State of Maine, Department of Environmental Protection and Land Use Regulatory Commission

CENTRAL MAINE POWER COMPANY NEW ENGLAND CLEAN ENERGY CONNECT Application for Site Location of Development Act permit, and Natural Resources Protection Act permit for the New England Clean Energy Connect ("NECEC") Project in 25 municipalities, 13 Townships or Plantations and 7 Counties from Beattie Township to Lewiston and Wiscasset to Windsor. L-27625-26-A-N L-27625-TB-B-N L-27625-2C-C-N L-27625-VP-D-N L-27625-IW-E-N

Pre-filed Testimony of Jeff Reardon
Maine Brook Trout Project Director
Trout Unlimited
Manchester, ME
Witness for Trout Unlimited

Qualifications and Purpose of Testimony

1. State your name, address and current occupation:

Jeff Reardon, 267 Scribner Hill Road, Manchester, ME 04351. For the past 20 years I have worked for Trout Unlimited in Maine. My current title is Maine Brook Trout Project Director.

2. What is your relevant professional experience?

I have been working for Trout Unlimited in a variety of positions since 1999. I worked as New England Conservation Manager from 1999-2006. From 2006 to 2011 was the Design and Permitting Coordinator for the Penobscot River Restoration Project. Since 2011, I have worked full time on brook trout conservation at Maine Brook Trout Project Director. I have broad experience working on coldwater fish conservation. I have represented Trout Unlimited in more than a dozen hydroelectric dam relicensings before the Federal Energy Regulatory Commission; coordinated four dam removals and construction of a "nature-like" fish bypass; overseen TU's efforts to identify and fix impassable culverts; coordinated citizen-science projects related to water temperature monitoring and identifying undocumented brook trout populations in remote ponds and coastal streams; testified on legislation and regulatory rule-making in the Maine and New Hampshire legislatures and the US House of Representatives; and worked to identify and complete land conservation projects intended to protect brook trout habitat in Maine's rivers, streams, and ponds. Before working for Trout Unlimited, I worked for the Sheepscot Valley Conservation Association, a land trust in mid-Coast Maine, as the Watershed Projects Director for 3 years. In that role, I identified parcels and coordinated conservation of lands through conservation purchase or conservation easement to protect Atlantic salmon habitat; worked with landowners to improve riparian buffers to protect coldwater aquatic habitat; and surveyed the entire length of the Sheepscot River to monitor the condition of riparian buffers.

3. What is your education?

I graduated from Williams College with a degree in biology in 1989. My senior honors thesis was related to impacts of disturbance on northern forests.

4. Have you previously testified before the Maine Department of Environmental Protection (DEP) or the Maine Land Use Planning Commission (LUPC?)

I have testified at many DEP and LUPC (or LURC) hearings, but this is the first time I have done so as an expert witness.

5. Do you have specific expertise that relates directly to your testimony in this case?

I have worked on a number of projects directly related to the issues I am testifying on here, chronologically:

1. In 1997-99, working for the Sheepscot River Conservation Association and as lead for the Sheepscot River Watershed Council, I helped implement and test a "Methodology for Determining Optimal Riparian Buffer Width" that had been developed by Kleinschmidt Associates for the Maine Atlantic Salmon Commission. My role was to work with two landowners to implement the method on conservation lands adjacent to Atlantic salmon habitat in the Sheepscot River. More information on this project is available here: http://kleinschmidtgroup.com/index.php/projects/eco-fisheries/atlantic-salmon-riparian-buffer-zone-determination
2. In 1999, for the Sheepscot Valley Conservation Association, I worked closely with the Maritimes and Northeast Pipeline to coordinate construction of a pipeline corridor through the Sheepscot watershed with no damage to aquatic habitat at stream crossings.
3. From 1999 to 2002 I represented Trout Unlimited during the relicensing of the Indian Pond Dam on the Kennebec River, and, with other parties, negotiated a settlement agreement that required extensive studies of the brook trout population in the Upper Kennebec watershed. These studies informed decisions by the Indian Pond Fisheries Habitat Committee, which used the information to plan habitat restoration and protection projects funded by the Indian Pond licensee. Those studies documented, for the first time, extensive migrations of brook trout between the Kennebec and Dead River mainstems and multiple small tributaries, particularly Cold Stream and Tomhegan Stream. I continue to serve as a member of the Indian Pond Fisheries Habitat Committee.

4. On behalf of Trout Unlimited, in 2003-2006, I hired Kleinschmidt Associates to refine their Atlantic salmon riparian buffer methodology for protection of brook trout habitat, particularly in higher elevation streams in western Maine. We developed a recommended buffer that was broadly applicable for brook trout habitat in Maine. The recommendations were then vetted with fisheries biologists from the Maine Department of Fisheries and Wildlife, and, in cooperation with the Forest Society of Maine, with large forest landowners. Trout Unlimited and partners have used those recommendations as the basis for planning conservation projects, including conservation easement terms, ever since.
5. In 2010-2016, I worked closely with partners at the Maine Department of Inland Fisheries and Wildlife (MDIFW), Maine Bureau of Parks and Lands (MBPL), Trust for Public Land and landowner Plum Creek on the Cold Stream Forest Project, in which MBPL acquired the 8,200-acre parcel primarily to protect brook trout habitat in Cold Stream and its tributaries. Since acquisition was completed in 2016, I have been working with BPL staff to develop the management plan for the property by serving on the Advisory Committee for that planning process.

6. Are you familiar with the application for the New England Clean Energy Connect (NECEC)?

I have reviewed the Site Law application and the Natural Resources Protection Act application. I have spent extensive time reviewing the route and proposed stream crossings, both on the map—primarily using the KMZ layer provided by Maine DEP—and on paper. I have reviewed much of the agency consultation regarding stream crossings, fisheries, riparian buffers, and proposed mitigation. I have reviewed the Compensation Plan, dated January 30, 2019, in detail. I have compared the information and data presented in these documents to other available data on fisheries and aquatic habitat, primarily available in on-line GIS format from the Maine Department of Inland Fisheries and Wildlife[1], from the Eastern Brook Trout Joint Venture[2], from the National Fish Habitat Partnership[3], and from Trout Unlimited's Conservation Portfolio Analysis of native brook trout habitat[4].

7. Are you familiar with area through which the NECEC will pass?

I have worked extensively in two regions that will be impacted by the NECEC. I worked full time on the Sheepscot River from 1996 to 1999, while working as the Watershed Program Director. I have worked extensively in the Upper Kennebec Watershed for my entire 20-year career with TU, with multiple projects in the Dead, Kennebec, and Sandy River drainages. I am most familiar with the Cold Stream watershed, where I worked nearly full time from 2010-2016. I have also fished, hiked and paddled throughout the Upper Kennebec region. I have fished many of the streams that will be crossed by the NECEC and the ponds where the route will pass nearby.

8. What is the purpose of your testimony?

My testimony addresses the impacts of the project as proposed on brook trout and Atlantic salmon fisheries habitat; the failure of the Applicant to adequately assess these impacts; the

[1] Maine Stream Habitat Viewer: https://www.maine.gov/dmr/mcp/environment/streamviewer/
[2] EBTJV data are viewable in an online GIS at http://ecosheds.org:8080/geoserver/www/Web_Map_Viewer.html
[3] http://assessment.fishhabitat.org/
[4] http://trout.maps.arcgis.com/apps/webappviewer/index.html?id=1bbd262b634647b3beb78a6685a607d5

inadequacy of proposed buffers to protect brook trout habitat; the failure of the applicant to adequately assess and pursue potential alternatives to the project that would be less damaging to natural resources, including brook trout habitat—particularly alternative methods or sites for stream crossings; the degree of impact and the quality of resources impacted by the proposed NECEC project; the quality and quantity of brook trout habitat on parcels and funds proposed as compensation for impacts of the proposed project; and the failure of the applicant to adequately mitigate the impacts of the NECEC project on brook trout habitat.

9. Summarize your testimony.

The region through which the proposed NECEC project will be completed is the heart of the largest reservoir of intact aquatic habitat in the Northeast. This habitat supports populations of native brook trout that have been identified as the "last true stronghold for brook trout in the United States."[5] The proposed new corridor would substantially fragment this habitat, with multiple stream crossings that impact brook trout habitat, and the creation of a new corridor that could be a vector for increased human use and introduction of invasive species. The Applicant's assessment of these resources and impacts is inadequate, does not contain a specific analysis of impacts to brook trout habitat, and assumes the impacts of the new permanent corridor will be identical to the impacts of past and present forest management. The Application fails to consider reasonable alternatives to reduce impacts on brook trout habitat—including alternatives that were employed to reduce impacts on other resources. There are practicable alternatives to the project that would be less damaging to brook trout habitat. The Application's proposed mitigation is

[5] Eastern Brook Trout Joint Venture (2006): Eastern Brook Trout: Status and Threats. https://easternbrooktrout.org/reports/eastern-brook-trout-status-and-threats%20%282006%29/view

inadequate to compensate for impacts on brook trout habitat.

With respect to the DEP Site Law and Natural Resources Protection Act Application, the provisions for buffer strips are inadequate to protect brook trout habitat, including brook trout migration. The application does not meet the Chapter 375 standard that "Proposed alterations and activities will not adversely affect wildlife and fisheries lifecycles," particularly with respect to brook trout. The proposed mitigation to address these adverse effects on brook trout is not adequate. The DEP should therefore deny the permit.

With respect to the LUPC's certification that a utility corridor should be allowed within the PRR Zone around Beattie Pond, the Applicant has not demonstrated that there is "no alternative site that is both suitable for the use and reasonably available to the applicant", or that existing uses can be reasonably buffered from the impacts of the NECEC corridor. In particular, we are concerned that the NECEC corridor will become a pathway for motorized vehicles, including ATV's, and this increased motorized use around Beattie Pond will substantially increase the risk that invasive fish species become established in Beattie Pond, a designated State Heritage Fish Water for brook trout.

Brook Trout Habitat Values of Maine's Western Mountains and Impacts of NECEC on Selected Brook Trout Resources

10. Please describe the aquatic habitat and brook trout resource in Maine's Western Mountains Region.

Other witnesses will speak to the broader ecological values of the uninterrupted forest in western Maine, and they will primarily focus on terrestrial resources. I will address the aquatic resources. These are among the most intact watersheds remaining in the continental United States. Western Maine contains the vast majority of un-degraded aquatic habitat in the northeastern states. Just 17% of the land area in the region is considered to have "very low" levels of aquatic habitat degradation, and most of this is in western and northern Maine. The entire Maine/Quebec border falls into this category[6]. (See Exhibit 1.)

