. In addition, the width of existing crossings can limit placement of diversion channels.

Pumped Diversion

Prior to construction, MaineDOT provides the contractor with potential stream flow data that can be used to match the bypass pump capacity with the expected stream flows during the construction period. Construction sequencing is described below.

Construction Sequence

1. Prior to in-water work, a diversion culvert will be placed under the road and away from the stream to run a bypass hose. This protects the hose during the construction activities. Another common way of doing this is by running the hose over the road and blocking up around it with wood to protect it from traffic.
2. The intake hose will be placed just upstream of the cofferdam. To minimize impact on the streambed, the hose end will be placed in a bucket and/or the stream bottom will be lined with geotextile. A screen will be placed at the intake hose end to prevent injury to fish and entrapment within the work area (Figure 3-15). To prevent fish entrainment into the hose, the screen openings will not exceed 3/32 inches (2.38 millimeters) in the narrow direction. To prevent impingement of Atlantic salmon parr on the screened intake hoses, additional barriers consisting of either placing the intake within a 5-gallon bucket or creating a barrier with a ¼ knotless block seine around the perimeter of the intake will be utilized. Other additional barriers, including barriers made of sandbags, plastic sheeting, or other suitable materials will be utilized depending on site conditions (Figure 3-16). The approach velocity will be kept below 0.2 feet per second (0.06 meters per second) to avoid impingement of Atlantic salmon juveniles (NMFS 2008). AMM #29
3. The gasoline diversion pumps will then be setup as far away from the stream as possible. The pump systems are contained and pose little to no risk for spills. The number and size of pumps used varies depending on the water level present when the work is being conducted. AMM # 23.
4. Non-woven geotextile fabric or plastic sheeting will be laid along the streambed to protect the stream from scour caused by the high water velocity coming from the hose(s) at the downstream end. AMM # 18.

Figure 3-15. Box and screening used as a pump intake screen.

Figure 3-16. Plastic sheeting and hay bales can be used for a pump outlet or outlet of a bypass channel.

Bypass Channel

This section describes the typical process used to divert flow through a temporary culvert installed next to the stream to move water from upstream to downstream as illustrated in Figure 3-17. MaineDOT provides the contractor with potential stream flow data so the contractor can match the bypass channel size with the expected stream flows during the low flow construction period. Section III(F)3 in the MaineDOT BMP Manual (MaineDOT 2008) has sizing guidance for bypass channels.

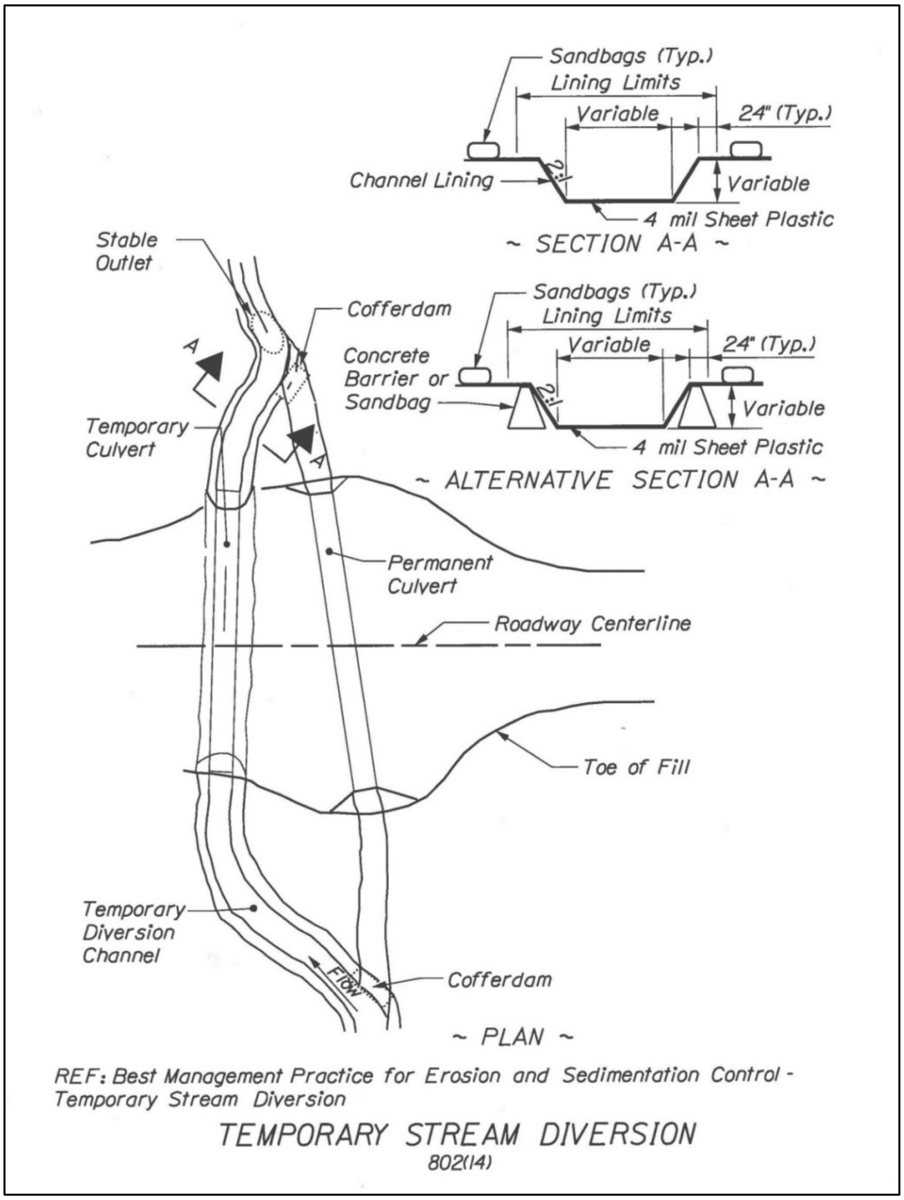

Figure 3-17. Typical layout and cross-section of a bypass channel used for temporary stream diversion.

After the bypass channel is diverted the stream around the work area and cofferdams, it will be necessary to dewater the work area itself. This water will be pumped into a sediment basin for filtration as described in Section 3.2.1 above.

3.4.3 Culvert Replacement

Once flow is diverted and the work area is dewatered, the crossing removal and installation can commence. At this point, the crews are working within the contained area and there is no sediment release into the stream. All pumps, hoses, dams, and the sediment basin are monitored closely and maintained throughout construction. The old culvert will be removed and the new one placed in the dry. When the crossing and riprap installation are complete, all headwalls, disturbed areas, and permanent road drainage ditches are stabilized with final treatments, utilizing temporary erosion control BMPs as necessary.

3.4.3.1 Construction Sequence

A culvert replacement will follow the process explained below. Figure 3-18, Figure 3-19, and Figure 3-20 illustrate some of the scenarios for replacing culvert. The construction sequence of a culvert replacement initially always begins with implementation of the SEWPCP, SPCCP, preparation of the site, clearing of vegetation for equipment access, and typical cofferdam installation, as described previously, and proceeds as follows:

1. Remove the old culvert
2. Excavate and place fill for foundation of new culvert.
3. Place new culvert.
4. Construct riprap scour pad at end of new culvert crossing.
5. Place backfill into the new structure and over riprap scour pads (Figure 3-20).
6. Wash fine sediment material into new backfill to ensure water flow remains on top on newly constructed stream substrate.
7. Stop pumps, restore flow, and then remove cofferdams (described in Section 3.3.7).

Figure 3-18. Setting a 26-foot wide concrete box structure.

Figure 3-19. Bedding a corrugated metal culvert.

Figure 3-20. Concrete box structure being backfill and receiving bedload.

3.4.4 Bridge Replacement

The materials and techniques described for culvert replacements (discussed in Section 3.3.4) will apply to bridge replacements with distinctions associated with the deeper water conditions and the different arrangement of structural components. This section summarizes the differences associated with replacing bridges as compared to culverts and bridges greater than 20 feet.

The construction sequence of a bridge replacement initially always begins with implementation of the SEWPCP, SPCCP, preparation of the site, clearing of vegetation for equipment access, and typical cofferdam installation, as described previously.

3.4.4.1 Sandbag Cofferdam

Constructing a sandbag cofferdam used for bridge replacement would implement the following steps.

1. The upstream portion of the cofferdam is placed first. Plastic sheeting is required to seal water from flowing into the work area. After the sheeting is in place, the sandbags are then placed.

2. Placing the upstream sandbags first will cause water velocities to lessen in downstream areas where the rest of the cofferdam will be constructed. This will help minimize turbidity releases during sandbag placement.

3. The sandbags are then continually placed moving from upstream to downstream until the work area is enclosed.

4. The work area is dewatered following the procedure outlined in Section 3.4.3.1.

Cofferdams that are used for abutment construction in stream crossing structures that are >20 feet wide are constructed around the abutments and not across the entire stream (Figure 3-11 and Figure 3-21). Because of this, bypass systems such as pumps and diversion channels are not required.

Figure 3-21. Bridge abutment construction behind a cofferdam constructed of industrial sandbags

3.4.4.2 Sheet Pile Cofferdam

Constructing a sheet pile cofferdam for bridge replacements (Figure 3-22) generally follows the steps outlined above for sandbag placement. However, plastic sheeting is not used to help seal sheet pile cofferdams. Sheet piles are driven in pairs around the work area to create the cofferdam. Depending on the soil and substrate in the vicinity of placement of the sheet pile cofferdam, the sheet piles may be driven down to ledge or refusal. When the cofferdam is located on ledge, the sheets may not be driven into the substrate. Instead, a contractor may cut the bottom of the sheets to fit the contour of the ledge and build a frame system to hold the sheet piles in place. Once the cofferdam is installed, construction of the replacement bridge can begin.

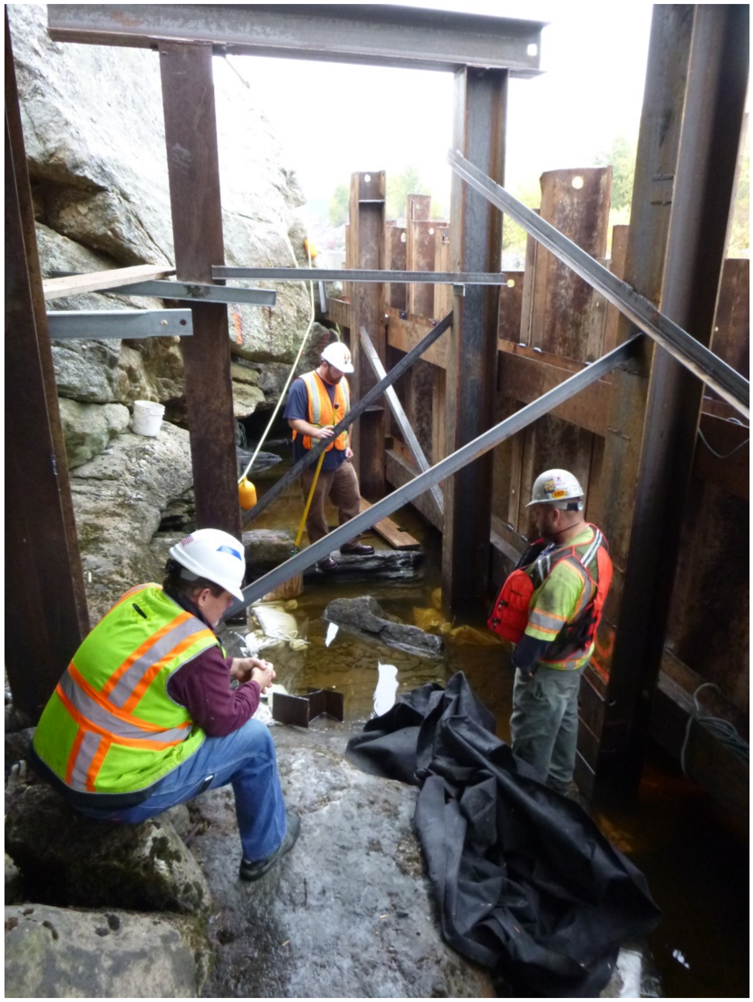

Figure 3-22. Example of the inside of a sheet pile cofferdam used for abutment construction on a bridge replacement project.

Stream flow for bridge replacements is maintained between the cofferdams. Most existing bridge abutments protrude into the stream and cofferdams need to be constructed around them, resulting in the cofferdams protruding even farther into the stream than the existing abutments. When abutment construction requires excavation, stable slopes must be maintained for worker safety.

3.4.4.3 Bridge Replacement Construction Sequence

A typical bridge replacement would implement the following sequence, but may vary slightly depending on the selected contractor. For example, installation of a bridge used for traffic maintenance during construction and removal of the deck from the existing bridge may take place prior to the placement of cofferdams.

The construction sequence of a bridge replacement initially always begins with implementation of the SEWPCP, SPCCP, preparation of the site, clearing of vegetation for equipment access, and typical cofferdam installation, and proceeds as follows:

1) Bridge Demolition

a) Removal of existing bridge deck (if not completed to prior to cofferdam installation)

b) Removal of existing bridge pile supports (if necessary)

c) Removal of existing bridge abutments

2) Bridge Construction

a) Replacement of bridge abutments

b) Installation of new bridge support beams/deck

The construction sequence sometimes dictates that heavy equipment needs to move through the stream. This can occur when a piece of equipment needs to be moved across a stream and the existing bridge has been removed to the point it cannot be used for equipment travel, and any temporary bridge cannot be used due to traffic issues, is it too small for the equipment, or is not part of construction. This only occurs for bridge replacements when the stream is too wide to reach from one side to the other (greater than ~20 feet) with the excavator. Travel of construction equipment on stream substrate will only occur when the stream substrate is non–erodible (e.g., ledge, cobble) (AMM #14) and the contractor has received approval from MaineDOT environmental field staff.

3.4.4.4 Bridge Demolition

Deck Removal

Demolition will begin by removing the bridge deck. The bridge deck will likely be cut into pieces that can be removed with an excavator. Measures will be taken to ensure debris is not dropped into the river during demolition. These measures include lifting the bridge away from the river and containing debris with items such as tarps hanging under the bridge. The contractor must submit a demolition plan to MaineDOT for approval prior to the start of demolition. The plan will include measures the contractor plans to implement to contain demolition debris.

Abutment Removal

The contractor will remove the existing abutments to gain the necessary river width required by the new design and prepare for the construction of new abutments. Portions of the old abutment are removed by pulling material away from the stream channel using an excavator bucket to avoid demolished material falling into flowing water. An excavator mounted hydraulic breaker may also be used to break large pieces of concrete to facilitate removal and hauling. The amount of excavation is dependent upon the type of abutment being removed.

Pier Removal

After the bridge deck has been removed, the contractor will remove the existing support piles. The piles may be removed one of the following three ways:

1. Using a vibratory extractor;
2. Pulled out using an excavator;
3. Cut flush with or below surrounding substrate using an underwater saw.

‘Pulling’ a pile may generate higher levels of turbidity than the other two options. If pulling is the chosen method, the work will be completed using a BMP specifically for minimizing turbidity, such as a turbidity curtain.

A hoe ram is often used to demolish concrete bridge piers. Concrete piers typically consist of large rebar cages, so a hoe ram may be required to break the piers apart. Hoe rams use a series of impacts with the breaker portion of the machinery to break the concrete up into smaller pieces (4-5 feet) that can be removed. The hoe ram is typically attached to the arm of an excavator.

The Proponents will not use in-water blasting to remove bridge piers.

3.4.4.5 Bridge Construction

Abutments

All abutment work will take place behind a cofferdam as MaineDOT Standard specifications do not allow fresh concrete in contact with a waterbody (AMM # 33). MaineDOT uses two primary abutment designs for new bridges: integral abutments and vertical abutments. Integral abutments are founded on piles that are driven to bedrock or a specified refusal. Refusal is defined by the analysis of how many blows with an impact hammer it takes to move a pile a specified distance in a specific soil material. After the piles are driven, a concrete abutment is cast as the foundation for the bridge deck. Vertical abutments are founded on ledge or placed on a spread footing. If founded on ledge, excavation down to ledge is necessary, along with cleaning and flattening the ledge to ensure the abutment is properly founded. To flatten the ledge, a hydraulic breaker may be used to remove ledge to a consistent elevation. A spread footing foundation requires a large mass of concrete to be placed at approximately 6 feet below the thalweg of the stream. This requires substantial excavation and, although it is not a favored option, it remains a potential option for extraordinary circumstances.

After the abutments are complete, the superstructure will be constructed and attached to the abutments. The deck portion of the project will be contracted out as a ‘detail build’ so the type of super structure is likely to be unknown at the time of consultation.

Piers

If in-water piers are part of the replacement design, they are typically either concrete spread footing piers or pile bents, which are both described and depicted below. Drilled shafts are also another option that is becoming more common within the construction industry for bridge pier construction.

Pier Option 1: Concrete Spread Footing Piers

The construction of a spread footing pier requires the use of a four-sided, rectangular-shaped cofferdam constructed of sheet piles (Figure 3-23). The stream substrate inside of the sheet pile enclosure is excavated to a depth that will allow construction of a stable pier. The excavated substrate material can be placed onto a barge or on the temporary work trestle for proper disposal. The contractor’s proposal for this activity is reviewed by MaineDOT as part of the SEWPCP.

Some concrete piers require H-shaped piles driven into the substrate prior to construction of the pier. The need for H-piles is determined by many factors, including distance to bedrock, subsurface soil conditions, and pier size. As shown in Figure 3-23, H-piles are driven into templates created to ensure propped spacing of the H-piles. A pier constructed in this manner typically requires installation of 15 to 20 H-piles.

Figure 3-23. Constructing a spread footing pier requires use of a four-sided cofferdam.

After the material has been excavated from the cofferdam and H -piles are installed as necessary, a concrete ‘seal’ is poured. Concrete is placed across the entire bottom inside of the sheet pile cofferdam (Figure 3-24). This concrete seal is necessary to isolate the work area for construction of the pier. However, the concrete and sheet piles do not create a water tight seal, and so a maintenance pump draws freshwater from the surrounding stream. After the seal is placed, the contractor must wait until the pH of the water inside of the cofferdam is within 1 pH unit of that of the background in the stream (AMM # 34). At this time, the water inside the cofferdam has also had time to settle any fine material out of suspension. When this water is visually similar to the water in the stream and the pH is within 1 pH unit of the stream itself (and because this water has the same water quality as the stream), the water is pumped directly back into the stream.

Per MaineDOT’s Standard Specifications 656.3(6)(e), it is the responsibility of the contractor to purchase a calibrated meter and monitor the pH levels with a calibrated meter accurate to 0.1 units. Records of the pH measurements will be kept in the MaineDOT Environmental Coordinator’s log. MaineDOT is responsible for performing quality control.

Figure 3-24. After excavating the substrate, concrete is poured across the entire bottom inside of the sheet pile cofferdam to create a “dry” work area for constructing the pier. A maintenance pump is still necessary for maintaining the “dry” conditions.

After the seal has been placed and the cofferdam is dewatered, construction of the pier will commence. The pier is created by forming a series of lifts, moving upward from the seal. Figure 3-25 shows an example of a bridge constructed with cast-in-place pier. Once the pier is completed, the cofferdam will be removed. The cofferdam will be allowed to slowly fill with water by either turning off the maintenance pump or by removing a portion of one pair of sheet piles. Because the sheet piles are typically driven to a depth >25 feet, a vibratory extractor will be used to remove the sheet piles.

Figure 3-25. The Richmond-Dresden Bridge over the Kennebec River is constructed with cast-in-place, concrete, spread footing piers.

Pier Option 2: Pile Bents

Bridges may also be supported by pile bents. Pile bents consist of a series of multiple piles aligned with the stream flow and used to support the bridge. A typical pile bent contains 5 to 7 piles that vary from 18-inch to 30-inch diameter steel pipe piles. Figure 3-26 shows views of a bridge with typical pile bents. The most upstream and downstream piles are inserted at an angle to aid with long-term stability and are called ‘battered’ piles. Piles are first placed with a vibratory hammer. Piles may be drilled into place when practicable. Alternatively, an impact hammer may be necessary to seat piles in certain substrates to ensure their long-term stability.

Forms are then placed on top of the piles, and a concrete cap is placed to tie all of the piles together and prepare for placement of the bridge superstructure. As with all concrete placement activities discussed above, uncured concrete will not be allowed to make contact with any waterbody (AMM # 33).

Figure 3-26. Four views of a bridge with piers constructed using pile bents.

Pier Option 3: Drilled Shafts

Drilled shafts are installed by rotating a large steel tube inside a larger containment tube to seat the shaft into the bedrock to act as a solid foundation. There is currently no established procedure in terms of whether the containment tube is installed first or the shaft is placed in the substrate and a tube put around it. Drilling operations do not take place until the larger containment tube is in place. The drilled shafts have cutting teeth and are drilled into the substrate and bedrock. Water is required inside the shaft for the drilling process; this water and the material (grindings and sediments) from inside the shaft will be pumped out, the water filtered and returned into the stream, and the sediment will be placed onto an upland area to avoid water sedimentation. Pier diaphragm walls and floating caps are expected to be constructed using a concrete tub, casted using steel forms, built around the drilled shaft at the trestle or drilled shaft template, above the water and totally in the dry. Drilled shafts range from 24 inches to 9 feet in diameter.

Bridge Deck

Once piers (if any) and both abutments are competed, the bridge deck is then connected. Bridge construction will utilize a variety of support beams arrangements that are made of steel, concrete, and/or a composite material. The deck portion of the bridge will be contracted out as a ‘detail build’ so the type of superstructure is likely unknown at the time of consultation. This allows for a contractor to detail a superstructure type that is most cost effective for them to install. Typically support beams are used and structural concrete slabs will be placed on the top of the support beams. Pavement will then be placed on top of the concrete slabs to create the road surface.

3.4.5 Cofferdam & Bypass Channel Failure Procedures for Cofferdams and Bypass Channels

Cofferdam failures can occur, particularly in exceptionally high water events or hazard events (e.g. high wind, power failures), and they can occur relatively quickly. In the event of a cofferdam failure, the contractor will attempt to move all water pumps away from the stream and attempt to minimize turbidity releases as much as possible. The site will be stabilized as soon as possible after the high-water or hazard event subsides. The cofferdam will be inspected for condition and presence of fish, and pumping procedures will start over as described in Section 3.4.2. Failure of a bypass channel due to exceptionally high-water events is likely to result in the loss of material used to stabilize the channel (e.g., plastic lining). If unexpectedly high flows arise and the lining of the bypass channel is lost, the contractor will attempt to reinstall the lining when it is safe to enter the water again. MaineDOT or MTA environmental staff, FHWA, USACE, and USFWS will be notified if a cofferdam failure occurs, as necessary, within 24 hours.

3.4.6 Cofferdam Removal

After all work that requires isolation from the stream environment is completed the cofferdam can be removed to restore stream flow through the crossing structure. Cofferdams that are placed across the entire stream are removed as followed.

1. The diversion pump system will be stopped and the upstream cofferdam will slowly be breached. The first flush of dirty water will be captured by the downstream “dirty water” pump, which will pump the water into the sediment treatment system;
2. When the water behind the remaining intact cofferdam is visually similar, that dam will be breached as well;
3. The remainder of the upstream cofferdam and the diversion pump system will then be removed;
4. Sandbag cofferdams will be removed by hand, if they are small, or by an excavator working from the stream banks if they are the large industrial-sized sandbags.

Cofferdams that are either along the edge or in middle of a stream (i.e., constructed for a bridge pier) will be removed in a similar sequential pattern. Cofferdams will slowly be breached, allowed to fill with water, and then either fully removed or cut off at or just below substrate level. Should there be a cofferdam failure during removal, all areas of temporary waterway or wetland fill will be restored to their original contour and character upon completion of the project (AMM #3).

3.4.7 Post-construction Site Stabilization

Once water flow is restored to the area inside of the new crossing structure or around the new surrounding bridge elements, and the in-water portion of the stream crossing replacement is complete, the contractor can begin restoration of the construction site. The contractor will be working on final stabilization treatments, restoration any temporary work areas, and rebuilding the roadway on top of the new crossing structure. Some final stabilization treatments are part of the design developed by the Proponents, and others are reviewed as part of the SEWPCP.

Riprap (not requiring in-water work) is used to provide long-term stability in areas that have steeper than 2:1 slopes. More gradual slopes will be stabilized using vegetation by placing a native seed mix that will allow for rapid growth and stabilization as well as plants that have substantial root systems for stabilization that take longer periods to be established.

3.4.8 Stream Crossing Replacement Activity AMMs

- No heavy construction equipment will travel into or through any flowing streams with erodible substrate (e.g., sand, silt, and clay). Travel of heavy construction equipment into or through flowing streams and on stream substrate will only occur when the stream substrate is non-erodible (e.g., ledge, cobble) and the contractor has received approval from MaineDOT environmental field office staff. (AMM #14)
- In-water work in streams with a clay substrate (defined in Glossary) will not occur outside of a sealed cofferdam. (AMM #17)
- Excavation will not occur outside of a cofferdam. (AMM #17)
- In rearing habitat, bridge replacements with piers will not increase existing structure footprint.
- The proponents will not affect Atlantic salmon adults sheltering in holding pools. (AMM #47)
    - To provide further clarification of AMM #47 for this specific activity (stream crossing replacements), no direct or indirect, adverse or no adverse (e.g., placement of a bridge pier in a holding pool, turbidity and sedimentation from construction, etc.) effects to Atlantic salmon that are sheltering in holding pools are allowed. If there is the potential to have any effects on Atlantic salmon sheltering in holding pools as a result of any proposed activity, it is not allowed under the programmatic.
- All in-water work on bridge replacement (> 20’) projects (and associated sub-activities, e.g., pier installation, temporary access installation) will occur between July 15 and April 15. (AMM #2)
    - To provide further clarification of AMM #2, the standard in-water work window is from July 15 to October 1, however, for bridge replacement projects, construction typically takes anywhere from 2.5 months to 24 months to complete, depending on the magnitude and scope of the replacement work. The Proponents, Action Agencies and USFWS agreed that under this programmatic, and for bridge replacement projects only, in-water work could take place during the otherwise avoided fall adult migration window, resulting in the July 15 to April 15 in-water work window.
- See Table 5-17 for additional AMMs.

3.5 Activity 2: Bridge or Culvert Removal

This activity includes removing an existing stream crossing structure with no replacement. This is a recovery action. This will occur in those places where a bridge or culvert is redundant and/or poses a risk to the traveling public.

A bridge or culvert removal will follow the process explained for Activity 1: Stream Crossing Replacement, but will not include the construction of a new crossing structure. Bridge or culvert removal can include typical cofferdam installation and removal, structure demolition, and re-creation of a stream channel as necessary to meet width criteria established for the stream's Tier priority. See Sections 3.3.3 through 3.3.8 for descriptions of these construction components, including implementation of SEWPCP, SPCCP, site stabilization, etc. The following outlines a general process for culvert and bridge removal after the initial site preparation:

Culvert Removal

- Install cofferdam
- Remove fill around culvert
- Remove culvert
- Excavate remaining material to re-create stream channel
- Place ESM in re-created stream channel where naturally occurring stream substrate is absent (as described in Appendix B).
- Stabilize stream banks
- Remove cofferdams

Bridge Removal

- Remove existing bridge deck, then abutments and piers (explained in Section 3.4.4.4)
- Install cofferdam around abutment (if in water and Atlantic salmon are present)
- Remove abutments and piers (note: no cofferdams are typically installed around piers during pier removal)
- Place ESM below bankfull elevation where abutments were removed.
- Stabilize stream banks
- Remove cofferdams

3.5.1 Activity AMMs

- No heavy construction equipment will travel into or through any flowing streams with erodible substrate (e.g., sand, silt, and clay). Travel of heavy construction equipment into or through flowing streams and on stream substrate will only occur when the stream substrate is non-erodible (e.g., ledge, cobble) and the contractor has received approval from MaineDOT environmental field office staff. (AMM #14)
- In-water work in streams with a clay substrate (defined in Glossary) will not occur outside of a sealed cofferdam.
- Excavation will not occur outside of a cofferdam (AMM # 17).
- In rearing habitat, bridge replacements with piers will not increase existing structure footprint.
- Bridge replacements with piers will not be constructed during migration period (AMM # 2).
- See Table 5-17 for additional AMMs

3.6 Activity 3: Culvert End Resets and Extensions

Culvert end resets and extensions will apply to crossing structures ≤ 20 feet wide but typically occur only on culverts that are 2 to 10 feet in diameter. Culvert end resets and extensions will occur in Tier 1, Tier, 2, and Tier 3 priority areas.

End sections of culverts can separate from the culvert barrel (Figure 3-27) as a result of freezing and thawing, substrate settlement, scour, undermining, and other causes. End resetting is the process of tying an end section of a culvert to repair the separation to hopefully prevent future separation. If in sound condition, the existing end can be salvaged and retied; otherwise a new end can be installed.

Figure 3-27. View of a culvert where the end has become separated.

Extension is another form of culvert end repair. Culverts should extend far enough from the road shoulder to avoid erosion near the end of the pipe. Some older culverts may not be long enough and need to be extended to prevent shoulder erosion. Extensions are necessary when previously installed crossing structures do not allow for proper slope stabilization from the road down to the stream crossings inlet or outlet (Figure 3-28).

MaineDOT is proposing to limit the culvert extension scope under this PBA to a cumulative 8 foot extension upstream and downstream of the existing crossing structure. In MaineDOT's past experience, an 8 foot extension is enough to allow for proper slope and crossing structure stabilization. 8 foot extensions will also minimize the effects to the stream by limiting the extent of the downstream or upstream effects.

Culverts that need to be extended are typically already undersized and often have outlets that are hanging that preclude fish and other aquatic habitat connectivity. These undersized crossings typically have a 'scour pool' that has been created by the water energy while flowing through an undersized culvert for the period it has been installed, which degrades salmon habitat. A culvert extension scope cannot alleviate these scour issues and is likely to cause scour issues to move farther downstream if the culvert extension is on the downstream side of the crossing structure.

Culvert extensions on the upstream side of the crossing structure may require a small amount of stream relocation to ensure the stream will be aligned properly with the inlet of the extended culvert. If the stream flows directly into the new culvert, stream relocation will not be necessary. In MaineDOT's experience, stream re-location is necessary on approximately 15 percent of upstream culvert extensions. Experience also shows that re-location is less than 25 linear feet of the stream. If stream relocation is required, MaineDOT will implement the following design methods.

- The width of the relocated channel will match that of the pre-existing width.
- Channel depths will match that of the pre-existing stream section
- ESM will placed along the bottom of the reconstructed stream channel to re-establish stream substrate
- Riprap material placement in the stream.

Figure 3-28. A culvert end where the embankments are too steep and eroding. This otherwise sound crossing can be rehabilitated by extending the length of the culvert.

Riprap aprons at the inlet and outlet of the structures will be constructed at the time the extension is installed. The riprap will be embedded into the stream channel so it does not act as a barrier to fish passage after its placement. Material that is similar to the natural streambed material will be placed on top of the riprap (AMM # 41).

3.6.1 Construction Sequence

The construction process mirrors the process for small culvert replacements described in Section 3.4.3. End resets and extensions will require cofferdams as explained in Section 3.4.1.4, water diversions as explained in Section 3.3, and dewatering procedures described in Section 3.4.1.2.

After a dewatered work area is created, a culvert end reset takes 1 to 2 hours to complete. The existing culvert end is removed and fill material is placed under the reset section to stabilize the bedding. Riprap material is then placed in the stream to stabilize the area adjacent to the reset in the stream. The culvert end is then reconnected to the culvert. Often this requires "ties" that consist of steel wire and creates a connection between the reset end and the remainder of the culvert. Fill is then placed around and on top of the culvert end to create a stable slope up to the roadway. The site is then stabilized (AMMs #5 and #7).

3.6.2 Activity AMMs

- No heavy construction equipment will travel into or through any flowing streams with erodible substrate (e.g., sand, silt, and clay). Travel of heavy construction equipment into or through flowing streams and on stream substrate will only occur when the stream substrate is non-erodible (e.g., ledge, cobble) and the contractor has received approval from MaineDOT environmental field office staff. (AMM #14)
- In-water work associated with culvert end reset or extension activities located in streams with a clay substrate (see definition in Section 8.3) will occur within a sealed coffer dam due to the unpredictable nature of undesirable effects.
- Extensions >8 feet at either upstream or downstream ends of culverts in Tier 1 and Tier 2 priority areas are prohibited.
- Riprap aprons at the inlet and outlet of the structures will be constructed at the time the extension is installed. The riprap will be embedded into the stream channel so it does not act as a barrier to fish passage after its placement. Material that is similar to the natural streambed material will be placed on top of the riprap (AMM #41).
- See Table 5-17 for additional AMMs

3.7 Activity 4: Bridge Scour Countermeasures

Bridge scour is defined as the erosion of streambed material surrounding a bridge foundation (piers or abutments) caused by flowing water. As swiftly moving water flows past a bridge foundation, it can scoop away material, create holes, and expose the pier or abutment, compromising a bridge's structural integrity. Scour is the most common cause of bridge failures. If inspections of a bridge substructure have revealed that the bridge is unstable and scour-critical, the Proponents will implement scour countermeasures to reestablish embedment of pier or abutment footings. Scour countermeasures are necessary to maintain bridge structures that are in otherwise sound structural condition.

The scour countermeasure design will depend on site conditions, including stream hydraulics and the bridge's foundation engineering. For the purposes of this PBA, scour countermeasures will only include an articulated concrete block system, commonly referred to as concrete cable mats (Figure 3-29). This will minimize ATS effects as concrete cable mats require less excavation and preparation of the stream bed than other scour countermeasures, such as riprap.

3.7.1 Concrete Cable Mats

This scour countermeasure is a system of pre-cast concrete blocks interconnected laterally and longitudinally with stainless steel cables that are placed on a surface prepared by heavy equipment (Figure 3-29 and Figure 3-30). Individual mats are linked together by clamping adjacent mat cables to form a continuous scour countermeasure. The concrete cable mat design is intended to rehabilitate the substructure of the bridge and extend its life 15 to 20 years.

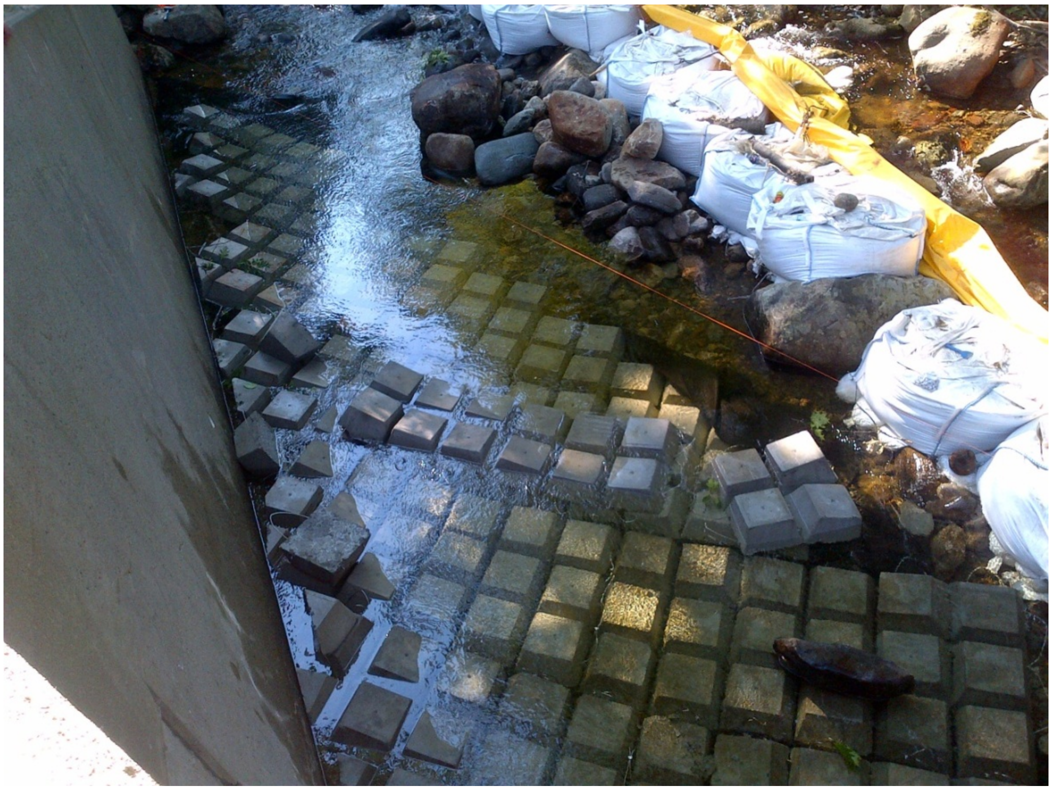

Figure 3-29. A typical cable mat installation.

Scour countermeasures in streams with clay substrate do not qualify for coverage under this PBA. Geotechnical sampling will be conducted for all scour countermeasures potentially conducted under this PBA to provide site-specific confirmation of substrate conditions ruling out the presence of a clay substrate.

Figure 3-30. Concrete cable mat installation. A migratory pathway will be maintained throughout the construction process in situations where stream width will allow.

3.7.2 Construction Sequence

A bridge scour countermeasure installation often requires multiple stages of in-water work. While each contractor may complete the work differently, the explanation below captures the typical process for scour countermeasures using concrete cable mats.

3.7.2.1 Site Preparation

1. Clear vegetation for equipment access.
2. Implement erosion and sedimentation control plan as approved by MaineDOT or MTA.
3. Cofferdams are required during construction of the majority of scour countermeasures so that work areas can be dewatered. Install cofferdams for one abutment at a time (see Sections 3.3.3 and 3.3.5). The stream will be diverted to the other side of the bridge away from the abutment or pier that is being worked on. For those streams that are wide enough, a migratory pathway will be maintained throughout the duration of construction so that aquatic organisms may pass through the site (Figure 3-30).

4. Inspect water control system and work area for presence of Atlantic salmon. This will be completed by a qualified biologist following MaineDOT's Atlantic Salmon Evacuation Plan and Disinfection Procedures (Appendix A).
5. Complete necessary excavation inside of cofferdam. Cable mat installation requires excavation and preparation of the streambed but only to allow for the thickness (~8 inches) of the scour countermeasure and its bedding material so that it is level with the streambed.
6. Grade and prepare streambed and place bedding material (i.e. filter fabric and filter layer of stone) in preparation for scour countermeasure. An erosion control geotextile filter will be used under the concrete cable mats to prevent the loss of streambed fines.

Once the site is prepared, the contractor will install the countermeasure. All pumps, hoses, dams, and the sediment basin will be monitored closely and maintained continuously throughout construction.

One row of the blocks (~4 feet wide) is buried at least 6 inches into the stream channel completely around the perimeter of the concrete-block mat. The upstream and downstream edges of the cable mats are embedded approximately 2 feet further into the newly excavated streambed by turning the edges down and burying them (Figure 3-31). The mats must be attached to the bridge abutments using a grout mixture (AMM #33, 34). The mats are backfilled with a gravel-like material between the voids. Any larger stones or streambed material excavated for the placement of the mats will then be distributed on top of the countermeasures (AMM # 46).

Figure 3-31. Concrete cable mats "toed in" on the upstream edge of a bridge.

3.7.2.2 Closeout Procedures

When scour countermeasure installation is complete, all disturbed areas will be stabilized with final treatments, utilizing temporary erosion and sedimentation control BMPs as necessary. The steps below are implemented by AMMs #5 and #7.

1. Any pumps will be removed.
2. Sediments that are suspended in the water inside of the cofferdam will be allowed to settle out before water is released during cofferdam removal.
3. The cofferdam will be removed gradually to ensure minimal sediment release. The cofferdam removal process is explained in Section 3.4.7.
4. All disturbed areas on the slopes outside of the stream will be stabilized with riprap or vegetation as described in (AMMs #5 and #7), and all permanent erosion and sedimentation control BMPs will be installed.

3.7.3 Activity AMMs

- No heavy construction equipment will travel into or through any flowing streams with erodible substrate (e.g., sand, silt, and clay). Travel of heavy construction equipment into or through flowing streams and on stream substrate will only occur when the stream substrate is non-erodible (e.g., ledge, cobble) and the contractor has received approval from MaineDOT environmental field office staff. (AMM #14)
- No activities will be conducted in streams with clay substrates (defined in Glossary, Appendix C) that include in-water work outside of a sealed cofferdam. This is due to the unpredictable nature of undesirable effects (AMM #15).
- Excavation will not occur outside of a cofferdam once the cofferdam is installed. Initial substrate manipulation may be necessary for cofferdam placement (e.g., hand-moving of rocks (AMM #4).
- See Table 5-17 for additional AMMs

3.8 Activity 5: Bridge Maintenance: Grout Bag Installation and Concrete Repair

3.8.1 Underwater Grout Repair

Grout bags will be installed or replenished, if already installed, along walls, abutments, or piers to prevent scour. Cofferdams are not used during a grout bag repair. The process can be conducted in the wet (i.e., if the grout is in a bag, it is not freely in the water) because it does not create circumstances that result in increased turbidity levels potentially harmful to fish species.

Grout bags are individual nylon or acrylic bags fabricated from panels of material to create a rectangular block form. Every bag is heavy enough to resist movement during most flows. The bags are positioned like tiles around the bridge pier to form an erosion-resistant floor. The bags are pumped full of pressurized grout or concrete after they have been positioned on the channel bed. A typical freshwater grout mix includes 850 pounds per cubic yard of cement, fine aggregate, a water cement ratio of 0.80, air entrainment, and anti-washout admixture (Browne et al. 2010).

Figure 3-32 provides a diagram of the procedure for a grout bag repair to an abutment. Figure 3-33 shows an installation of grout bags by the MaineDOT dive team. In the photo, the PVC pipe used for filling the bags in water is handled by divers.

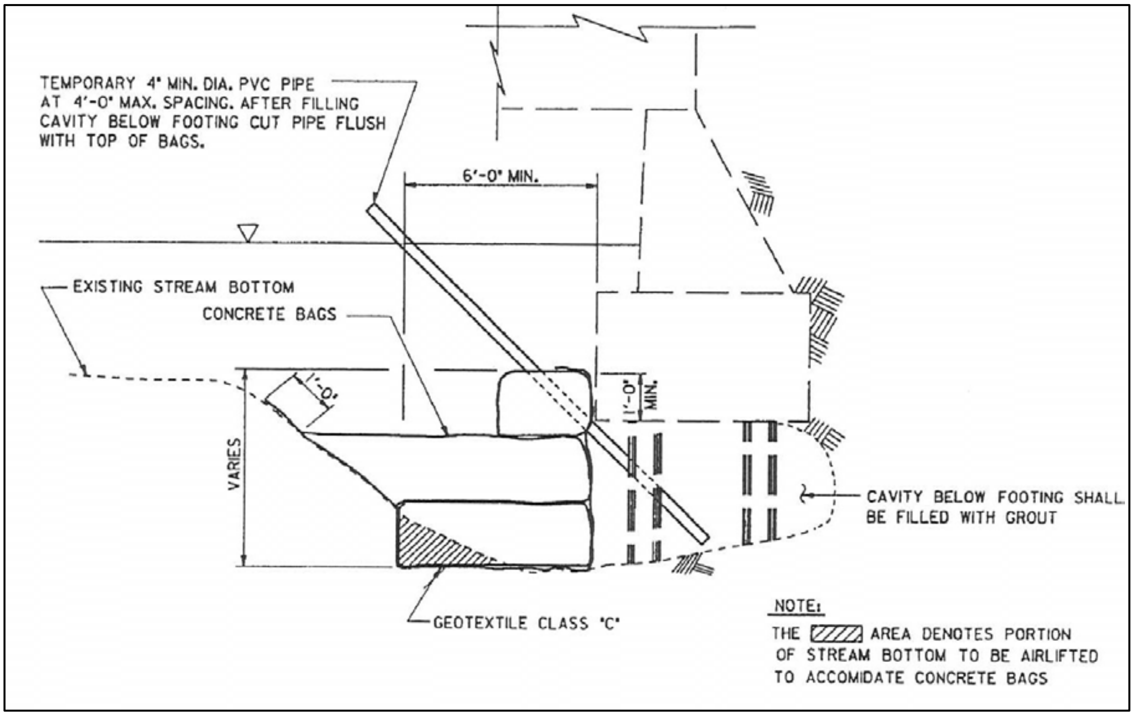

Figure 3-32. Grout bag repair at a bridge abutment (Source: Browne et al. (2010).

Figure 3-33. Grout bag repair at a bridge in Maine.

3.8.1.1 Construction Sequence for Grout Bags

Grout bag installation generally follows this procedure and occurs within a 3-hour period.

1. Set grout pipes into the undermined area, typically pipes are 4-inch PVC pipe or similar.
2. Fill bags with grout. Reinforcing bar dowels can be pushed down through the bags to prevent rolling.
3. After the grout in the bags has set, fill the undermined area by pumping in grout or concrete, through the grout pipes.
4. Remove grout pipes if desired.

3.8.2 Concrete Repair

This activity can include repair of concrete beams, wing walls, bridge decks, and other concrete components of the bridge superstructure. Manifestations of concrete deterioration include, but are not limited to, cracking, scaling (gradual loss of surface mortar or aggregate), delamination, construction defects, and general wear. Ideally, concrete repairs are carried out as quickly as possible upon discovery.

Concrete repairs on abutments or piers will take place inside of a cofferdam if they are below the water level at the time of construction. Concrete repairs on beams will be completed from staging placed in the stream or attached to the bridge deck or wing wall (Figure 3-34).

3.8.2.1 Construction Sequence for Concrete Repair

1. Implement erosion and sedimentation control plan as approved by MaineDOT or MTA.
2. Install cofferdams along crossing elements that are being rehabilitated (wing walls, t- walls, head walls). The cofferdams will be confined to the portions undergoing rehabilitation and will not stretch across the entire stream at any point during construction.
3. Install staging and ladders if they are needed for rehabilitation work. These will be required to gain access to begin fixing items, such as bridge beams underneath the structure. The bases of the ladders may have to be placed in the stream.
4. Begin dewatering the cofferdams as described in Section 3.4.2.
5. Conduct fish evacuation as described in Section Appendix A.
6. Conduct concrete rehabilitation work.
7. Remove cofferdam when the water within the excluded area is within 1 pH unit of background stream pH.
8. Stabilize and restore any disturbed bank soils as described in the SEWPCP.

Figure 3-34. Concrete repairs on beams will be completed from staging. In this photo, the staging is attached to the wing wall.

Activity AMMs

- There will be no placement of uncontained grout; i.e., grout will be contained either within a bag or pumped behind a row of grout bags (as depicted in Figure 3-32) (AMM #33).
- Prevent uncured concrete from coming in contact with flowing stream (AMM #34).
- See Table 5-17 for additional AMMs

3.9 Activity 6: Temporary Work Access and Temporary Bridges

Temporary access, in the form of trestles (via pile installation) or stone causeways (i.e., riprap/wet road), is used on MaineDOT projects to support equipment, enable the movement of personnel and material, and help facilitate construction. MaineDOT does not typically dictate to the contractor how a project should be constructed, as there are multiple techniques that may result in similar effects to either Atlantic salmon or its designated critical habitat. However, if the water depths at the site are <6 feet, a contractor would typically choose to install a stone causeway. Accordingly, if the water depths at the site are >6 feet, a contractor would typically decide to install piles and build a work trestle platform. In certain instances, a contractor may choose a combination of a temporary stone causeway and a temporary trestle. Projects that often require temporary work access can include, but are not limited to, bridge replacements, bridge removals, bridge maintenance, and pre-project geotechnical drilling.

Temporary access in the form of trestles may also be used on MaineDOT projects to temporarily detour and facilitate the movement of traffic away from the main roadway so that construction can occur on the primary travel route without impeding or disrupting traffic. This is typically referred to as a temporary bridge and occurs most often bridge replacements (>20 feet in width). Temporary bridges are necessary when complete closure of the bridge for the duration of construction and/or alternate detour routes are not feasible for the traveling public and staged construction of the new crossing structure cannot maintain traffic.

3.9.1 SEWPCP Review

All temporary work access plans are required to be described by the contractor in their SEWPCP. For temporary work access, the key points of review may include the size of pile needed for a trestle, the type of fill material proposed for any stone causeways and how the contractor plans to obtain “clean” riprap. At this time, the environmental field representative will review this plan to make sure all of the planned construction components are in compliance with the contract stipulations and AMMs that are a part of this PBA.

3.9.2 Temporary Trestles and Bridges

Temporary trestles are installed and supported by piles. The processes for pile installation and removal are similar for temporary trestles installed for facilitating the movement of either construction equipment (temporary work platform) or traffic (temporary bridge). The only difference being the temporary bridge would extend the entire stream width; whereas the temporary work platform would typically extend into only a portion of the stream’s width. The contractor has the ability to locate and install the temporary bridge at their discretion, as long as it meets the commitments for AMMs proposed as a part of this PBA (and other permitting requirements). Typically, the location of a temporary bridge is within 200 feet upstream or downstream of the existing bridge.

Typically, round steel pipe piles or steel H-shaped piles are used to support temporary trestles/bridges. Size is typically determined by the contractor. The Proponents will limit the size of piles to those that will not result in injury to Atlantic salmon (AMM# 37). The piles are first placed with a vibratory hammer and driven to a specified depth (AMM# 39). A vibratory hammer is a large, mechanical device, mostly constructed of steel that is suspended from a crane by a cable. A vibratory 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, an impact hammer is typically required to “seat” the piles to ensure they are structurally adequate to allow heavy machinery and equipment and/or the traveling public’s use of the temporary bridge. Seating the piles typically involves striking the pile with an impact hammer to determine the load bearing capacity of the pile and may involve multiple impacts. The number of seating strikes is considerably less than the strikes needed if one were to use only an impact hammer to drive a pile the full depth. Although driving effort varies depending on site conditions, we expect that use of a vibratory hammer will reduce the use of an impact hammer up to 90%. In-water use of an impact hammer will be subject to the July 15 to April 15 work window to avoid impacts to smolts and minimize impacts to migrating adult Atlantic salmon (AMM #2).

Pile driving activities for the temporary work trestles and bridges will be subject to all of the AMMs and commitments provided for bridge replacements that include pile driving.

After the new bridge is complete and being used by traffic, the temporary bridge or trestles will be removed. The deck will be removed by cutting any of the welds, removing fasteners, and removing decking material. Methods to remove in-water piles include extraction the piles with a vibratory hammer or pulling the pile with a clamshell bucket. Holes created by pile removal are allowed to fill in naturally.

3.9.2.1 Construction Sequence:

1. Implement SEWPCP.
2. Clear vegetation for equipment access.
3. Begin vibratory installation of piles from shoreline/bank.
4. Seat piles with an impact hammer
5. Attach the trestle deck using fasteners such as nuts and bolts or welding metal cross supports.

3.9.2.2 Closeout Procedures:

1. Remove decking
2. Remove temporary piles

Figure 3-35. Typical trestle/temporary bridge construction.

3.9.3 Temporary Stone Causeways

A temporary stone causeway (a.k.a. temporary wet road, temporary stone access road) is comprised of large, clean, non-erodible material placed on geotextile fabric (Figure 3-36). The clean stone helps to minimize sedimentation and turbidity during causeway installation and removal, and the geotextile fabric helps to minimize disturbance to the streambed in addition to helping restore habitat to pre-construction conditions once the causeway is removed. Stone causeways will be constructed of material that meets MaineDOT's standard specifications for plain or large riprap (MaineDOT Standard Specification 703.26 and 703.28). Stone causeways typically extend into the stream to the extent necessary to facilitate construction. To minimize their impacts on critical habitat and fish passage, the Proponents will limit causeway length to extend no more than 25 percent of the BFW of the stream (AMM #32). Stone causeways will not be placed in areas that contain Atlantic salmon spawning habitat (AMM #12, 13).

Figure 3-36. A typical stone causeway.

3.9.3.1 Construction Sequence

Construction of a stone causeway will typically include the following steps.

1. Implement SEWPCP as approved by MaineDOT or MTA.

2. Clear vegetation for equipment access.
3. Place geotextile fabric on streambed.
4. Use excavator bucket to place riprap on top of geotextile fabric; begin at the shoreline/bank, and extend into the stream.
5. Stone causeway will be finished at a level that is above the expected water levels during construction.

3.9.3.2 Closeout Procedures

1. Begin stone removal.
2. After all stone has been removed, geotextile fabric will be removed from on top of the streambed.

3.9.4 Heavy Equipment Access

For some projects and at some point in construction, heavy equipment may need to enter or cross a flowing stream. This is not common and has occurred on less than 5% of MaineDOT stream crossing projects historically. This will not occur on streams where equipment can reach from bank-to-bank. The Proponents propose allowing this in streams with cobble, rock, or ledge bottoms (defined in Glossary, Appendix C). Heavy equipment will not enter or cross streams at sites possessing spawning habitat.

The only equipment that generally enters a resource is a tracked excavator. The tracks consist of metal sheets that are wrapped around a wheel system, and there are two tracks on each piece of equipment. Though it varies with equipment size, these tracks are roughly 16 inches wide and 20 feet long.

3.9.5 Activity AMMs

- The Proponents will follow the July 15 to April 15 in-water work window in Tier 1 priority and Tier 2 areas that have expected ATS presence for creation of temporary work accesses or temporary bridges for crossing replacements that are greater than 20 feet in length.
- In Tier 1 priority areas and Tier 2 areas that have expected ATS presence, the contractor will employ the pile size and driving restrictions for minimizing hydroacoustic effects (AMM #37-41).
- Construction of temporary accesses will only employ clean riprap. The cleanliness of the riprap will be determined in the field by the Resident Engineer and MaineDOT or MTA environmental field representative.
- Construction of temporary bridges and trestles will not involve the installation of round piles >30 inches in diameter.
- Construction of temporary bridges and trestles will not involve the installation H-piles >14 inches
- Stone causeways will be constructed of material that meets MaineDOT's standard specifications for plain or large riprap (MaineDOT Standard Specification 703.26 and 703.28).
- To minimize their impacts on critical habitat and fish passage, the Proponents will limit causeways length to extend no more than 25% of the BFW of the stream (AMM #32).

- The proponents will not affect Atlantic salmon adults sheltering in holding pools (AMM #47).
    - To provide further clarification of AMM #47 for this specific activity, no direct or indirect, adverse or no adverse (i.e., placement of a temporary bridge pile or stone causeway in a holding pool, turbidity and sedimentation from construction, etc.) effects to Atlantic salmon that are sheltering in holding pools are allowed. If there is the potential to have any effects on Atlantic salmon sheltering in holding pools as a result of any proposed activity, it is not allowed under the programmatic.
- The proponents will not have any disturbance (turbidity, acoustic, direct effects) in spawning areas during spawning and egg incubation periods (November 1-April 30) (AMM #12).
- The proponents will not temporarily affect spawning habitat without restoration (AMM #13).
- No heavy construction equipment will travel into or through any flowing streams with erodible substrate (e.g., sand, silt, and clay) (AMM #14)
- See Table 5-17 for additional AMMs

3.10 Activity 7: Invert Line and Slipline Culvert Rehabilitation

Invert lining and slip lining are two methods used to rehabilitate culvert crossings. These activities are completed when metal culvert crossings start to show signs of failure (e.g. rusting, deformations), but enough structural stability remains that a rehabilitation project can address the deterioration. This method of rehabilitation will occur on structures that are anywhere from 20 to 50 years old. Structures installed at that time were not commonly designed for fish passage or aquatic habitat connectivity. Rehabilitating these structures prolongs the life of undersized culvert crossings with aquatic habitat connectivity issues of varying severity.

The proponents propose three AMMs for design and implementation of invert line and slipline rehabilitation projects.

AMM #49- All invert line and slipline projects analyzed as a part of this PBA will have fish passage measures included in the design. Fish passage measures include weirs inside and outside of the crossing structures to ensure that water depths and velocities allow for fish passage at a range of flows.

Following past advice from the Services, the proponents recognize that fish passage measures will not aid in the recovery of Atlantic salmon. However, implementation of fish passage measures is still an important step to minimize the effects of these activities on Atlantic salmon as well as other fish species.

AMM #50- Invert line and slipline rehabilitation activities will not occur in Tier 1 priority areas. Invert line and slipline rehabilitation activities can occur in Tier 2 and Tier 3 priority areas. To aid in the recovery of Atlantic salmon, the Proponents will provide mitigation (CM #2) for invert line and slipline rehabilitation projects that occur in Tier 2 priority areas.

3.10.1.1 Construction Sequence

Both invert line and slip line culvert rehabilitation projects will follow the process explained below, which includes a typical cofferdam installation. Please see Sections 3.4.1-3.4.3 for more in depth explanation of the cofferdam installation process.

1. Clear vegetation for equipment access.

2. Implement erosion and sedimentation control plan as approved by MaineDOT or MTA.
3. Complete Fish Evacuation Plan (Appendix A). If water depths are conducive to electrofishing, the fish evacuation will take place prior to placement of the upstream and downstream cofferdam.
4. Install upstream cofferdam.
5. Install downstream cofferdam.
6. Maintain downstream flow using a bypass pump system or diversion channel.
7. Begin to dewater the work area.
8. Rehabilitate culvert.
9. Replace riprap at culvert as necessary.
10. Stop pumps, restore flow, and then remove cofferdams as described in Section 3.4.2.

Preparing Existing Culvert for Treatment

Prior to installing the invert line or slipline, but after dewatering the work area, the culvert will be cleaned of debris, and structural components (e.g., rebar and/or two-by-fours) will be secured. In addition, the existing metal pipe may need to be cut on either end. The inside walls and invert of the existing culvert are typically patched with grout where there are holes or corrosion. The annular space must be sealed with bulkheads at both ends of the culvert to contain the grout and keep water from seeping into the space between the existing culvert and the liner. Cement is commonly used to create the bulkheads.

3.10.1.2 Invert Line

The word invert refers to the bottom half of a culvert. Corrugated metal pipe (CMP) culverts are a common means of carrying roadways over streams. Over time the wetted portion of a CMP culvert will corrode and weaken, largely due to abrasion from materials in water flowing through the culvert. For the purposes of this PBA, invert lining will involve using a reinforced concrete or CMP liner.

To install a concrete liner, the culvert must be of sufficient size to permit worker access. The concrete liner is crafted in place by adding a reinforced concrete invert pavement section (Figure 3-37). A layer of steel reinforcement or wire mesh is placed in the invert and secured to the culvert bottom. Concrete is then placed in the invert to a thickness typically ranging from 3 to 5 inches. The surface of the concrete is shaped to match the geometry of the original culvert invert as much as possible. The surface of the concrete is usually finished with an approved sealant or curing compound, and the edges of the invert pavement can be sealed with mastic or asphalt emulsion.

Figure 3-37. Concrete freshly placed during an invert lining. Note the rebar cage for fish weir support.

3.10.1.3 Slip Line

Slip lining is a method of culvert rehabilitation where a rigid-walled liner pipe is inserted into the existing host pipe. The liner pipe is moved into the culvert either one section at a time or as an entire unit after being butt-fused. For the purposes of this PBA, slip lining will involve inserting a high-density polyethylene (HDPE) or CMP pipe of a slightly smaller diameter directly into the deteriorated culvert.

Once cofferdams are installed, pumps are running, and the work area is dewatered, the slip lining process can commence. At this point, the crews will be working in the dry, and there will be no sediment release into the stream. All pumps, hoses, dams, and the sediment basins will be monitored closely and maintained throughout construction.

Next, the culvert is patched using grout to fill the annular space between the bulkheads and between the old culvert and the liner. The liner is then inserted into the host pipe by either pulling or pushing the liner into place usually with construction equipment (Figure 3-38). When the liner is in place, grouting is used to fill any remaining annular space between the new and old culvert and any other voids. Bulkheads must be installed before grouting to seal the ends of the pipe. Although the diameter of the pipe is decreased, the pipe will have a greater flow capacity due to the composition of the new liner.

Figure 3-38. Slip line being inserted.

3.10.1.4 Fish Passage Weirs and Scour Prevention

Installing either an invert liner or slipline will also include installing fish passage weirs in streams where fish passage is necessary. Each weir may incorporate an adjustable notched weir plate. Also, any planned riprap aprons at the inlet and outlet of the structures will take place once the liner and weirs are installed. The riprap will be embedded into the stream channel so it does not act as a barrier to fish passage after its placement. Riprap at the outlet end will prevent scouring of stream substrate. Depending on the stream conditions associated with culvert rehabilitation, the liner and weir installation may also include constructing stilling pools in the stream at the downstream end of the culvert to dissipate flow energy and further facilitate fish passage.

3.11 Activity 8: Pre-project Geotechnical Drilling

The engineering design process for transportation projects typically includes geotechnical sampling and testing to determine soil and substrate characteristics and topographical surveys. The PBA addresses the potential effects of geotechnical explorations and topographic surveys for all projects that require them. This activity specifically addresses drilling in the bed of a stream/river.

The proponents conduct case wash borings. This process includes advancing a 3 or 4 inch diameter steel case downward in 5 or 6 foot intervals. The case is advanced using a small (20 pound) drop weight. A small diameter drill string is used to wash the substrate out of the casing. A 24 inch long sampling device is then drilled into the substrate and a ‘core’ of the substrate is removed for analysis. This process is repeated to the desired depth of the sample. The water from the stream acts to keep the drill bit cooled and aids in drilling. Drilling fluid is not required.

Rock and soil samples are collected to measure chemical and physical properties and test for hazardous substances. The time to drill a single test hole will vary depending on the substrate material, but the average period is roughly 8 hours.

Geotechnical sampling that does not require a trestle or causeway can be conducted at any time of year. Collection of geotechnical information that requires the construction of a temporary work trestle or stone causeway will be conducted within the July 15 to October 1 in-water work window in Tier 1 Priority Areas and Tier 2 Priority Areas where ATS are present. See Section 3.9 for a description of the work.

Geotechnical sampling will follow the standard BMPs and measures specified in the SEWPCP approved by the proponent.

3.12 Summary of Avoidance and Minimization Measures (AMMs)

As stated earlier in Section 3.1, AMMs are those measures that either eliminate or reduce the impact of a project on listed species or habitats. AMMs are protective steps, such as relocating activities, precautionary procedures (i.e., erosion control), timing restrictions, and buffers around sensitive habitats important to listed species. The AMMs listed below are primarily instituted during construction. Measures that the Proponents use to avoid and minimize impacts to Atlantic salmon and critical habitat during project design are listed in the action descriptions for each activity above.

All elements of any activity will comply with MaineDOT’s Standard Specifications (MaineDOT 2014; http://maine.gov/mdot/contractors/publications/standardspec/). The Standard Specifications is a textual compilation of provisions and requirements for the performance of any MaineDOT work and includes general AMMs. In 2014, MaineDOT published and approved, pursuant to 23 MRSA § 4243, the Standard Specifications and Standard Details for Construction for the general application and repetitive use on Projects.

Minimization measures include BMPs and apply to all activities. All construction practices will follow the MaineDOT: Best Management Practices for Erosion and Sedimentation Control (MaineDOT 2008a). BMPs are methods, facilities, built elements, and techniques implemented or installed during construction and help to reduce short- and long-term impacts on listed species and critical habitat. These BMP measures include many filtering and sedimentation control techniques designed to dissipate water discharge energy (flow), filtering of sediments, and allowing particulate matter to settle out from suspension.

AMMs and BMPs are measures that are considered part of the proposed activity that will be implemented. AMMs are not recommendations, guidelines, or suggestions. For the purposes of this PBA, are considered part of the proposed activity that will be implemented. AMMs are listed below and specified for each individual construction activity as indicated in the corresponding Sections 3.4 through 3.10 activities. Specific AMMs for different If an AMM is not indicated for a specific Tier priority area, it should be assumed it applies to all activities in all areas.

3.12.1 In-water Construction Period AMMs

AMM 1- In-water work for all activities other than bridge replacement and geotechnical sampling without temporary trestles in Tier 1 priority areas or Tier 2 priority areas where Atlantic salmon are expected to be present will be conducted during the low stream flow period (July 15 to October 1).

The in-water work window avoids the smolt life stage of Atlantic salmon, as smolts make their seaward migration during the period from mid-April through mid-June (Baum 1997). This life stage is very sensitive to migration disruption. It also emphasizes completing in-water work during the period when adult salmon are less mobile. The in-water work window is based on the timing of typically low flows in Maine's rivers. Working in low flows avoids and minimizes numerous potential impacts associated with isolating and diverting water. This AMM will be in place for all projects other than bridge replacement, which typically takes from 2.5 to 24 months and the short work window would make construction infeasible. Pre-project geotechnical sampling that does not necessitate the use of a temporary trestle will not result in significant effects to salmon or their habitat so the in-water work window is unnecessary.

For further discussion on the effects expected from utilizing this work window, see Chapter 5.

AMM 2- All in-water work on bridge replacement (> 20') projects (and associated sub-activities, e.g., pier installation, temporary access installation, as necessary) will occur between July 15 and April 15.

The standard in-water work window is from July 15 to October 1, however, for bridge replacement projects, construction typically takes anywhere from 2.5 to 24 months to complete, depending on the magnitude and scope of the replacement work. The Proponents, Action Agencies and USFWS agreed that under this programmatic, and for bridge replacement projects, in-water work could take place during the otherwise avoided fall adult migration window, resulting in the July 15 to April 15 in-water work window.

3.12.2 General AMMs

AMM 3- All areas of temporary waterway or wetland fill will be restored to their original contour and character upon completion of the project. Temporary fill includes fill that received authorization and fill that mistakenly enters a resource (i.e., from slope failures, accidental broken sandbag cofferdams).

AMM 4- All in-water excavation will be conducted within a cofferdam.

AMM 5 – All areas of disturbed soil will be mulched and seeded with an approved native or noninvasive herbaceous seed mix following construction and/or planted with native woody vegetation and trees appropriate during the first available planting season. In areas where there is little to no slope and erosion and invasive species establishment is unlikely, the native woody vegetation on the site will be allowed to regenerate naturally.

AMM 6- Temporary access roads placed in the riparian area will be constructed in a manner that they do not allow erosion into resources during construction. This will be reviewed and approved as a part of the SEWPCP, including review of location as well as placing a non-erodible material on the surface of the road.

AMM 7 – Vegetation rootstock will only be removed in those areas that are subject to permanent impacts. Replanting will be completed as necessary and feasible, but may not be possible in certain situations, such as permanent impact areas, roadway clear zone, or adjacent to or under bridges.

AMM 8- To minimize the spread of noxious weeds into the riparian zone, all off-road equipment and vehicles operating from existing open and maintained roads must be cleaned prior to entering the construction site to remove all soil, seeds, vegetation, or other debris that could contain seeds or reproductive portions of plants. All equipment will be inspected prior to off-loading to ensure that they are clean.

AMM 9- During construction, any disturbed soils will be temporary stabilized with BMPs, such as hay mulch, plastic sheeting, erosions control mix, or other appropriate BMPS. Disturbed areas with erodible soil can include, but are not limited to, temporary storage piles, access ways, partially constructed slopes, etc.

AMM 10- The Proponents will hold a pre-construction meeting for each project with appropriate Environmental Field Representatives, other MaineDOT or MTA staff, and construction crew or contractor(s) to review all procedures and requirements for avoiding and minimizing effects to Atlantic salmon and to emphasize the importance of these measures for protecting salmon and its critical habitat. The USACE, FHWA, and USFWS staff will be notified and attend these meetings as practicable.

AMM 11- The proponents are not proposing to include any new road facilities in this PBA.

A new road facility will be defined as the creation of a new road longer than 0.5 mile in length. The new creation can include new connections and re- aligned portions of intersections with new inputs. Highway relocations and realignments are not considered a new road facility if drainage patterns are not altered and drainage remains within the same watershed as the previous highway portion.

AMM 12- The proponents will not have any disturbance (turbidity, acoustic, direct effects) in spawning areas during spawning and egg incubation periods (October 1-April 30).

AMM 13- The proponents will not temporarily affect spawning habitat without restoration.

AMM 14- No heavy construction equipment will travel into or through any flowing streams with erodible substrate (e.g., sand, silt, and clay). Travel of heavy construction equipment into or through flowing streams and on stream substrate will only occur when the stream substrate is non-erodible (e.g., ledge, cobble) and the contractor has received approval from MaineDOT environmental field office staff.

AMM 15- No activities that disturb the substrate will be conducted in streams with clay substrates (defined in Glossary, Appendix C) that include in-water work outside of a sealed cofferdam. This is due to the unpredictable nature of undesirable effects.

3.12.3 Soil Erosion and Water Pollution Control Plan (SEWPCP)

The SEWPCP documents what practices and management procedures will be used to prevent a discharge of sediment and pollutants. When they apply, state and federal regulations require assurance that the proper BMPs will be installed in the right sequence and maintained for their intended use; this requires a written plan. The written plan facilitates the contractor's process of integrating BMPs into the construction project. The SEWPCP takes into account the project's relationship to the watershed, site soils and drainage, construction timing and phasing, water control, and soil stabilization.

The Contractor will provide continuous and effective temporary soil erosion and water pollution control for the project that is appropriate to the construction means, methods, and sequencing allowed by the Contract and selected by the Contractor. To do so, the Contractor will prepare and submit a SEWPCP that complies with Section 656 of MaineDOT's Standard Specifications.

AMM 16 - The Proponents will require any work being completed under this PBA to submit a SEWPCP for review and approval of MaineDOT staff prior to the start of work. The plan includes the review of the implementation of any AMMs proposed.

3.12.4 Cofferdam Installation and Removal

Cofferdam installation and removal will follow the steps described in Section 3.2.1.

AMM 17- The installation of cofferdam systems encloses a work area and reduces sediment pollution generated from construction work. All in stream work will take place inside of a cofferdam except for the following sub activities: pile driving, clean rip rap placement for temporary access roads, bridge pier demolition, and geotechnical drilling. In-water work in streams with a clay substrate (defined in Glossary) will not occur outside of a sealed cofferdam.

AMM 18- Suspended sediment treatment will follow the procedures described in Section 3.4.2 "Dirty Water" Treatment System.

AMM 19- For activities requiring bypass pumping in streams, stabilization techniques (such as sheets of poly) will be used to protect the stream from scour caused by the high water velocity coming from the hose(s) at the downstream end.

AMM 20- Temporary bypass systems will utilize non-erosive techniques, such as pipe or a plastic-lined channel that will accommodate the predicted peak flow rate during construction. These are reviewed as part of the contractor's SEWPCP. Predicted peak flows are provided to the contractor in the bid documents; these values are derived from the USGS regression (USGS 2015).

AMM 21- Sheet pile driving (if utilized) will be completed using a vibratory hammer.

AMM 22- All cofferdams will be fully removed from the stream immediately following completion of in-water work, minimizing delays due to high stream flows following heavy precipitation, so that fish and aquatic organism passage are not restricted any longer than necessary. If a project is not completed and there will be substantial delays in construction, cofferdams will be at least partially removed to allow passage of Atlantic salmon until construction resumes. All areas of temporary bottom disturbance will be restored to their original contour and character upon completion of the project.

AMM 23- All cofferdams will be removed using techniques to minimize turbidity releases. This includes allowing for the slow reintroduction of water into the work area and utilizing dirty water treatment systems for turbid water.

AMM 24- Bypass pumps will be sized according to the expected flows during construction. See Section III(F)3 in the MaineDOT BMP Manual (MaineDOT 2008) for guidance on pump capacity.

3.12.5 Spill Prevention Control and Countermeasures Plan (SPCC)

As a component of the SEWPCP, each project will implement an SPCC Plan designed to avoid any stream impacts from hazardous chemicals associated with construction activities, such as diesel fuel, oil, lubricants, and other hazardous materials. All refueling or other construction equipment maintenance will occur at a location consistent with the SPCC Plan and in a manner that avoids chemical or other hazardous materials getting into the stream. To avoid and minimize the potential for introducing contaminants into the waterbody during construction activities, the Proponents will require the contractor to follow BMPs and MaineDOT's Standard Specifications. These measures include the following:

AMM 25- No equipment, materials, or machinery will be stored, cleaned, fueled, or repaired within any wetland or watercourse. All vehicle and equipment refueling activities will occur more than 100 feet from any water course and if not, all refueling areas will require fuel spill containment structures as per the SPCC Plan. Other construction equipment maintenance will be done at a location consistent with SPCC Plan and in a manner that avoids hazardous materials getting into the stream.

AMM 26- All pumps and generators will have appropriate spill containment structures and/or spill remediation materials available, such as absorbent pads.

AMM 27- All equipment used for in-stream work will be cleaned of external oil, grease, dirt, and mud such that turbid water does not drain to any wetland or watercourse. Any leaks or accumulations of these materials will be corrected before entering streams or areas that drain directly to streams or wetlands. All releases into surface waters or wetlands will be reported immediately to the appropriate regulatory body.

AMM 28- Any removed piling or other demolition material will be properly disposed of at a location in compliance with applicable regulatory approvals.

3.12.6 Fish Protection and Handling

These AMMs are design to minimize effects to Atlantic salmon during cofferdam installation and construction. These will be implemented on projects that occur in Tier 1 Priority or other areas where Atlantic salmon could potentially be present in the work area.

AMM 29- To minimize fish stranding inside the cofferdam when dewatering, MaineDOT environmental staff or similarly qualified consultants will capture and remove as many Atlantic salmon and other fish species as possible. MaineDOT environmental staff or similarly qualified consultants will inspect the cofferdams after placement for presence of adult Atlantic salmon. If adult Atlantic salmon are observed during active construction, all activities will cease and MaineDOT environmental staff or similarly qualified consultants will immediately contact the USFWS Maine Field Office (207-866-3344). MaineDOT environmental staff or similarly qualified consultants will complete a fish evacuation where water depths allow following the plan found in Appendix A.

As stated in Appendix A, nets will be used to "herd" fish out of the work area to the extent practicable prior to electrofishing and cofferdam installation. This kind of fish exclusion measure can occur prior to cofferdam construction when water depths are less than <2 feet.

Appropriate fish evacuation techniques in cofferdams are required for bridge pier construction. Water depths and access make these evacuations a unique situation. In these cases, the Proponents will provide project-specific fish evacuation plans to the USFWS prior to programmatic approval.

AMM 30- All intake pumps within fish bearing streams will have a fish screen installed, operated, and maintained. To prevent Atlantic salmon juvenile entrainment related to water diversions, the contractor will use a screen on each pump intake large enough so that the approach velocity does not exceed 6.10 meters second^{-1} (0.20 feet second^{-1}). Square or round screen face openings are not to exceed 2.38 millimeters (3/32 inch) on a diagonal. Criteria for slotted face openings will not exceed 1.75 millimeters (~1/16 inch) in the narrow direction. These screen criteria follow those indicated in NMFS (2008). Intake hoses will be regularly monitored while pumping to minimize adverse effects to Atlantic salmon.

3.12.7 In-water Temporary Work Access Roads and Temporary Bridges

Temporary access to a site and its associated fill may be necessary for some activities. Appropriate measures will be taken to maintain normal downstream flows and minimize flooding to the maximum extent practicable, when these temporary structures are necessary. All temporary crossings and bridges are reviewed as part of the SEWPCP and will meet, at a minimum, the following conditions.

AMM 31- Temporary roads in stream channels will be constructed of non-erodible material, i.e., plain riprap or large riprap (per MaineDOT standard specifications) over geotextile fabric.

AMM 32- Stone causeways will extend only to within 25 percent of the BFW of the stream/river.

See AMM 3 above- Temporary fills must be removed in their entirety after the work is completed.

All bridge replacement AMMs also apply to temporary bridges and trestles.

3.12.8 Grout Bag Repair and Bridge Maintenance

AMM 33- The Proponents will employ the following procedure when completing grout bag repairs.

1. Apply the grout slurry at a rate of 2 cubic yards per hour to reduce the likelihood of elevated pH values downstream.
2. Turbidity curtains will be used when practicable (in flows $\leq$1 foot per second) to separate high pH water from the rest of the river.
3. An anti-washout admixture (AWA) will be mixed with the grout prior to application.
4. Grout will be piped into or behind grout bags.

AMM 34- As per Standard Specification 656.3.6 (e)), the contractor will not place uncured concrete directly into a water body. The contractor shall not wash tools, forms, or other items in or adjacent to a water body or wetland.