This intact habitat supports the nation's most significant stronghold of native brook trout populations. More than half of all subwatersheds designated as supporting "intact" populations of brook trout are in Maine, and the Western Mountains Region is the heart of this stronghold. Maine is the only state with any significant remaining lake and pond populations of brook trout, with more than 97% of those remaining[7]. (See Exhibit 2.) With the notable exception of the mainstem Dead River and the Kennebec River downstream of the Williams Dam, both of which are stocked annually with hatchery trout, virtually every stream and river in the region supports wild brook trout, and assessments of these populations for the Eastern Brook Trout Joint Venture classify almost all of them as "intact" at the subwatershed scale.

This is a resource of national significance. It is without doubt the most important and extensive reservoir of native trout biodiversity east of the Mississippi and may be the most intact native trout resource in the continental United States.

11. Does the Application accurately describe this resource?

No. The description of the brook trout resource in the Site Law Application is limited to a

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[6] National Fish Habitat Partnership, 2015. Through a Fish's Eye, the Status of Fish Habitat's in the United States, 2015.

[7] Eastern Brook Trout Joint Venture (2006): Eastern Brook Trout: Status and Threats. https://easternbrooktrout.org/reports/eastern-brook-trout-status-and-threats%20%282006%29/view

single paragraph. Although this paragraph[8] notes that "Brook trout are essentially pervasive in the Project Area and may be found in some portion of many of the waterbodies," it does not distinguish between the essentially intact populations in the region crossed by the "Greenfield" route from Beattie Township to Moxie Gore, and the far less extensive and more fragmented resources found in areas at lower elevations, within the mainstem Kennebec and Dead River and farther south. It also does not provide the important context that intact populations of brook trout at the landscape scale essentially exist only in western and northern Maine, and nowhere else within the species' US range. Other than counting stream crossings—without providing information on the fisheries values of the streams in question—the Alternatives Analysis in the NRPA Application does not discuss fisheries impacts.[9] In the discussion of "Site Specific Design to Minimize Environmental Impacts", measures to avoid or protect fisheries are not discussed, although the Applicant notes that "CMP has been in consultation with MNAP and MDIFW regarding potential rare, threatened, and endangered plant communities and animal occurrences."[10] Consultation with MDIFW staff about brook trout presence at crossings appears to have been left until very late in the process, with handwritten comments on the NECEC Water Body Crossing Table (Exhibit 7-7) provided on by MDIFW February 2, 2019.[11]

Similarly, the Revised Compensation Plan, dated January 30, 2019, contains little information regarding brook trout. Table 1-1: "Summary of Compensation as Required by NRPA and USACE" does not mention impacts to fisheries habitat. In Table 1-2: "Summary of

[8] Site Law Application, Chapter 7, page 40.
[9] NRPA Application, Pages 2-2 to 2-23.
[10] NRPA Application, Pages 2-22 to 2-23.
[11] See emails from Bob Stratton (MDIFW) to Jim Beyer (MDEP), late January/early February 2019, retrieved at: https://www.maine.gov/dep/ftp/projects/necec/review-comments/2019-02-01%20MDIFW%20Comments/

Compensation Resulting from Consultation with Resource Agencies," the only indirect reference to fisheries habitat is the inclusion of "12.02 linear miles of stream" in preservation parcels to compensate for 11.02 linear miles of forested conversion in riparian buffers. There is no assessment of the fisheries resources or habitat values of the streams on the preservation parcels compared to the impacted streams.[12] In the section regarding "Indirect Impacts to Coldwater Fisheries", there is discussion of the need to provide mitigation for the impacts of inadequate buffers, a notation that "CMP also intends to replace improperly installed or non-functioning culverts to improve habitat connectivity", and another reference to the 12.02 miles of streams to be protected on the Grand Falls, Basin, and Lower Enchanted Tracts under a deed restriction or conservation easement.[13] CMP also proposes to make two monetary contributions: $180,000 to the Maine Endangered and Nongame Wildlife Fund "to protect coldwater fishery habitat" and a contribution of "$200,000 of funding, sufficient to replace approximately 20-35 culverts."[14] But there is no actual assessment of the impacts to coldwater fisheries habitat, of the appropriate scale of mitigation, nor of the coldwater fisheries values to be protected, restored, or enhanced by the Compensation Plan.

Finally, there is no discussion whatsoever of impacts to Atlantic salmon habitat, or mitigation for these impacts.

12. Are there particular locations where impacts to brook trout habitat are significant?

Yes. I have not completed an exhaustive analysis of all of the stream crossings, but in the

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[12] Compensation Plan, Revised January 30, 2019, pages 5 and 6.
[13] Compensation Plan, Revised January 30, 2019, pages 20-22.
[14] Compensation Plan, Revised January 30, 2019, page 35.

"Greenfield" route from Beattie Township to Moxie Gore, I have identified several locations where high value brook trout streams—some of the "best of the best" of the state's headwater brook trout waters—are impacted by multiple stream crossings that impact a single, relatively small stream. For example:

1. In Skinner TWP, the route includes 18 separate crossings (3 on permanent streams, 12 on intermittent streams, and 3 on ephemeral streams) that impact the West Branch and South Branch of the Moose River near their confluence just east of Moose Mountain. The combination of multiple crossings, each of which will be maintained without a closed canopy cover, in a relatively small area risks cumulative impacts on the headwaters of one of Maine's most remote wilderness trout rivers. (Exhibit 3A)
2. On Piel Brook near the four corners of Bradstreet, Parlin Pond, Upper Enchanted and Johnson Mountain TWPs, a total of 10 crossings (3 on permanent streams, 5 on intermittent streams, and 2 on ephemeral streams) impact the headwaters. (Exhibit 3B)
3. The Cold Stream crossing in Johnson Mountain TWP is an especially important site for brook trout. (See additional discussion about the special value of Cold Stream for brook trout below.) It's also a particularly impactful crossing. In this case, the issue is not so much the number of crossings in close proximity to each other within a single watershed, but the fact that in addition to a crossing of Cold Stream, the NECEC ROW parallels two small perennial tributaries that have their confluence essentially at the NECEC crossing of Cold Stream. This results in an extended reach—about 1400 feet of stream—that closely parallels the cleared ROW. These

impacts are increased because the NECEC ROW abuts an existing cleared ROW at the Capital Road. The ROW also has direct impacts on BPL's Cold Stream Forest Unit, which abuts the ROW to both the north and south. Lack of shade and warming are likely exacerbated by this long parallel impact of road and utility ROW. (Exhibit 3C)

4. The Tomhegan Stream crossing in West Forks Plantation is another example where there are multiple crossings of permanent streams, all of which are either tributaries to or braided channels of Tomhegan Stream, in a very short section. In this case, there are 9 crossings—8 of permanent streams and 1 of an intermittent stream—within about 1200 feet. Like Cold Stream, Tomhegan Stream and its importance to brook trout conservation is discussed in more detail below. (Exhibit 3D)

Failure to Consider Alternatives That Could Have Avoided or Minimized Brook Trout Habitat Impacts

13. Did the Applicant consider alternatives that would avoid or minimize impacts to brook trout and Atlantic salmon habitat?

No. As discussed above, in the Alternatives Analysis, there is no assessment—other than the total number of stream crossings—of the relative fisheries habitat impacts of the alternative routes considered. Nor are any routes co-located along existing disturbed areas—for example, buried along a road corridor. More importantly, with respect to fisheries, minor modifications to the route or to the size and location of structures could have been considered or implemented to avoid or reduce the impacts of lost riparian buffers on brook trout and salmon habitat but were not. These include taller poles to put the wires high enough that full forest canopy closure could be maintained; changing locations of poles—for example, higher on slopes, to achieve the same effect; and minor route changes to avoid stream crossings altogether or to cross at locations where impacts would be smaller.

Significantly, these measures have been used at some stream crossings to reduce impacts on wildlife resources and on recreational users. Similar measures could have been used to reduce impacts on important brook trout streams. Some examples of these measures include:

1. Gold Brook is a highly significant brook trout water that is in a watershed with Rock Pond and Iron Pond, both State Heritage Fish Waters for brook trout, and is a tributary to Baker Stream, which flows into Baker Pond, another State Heritage Water. Gold Brook is important spawning and rearing habitat for these three ponds and is also a fine trout stream on its own. Significant impacts to Gold Brook are caused by a combination of multiple stream crossings, a long section of the ROW that parallels Gold Brook, and additional crossings in the watershed on the inlet to Rock Pond. In this case, however, these impacts were reduced by raising the structure heights at most of these crossings to allow mature trees to be maintained along most of this section of the ROW. These changes were made to address concerns about Roaring Brook Mayfly and Northern Spring Salamander habitat in Gold Brook.[15] (Exhibit 4A) A better solution at this site might have been to reroute the ROW slightly to the north or south. As currently laid out, the

[15] Philip DeMaynadieres, ME DIFW, personal communication.

ROW crosses a curve in Gold Brook twice in a short reach, then closely parallels the shore of Rock Pond, with multiple other crossings nearby. All of these impacts could have been avoided if the ROW had been located a half mile to the north or south to avoid Gold Brook and Rock Pond altogether. (Exhibit 4A)

2. Similar measures were taken, also to prevent impacts to Roaring Brook Mayfly and Northern Spring Salamander, at the crossing on Mountain Brook in Johnson Mountain Township[16]. Again, taller structures allowed for the ROW to be constructed while leaving an intact forested canopy for a buffer on the stream. (Exhibit 4B)
3. Originally, similar plans were made to use tall structures placed high on the walls of the Kennebec Gorge to allow an over-water crossing of the Kennebec River from West Forks TWP to Moxie Gore while maintaining an undisturbed forested buffer on both banks. Impacts at this site have been further reduced by locating the lines underneath the river bed. (Exhibit 4C)

These or similar measures should have been evaluated as alternatives that could avoid or minimize impacts of the NECEC at stream crossings where the Applicant is not proposing to maintain a forested canopy in the buffer area. If these alternatives were reasonable to protect particularly sensitive insect and salamander populations, they could also have been used to protect particularly sensitive brook trout.