AMM 35- Prior to release to a natural resource, any impounded water that has been in contact with concrete placed during construction must have a pH between 6.0 and 8.5, must be within one pH unit of the background pH level of the resource and must have a turbidity level no greater than the receiving resource. This requirement is applicable to concrete that is placed or spilled (including leakage from forms) as well as indirect contact via tools or equipment. Disposal or treatment of water not meeting release criteria shall be addressed in the SEWPCP. Discharging impounded water to the stream must take place in a manner that does not disturb the stream bottom or cause erosion. The Contractor shall be responsible for monitoring pH with a calibrated meter accurate to 0.1 units. A record of pH measurements shall be kept in the Environmental Field Representative's log. Concrete being placed as a seal in a cofferdam for bridge pier construction is considered “impounded water’.

3.12.9 Bridge Demolition

AMM 36- Demolition and debris removal and disposal will comply with Section 202.03 of MaineDOT's Standard Specifications. The Contractor will contain all demolition debris, including debris from wearing surface removal, saw cut slurry, dust, etc., and will not allow it to discharge to any resource. The

Contractor will dispose of debris in accordance with the Maine Solid Waste Law (Title 38 M.R.S.A., Section 1301 et. seq.). The demolition plan, containment, and disposal of demolition debris will be addressed in the Contractor's SEWPCP.

3.12.10 Pile Driving

AMM 37- Round pile size is limited to ≤ 30 inches in diameter. H-pile size is limited to ≤ 14 inches.

AMM 38- Piles that are between 24 and 30 inches must have attenuation devices installed for all impact pile driving.

AMM 39- A vibratory hammer will be used as much as possible for all pile driving activities.

AMM 40- Pile driving will occur during the day when fish are less active and salmon migrations are minimized.

AMM 41- Hydroacoustic monitoring will be completed for all impact pile driving using the monitoring template developed by the Fisheries Hydroacoustic Working Group (FHWG)[7] and following the methods described in the Technical Guidance (Caltrans 2015).

AMM 42- A bubble curtain meeting the design criteria, as defined in the User's Guide, will be employed during all impact pile driving events. The bubble curtain design will mimic specifications for devices tested and employed for previous pile driving events.

AMM 43- In-water blasting is not allowed when Atlantic salmon could be present.

3.12.11 Critical Habitat

AMM 44- Permanent riprap placed in a stream below the bankfull elevation will be covered by ESM material.

AMM 45- Any riprap that is placed in a stream that is not within a cofferdam will be cleaned prior to placement.

AMM 46- Cable mats used for scour protection (Activity 4, Section 3.7) will be backfilled with a gravel-like material between the voids. Any larger stones or streambed material excavated for the placement of the mats will then be distributed on top of the countermeasures.

AMM 47- The proponents will not affect Atlantic salmon adults sheltering in holding pools.

AMM 48- In rearing habitat, bridge replacements with piers will not result in a net increase of structure footprint.

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[7] The FHWG is composed of representatives from Caltrans, FHWA, Oregon DOT, Washington DOT, NMFS, USFWS, and USACE. The FHWG works to improve and coordinate information on fishery impacts due to underwater sound pressure caused by in-water pile driving and is supported by a panel of hydroacoustic and fisheries experts. It is FHWG's goal to reach agreement on the following: 1) The nature and extent of knowledge about the current scientific basis for underwater noise effects on fish, 2) Interim guidelines for project assessment, mitigation, and monitoring for effects of pile-driving noise on fish species, and; 3) Future scientific research needed to satisfactorily resolve uncertainties regarding hydroacoustic impacts on fish species (Caltrans 2016).

3.12.12 Invert Line and Slipline Culvert Rehabilitation

AMM 49 – All invert line and slipline projects analyzed as a part of this PBA will have fish passage measures included in the design. Fish passage measures include weirs inside and outside of the crossing structures to ensure that water depths and velocities allow for fish passage at a range of flows.

Following past advice from the Services, the proponents recognize that fish passage measures will not aid in the recovery of Atlantic salmon. However, implementation of fish passage measures is still an important step to minimize the effects of these activities on Atlantic salmon as well as other fish species.

AMM 50 – Invert line and slipline rehabilitation activities will not occur in Tier 1 priority areas. Invert line and slipline rehabilitation activities can occur in Tier 2 and Tier 3 priority areas. To aid in the recovery of Atlantic salmon, the Proponents will provide mitigation (CM #2) for invert line and slipline rehabilitation projects that occur in Tier 2 priority areas.

Chapter 4 PBA Action Area

Figure 4-1 and Figure 4-2 display the estimated inland range of the GOM DPS of Atlantic salmon and designated critical habitat. The action area includes all perennial freshwater streams and waterbodies above the head of tide and within the salmon GOM DPS geographic area that are affected by MaineDOT and MTA roadway facilities. This PBA covers 8 activities that the Proponents use for the preservation, improvement, removal, and/or maintenance of federal and state maintained transportation facilities and the Maine Turnpike System.

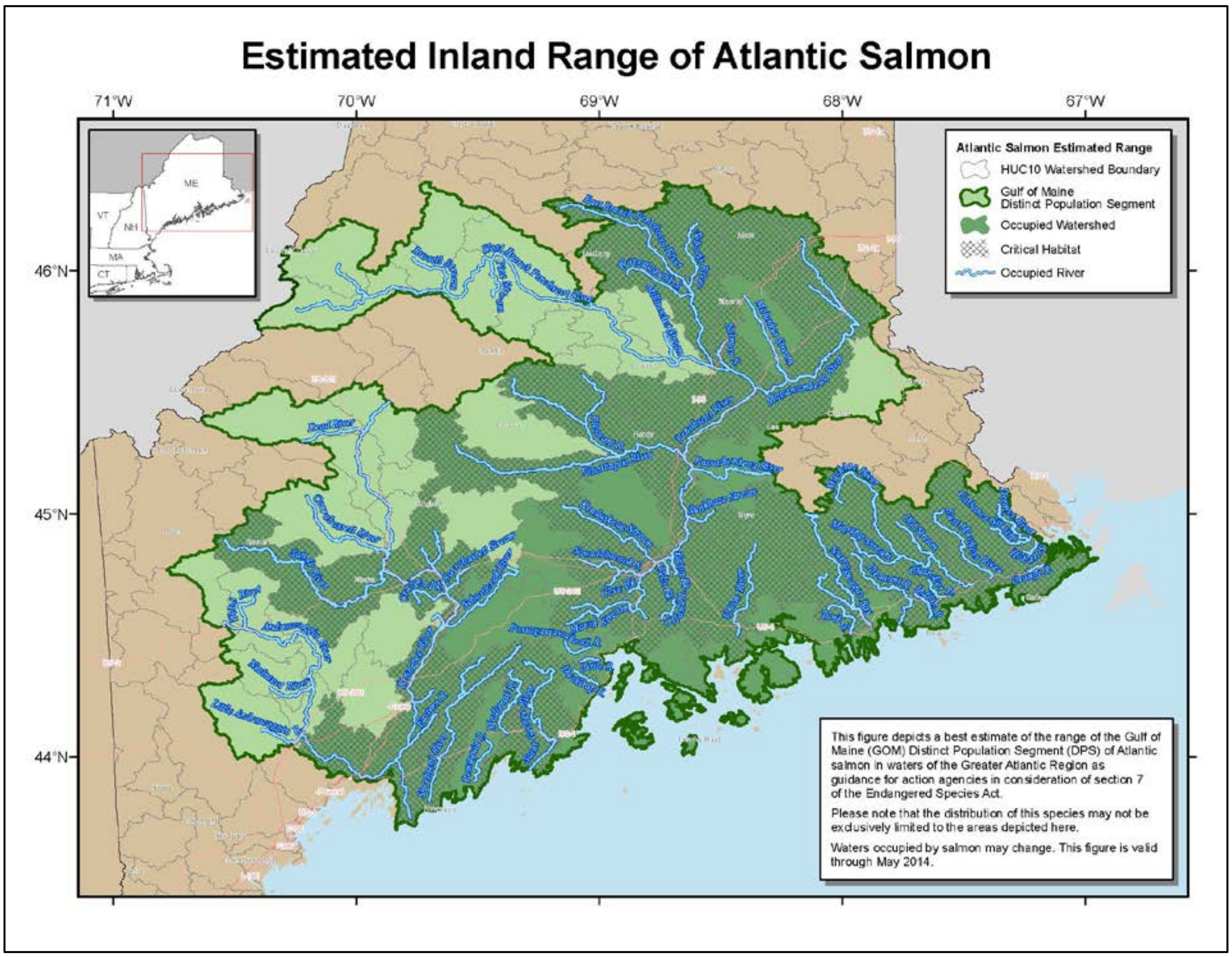

Figure 4-1. Range of Gulf of Maine Distinct Population Segment of Atlantic salmon. Source: NMFS (2014)

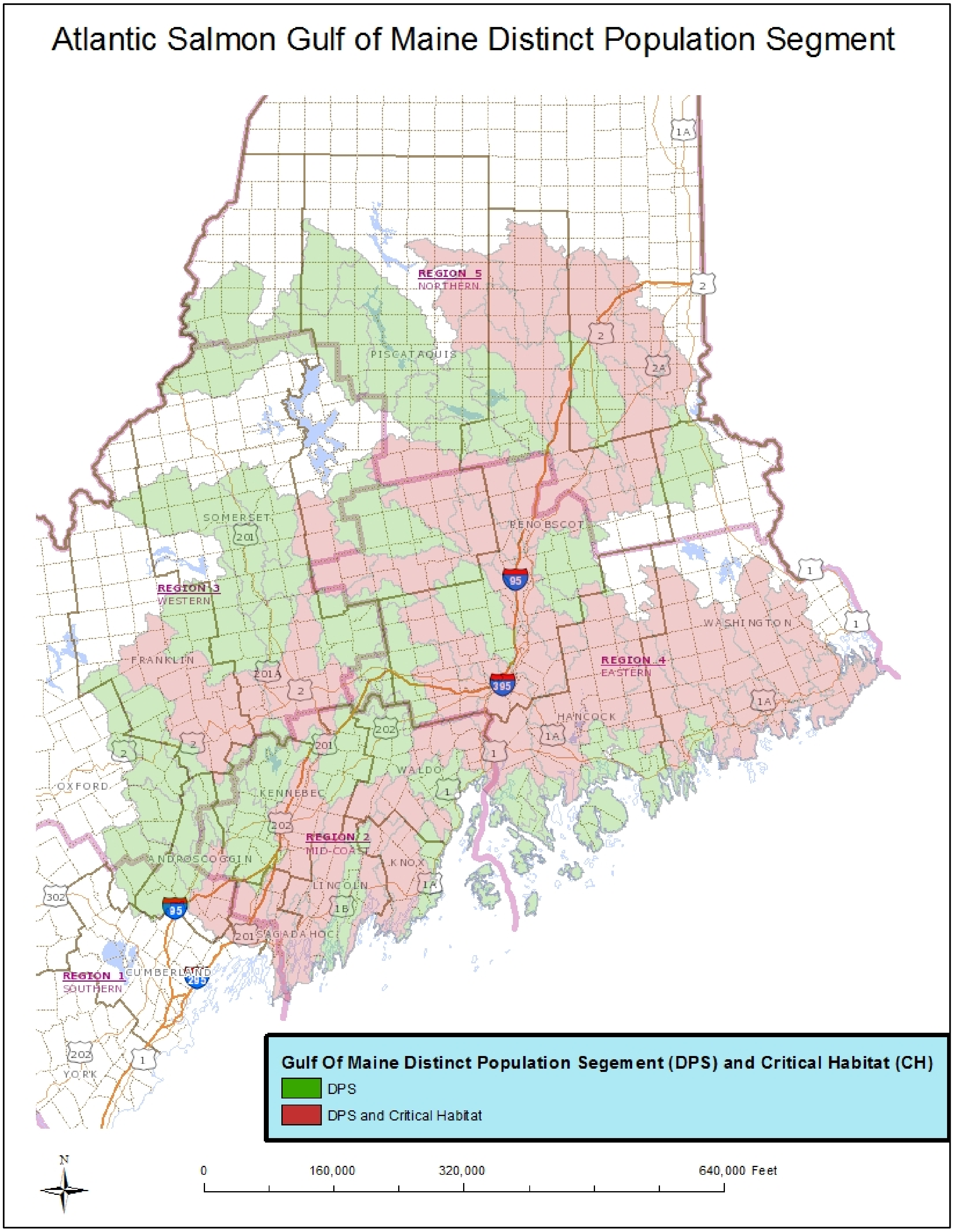

Figure 4-2. Range and designated critical habitat for the Gulf of Maine Distinct Population Segment of Atlantic salmon.

Chapter 5 Effects of the Action

This PBA analyzes the potential direct and indirect effects of the proposed action on the GOM DPS of Atlantic salmon in the action area within the context of its current status, the environmental baseline, and cumulative effects, as well as interrelated and interdependent actions. Indirect effects are those that are caused later in time, but are still reasonably certain to occur. Interrelated actions are those that are part of a larger action and depend upon the larger action for their justification. Interdependent actions are those that have no independent utility apart from the action under consideration (50 CFR 402.02).

Also, this effects analysis determines whether any of the proposed activities will adversely affect designated critical habitat for Atlantic salmon by assessing potential changes in the value of any essential features. The Proponents assume that most projects that meet the criteria for coverage in this PBA will occur within HUC-10 watersheds that are designated as critical habitat for the GOM DPS of Atlantic salmon. However, the Proponents will conduct similar activities within HUC-10 watersheds that are excluded from the GOM DPS of Atlantic salmon critical habitat, particularly when they flow through tribal lands (pursuant to Secretarial Order 3206). MaineDOT conducts projects on tribal lands of the Penobscot Indian Nation and the Passamaquoddy Tribe that are within the geographic range of the GOM DPS of Atlantic salmon.

Designated critical habitat for Atlantic salmon within the GOM DPS consists of two PCEs: 1) spawning and rearing habitat and 2) migration habitat. Within the GOM DPS, 45 HUC-10 watersheds are designated as critical habitat. At the time of listing the GOM DPS, the Services considered these 45 HUC-10 watersheds as occupied by Atlantic salmon. However, not all water bodies within a given HUC-10 watershed were necessarily occupied by salmon at that time nor are they currently. Critical habitat includes perennial rivers and streams, estuaries, and lakes.

For both species and critical habitat effects, the PBA is relatively general as the Proponents can predict the kinds of effects and provide estimated magnitudes that may result from each general activity, but the actual magnitude will be project-specific and revealed in the reporting form for each covered project. Using site-specific information and project design detail, Proponents will estimate magnitude in each project-specific reporting form.

5.1 Effects Not Allowed by the Proposed Action

The Proponents recognize that effects on portions of the Atlantic salmon life cycle and habitat elements cannot be included in this PBA due to the unpredictability of the effects in these sensitive areas. The proposed action and AMMs are designed to avoid these effects:

1. Disturbance (turbidity, acoustic, direct effects) in spawning areas during spawning and egg incubation periods (November-April).
2. Directly affecting spawning habitat with no restoration.
3. Potential delay to the seaward migration of smolts.

5.2 Turbidity and Sedimentation

Activities that involve construction in a stream or on or near the banks of a stream are likely to result in some level of sediment discharge from disturbance to either land-based soils or stream substrates. Construction elements (some are components of larger construction activities) that can elevate turbidity and elicit sediment transport include: cofferdam installation and removal (with the pump bypass systems), stream diversion/bypass channel installation and removal, pile installation and removal, geotechnical drilling, riprap placement, temporary access road installation and removal, and old bridge/structure demolition.

For this PBA, the Proponents are not proposing to conduct any in-water work outside of a cofferdam where substrates contain or are underlain by a clay substrate (defined in Glossary) that may be disturbed during construction. When making this determination, the Proponents will use at least one or more of the following three sources to identify the presence of clay substrates:

- Maine surficial geology mapping;
- Geotechnical surveys; and
- MaineDOT environmental stream assessments

5.2.1.1 Cofferdam Installation and Removal with a Pump Bypass System

Cofferdams will be used for a number of activities proposed under this PBA. For example, stream crossing replacements (culverts and bridges), culvert end resets and extensions, scour countermeasures, and invert line and slipline culvert rehabilitation projects could all include a sub-activity of cofferdam installation (AMM# 4). Cofferdam installation and removal is described in Chapter 3. Cofferdams may consist of different materials, but are most commonly constructed of sandbags laid across a sheet of plastic material that acts as a seal. Only non-erosive materials will be used as cofferdam components (i.e., no unconsolidated fill). Turbidity releases occur when workers are walking around in the stream, laying out the plastic sheet, and placing the bottom row of the cofferdam on the substrate (see Figure 3-2). This same process is repeated on both the upstream and downstream cofferdams.

Once both cofferdams have been installed, the contractor will begin to dewater the area between the cofferdams. If the water still appears turbid from the installation activities, it will be pumped to a dirty water treatment system (see Section 3.4.2.1). The dirty water treatment will not remove all suspended sediment from water removed from cofferdam. This water will be filtered back through a vegetated buffer. It is unknown what the intensity of these releases may be. If the water does not visually exceed baseline turbidity, it will be pumped downstream of the downstream cofferdam. At this same time pumps are used to dewater the work area, a bypass pump will be placed in the stream upstream of the upstream cofferdam.

At the outlet of both work area dewatering and bypass pumps, high velocity (>5 feet per second) water is discharged back into the stream. This water has the potential to disturb the stream substrate and cause a turbidity release. The Proponents will implement scour prevention measures at the discharge site to reduce energy at the point of discharge and prevent elevated turbidity levels (Section 3.4.2).

Once work is complete inside of the cofferdam, the contractor will implement the cofferdam removal procedure (Section 3.4.6). A turbidity release will occur during the cofferdam removal procedure. The upstream cofferdam is slowly breached and water is allowed to slowly fill the previously dewatered work area. The contractor will begin to pump dirty water into the dirty water treatment system as the work areas fills. Turbidity releases will occur when the bottom row of sandbags and plastic sheeting are removed.

A turbidity release may also occur if there is a large rainfall event or pump failure when the cofferdam is in place. The potential release during this event is likely greater than the release expected during the cofferdam removal process. However, MaineDOT does not have monitoring results to inform an understanding of the intensity and duration of a typical release. Under these scenarios, water levels upstream of the project will slowly rise over the upstream cofferdam and slowly fill the work area. Any substrate that was disturbed during project work would be suspended in the water that is introduced into the dry work area. Construction crews will try to minimize releases during such an event by pumping as much turbid water from inside the cofferdam into the dirty water treatment system until the turbidity releases have ceased. The chance of failures will be minimized by sizing of bypass pumps to handle stream flows and use of the low flow window (July 15 through October 1) (AMM #1).

If the contractor chooses to use sheet piles to construct a cofferdam, the turbidity releases for installation will follow the explanation below for pile driving but the operation of the dirty water treatment system and bypass pumping system will be similar to what is explained for a sandbag cofferdam.

MaineDOT completed turbidity monitoring during a culvert installation project in Brownville, Maine (MaineDOT WIN 17870.00). The contractor installed a cofferdam consisting of large industrial sandbags and used a pump bypass system to maintain downstream flow during construction. MaineDOT set up a monitoring station approximately 275 feet downstream of the crossing. Results from the event showed a maximum release of 40 NTU above background that lasted for approximately 5 minutes. Turbidity releases that measured above the background NTU of the stream lasted for approximately 1 hour (MaineDOT, unpublished data). MaineDOT also measured NTU releases that were above background conditions up to approximately 1,000 feet downstream. Placing both sandbags and plastic sheeting were the largest contributors to downstream turbidity releases at this site. The stream substrate consisted of sand, gravel, and cobble at this location. All AMMs described above were used during the cofferdam installation that MaineDOT monitored.

The Proponents predict that cofferdam installation in similar sand, gravel, cobble substrates will result in similar intensities (~40 NTU), similar durations for installation (1 hour)/ removal (1 hour), and similar extents (~1000 feet downstream).

After the cofferdams are installed, the water that remains inside the cofferdam remains turbid. MaineDOT has never monitored turbidity levels inside of the cofferdam. In situations where a fish evacuation (described in Appendix A) cannot occur prior to cofferdam installation, any Atlantic salmon in the cofferdam will not be able to escape from the turbid water. To minimize this effect, MaineDOT or MTA environmental field representatives will conduct a fish evacuation as soon as water levels allow for access.

Though cofferdam placement will result in brief (<1 hour) turbidity releases, these in-water construction elements themselves are AMMs. Specifically, a cofferdam is a turbidity minimization technique used for most in-water work. Without the use of cofferdams for work-area isolation, turbidity limits would be expected to reach limits that would cause fish injury and have habitat impacts.

5.2.1.2 Stream Diversion/Bypass Channel Installation and Removal

The contractor may choose to construct a diversion channel to move clean water around the worksite during construction and maintain downstream flows. Diversion channels are generally used when maintenance of water flow around the site cannot be completed by use of large bore pumps and when maintenance of vehicle traffic is not necessary. Figure 3-17 shows a plan view sketch, and Figure 3-16 is a photograph showing a diversion channel outlet. The contractor will first dig all but the most upstream and downstream portions of the channel. This will be complete in the dry adjacent to the existing stream channel. Construction will include measures to prevent flowing waters in the channel from making contact with exposed banks and soils (AMM #20; see Figure 3-12). The channel will be lined with either plastic sheeting or rock to limit erosion of the material on the channel walls/ bottom. Turbidity releases are not expected during this component of a diversion channel.

Once the majority of the diversion channel is constructed, water flow is moved into the diversion channel. Before water is moved into the diversion channel, the contractor will connect the channel to the stream at the downstream and upstream ends. The contractor will first connect the downstream portion of the channel to the stream by removing the soil between the channel and the stream. The contractor will then install sheeting or channel protection in the portion of the diversion channel connected. The removal of the remaining fill and installation of the channel protective devices will result in a turbidity release. The contractor will repeat these steps to move water flow into the channel at the upstream end. Turbidity releases will result during this activity as well. An upstream and downstream cofferdam will be created to keep all water flowing through the diversion channel.

This technique may also be used to create a diversion channel between two bridge abutments as well as around a work area. In that case, partial cofferdams are used to divert water away from the abutments and into a channel that is located in the middle of the existing stream. Similarly, the channel is protected with sheeting if the existing stream substrate will erode under the increased stream flows. The duration of a bridge replacement often extends beyond the low-flow period in Maine. However, the implementation of a diversion channel will occur during the low-flow period when the constricted channel size is expected to handle the anticipated stream flows.

The Proponents do not have data from a similar installation and removal of a diversion channel. It is reasonable to believe that the intensity and extent of the turbidity effects will be similar to what was observed during monitoring of a cofferdam placement in sand, gravel, and cobble substrate. However, the duration is likely to be longer as there are more construction elements that produce turbidity in diversion channel installation and removal. MaineDOT environmental field representatives have witnessed these activities and find it is reasonable to assume turbidity releases will last for approximately 2 hours during installation and 2 hours during removal.

5.2.1.3 Pile Installation and Removal

Contractors drive piles using two methods: vibratory hammer and impact hammer. A vibratory hammer causes the pile to vibrate and disturb or "liquefy" the soil next to the pile causing the soil particles to lose their frictional grip on the pile. As the soil liquefies, the weight of the pile and hammer push the pile further into the soil. The substrate around the pile becomes unconsolidated during pile driving and causes turbidity releases. An impact hammer uses weight that is constantly dropped on the top of the pile to push the pile further into the soil.

Temporary or old piles are removed using two methods, vibratory extraction and pulling. Vibratory extraction is completed by attaching the same vibratory hammer used for driving the pile and then slowly pulling the pile as the hammer vibrates. A chain is attached to the pile, and a piece of heavy equipment such as an excavator is to remove the pile.

MaineDOT has not monitored turbidity releases from pile driving and removal events. Turbidity monitoring was completed during the driving of sheet piles during a project completed by the City of Brewer. The results from this event showed that driving of sheet piles in a fine-grained substrate resulted in changes of up to 3 NTU above background whenever the hammer was being operated (City of Brewer, Maine, unpublished data).

Washington DOT (WSDOT) has completed turbidity monitoring while driving steel pipe piles in a gravel and cobble substrate. Results showed there were no differences in water quality from background conditions during pile driving activities (WSDOT 2003).

There is considerable variability on times for installing a pile. Factors such as pile size, depth driven, and subsurface conditions can affect duration. On average, the Proponents believe that pipe piles will take approximately 1 hour to install. Sheet piles for a cofferdam will take approximately 30 minutes per pair of sheets. This is also a reasonable duration estimation for round piles and H-piles. This is the Proponents' best estimate for an average duration across all driving conditions.

The studies referenced above for the intensity of turbidity during pile driving did not make conclusions on the extent of the effect. The extent of the turbidity releases would be largely determined by the type of substrate being driven into/removed from as well as water velocity at the pile driving locations. MaineDOT environmental field representatives have observed many pile driving events and never recorded turbidity releases beyond 100 feet downstream of the pile driving activity. Though monitoring data are not available, the Proponents will use MaineDOT's past experience and assume the downstream extent of turbidity releases will not exceed 100 feet. These turbidity releases from pile driving will be short duration localized effects.

5.2.1.4 Geotechnical Drilling

Geotechnical information will need to be collected for stream crossing replacements and scour countermeasure projects. The geotechnical information is collected by using a small diameter (<12 inches) drill to take core samples from the soils underlying the proposed project. The use of this drill in a waterbody will result in turbidity releases.

The Proponents have not collected any turbidity data from the use of a drill this size. It is reasonable to assume that the intensity and extent of turbidity effects from drilling will be similar to those anticipated from pile driving. From field experience, MaineDOT estimates that each drilling event will last up to 2 hours in most subsurface conditions. Following the pile driving expectations, there is a maximum intensity of ~3 NTU and a downstream extent of 100 feet.

5.2.1.5 Riprap Placement

Whenever a cofferdam is created for dry work, activities conducted inside the cofferdam often include riprap placement. However, there are instances where riprap placement will occur in an area relatively remote to a cofferdam or when no activities require a cofferdam. Hence, the Proponents are proposing to place riprap (with no excavation) in streams outside of a cofferdam in certain instances. These instances include bank stabilization, temporary access roads, and when large areas of riprap are required for abutment protection. These instances of riprap placement do not require excavation. The Proponents predict that the intensity, duration, and extent of the turbidity effects associated with riprap placement in these instances will be similar to or less than that found during cofferdam installation or removal. Because of this, the Proponents believe that the creation of a cofferdam would not be necessary or beneficial for placing riprap in these situations. Whenever a cofferdam is created for dry work for other scopes, the cofferdam will be made large enough that riprap placement will occur inside of the cofferdam.

As required, the contractor will develop a plan to have clean riprap delivered to the worksite (AMM #45). When placed in a stream, riprap is typically placed using an excavator bucket. Dump trucks deliver the rock adjacent to the waterbody, and an excavator is used to place a bucket at a time where needed. When the riprap is placed on the stream substrate, the substrate is disturbed and turbidity releases occur. Any riprap that is placed in a waterbody is inspected for cleanliness prior to its installation.

5.2.1.6 Temporary Access Road Installation and Removal

Temporary access roads may be necessary to complete scour countermeasure projects, crossing structures >20 feet in length, and pre-project geotechnical investigations. Temporary access roads will consist of either pile-supported trestles or stone causeways (see action description in Section 3.9). Temporary work trestles will consist of driving piles in the resource and stone causeways involve placement of riprap in waterbodies. If a stone causeway is used, geotechnical fabric will be placed over any areas prior to placement of any causeway material. Geotechnical fabric will minimize turbidity releases and minimize effects to the habitat, due to the stones being placed directly onto the fabric and not the actual habitat itself. Stone causeways will include material that meets MaineDOT specifications for regular or large riprap (MaineDOT Standard Specification 703.26 and 703.28). The anticipated intensity, duration, and extent of those activities will be within the limits explained for pile driving and riprap placement.

5.2.1.7 Heavy Equipment Operation

The Proponents do not have monitoring data of turbidity caused by the use of heavy equipment in streams with stable substrate consisting of cobble, rock, or ledge (AMM #14). These substrates are large and non-erosive. This element will cause a turbidity release, but the Proponents do not anticipate a measureable release of turbidity during heavy equipment operation in a resource with non-erodible substrate. There will be no further discussion of this activity in this portion of the effects analysis.

5.2.1.8 Old Bridge/Structure Demolition

For stream crossing replacements and bridge or culvert removals, there is the potential for turbidity and sedimentation releases and small particles or debris to enter the stream or river during removal of the bridge superstructure (e.g., bridge deck, bridge rail, etc.) and removal of the bridge substructure (e.g., in-water bridge piers and bridge abutments). Pieces of the existing structure (which could range in materials from anywhere from steel, concrete, aggregate, asphalt pavement, etc.) or demolition debris (e.g., saw cut slurry, dust, etc.) can enter and fall into the stream, causing increases in turbidity and sedimentation within the stream or river. For all projects included in this PBA involving demolition work, the contractor is required to submit a demolition plan to MaineDOT for approval prior to the start of demolition, which includes methods of containment that will be used, such as tarps hanging under the bridge (AMM #36).

Contractors use a vibratory extractor, pull the piles out using an excavator, or cut the piles flush with (or below) the surrounding substrate when removing existing support piles/piers. Each of these methods of pier removal, especially vibratory pulling, can generate increases in turbidity, mixing up the substrate and causing the stream to become cloudy. If pulling of piles, which causes the highest level of turbidity increase over the other methods, is chosen, the work will be completed using a BMP specifically for minimizing turbidity, such as a turbidity curtain.

To avoid and minimize turbidity and sedimentation releases into the stream during structure demolition, the Proponents are not proposing to perform any excavation or removal of previously existing abutments outside of a cofferdam (AMM #4).

Additionally, no heavy construction equipment will be allowed to travel into or through any flowing streams with erodible substrate (e.g., sand, silt, and clay). Construction equipment needed for facilitating the demolition of existing structures would be required to remain on the banks of the stream, or on top of the existing roadway, out of the water (AMM #14).

5.2.2 Effects to the Species

Atlantic salmon are adapted to natural fluctuations in water turbidity, such as during high water events from spring runoff. However, a variety of anthropogenic activities can result in short-term increases in sediment deposition and above normal increases in turbidity (Robertson et al. 2007). Potential adverse effects of these increases in turbidity on Atlantic salmon may include the following:

1. reduction in feeding rates;
2. increased mortality;
3. physiological stress, including changes in cardiac output, ventilation rate, and blood sugar level;
4. behavioral avoidance;
5. physical injury (e.g., gill abrasion);
6. reduction in macroinvertebrates as a prey source; and
7. reduction in territorial behavior (Robertson et al. 2006, Newcombe 1994).

Effects on fish from short-term turbidity increases (hours or days) are generally temporary and are reversed when turbidity levels return to background levels (Robertson et al. 2006). Effects to Atlantic salmon worsen with increased levels of turbidity (Newcomb 1994).

In a biological opinion issued by the USFWS Office in Orono Maine for a Natural Resources Conservation Service (NRCS) programmatic consultation request, the USFWS also came to the conclusion that in-water activities from similar activities (culvert replacement using cofferdams and bypass pumping or bypass channels) would result in avoidance of work area by Atlantic salmon parr and adults (USFWS 2011).

The Proponents are proposing to avoid and minimize turbidity effects on parr and adult life stages of Atlantic salmon. This is based on the proposed work window (AMM #1) and other AMMs (Section 3.12). Both parr and adult life stages are highly mobile and likely able to avoid any turbidity releases resulting from the proposed activities. This displacement will cause Atlantic salmon adults to relocate into other holding areas and Atlantic salmon parr to relocate into alternative rearing habitat. Once the projects are complete, the Proponents assume that parr and adults can return to the affected areas.

Newcomb and Jensen (1996) completed a literature review of 80 publications. The review included references on Atlantic salmon as well as other salmonids. They analyzed the effects of turbidity releases on juvenile and adult salmonids and calculated a severity of ill-effects (SE) score for the intensity and duration of turbidity releases. Data from the studies were used to predict species response at concentrations and durations. The SE score can be used to predict the potential species response. Newcomb and Jensen (1996) provide a combined table for both juveniles and adults because data analysis indicated that responses to turbidity between the different life stages were not significantly different. For purposes of analysis in this PBA, we assume the effects among parr and adult life-stages will be similar.

For analysis in this PBA, the biological responses were classified into three major categories. The three categories are behavioral responses, sub-lethal effects, and potential mortality, and they are defined below.

Behavioral response - The range of turbidity releases expected to result in behavioral reactions ranging from a startle response to avoidance.

- 1-20 mg/L for 1 hour
- 1 mg/L for 24 hours

Sub-lethal effects – The ranges of turbidity releases expected to result in sub-lethal effects including stress, reduction in feeding rates, and increased respiration rates.

- 20-22026 mg/L for 1 hour
- 1 mg/L for 6 days

Potential mortality - A higher range of releases has the potential to result in fish mortality.

- >22026 mg/L for 1 hour
- 7 mg/L for 30 months

Newcomb and Jensen (1996) provide a range of turbidity release intensity and durations to help predict potential fish response. The reported values above are meant to display the potential limits in which each response (avoidance, stress, and mortality) can potentially occur.

However, Atlantic salmon eggs and fry are highly sensitive to elevated turbidity and sedimentation in the redds. Embedded sediment in the interstitial spaces in a redd can significantly impede or prevent emergence. Increasing amounts of fine sediments in stream substrates reduces egg-to-fry survival for salmonids (Jensen et al. 2009). Because of the high sensitivity of Atlantic salmon eggs and fry to elevated turbidity and sedimentation, a commitment is being made to avoid any activities that affect redds or spawning habitat.

For the purposes of this PBA, construction elements that are likely to result in turbidity releases on spawning habitat between October 1 and April 30 are prohibited (AMM #12). This is when Atlantic salmon will be depositing eggs and when fry remain in and around the Atlantic salmon redds. This will ensure that activities will not affect eggs or fry (alevins).

Activities covered under this PBA will not affect smolts. The Proponents propose to complete all projects with a duration that allows them to be completed in the standard 2.5-month in-water work window (July 15 through October 1). The exception to the standard work window for activities will be for bridge replacements (i.e., spans > 20'). However, although bridge replacements will have a larger in-water work window than other activities covered under this PBA, it will be a split work window to still avoid in-water work during the smolt out-migration period (April 1 through June 30) (Baum 1997). This is a conservative window derived from timing reported from smolt movement for multiple rivers in Maine. In-water work on bridge replacements will take place between July 15 and April 15 (AMM #2).

MaineDOT conducts limited turbidity monitoring on its projects and relies on data from monitoring events and from other states to predict effects from sediment discharges. The Proponents recognize that the results described above are based on turbidity monitoring, and the guidance presented above in Section 5.2.2 is expressed in quantitative mass measurements (mg/L). Despite the lack of laboratory analysis, the data that MaineDOT has collected likely represent the best available information and will use a 1:1 (Packman, undated) ratio for effect determinations while recognizing its limitations. The effect determinations below attempt to relate the data collected and also represent a conservative analysis that identify potential adverse effects from activities that USFWS has previously determined do not adversely affect Atlantic salmon. While the monitoring that MaineDOT has completed is limited and cannot be directly related the quantitative mass measurements, the Proponents believe the data can be used to reach conclusions about the potential effects to Atlantic salmon.

USFWS (2010) provided data from turbidity monitoring from 8 culvert removal and replacement projects in Washington. Each project had different monitoring locations and durations. The collected data were used to calculate severity of effects (SEs) on adult and juvenile salmonids (using Newcomb and Jensen 1996) as well as habitat (using Anderson et al. 1996) from these efforts. The report does not indicate what, if any, BMPs were used during each of the construction activities, however, Washington DOT has a suite of required turbidity-minimizing BMPs that are required for in-water work. Notes on one of the projects imply a diversion channel was used for water flow maintenance during construction.

- All of the SEs for effects on adult and juvenile salmonids entered into the expected behavioral effect and sub lethal effect thresholds. None of the monitored projects entered into the area of expected lethal effects.
- All of SEs for habitat effects entered into levels that resulted in measured affects to habitat used preference and measured effects to invertebrate communities. None of the SEs elevated into the moderately severe habitat degradation (SE >10) ranges.

5.2.3 Conclusions

The Proponents are proposing to conduct activities that will only have the potential to affect Atlantic salmon parr and adults. The effect determinations below are specific to each life stage of Atlantic salmon. Effect determinations are summarized in Table 5-10. Table 5-2 provides area estimates of impact for activities resulting in turbidity effects that may have adverse effects to Atlantic salmon.

5.2.3.1 Cofferdam Installation and Removal with a Pump Bypass System

Activities that include sandbag cofferdam installation and removal in streams may result in turbidity releases that reach levels of harassment in Atlantic salmon adults and parr. The Proponents have limited data on turbidity releases from specific activities. The limited data indicates that turbidity levels will be above levels that may cause stress and avoidance of Atlantic salmon parr and adults.

The data indicates that turbidity releases between 1 mg/l and 20 mg/l for 1 hour can result in Atlantic salmon avoidance, and fish stress can occur for concentrations over 20 mg/L for 1 hour (Newcombe and Jensen 1996). It is reasonable to believe that Atlantic salmon will avoid the turbidity releases before the onset of physical stress. Because turbidity releases of up to 40 NTU for 2 hours can be expected from this cofferdam installation and removal with a pump bypass system, this activity has the potential to significantly disrupt the normal feeding and sheltering patterns of Atlantic salmon. Atlantic salmon parr may avoid high quality rearing habitat and move to less advantageous habitat. This has the potential to expose parr to increased predation and competition resulting in reduced fitness in parr. Additionally, turbidity releases have some potential to displace adult Atlantic salmon from holding pools. Adult Atlantic salmon hold in deep, cool pools during the summer months. They represent areas where they can minimize predation and reduce the physical stress brought on by increased water temperatures. If adults are displaced from holding pools, increased physiological stress could result as they search for new cool water refugia. Due to the unknown locations of the projects subject to review under this PBA, the availability of other holding pools is unknown. Temporary displacement from cofferdam placement would likely occur if a cofferdam is installed in a portion of a holding pool. Therefore, the Proponents will avoid any effect with the potential to result in Atlantic salmon adults sheltering in holding pools, because the Proponents will avoid all sheltering pools occupied by Atlantic salmon (AMM #47).