14. Are there places where using these techniques to maintain forested riparian buffers

[16] Philip deMaynadier, ME DIFW, personal communication.

would significantly reduce the impacts of the project?

Yes. The crossings at the South Branch/West Branch Moose River, at Cold Stream, and at Tomhegan Stream all are of significantly high impact on brook trout resources of very high value. Further analysis would likely reveal some others. The additional cost of installing taller structures at these sites would be marginal given the total cost of the project.

15. Are there places where impacts to brook trout and salmon habitat especially concern you?

Several areas are of special concern to me.

1. Cold Stream, including Tomhegan Stream and other tributaries. Cold Stream represents one of the most intact and highest value watersheds for native brook trout in Maine. The Cold Stream property contains a combination of pristine native brook trout ponds and intact streams. Cold Stream from its source to its mouth at the Kennebec River is a brook trout factory and there is not a single known occurrence of non-native fish in the watershed. Both the stream and the ponds have been destination fisheries for anglers for more than 100 years. Extensive fisheries studies were conducted before, during, and after the Indian Pond Dam FERC relicensing, including habitat surveys of the Kennebec River and many tributaries, electrofishing, water temperature profiles, and radio-telemetry of adult brook trout. These resources documented the importance of Cold Stream to supporting the Kennebec and Dead River fisheries for wild brook trout. Key findings include: (1) More than 98% of Kennebec River brook trout are wild. (2) No brook trout spawning or juveniles were observed in the Kennebec mainstem. (3) All tributaries to Kennebec Gorge except

Cold Stream have impassable blockages very close to Kennebec River. (4) Cold Stream was the only location where radio-tagged brook trout were observed spawning, with tagged fish during spawning period recorded as much as five miles up Cold Stream. (5) Tagged brook trout also moved into Cold Stream during summer warm periods for thermal refuge. (6) Tagged brook trout seeking thermal refuge not only entered Cold Stream, but also swam upstream and into Tomhegan Stream. (7) The Cold Stream fish community is markedly different from Kennebec mainstem based on angling, snorkel, and electrofishing surveys, and contains no non-native fish species. The Kennebec supports slimy sculpin, blacknose dace, smallmouth bass, fallfish; limited numbers of adult brook trout and landlocked salmon. Cold Stream is dominated by brook trout, mostly juveniles, with limited numbers of slimy sculpin and blacknose dace. [17]

Because of these findings, Cold Stream was prioritized for habitat protection, and TU worked with the ME DIFW, ME BPL, Trust for Public Lands and many other partners to help the state acquire 8,200 acres that protects all the headwater ponds in the Cold Stream watershed and protects the stream corridor from its source to its mouth EXCEPT FOR a narrow corridor along the Capital Road. In the ultimately successful application for funding for the Cold Stream Forest Project from the Land for Maine's Future Fund, the project partners identified the brook trout habitat in on the property as a "Single Exceptional Value" for the property.

The NECEC ROW crosses Cold Stream through this corridor. In addition to this

[17] E/PRO Engineering & Environmental Consulting, LLC. November 2000. Assessment of Salmonid Fishes in the Upper Kennebec/Lower Dead River Watershed, Maine. Report for The Indian Pond Project Relicensing, FERC # 2142.

crossing—discussed in detail above—there are more than 20 additional NECEC ROW crossings of perennial and intermittent streams in the Cold Stream watershed. The cumulative effects of these crossings, in particular the impacts depicted in Exhibits 3C and 3D at the Cold Stream and Tomhegan Stream ROW crossings, threaten to degrade the public's investment in protecting this valuable habitat.

2. Lakes and Ponds Designated as State Heritage Fish Waters. The NECEC ROW passes very close to several designated State Heritage Fish Waters. These are waters are designated by the ME DIFW based on their native brook trout populations that have been self-sustaining for at least 25 years with no history of stocking. The following designated State Heritage Fish Waters are within less than one mile of the NECEC ROW.

    a. Beattie Pond, Beattie TWP. 1200 feet from the ROW.
    b. Rock Pond, T5R6 BKP WKR. 900 feet from the ROW. (The ROW also crosses the inlet to Rock Pond.)
    c. Iron Pond, T5R6 BKP WKR. 2500 feet from the ROW.
    d. Mountain Pond #1, Johnson Mountain TWP. 3700 feet from the ROW.
    e. Little Wilson Hill Pond, Johnson Mountain TWP. 1300 feet from the ROW. (The ROW also crosses the inlet to the pond.)
    f. Big Wilson Hill Pond, West Forks PLT. 4300 feet from the ROW.
    g. Baker Pond, Caratunk. 2300 feet from the ROW

The primary concern for these waters is increased ease of access, if the NECEC ROW is used formally or informally as a motorized road or trail. The primary threat to lake and pond brook trout populations is introduction of non-native fish species that compete with or prey on brook trout.[18]

3. West Branch Sheepscot River. The concern here is the cumulative impact of an additional crossing of the West Branch Sheepscot, an important river for endangered Atlantic salmon. The West Branch Sheepscot is already heavily impacted by powerline and pipeline crossings that have removed most of the riparian vegetation from almost a half mile of the river. The new crossing will have significant impact because it crosses the West Branch at a shallow angle and parallels the river. As a result, the ROW clearing limits stretch for more than 1300 feet along stream. The Google Earth View (Exhibit 5) clearly shows that what little riparian vegetation remains on this impacted river reach is within the ROW clearing limits and will be removed. This is another area where alternatives, including an alternate route or using taller structures so that mature trees could be allowed to remain standing, would have substantially reduced the impact on Atlantic salmon habitat in the Sheepscot.

The Proposed Riparian Buffers Will Not Protect Aquatic Habitat, Including Brook Trout Habitat.

16. What is an adequate buffer to protect brook trout and other aquatic habitat? What are the most important functions of this buffer?

There are a variety of recommendations for buffers to protect brook trout and other aquatic habitat. The Maine Natural Areas Program's Beginning with Habitat reviewed buffer practices

[18] Eastern Brook Trout Joint Venture (2006): Eastern Brook Trout: Status and Threats. https://easternbrooktrout.org/reports/eastern-brook-trout-status-and-threats%20%282006%29/view

and standards from a range of landowners, managers, foresters, and regulators in northern New England. Their report (attached as Exhibit 6) emphasizes the importance of closed canopy in the riparian zone for some wildlife species and of organic and woody debris inputs to streams that result from allowing standing wood to die and be recruited. The report recommends retention of "relatively continuous forest canopy closure (>70%) in riparian management zones" and consideration of "a limited no-cut zone (25-100 ft is often recommended) immediately adjacent to the stream or wetland shoreline, particularly in areas containing steep slopes and shallow or poorly drained soils."[19]

To protect brook trout habitat, ME DIFW recommends:

> *limiting the harvest of trees and alteration of other vegetation within 100 feet of streams and their associated fringe and floodplain wetlands to maintain an intact and stable mature stand of trees, characterized by heavy crown closure (at least 60 –70%) and resistance to wind-throw. In some situations wider buffers should be considered where severe site conditions (e.g., steep slope, vulnerable soils, poor drainage, etc.) increase risk to soil and stand stability. Any harvest within the riparian management zone should be selective with a goal of maintaining relatively uniform crown closure.* [20]

In a 2005 report for Trout Unlimited, after an extensive literature review and consultation with fisheries biologists, foresters, and land managers, Kleinschmidt Associates recommended a multiple zone buffer with a fixed width no-cut buffer of at least 75 feet, followed by an

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[19] deMaynadier, P., T. Hodgman, and B. Vickery. 2007. Forest Management Recommendations for Maine's Riparian Ecosystems. Technical report submitted to the Maine Department of Inland Fisheries and Wildlife, Bangor, ME.
[20] ME DIFW, undated. Forest Management Recommendations for Brook Trout. https://www.maine.gov/ifw/docs/brook_trout_factsheet_forestry.pdf

additional 75 feet with no soil disturbance and relatively high stocking levels of standing timber. The primary functions of the no-cut buffer—which is difficult to provide with even relatively light levels of cutting, are shading and temperature regulation, large woody debris inputs (dead trees that provide instream habitat when they are recruited into the stream), protection of water quality and bank stabilization.[21] The report is attached. (Exhibit 7)

17. Are the "100-foot riparian buffers" proposed for the stream crossings on the NECEC project adequate to protect brook trout?

They are not. CMP has committed to 100-foot buffers adjacent to all streams identified as "coldwater fisheries", an all perennial streams within segment 1—the "greenfield" portion of new transmission line from Beattie TWP to Moxie Gore. All other streams will have a 75-foot buffer applied. There are several concerns.

1. It is not clear that CMP and ME DIFW have reached agreement on which streams are "coldwater fisheries". The current "record" is a set of hand-marked and highlighted tables provided by Bob Stratton of ME DIFW in early February. There is no evidence that CMP concurs that this is the correct list.
2. The designations of streams as "brook trout" or not appear to be somewhat arbitrary. Based on my experience, anywhere along the NECEC "Greenfield" route in the Moose, Dead, Cold Stream or other Kennebec River tributaries watersheds should be considered as brook trout habitat.

[21] Trout Unlimited. 2005. Riparian Buffer and Watershed Management Recommendations for Brook Trout Habitat Conservation. Focus: Mountainous Brook Trout Watersheds of Maine and Northern New Hampshire. Report Prepared for Trout Unlimited, Augusta, Maine, by Kleinschmidt Associates, Pittsfield, Maine.

3. The biggest concern, however, is not with the width of the buffer, but with how the buffer will be maintained. Nowhere within the clearing limits of the ROW will there be the mature trees and full canopy closure that are required to provide the most important buffer functions for brook trout habitat: shading, recruitment of organic matter and large woody debris, and bank stabilization. In the center 30 feet of the cleared ROW, vegetation will be no more than 10 feet tall. Outside that zone, all "capable" vegetation will be removed. The "100-foot riparian buffer" will therefore be a scrub/shrub habitat at best and will not fulfill the most important buffer functions that are envisioned by the recommendations in ME DIFW and MNAP for closed canopy forest.

18. Do the proposed compensation parcels contain valuable brook trout habitat that would compensate for impacts from inadequate riparian buffers on impacted streams.

As described in the revised Compensation Plan dated January 30, 2019, they provide very little.