Elevated turbidity from sandbag cofferdam installation and removal with a pump bypass system is likely to result in behavioral and sublethal affects and is **likely to adversely affect** Atlantic salmon parr/fry.

The Proponents are implementing AMMs #1, #2 and #47. Therefore turbidity releases are **not likely to adversely affect** Atlantic salmon adults.

5.2.3.2 Stream Diversion/Bypass Channel Installation and Removal

Activities that include bypass channel installation and removal in streams will have similar effects as those described for cofferdam installation and removal with a pump bypass system (see previous section on cofferdam installation). Stream diversion/bypass channel installation and removal may result in turbidity releases that reach levels of harassment in Atlantic salmon adults and parr. The Proponents have limited data on turbidity releases from specific activities. The limited data indicates that turbidity levels will be above levels that may cause stress and avoidance of Atlantic salmon parr and adults.

The avoidance behavior of Atlantic salmon can result in varying affects. The data referenced above states that turbidity releases of between 1 and 20 mg/l for 1 hour can result in Atlantic salmon avoidance and fish stress can be expected for concentrations over 20 mg/L for an hour (Newcombe and Jensen 1996). It is reasonable to believe that Atlantic salmon will avoid the turbidity releases before the onset of physical stress. Because turbidity releases of up to 40 NTUs for 2 hours can be expected from stream diversion/bypass channel installation and removal, this activity has the potential to significantly disrupt the normal feeding and sheltering patterns of Atlantic salmon. Atlantic salmon parr may avoid high quality rearing habitat and move to less advantageous habitat. This has the potential to result in reduced fitness in parr, and increased predation from other competing species. Adult Atlantic salmon may avoid a holding area that is subject to turbidity releases from a stream diversion or bypass channel installation or removal. This may result in Atlantic salmon adults sheltering in holding pools that have warmer water that may cause a reduction in fitness.

Elevated turbidity from bypass channel installation and removal is likely to result in behavioral and sublethal effects and is **likely to adversely affect** Atlantic salmon parr/fry. The Proponents are implementing AMMs #1, #2 and #47. Therefore turbidity releases are **not likely to adversely affect** Atlantic salmon adults.

5.2.3.3 Pile Installation and Removal

Pile driving activities may result in turbidity releases that reach levels of harassment in Atlantic salmon adults and parr. The Proponents have limited data on turbidity releases from specific activities. The limited data indicates that turbidity levels will be above levels that may cause avoidance in Atlantic salmon parr and adults.

Pile installation and removal are likely to have a similar avoidance response from salmon as cofferdam installation and removal. The avoidance behavior of Atlantic salmon can result in varying affects. The data referenced above states that turbidity releases of between 1 and 20 mg/l for 1 hour can result in Atlantic salmon avoidance and fish stress can be expected for concentrations over 20 mg/L for an hour (Newcombe and Jensen 1996). It is reasonable to believe that Atlantic salmon will avoid the turbidity releases before the onset of physical stress. The hydroacoustic effects that result from pile driving are also likely to make Atlantic salmon avoid pile driving activities prior to the onset of sub lethal effects. Because turbidity releases of up to 3 NTU for 6 hours a day can be expected from pile installation/removal, this activity has the potential to significantly disrupt the normal feeding and sheltering patterns of Atlantic salmon. Atlantic salmon parr may avoid high quality rearing habitat and move to less advantageous habitat. This has the potential to result in reduced fitness in parr, and increased predation from other competing species. Adult Atlantic salmon may avoid a holding area that is subject to turbidity releases from pile installation and removal. This may result in Atlantic salmon adults sheltering in holding pools that have warmer water that may cause a reduction in fitness.

Turbidity releases and elevated turbidity from pile driving activities are likely to result in behavioral and sublethal effects and are **likely to adversely affect** Atlantic salmon parr/fry. The Proponents are implementing AMMs #1, #2 and #47. Therefore turbidity releases are **not likely to adversely affect** Atlantic salmon adults.

5.2.3.4 Geotechnical Drilling

Drilling activities may result in turbidity releases that reach levels of harassment in Atlantic salmon adults and parr. The Proponents have limited data on turbidity releases from specific activities. The limited data indicate that turbidity levels will be above levels that may result in avoidance behavior exhibited by Atlantic salmon parr and adults.

Conclusions from drilling activities are the same as explained in the pile driving section above.

Elevated turbidity from drilling is likely to result in behavioral and sublethal effects and is **likely to adversely affect** Atlantic salmon parr/fry. The Proponents are implementing AMMs #1, #2 and #47. Therefore turbidity releases are **not likely to adversely affect** Atlantic salmon adults.

5.2.3.5 Riprap Placement

Activities that involve riprap placement in streams may result in turbidity releases that reach levels of harassment in Atlantic salmon adults and parr. The Proponents have limited data on turbidity releases from specific activities. The limited data indicates that turbidity levels will be above levels that may cause stress and avoidance of Atlantic salmon parr and adults.

The avoidance behavior of Atlantic salmon can result in varying affects. The data referenced above states that turbidity releases of between 1 and 20 mg/l for 1 hour can result in Atlantic salmon avoidance and fish stress can be expected for concentrations over 20 mg/L for an hour (Newcombe and Jensen 1996). It is reasonable to believe that Atlantic salmon will avoid the turbidity releases before the onset of physical stress. Because turbidity releases of up to 11 NTU for 4 hours can be expected from riprap placement, this activity has the potential to significantly disrupt the normal feeding and sheltering patterns of Atlantic salmon. Atlantic salmon parr may avoid high quality rearing habitat and move to less advantageous habitat. This has the potential to result in reduced fitness in parr, and increased predation from other competing species. Adult Atlantic salmon may avoid a holding area that is subject to turbidity releases from the placement of riprap. This may result in Atlantic salmon adults sheltering in holding pools that have warmer water that may cause a reduction in fitness.

Turbidity releases and elevated turbidity from the placement of riprap are likely to result in behavioral and sublethal effects and are **likely to adversely affect** Atlantic salmon parr/fry. The Proponents are implementing AMMs #1, #2 and #47. Therefore turbidity releases are **not likely to adversely affect** Atlantic salmon adults.

5.2.3.6 Temporary Access Road Installation and Removal

Temporary access creation contains elements of riprap placement and pile driving. Following the above effect determinations for those activities, temporary access roads are **likely to adversely affect** Atlantic salmon parr/fry. The Proponents are implementing AMMs #1, #2 and #47. Therefore, turbidity releases are **not likely to adversely affect** Atlantic salmon adults.

5.2.3.7 Old Bridge/Structure Demolition

Elevated turbidity from old bridge/structure demolition is likely to result in behavioral effects and is **not likely to adversely affect** Atlantic salmon parr/fry or adults, due to implementation of AMMs #1, 2 & 47.

Table 5-1. Effect determinations for those construction activities or components that have the potential to result in elevated levels of turbidity.

	Atlantic Salmon Life Stage				
Activity or Component	**Eggs**	**Fry**	**Parr**	**Smolt**	**Adult**
Cofferdam installation and removal with a pump bypass system	NE	NE	LAA	NE	NLAA
Stream diversion/bypass channel installation and removal	NE	NE	LAA	NE	NLAA
Pile installation and removal	NE	NE	LAA	NE	NLAA
Geotechnical drilling	NE	NE	LAA	NE	NLAA
Riprap placement	NE	NE	LAA	NE	NLAA
Temporary access road installation and removal	NE	NE	LAA	NE	NLAA
Old bridge/structure demolition	NE	NE	NLAA	NE	NLAA

Table 5-2. Area estimates for activities resulting in turbidity effects that may have adverse effects on Atlantic salmon.

Activity or Component	Estimated Number of Projects	Estimated Area of Impact Per Project (Feet^2)	Total Estimated Area (Feet^2)
Cofferdam installation and removal with a pump bypass system	45	10,000	450,000
Stream diversion/bypass channel installation and removal	5	10,000	50,000
Pile installation and removal	20	1,000	20,000
Geotechnical drilling	15	1,000	15,000
Riprap placement	15	10,000	150,000
Temporary access road installation and removal	15	10,000	150,000
Old bridge/structure demolition	48[8]	1,000	48,000

5.2.4 Effects to Critical Habitat

Turbidity releases can result in sedimentation of the substrate that is important for multiple Atlantic salmon life stages. Sedimentation can result in increased substrate embeddedness, which is the measure of the extent a rock particle is buried or embedded in the substrate. Bjornn et al. (1974, 1977 as cited in NMFS and USFWS 2005) found that embedding cobble substrates in sediment reduced the amount of habitat available for juvenile salmonids (salmon and trout) and affected their density and distribution. Substrate embeddedness may block juvenile salmon from accessing winter sheltering habitat and lower survival rates (Atkinson and Mackey 2005 as cited in NMFS and USFWS 2005). Consequently, the loss of shelter in gravel and cobble interstitial spaces can increase the incidence of predation on juvenile salmon (McCrimmon 1954 as cited by Cordone and Kelley 1961). The loss of interstitial spaces in the stream substrate can also reduce stream productivity and food sources for Atlantic salmon parr that are rearing.

5.2.4.1 Spawning and Rearing PCE

The physical and biological features of the Spawning and Rearing (SR) PCE for Atlantic salmon critical habitat are as follows:

- SR 1. Deep, oxygenated pools and cover (e.g., boulders, woody debris, vegetation, etc.), near freshwater spawning sites, necessary to support adult migrants during the summer while they await spawning in the fall.
- SR 2. Freshwater spawning sites that contain clean, permeable gravel and cobble substrate with oxygenated water and cool water temperatures to support spawning activity, egg incubation, and larval development.

[8] Estimate includes the demolition of existing structures on bridge replacement projects and the permanent removal of structures without replacement.

- SR 3. Freshwater spawning and rearing sites with clean, permeable gravel and cobble substrate with oxygenated water and cool water temperatures to support emergence, territorial development and feeding activities of Atlantic salmon fry.
- SR 4. Freshwater rearing sites with space to accommodate growth and survival of Atlantic salmon parr.
- SR 5. Freshwater rearing sites with a combination of river, stream, and lake habitats that accommodate parr's ability to occupy many niches and maximize parr production.
- SR 6. Freshwater rearing sites with cool, oxygenated water to support growth and survival of Atlantic salmon parr.
- SR 7. Freshwater rearing sites with diverse food resources to support growth and survival of Atlantic salmon parr.

Spawning and Rearing PCEs are highly dependent on stream substrate and river morphology. Excessive turbidity releases could potentially fill pools necessary for PCE SR 1. Clean gravel and cobble is essential for PCE SR 2 and SR 3, and turbidity releases can fill voids between larger substrate. PCEs SR 4-7 are all PCEs that relate to salmon parr rearing. Sediment deposited in clean gravel and cobble substrates that provide rearing habitat can reduce habitat values due to its effect on stream invertebrate productivity. Sediments may also fill interstitial spaces between rocks that are used for sheltering juvenile Atlantic salmon.

Severity

Anderson et al. (1996) used the same methods developed by Newcomb and Jensen (1996) to calculate a severity of effects (SE) scale for effects on salmonid habitat. The regression equation is below:

$$Z = 0.032+0.978 \text{ Ln (concentration in mg/L)} + 1.008 \text{ Ln (duration in hours)}$$

Z = Severity of ill-effect (SE)

Anderson et al. (1996) also provided a classification of the following corresponding SE values.

SE = 3 Measured change in habitat preference

SE = 7 Moderate habitat degradation- measured by a change in the invertebrate community

SE = 10 Moderately severe habitat degradation, as defined by measureable reductions in the productivity of habitat for extended periods (months) or over a large area (kilometers)

SE = 12 Severe habitat degradation – as measured by long-term (years) alterations in the ability of existing habitats to support fish or invertebrates

SE = 14 Catastrophic or total destruction of habitat in the receiving environment

Duration

Habitat that is subject to events resulting in SEs <10 are likely to recover and be recolonized by fish and invertebrates after the deposited sediments have been removed. The recovery period is dependent on the particle size to be flushed from the system and the stream flow intensity and duration of flows required for this event (Anderson et al. 1996). The projects and activities proposed in this PBA have a wide range of sediments and stream sizes. It is reasonable to assume that spring flows resulting from snow melt (generally in April in Maine) will provide a flushing flow and restore habitat affected by sedimentation to pre-project conditions. This will result in a temporary effect on these systems for 6 to 10 months (July-April).

Conclusions

Effect determinations for the spawning and rearing PCE are discussed in the following sections and summarized in Table 5-3.

Cofferdam Installation and Removal with a Pump Bypass System

Turbidity releases and intensity and durations can result in releases of up to 40 NTU that last for a 1-hour period during cofferdam installation and removal (as explained above). Following the equation above, these releases will result in an SE that is 3.64.

Effects to critical habitat are evaluated by determining the likelihood that the effect will influence the function and role of the critical habitat. The data referenced above state the calculated SE will result in a measurable change in habitat preference. It is reasonable to believe that Atlantic salmon will seek alternative rearing habitat with properly functioning Spawning and Rearing PCEs. These effects will significantly affect the function of the Atlantic salmon critical habitat temporarily by reducing productivity and feeding and sheltering opportunities.

Turbidity releases from cofferdam installation and removal with a pump bypass system are **likely to adversely affect** the spawning and rearing PCE temporarily.

Stream Diversion/Bypass Channel Installation and Removal

Turbidity releases and intensity and durations can result in releases of up to 40 NTU that last for a 2 hour period during stream diversion/bypass channel installation and removal (as explained above). Following the equation above, these releases will result in an SE that is 4.33.

Effects to critical habitat are evaluated by determining the likelihood that the effect will influence the function and role of the critical habitat. The data referenced above states the calculated SE will result in a measurable change in habitat preference. It is reasonable to believe that Atlantic salmon will seek alternative rearing habitat with properly functioning Spawning and Rearing PCEs. These effects will temporarily significantly affect the function of the Atlantic salmon critical habitat by reducing productivity as well as feeding and sheltering opportunities.

Turbidity releases from stream diversion/bypass channel installation and removal are **likely to adversely affect** the spawning and rearing PCE temporarily.

Pile Installation and Removal

Turbidity releases and intensity and durations can result in releases of up to 3 NTU that last for a 6 hour period during pile driving (as explained above). Following the equation above, these releases will result in an SE that is 2.92.

Effects to critical habitat are evaluated by determining the likelihood that the effect will influence the function and role of the critical habitat. The data referenced above states the calculated SE will not result in a measurable change in habitat preference. Because the effect to the critical habitat is not measureable, these effects will not significantly affect the function of the Atlantic salmon critical habitat.

Turbidity releases from pile installation and removal are **not likely to adversely affect** the spawning and rearing PCE.

Geotechnical Drilling

Turbidity releases and intensity and durations can result in releases of up to 3 NTU that last for a 2 hour period during drilling (as explained above). Following the equation above, these releases will result in an SE that is 1.82.

Effects to critical habitat are evaluated by determining the likelihood that the effect will influence the function and role of the critical habitat. The data referenced above states the calculated SE will not result in a measurable change in habitat preference. Because the effect to the critical habitat is not measureable, these effects will not significantly affect the function of the Atlantic salmon critical habitat.

Turbidity releases from drilling are **not likely to adversely affect** the spawning and rearing PCE.

Riprap Placement

Turbidity releases and intensity and durations can result in releases of up to 11 NTU that last for a 4 hour period during drilling (as explained above). Following the equation above, these releases will result in an SE that is 3.82.

Effects to critical habitat are evaluated by determining the likelihood that the effect will influence the function and role of the critical habitat. The data referenced above states the calculated SE will result in a measurable change in habitat preference. It is reasonable to believe that Atlantic salmon will seek alternative rearing habitat with properly functioning Spawning and Rearing PCEs. These effects will significantly affect the function of the Atlantic salmon critical habitat by reducing productivity as well as feeding and sheltering opportunities.

Turbidity releases from the placement of riprap is **likely to adversely affect** the spawning and rearing PCE temporarily.

Temporary Access Road Installation and Removal

The discussions for the SE for both pile installation and removal and riprap installation and removal, provided above, apply to temporary access road creation and removal. Temporary access creation and removal is **likely to adversely affect** the spawning and rearing PCE.

Old Bridge/Structure Demolition

Old bridge/structure demolition is **not likely to adversely affect** the spawning and rearing PCE.

5.2.4.2 Migration PCE

The physical and biological features of the Migration (M) PCE for Atlantic salmon critical habitat are as follows:

- M 1. Freshwater and estuary migratory sites free from physical and biological barriers that delay or prevent access of adult salmon seeking spawning grounds needed to support recovered populations.
- M 2. Freshwater and estuary migration sites with pool, lake, and in-stream habitat that provide cool, oxygenated water and cover items (e.g., boulders, woody debris, and vegetation) to serve as temporary holding and resting areas during upstream migration of adult salmon.
- M 3. Freshwater and estuary migration sites with abundant, diverse native fish communities to serve as a protective buffer against predation.
- M 4. Freshwater and estuary migration sites free from physical and biological barriers that delay or prevent emigration of smolts to the marine environment.

- M 5. Freshwater and estuary migration sites with sufficiently cool water temperatures and water flows that coincide with diurnal cues to stimulate smolt migration
- M 6. Freshwater migration sites with water chemistry needed to support sea water adaptation of smolts.

Severe turbidity releases have the potential to fill pools and alter habitat necessary for resting areas as stated in PCE M 2. All of the SEs calculated above do not correspond with habitat effects that are measurable over time and extent and that have a lasting moderate effect (SE ≥10). Turbidity releases are not expected to be severe enough to create physical barriers to migration for any life stage of Atlantic salmon. The Proponents are not proposing to conduct activities that will result in impacts on Atlantic salmon smolts. In-water work is prohibited when smolt migration occurs between April 1 and June 30. There will be no effect on the PCE M 4 and M 6 as a result of any activities proposed in this PBA.

Turbidity releases can also affect native fish communities that are present in streams, rivers, and lakes where Atlantic salmon may be migrating. Each one of these life stages presents specific conservation needs and has different life histories and habitat requirements than the ones for Atlantic salmon that are explained in this document. Protections for all of these species are required under various state and federal laws as follows: Maine’s Natural Resource Protection Act, the Clean Water Act of 1972, the Magnuson-Stevens Fishery Conservation and Management Act, and the Fish and Wildlife Coordination Act. The existing laws and regulations ensure that the Proponents to do not adversely affect the function and conservation role of cover species (PCE M 3, listed above).

Conclusions

Elements important for the migration PCE are less dependent on the embeddedness and substrate composition than the physical and biological features of the Spawning and Rearing PCE. The changes in turbidity and sedimentation due to the activities and components proposed in this PBA and as stated above are **not likely to adversely affect** the conservation function or role of the migratory PCE for Atlantic salmon critical habitat (Table 5-3).

Table 5-3. Effect determinations of turbidity and sedimentation on PCEs of Atlantic salmon critical habitat resulting from the implementation of each proposed activity.

Stressor: Turbidity and Sedimentation	**Critical Habitat Effect**		**Overall Critical Habitat Effect Determination**
Activity or Component	**Spawning and Rearing PCE**	**Migration PCE**	
Cofferdam installation and removal with a pump bypass system	LAA	NLAA	LAA
Stream diversion/bypass channel installation and removal	LAA	NLAA	LAA
Pile installation and removal	NLAA	NLAA	NLAA
Geotechnical drilling	NLAA	NLAA	NLAA
Riprap placement	LAA	NLAA	LAA
Temporary access road installation and removal	LAA	NLAA	LAA
Old bridge/structure demolition	NLAA	NLAA	NLAA

5.3 Temporary Migration and Movement Barriers[9]

The most common temporary barrier to Atlantic salmon migration and movement is cofferdams. Cofferdams are proposed for all stream crossing replacements, bridge or culvert removals, culvert end resets and extensions, scour countermeasures, a portion of the bridge maintenance projects, and invert line and slip line culvert rehabilitation projects. Cofferdams themselves are measures used to avoid turbid water releases, but they can block fish passage and other stream processes during construction. They can also block passage for other aquatic organisms that use the streams and stream corridors. For the purposes of analysis, parameters necessary to determine “fish passage” will be considered 6 inches or more of water depth and water velocities of approximately 2 feet per second (FPS) and up to 4 FPS for short burst for juvenile salmon. Adult Atlantic salmon require approximately 1 foot of water depth and can swim up to 6.5 FPS (Peake 2008).

Culvert replacements and removals, culvert end resets and extensions, and invert line and slipline culvert rehabilitations typically require cofferdams that block the entire stream flow. Bridge replacements and bridge removals typically require a cofferdam on one or both sides of the stream. Scour countermeasures may employ a full stream width cofferdam on smaller streams (< 30 feet BFW) and cofferdams on both sides of the streams for any larger flows. As for bridge maintenance activities, it depends on the nature of the maintenance as to whether or not cofferdams are used. All these scenarios may affect fish passage and stream processes during construction.

[9] Note that unlike Section 5.2, this section breaks down the effects based on each main construction activity, rather than each stressor. The associated stressors can be found in the Effects Summary Table (Table 5-16).

Temporary work access and temporary bridges (in the form of trestles (via pile installation) or stone causeways (i.e., riprap/wet road)) are another common temporary barrier to Atlantic salmon migration and movement. Temporary work access and temporary bridges are a common element to several main construction activities proposed in this PBA (e.g., stream crossing replacements ≤ 20' (culvert replacements), stream crossing replacements > 20' (bridge replacements), bridge and culvert removals, and bridge maintenance), but have been broken out into their own main construction activity for purposes of analysis in this PBA.

Old bridge/structure demolition (particularly from removal of in-water piers) is another temporary barrier to Atlantic salmon migration and movement, where the immediate demolition or removal is taking place.

The estimated duration and extent of stream affected will vary depending on the activity. Table 5-4 shows the expected duration of each activity, based on history of past projects with similar scopes.

Table 5-4. Estimated durations of in-water work for proposed activities.

Activity or structure type	Typical in-water Construction Duration (working days)
Stream Crossing Replacement (Culverts):	--
< 10 feet	3 to 5 days
10 to ≤ 20 feet	10 to 60 days
Stream Crossing Replacement (Bridges):	--
< 20 feet	75 to 250 days
Bridge and Culvert Removals	10 to 30 days
Culvert End Resets and Extensions	1 to 2 days
Bridge Scour Countermeasures	15 to 30 days
Bridge Maintenance	2 to 30 days
Temporary Work Access and Temporary Bridges	1 to 40 days
Invert Line and Slipline Culvert Rehabilitation	10 to 25 days

5.3.1.1 Culvert Replacements

MaineDOT has proposed two different methods of water control with cofferdam installation: bypass pumping and diversion channels. Neither of these methods will allow for aquatic habitat connectivity during construction. Although a diversion channel may allow for some fish passage, it is not feasible to design the channels for aquatic habitat connectivity due to site restrictions and traffic maintenance requirements. For the purpose of this PBA, the Proponents assume both methods will create temporary barriers to aquatic habitat connectivity. These temporary barriers will be in place for roughly 3 to 5 days for culverts <10 feet wide and 10 to 60 days for culverts 10 to 20 feet wide. These barriers will occur during the standard in-water work window when streams are typically experiencing low-flow conditions.

5.3.1.2 Bridge Replacements

Effects on aquatic habitat connectivity during construction can vary when water is allowed to flow between the abutments during construction. Abutment designs (concrete mass abutments) that require excavation typically require cofferdams (within which the abutment work is taking place) to extend more than 25 feet into the stream channel to ensure that workers inside the cofferdam/excavated area meet the federal safety regulations for slide slopes. If the bridge design includes a vertical wall abutment attached to a ledge that is within 5 feet of the surface, stream channel effects during construction will be much less. Bridge replacement projects that require in-water work outside of the standard in-water work window will provide for fish passage during construction.

For the purposes of this PBA and based on history and experience with past bridge replacement projects, a bridge replacement with a total span of <100 feet in width has the potential to affect aquatic habitat connectivity and fish passage during construction (i.e., forms a partial barrier) due to the potential for abutment cofferdams to significantly protrude into and pinch the stream channel. Bridges ≥ 100 feet in width typically do not have the potential to affect aquatic habitat connectivity and fish passage, because the rivers/streams are large enough to accommodate the construction work (cofferdams) and provide for adequate fish passage.

5.3.1.3 Bridge and Culvert Removals

This activity has a similar description to bridge replacements and culvert removals as stated above, with the exception of no installation of a new structure. This is a recovery activity.

5.3.1.4 Culvert End Resets and Extensions

Culvert end resets and extensions require installation and removal of cofferdams with a pump bypass system, installation of water diversions and dewatering of the work area. The installation of the stream diversion or bypass channel essentially blocks or limits aquatic organism fish passage for the duration of construction. Atlantic salmon and other aquatic organisms moving through the area will not be allowed to pass through. However, culvert end resets and extensions typically are finished within 1 to 2 days and the in-water portion of the work takes place only several hours, having negligible consequences on aquatic habitat.

5.3.1.5 Bridge Scour Countermeasures

The construction process for a bridge scour countermeasure is described in Section 3.7. Cofferdams will be constructed around each abutment and occupy up to half of the stream channel at a time. Fish passage for Atlantic salmon parr and adults at normal flows will be maintained during construction. Water velocities are increased and passage is not likely available to all life stages of other stream resident fish species and aquatic organisms.

When a scour countermeasure project requires a full stream width cofferdam system (which occurs approximately 25% of the time), aquatic habitat connectivity will be blocked for the duration of construction (i.e., 15 to 30 days). The Proponents anticipate that 25% of scour countermeasures activities will require a cofferdam system that covers the full width of a stream.

5.3.1.6 Bridge Maintenance

For bridge maintenance activities involving underwater grout bag repair, cofferdams are not typically used and turbidity curtains are more common. For bridge maintenance activities involving concrete abutment and pier repairs, cofferdams are used if the work is taking place below the water level at the time of construction. Cofferdams employed for use on bridge maintenance activities typically do not block the entire stream.

5.3.1.7 Temporary Work Access and Temporary Bridges

The construction process for installation and removal of temporary work access and temporary bridges is described in Section 3.9. Temporary work access or temporary bridges are either supported by piles (also known as a temporary trestle/work platform or temporary bridge) or comprised of large, clean, non-erodible material (also known as a temporary stone causeway). Both temporary trestles and temporary stone causeways protrude into the stream and extend a portion of the stream's width, but only to the extent necessary to facilitate construction. To limit the protrusion of temporary stone causeways into the stream or river, the Proponents propose to only allow temporary stone causeways extend up to 25 percent of the BFW of the stream/river (AMM #32). Additionally, all temporary fill must be removed in its entirety after the construction work is completed (AMM #3). Temporary bridges extend the entire stream width, usually located within 200 feet upstream or downstream of the existing bridge. While temporary work access and temporary bridges extend into the existing river/stream, they will not be a full barrier or block aquatic organism passage or aquatic habitat connectivity.

5.3.1.8 Invert Line and Slipline Culvert Rehabilitation

The construction process for invert line and slipline culvert rehabilitation projects is outlined in Section 3.10. Similarly to culvert end resets and extensions, invert line and slipline rehabilitation projects require installation and removal of cofferdams with a pump bypass system, installation of water diversions and dewatering of the work area. Installation of the stream diversion or bypass channel essentially blocks or limits aquatic organism fish passage for the duration of construction. Atlantic salmon and other aquatic organisms moving through the area will not be allowed to pass through.

5.3.1.9 Biological Response

Estimated effects associated with biological responses will be analyzed by HUC-10 watershed on the standard reporting form. Tier 1 priority areas are the primary areas where Atlantic salmon presence is expected, though they are not expected in all Tier 1 priority areas. Atlantic salmon parr and juveniles are not expected in most Tier 2 priority areas. A temporary fish passage barrier (i.e., cofferdam, temporary access (stone causeway or trestle made of piles) or temporary bridge, or bypass channel or stream diversion) will have no effect in the areas where any life stage of Atlantic salmon is not expected to be present.

Atlantic salmon parr rear in freshwater streams for up to 4 years before becoming a smolt and migrating out to the ocean. While rearing, Atlantic salmon parr will move around freshwater streams in search of new feeding locations, utilizing different habitats for seasonal survival. In the low flow period, Atlantic salmon parr are actively feeding and moving around stream systems on a daily basis. Though Atlantic salmon are known to be territorial feeders, movement in freshwater streams is also an important part of their life history. Blocking these migrations and movements could have varying effects. It may lead to a high density of parr that cannot disperse to less densely populated habitat. This may result in decreased fitness of Atlantic salmon. Parr may also be seeking cooler water in the headwaters of stream systems during the warmer months that coincide with the July 15 through October 1 standard in-water work window. Cofferdams may inhibit access to this cooler water, exposing parr to warmer water temperatures and decrease fitness. Loss of the ability to freely migrate may also make Atlantic salmon parr more subject to predation. The exposure duration of Atlantic salmon parr to these effects will be determined by the duration of the cofferdam use. The degree of effects will also be influenced by whether the cofferdam is a complete or partial barrier.

Adult Atlantic salmon primarily migrate into freshwater systems in the spring. During the proposed work window, Atlantic salmon adults are likely to be in holding pools waiting for cooler fall temperatures and spawning season. When water temperatures cool, adult Atlantic salmon exhibit highly migratory behavior in freshwater streams and rivers. This coincides with the close of the in-water work window (October 1) for those activities that can be completed in that time frame. Bridge replacements that require an extended in-water work window will provide for fish passage during construction.

The remediation of any temporary effects to fish passage and stream processes during construction can be accomplished by removal of the cofferdams as soon as the project is complete (AMM #22).

5.3.1.10 Habitat Response

Effects from temporary migration and movement barriers effects will only be realized by Atlantic salmon, the species, not the habitat itself. Therefore, temporary migration and movement barriers such as cofferdams and temporary access were considered to have **no effect** on critical habitat.

5.3.1.11 Conclusions

Culvert Replacements

Placement of cofferdams and bypass pumping and diversion channels to replace a culvert will result in movement barriers to Atlantic salmon parr and adults. These barriers to movement can be in place up to 60 days. Effects to Atlantic salmon during this time include behavioral responses, such as avoidance, and altered sheltering and feeding patterns of parr. Adult Atlantic salmon may avoid the work area during construction until after the in-water work is completed.

Cofferdam installation, removal, and bypass pumping and diversion channels will result in behavioral effects, increased chance of harm through predation, and potential exposure to stressful water quality. Cofferdam placements, bypass pumping, and diversion channels for culvert replacements **are likely to adversely affect** Atlantic salmon parr and adults in Tier 1 priority areas and Tier 2 priority areas where Atlantic salmon occur.

Stream crossing replacements in Tier 2 priority areas will not result in a loss of fish passage or are located in watersheds when Atlantic salmon presence in any life stage is unlikely. Culvert replacements in Tier 2 priority areas without Atlantic salmon presence will have **no effect** on Atlantic salmon.

Bridge Replacements

Placement of cofferdams to complete bridge replacements will result in barriers to movement of Atlantic salmon parr and adults. These barriers to movement can be in place for 75 to 250 days. Effects include behavioral responses, such as avoidance, and altered sheltering and feeding patterns of rearing parr. These behavioral responses could have consequences on lifetime fitness, such as increased risk of predation, reduced foraging ability, and decreased success in locating suitable thermal refugia.

Cofferdam placement will result in behavioral effects and increased chance of harm through predation. Cofferdam placement for bridge replacements that are <100 feet wide are **likely to adversely affect** Atlantic salmon parr and adults in Tier 1 priority areas. Bridge replacements that are ≥100 foot in width will provide for a migratory pathway during construction. Therefore, bridge replacements that are ≥100 feet in width are **not likely to adversely affect** Atlantic salmon parr and adults migration and movements in Tier 1 priority areas and Tier 2 priority areas where Atlantic salmon occur.

Bridge replacements are not expected to result in a loss of fish passage or are located in watersheds where Atlantic salmon presence in any life stage is unlikely. Bridge replacements in Tier 2 priority areas where Atlantic salmon are not likely to occur will have **no effect** on Atlantic salmon.

Bridge and Culvert Removals

This activity has a similar description to bridge replacements and culvert removals as stated above, with the exception of no installation of a new structure. This is a recovery activity. Cofferdam placements and old structure demolitions for culvert replacements are **likely to adversely affect** Atlantic salmon parr and adults in Tier 1 priority areas and Tier 2 priority areas where Atlantic salmon occur.

Similarly as stated above, cofferdam placement will result in behavioral effects and increased chance of harm through predation. For bridge removal projects, cofferdams will only be used around the abutments, not around any in-water piers. Cofferdam placement for bridge removals that are <100 feet wide are **likely to adversely affect** Atlantic salmon parr and adults in Tier 1 priority areas. Bridge removals that are ≥100 foot in width will provide for a migratory pathway during construction. Therefore, bridge removals that are ≥100 feet in width are **not likely to adversely affect** Atlantic salmon parr and adults migration and movements in Tier 1 priority areas and Tier 2 priority areas where Atlantic salmon occur.

Culvert End Resets and Extensions

Placement of cofferdams to complete culvert end resets and extensions may result in varying levels of effects to Atlantic salmon parr and adults. These barriers to movements can be in place for 1 to 2 days.

Cofferdam placement will result in behavioral effects and increased chance of harm through predation. Cofferdam placements for culvert end resets and extensions **are not likely to adversely affect** Atlantic salmon parr and adults in Tier 1 priority areas or anywhere Atlantic salmon presence is expected. Because this barrier is in place for such a short duration, it is not likely to result in consequences to lifetime fitness such that an individual could not recover.

Culvert end resets and extensions are unlikely to affect Atlantic salmon migration or movement due to the rare occurrence of fish passage or individuals. Tier 2 priority areas are located in watersheds where Atlantic salmon presence in any life stage is unlikely. Therefore, culvert end resets and extensions will have **no effect** on Atlantic salmon in Tier 2 priority areas where they do not occur.

Bridge Scour Countermeasures

Placement of cofferdams to complete scour countermeasure projects may result in varying levels of effects to Atlantic salmon parr and adults. These barriers to movements can be in place for anywhere from 15 to 30 days.

Cofferdam placement will result in behavioral effects, increased chance of harm through predation, and potential exposure to stressful water quality. Though some levels of fish passage may be maintained, Cofferdam placements for scour countermeasures **are likely to adversely affect** Atlantic salmon parr and adults in Tier 1 priority areas and Tier 2 priority areas where Atlantic salmon may occur.

Scour countermeasures in Tier 2 priority areas where Atlantic salmon are not expected to be present will not impact Atlantic salmon migration or are located in watersheds where Atlantic salmon presence in any life stage is unlikely. Therefore, scour countermeasures will have **no effect** on Atlantic salmon in Tier 2 priority areas where Atlantic salmon are unlikely to occur.

Bridge Maintenance

For bridge maintenance activities involving underwater grout bag repair, cofferdams are not typically used and turbidity curtains are more common. For bridge maintenance activities involving concrete abutment and pier repairs, cofferdams are used if the work is taking place below the water level at the time of construction. Cofferdams employed for use on bridge maintenance activities typically do not block the entire stream and **are not likely to adversely affect** Atlantic salmon parr and adults in Tier 1 or Tier 2 priority areas or anywhere Atlantic salmon presence is expected.

Invert Line and Slipline Culvert Rehabilitation

Invert line and slipline rehabilitation projects require installation and removal of cofferdams with a pump bypass system, installation of water diversions and dewatering of the work area. Installation of the stream diversion or bypass channel essentially blocks or limits aquatic organism fish passage for the duration of construction. Atlantic salmon and other aquatic organisms moving through the area will not be allowed to pass through. Invert line and slipline culvert rehabilitation projects **are not likely to adversely affect** Atlantic salmon parr and adults in Tier 2 priority areas or anywhere Atlantic salmon presence is expected. Insert language here.

Temporary Work Access and Temporary Bridges

The construction process for installation and removal of temporary work access and temporary bridges is described in Section 3.9. Temporary work access or temporary bridges are either supported by piles or comprised of large, clean, non-erodible material. Both temporary trestles and temporary stone causeways protrude into the stream and extend a portion of the stream's width, but only to the extent necessary to facilitate construction. To limit the protrusion of temporary stone causeways into the stream or river, the Proponents propose to only allow temporary stone causeways extend up to 25 percent of the BFW of the stream/river (AMM #32). Additionally, all temporary fill must be removed in its entirety after the construction work is completed (AMM #3). Temporary bridges extend the entire stream width, usually located within 200 feet upstream or downstream of the existing bridge. While temporary work access and temporary bridges extend into the existing river/stream, they will not be a full barrier or block aquatic organism passage or aquatic habitat connectivity.

Placement of piles or stone for temporary trestles/bridges/causeways will result in behavioral effects and increased chance of harm through predation. Temporary pile placement/removal or temporary stone placement/removal for all activities (except for bridge removals or replacements ≥100 feet) are **likely to adversely affect** Atlantic salmon parr and adults in Tier 1 priority areas. Bridge removals or replacements that are ≥100 feet in width will provide for a migratory pathway during construction. Therefore, bridge removals or replacements that are ≥100 feet in width are **not likely to adversely affect** Atlantic salmon parr and adults migration and movements in Tier 1 priority areas and Tier 2 priority areas where Atlantic salmon occur.

Table – Effect determinations of temporary migration and movement barriers on Atlantic salmon and critical habitat from the implementation of each proposed activity.

Stressor: Temporary Migration and Movement Barrier **Activity**	**Critical Habitat Effect**	**Species Effect**
Culvert Replacements	NE	LAA
Bridge Replacements Total span <100’ in width Total span ≥100’ in width	NE NE	LAA NLAA
Bridge and Culvert Removals Culvert Removals Bridge Removals, total span <100’ in width Bridge Removals, total span ≥100’ in width	NE	LAA LAA NLAA
Culvert End Resets and Extensions	NE	NLAA
Bridge Scour Countermeasures	NE	LAA
Bridge Maintenance	NE	NLAA
Invert Line and Slipline Culvert Rehabilitation	NE	NLAA
Temporary Work Access and Temporary Bridges *All activities except for bridge removals and replacements with a total span ≥100’ in width *Bridge removals and replacements with a total span ≥100’ in width	NE	LAA NLAA

5.4 Temporary Displacement from Cofferdam Activities

In the Effects Summary Table 5-17 below, temporary displacement from cofferdam activities is indicated as an effect, not a stressor or associated activity. For purposes of detailing displacement, this section has been included in the PBA. Atlantic salmon parr are highly territorial and actively defend their feeding territory to maximize their opportunity to capture prey items, such as aquatic invertebrates. Territory size increases with fish age and fish size. Atlantic salmon parr may be temporarily displaced from their territory by construction activities, particularly the dewatering of a section of stream, may be more vulnerable to predators, may be less able to capture prey, and may experience stress while looking for another suitable, unoccupied area of stream in which to establish a new territory. Construction activities are likely to displace parr from rearing habitat.

Additionally, construction activities have some potential to displace adult Atlantic salmon from holding pools. Adult Atlantic salmon tend to hold in deep, cool pools during the summer months where they can minimize predation and reduce the physical stress brought on by increased water temperatures. If adults are displaced from holding pools, increased physiological stress could result as they search for new, cool water refugia. Due to the unknown locations of the projects subject to review under this PBA, the availability and specific locations of holding pools are unknown. Temporary displacement from cofferdam placement would likely occur if a cofferdam is installed in a portion of a holding pool. Therefore, the Proponents will avoid any effects with the potential to result in displacement of an adult

Atlantic salmon sheltering in a holding pool (AMM #47). Other potential displacement from turbidity and hydroacoustic effects are addressed in Sections 5.2 and 5.6, respectively.

Eggs and fry will not be affected due to the proposed work timeframes and the avoidance of sensitive habitat (i.e., spawning).

Displacement effects will occur for all projects that require cofferdams for completion. The duration of the displacement will vary on project type (see Table 5-4 for project durations). This includes all project activities listed and proposed in this PBA. Once construction activities are finished and stream flows are restored, both parr and adult salmon will be able to re-occupy habitat.

This habitat displacement will be temporary and insignificant as parr can occupy other habitat in the vicinity of the project. Therefore, displacement effects **are not likely to adversely affect** Atlantic salmon parr. The Proponents will not propose activities that will result in displacement of adults from holding pools. Hence, effects associated with displacing adults from holding pools **are not likely to adversely affect** adult salmon.

5.5 Aquatic Habitat Connectivity

Road-stream crossing structures, particularly culverts, can have adverse effects on the passage of aquatic organisms, including Atlantic salmon. Reduced habitat connectivity has been identified as a stressor to the Atlantic salmon. Reduced connectivity prevents Atlantic salmon from fully using substantial amounts of freshwater habitat and changes native fish community structure by preventing or impairing access for other fish species (NMFS 2009a; 74 FR 29300-29341; June 19, 2009). [Impairing access for all aquatic organisms affects migration PCE feature M 3: Freshwater and estuary migration sites with abundant, diverse native fish communities to serve as a protective buffer against predation.] The Proponents are proposing activities that may temporarily and permanently affect aquatic habitat connectivity. These activities include stream crossing replacements, culvert end resets, culvert end extensions, and scour countermeasures.

Engineered streambed material (ESM) will be designed according to the guidance found in Appendix B. Though the design approach is more 'engineered' than the stream simulation approach, the material that will placed in/under the replacement crossing structures will be similar. In natural streams, the substrate is a function of stream gradient, stream width, and stream flows (resulting in different water velocities). The Proponents approach found in Appendix B uses these same factors to predict what the streambed material would be in those conditions instead of relying on survey of a reference reach of the stream. The Proponents believe that this streambed material will be stable under the design flows and may become mobile under high flow situations where natural stream material will also move.

5.5.1 Stream Crossing Replacements

Stream crossing replacements account for the majority of projects that are analyzed in this PBA (see Table 1-1). Stream crossing replacements refer to all sizes of stream crossings. Stream crossing replacements will affect aquatic habitat connectivity at two stages: during construction and post-project completion.

Stream crossing design techniques for aquatic habitat connectivity and habitat connectivity are proposed to provide a long-term beneficial effect to Atlantic salmon. Proper design of the stream substrate (using ESM) placed inside a crossing structure is important to aquatic habitat connectivity and habitat connectivity. The Proponents are proposing to follow guidance for stream crossing design and methodologies from other states and field experts to create a stable material that mimics stream substrate found in the vicinity of the project (CM #1). Riprap material required for stability will be embedded below the substrate, and ESM will be placed on the surface of the riprap (AMM #44).

The width of the new crossing structures will be determined by the BFW of the stream being carried by the crossing structure. BFWs are measured in undisturbed areas of the stream and follow and standard protocol (Abbott 2012). In certain cases with larger altered streams, a regression analysis (Dudley 2004) will be used to calculation the BFW for design purposes.

Stream crossing replacements that have a bottom include corrugated metal pipes (CMPs), reinforced concrete pipes (RCPS), arch culverts, and concrete box structures. The structures will have ESM placed in them to recreate stream substrate as well as have a channel shape created with banks. The recreated channel will match the BFW of the stream, and the banks will occupy the width represented by the 1.2 times the BFW.

Stream crossing replacements that are become bottomless bridge structures will require some stream channel restoration. When removing structures that are less than the BFW of a stream, there will be areas in the new channel that will require fill removal. Effects to the natural stream channel between abutments will be avoided. The areas of the channel that need to be recreated will also have ESM placed in the channel and have banks created along the outside.

5.5.1.1 Stream Crossing Replacements - Tier 1 Priority Areas

The Proponents are proposing to size stream crossing replacement structures to 1.2 times the BFW in designated Tier 1 priority areas.

ESM will be placed inside of structures with bottoms and banks will also be installed inside of the crossing structure. Bottomless structures may have a combination of pre-existing substrate that is augmented with ESM. See the action description in Section 3.4.3.1 for further description of the construction process for this activity.

5.5.1.2 Stream Crossing Replacements - Tier 2 Priority Areas

The Proponents are proposing to size stream crossing replacement structures that are equal to or greater than the BFW in designated Tier 2 priority areas.

ESM will also be placed inside of these structures to create natural stream substrate. Bottomless structures may have a combination of pre-existing substrate augmented with ESM. See the action description in Section 3.4.3.1 for further explanation of the construction process of this activity.

5.5.2 Culvert End Resets and Extensions

A culvert end reset project does not present the opportunity to improve fish passage over the existing condition. Reset projects take <1 day to complete, and are planned to maintain a crossing structure that is good condition other than the separated end. End resets typically are completed on round culverts (CMP or RCP) that are <10 feet in diameter.

Extensions are necessary when previously installed crossing structures do not allow for proper slope stabilization along the road and down to the stream crossings inlet or outlet. A crossing structure that is too short requires that steep slopes that do not remain stable typically exist. These occur when the stream crossing structure is in good structural condition but the slope needs to be stabilized.

MaineDOT is proposing to limit the culvert extensions to 8-foot extensions upstream and downstream of the existing crossing structure. In MaineDOT's past experience, an 8-foot extension is enough to allow for proper slope and crossing structure stabilization. Also, limiting lengths to 8-foot extensions will minimize effects on the stream.

Stream crossing structures that need to be extended are typically already undersized and are often have outlets that are hanging that preclude the passage of fish and other aquatic organisms. These undersized crossings typically have a scour pool created by high-energy flows resulting from water exiting an undersized culvert during the period of the culvert's operation. A culvert extension cannot alleviate these scour issues and is likely to cause scour issues to move further downstream (if the culvert extension is on the downstream side of the crossing structure).

Culvert extensions on the upstream side of the crossing structure may require a small amount of stream location to ensure the stream will alignment properly with the inlet of the extended culvert. If the stream flows directly into the new culvert, stream relocation will not be necessary. In MaineDOT's experience, stream re-location is necessary on approximately 50 percent of upstream culvert extensions. Experience also shows that re-location is <25 linear feet of the stream.

5.5.3 Scour Countermeasures

Scour countermeasures are designed to re-stabilize a bridge that becomes unstable due to the loss of soil material around or under the footing. The elevation of the scour countermeasure is determined by the footing depth where the cable mats meet the bridge abutments. Portions of a cable mat away from the abutments can be embedded into the stream. The installation of the countermeasures requires flattening of the streambed and small amounts of streambed removal limited to approximately 8 inches. The material that is removed during streambed preparation will be placed back on top of the cable mats once the project is finished (AMM #46).

The width of the bridge, substrate material, and expected flows dictate how large cable mats must be to protect the bridge structure. When possible, the Proponents will try to the limit the footprint of the cable mats and allow an area of natural stream substrate to exist between the countermeasures. This is not listed as a separate AMM as it cannot be a commitment for all projects.

The placement of the cable mats under the bridge structure can affect aquatic habitat connectivity in two ways. The placement of cables mats may cause a rise in streambed and lead to stream velocity and water depth issues. The cable mats also remove the roughness of the natural streambed. That roughness lessens water velocities, creates many different migratory pathways, and serves as habitat for other aquatic organisms such as invertebrates. The life expectancy of a scour countermeasure project is 25 years.

5.5.4 Biological Response

Stream crossing structures, particularly culverts, can have adverse effects on the passage of aquatic organisms, including Atlantic salmon. Reduced habitat connectivity associated with culverts is an established stressor to the GOM DPS of Atlantic salmon. Altered habitat connectivity prevents salmon and other fish from fully using substantial amounts of freshwater habitat and changes fish community structure (NMFS and USFWS 2009).

As stated above, the Proponents are not proposing any effects to Atlantic salmon spawning areas as a part of this PBA. The analysis and conclusions below will be made assuming that eggs and fry will not be found in the action area of any of these activities. Impacts on the smolt life stage will be minimal, but smolts may migrate through the stream crossing structures after their completion.

The USFWS stated that fully accessible crossing structures are required to move towards recovery of Atlantic salmon and Atlantic salmon critical habitat. This standard for a crossing structure to meet to be considered fully accessible require a structure width that is equal or greater the 1.2 times the bank full width of the stream where the structure replacement is occurring. These crossing structures must also be designed to fit into the stream channel and recreate the natural stream through them follow principles outlined in US Forest Service's stream simulation design guidance (USDA-FS 2008). The overall goal of this concept is to recreate the stream within the new crossing structure and allow for stream processes to occur as if the road crossing was not present. Crossing structures designed following this guidance are not designed specifically for fish passage, but are assumed to have adequate fish passage similar to that of a natural stream.

Crossings that are less than 1.2 times the BFW may inhibit natural stream processes and influence long-term substrate composition inside of any stream crossing structures. In the attached memo (Appendix D), a MaineDOT hydrologist provided an analysis of the differences between a 1.2 times BFW structure and a BFW structure. Though a BFW structure does not meet the fully accessible standard as established by the Services, it will not delay fish migration during all but the highest flows, will allow for substrate sized similarly to the natural stream to remain stable, and will allow for the majority of natural stream processes to occur. Terrestrial mammal movement along stream banks will not be as available as a 1.2 times the BFW sized crossing.

Crossing structures that are sized less than the BFW of the stream can cause delays to fish migration. Undersized culverts result in elevated water velocities. These crossings may provide fish passage at low to moderate stream flows, but act as a barrier under moderate to high flow conditions. The increased velocities resulting from undersized crossings also have the potential to cause downstream erosion and alter habitat downstream of the crossing. The increased velocities can create a scour pool and result in a hanging culvert over time. Undersized crossings also are less efficient at passing large woody debris downstream. Though large woody debris generally orients itself parallel to the flow when mobile, small crossings have greater potential for blocking large woody debris passage. Small woody debris also tends to clog undersized crossings more readily. Although the Proponents are not proposing to install any new culverts that are less than BFW in Tier 1 and Tier 2 priority areas as a part of this PBA, these effects will continue to occur at culverts where end resets and extensions occur.

The primary AMMs for effects to aquatic habitat connectivity and stream processes are addressed during project planning and design. The commitments made by the Proponents are stated in the AMM summary in Section 3.12 above.

5.5.5 Conclusions

As stated above, the Proponents are not proposing to conduct activities that may affect Atlantic salmon spawning areas as part of this PBA. The conclusions below are made assuming that eggs and fry will not be found in the action area of any of the proposed activities.

Impacts on the smolt life stage will be insignificant. Smolts may migrate downstream through the stream crossing structures after project completion. The discussion below primarily analyzes the effects on Atlantic salmon parr (migration and rearing) and adults that will migrate through the structures and use the habitat within the stream crossing structures. Aquatic habitat connectivity itself is more a function of properly functioning habitat than of fish passage parameters, resulting in overlap in the assessment of aquatic habitat connectivity (water depth and velocities) and habitat function below.

Table 5-5 summarizes effect determinations for proposed activities with potential to affect passage of Atlantic salmon.

5.5.5.1 Culvert Crossing Replacements

Tier 1 Priority Areas

The proposal for replacement at widths that are at least 1.2 times the BFW of the stream and stream substrate material that matches what the stream conditions would dictate will allow for natural stream function.

The substrate and stream banks will also allow for passage of other aquatic organisms without interruption. This satisfies the requirements of the USFWS guidance for ‘fully accessible’ stream crossings. The stream flowing through the crossing structure should function similarly to a natural portion of the stream channel.

Crossings meeting ‘fully accessible’ standards will result in beneficial effects to Atlantic salmon and critical habitat. Aquatic habitat connectivity effects from stream crossing replacements in Tier 1 priority areas are **not likely to adversely affect** Atlantic salmon and critical habitat.

Tier 2 Priority Areas

As stated above, the recovery goal for culvert crossings is to allow for natural stream processes as well as providing benefit to the entire stream ecosystem. USFWS guidance for this is following a stream simulation design type. 1.2 BFW design provides stream banks inside of the crossing structure. The proposal for replacement at widths that are at least equal to the BFW of the stream will not provide the stream bank. The lack of stream bank will affect stream flows along the edges of the structure. Stream banks provide ‘roughness’ that limit stream velocities and create habitat for Atlantic salmon. The extra structure width also provides for a larger flow area during flood flows and limits to potential for streambed and downstream scour.

MaineDOT has completed post project monitoring at multiple structures following a BFW design standard and has demonstrated that they provide stream velocities and water depths that allow for fish passage at almost all stream flows. The monitoring has not been completed at high flows and it is assumed that some water velocity barriers may exist at flood flows similarly as they do in natural stream reaches.

Though the long-term effects of BFW culvert crossings is largely unknown, it does not meet the standards and goals set forth by USFWS that are required for Atlantic salmon recovery. BFW crossing structures still allow for the passage of fish and other aquatic organisms at a wide range of flows. They also will provide substrate throughout the crossing to provide habitat for invertebrates and roughness and flow variation important for other fish movement as well. BFW stream crossing replacements are proposed in areas that are not Tier 1 priority areas for Atlantic salmon and will provide natural stream functions at most stream flows. These projects will be significant improvements over the existing site conditions.

Effects to critical habitat are evaluated by determining the likelihood that the effect will influence the function and role of the critical habitat. BFW culvert crossing structures in Tier 2 priority areas do not meet the goals for functions of stream crossings and Atlantic salmon recovery. They largely provide stream connectivity, but lack streak banks and the width to be considered fully accessible. Because culvert replacements in Tier 2 priority areas are likely to diminish the function of Atlantic salmon critical habitat, they are **likely to adversely affect** Atlantic salmon and critical habitat.

To ensure that the Proponents are helping to recovery Atlantic salmon and contribute towards their Section 7(a)1 duties, the Proponents will provide mitigation for the impacts associated with BFW crossings. This proposal is included as a conservation measure described in Section 3.2.2.

5.5.5.2 Bridge Crossing Replacements

Bridge crossings will be sized to accommodate 100-year storm flows. Sizing for these large storm flows will also allow for aquatic habitat connectivity. Due to the large variation in flow resulting from the substrates associated with large bridge crossings, fish and aquatic organisms will be able to use the habitat under these bridges just as they would use stretches of natural habitat.

The sizing of bridge replacements to meet flood standards will not result in a measurable effect to aquatic habitat connectivity as compared to undisturbed portions of streams and rivers. Therefore, the effects are discountable. Aquatic habitat connectivity effects from bridge crossing replacements in Tier 1 and Tier 2 priority areas are **not likely to adversely affect** Atlantic salmon and critical habitat.

5.5.5.3 Culvert End Resets and Extensions

End resets and extensions will maintain existing passage conditions at the culverts being repaired. Working on very small portions of the structures does not allow for full replacement or meet fully accessible stream crossing standards. MaineDOT has never completed a reset or extension on a culvert crossing that met fully accessible standards. The Proponents expect that all culvert resets and extensions will not meet fully accessible standards when completed. In MaineDOT’s experience, approximately 50% of these projects will allow for fish passage once completed. Culvert resets and extensions also take place on structures that are <10 feet in width. It is not expected that these projects will occur in areas that will affect any life stage of Atlantic salmon other than parr.

Effects to critical habitat are evaluated by determining the likelihood that the effect will influence the function and role of the critical habitat. The entire crossing structure will not meet fully accessible standards once the culvert end reset or extension is complete. Therefore culvert end resets and extensions are **likely to adversely affect** Atlantic salmon critical habitat. They are also **likely to adversely affect** Atlantic salmon parr in Tier 1 priority areas where Atlantic salmon parr are expected to be present.

5.5.5.4 Scour Countermeasures

Scour countermeasure projects will not adjust the width of the bridge where the project is taking place. They will not result in structures that are fully accessible and often may have a net negative effect on fish passage and connectivity as a result of a project. The proposed AMMs will limit the effects to the maximum extent practicable, but will not totally negate effects on connectivity.

Affects to critical habitat are evaluated by determining the likelihood that the effect will influence the function and role of the critical habitat. The entire crossing structure will not meet fully accessible standards and the scour countermeasures may result in passage conditions that are more challenging than prior to the project. Therefore, scour countermeasures are **likely to adversely affect** Atlantic salmon and critical habitat in Tier 1 and Tier 2 priority areas.

Table 5-5. Effect determinations for proposed activities that have potential to affect passage of Atlantic salmon individuals.

	Atlantic Salmon Life Stage				
Activity or component	**Eggs**	**Fry**	**Parr**	**Smolt**	**Adult**
Culvert replacement					
Tier 1	NE	NE	NLAA	NLAA	NLAA
Tier 2	NE	NE	LAA	LAA	LAA
Bridge replacement	NE	NE	NLAA	NLAA	NLAA
Culvert end reset	NE	NE	LAA	LAA	LAA
Culvert end extension	NE	NE	LAA	LAA	LAA
Scour countermeasure	NE	NE	LAA	LAA	LAA

5.6 Hydroacoustic Effects

The Proponents are proposing eight activities that may result in elevated underwater sound pressure during construction: sheet pile cofferdam installation; stream crossing replacements greater than and less than 20 feet in width; stream crossing removal; temporary work access and temporary bridges; pre-project geotechnical drilling; drilled shaft construction; and bridge construction. Each one of these activities has sub-activities that will result in potential hydroacoustic effects to Atlantic salmon. Specific work sub-activities of concern are impact and vibratory pile driving, in-water drilling, and in-water hoe ram use.

Hydroacoustic effects can result in fish behavioral effects, injury and mortality. When a fish with a swim bladder is exposed to a sound wave, gas in their swim bladder expands and contracts more than the surrounding tissue during periods of under pressure and overpressure, respectively (Caltrans 2009). This can cause the swim bladder to oscillate resulting in tissue damage and possibly rupture. Hearing loss in a fish is likely to result in reduced fitness from decreased ability to detect and avoid predators, locate prey, communicate with peers, or sense physical environment (Caltrans 2015). Data for direct effects to Atlantic salmon are not available. The data collected on salmonid species has been multiple species from the west coast of the United States. This data represents the best available date for hydroacoustic effects to Atlantic salmon.

Sound pressure naturally attenuates as the sounds waves move further from the source. NMFS provides a pile driving calculator to help calculate the extent of pile driving effects (NMFS 2012). The pile driving calculator will be used to estimate the extent of hydroacoustic effects for this PBA. Results from an effort to predict project effects completed by Caltrans can be found in Table 5-8. These tools will be used to estimate impact areas from similar activities found in this BA. The different construction elements that result in increases in underwater noise are discussed below. Specific work activities of concern are impact and vibratory pile driving, in-water drilling, and in-water hoe ram use.

5.6.1 Sheet Pile Cofferdam Installation

Sheet pile cofferdams are employed during both culvert and bridge replacements, and may also occur on bridge culvert or removal projects, culvert end resets and extensions, bridge scour countermeasures projects, bridge maintenance projects (with concrete repair below water line), and invert line and slipline culvert rehabilitation projects. If sheet piles are used for cofferdam installation/removal on any activity, it will always be with a vibratory hammer, never an impact hammer (AMM #21). (Note that pile installation for activities such as temporary access are noted separately, below)

These cofferdams may be employed in small stream crossings to stop water flow to be pumped around the work area and may also be used to divert water flow into bypass channels (see Section 3.4) of the Action description for photos and large description). Sheet pile cofferdams are also used along the edges of streams during bridge replacements to seal off the area for abutment removal and construction. In general, sheet pile cofferdams are used when water depths are >6 feet or when a 'seal' is required for a foundation. Some contractors prefer them to sand bag cofferdams even in shallow streams. Sheet pile cofferdams are used on 5 percent of culvert replacements and 60 percent of bridge replacements.

Steel sheets are normally driven in pairs. Each sheet has an interlocking groove on the outside where the sheets will connect to each other. A vibratory hammer is connected to a pair of 12-inch wide sheet piles and they are driven concurrently. The substrate that the sheets are being driven into determines the duration of the driving event for each pair of sheets. A pair of sheets that are driven into finer material will take approximately 15 minutes. A pair of sheets driven into material with larger rocks and substrate that makes for more challenging driving conditions can take up to 1 hour. The size of the cofferdam varies depending on the need of the project. However, it is reasonable to assume that a cofferdam would take 1-2 days to install.

MaineDOT monitored acoustic effects from sheet pile driving with a vibratory hammer on a pier reconstruction project in Eastport, Maine (Table 5-6).

Table 5-6. Summary of results of hydroacoustic monitoring of vibratory hammers used on a project in Maine.

Project	**Water Depth (feet)**	**Pile Size (inches)**	**Distance (meters)**	**dB Peak**	**dB RMS**	**SEL**
Eastport, Maine	3-16	24-inch sheet pile	10	160	130	-

Signal analysis on vibratory pile driving is different than impact driving due to the continual nature of the wave form (Caltrans 2015). The RMS values and SEL values are reported as similar values due to the type of signal (Caltrans 2015). The above values are input into the NMFS pile driving to help predict the extent of the expected impacts. Because the onset of behavioral effects is assumed to 150 db RMS, it is not expected that vibratory driving resulting in any behavioral impacts to fish in the above instance. Caltrans reports on three different driving events and reported a peak dB RMS of 165. The NMFS pile driving calculator predicts that behavioral effects to fish may occur up to 100 meters (328 feet) from that activity.

There are no established injury criteria for vibration pile driving and resource agencies in general are not concerned that vibratory pile driving will result in adverse effects on fish (Caltrans 2015). Vibratory driving of sheet piles is expected to result in minor behavioral effects within 328 feet of the activity.

5.6.2 Drilling

The Proponents are proposing three sub-activities that require drilling pre-project geotechnical drilling, drilled shaft installation and micropile installation, as further explained below. Signal analysis of the hydroacoustic effects for drilling is similar to vibratory driving (NMFS 2013). It is not expected that the below activities will result in any fish injury, though the activities below have the potential to result in behavioral responses.

5.6.2.1 Pre-project Geotechnical Drilling

Geotechnical information is collected for all stream crossing replacements (culverts and bridges) and all scour countermeasures projects. The geotechnical information is collected using a small-diameter (<12 inches) drill to take core samples from the soils underlying the site of the proposed project. The duration of drilling activities will vary with the substrate type and depth of data collected. It is reasonable to assume that each boring will take 8 hours to complete.

The Proponents have not collected any hydroacoustic data from this activity. Source/peak levels for underwater geotechnical drills are estimated to range from 118 to 145 dB peak (approximately 120 dB Sound Exposure Level (SEL) and 130 dB RMS) at one meter from the source, with underwater noise levels decreasing to 101.5 dB by 150 meters (Deepwater Wind 2009, Fishermen's Energy of New Jersey 2009, NMFS 2011).

The dB RMS levels from these projects are reported to be lower than 150 dB RMS. Effects from this activity are not expected to result in levels that result in behavioral effects to ATS.

5.6.2.2 Drilled Shafts

Bridges can also be supported by piles that are outfitted for drilling into the substrate. These piles are slowly turned into the substrate until they reach the desired elevation. The soil material is then removed from the inside of the pile, which is then filled with concrete. The shafts can be anywhere from 24 inches to 8 feet in diameter.

Drilling shafts installs the pile at a much slower rate than pile driving. MaineDOT has limited data on drilling shaft timeframes, but drilling can take approximately 1 to 2 weeks per pile for larger piles (3-8 feet in diameter).

To date, MaineDOT has not completed any monitoring of sound pressure levels created by drilling shafts. The underwater noise created by drilling shafts is likely to be below levels that will result in a measurable effect to fish.

The dB RMS levels from these projects are reported to be lower than 150 dB RMS. Effects from this activity are not expected to result in levels that result in behavioral effects to ATS.

5.6.2.3 Micropiles

The use of micropiles is a technology that is most commonly used to insert a smaller pile into an existing pier/abutment to rehabilitate. To insert the pile, a down hole hammer drill is used to drill through existing concrete. A small pile is than inserted into the hole created by the down hole hammer.

The down hole hammer drilling results in hydroacoustic impacts that are similar to the drilling explained in Section 5.6.3.2. New Hampshire DOT completed acoustic monitoring on the use of a downhole hammer drill. The results showed peak dB levels that peaked below 160 dB and averaged ~140 dB at 20-25 meters from the activity (unpublished data).

The extent, duration, and intensity of impacts from the installation of micropiles are expected to be the same as the geotechnical drilling as described above.

5.6.3 Old Bridge/Structure Demolition

Old bridge/structure demolition requires the removal of bridge support elements such as in-water piers. If the existing piers and abutments consist of stacked stone or similar material, they can be removed with an excavator. Piers and abutments that consist of cast-in-place concrete elements containing metal rebar are typically broken into pieces using a hoe ram (hydraulic breaker). The hoe ram is used to break the concrete structures into small pieces to facilitate removal. To date, the Proponents have not completed hydroacoustic monitoring on any of their demolition activities.

WSDOT completed monitoring of the demolition of two bridge piers using a hoe ram. The monitoring results indicate that the wave form from hoe ramming activities is comparable to impact driving and should be analyzed using the same metrics as impact pile driving (WSDOT 2013). One difference between the two is that the total energy per strike is less with a hoe ram but the frequency of “strikes” is substantially higher. The monitoring took place for demolition of a portion of a pier that was above the water line and for demolition of the pier below the water line. The results from WSDOTs monitoring is in Table 5-7 below.

Table 5-7. Results from monitoring of Manette Bridge Demolition

	Peak (dB)	Average Peak (dB)	Average RMS	Single Strike SEL (dB)	Number of record strikes	Cumulative SEL (dB)
Hoe Ram	189	183	173	160	3022	195
Hoe Ram	205	197	186	171	707	196

Hydroacoustic monitoring data from bridge demolition conducted by Caltrans at Ten Mile Bridge (Illingworth and Rodkin 2010) also suggests that hoe ram activity at or below the water line can result in sound levels similar to impact pile driving. Monitoring at other Caltrans bridge locations indicates that demolition work on elevated structures or outside of the wetted channel does not result in potentially injurious noise levels for fish. The sample size for monitoring data for this activity is small compared to impact pile driving and results have been variable depending on multiple factors. In past consultations, the Proponents and USFWS analyzed demolition data similarly to vibratory driving but bridge demolition hydroacoustic monitoring data suggests that approach will be changed.

The duration of use of a hoe ram on bridge piers and abutments vary depending on the size of the structure and the components of the structural element. Invariably, large piers take longer to demolish than small piers when a hoe ram is used. Components that contain concrete and metal rebar in better condition may take longer to demolish than more deteriorated elements. Despite the variable nature of demolition conditions, it is reasonable to believe that demolition of a single pier can be accomplished in ~5 days. The number of ‘strikes’ per day needed for a hoe ram to demolish an old portion of a bridge component is highly variable as stated above. For the purposes of this BA, the Proponents are conservatively assuming that bridge demolition (particularly by hoe ramming) could result in a zone of injury to Atlantic salmon.

5.6.4 Sheet Pile Driving for Temporary and Permanent In-water Supports

Pile driving (using either or both a vibratory hammer and/or an impact hammer) is required for roughly 50 percent of stream crossing replacement projects larger than 20 feet in length. A vibratory hammer will be used as much as possible for all pile driving activities (AMM #39), however, in order to seat the pile, and depending on the substrate in the vicinity of the project, an impact hammer may be needed. Temporary sheet pile driving (using a vibratory and impact hammer) may be used for several activities that fall under this PBA for temporary access, such as stream crossing replacements (both culverts and bridges), bridge culvert removals, and bridge maintenance.

If the geotechnical conditions dictate, permanent in-water supports (i.e., piles) may require driving inside of a sheet pile cofferdam to support a new concrete pier. These piles must be driven before the cofferdam is dewatered as they must be installed prior to the installation of the concrete seal in the cofferdam. H-piles are typically used for this application. Piers will only be used for bridge replacement projects and not for temporary work access platforms or temporary bridges.

The duration of the driving events vary according to desired pile depth as well as substrate conditions. A typical H-pile will be vibrated into place for 30 to 60 minutes and then seated with an impact hammer for 5-10 minutes.

Bridges can also be supported by a series of piles called pile bents. Typically, 5 to 7 piles are used in each pile bent. The piles on the upstream and downstream side are installed at an angle and referred to as 'battered' piles (see Figure 3-26). Pile bents can be used for bridge replacement projects, temporary work access platforms, and temporary bridges.

Pile type can vary greatly depending on geotechnical conditions. Potential variations include H-piles, steel round piles, round piles with H-piles inside, round steel piles that are filled with concrete. When conditions allow, these piles are driven to the same elevation as bedrock. When that is not attainable, they are driving into the substrate to meet specific structural integrity requirements.

The duration of the driving events varies according to desired pile depth as well as the type of substrate. A pile will be vibrated into place for 30 to 60 minutes and then seated with an impact hammer for 10 to 15 minutes.

Piles are also used to support temporary work bridges and temporary bridges required for traffic maintenance. The piles are similar in size and installation techniques to the H-piles and round piles described above.

Impact pile driving events can require as little as 25 piles strikes and as many as 1000 strikes in some geotechnical conditions. These numbers are estimates following a review of pile driving logs and discussions with MaineDOT field staff. To make a conservative prediction, the Proponents will assume that each pile to be seated with an impact hammer will require 250 strikes, as that number is more common than the extremes stated above.

The Proponents have proposed to limit pile size to ≤ 30 inches in diameter for round steel piles and ≤ 14 inches for H-piles (AMM #37). Using the NMFS pile driving calculator, 250 strikes on a 30 inch pile could result in injurious levels (greater than 187 dB SEL) up to 85 meters (279 feet) from the pile driving activity.

The intensity of the sound pressure resulted from pile driving varies greatly between pile type, water depth, and substrate. MaineDOT completed several hydroacoustic monitoring events on different piles types and sizes. Table 5-8 provides a summary the results for impact pile driving. The data includes the pile sizes and types that are included as part of the proposed activities in this PBA. The SEL values for the driving events in the table below are presented for one project (Kittery).

5.6.5 Summary of Impact Pile Driving Data

The proponents are currently re-analyzing hydroacoustic data it has collected in the past. At this time, the proponents are only presenting data SEL data from a single project.

Table 5-8. Summary of results of hydroacoustic monitoring of impact hammers used on projects in Maine

Project Location	Pile Type	Distance to Measurement (m)	Pile Diameter	Water Depth	dB Peak	AVG dB SEL
York	Round Steel	10	24”	7-24 ft.	212 dB	
Kennebunk	Round Steel	10	24”	8-13 ft.	210 dB	
Portland	Round Wood	10	12”	36 ft.	196 dB	
Portland/Falmouth	Round Steel	10	30”	15-22 ft.	213 dB	
Kittery	Round Steel	10	30”	~5 ft.	191 dB	160
Howland/Enfield	Round Steel	10	30”	8 ft.	209 dB	
Howland/Enfield	Round Steel	10	24”	8 ft.	205 dB	
Howland/Enfield	Steel H-pile	10	14”	16 ft.	204 dB	
Richmond/Dresden	Steel H-pile	10	14”	20-25 ft.	200 dB	

Table 5-9 below is information from Caltrans’ *Hydroacoustic Effects of Pile Driving on Fish* November 2015. The chart is a screening tool used to predict the effects from a pile driving activity for different size piles. The proponents have limited data on single strike SEL and cumulative SEL limits from pile driving activities. Table 5-9 will be used to predict potential effects of pile driving activities proposed in this PBA.

Table 5-9. From Caltrans 2015.

Pile	Single Strike at 10			Distance to Effective Quiet	Number of Strikes Per Day																		Peak Effect Distance
					3		10		32		100		320		1,000		1,995		3,200		5,012		
	Peak	SEL	RMS		SEL_{cumul}	Eff Dist	SEL_{cumul}	Eff Dist	SEL_{cumul}	Eff Dist	SEL_{cumul}	Eff Dist	SEL_{cumul}	Eff Dist	SEL_{cumul}	Eff Dist	SEL_{cumul}	Eff Dist	SEL_{cumul}	Eff Dist	SEL_{cumul}	Eff Dist	
12 inch	182	157	167	29	162	<10	167	<10	172	<10	177	<10	182	<10	187	10	190	16	192	22	194	29	<10
18 inch	185	160	170	46	165	<10	170	<10	175	<10	180	<10	185	<10	190	16	193	25	195	34	197	46	<10
24 inch	192	174	181	398	179	<10	184	<10	189	14	194	29	199	64	204	136	207	215	209	295	211	398	<10
12 inch	200	166	178	117	171	<10	176	<10	181	<10	186	<10	191	19	196	40	199	63	201	86	203	117	<10
14 inch	208	177	187	631	182	<10	187	10	192	22	197	46	202	101	207	215	210	341	212	468	214	631	14
24 inch AZ	205	180	190	1000	185	<10	190	16	195	34	200	74	205	160	210	341	213	541	215	741	217	1000	<10
12 inch	192	167	177	136	172	<10	177	<10	182	<10	187	10	192	22	197	46	200	74	202	101	204	136	<10
14 inch	200	175	185	464	180	<10	185	<10	190	16	195	34	200	74	205	158	208	251	210	344	212	464	<10
20 inch	208	176	187	541	181	<10	186	<10	191	19	196	40	201	86	206	185	209	293	211	401	213	541	14
30 inch	210	177	190	631	182	<10	187	10	192	22	197	46	202	101	207	215	210	341	212	468	214	631	18
36 inch	210	183	193	1585	188	11	193	25	198	55	203	117	208	253	213	541	216	858	218	1175	220	1585	18
48 inch	213	179	192	2929	192	21	197	46	202	101	207	215	212	468	217	1000	220	1585	222	2172	224	2929	25
60 inch	210	185	195	2154	190	15	195	34	200	74	205	158	210	344	215	736	218	1166	220	1597	222	2154	18
96 inch	220	195	205	10000	200	71	205	158	210	344	215	736	220	1597	225	3415	228	5412	230	7415	232	10000	86

Notes:	Assumes attenuation of 4.5 dB per doubling of distance.	
	Single strike values are from Appendix I (Caltrans 2015). Where the data are incomplete, the incomplete missing data is calculated per NMFS guidance. Peak = SEL + 25. RMS = SEL + 10.	
	"Effect distance" is the distance within which injury criterion is predicted to be exceeded.	
	Underwater sound does not accumulative when the sound level drops below "effective quite" which is 150 dB.	
	Increasing the number of strikes beyond 5,012 strikes per day does not increase the 187 dB effect distance beyond the distance to effective quiet.	
	Increasing the number of strikes beyond 1,995 strikes per day does not increase the 183 dB effect distance beyond the distance to effective quiet.	
	SEL_{cumul} is at 10 meters from pile.	
	All distances are in meters	
	0	Enter dB attenuation assumed from attenuation system or driving on land. Use 5 dB for bubble curtain or dewatered cofferdam. Use 10 dB for driving on land.
	187	Enter cumulative SEL threshold. 187 dB for fish greater than 2 g. 183 dB for fish 2g or less.

*red indicates that activity may result in injury to ATS of any life stage.

5.6.6 Biological Response

When a fish is exposed to a sound wave, gas in their swim bladder expands and contracts more than the surrounding tissue during periods of under pressure and overpressure, respectively (Caltrans 2009). This can cause the swim bladder to oscillate resulting in tissue damage and possibly rupture. Hearing loss in a fish is likely to result in reduced fitness from decreased ability to detect and avoid predators, locate prey, communicate with peers, or sense physical environment (Caltrans 2009).

Hearing sounds is important for fish survival, and anything that impedes the ability of fish to detect a biologically relevant sound could affect individual fish. Fish may experience a variety of different potential effects from sound, with a decreasing range of effects at greater distances from the source. Very close to the source, effects may range from mortality to behavioral changes. Effects are also influenced by a number of factors, for example, a fish's hearing sensitivity, sound source level, and propagation and eventual sound level at the receiving fish.

Acoustic criteria intended to protect fish from harm and mortality from pile driving activities were developed by an interagency work group (including USFWS and NMFS), focusing on west coast ESA-listed fish. This interim criteria identifies an agreement in principal regarding the noise levels at which the onset of physical injury occurs from impact pile driving (i.e., "harm" in terms of the ESA) (Fisheries Hydroacoustic Working Group (FHWG) 2008). This group has not yet provided criteria for sound levels that would affect the behavior of fish and, therefore, might be considered to "harass" fish in terms of the ESA. The workgroup established dual sound criteria for injury, measured 10 meters away from the pile, of 206 dB_{peak} and 187 dB Sound Exposure Level (SEL) (the second criteria applies only to fish weighing 2 grams or more). When evaluating potential injury impacts to fish, peak sound pressure (dB_{peak}) is often used (WSDOT 2008).

The proponents are not proposing any impacts to fish less than 2 grams (0.004 pounds) in this programmatic biological assessment. Therefore, the 183 c SEL limit will not be applied to the analysis.