1. The Little Jimmie Pond-Harwood Tract has no value for wild brook trout. All streams on the parcel are warmwater habitat.
2. The Flagstaff Lake parcel has very limited value for wild brook trout. Flagstaff Lake is primarily warm water habitat with some stocked salmonids.
3. The Pooler Ponds Tract has some limited value for brook trout habitat, all of it in the mainstem Kennebec River. The Pooler Ponds tract protects only one shore of the Kennebec River, so habitat in the 0.8 miles of Kennebec River that abuts the parcel is not fully protected. This is habitat that provides seasonal angling opportunities, but studies on the Kennebec River have shown that all brook trout spawning and rearing occur in tributaries. This parcel is more valuable for recreation and water access than for fisheries habitat.

4. The Grand Falls Tract, like the Pooler Ponds Tract, primarily provides river access and angling opportunity. It contains only 0.7 miles of streams, the mainstem of the Dead River. Like the Kennebec, the Dead River serves primarily as seasonal habitat for adult trout. The river is stocked with both landlocked salmon and brook trout. There is a wild component to the fishery, but it is supported from habitat in tributaries, not in the mainstem of the Dead River.
5. The Lower Enchanted Tract provides 3.6 miles of river frontage, but most of that is along the northern shore of the Dead River, where the fishery is supported in part by stocking. Like the Pooler Ponds Tract, by protecting only one shoreline the habitat conservation benefits of the parcel are limited. There is approximately 1 mile of Enchanted Stream protected on the parcel. Enchanted Stream is an important tributary for spawning and rearing of wild brook trout. However, without protection of the watershed above this habitat, it is not protected future land use impacts upstream.
6. The Basin Tract has 4.8 miles of stream, almost all of it on the mainstem Dead River where the fishery is largely supported by stocking. Like the other protected sections of the Dead and Kennebec Rivers, this is habitat primarily for adult brook trout and landlocked salmon, with any production of wild brook trout relying on tributary habitat which is not protected, and the conservation land encompasses only one shore of the river.

In summary, most of the river and stream habitat protected on these compensation parcels is unlike the streams that are impacted by the NECEC's inadequate buffers. The impacted streams are mostly cold, high elevation, headwater streams that are highly productive of wild brook trout. The streams "protected" on the compensation parcels are mostly large mainstem rivers that warm significantly in the summer, are protected on only one shoreline, have a recreational fishery at least partially supported by stocking, and have limited or no potential to produce wild brook trout. The one exception is the short reach of Enchanted Stream, but even this is quite unlike most impacted waters.

I would add that even if the parcels contained large amount of valuable and vulnerable coldwater habitat—and they don't—the extent to which the coldwater habitat values, or any other important resources values on the property, will be protected will depend entirely on the terms of the deed restriction, conservation easement, or other durable instrument negotiated for protection. We would recommend specific terms to protect all riparian vegetation from any cutting except that needed to fisheries or wildlife habitat improvement, or to control invasive species if necessary. Any cutting in the riparian zone should require consultation with ME DIFW. Finally, the quality of the easement holder is critical. The easement should be held by either the state of Maine, or by a land trust accredited by the Land Trust Alliance.

A better strategy for coldwater habitat conservation would have been to protect headwater streams like those that are impacted. This would have provided far more brook trout habitat value, particularly if the compensation parcels include long stream reaches where both shorelines and important tributaries are protected. A project of the scale of the Cold Stream Forest Project—which protected 15 miles of stream habitat in the Cold Stream watershed, would be more appropriate.

19. Have you reviewed the proposed NECEC Culvert Replacement Program? Do you think it will result in meaningful benefits to instream habitat for brook trout and salmon?

I have reviewed CMP's proposal. With respect to the fund for off-corridor culvert replacements, I believe CMP's estimate that the $200,000 fund will be sufficient to replace approximately 20-35 culverts is wildly optimistic. My own experience with several culvert projects suggests that cost estimates of $50,000 to $100,000 per culvert are conservative. Costs may be somewhat lower if the culverts to be replaced are on logging roads and need not meet DOT standards. However, some of the most important culverts we identified in surveys of the Kennebec and Dead River watersheds were on tributaries to the Kennebec River that crossed Route 201. A single Route 201 culvert would almost certainly cost more than the entire fund. It is impossible to say how much habitat benefit might accrue from the $200,000 fund, because it depends on the numbers of sites and their habitat impact. My best professional assessment is that with $200,000, it's likely that access to less than 10 miles of additional habitat would be restored.

It is much harder to estimate the potential value of the Culvert Replacement on CMP Controlled Lands. This would be a very meaningful commitment if CMP were to replace or upgrade all of its culverts on all CMP-owned lands in Somerset and Franklin Counties. However, CMP's commitment is qualified. They will replace or remove all culverts on "CMP controlled lands associated with the NECEC." This appears to be a much more limited commitment, particularly given the very small number of streams—and therefore few culverts—on the mitigation parcels. Based on my review of the stream networks on the mitigation parcels, I believe there are likely fewer than 10 culverts on the mitigation parcels.

20. How much coldwater habitat restoration could be completed with the $180,000 contribution to the Maine Endangered and Nongame Wildlife Fund "to protect coldwater fishery habitat"?

First, it's not clear to me that funds from that source would be used for fisheries restoration. I've worked on restoration projects for coldwater fish in Maine for almost 25 years, and I cannot recall a project that used the Maine Endangered and Nongame Wildlife Fund. However, if the funds were allocated to a specific purpose, $180,000 is likely enough funding to accomplish one or two meaningful fish passage (culvert) or instream restoration (rock structures, barrier removal, or large wood additions) on streams that are accessible by equipment.

List of Exhibits

1. Reardon Exhibit 1: Map of Aquatic Habitat Degradation Compared to NECEC Route
2. Reardon Exhibit 2: Brook Trout Population Assessments and NECEC Route
3. Reardon Exhibit 3: Examples of Brook Trout Streams with High Impact—Multiple Crossings in Proximity.
    a. Exhibit 3A—West Branch/South Branch Moose River
    b. Exhibit 3B—Piel Brook
    c. Exhibit 3C—Cold Stream
    d. Exhibit 3D—Tomhegan Stream
4. Reardon Exhibit 4: Stream Crossing Alternatives That Maintain 100% Canopy Cover
    a. Exhibit 4A: Gold Brook
    b. Exhibit 4B: Mountain Brook
    c. Exhibit 4C: Kennebec River Drill
5. Reardon Exhibit 5: West Branch Sheepscot River Crossing
6. Reardon Exhibit 6: Maine Natural Areas Program: <u>Forest Management Recommendations for Maine's Riparian Ecosystems</u>
7. Reardon Exhibit 7<u>: Riparian Buffer and Watershed Management Recommendations for Brook Trout Habitat Conservation. Focus: Mountainous Brook Trout Watersheds of Maine and Northern New Hampshire.</u>

<u>Notarization</u>

I, Jeffrey Reardon, being first duly sworn, affirm that the above testimony is true and accurate to the best of my knowledge.

Name (signature) Date 7/27/2019

Maine Brook Trout Project Director
Title

Personally appeared the above-named Jeffrey Reardon and made affirmation that the above testimony is true and accurate to the best of his knowledge.

Date: 7/27/2019 Notary: Debora Southiere

DEBORA SOUTHIERE
NOTARY PUBLIC
KENNEBEC COUNTY
MAINE
MY COMMISSION EXPIRES APRIL 2, 2022

Jeff Reardon Testimony Exhibits

Group 4
Exhibit 1-JR

Reardon Exhibit 1: Map of Aquatic Habitat Degradation Compared to NECEC Route

- This map is copied from the National Fish Habitat Partnership's report Through a Fish's Eye, the Status of Fish Habitat's in the United States, 2015.

- It can be accessed in full at http://assessment.fishhabitat.org/

- The map on the following page is from the second page of the "Northeastern States Region" section of the report: http://assessment.fishhabitat.org/#578a9a00e4b0c1aacab896c1/578a9a9fe4b0c1aacab8985c

- NECEC Route is mapped with the most recent KMZ file from Maine DEP: https://www.maine.gov/dep/gis/datamaps/

NECEC “Greenfield” Route Passes Through the Least Degraded Aquatic Habitat in Northern New England.

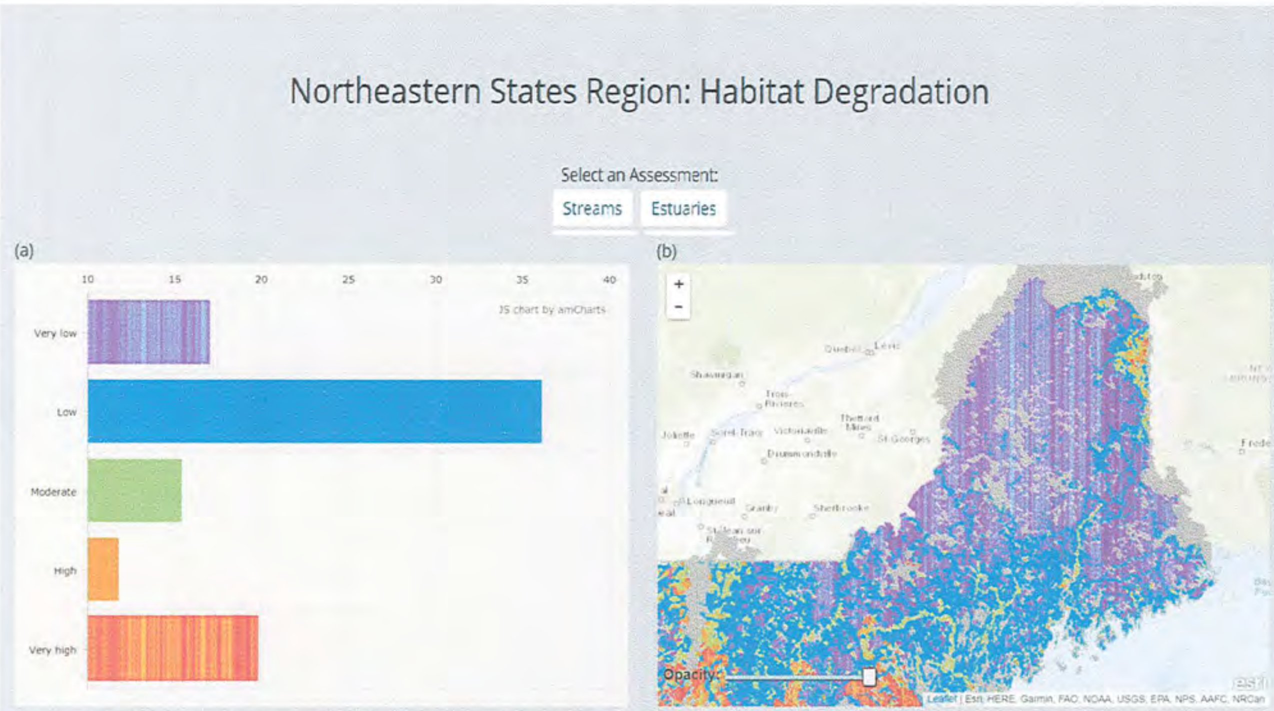
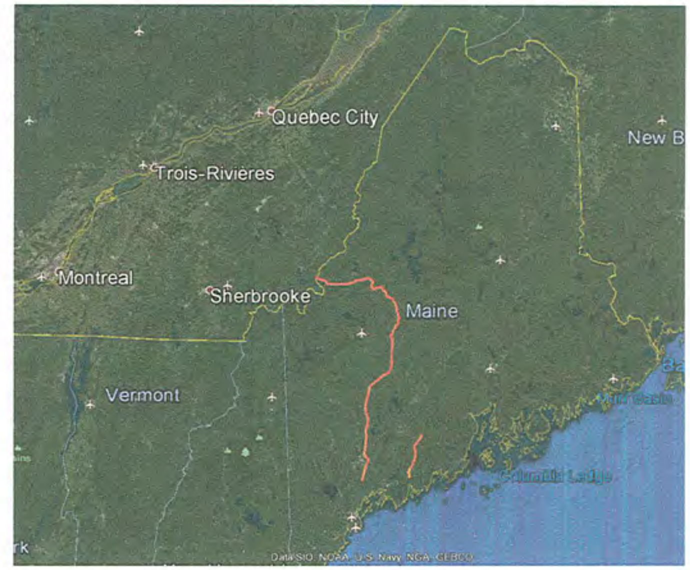


Figure1: This interactive figure summarizes the risk of fish habitat degradation for both perennial and intermittent waters as defined by the National Hydrography Dataset Plus Version 1. Future assessment enhancements will include a map of scores for only perennial streams in the U.S. The currently selected tab shows data from the inland assessment of streams for the contiguous United States. (a) Relative condition of fish habitat in streams. Stream summaries represent percentage of total stream length in each condition class. (b) Map showing risk of fish habitat degradation. The default view shows all stream condition classes. User may change map display by selecting a bar in (a), resulting in a display of the selected condition class in (b). Please see How to Read this Report for important information about strengths and limitations of these findings. Click here to download scores from the inland assessment of streams for the United States.



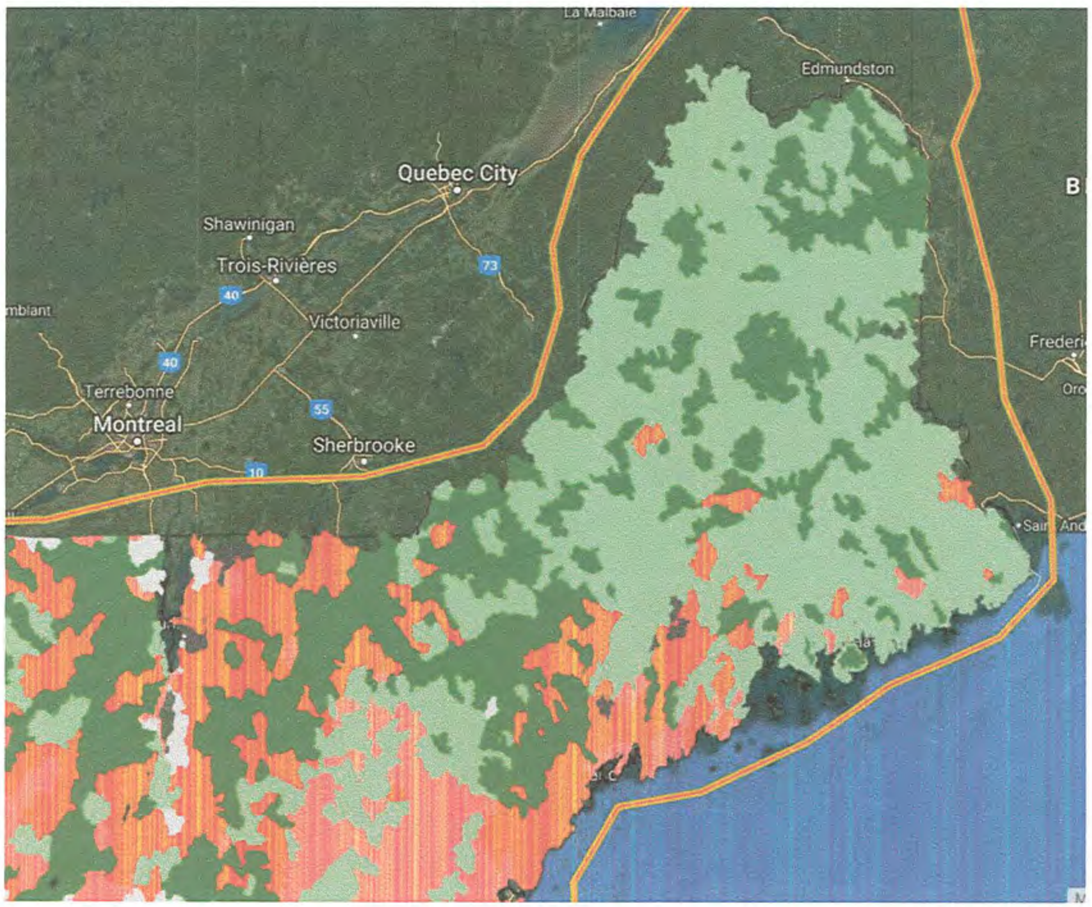
NECEC Route for Comparison

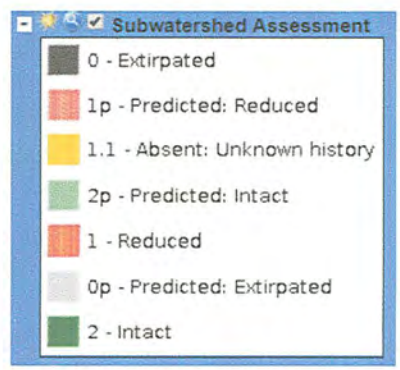
Group 4
Exhibit 2-JR

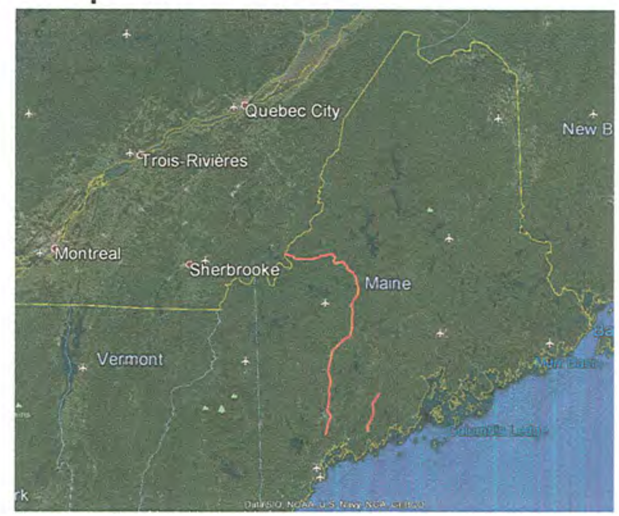
Reardon Exhibit 2: Brook Trout Population Assessments and NECEC Route

- The map is screenshot of a web-based viewer of Eastern Brook Trout Joint Venture data, described as an "Interactive GIS map featuring data layers (brook trout status and habitat patches) and tools (riparian prioritization, drainage area calculator) developed and endorsed by the EBTJV."
- It can be accessed at: http://ecosheds.org:8080/geoserver/www/Web_Map_Viewer.html
- The map on the following page is a screenshot of Subwatershed Assessments of Brook Population Status data (Ranging from "extirpated" to "intact" in green.
- NECEC Route is mapped with the most recent KMZ file from Maine DEP: https://www.maine.gov/dep/gis/datamaps/

Entire NECEC "Greenfield" Route Passes Through Subwatersheds Assessed as "Intact" Brook Trout Populations.







NECEC Route for Comparison

Reardon Exhibit 3: Examples of Brook Trout Streams With High Impact—Multiple Crossings in Proximity

- The maps are screen shots of the the NECEC Route is mapped with the most recent KMZ file from Maine DEP, showing stream crossings, overlaid on USGS topo data:
  - NECEC Route KMZ File (Jan, 2019) from Maine DEP at https://www.maine.gov/dep/gis/datamaps/
  - USGS Topo Data Downloaded from Earthpoint http://www.earthpoint.us/TopoMap.aspx
  - Aerial Photos/Satellite from Google Earth.
  - Stream Crossing Tables Compiled from NECEC KMZ Files.
- These are selected sites with high impact laid out from west to east.
  - Not a comprehensive survey.

Group 4
Exhibit 3-JR

Exhibit 3A—W. Branch/S. Branch Moose River.