The intensity of a sound wave in water is typically expressed in terms of decibels relative to 1 micro-Pascal (dB re μPa). The following are commonly used metrics of sound:

- Peak sound pressure level (SPL, measured in dB re 1 μPa): the maximum sound pressure level (highest level of sound) in a signal
- Sound exposure level (SEL, measured in dB re 1μPa2-s): the integral of the squared sound pressure over the duration of the pulse (e.g., a full pile driving strike)
    - SEL is the integration over time of the square of the acoustic pressure in the signal and an indication of the total acoustic energy received by an organism from a particular source (e.g., pile strikes).
- Single Strike SEL: the amount of energy in one strike of a pile
- Cumulative SEL (cSEL): the energy accumulated over multiple strikes
    - cSEL indicates the full energy to which an animal is exposed during any kind of signal. The rapidity with which the cSEL accumulates depends on the level of the single strike SEL. The actual level of accumulated energy (cSEL) is the logarithmic sum of the total

number of single strike SELs. Thus, cSEL (dB) = Single-strike SEL + $10_{\log 10}$ (N); where N is the number of strikes.

- Root Mean Square (RMS): the average level of a sound signal over a specific period of time

Behavioral effects may include altered migration routes, changes in forage areas, and altered behavior in the presence of predators. Elevated noise levels may reduce the ability of a listed species to hear and avoid a predator.

Behavioral responses can be expected from Atlantic salmon as a result of elevated sound pressure levels. NMFS (2012) indicates that the onset of behavioral responses can begin at 150 dB root mean squared (RMS).

Caltrans (2009) examined information provided by Popper et al (2006) and concluded that the threshold for “harm” when using a vibratory hammer is likely to be between 187 decibels (dB) and 220 dB sound exposure level (SEL).

5.6.7 Conclusions

By implementation of the work windows, it is likely that parr and adults will be the only life stages to experience hydroacoustic effects. The conclusions made below are specific to those two life stages.

The conclusions below are made after analyzing the potential effects and employing the AMMs listed below.

- In-water pile driving to support temporary work areas for bridge replacements will occur between July 15 and April 15 (AMM #2).
- Pile driving will occur during the day when fish are less active and migrations are minimized (AMM #40).
- Hydroacoustic monitoring will accompany all impact pile driving (AMM #41).
- A bubble curtain meeting the design criteria, as defined in the User’s Guide, will be employed during all impact pile driving events. The bubble curtain design will mimic specifications for devices tested and employed for previous pile driving events (AMM #42).
- In-water blasting is not allowed when Atlantic salmon could be present (AMM #43).

The Proponents also propose to limit pile size to minimize effects. Though there are many factors that influence hydroacoustic pressures from pile driving, pile size has a large potential to generate hydroacoustic pressures with potential to injure Atlantic salmon.

- Round pipe pile size is limited to ≤ 30 inches in diameter and H-pile size is limited to ≤ 14 inches. (AMM #37)

Impact hammer pile driving on piles of any size can produce sound pressure levels that can injure fish. However, impact pile driving on piles that require structural load must be ‘seated’ with an impact hammer to remain structurally sound. This is necessary for piles that function as permanent bridge supports as well as temporary work access. MaineDOT will limit impact pile driving as much as practicable and not allow it when it is reasonable to assume construction can occur without it.

- A vibratory hammer will be used as much as possible for all pile driving activities (AMM #39).

5.6.7.1 Sheet Pile Cofferdam Installation

Sheet pile cofferdam installation (including removal) will result in elevated underwater continuous sound that may elicit a startle or avoidance behavior from any Atlantic salmon parr or adult in the affected area. Use of a vibratory driver is a preferred method to avoid adverse hydroacoustic effects on fish. Caltrans (2009), along with other DOTs on the west coast, concludes that vibratory driving is not likely to result in adverse effects. Due to the work windows, this activity will occur at times when Atlantic salmon parr may be rearing or an adult Atlantic salmon will be holding or migrating. Vibratory driving could take place for up to 4 hours a day.

Hydroacoustic effects resulting from cofferdam installation may result in a behavioral response that is not expected to reach the level of harassment and are therefore **not likely to adversely affect** Atlantic salmon parr and adults.

5.6.7.2 Drilling

Pre-project drilling to collect geotechnical information, drilled shaft installation, and micro pile installation will result in hydroacoustic effects that are not expected to elicit a startle or avoidance behavior from any Atlantic salmon parr or adult in the action area (less than 150 dB RMS). Hydroacoustic effects resulting from drilling are **not likely to adversely affect** Atlantic salmon parr and adults.

5.6.7.3 Bridge Demolition

The use of a hoe ram for demolition will result in hydroacoustic effects that may elicit a startle or avoidance behavior from any Atlantic salmon parr or adult in the affected area. Due to the work windows, this displacement will occur at times when Atlantic salmon parr may be rearing or an adult Atlantic salmon migrating.

To date, there is conflicting literature on the effects of hoe ram use on ATS. Past literature stated that it was not likely to result in adverse effects while more recent literature states potential adverse effects from the activities (Table 5-7). The most recent literature represents a small sample size and has not been formally addressed by the FHWG. However, to be conservative, the Proponents are assuming that hydroacoustic effects from bridge demolition are **likely to adversely affect** Atlantic salmon parr and adults.

5.6.7.4 In-water Supports

Pile driving for bridge supports, temporary bridge supports, and supports for temporary work access will result hydroacoustic effects that may elicit a startle or avoidance behavior from any Atlantic salmon parr or adult in the affected area. Due to the work windows, this displacement will occur at times when Atlantic salmon parr may be rearing or an adult Atlantic salmon will be migrating.

Though the Proponents are proposing to limit pile size and attenuate noise with bubble curtains, injurious levels of hydroacoustic pressure are likely to occur. Hydroacoustic effects resulting from impact hammer use during the installation of in-water supports are likely to result in a behavioral response, ATS injury, and potential ATS mortality. Therefore, impact pile driving is **likely to adversely affect** Atlantic salmon parr and adults.

Table 5-10. Effect determinations for proposed activities that have potential to result in hydroacoustic effects to Atlantic salmon.

Stressor: Hydroacoustic and underwater noise	**Atlantic Salmon Life Stage**				
Activity or component	**Eggs**	**Alevin**	**Fry/Parr**	**Smolt**	**Adult**
Sheet Pile Cofferdam Installation	NE	NE	NLAA	NE	NLAA
Drilling (includes geotechnical drilling, drilled shafts and micro piles)	NE	NE	NLAA	NE	NLAA
Old Bridge/ Structure Demolition	NE	NE	LAA	NE	LAA
Sheet Pile Driving for Temporary and Permanent In-water Supports (which includes Vibratory and Impact Pile Driving)	NE	NE	LAA	NE	LAA

Table 5-11. Potential area of adverse effects from impact pile driving

Activity or Component	**Number of Projects**	**Area of Impact Per Project (Feet^2)**	**Total area (Feet^2)**
Impact pile driving	± 20	± 244,500	4,890,000

The estimated area of impact per project was based on analyzing past projects with similar scopes.

5.7 Water Quality

Poor water quality can have varying levels of effects in fish such as inability for fish to reproduce, finding a steady food supply, and surviving the stress of life in their environment.

5.7.1 pH on Bridge Maintenance Activities

In Activity 5, bridge maintenance, the grout used in the repair of bridge piers and abutments can affect water quality. Specifically, it can increase the concentration of hydroxyl ions in the water.

5.7.1.1 Grout Bag Repair

Grout bag repair activities will occur in the wet (but within a bag). Grout will always be piped into grout bags or behind bags. The containment provided by the bags reduces the amount of high pH sediments being released into the water column. Grout bag activities will implement AMM #33 and AMM #34 to avoid significant increases in pH.

5.7.1.2 Concrete Repair

Concrete repair on wing walls, piers, or other bridge elements below the waterline will be completed behind a cofferdam. Following MaineDOT's standard specification (AMM #34), uncured concrete will not be allow to come into contact with water outside of a cofferdam. A low flow rate will be maintained when applying grout. MaineDOT generally applies the grout slurry at a rate of 2 cubic yards per hour; significantly below the 13 cubic yards per hour threshold that Fitch (2003) indicates will lead to significantly elevated pH values downstream.

If practicable, turbidity curtains will be used to separate elevated pH water from the rest of the stream. The benefit of using the curtain is that the water downstream of the project does not see the same increase in pH as would be seen without the curtains (maximum pH observed of 9.0 with curtains versus 10.9 without curtains). On the other hand, the pH of the water within the curtain (maximum pH observed of 11.1) exceeds levels safe for fish. If turbidity curtains are used, all fish will be removed from within the enclosed area to ensure that they are not exposed to potentially lethal conditions. It is difficult to maintain a seal on turbidity curtains if the water velocities exceed 1 foot per second. It is unknown at what distance downstream of the application that pH returns to background levels.

An anti-washout admixture (AWA) will be mixed with the grout prior to application. The admixture minimizes the washout of cement and fines into the water column during the placement of concrete. Fitch (2003) describes a project in Virginia where AWA was used, where the pH downstream never exceeded 9.0 (maximum pH observed of 8.9). In that study, several water quality parameters (pH, temperature, alkalinity, conductivity, and dissolved oxygen) were monitored at projects where the AWA was used as well as projects where it was not. Other than pH, none of these parameters fluctuated with the addition of the admixture.

5.7.1.3 Effects to the Species

A significant rise in pH can kill fish; cause damage to or burn outer surfaces, including gills, eyes, and skin; and impair a fish's ability to dispose of metabolic wastes. Based on a literature review, Alabaster and Lloyd (1980 as cited by Robertson-Bryan 2004) found that chronic exposure to pH values above 10 was harmful to all species studied, and salmonids were harmed at pH values above 9. Virginia DOT (2003) study found that high pH (>9.0) resulting from grout repair projects can lead to fish kills. Fitch (2003) found that when the rate of grout application exceeded 13 cubic yards per hour, the pH downstream of the project was likely to exceed a pH of 9.0. Conversely, in streams where there was a high rate of stream flow in relation to the rate of grout application, there were minimal effects to the pH of the downstream environment (Fitch 2003).

Conclusion

Grout bag activities will implement the AMMs listed in 3.12 to avoid increasing pH levels to >9. Effects to water quality from grout bag activities are not likely to occur. Effects to water quality from grout bag and concrete repair activities are likely to be insignificant and are **not likely to adversely affect** Atlantic salmon.

5.7.1.4 Effects to Critical Habitat

Uncured concrete and grout materials can enter streams and alter water quality by raising pH levels. pH levels >9 would make water quality conditions unsuitable for salmon and other fish.

Conclusion

In summary, uncured concrete or grout released into the water could have adverse effects to critical habitat should this occur. However, the Proponents will implement the specified AMMs to prevent releases of uncured concrete and grout. Careful adherence to the SPCC Plan (CM #25-27) and AMM 34 makes it highly unlikely that this will occur in critical habitat. Increases in pH from concrete or grout releases are unlikely; hence, these effects are discountable. These effects **are not likely to adversely affect Atlantic** salmon critical habitat.

5.7.2 Pollutant or Materials Releases

All of the project activities have the potential to result in pollutant or materials releases related to general construction activities. Petroleum-based materials, such as diesel fuel and oil, can enter streams from a spill or stormwater runoff affecting Atlantic salmon individuals and critical habitat. All in-water excavation will take place inside of a cofferdam.

The Proponents do not allow intentional discharges of any sort in association with construction activities. However, the use of heavy equipment in or near a waterbody increases the risk of contaminants (fuel, oil, hydraulic fluid, etc.) releasing into the project site and possibly degrading habitat conditions and threatening aquatic organisms.

As a component of the SEWPCP for each project, the Proponents (or their contractor) will develop and implement an SPCC Plan, designed to avoid any stream impacts from hazardous chemicals associated with construction activities, such as diesel fuel, oil, lubricants, and other hazardous materials. The SPCC Plan includes the assurance that necessary BMPs will be on site and employed in the event of a hazardous materials release. Careful adherence to an approved SPCC Plan, as part of an overall SEWPCP, will make it highly unlikely that Atlantic salmon will be exposed to harmful chemicals from a spill or accident.

The Proponents will implement the specified AMMs to prevent spill incidents. The AMMs related to potential hazardous materials releases are addressed in above in Section 3.12. MaineDOT's Standard Specifications require that refueling, equipment maintenance, and materials storage occur at least 100 feet from a watercourse (MaineDOT 2014). All pumps will be maintained, refueled, and operated at a location consistent with the SPCC Plan and in a manner that avoids chemical or other hazardous materials getting into the stream.

In-water work will be conducted during low flows, and any storm water impact area is likely to be relatively small and localized should runoff occur. The Proponents and their contractors will carefully adhere to the project specific SEWPCP, making incidences of storm water runoff during and after construction unlikely. AMM# 11 in Section 3.12 addresses stormwater.

Effects to the Species

Petroleum-based materials, such as diesel fuel and oil, contain polycyclic aromatic hydrocarbons (PAHs), which can enter streams from a spill or stormwater runoff affecting Atlantic salmon individuals. PAHs can be acutely toxic to salmonids and other aquatic organisms at high exposure levels or can cause sublethal effects at lower exposures (Albers 2003, Meador et al. 2006).

Conclusion

In summary, depending on the nature of released material, a spill could have adverse effects to salmon individuals should one occur. However, the Proponents will implement the specified AMMs to prevent spill incidents. Careful adherence to the SPCC Plan (Section 3.10.1.5) makes it highly unlikely that Atlantic salmon will be exposed to harmful chemicals from a spill or release. A hazardous materials release is unlikely; hence, these effects are discountable. These effects **are not likely to adversely affect** Atlantic salmon of any life stage.

Effects to Critical Habitat

Petroleum-based materials, such as diesel fuel and oil, contain polycyclic aromatic hydrocarbons (PAHs), can enter streams, settle out in the substrate, and remain in the substrate for long periods of time making substrates unsuitable for aquatic organisms or have direct biological consequences. PAHs have been studied extensively in the aquatic environment, and they cause a broad range of effects on organisms, including inhibition of reproduction, delayed emergence in invertebrates, mortality, and sediment avoidance (Scoggins et al. 2007).

Conclusion

In summary, depending on the nature of released material, a spill could have adverse effects to critical habitat should one occur. However, the Proponents will implement the specified AMMs to prevent spill incidents. Careful adherence to the SPCC Plan (CM #19-23) makes it highly unlikely that chemical spills or releases will occur in critical habitat. A hazardous materials release is unlikely; hence, these effects are discountable. These effects **are not likely to adversely affect** Atlantic salmon critical habitat.

5.7.3 Stormwater Runoff

Culvert and bridge replacements will also include replacing the road surface at each crossing. Under some circumstances, the area of new road surface may exceed the previous area of surface, resulting in a net increase in the amount of impervious surface.

The primary source of contaminants from transportation systems is runoff from untreated impervious surface. Roadway and pavement runoff contains organic and inorganic contaminants that can enter streams and impair water quality and affect aquatic and benthic communities. On new and existing road surfaces, chemical contaminants can enter into waterbodies through direct contact with contaminated surfaces or released in stormwater runoff and can remain in solution in the water column or deposit on the substrate. Potential contaminants in roadway runoff include suspended solids, heavy metals, hydrocarbons, indicator bacteria and pathogens, and deicing salts (Grant et al. 2003), all of which can negatively affect salmon and salmon habitat. Stormwater runoff can also cause changes in water temperature, as the runoff tends to be warmer relative to that in the stream.

The proponents are not proposing to include any new road facilities for review under this PBA (see AMM #11).

5.7.3.1 AMMs

Both state and federal regulations address stormwater. The State of Maine Stormwater Rule, Chapter 500, requires treatment of stormwater for the creation of new impervious area in excess of regulatory thresholds. MaineDOT has a Memorandum of Agreement (MOA) with the MDEP (administrator of Chapter 500) that requires the analysis of stormwater treatment of new roadway facilities and upgrades of roadway facilities that exceed state thresholds.

Contaminant exposure from increased impervious surface and other contaminant sources associated with transportation projects will be minimized through the use of water quality treatment measures and precautionary measures during construction.

5.7.3.2 Effects to the Species

Untreated stormwater can degrade water quality and result in lethal and sub-lethal physiological effects on Atlantic salmon individuals. Higher concentrations of toxic substances have caused rapid mortality in salmonids. Lower concentrations can result in delayed mortality or a variety of sub-lethal effects in salmonids, including impaired swimming ability, delayed spawning, reduced resistance to stress, and a variety of behavioral responses (Ewing 1999, Beschta et al 1995).

Conclusion

The small portions of roadways that drain to the streams being crossed result in effects to Atlantic salmon individuals and critical habitat from stormwater runoff are not like to be meaningful or measurable and, therefore, are discountable. Instances of stormwater runoff from the proposed activities **are not likely to adversely affect** Atlantic salmon and Atlantic salmon critical habitat.

5.7.3.3 Effects to Critical Habitat

Stormwater runoff can contain petroleum-based materials which contain PAHs, can enter streams, settle out in the substrate, and remain in the substrate for long periods of time making substrates unsuitable for aquatic organisms or have direct biological consequences. PAHs have been studied extensively in the aquatic environment, and they cause a broad range of effects on organisms, including inhibition of reproduction, delayed emergence in invertebrates, mortality, and sediment avoidance (Scoggins et al. 2007).

Conclusion

In summary, stormwater could have adverse effects to critical habitat. The Proponents do not have a full understanding of the extent to which stormwater runoff from impervious surface affects Atlantic salmon. To date, the USFWS has not expressed concern for stormwater issues for previous projects with similar elements as the activities proposed in this PBA. This PBA does not include new road facilities (AMM 11), which would create added stormwater issues. These effects **are not likely to adversely affect** Atlantic salmon critical habitat.

5.8 Atlantic Salmon Handling

Capturing and handling salmon can cause physiological stress and possibly physical injury or death, including cardiac or respiratory failure from electrofishing (Snyder 2003). Studies show all aspects of fish handling, such as electrofishing, dip-netting, time out of water, and data collection (e.g., measuring and weighing), are stressful and can lead to immediate or delayed mortality (Murphy and Willis 1996). Direct mortality may occur when fish are handled roughly or kept out of the water for extended periods. Clement and Cunjak (2010) found a low incidence and severity of injuries to juvenile Atlantic salmon from electrofishing in New Brunswick, but injuries were more prevalent in larger parr. The sublethal effects associated with electrofishing, other than physical injury, remain largely unknown.

Delayed fish mortality is often associated with a disease epizootic, which generally occurs from 24 hours to 14 days after handling. If a fish is injured during handling, disease may develop within a few hours or days. Examples of injuries which can lead to disease problems are loss of mucus, loss of scales, damage to the integument, and internal damage. Internal injuries occur when fish are not properly restrained or not sedated during handling. It is common for fish to jump out of a worker's hand and fall onto a hard surface, resulting in internal injuries and mortality.

Relocating fish will temporarily displace and disrupt their normal behaviors. Atlantic salmon parr are highly territorial and actively defend their feeding territory to maximize foraging. Atlantic salmon parr temporarily displaced from their territory by construction activities, particularly the dewatering of a section of stream, may be more vulnerable to predators, may be less able to capture prey, and may experience stress while looking for another suitable, unoccupied area of stream in which to establish a new territory.

The MDMR usually handles a few thousand juvenile salmon each year while electrofishing. Recorded mortalities are generally less than 2% of fish captured (USFWS 2011) and predominately young-of-the-year (YOY) salmon (parr during their first year after hatching).

Some of the Proponents' projects are likely to be in locations where there is no stocking or wild spawning, so we will expect juvenile salmon densities to be low or absent altogether. Additionally, the quality of salmonid habitat that will be dewatered will vary, depending on cofferdam location, and could influence the number of salmon encountered during dewatering.

To minimize dewatering-related fish stranding inside the cofferdam, MaineDOT (or approved consultants) will capture and remove as many Atlantic salmon and other fish species as possible. The Proponents will conduct evacuation procedures according to MaineDOT's Atlantic Salmon Evacuation Plan and Disinfection Procedures (Appendix A) to minimize the amount of Atlantic salmon parr subject to stranding.

Handling stress and risk of injury will be minimized by 1) ensuring minimal handling time (no data will be collected from individual Atlantic salmon other than record capture amounts); 2) ensuring minimal time that fish are held out of water and the stream; and 3) using transfer containers with aerated stream water of ambient temperature.

5.8.1.1 Biological Response

When cofferdams are dewatered and construction activities begin to replace or remove the existing stream crossing (e.g., excavation of the substrate), any fish left stranded in the substrate will be killed. MaineDOT or MTA will indicate on the Standard Reporting Form whether the presence of Atlantic salmon is expected for each specific project. When completed for projects that occur in areas that are unoccupied by Atlantic salmon, cofferdam construction may affect, is not likely to adversely affect Atlantic salmon. When completed for projects that occur in areas that are likely occupied by Atlantic salmon, cofferdam construction may affect, is likely to adversely affect Atlantic salmon. Any Atlantic salmon trapped inside of a cofferdam will be subject to adverse effects in the form of harassment or handling. Mortality can be expected for a small portion of Atlantic salmon during handling and due to stranding.

5.8.1.2 Conclusion

Dewatering cofferdams in occupied Atlantic salmon rearing habitat is likely to result in mortality of any Atlantic salmon parr that were not evacuated from the work area.Capturing and handling effects are **likely to adversely affect** Atlantic salmon parr. Due to their size, Atlantic salmon adults are not expected to be missed during cofferdam dewatering and therefore, capturing or handling an Atlantic salmon will be **not likely to adversely affect** Atlantic salmon adults.

Table 5-12. Effect determinations for proposed activities that have potential to result in handling effects to Atlantic salmon.

	Atlantic Salmon Life Stage				
Activity or component	**Eggs**	**Fry**	**Parr**	**Smolt**	**Adult**
Fish handling	NE	LAA	LAA	NE	NLAA

Critical habitat within the dewatered work area is temporary unavailable during cofferdam installation and/or bypass stream channel installation, on appropriate activities. However, capturing, handling stranding and relocation fish results in a no effect to critical habitat.

5.9 Impingement and Entrainment

The intake hose during any pumping process has the potential to adversely affect fish, including juvenile Atlantic salmon, through entrainment and impingement. All project activities proposed in this PBA have the potential to require pumping of water for different portions of the activity. Water pumping will primarily be for water diversions and cofferdam dewatering. Approach velocities across the screen that are faster than a fish's swimming capability can draw and hold fish against the screen surface (i.e., impingement), resulting in suffocation or physical damage to the fish (NMFS 2008). Pump intake hoses without screens or with improper screens can result in fish being drawn into the pump (entrainment) and killed (impingement). Additionally, fish can become impinged in block nets that have been positioned to prevent fish from moving into a work area. This could be an additional source of mortality associated with construction site isolation procedures.

NMFS (2008) provides criteria to minimize effects from entrainment and impingement. These include:

- Ensure the pump intake is sufficiently large so that the approach velocity does not exceed 6.10 meters second^{-1} (0.20 feet second^{-1}).
- Square or round screen face openings are not to exceed 2.38 millimeters (3/32 inch) on a diagonal. Criteria for slotted face openings shall not exceed 1.75 millimeters (~1/16 inch) in the narrow direction.
- Intake hoses shall be regularly monitored while pumping to minimize adverse effects to Atlantic salmon.

The implementation of protective measures in MaineDOT's Atlantic Salmon Evacuation Plan and Disinfection Procedures (see Appendix A) and implementation of the proper pump screen (AMM #30) will reduce the likelihood of fish injury or mortality from interactions with the pumped diversion process. The timeframe for implementing the pumped diversion will be limited to that which is necessary to divert water around the construction project, generally from a few days to a few weeks.

MaineDOT's experience with the use of block nets set around construction areas at culvert replacement projects in Maine has not shown that fish from outside the construction area become trapped in these nets. In a Biological Opinion for culvert replacement and removal projects in Idaho, NMFS (2006) concluded that the risk of fish mortality from impingement on block nets was discountable. Therefore, we do not anticipate any injury or mortality of Atlantic salmon associated with impingement on block nets.

5.9.1.1 Conclusion

The implementation of protective measures during the pumping process will reduce the likelihood of entrainment and impingement (AMM #30, and Appendix A). The Proponents are proposing to complete water pumping activities in windows that are designed to avoid effects on Atlantic salmon fry, eggs, and smolts. Impingement and entrainment from the proposed activities is **not likely to adversely affect** adult Atlantic salmon due to their strong swimming ability and size. Parr is the primary life stage of Atlantic salmon that is subject to impingement and entrainment effects. Due to the implementation of the measures listed above, impingement and entrainment resulting in take of Atlantic salmon parr is unlikely. Therefore, adverse effects resulting from impingement and entrainment is **not likely to adversely affect** Atlantic salmon parr. Impingement and entrainment will have no effect on Atlantic salmon critical habitat.

Table 5-13. Determination of effects to Atlantic salmon associated with impingement and entrainment during water pumping procedures.

	Atlantic Salmon Life Stage				
Activity or component	**Eggs**	**Fry**	**Parr**	**Smolt**	**Adult**
Cofferdam pumpout	NE	NE	NLAA	NE	NLAA
Pumped diversion	NE	NE	NLAA	NE	NLAA

5.10 Stranding

Cofferdam establishment requires dewatering activities within the dammed area. During the cofferdam process, individual Atlantic salmon may be killed, injured or temporarily disturbed or displaced by in-water construction. Mortality will occur if juvenile fish are missed or stranded in substrate interstices within the dewatered cofferdam. Highly territorial salmonids, such as Atlantic salmon, that hold station and establish territories may be more vulnerable to stranding effects owing to their reluctance to abandon territories (Armstrong et al. 1998). Stranding incidences tend to be higher during the day, and this is probably because salmon are predominantly active at night and more likely to move out of substrates.

During dewatering, stranding does not always lead to mortality, as fish can survive for several hours in the substrate after dewatering. However, stranding over a longer time period (which would be typical for culvert replacement projects or removal of stream substrate for project construction) would result in mortality. All of the cofferdams associated with activities covered in this PBA are likely to have durations long enough to result in mortality of any fish stranded in the cofferdam.

In a field experiment conducted in cold water (<4.5°C [40.1°F]), Saltveit et al. (2001) found that 60% of Atlantic salmon young of the year (YOY) became stranded during dewatering over a period of 42 minutes. After searching the substrate, about 39% of the stranded fish could not be found. YOY Atlantic salmon were affected more severely than older juveniles. Only about 10% of 1+ Atlantic salmon parr were stranded during daylight hours in water with temperatures >9°C (>48.2°F).

For ESA-listed Pacific salmon and steelhead, NMFS (2006) provides an expected stranding rate of 8% (of the total exposed population) for both electrofished and non-electrofished sites. Furthermore, the relatively low voltages, which are typically used in Maine to minimize injury or death of Atlantic salmon from electrofishing, makes it possible that some juvenile Atlantic salmon (especially YOY) could be left in the stream substrate when dewatering begins (N. Dubé, formerly of MDMR, personal communication; Scott Craig, USFWS; personal communication).

Given the best available scientific information, it is assumed that some juvenile Atlantic salmon will be left stranded inside a cofferdam, particularly in streams with coarse gravel and cobble substrate where small fish can be very difficult to detect and remove. Because of the proposed in-water work windows (avoidance of smolts and alevins) and the visibility of larger fish, it is expected that Atlantic salmon parr are the only life stage subject to potential stranding.

To minimize dewatering-related fish stranding inside the cofferdam, the Proponents or approved consultants will capture and remove as many Atlantic salmon and other fish species as possible. The Proponents will conduct evacuation procedures according to MaineDOT's Atlantic Salmon Evacuation Plan and Disinfection Procedures (Appendix A) to minimize the amount of Atlantic salmon parr subject to stranding.

If a bridge replacement activity requires the installation of a bridge pier and sheet pile cofferdam to create a dry work area, the proponents cannot complete a comprehensive fish evacuation due to water depth. Appropriate evacuation techniques will be discussed with the USFWS at the time of project submittal to ensure that the amount of take is properly analyzed.

5.10.1.1 Biological Response

When cofferdams are dewatered and construction activities begin to replace or remove the existing stream crossing (e.g., excavation of the substrate), any fish left stranded in the substrate will be killed. MaineDOT or MTA will indicate on the Standard Reporting Form whether the presence of Atlantic salmon is expected for each specific project. When completed for projects that occur in areas that are unoccupied by Atlantic salmon, cofferdam construction may affect, **is not likely to adversely affect** Atlantic salmon. When completed for projects that occur in areas that are likely occupied by Atlantic salmon, cofferdam construction may affect, is **likely to adversely affect** Atlantic salmon. Any Atlantic salmon trapped inside of a cofferdam will be subject to adverse effects in the form of harassment or handling. Mortality can be expected for a small portion of Atlantic salmon during handling and due to stranding.

5.10.1.2 Conclusion

Dewatering cofferdams in occupied Atlantic salmon rearing habitat is likely to result in mortality of any Atlantic salmon parr that were not evacuated from the work area. Stranding impacts are **likely to adversely affect** Atlantic salmon parr. Due to their size, Atlantic salmon adults are not expected to be missed during cofferdam dewatering. The proposed activities will not occur in spawning habitat, and eggs and fry are not at risk of stranding. Additionally, proposed activities will not occur during smoltification and smolt migration. Therefore, stranding is **not likely to adversely affect** eggs, smolt, or adult Atlantic salmon.

Table 5-14. Determination of effects to Atlantic salmon associated with stranding in cofferdams.

	Atlantic salmon Life Stage				
Activity or component	**Eggs**	**Fry**	**Parr**	**Smolt**	**Adult**
Cofferdam installation	NE	NE	LAA	NE	NLAA

Table 5-15. Potential cofferdammed area that will potentially result in adverse effects due to stranding (estimated area calculated using past project history of similar project scopes)

Activity or Component	Number of Projects	Area of Impact Per Project (Feet^2)	Total area (Feet^2)
Cofferdammed area	± 200	± 20,000	± 3,600,000

5.11 Critical Habitat Alteration

NMFS designated critical habitat necessary to the recovery of the GOM DPS of Atlantic salmon, and PCE's were designated to protect the different habitats that are important to different life stages of Atlantic salmon (discussed in Section 2.4). Some proposed activities may affect Atlantic salmon critical habitat and may result in losses in critical habitat. Other activities (such as bridge removals, for example) will restore critical habitat. For activities covered in this PBA, permanent riprap will be used for culvert replacements, bridge replacements, culvert end resets and extensions, and scour countermeasures. Several activities proposed under this PBA will improve fish passage and open up access to habitat upstream. In particular, new stream crossing replacements will have an increased hydraulic opening to allow for more natural stream processes.

5.11.1 Culvert Replacements

Stream crossing replacements require the use of riprap in Atlantic salmon critical habitat to ensure that water flow will not scour around the inlet and outlet of the culvert. Water flow that does not remain in the crossing structure can cause bank failure or destabilization of the materials which the crossing is founded on resulting in a failure. The riprap placed in the stream at the inlet and outlet of the culvert is referred to as a riprap apron.

Riprap aprons typically are 2 feet deep and extend 10 feet upstream and 10 feet downstream of crossing structures (including culvert replacements and culvert end resets/extensions). They are intended to remain in place for the life of the crossing structure.

To minimize the effects of the riprap placement on Atlantic salmon critical habitat, the Proponents are proposing to embed riprap aprons and cover the riprap with ESM (see the design guidance in Appendix B). This will ensure that the stream substrate remains natural material and functions as critical habitat similar to other areas in the stream.

5.11.2 Bridge Replacements

Riprap is also used to ensure the long-term stability of bridge abutments. Designs with different abutment depths and different bridge heights above the stream may require more or less riprap. This riprap is placed along the length of the abutment and can extend up to 20 feet in front of the abutment.

To minimize the effects of the riprap placement on Atlantic salmon critical habitat, the Proponents are proposing to ensure the abutment protection is covered with ESM within the limits of the stream channel (see the design guidance in Appendix B). This will ensure that the stream substrate remains similar to natural material and functions as critical habitat just as other areas in the stream.

5.11.3 Culvert End Reset

Riprap is also placed at the inlet or outlet of any culvert reset. Streambed material will be placed on top of this riprap to minimize the effects to critical habitat (AMM #44).

5.11.4 Culvert End Extension

This riprap is also placed at the inlet or outlet of any culvert extension. Streambed material will be placed on top of this riprap to minimize the effects to critical habitat (AMM #44).

The lengthening of a culvert resulting from a culvert extension project will result in the loss of functioning critical habitat. Often, culvert extensions cannot be filled with ESM and are not sized properly to maintain ESM. This will result in the loss of 8 of linear streambed per extension. As stated in Section 3.6, most culvert extensions take place on crossing structures that are <10 feet in width. It is reasonable to believe that a conservative estimate for habitat loss per project is 80 square feet of critical habitat potentially functioning as rearing habitat.

Culvert extensions in the upstream direction may also require a stream channel relocation if the stream is not properly aligned with the existing crossing. This upstream channel relocation is typically no more than 25 feet of linear stream. In MaineDOT’s past experience, it is necessary on only about 15% of upstream culvert extensions. The relocated channel will be constructed to match the pre-existing channel’s width, depth, and substrate. Critical habitat loss is not expected as a result of these channel relocations.

The Proponents are proposing mitigation for all culvert end resets and extensions in Tier 1 and Tier 2 priority areas within the PBA (CM #2).

5.11.5 Scour Countermeasures

Scour countermeasures will alter the entire critical habitat in the area where concrete cable mats are going to be installed. The concrete cable mats will be embedded below the existing substrate and will form a low flow channel to allow for water depth at the lowest flows. This low flow channel will match existing low flow channels if they are present under the bridge. Stream substrate will then be placed back on top of the concrete cable mats. This substrate will consist of any stream materials that were moved and excavated to place the concrete cable mats and will not cover the entire mat.

The Proponents are proposing mitigation for all scour countermeasures projects in Tier 1 and Tier 2 priority areas within the PBA (CM #2).

5.11.6 Effects to Critical Habitat

The duration of the habitat alteration effect will be similar across all scour countermeasure activities and will be for the life of the project.

Effects to more sensitive habitats may be more severe with even if it has a smaller footprint. That is due to the important nature and limited availability of some habitat elements such as spawning habitat. For that reason, the Proponents are proposing to avoid and minimize effects to important portions of Atlantic salmon by following the AMMs #12, #13, #47 and #48.

5.11.6.1 Conclusions

Culvert Replacements

Culvert replacements in critical habitat will result in functioning critical habitat in and directly adjacent to crossing structures after they are completed. This will be result of the placement of ESM material inside of the crossing structures as well as on top of any riprap required for inlet and outlet protection.

Culvert replacements will not result in loss of critical habitat, and placement of ESM will replicate natural stream substrate. Effects to critical habitat from culvert replacements in the action area will be insignificant. Therefore, culvert replacements are **not likely to adversely affect** critical habitat.

Bridge Replacements

Bridge replacements in critical habitat will result in functioning critical habitat in and directly adjacent to crossing structures after they are completed. This will be result of the placement of ESM material inside of the crossing structures as well as on top of any riprap required for abutment protection.

Bridge replacements will not result loss of critical habitat (AMMs #44 and #48), and placement of ESM will replicate natural stream substrate. Effects to critical habitat from bridge replacement activities in the action area will be insignificant. Therefore, bridge replacements are **not likely to adversely affect** critical habitat.

Bridge/ Culvert Removal

Bridge/ culvert removal in critical habitat will result in fully functioning critical habitat in and directly adjacent to crossing structures that have been removed. This will be result of the placement of ESM material inside in the streambed where the crossing was removed and restoration of the stream channel.

Long term effects from bridge/ culvert removal will result in wholly beneficial effects to critical habitat. Effects to critical habitat from bridge/ culvert removals in the action area will be insignificant. Therefore, bridge/culvert removals are **not likely to adversely affect** critical habitat.

Scour Countermeasures

Scour Countermeasures will result in a loss of functional habitat for the entire area of concrete cable mat. The cable mats will convert habitat with substrate that has flow refugia and a higher density of invertebrate prey to a harder substrate without refugia and likely will lessen the amount of prey available. Though placing substrate back on a mats and embedded them will minimize these affects, they will still have a significant effect on the function of the critical habitat. Therefore, scour countermeasures **are likely to adversely affect** Atlantic salmon critical habitat.

Table 1-1 provides impact estimates for the number of projects over the period of authorization for this PBA. These values are meant to provide an extent of expected impacts to facilitate estimates of take of salmon and adverse modification of critical habitat. Impacts are to those areas where in-water work will be conducted. These average impacts are based on a review of estimated impacts from past consultations between MaineDOT and either USFWS or NMFS.

Culvert End Reset

Culvert end resets occurring in critical habitat will result in a loss of critical habitat associated with riprap placement (~100 square feet per project). End resets will maintain existing conditions at the culverts rehabilitated. However, working only on the ends of a culvert will not change its passage character, and any culvert that is not fully accessible will remain so. MaineDOT has never completed a reset on a culvert crossing that met fully accessible standards.

Affects to critical habitat are evaluated by determining the likelihood that the effect will influence the function and role of the critical habitat. The entire crossing structure will not meet fully accessible standards once the culvert end reset is completed. Therefore culvert end resets **are likely to adversely affect** Atlantic salmon critical habitat.

Culvert Extensions

Culvert extensions occurring in critical habitat will result in a loss of critical habitat (~80 square feet per project). It is also likely to result in additional scour impacts downstream of the crossing structure from the extension into downstream habitat. Because this will not change the size of the crossing structure, it is reasonable to assume that the scour will move downstream as far as the extension (8 feet) and will affect an additional 80 square feet per project. Culvert extensions on the upstream side have the potential to necessitate channel relocation, which will produce an additional loss in critical habitat (~250 square feet per project).

Because this has the potential to affect the site's critical habitat role in the conservation of salmon, culvert extensions are **likely to adversely affect** critical habitat.

Table 5-16. Estimates of impacts to critical habitat for MaineDOT projects over the 5-year period allocated for this PBA.