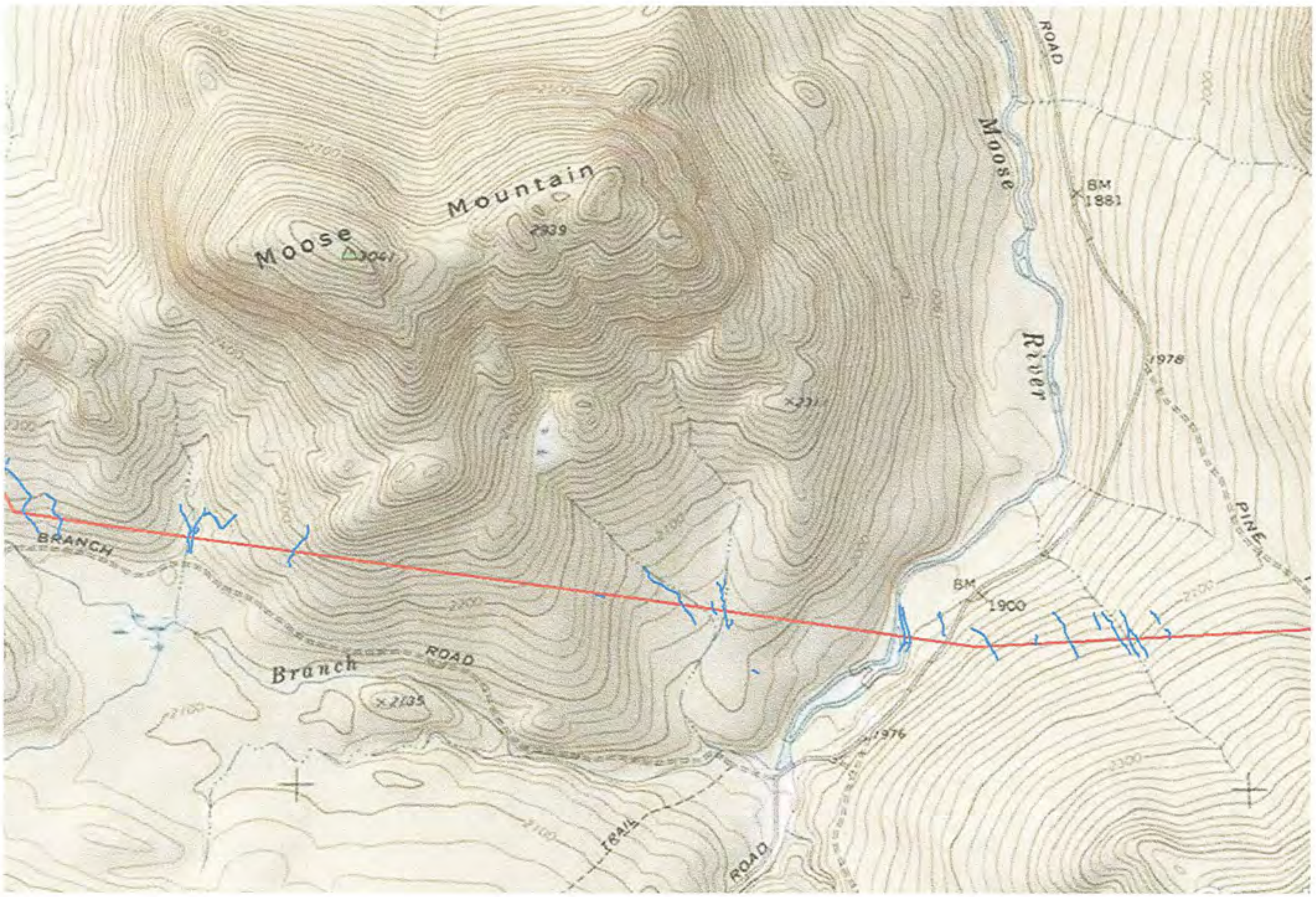


Exhibit 3A—West Branch/South Branch Moose River.

South Branch Moose River	PSTR	ISTR	ESTR	STI-STR
	08-04	07-08	07-05	25
	09-11	07-07	09-01	08-01
	09-06	07-03		28
		07-01		
		08-01		
		09-10		
		09-09		
		09-04		
		09-05		
		09-06		

ROW Length: 2.5 miles

- Stream Crossings
  - Permanent: 3
  - Intermittent
    - ISTR: 10
    - STI-STR: 2
  - Ephemeral: 3

    - **Total: 18**

Exhibit 3B-Piel Brook

Notes:

- The ROW crosses Piel Brook twice in 0.9 miles of stream.
- Parallels this length of stream that distance, never more than 800 feet away.

Exhibit 3B—Piel Brook

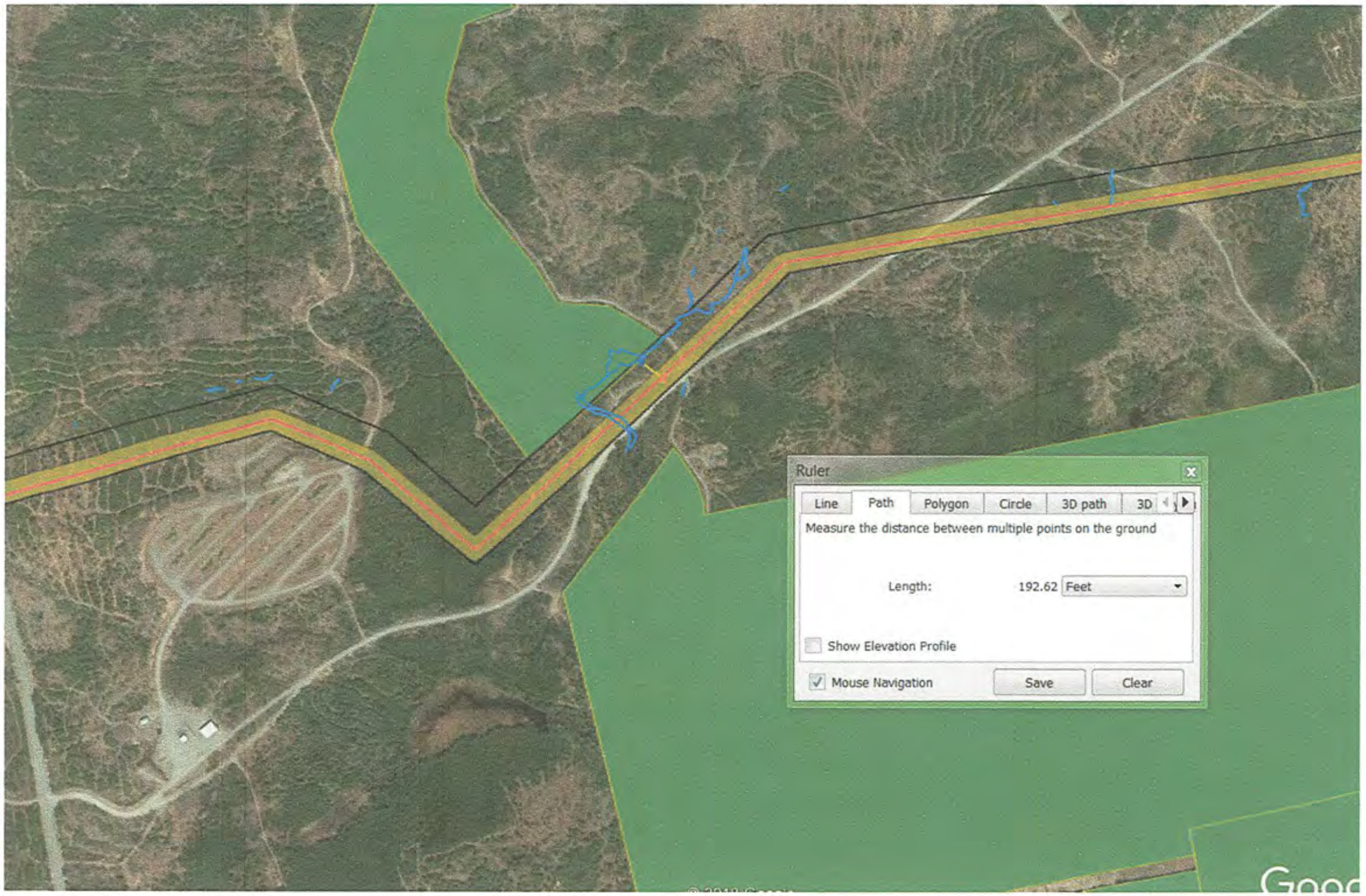
Piel Brook	PSTR	ISTR	ESTR	STI-STR
	30-01	30-02	31-07	
	Sr-31-01	31-02	31-03	
	31-06	31-01		
		32-01		
		32-02		

ROW Length: 2.4 miles

- Stream Crossings
  - Permanent: 3
  - Intermittent
    - ISTR: 5
    - STI-STR: 0
  - Ephemeral: 2

    - **Total: 10**

Exhibit 3C—Cold Stream



Notes:

- Crossing of Cold Stream and 1400 foot long parallel to small tributary.
- ROW within <250 feet of stream for entire length.
- Impacts additive to exiting impact of Capital Road.

Exhibit 3C—Cold Stream

Cold Stream, Capital Road	PSTR	ISTR	ESTR	STI-STR
	40-06			
	40-07			
	40-08			

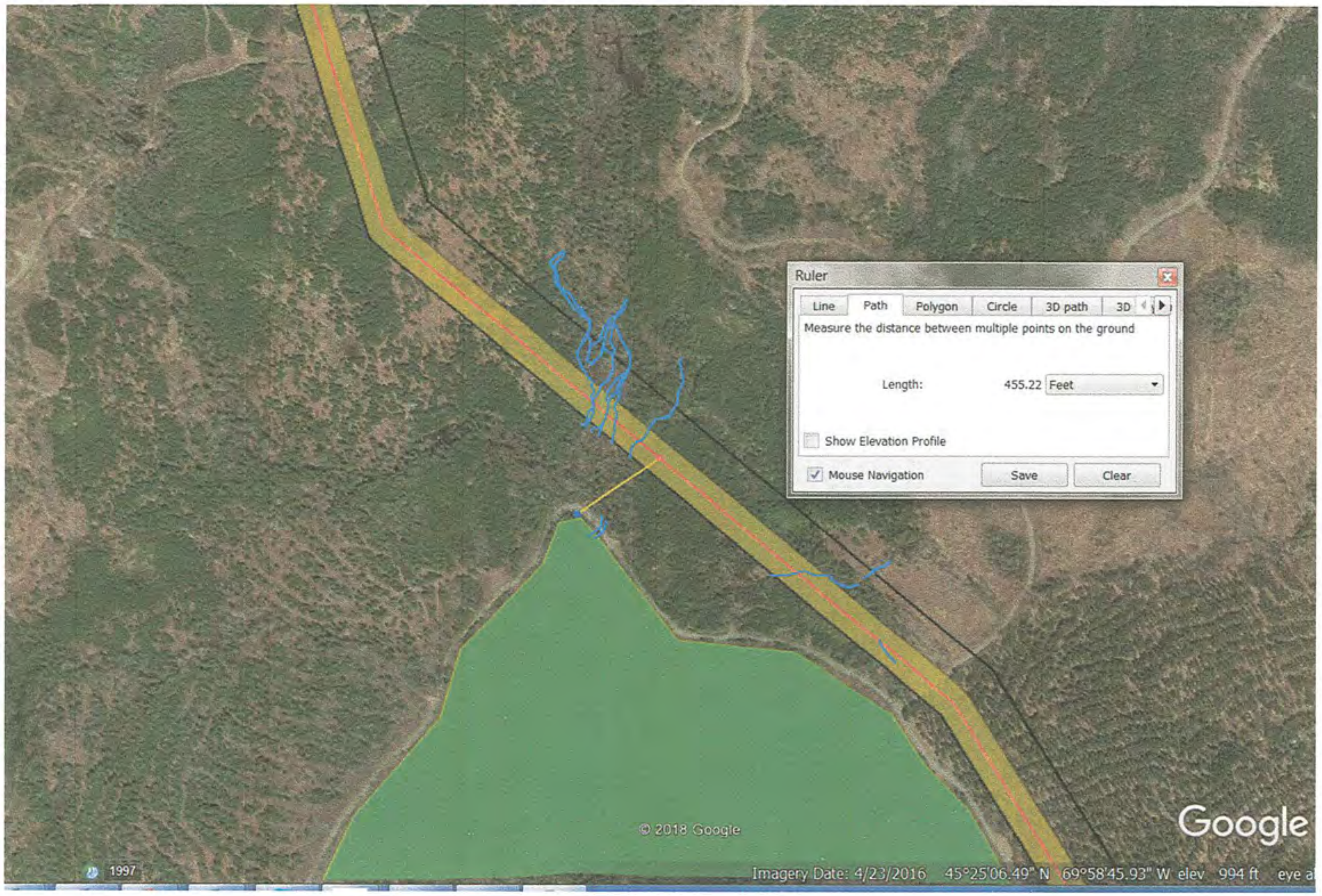
Cold Stream is a very high value resource for brook trout.

- Entire length of Cold Stream from Source to Mount protected for the primary purpose of protecting intact brook trout habitat.
  - Except ~700 foot strip along the Capital Road.
  - $7.5 million in Federal Forest Legacy and Land for Maine's Future Funding to purchase 8,200 acres for state.
  - "Wild Native Brook Trout Habitat" was identified as a "single exceptional value" to justify the LMF Funding.

ROW Length: 1500 Feet

- Stream Crossings
  - Permanent: 1
    - Cold Stream
- Stream Parallel
  - 1400 foot parallel to small perennial tributary.

Exhibit 3D—Tomhegan Stream



Notes:

- Crossing location has multiple permanent stream crossings.
- Less than 500 feet from Cold Stream Forest BPL Unit.

Exhibit 3D—Tomhegan Stream

Tomhegan Stream	PSTR	ISTR	ESTR	STI-STR
	45-03	45-02		
	44-07			
	44-06			
	44-04			
	44-08			
	44-01			
	44-09			
	44-02			

ROW Length: 1200 Feet

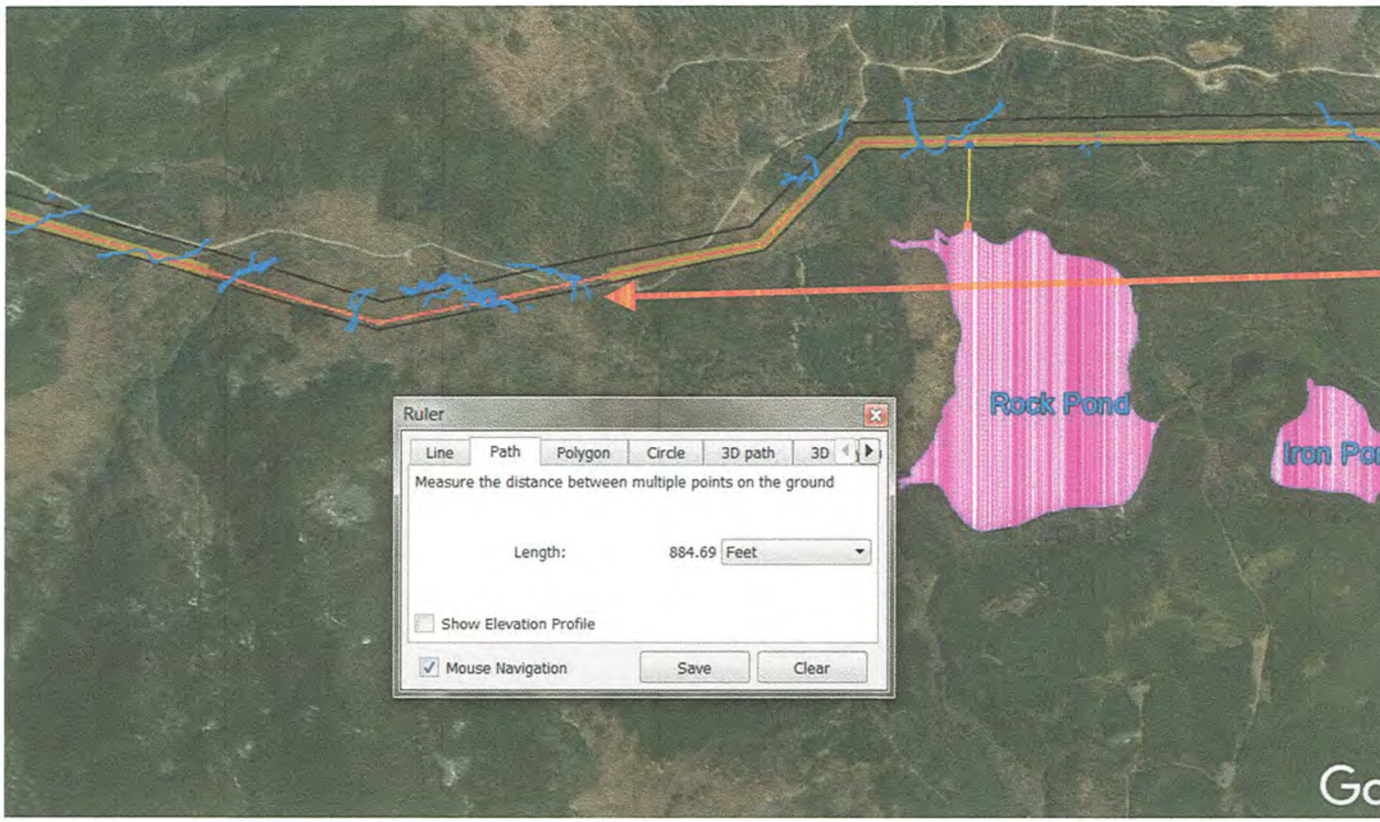
- Stream Crossings
  - Permanent: 8
    - Tomhegan Stream
  - Intermittent: 1
  - **Total: 9**

Reardon Exhibit 4: Stream Crossing Alternatives That Maintain 100% Canopy Cover

- The maps are screen shots of the NECEC Route as mapped with the most recent KMZ file from Maine DEP, showing stream crossings, overlaid on USGS topo data:
  - NECEC Route KMZ File (Jan, 2019) from Maine DEP at https://www.maine.gov/dep/gis/datamaps/
  - Aerial Photos/Satellite from Google Earth.
- At two sites, structure heights were raised to eliminate the need for clearing over stream segments supporting Roaring Brook Mayfly and/or Northern Spring Salamander.
- At a third site, the NECEC line will be drilled under the Kennebec River to avoid visual impacts.

Group 4
Exhibit 4-JR

Exhibit 4A— Gold Brook



Note:

- No cleared ROW.
- Structure heights or placement changed to allow full forested buffer

Exhibit 4A—Gold Brook

Gold Brook/Baker Stream	PSTR	ISTR	ESTR	STI-STR
	16-14	*16-16*	*16-08*	
	16-01	*16-05*	*15-11*	
	16-101	*16-04*		
	16-10	*16-03*		
	16-07	*16-01*		
	15-06	*15-10*		
	15-04			

Notes:

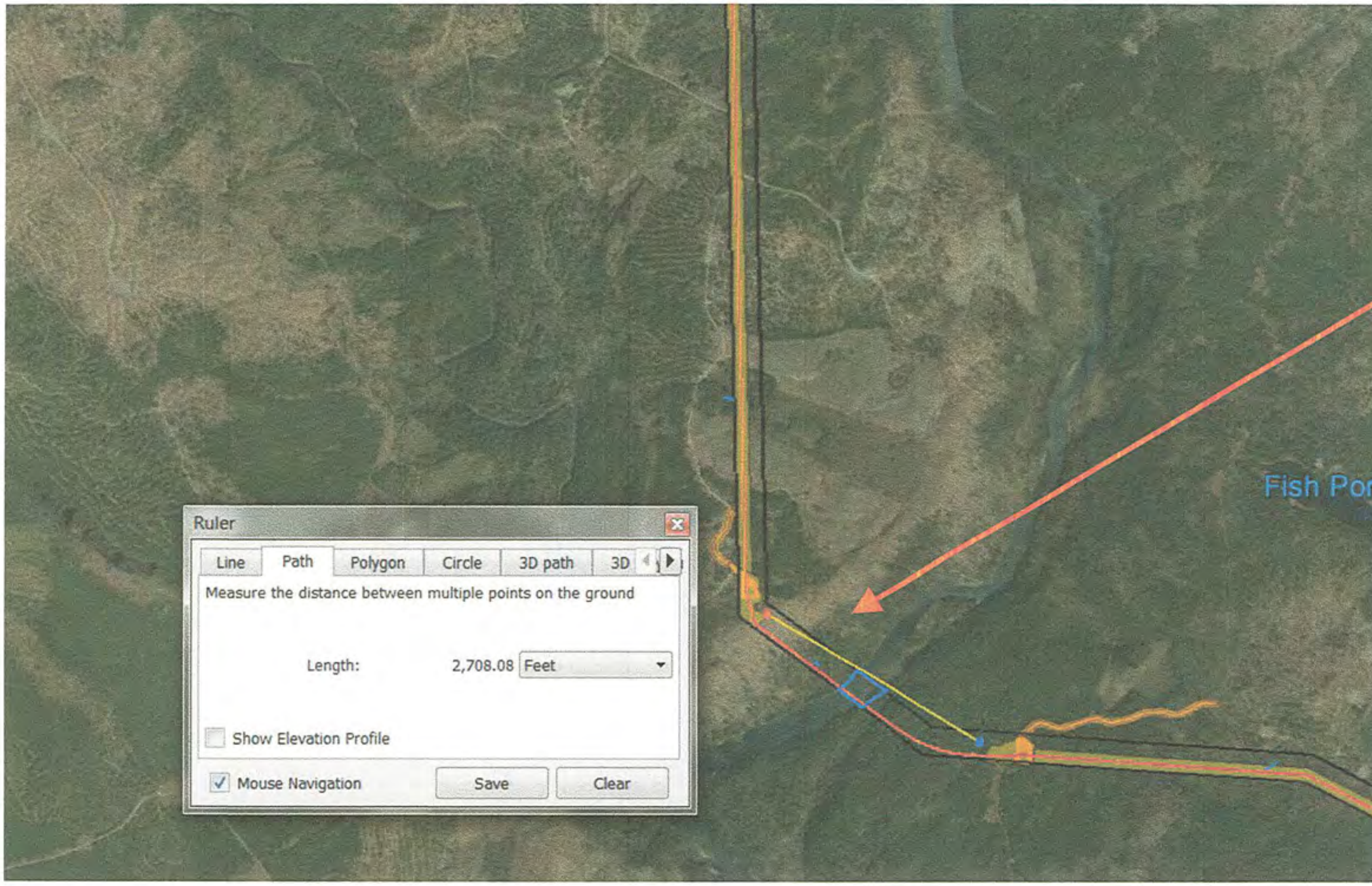
- The ROW crosses Gold Brook mainstem twice in ~0.5 miles of stream.
- Parallels stream between crossings-always within 400 feet.
- Raised pole height through 5 structures and 4300 feet of ROW eliminates most impacts.
  - Eliminated impacts highlighted.