Activity	**Average Extent of Permanent Impacts** (feet^2)	**Number of Projects**	**Total Impacts** (feet^2)
Stream Crossing Replacements (Culverts, spans ≤ 20')	10,000	50	500,000
Stream Crossing Replacements (Bridges, spans > 20')	30,000	45	1,350,000
Bridge and Culvert Removal	20,000	3	60,000
Scour Countermeasures	5,000	15	75,000
Culvert End Resets	100	25	2,500
Culvert End Extensions	250	25	6,250
Bridge Maintenance	75	16	12,000
Invert Line and Slipline Culvert Rehabilitation	250	15	3,750
Overall	--	194	2,009,500

Some of the impacts to critical habitat will be adverse. However, the result of many of the projects in Tier 1 and Tier 2 priority areas will have beneficial consequences where habitat connectivity is restored in those places that posed partial or complete barriers to passage. The Proponents estimate that the ultimate results of implementing this PBA will aid in the recovery of Atlantic salmon.

Directions for Table Use:

- *For each specific stressor and associated activity listed in the table, specific AMMs have been proposed that will be implemented in order to avoid and minimize the overall effect determination resulting from that stressor and associated activity. The species and habitat effects that are listed in the table are the species and habitat effects of that particular stressor and associated activity prior to implementation of any AMMs. The overall effect determination shown in the table is the overall effect determination of that particular stressor and associated activity after all proposed AMMs have been implemented. The table should be used and read across from left to right, looking at each row as an equation (i.e., Stressor & Associated Activities + Species Effect (from the before-mentioned stressor/sub-activity) + Habitat Effect(from the before-mentioned stressor/sub-activity) + AMMs = Overall Effect Determination).*
- *The various different bullet types are meant to distinguish different sub-activities within the main construction activity and per stressor. Sometimes a stressor may not need the sub-activities. The bullet type can be followed across the row for things unique to it (like different effects or AMMs or effect determinations). If there is no bullet as you work your way across, the content of that particular box applies to all the sub-activities.*
- *The programmatic biological assessment does not propose effects to any life stage of Atlantic salmon that can occur in a redd as well as effects to adult salmon while spawning, or smolts when making their seaward migration. For the purpose of this table, all effects will be potential on Atlantic salmon parr and adult Atlantic salmon, unless broken out and separately defined.*
- *The term "cofferdam" that is use throughout this table includes all options mentioned in the programmatic (i.e., sandbag, industrial sandbag, plastic sheeting and sheet piles). If sheet piles are used for cofferdam installation/removal on any activity, it will always be with a vibratory hammer, never an impact hammer.*

Table 5-17. Summary Table.

Stressor and Associated Activities	Species Effect	Critical Habitat Effect	Avoidance and Minimization Measures	Overall Effect Determination (Species / Critical Habitat)
ACTIVITY #1a: Stream Crossing Replacements ≤ 20 feet (Culvert Replacements)				
Elevated turbidity, sediment transport[10] o Cofferdam installation and removal • Bypass channel installation and removal ❖ Discharge of water from outlet of pump bypass (velocity >5 fps)	Physical injury or mortality, avoidance, displacement, loss of fitness, temporary behavior modification	Temporarily affected water quality, localized, short-duration habitat degradation, affected prey resources	AMM 4-6, 9,14-20, 23, 31	Adults: NLAA Parr: LAA CH: LAA
Hydroacoustic/ underwater noise[11] o Cofferdam installation and removal	Avoidance, displacement, loss of fitness, temporary behavior modification	NE	AMM 21- use of vibratory hammer only	NLAA / NE
Migratory or movement barrier for fish passage o Cofferdam installation, removal and duration • Bypass channel installation, removal, and duration	Avoidance, displacement, loss of fitness, temporary behavior modification, potential temporary exclusion from upstream habitat, delayed spawning	NE	AMM 22- remove cofferdams ASAP	LAA / NE

8This stressor includes a sub-activity of installation/removal of temporary access. Because this sub-activity is common to several of the main construction activities, it has been addressed separately, as its own main construction activity.

[11] This stressor includes a sub-activity of installation/removal of temporary access. Because this sub-activity is common to several of the main construction activities, it has been addressed separately, as its own main construction activity.

Stressor and Associated Activities	Species Effect	Critical Habitat Effect	Avoidance and Minimization Measures	Overall Effect Determination (Species / Critical Habitat)
Capturing, handling, stranding, and relocating fish o Work area isolation and fish evacuation (i.e., hand netting, seining, trapping or electrofishing) for cofferdam and/or bypass stream channel installation	Injury or mortality, delayed migration, disruption of rearing, and temporary loss of foraging, harassment, harm, physiological stress, temporary displacement and increased energy expenditures, disruption to normal behaviors including increased vulnerability to predators and missed feedings.	NE	AMM 29- Complete fish evacuation protocol	Adults: NLAA, Parr: LAA, CH: NE
Impingement or entrainment of fish during operation of pump diversion o Cofferdam dewatering • Stream channel bypass system installation and operation	Physical injury, mortality, suffocation, or physical bodily injury	NE	AMM 30- Employ pump screens	NLAA / NE
Water quality alteration due to pollutant/ materials discharge, increases in pH levels or stormwater o Heavy equipment use in or near a waterbody • Operation of bypass pumps or other gas powered motors	Increased risk of contaminants (fuel, oil, hydraulic fluid, etc.) resulting in potential for exposure of toxins causing death at high exposure levels or sub-lethal effects at lower exposures, inhibition of reproduction, delayed emergence in invertebrates, and sediment avoidance	Temporary habitat loss and degradation.	AMM 25-28	NLAA / NLAA
Habitat and Critical Habitat Alteration o Lengthening of crossing structures • Placement of rip rap at inlet/outlet of structure	NE	Altering critical habitat by changing substrate type and losing interstitial spaces	AMM 44, 45 **CM 1**	NE / NLAA

Stressor and Associated Activities	Species Effect	Critical Habitat Effect	Avoidance and Minimization Measures	Overall Effect Determination (Species / Critical Habitat)
Permanent Fish Passage and Stream Habitat Connectivity o Tier 1- 1.2 BFW replacements • Tier 2 BFW replacements	Restoration of ATS full access to habitat above crossing structures Restore ATS habitat in structure for utilization	o Restoration of stream habitat connectivity • Restoration of stream habitat connectivity, lacking bank roughness	**CM 1**	o NLAA / NLAA • LAA / LAA
ACTIVITY #1b: Stream Crossing Replacements > 20 feet (Bridge Replacements)				
Elevated turbidity, sediment transport[12] o Cofferdam installation and removal • Permanent pile or bridge support installation from impact pile driving (Drilled shaft/ micropile installation) ❖ Stream channel diversion or relocation ✓ Permanent riprap placement/ installation[13] ▪ Old bridge/structure demolition	Physical injury or mortality, avoidance, displacement, loss of fitness, temporary behavior modification	Temporarily affected water quality, localized, short-duration habitat degradation, affected prey resources	AMM 4-6, 9,14-20, 23, 31,36	o Adults: NLAA, Parr: LAA, CH: LAA • Adults: NLAA, Parr: LAA, CH: NLAA ❖ Adults: NLAA, Parr: LAA, CH: LAA ✓ Adults: NLAA, Parr: LAA, CH: LAA ▪ NLAA / NLAA

[12] This stressor includes a sub-activity of installation/removal of temporary access and pre-project sampling/drilling. Because those sub-activities are common to several of the main construction activities, those will be addressed separately, as their own main construction activity.

[13] Note that riprap placement is being treated differently than installation/removal of temporary access roads because it could be included as part of some activities for permanent inclusion in the project (i.e., placement for bank stabilization).

Stressor and Associated Activities	Species Effect	Critical Habitat Effect	Avoidance and Minimization Measures	Overall Effect Determination (Species / Critical Habitat)
Hydroacoustic/ underwater noise[14] o Cofferdam installation and removal • Old bridge/ structure demolition ❖ Drilled shaft/ micropile installation ✓ Permanent pile or bridge support installation from impact pile driving	o Avoidance, displacement, loss of fitness, temporary behavior modification • Avoidance, displacement, loss of fitness, temporary behavior modification ❖ Avoidance, displacement, loss of fitness, temporary behavior modification ✓ Physical injury or mortality, avoidance, displacement, loss of fitness, temporary behavior modification	NE	AMM 21- use of vibratory hammer only, AMM 37-43	o NLAA / NE • LAA / NE ❖ NLAA / NE ✓ LAA / NE
Migratory or movement barrier for fish passage o Cofferdam installation, removal and duration • Permanent pile or bridge support installation from impact pile driving ❖ Stream channel diversion or relocation and duration ✓ Old bridge/structure demolition	o Physical barrier to fish movement and migration/movement, temporary exclusion from upstream habitat • Potential movement and migration effects resulting from the ensonified area ❖ Physical barrier to fish movement and migration/movement, temporary exclusion from upstream habitat ✓ Potential movement and migration effects resulting from the ensonified area	NE	AMM 22- remove cofferdams ASAP	Bridges <100 feet: LAA / NE; Bridges ≥100 feet: NLAA / NE

[14] This stressor includes a sub-activity of installation/removal of temporary access and pre-project sampling/drilling. Because those sub-activities are common to several of the main construction activities, those will be addressed separately, as their own main construction activity.

Stressor and Associated Activities	Species Effect	Critical Habitat Effect	Avoidance and Minimization Measures	Overall Effect Determination (Species / Critical Habitat)
Capturing, handling, stranding, and relocating fish o Work area isolation and fish evacuation (i.e., hand netting, seining, trapping or electrofishing) for cofferdam and/or stream channel diversion installation	Injury or mortality, delayed migration, disruption of rearing, and temporary loss of foraging, harassment, harm, physiological stress, temporary displacement and increased energy expenditures, disruption to normal behaviors including increased vulnerability to predators and missed feedings	NE	AMM 29- Complete fish evacuation protocol	Adults: NLAA, Parr: LAA, CH: NE
Impingement or entrainment of fish during operation of pump diversion and cofferdam dewatering o Cofferdam dewatering • Stream channel diversion installation and operation	Physical injury, mortality, suffocation, or physical bodily injury	NE	AMM 30- Employ pump screens	NLAA / NE

Stressor and Associated Activities	Species Effect	Critical Habitat Effect	Avoidance and Minimization Measures	Overall Effect Determination (Species / Critical Habitat)
Water quality alteration due to pollutant/ materials discharge, increases in pH levels or stormwater o Heavy equipment use in or near a waterbody • Net increase in amount of impervious area	o Increased risk of contaminants (fuel, oil, hydraulic fluid, etc.) resulting in potential for exposure of toxins causing death at high exposure levels or sub-lethal effects at lower exposures, inhibition of reproduction, delayed emergence in invertebrates, and sediment avoidance • Untreated stormwater runoff from impervious surfaces can degrade water quality and result in lethal and sub-lethal physiological effects. Higher concentrations of toxic substances have caused rapid mortality, including impaired spawning ability, delayed spawning, reduced resistance to stress	Temporary habitat loss and degradation	AMM 11, 25-28	NLAA / NLAA
Habitat and Critical Habitat Alteration o Widening of bridges • Placement of rip rap at abutments/ wingwalls	NE	Altering critical habitat by changing substrate type and losing interstitial spaces	AMM 44, 45 **CM 1**	NE / NLAA

Stressor and Associated Activities	Species Effect	Critical Habitat Effect	Avoidance and Minimization Measures	Overall Effect Determination (Species / Critical Habitat)
Permanent Fish Passage and Stream Habitat Connectivity Tier 1 and Tier 2	Restoration of ATS full access to habitat above crossing structures Restore ATS habitat in structure for utilization	Restoration of stream habitat connectivity	**CM 1**	NLAA / NLAA
ACTIVITY #2: Bridge or Culvert Removal				
Elevated turbidity, sediment transport[15] o Cofferdam installation and removal • Old bridge/ structure demolition	Avoidance, displacement, loss of fitness, temporary behavior modification	Temporarily affected water quality, localized, short-duration habitat degradation, affected prey resources	AMM 4-6, 9,14-20, 23, 31,36	o Adults: NLAA, Parr: LAA, CH: LAA • NLAA / NLAA
Hydroacoustic/ underwater noise[16] o Cofferdam installation and removal • Old bridge/ structure demolition	Avoidance, displacement, loss of fitness, temporary behavior modification	NE	AMM 21- use of vibratory hammer only for cofferdam installation/removal	o NLAA / NE • LAA / NE

[15] This stressor includes a sub-activity of installation/removal of temporary access and pre-project sampling/drilling. Because those sub-activities are common to several of the main construction activities, those will be addressed separately, as their own main construction activity.
[16] This stressor includes a sub-activity of installation/removal of temporary access and pre-project sampling/drilling. Because those sub-activities are common to several of the main construction activities, those will be addressed separately, as their own main construction activity.

Stressor and Associated Activities	Species Effect	Critical Habitat Effect	Avoidance and Minimization Measures	Overall Effect Determination (Species / Critical Habitat)
Temporary Migratory or movement barrier for fish passage o Cofferdam installation, removal and duration • Old bridge/structure demolition	o Avoidance, displacement, loss of fitness, temporary behavior modification, potential temporary exclusion from upstream habitat, delayed spawning • Avoidance, displacement, loss of fitness, temporary behavior modification, potential temporary exclusion from upstream habitat, delayed spawning.	NE	AMM 22- remove cofferdams ASAP	Culverts: LAA / NE; Bridges <100 feet: LAA / NE; Bridges ≥100 feet: NLAA / NE
Capturing, handling, stranding, and relocating fish o Work area isolation and fish evacuation (i.e., hand netting, seining, trapping or electrofishing) for cofferdam installation	Injury or mortality, delayed migration, disruption of rearing, and temporary loss of foraging, harassment, harm, physiological stress, temporary displacement and increased energy expenditures, disruption to normal behaviors including increased vulnerability to predators and missed feedings.	NE	AMM 29- Complete fish evacuation protocol	Adults: NLAA, Parr: LAA, CH: NE
Impingement or entrainment of fish during operation of pump diversion o Cofferdam dewatering	Physical injury, mortality, suffocation, or physical bodily injury	NE	AMM 30- Employ pump screens	NLAA / NE
Water quality alteration due to pollutant/ materials discharge, increases in pH levels or stormwater o Heavy equipment use in or near a waterbody	Increased risk of contaminants (fuel, oil, hydraulic fluid, etc.) resulting in potential for exposure of toxins causing death at high exposure levels or sub-lethal effects at lower exposures, inhibition of reproduction, delayed emergence in invertebrates, and sediment avoidance.	Temporary habitat loss and degradation.	AMM 11, 25-28	NLAA / NLAA

Stressor and Associated Activities	Species Effect	Critical Habitat Effect	Avoidance and Minimization Measures	Overall Effect Determination (Species / Critical Habitat)
Habitat and Critical Habitat Alteration o Removal of crossing structure from the stream	Restoration of ATS full access to habitat above crossing structures Restore ATS habitat in structure for utilization	Restoration of critical habitat	**CM #1** in Tier 1 areas	NE / NLAA
Permanent Fish Passage and Stream Habitat Connectivity o Crossing removal and new channel sized to 1.2 BFW in Tier 1 and Tier 2 priority areas	Restoration of ATS full access to habitat above crossing structures Restore ATS habitat in structure for utilization	Restoration of stream habitat connectivity	**CM #1** in Tier 1 areas	NLAA / NLAA
ACTIVITY #3: Culvert End Resets and Extensions				
Elevated turbidity, sediment transport o Cofferdam installation and removal • Bypass channel installation and removal ❖ Discharge of water from outlet of pump bypass (velocity >5 fps)	Avoidance, displacement, loss of fitness, temporary behavior modification	Temporarily affected water quality, localized, short-duration habitat degradation, affected prey resources	AMM 4-6, 9, 14-20, 23,31	Adults: NLAA Parr: LAA CH: LAA
Hydroacoustic/ underwater noise o Cofferdam installation and removal	Avoidance, displacement, loss of fitness, temporary behavior modification	NE	AMM 21- use of vibratory hammer only	NLAA / NE
Migratory or movement barrier for fish passage o Cofferdam installation, removal and duration • Bypass channel installation, removal, and duration	Avoidance, displacement, loss of fitness, temporary behavior modification, potential temporary exclusion from upstream habitat, delayed spawning	NE	AMM 22- remove cofferdams ASAP	NLAA / NE

Stressor and Associated Activities	Species Effect	Critical Habitat Effect	Avoidance and Minimization Measures	Overall Effect Determination (Species / Critical Habitat)
Capturing, handling, stranding, and relocating fish o Work area isolation and fish evacuation (i.e., hand netting, seining, trapping or electrofishing) for cofferdam installation and/or bypass stream channel installation	Injury or mortality, delayed migration, disruption of rearing, and temporary loss of foraging, harassment, harm, physiological stress, temporary displacement and increased energy expenditures, disruption to normal behaviors including increased vulnerability to predators and missed feedings.	Habitat within the dewatered work area is temporarily unavailable.	AMM 29- Complete fish evacuation protocol	Adults: NLAA, Parr: LAA, CH: NE
Impingement or entrainment of fish during operation of pump diversion o Cofferdam dewatering • Stream channel bypass system installation and operation	Physical injury, mortality, suffocation, or physical bodily injury	NE	AMM 30- Employ pump screens	NLAA / NE
Water quality alteration due to pollutant/ materials discharge, increases in pH levels or stormwater o Heavy equipment use in or near a waterbody	Increased risk of contaminants (fuel, oil, hydraulic fluid, etc.) resulting in potential for exposure of toxins causing death at high exposure levels or sub-lethal effects at lower exposures, inhibition of reproduction, delayed emergence in invertebrates, and sediment avoidance.	Temporary habitat loss and degradation.	AMM 25-28	NLAA / NLAA
Habitat and Critical Habitat Alteration o Replacement of culvert end • Extension of culvert end ❖ Rip rap placement	NE	o Maintenance of existing non accessible stream crossings • Loss of critical habitat • Increase downstream erosion by extending culvert length ❖ Altering critical habitat by changing substrate type and losing interstitial spaces	AMM 44-45, **CM #2**	NE / LAA

Stressor and Associated Activities	Species Effect	Critical Habitat Effect	Avoidance and Minimization Measures	Overall Effect Determination (Species / Critical Habitat)
Permanent Fish Passage and Stream Habitat Connectivity Maintain existing passage/ connectivity conditions	No improvement	No improvement	**CM #2**	LAA / LAA
ACTIVITY #4: Bridge Scour Countermeasures				
Elevated turbidity, sediment transport o Cofferdam installation and removal • Stream channel diversion or relocation ❖ Discharge of water from outlet of pump bypass (velocity >5 fps)	Physical injury or mortality, avoidance, displacement, loss of fitness, temporary behavior modification	Temporarily affected water quality, localized, short-duration habitat degradation, affected prey resources	AMM 4-6, 9, 14-20, 23,31	Adults: NLAA Parr: LAA CH: LAA
Hydroacoustic/ underwater noise o Cofferdam installation and removal	Avoidance, displacement, loss of fitness, temporary behavior modification	NE	AMM 21- use of vibratory hammer only	NLAA / NE
Migratory or movement barrier for fish passage o Cofferdam installation, removal and duration • Stream channel diversion or relocation and duration	Avoidance, displacement, loss of fitness, temporary behavior modification, potential temporary exclusion from upstream habitat, delayed spawning	NE	AMM 22- remove cofferdams ASAP	LAA / NE

Stressor and Associated Activities	Species Effect	Critical Habitat Effect	Avoidance and Minimization Measures	Overall Effect Determination (Species / Critical Habitat)
Capturing, handling, stranding, and relocating fish o Work area isolation and fish evacuation (i.e., hand netting, seining, trapping or electrofishing) for cofferdam and/or stream channel diversion installation	Injury or mortality, delayed migration, disruption of rearing, and temporary loss of foraging, harassment, harm, physiological stress, temporary displacement and increased energy expenditures, disruption to normal behaviors including increased vulnerability to predators and missed feedings.	Habitat within the dewatered work area is temporarily unavailable.	AMM 29- Complete fish evacuation protocol	Adults: NLAA, Parr: LAA, CH: NE
Impingement or entrainment of fish during operation of pump diversion o Cofferdam dewatering • Stream channel diversion installation and operation	Physical injury, mortality, suffocation, or physical bodily injury	NE	AMM 30- Employ pump screens	NLAA / NE
Water quality alteration due to pollutant/ materials discharge, increases in pH levels or stormwater o Heavy equipment use in or near a waterbody	Increased risk of contaminants (fuel, oil, hydraulic fluid, etc.) resulting in potential for exposure of toxins causing death at high exposure levels or sub-lethal effects at lower exposures, inhibition of reproduction, delayed emergence in invertebrates, and sediment avoidance.	Temporary habitat loss and degradation.	AMM 25-28	NLAA / NLAA
Decreased open area under bridge	No improvement	No improvement	AMM 46, **CM #2**	LAA / LAA
Habitat and Critical Habitat Alteration o Installation of a concrete cable mat in stream bed	NE	Loss of critical habitat Altering critical habitat by changing substrate type and losing interstitial spaces.	AMM 44	LAA / LAA

Stressor and Associated Activities	Species Effect	Critical Habitat Effect	Avoidance and Minimization Measures	Overall Effect Determination (Species / Critical Habitat)
Permanent Fish Passage and Stream Habitat Connectivity	Delayed migration, displacement	Loss of critical habitat.	**CM #2**	LAA / LAA
ACTIVITY #5: Bridge Maintenance – Grout Bag Installation and Concrete Repair				
Elevated turbidity, sediment transport[17] o Cofferdam installation and removal	Avoidance, displacement, loss of fitness, temporary behavior modification	Temporarily affected water quality, localized, short-duration habitat degradation, affected prey resources	AMM 4-6, 9, 14-20, 23, 31	Adults: NLAA Parr: LAA CH: LAA
Hydroacoustic/ underwater noise[18] o Cofferdam installation and removal	Avoidance, displacement, loss of fitness, temporary behavior modification	NE	AMM 21- use of vibratory hammer only	NLAA / NE
Migratory or movement barrier for fish passage o Cofferdam installation, removal and duration	Avoidance, displacement, loss of fitness, temporary behavior modification, potential temporary exclusion from upstream habitat, delayed spawning	NE	AMM 22- remove cofferdams ASAP	NLAA / NE
Capturing, handling, stranding, and relocating fish o Work area isolation and fish evacuation (i.e., hand netting, seining, trapping or electrofishing) for cofferdam installation	Injury or mortality, delayed migration, disruption of rearing, and temporary loss of foraging, harassment, harm, physiological stress, temporary displacement and increased energy expenditures, disruption to normal behaviors including increased vulnerability to predators and missed feedings.	Habitat within the dewatered work area is temporarily unavailable.	AMM 29- Complete fish evacuation protocol	Adults: NLAA, Parr: LAA, CH: NE

[17] This stressor includes a sub-activity of installation/removal of temporary access. Because this sub-activity is common to several of the main construction activities, it has been addressed separately, as its own main construction activity.
[18] This stressor includes a sub-activity of installation/removal of temporary access. Because this sub-activity is common to several of the main construction activities, it has been addressed separately, as its own main construction activity.

Stressor and Associated Activities	Species Effect	Critical Habitat Effect	Avoidance and Minimization Measures	Overall Effect Determination (Species / Critical Habitat)
Impingement or entrainment of fish during operation of pump diversion o Cofferdam dewatering	Physical injury, mortality, suffocation, or physical bodily injury	NE	AMM 30- Employ pump screens	NLAA / NE
Water quality alteration due to pollutant/ materials discharge, increases in pH levels or stormwater o Heavy equipment use near a waterbody • Grout bag installation and concrete repair outside of a cofferdam	o Increased risk of contaminants (fuel, oil, hydraulic fluid, etc.) resulting in potential for exposure of toxins causing death at high exposure levels or sub-lethal effects at lower exposures, inhibition of reproduction, delayed emergence in invertebrates, and sediment avoidance. • Increased probability of death • "Uncured concrete and grout materials can enter streams and alter water quality by raising pH levels. pH levels >9 would make water quality conditions unsuitable for salmon	o Temporary habitat loss and degradation.	AMM 25-28	NLAA / NLAA
ACTIVITY #6: Temporary Work Access and Temporary Bridges[19]				

[19] This main construction activity is common to the following other main construction activities: Stream Crossing Replacements ≤ 20 feet (Culvert Replacements), Stream Crossing Replacements > 20 feet (Bridge Replacements), Bridge and Culvert Removals, and Bridge Maintenance: Grout Bag Installation and Concrete Repair.

Stressor and Associated Activities	Species Effect	Critical Habitat Effect	Avoidance and Minimization Measures	Overall Effect Determination (Species / Critical Habitat)
Elevated turbidity, sediment transport o Pile installation and removal from vibratory pile driving • Pile installation[20] from impact pile driving ❖ Riprap/stone installation and removal	o Avoidance, displacement, loss of fitness, temporary behavior modification • Physical injury or mortality, avoidance, displacement, loss of fitness, temporary behavior modification ❖ Avoidance, displacement, loss of fitness, temporary behavior modification	Temporarily affected water quality, localized, short-duration habitat degradation, affected prey resources	AMM 4-6, 9, 14-20, 23, 31	o Adults: NLAA, Parr: LAA, CH: NLAA • Adults: NLAA, Parr: LAA, CH: NLAA ❖ Adults: NLAA, Parr: LAA, CH: LAA
Hydroacoustic/ underwater noise o Pile installation and removal from vibratory pile driving • Pile installation[21] from impact pile driving	o Avoidance, displacement, loss of fitness, temporary behavior modification • Physical injury or mortality, avoidance, displacement, loss of fitness, temporary behavior modification	NE	AMM 37-41	o NLAA / NE • LAA / NE
Migratory or movement barrier for fish passage o Pile installation, removal and duration • Riprap/ stone installation, removal and duration	Avoidance, displacement, loss of fitness, temporary behavior modification, potential temporary exclusion from upstream habitat, delayed spawning	NE	AMM 22- remove cofferdams ASAP	LAA / NE all activities, except for Bridges ≥ 100'which are NLAA / NE

[20] Piles will never be removed using an impact hammer.

[21] Piles will never be removed using an impact hammer.

Stressor and Associated Activities	Species Effect	Critical Habitat Effect	Avoidance and Minimization Measures	Overall Effect Determination (Species / Critical Habitat)
Water quality alteration due to pollutant/ materials discharge, increases in pH levels or stormwater o Heavy equipment use near a waterbody	Increased risk of contaminants (fuel, oil, hydraulic fluid, etc.) resulting in potential for exposure of toxins causing death at high exposure levels or sub-lethal effects at lower exposures, inhibition of reproduction, delayed emergence in invertebrates, and sediment avoidance.	Temporary habitat loss and degradation.	AMM 25-28	NLAA / NLAA
Habitat and Critical Habitat Alteration	NE	Temporarily unavailable habitat Potential for alteration of substrate if temporary access not wholly removed	AMM 3	NE / NLAA
ACTIVITY #7: Invert Line and Slipline Culvert Rehabilitation				
Elevated turbidity, sediment transport o Cofferdam installation and removal • Stream diversion or relocation, or bypass channel installation and removal ❖ Discharge of water from outlet of pump bypass (velocity >5 fps)	Avoidance, displacement, loss of fitness, temporary behavior modification	Temporarily affected water quality, localized, short-duration habitat degradation, affected prey resources	AMM 4-6, 9, 14-20, 23, 31	Adults: NLAA Parr: LAA CH: LAA
Hydroacoustic/ underwater noise o Cofferdam installation and removal	Avoidance, displacement, loss of fitness, temporary behavior modification	NE	AMM 21- use of vibratory hammer only	NLAA / NE

Stressor and Associated Activities	Species Effect	Critical Habitat Effect	Avoidance and Minimization Measures	Overall Effect Determination (Species / Critical Habitat)
Migratory or movement barrier for fish passage o Cofferdam installation and removal • Stream diversion or relocation, or bypass channel installation and removal	Avoidance, displacement, loss of fitness, temporary behavior modification, potential temporary exclusion from upstream habitat, delayed spawning	NE	AMM 22- remove cofferdams ASAP	NLAA / NE
Capturing, handling, stranding, and relocating fish o Work area isolation and fish evacuation (i.e., hand netting, seining, trapping or electrofishing) for cofferdam installation and/or	Injury or mortality, delayed migration, disruption of rearing, and temporary loss of foraging, harassment, harm, physiological stress, temporary displacement and increased energy expenditures, disruption to normal behaviors including increased vulnerability to predators and missed feedings.	Habitat within the dewatered work area is temporarily unavailable.	AMM 29- Complete fish evacuation protocol	Adults: NLAA, Parr: LAA, CH: NE
Impingement or entrainment of fish during operation of pump diversion o Cofferdam dewatering • Bypass pumping	Physical injury, mortality, suffocation, or physical bodily injury	NE	AMM 30- Employ pump screens	NLAA / NE
Water quality alteration due to pollutant/ materials discharge, increases in pH levels or stormwater o Heavy equipment use in or near a waterbody	Increased risk of contaminants (fuel, oil, hydraulic fluid, etc.) resulting in potential for exposure of toxins causing death at high exposure levels or sub-lethal effects at lower exposures, inhibition of reproduction, delayed emergence in invertebrates, and sediment avoidance.	Temporary habitat loss and degradation.	AMM 25-28	NLAA / NLAA

Stressor and Associated Activities	Species Effect	Critical Habitat Effect	Avoidance and Minimization Measures	Overall Effect Determination (Species / Critical Habitat)
Habitat and Critical Habitat Alteration o Decreasing structure opening • Raising the structure invert elevation ❖ Placing rip rap at inlet/outlet of the rehabilitated structure	Improve fish passage conditions with weir installations	Loss of critical habitat Altering critical habitat by changing substrate type and losing interstitial spaces. Increase downstream erosion by decreasing structure opening	AMM 44, 49-50	LAA / LAA
ACTIVITY #8: Pre-project Geotechnical Drilling[22]				
Elevated turbidity, sediment transport[23] o Geotechnical drilling	Avoidance, displacement, loss of fitness, temporary behavior modification	Temporarily affected water quality, localized, short-duration habitat degradation, affected prey resources	AMM 1	Adults: NLAA Parr: LAA CH: NLAA
Hydroacoustic/ underwater noise[24] o Geotechnical drilling	Avoidance, displacement, loss of fitness, temporary behavior modification	NE	AMM 1	NLAA / NE

[22] This main construction activity is common to the following other main construction activities: Stream Crossing Replacements > 20 feet (Bridge Replacements) and Bridge Scour Countermeasures. Geotechnical drilling may occur under other main construction activities, but the drilling will not occur within the stream or river and will not affect Atlantic salmon or critical habitat.

[23] This stressor includes a sub-activity of installation/removal of temporary access. Because this sub-activity is common to several of the main construction activities, it has been addressed separately, as its own main construction activity.

[24] This stressor includes a sub-activity of installation/removal of temporary access. Because this sub-activity is common to several of the main construction activities, it has been addressed separately, as its own main construction activity.

Stressor and Associated Activities	Species Effect	Critical Habitat Effect	Avoidance and Minimization Measures	Overall Effect Determination (Species / Critical Habitat)
Water quality alteration due to pollutant/ materials discharge, increases in pH levels or stormwater o Heavy equipment use in or near a waterbody	Increased risk of contaminants (fuel, oil, hydraulic fluid, etc.) resulting in potential for exposure of toxins causing death at high exposure levels or sub-lethal effects at lower exposures, inhibition of reproduction, delayed emergence in invertebrates, and sediment avoidance.	Temporary habitat loss and degradation.	AMM 25-28 & 33-35	NLAA / NLAA

Chapter 6 Cumulative Effects

Cumulative effects include the effects of future state, tribal, local, and private actions that are reasonably certain to occur in the action area for this PBA. Future federal actions that are unrelated to the proposed action are not considered in this section because they require separate consultation pursuant to section 7 (a)(2) of the ESA.

The comprehensive action area encompasses the entire geographic range of the GOM DPS of Atlantic salmon and an extensive area of land (17,753 square miles) associated with many rivers, stream, ponds, and lakes. Hence, an array of future state, tribal, local, and private actions are likely to occur. However, action areas for individual project activities will be much more limited in scope, and overall the individual project action areas over the 5-year period of this PBA will occur on a fraction of the entire range of the GOM DPS. For each individual project review, cumulative effects will be briefly described in the standard reporting form.

The GOM DPS contains very little federal land. Broadly speaking, future activities will include (but are not limited to) agriculture, forestry, municipal infrastructure maintenance, residential and commercial/industrial development, energy projects, and recreational fishing. Within each of these broad categories, a variety of actions that could affect Atlantic salmon and their habitat include water withdrawal to irrigate crops, logging roads and stream crossings, non-point source pollution from residential and commercial development, and loss of forest and other natural habitats within a watershed from development.

Blueberry and cranberry fields are irrigated using withdrawal from both surface waters and wells, an ongoing practice often with no federal nexus. Withdrawals will increase if crop acreages increase. Reduction in stream flows from irrigation practices during the summer when stream flows are naturally low in most years can affect salmon. The Services continue to work with state regulatory agencies to address impacts to Atlantic salmon from irrigation.

Many areas around road crossings are subject to recreational angling pressure. Atlantic salmon parr can be regularly caught while fishing for other sport fish. Angling also has the potential to adversely affect Atlantic salmon in locations where anglers and adult salmon are expected to interface.

Many activities that impact streams, ponds, and wetlands require federal permits from the USACE under the CWA and Rivers and Harbors Act. Therefore, these potential future actions (state, tribal, local, and private) that will affect Atlantic salmon and critical habitat will be subject to ESA section 7 (a)(2) consultation.

Maine’s total population, as of July 2015, was 1,329,328 compared to 1,125,043 in 1980 (18.2% growth over 35 years). Maine’s population is expected to grow by 11.5% through 2030 (U.S. Census Bureau 2012). Subsequently, patterns and types of land use and development are not expected to dramatically change relative to trends seen over recent decades. Activities that have affected Atlantic salmon and their habitat in recent years are expected to continue relatively unchanged, although various efforts at salmon conservation have and will continue to benefit Atlantic salmon (e.g., dam removals and riparian conservation easements).

Projects proposed under this PBA are not expected to increase traffic capacity along the roadway. They are not expected to increase development in the vicinities of this project for residential or commercial use as well. Developments that are not subject to federal jurisdiction are not included in this PBA as a part of this assessment.

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Chapter 8 Appendices

8.1 Appendix A- MaineDOT's Atlantic Salmon Evacuation Plan and Disinfection Procedures

1. An adequate number of qualified MaineDOT Environmental Office staff will be onsite during construction and dewatering of all cofferdams and for fish salvage activities.

2. If it is possible that an adult salmon could be present in the work area, a visual survey of the work area to inspect for the presence of an Adult salmon will be completed. Further precautions for adult salmon will be followed after the visual inspection to ensure that adult salmon are removed from the work area prior to electro fishing.

3. MaineDOT Environmental Office staff will follow the Maine Atlantic Salmon Commission Disinfection Procedures (MASC 2005).

4. Following installation of the upstream block net, haze fish out of the proposed dewatered sections by walking seines downstream from the upstream block net location to the end of the work site in an attempt to 'herd' fish out of the worksite. A downstream block net will then be installed, followed by efforts to capture remaining fish with dip-nets. Fisheries biologists experienced with work area isolation, and competent to ensure the safe handling of all ESA-listed fish will conduct or supervise the operation.

5. Install a block net or cofferdam downstream of the project site immediately after the sweep to ensure fish will not move back into the project area. The block net will be secured to the stream channel, bed, and banks until fish capture and transport activities are complete. Size and place the block net in the stream in such a way as to exclude ESA-listed juvenile salmonids expected to occur within the project vicinity at the time of work without otherwise impinging these fish on the net. Monitor the block net once a day to ensure that it is properly functioning and free of organic accumulate. Block nets will be placed were water levels allow. Cofferdams also act to exclude ESA-listed juvenile salmonids out of the work area.

6. Stream depths may dictate that evacuation activities cannot commence until water control devices have been installed and the water levels have been lowers to safe levels for netting and electrofishing. Some water control devices will not allow for dewatering. In cases when water depths are >2-3 feet, only netting, herding, and trapping strategies can be employed to haze fish out of the work area.

7. Use one or a combination of the following methods to most effectively capture ESA-listed fish and minimize harm (Figure 1). Fish salvage shall proceed from the least invasive method to most invasive.

a) <u>Hand Netting</u>. Collect fish by hand or dip-nets, as the area is slowly dewatered.

b) <u>Seining</u>. Seine using a net with mesh of such a size as to ensure entrapment of the residing ESA-listed fish. The bottom or lead line has lead weights strung or crimped onto it to weight the net. The top or float line includes cork, polystyrene foam, or plastic floats to keep the top of the seine near the water surface. The net is attached to wood or metal poles to handle the seine. Two persons hold the seine in a vertical position above the water and perpendicular to the flow at the downstream edge of a riffle. They then thrust the poles and lead line of the seine to the stream bottom. The poles are allowed to slant downstream so that the flow forms a slight pocket in the seine. This procedure is continued from one shoreline across the width of the channel to the other shoreline so that the entire riffle is sampled. The seine is then lifted out of the water and the fish removed (Bramblett and Fausch 1991).

c) Trapping. Minnow traps (or gee-minnow traps) are net or wire enclosures that trap live fish. Fish swim through the funnel shaped openings and are guided to a narrow opening at the center of the trap. These traps are best suited for collecting juvenile fish or small adult fish in pool habitat. Traps should be baited and fished overnight. In areas of moderate to high fish densities, maximum catches in minnow traps are approached within one to two hours, with catches dropping sharply when traps are fished longer than 24 hours between checks. For bait, salmon eggs are most widely used, but hamburger, canned cat food, salmon flesh, canned corn, shrimp, and sardines have been used successfully (Magnus et al. 2006).
d) Electrofishing. Before dewatering, electrofishing will be used as the last evacuation measure following the above other means of fish capture and if they are not practical or effective following NMFS (2000) guidelines found at: http://www.nwr.noaa.gov/ESA-Salmon-Regulations-Permits/4d-Rules/upload/electro2000.pdf .

- Prior to the start of sampling at a new location, water temperature and conductivity measurements must be taken to evaluate electroshocker settings and adjustments.
- Each electrofishing session must start with all settings (voltage, pulse width, and pulse rate) set to the minimums needed to capture fish. These settings should be gradually increased only to the point where fish are immobilized and captured, and generally not allowed to exceed conductivity-based maxima indicated in the NMFS (2000) guidelines. Only direct current (DC) or pulsed direct current (PDC) should be used.
- Electrofishing activities will be avoided if stream temperatures exceed 23 degrees Celsius. Electrofishing will take place before 9:00 AM to take advantage of daily temperature swings.
- Electrofishing will not commence if the presence of an adult Atlantic salmon is suspected.

Figure 1. Examples of fish salvaging methods.

8. Handling of fish:

a) Juvenile Atlantic salmon will be netted (1/4” knotless nylon) and immediately placed in a disinfected 5-gallon bucket filled with aerated stream water of ambient temperature.
b) Adult Atlantic salmon will be crowded into a handling device utilized by Maine Department of Marine Resources. The device consists of a rubber tube that is closed on one end and open on the other (Figure 2). Small holes are placed in the closed end to allow some water out but allow all of the water to drain. Any adults salmon captured this way will be moved immediately outside of the exclusion with the handling device and will not be held.
c) All other fish species will be placed in a disinfected 5-gallon bucket with aerated stream water of ambient temperature and released upstream is possible or downstream of the project if the upstream does not contain suitable habitat under assessment by the on-site biologist.
d) Minimize the number of fish stored in each 5-gallon buckets used for handling bucket to prevent overcrowding. If an Atlantic salmon is captured, it will be immediately relocated.
e) Handling time will be minimized. Monitor water temperature in buckets and well-being of captured fish.
f) Release fish from the isolated reach into a pool or area that provides cover and flow refuge after fish have recovered from stress of capture. Fish release upstream of the project site is preferred as sediment impacts would not likely affect individuals upstream of the crossing, but downstream release may be necessary if upstream reach is not suitable habitat for release.

Figure 2- ‘Rubber sock’ for adult salmon handling.
Photo courtesy of Maine Department of Marine Resources.

9. If need be, all salmonids will be clearly photo-documented for identification purposes. Photos will not be taken of Adult Atlantic salmon to ensure minimal handling time.

10. A report and any photographs of transferred salmon will be submitted to US Fish & Wildlife Service, National Marine Fisheries Service, the Maine Department of Marine Resources, the Maine Department of Inland Fisheries & Wildlife and the appropriate action agencies (USACE and FHWA).

Due to variability in construction timing, potential scheduling conflicts, and other potential unforeseen issues, to ensure coverage and eliminate project delays several MaineDOT employees or their designees will be available during construction and dewatering of cofferdams. MaineDOT or consultant staff will be reviewed for proper experience prior to completing a fish evacuation.

In addition to the staff listed above, other Environmental staff members, including qualified fisheries consultants, may be added pending USFWS approval. Anyone electrofishing will be required to have experience electrofishing salmonids in Maine. The Proponents may solicit the aid of fisheries biologists from the USFWS, NMFS or MDMR if agency staff is available to assist at the necessary time.

Biosecurity guidelines are practical steps that can be taken to minimize the spread of unwanted organisms. The guidelines below are designed to provide direction to MaineDOT biologists working in Maine’s lakes, rivers, and streams to minimize the potential for spread of aquatic species, particularly invasive species. These guidelines were adapted from the Maine Department of Inland Fisheries and Wildlife guidelines and have been written to separate aquatic plants, aquatic animals, and aquatic pathogens.

Equipment:

Portable hand-pump sprayer for field disinfection

Large stiff bristle brush

Spray bottle

Rubbing alcohol

Nolvasan disinfectant

II. Procedures to minimize the spread of aquatic plants

Personnel – visual inspection of personal equipment (i.e. boots/waders/gloves) with hand removal of plants before leaving area.

Other Equipment- *same as above*

Dip nets, trap nets and leads – aquatic plants must be removed from nets before they are moved between waters. Nets should be visually inspected on land with hand removal of plants before leaving the sampling area. After seasonal use, nets will be cleaned, thoroughly dried in direct sun or indoor storage area, and re-inspected to remove any remaining plant material. Ensure all net sections and components are thoroughly dry for a minimum of 3 days. When possible, clean/dry nets and leads should be used between waters.

Reporting Requirements – Aquatic plants of unknown species or plants known to be aquatic nuisance species should not be transported unless placed in a sealed container. Small specimens may be transported to the Maine Department of Environmental Protection for species identification (MDEP contact: John McPhedran (207) 287-2813).

Waters with Documented Infestations – Biological staff should be extra diligent when working on waters with known infestations to prevent the further spread of invasives. When possible, staff should minimize contact and disturbance of aquatic invasive plant beds to reduce the risks of spreading the plant within the water being sampled and elsewhere. A current list of known plant infestations is available at MDEP's website (www.maine.gov/dep/blwq/topic/invasives/doc.htm).

III. Procedures to minimize the spread of aquatic animals

Personnel- personal equipment (i.e. boots/waders/gloves) should be rinsed clean of all visible mud and aquatic debris.

Other Equipment – rinsed clean of mud and aquatic debris.

Dip nets, trapnets and leads – Remove as much mud and aquatic debris as possible on site. After seasonal use, trapnets should be transported to maintenance camp or other suitable location and cleaned, thoroughly dried in direct sun or indoor storage area, and re-inspected to remove any remaining material. Ensure all net sections and components are thoroughly dry for a minimum of 3 days. When possible, clean/dry nets and leads should be used between waters.

a. Reporting Requirements- Unknown specimens and known aquatic invasive species should be transported in sealed containers for identification. Identification of invasive aquatic species should be reported to Maine Department of Inland Fisheries and Wildlife

b. Waters w/ Documented Infestations – Biological staff should be extra diligent when working on waters with known infestations to prevent the further spread of invasives. In this case, nets should be cleaned, soaked in salt brine (3%) overnight to destroy freshwater aquatic organisms, rinsed, and dried in sunlight between uses.

IV. Procedures to minimize the spread of aquatic pathogens

a. Equipment – Field equipment that comes in constant contact with stream or lake water (i.e. waders, nets, seines, gloves, shocker wand and tail, buckets, measuring boards, etc.) should be cleaned & disinfected before use between waters. Disinfection for most equipment is accomplished with a 2oz. Nolvasan/gallon water solution in the large trashcan. Equipment should be allowed to set in solution for 10 minutes then rinsed thoroughly.

Equipment will be sprayed with a hand-pump style sprayer and allowed to set during transit to the new water.

Delicate equipment such as electronic scales, conductivity meters, thermometers, etc., should be sprayed with alcohol and allowed to air dry.

b. Dip nets, trapnets and leads – are too large to be soaked and unlikely to get reasonable disinfection with a spray system. After seasonal use, trapnets should be transported to the regional headquarters, cleaned, thoroughly dried in direct sun or indoor area, and re-inspected to remove any remaining material. Ensure all net sections and components are thoroughly dry for a minimum of 3 days. When possible, clean/dry nets and leads should be used between waters.

c. Reporting Requirements – Fish encountered with lesions of reportable pathogens, or unknown pathogens should be preserved in 10% buffered formalin for storage or sent for immediate necropsy to the MDIF&W Fish Health Laboratory. Fish with obvious signs of clinical disease should be disposed of on land, rather than returned to the water to spread the pathogen.

d. Waters with Documented Pathogens – Biological staff should be extra diligent with disinfection procedures when working on waters with known pathogen issues to prevent the further spread of the organisms.

Questions regarding proper cleaning and/or disinfection of field equipment should be addressed with the equipment manufacturer.

Maine Statutes

The “Invasive Aquatic Plants” provisions are codified in a number of places in Maine Revised Statutes Annotated:
38 MRSA 410-N – Aquatic nuisance species control
38 MRSA 419-C – Prevention of the spread of invasive aquatic plants
38 MRSA Chapter 20-A – Program to prevent infestation of and to control invasive aquatic plants

38 MRSA 20-B – Invasive aquatic plants and nuisance species control

Amendments from the 2003-2004 legislative session:

Chapter 627. An Act to Amend the Laws Regarding Invasive Aquatic Species (effective July 30, 2004)

Chapter 655. An Act to Revise the Fish and Wildlife Laws to Complement the Recodification of those laws (IN PART) (effective April 22, 2004)

Reference:

Chapter 136. An Act Regarding the Development and Implementation of an Eradication Plan for Invasive Aquatic Plants (effective September 13, 2003).

Chapter 434. An Act to Prevent Infestation of Invasive Aquatic Plants (effective June 20, 2001)

Chapter 722, An Act to Prevent the Spread of Invasive Aquatic Plants (effective April 14, 2000).

The “Chapters” are in the form that a bill is enacted and signed. They contain temporary provisions, such as report and budget provisions, which are not codified into MRSA.

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8.2 Appendix B- MaineDOT Design Approach for Culverts and Minor Spans under PBA

Introduction

MaineDOT has adapted general concepts from stream simulation methodology when designing culverts for aquatic habitat connectivity; foundational references for MaineDOT practice are listed below. For the purposes of this discussion it should assumed that effective open flow areas inside/beneath structures will be at least as wide as stream BFW.

The overarching design objective in a MaineDOT project is to construct a safe and cost-responsible structure that meets transportation needs and permit requirements. On culverts and minor spans (< 20 ft.), size, cost and excavation depth are closely linked. For the purposes of this discussion, the upper limit will be extended to 26-ft, the largest box culverts constructed by MaineDOT (even though structures equal to or wider than 20-ft are classified as major spans).

Three-sided, natural bottom structures are usually preferred for environmental reasons, but they can be cost-prohibitive except in the case of shallow ledge. In fact, with shallow ledge, three-sided structures may be the only feasible structure. Deep ledge requires deep excavation for stable footers (placed as much as 6' below stream grade) protected against scour, resulting in significant cost differences. Thus, except for shallow ledge settings, MaineDOT typically builds embedded culverts backfilled with engineered streambed material (ESM). Even when three-sided structures are possible, the entire bottom area may need to be excavated to ledge, possibly followed by reconstruction of a streambed between abutments. Embedded culverts offer the advantage of shallower placement and less excavation. At the same time, embedded culverts present the challenge of creating a "natural" streambed with backfilled material (ESM).

Design Approach

Design Hydrology: design hydrology will be estimated using the appropriate US Geological Survey regression equations (Hodgkins, 1999; Lombard & Hodgkins, 2015) and watershed delineations from *StreamStats* (USGS, 2015). The 2015 equations are good for watersheds as small as 0.3 mi^2. The 2015 equations are not currently implemented in StreamStats and must be calculated independently.

Structure Type: structure type may be "culvert" (buried) or "span", depending on subsurface conditions, project scope, and general constructability. Culvert shape may be box, round, or arch.

Structure Sizing: structures will be at least BFW in Tier 2 priority areas, and at least 1.2 x BFW in Tier 1 priority areas. BFW is determined by field measurement and checked for consistency with the regression estimate. When field measurement is problematic, the regression estimate will be the primary guide. When structure is 1.2 x BFW or wider, banks will be constructed in the structure and tied to external bank elevations. When a span is utilized, BFW will be preserved between constructed banks or abutment toe riprap protection. Culverts in watersheds <0.3 mi^2 will be sized according to 1.2 x measured BFW, with a minimum size of 3 feet in diameter.

Structure Hydraulic Capacity: crossings designed for BFW generally have capacity for flows $Q \geq Q_{100}$. Capacity will be checked against MaineDOT large culvert capacity standard ($H_w/D \leq 1$ at Q_{100}).

Structure Placement: a longitudinal stream profile will be developed (Harrelson, 1994) and the structure will be placed at a slope consistent with the profile and observed natural scour. Placement may be augmented with grade control (external and/or internal) to establish hydraulic connectivity and fish access between upstream and downstream. In addition to vertical placement, culverts and minor spans will be aligned with the general stream horizontal alignment.

Structure Backfill: the fundamental objective is to create a stable, nature-like streambed. Depending on the structure slope, the backfill may be augmented with streambed structural elements to enhance stability and create the necessary grade control. Streambed structures are constructed with rock and sized for stability.

The backfill mix, or engineered streambed material (ESM), is sized for stability and density according to methods documented in the references below. A stable, well-graded material is the end goal. All of the references follow the same general approach, differing only in details.

ESM Thickness: ESM shall be at least 2-ft thick.

Stable Size Fraction: the stable size fraction is chosen, usually the 84-th percentile D_{84}, though it can range down to D_{50}. The ESM is developed such that the D_{84} fraction (and larger) is stable at the design peak flow.

Design Flow for Stability: the design peak flow for stability is Q_{100}.

Stable Particle Size: the stable size D_{84} is calculated by a standard hydraulic analysis, usually either incipient motion / critical shear stress analysis, unit-discharge analysis, or other method as appropriate (Bernard, 2013, pp. 44-53). The assumption is that at Q_{100}, particle sizes $\geq D_{84}$ will remain in place; smaller particles may move out, but be replaced with sediment from upstream that is also moving. The particular stable percentile can range anywhere between 15% and 25%.

Grain Size Curve Development: there are two key values in the ESM gradation curve, the stable D_{84} size and the fines fraction needed to fill interstitial voids (so that water flows over, rather than through, the ESM). A generally desirable fines fraction has 2mm between D_5 and D_{10}. The remainder of the gradation is calculated using standard streambed size ratios and/or a modified form of the Fuller-Thompson equations (Bernard, 2013, pp. 50-52). The goal is a dense, well-graded mix described by a smooth, continuous gradation curve, with minimal voids so that streambed interflow is eliminated.

Backfill Structural Elements: Structural elements may be necessary to enhance stability and provide grade control for fish passage, for which there are a great many design references available. For low-gradient culverts, a simple backfill consisting of the ESM is sufficient. For slightly steeper culverts, rock bands embedded in the ESM provide additional stability. As grades steepen, a spectrum of streambed structure will be considered: plane bed / rock ramp, step-pool, through cascade at the steepest gradients. General guidance for profile control design is found in Love & Bates (2009; XII.54-94). Towler (2015) provides an engineering design procedure for step-pool structures; Newbury and Gadboury (1994) addresses stable riffle design; Kapitzke (2010) provides a design procedure for rock ramps. In addition, individual key feature rocks may also be placed, if they are also observed in the natural stream. Emplaced key features will replicate the size and spacing observed in the natural channel. Constructed bank lines will be designed according to guidance in Love & Bates (2009; XII.71-73) and Bates & Kirn (2009, Sec. 6.3.3.3). The purpose of banklines, as opposed to bare culvert walls, is to provide additional roughness and variability.

Backfill Placement: ESM should be placed in lifts no thicker than 12”. Each lift should be “washed in” so that the interstitial voids are filled. Additional granular material should be placed and washed in, until the voids are filled to the surface. With approval of the Resident Engineer, site excavation materials may be used in the first lift and also as a wash-in supplement.

Outlet Scour Pools: when outlet scour pools are present, there is the potential for backfill to wash out into the scour pool. If anticipated, this possibility can be addressed in the following ways:

- Place large rock at the outlet outside the pipe, up to the finished ESM surface; a rock band should also be placed flush at the outlet inside the pipe.
- Fill the scour pool to develop a continuous streambed from culvert outlet to scour pool push bar.

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8.3 Appendix C – Glossary of Terms

Definitions are provided below for regulatory, administrative, and technical terms used in this PBA and the ESA Section 7 consultation process.

action – (50 CFR 402.02) all activities or programs of any kind authorized, funded, or carried out, in whole or in part, by federal agencies in the United States or upon the high seas.

action agency – the federal agency proposing to undertake a major construction project (action).

action area – (50 CFR 402.02) all areas to be affected directly or indirectly by the Federal action and not merely the immediate area involved in the action. The limits of the action area are based upon the geographic extent of the physical, chemical, and biological effects resulting from the proposed action, including direct and indirect effects, as well as effects of interrelated and interdependent activities.

Agencies **–** collectively Maine Department of Transportation and Maine Turnpike Authority.

Avoidance and minimization measure – measures that reduce the impact of the project on listed species. Minimization measures are considered part of the proposed action that will be implemented, and are presented in the project description section of the biological assessment. They are not recommendations or suggestions.

Bankfull width- Bankfull width is that set by dominant channel forming flows, ranging in frequency from twice a year to once every two years for most streams

beneficial effects – contemporaneous positive effects without any adverse effects on the species or habitat. By definition, beneficial effects cannot be considered to have *no effect*.

best management practices (BMPs) – methods, facilities, built elements, and techniques implemented or installed during project construction to reduce short- and long-term project impacts on listed species and habitat. These measures are included as part of the federal agency's proposed action. They are not recommendations or suggestions.

biological assessment – (50 CFR 402.02) the information prepared by or under the direction of the federal agency concerning listed and proposed species and designated and proposed critical habitat that may be present in the action area and the evaluation potential effects of the action on such species and habitat.

biological opinion – (50 CFR 402.02) the document that states the opinion of the Service as to whether or not the federal action is likely to jeopardize the continued existence of listed species or result in the destruction or adverse modification of critical habitat.

clay substrate –This substrate has a sticky, cohesive feeling. The particles are fine. The spaces between the particles hold a lot of water, making the sediments behave like ooze.

conference **–** (50 CFR 402.02) a process [of early interagency cooperation] which involves informal discussions between a federal agency and the Service under section 7(a)(4) of the ESA regarding the impact of an action on proposed species or proposed critical habitat and recommendations to minimize or avoid the adverse effects.

conservation measure (CM) – activities or measures that help to recover listed species and critical habitat.

conservation recommendations – (50 CFR 402.02) suggestions of the Service [described in a biological opinion] regarding discretionary measures to minimize or avoid adverse effects of a proposed action on listed species or critical habitat [to help implement recovery plans, or to develop information].

critical habitat – (i) the specific areas within the geographical area occupied by a species, at the time it is listed in accordance with the provisions of the ESA, on which are found those physical or biological features (I) essential to the conservation of the species and (II) which may require special management considerations or protection; and (ii) specific areas outside the geographical area occupied by the species at the time it is listed in accordance with the ESA, upon a determination by the Secretary that such areas are essential for the conservation of the species (defined in Section 3 of the ESA).

cumulative effects – (50 CFR 402.02) those effects of future state or private activities, not involving federal activities, that are reasonably certain to occur within the action area of the federal action subject to consultation. (Note: This definition of cumulative effects is different from that defined by the National Environmental Policy Act.)

cumulative sound exposure level (cSEL) -

decibel (dB) – a unit describing the amplitude of sound, equal to 20 times the logarithm to the base 10 of the ratio of the pressure of the sound measured to the reference pressure. The reference pressure for water is 1 micro Pascal (μPa) and for air is 20 micro Pascal's (the threshold of healthy human audibility).

designated non-federal representative – (50 CFR 402.02) refers to a person designated by the federal agency as its representative to conduct informal consultation and/or to prepare any biological assessment.

destruction or adverse modification – (50 CFR 402.02) means a direct or indirect alteration that appreciably diminishes the value of critical habitat for both the survival and recovery of a listed species. Such alterations include, but are not limited to, alterations adversely modifying any of those physical or biological features that were the basis for determining the habitat to be critical.

direct effects – impacts resulting from the proposed action.

discountable effects – potential effects of a proposed action that are extremely unlikely to occur. Based on best judgment, a person would not expect discountable effects to occur.

distinct population segment (DPS) – a designation used by the U.S. Fish and Wildlife Service for a discrete vertebrate stock that is treated as an individual species (e.g., a specified seasonal fish run in a particular river). This is equivalent to the National Marine Fisheries Service evolutionarily significant unit (ESU) classification.

economic hardship – as defined under "urgency", economic hardship is difficulty caused by having too little money or too few resources.

effects of the action – (50 CFR 402.02) the direct and indirect effects of an action on the species or critical habitat, together with the effects of other activities that are interrelated or interdependent with that action that will be added to the environmental baseline. The environmental baseline includes the past and present impacts of all federal, state, or private actions and other human activities in the action area, the anticipated impacts of all proposed federal projects in the action area that have already undergone formal or early section 7 consultation, and the impact of state or private actions which are contemporaneous with the consultation in process. Indirect effects are those caused by the proposed action and are later in time, but still are reasonably certain to occur. Interrelated actions are those that are part of a larger action and depend on the larger action for their justification. Interdependent actions are those that have no independent utility apart from the action under consideration.

endangered species – a species that is in danger of extinction throughout all or a significant portion of its range.

federal action agency – the federal agency that proposes a specific action or triggers a federal nexus for a project (by providing permits, funding, etc.). This agency is responsible for formally submitting a biological assessment for the proposed action to the Services for review and consultation.

federal nexus – a project with a federal nexus has federal funding, requires federal permits, or takes place on federal lands.

formal consultation – (50 CFR 402.02) a process between the Service and the federal agency that commences with the federal agency's written request for consultation under section 7(a)(2) of the ESA and concludes with the Service's issuance of a biological opinion under Section 7(b)(3) of the ESA.

harass – (50 CFR 17.3) an intentional or negligent act or omission which creates the likelihood of injury to wildlife by annoying it to such an extent as to significantly disrupt normal behavioral patterns which include, but are not limited to, breeding, feeding, or sheltering.

harm – (50 CFR 17.3) significant habitat modification or degradation that results in death or injury to listed species by significantly impairing essential behavioral patterns, including breeding, feeding, or sheltering.

incidental take – take that is incidental to, and not the purpose of, the carrying out of an otherwise lawful activity.

***indirect effects* –** effects caused by the proposed action later in time but still reasonably certain to occur.

informal consultation – (50 CFR 402.02) an optional process that includes all discussions, correspondence, etc., between the Service and the federal agency or the designated non-federal representative prior to formal consultation, if required.

***insignificant effects* -** effects that should never reach the scale where *take* occurs. Based on best judgment, a person would not be able to meaningfully measure, detect, or evaluate insignificant effects.

***interdependent action* –** an action having no independent utility apart from the proposed action.

interrelated action – an action that is part of a larger action and depends on the larger action for its justification.

jeopardize the continued existence of – (50 CFR 402.02) to engage in an action that reasonably would be expected, directly or indirectly, to reduce appreciably the likelihood of both the survival and recovery of a listed species in the wild by reducing the reproduction, numbers, or distribution of that species.

likely to adversely affect – the appropriate finding in a biological assessment (or conclusion during informal consultation) if any adverse effect to listed species may occur as a direct or indirect result of the proposed action or its interrelated or interdependent actions, and the effect is not: discountable, insignificant, or beneficial.

listed species – (50 CFR 402.02) any species of fish, wildlife, or plant which has been determined to be endangered or threatened under section 4 of the ESA. Listed species are found in 50 CFR 17.11-17.12. [Under the statute, the two types of species are treated in virtually the same way.]

***may affect* -** the appropriate conclusion when a proposed action may pose any effects on listed species or designated critical habitat.

micro Pascal (μPa) – most underwater acoustic sound pressure measurements are stated in terms of a pressure relative to 1 micro Pascal.

mortality (fish) **-** cessation of all activity including movements of the operculum, or when all respiration stops and the fish lies motionless.

***no effect* -** the appropriate conclusion when the action agency determines its proposed action will not affect a listed species or designated critical habitat**.**

***not likely to adversely affect (NLAA)* -** the appropriate conclusion when effects on listed species are expected to be discountable, insignificant, or completely beneficial. **Beneficial effects** are contemporaneous positive effects without any adverse effects to the species. **Insignificant effects** relate to the size of the impact and should never reach the scale where take occurs. **Discountable effects** are those extremely unlikely to occur. Based on best judgment, a person would not: (1) be able to meaningfully measure, detect, or evaluate insignificant effects; or (2) expect discountable effects to occur.

occupied critical habitat – critical habitat that contains individuals of the species at the time of the project analysis. A species does not have to occupy critical habitat throughout the year for the habitat to be considered occupied. Subsequent events affecting the species may result in this habitat becoming unoccupied.

Pascal (Pa) – a unit of pressure equal to 1 newton per square meter.

peak (sound) – the absolute peak sound level measured during an event.

peak sound pressure (unweighted), dB re 1 µPa – the peak sound pressure level based on the largest absolute value of the instantaneous sound pressure over the frequency range from 20 Hz to 20,000 Hz. This pressure is expressed here as a decibel (referenced to a pressure of 1 μPa) but can also be expressed in units of pressure, such as μPa or PSI.

reasonable and prudent measures – actions that the Services believe are necessary and appropriate to minimize the impacts (amount or extent) of incidental *take*. These measures are communicated to an action agency in a biological opinion issued by the Service.

root mean square (RMS) – the average of the squared pressures over the time that comprise that portion of the waveform containing 90% of the sound energy for one pile driving impulse, commonly used in repetitive or relatively continuous measurements such as in speech or highway noise. It is not applicable to transient signals such as explosions. It is used in calculating longer-duration sound pulses such as a pile driving pulse of sound.

salmon habitat recovery unit (SHRU) – The critical habitat rule divided the DPS range into three recovery units, termed SHRU's: Merrymeeting Bay, Penobscot Bay, Downeast Coastal.

the Services – abbreviated term for the U.S. Fish and Wildlife Service and National Marine Fisheries Service.

sound exposure level (SEL) – a common unit of sound energy used in airborne acoustics to describe short-duration events. The time integral of frequency-weighted squared instantaneous sound pressures. It is proportionally equivalent to the time integral of the pressure squared and can be described in terms of μ Pa2 sec over the duration of the impulse.

sound pressure level (SPL) – sound pressure is the sound force per unit area, usually expressed in micro Pascal’s (or 20 micro Newtons per square meter), where 1 Pascal is the pressure resulting from a force of 1 newton exerted over an area of 1 square meter. The sound pressure level is expressed in decibels as 20 times the logarithm to the base 10 of the ratio between the pressure exerted by the sound to a reference sound pressure (e.g., 20 micro Pascal’s). SPL = 20 log { } ∂ *P* μ 1 1. Sound pressure level is the quantity that is directly measured by a sound level meter.

species – includes any subspecies of fish, wildlife, or plant, or any distinct population segment of any species of vertebrate fish or wildlife, which interbreeds when mature.

species of concern – a species, usually thought to be in decline that may be considered for federal candidate status in the future.

take **-** Take is defined in Section 3 of the ESA as harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in any such conduct.

terms and conditions – terms and conditions are non-discretionary, reasonable and prudent measures required by the USFWS or NMFS, and described in a biological opinion. Terms and conditions must be implemented by the action agency to be exempt from the prohibitions of section 9 of the Endangered Species Act.

threatened species – any species that is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range.

unoccupied critical habitat – critical habitat that is not occupied (i.e., not permanently or seasonally occupied) by the listed species at the time of the project analysis. The habitat may be suitable, but the species has been extirpated from this portion of its range. Conversely, critical habitat may have been designated in areas unsuitable for the species, but restorable to suitability with proper management, if the area is necessary to either stabilize the population or assure eventual recovery of a listed species. As recovery proceeds, this formerly unoccupied habitat may become occupied. Some designated, unoccupied habitat may never be occupied by the species, but was designated since it is essential for conserving the species because it maintains factors constituting the species’ habitat. For example, critical habitat may be designated for an upstream area maintaining the hydrology of the species’ habitat downstream. in watersheds smaller than 0.3 mi^2 will be sized according to 1.2 x measured bankfull width, with a minimum size of 3’ diameter.

urgency – to be defined as an urgency situation, the situation would have to meet the following criteria: result in an unacceptable hazard to life, a significant loss of property, or an immediate, unforeseen, and economic hardship if a corrective action requiring a permit is not undertaken within a time period less than that to process and receive an environmental permit under standard procedures. The final determination of an emergency or urgent situation will be made by the Chief Engineer or Director of Maintenance and Operations at MaineDOT.

Structure Hydraulic Capacity – crossings designed for BFW generally have capacity for flows $Q \geq Q_{100}$. Capacity will be checked against MaineDOT large culvert capacity standard ($H_w/D \leq 1$ at Q_{100}).

Structure Placement – a longitudinal stream profile will be developed (Harrelson, 1994) and the structure will be placed at a slope consistent with the profile and observed natural scour. Placement may be augmented with grade control (external and/or internal) to establish hydraulic connectivity and fish access between upstream and downstream. In addition to vertical placement, culverts and minor spans will be aligned with the general stream horizontal alignment.

Structure Backfill – the fundamental objective is to create a stable, nature-like streambed. Depending on the structure slope, the backfill may be augmented with streambed structural elements in order to enhance stability and create the necessary grade control. Streambed structures are constructed with rock and sized for stability. The backfill mix, or engineered streambed material (ESM), is sized for stability and density according to methods documented in the references below. A stable, well-graded material is the end goal. All of the references follow the same general approach, differing only in details.

8.4 Appendix D- Hydraulic Performance of Smooth vs. Rough-Sided Culverts in Bankfull Design

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MaineDOT /
ENV 8 June 2015

Executive Summary

A simple HEC-RAS model was created to evaluate the difference in calculated average velocity between culverts with smooth walls and rough banks. Both culverts have backfilled bottoms and effective open areas equal to bankfull width; the nominal structure opening of the culvert with banks is correspondingly larger, for example, 1.2 x bankfull width. The smoother wells have no significant effect on average velocity at bankfull flow in the culvert, with velocities just 6% greater than the culvert with rough banks.

Introduction

Environmental sizing of culverts for aquatic organism passage and general stream function is usually based on some multiplier of stream bankfull width w_{bf}. A multiplier of 1.2 is commonly used, though the science behind the choice of 1.2 is somewhat murky. One of the reasons heard for a structure width greater than w_{bf} is to allow for the construction of banks inside the structure while still allowing for a final effective channel width of w_{bf} (constructed banks intrude into the nominal open width of a culvert). The role of the constructed banks is to simulate the natural stream in general and provide bank roughness with the associated control on velocity. In a no-bank structure, the flowing water experiences the roughness of the culvert material (smooth concrete or corrugated metal) along the culvert walls instead of the nature- like roughness of a rock/cobble/gravel constructed bank. This question of relative velocity performance of culverts with and without banks was evaluated with a simple HEC-RAS model.

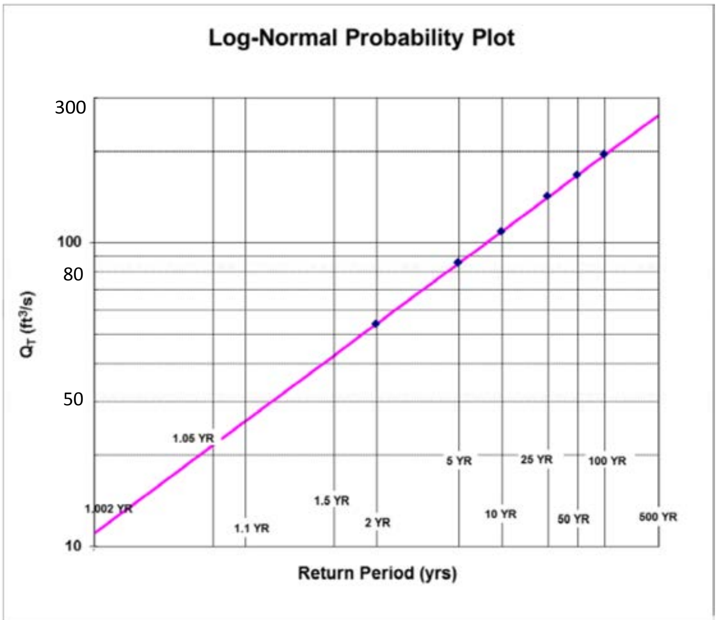
Watershed Hydrology

A representative watershed was constructed according to hydrologic regression equations for Maine watersheds (Dudley, 2004; Lombard and Hodgkins, 2015). Assuming a watershed area of $A = 1\ mi^2$ and NWI wetlands percentage (of watershed area) W = 5%, hydrology was calculated in Table 1; the complete flood frequency curve is show in Figure 1.

Table 1: Watershed Hydrology ($A = 1\ mi^2$, $W = 5\%$)

Quantity	**Equation**	**Value**
Bankfull width w_{bf} (ft)	$7.67 \times A^{0.52}$	7.6
Bankfull depth d_{bf} (ft)	$0.594 \times A^{0.34}$	0.6
Bankfull flow area A_{bf} (ft^2)	$4.55 \times A^{0.86}$	4.6
Q_{bf} (ft^3/s)	$5.19 \times A^{1.05}$	5.2
Q_{bf} = (4 ft/s)A_{bf}	(4 ft/s) $\times A_{bf}$	18.1
Q_{full} (ft^3/s)	*Just-full rectangular channel from HEC-RAS*	10.0
Q_1 (ft^3/s)	$18.836 \times A^{0.773} 10^{-0.013W}$	16.2
$Q_{1.1}$ (ft^3/s)	*Frequency curve extrapolation*	25.9
Q_2 (ft^3/s)	$64.121 \times A^{0.803} 10^{-0.015W}$	54.0
Q_5 (ft^3/s)	$102.565 \times A^{0.809} 10^{-0.016W}$	85.4

Figure 1: Flood Frequency Curve



A simple rectangular channel was assumed, using the calculated bankfull width and depth. Additionally, a channel slope of 0.01 and roughness of Manning's n = 0.045 were used.

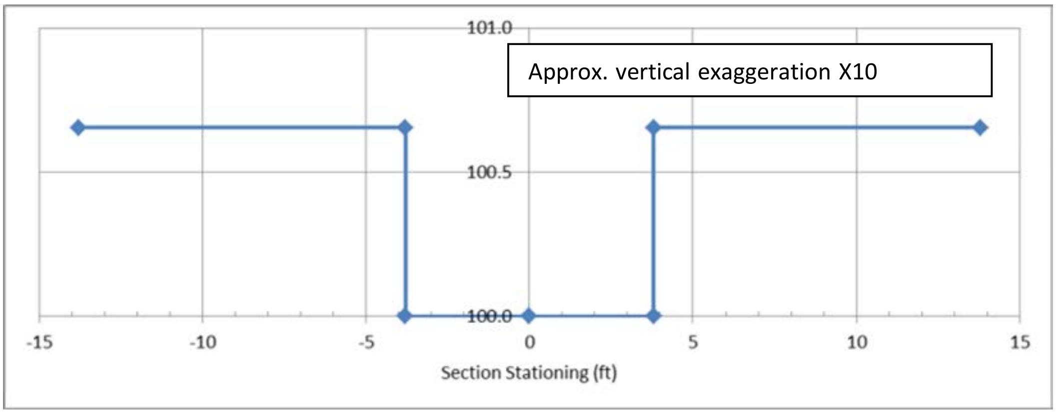
Bankfull flow is loosely related to flows on the order of the annual peak flow, anywhere between the 1-yr and 2-yr annual maximum. Dudley (2004) found that bankfull flow in Maine tends to be more frequent than in other parts of the country. Table 1 shows a range of flows that correspond to the bankfull flow. The various regression-based estimates do not relate to physical parameters such as roughness and channel slope. The HEC-RAS estimate, Q_{full} = 10

ft^3/s, was developed by choosing Q such that the rectangular channel was just full. This value is consistent with the range of reasonable bankfull flows (5 ft/s – 26 ft/s) and is taken as the best estimate for bankfull flow.

HEC-RAS Model

The HEC-RAS model was kept as simple as possible, allowing only for different sidewall roughness in the culvert. Uniform slope (0.01) and section (Figure 2) were assumed along the entire reach length (1000 ft). This same section was duplicated every 10 ft, dropping the elevations by 0.1 ft from section to section.

Figure 2. Standard Model Section



The culvert, 100 ft long, was located at the center of the reach length, between reach stations 550 and 450, well away from boundary end effects. Since flows of interest are limited to Q_{bf} or less, the floodplain is not of interest. Also, a real culvert would be taller than the modeled bankfull depth, but that additional height is irrelevant since flows are limited to Q_{bf} or less.

Two model alternatives were assessed:

Uniform roughness of n = 0.045 along entire reach length.

Reduced roughness in culvert (n = 0.041), n = 0.045 otherwise.

The reduced Manning's n value is calculated using the Horton-Einstein (U.S. Forest Service , 2006) equation and is a composite of the natural rough value and culvert wall value :

$$n_{comp} = \{(P_{wall}n_{wall}^{3/2} + P_{rough}n_{rough}^{3/2})/(P_{wall} + P_{rough})\}^{2/3}$$

where P and n are the corresponding perimeter and roughness values. Assuming a natural bottom roughness of 0.045 and wall roughness of 0.012 (concrete), the calculation is

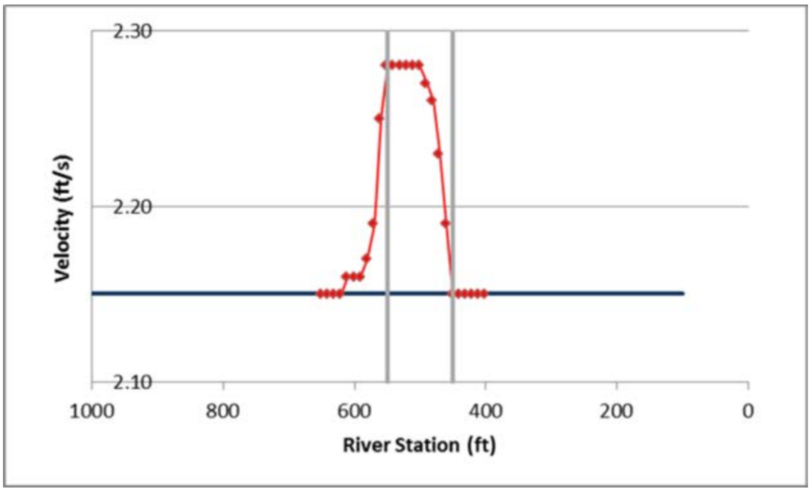
$$n_{comp} = \{(2 \times 0.6 \times 0.012^{3/2} + 7.6 \times 0.045^{3/2})/(2 \times 0.6 + 7.6)\}^{2/3}$$

$$= 0.041$$

As expected, the uniform roughness model produces a uniform flow result, with subcritical flow (Fr = 0.49) at a depth of 0.61 ft and velocity of 2.15 ft/s.

The effect of the smooth culvert walls on the overall composite roughness value is minor. The effect would be even less pronounced in the case of a corrugated metal pipe, since the corrugated n is greater than concrete. The effect on the calculated velocity is just as weak, as seen in Figure 3. For the culvert with rough banks, the velocity is 2.15 ft/s. When the banks are replaced with smooth walls, the velocity increases to 2.28 ft/s, an increase of just 6%. The model shows 3 regions of uniform flow: upstream of the culvert, in the culvert and downstream, with transitions between the uniform flow regions. Because of the simplifying assumptions, these same results could also have been achieved by simple Manning's equation calculations.

Figure 3. Velocity Profile



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