ROW Length: 2.06 miles

- Stream Crossings
  - Permanent: 7
  - Intermittent
    - ISTR: 6
    - STI-STR: 0
  - Ephemeral: 2
    - **Total: 15**

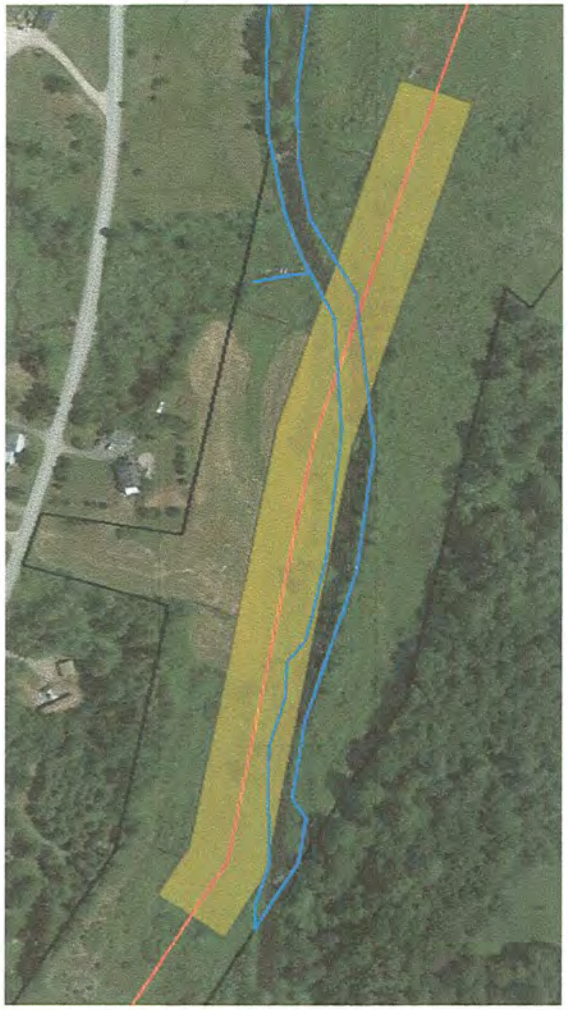
Exhibit 4B: Mountain Brook

Exhibit 4C: Kennebec River Drill



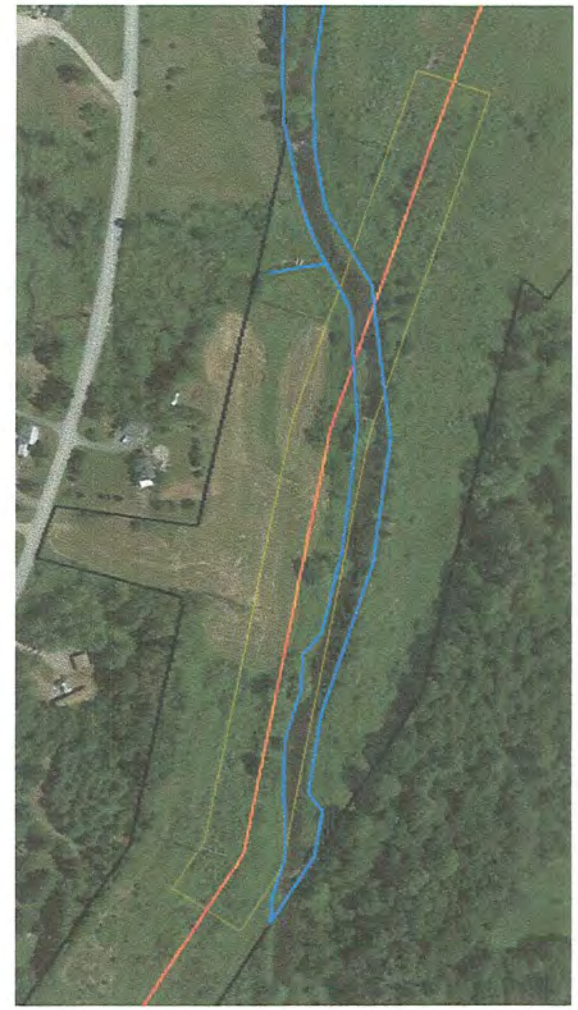
Direction Drill maintains 1000'+ buffers on both banks of Kennebec River.

Exhibit 5: West Branch Sheepscot River



Left view shows limits of new clearing

Right view shows only the outline of new clearing limits, to show existing trees that will be removed.



Group 4 Exhibit 5-JR

Group 4
Exhibit 6-JR

Reardon Exhibit 6:

Maine Natural Areas Program:
<u>Forest Management Recommendations for Maine's Riparian Ecosystems</u>

deMaynadier, P., T. Hodgman, and B. Vickery. 2007. Forest Management Recommendations for Maine's Riparian Ecosystems. Technical report submitted to the Maine Department of Inland Fisheries and Wildlife, Bangor, ME.

Riparian Ecosystems

Definition

Riparian ecosystems comprise an ecological tension zone between aquatic and terrestrial systems. Specific definitions as to the physical extent of riparian ecosystems vary greatly depending on the breadth of functional values included, from water quality to wildlife habitat.

Minimally, most definitions include a) the shoreline of lentic and lotic waterways (streams, rivers, ponds, and wetlands), b) the upland area influenced by these aquatic systems, and c) the area of adjacent uplands influencing the aquatic system. Definitions addressing wildlife habitat functions are further reaching and generally include a variable component of upland forest.

Background and Biodiversity Value

Riparian areas are among the most critical parts of any forest ecosystem because of the diverse ecological values they provide (Hunter 1990). Both structurally complex and ecologically dynamic, many scientists have argued that riparian areas are also among the most sensitive systems to environmental change. Some of the specific biodiversity values provided by a well-managed, ecologically functioning riparian zone include (Elliott 1999):

- Prevention of wetland and water-quality degradation;
- Buffering of aquatic and wetland plants and animals from disturbance;
- Provision of important plant and animal habitat; and
- Contributions of detritus, nutrients, insects, and structural complexity to aquatic systems

Wildlife Values

Although they make up a relatively small proportion of the forest landscape, riparian ecosystems often host some of the greatest species richness. For example, riparian zones, and their associated wetland systems, are utilized by over 90% of the northeastern region's vertebrate species and provide the preferred habitat for over 40% of these species (DeGraaf et al. 1992).

Like the ecotone itself, the suite of species benefiting from forested riparian ecosystems varies along a continuum from aquatic species, to riparian specialists, to upland forest species. Obligate aquatic species such as fish, wading birds, and aquatic invertebrates benefit from the water quality, nutrient input, habitat structure (e.g. woody debris dams), and disturbance-buffer values provided by forested riparian zones. Riparian specialists such as shoreland-nesting ducks (e.g. goldeneyes, mergansers, wood ducks), floodplain wildflowers, wood turtles, dragonflies, and mink frequent the aquatic-riparian gradient while fulfilling life-history requirements. Finally, a variety of largely upland species, from woodpeckers to white-tailed deer, reach peak densities during certain seasons in forested riparian ecosystems because of optimal foraging opportunities (e.g. high insect densities, soft and hard mast abundance) or preferences for riparian nesting or travel corridors.

In landscapes where intensive forest management is practiced forested riparian ecosystems often serve as de-facto refuges for late successional-associated species that prefer specific structural characteristics of mature forests. Among others, these characteristics include high crown height and closure (e.g. deer wintering areas), abundant standing and downed dead wood (e.g. cavity-nesters, shrews, and salamanders), diverse tree species and diameter classes (e.g. bark and foliage gleaning passerines, and lichens), and well-developed pit and mound topography and wind-throw (e.g. herbs, small mammals, northern waterthrush, winter wren and other root mass nesters).

Water Quality and Organic Inputs

Riparian vegetation provides numerous water quality, food-chain, and structural values with the major ones including (Castelle and Johnson 2000):

- Streambank stabilization – determined in part by the density and depth of herbaceous and woody streambank roots;
- Sediment reduction – both by canopy reduction of raindrop impacts and the slowing of surface sheet flow;
- Chemical and nutrient removal – including metals, excess nutrients, and other chemicals by filtering water via plant uptake;
- Shade production – water temperature increases when streamside vegetation, particularly overhead canopy, is reduced which in turn affects fish and aquatic insect species composition and growth.
- Organic inputs and debris structure – particularly important in lower order stream systems where the foodchain is fueled primarily by detrital inputs and where debris dams provide valuable microhabitat structure.

Management Considerations

Riparian ecosystems are among the most ecologically important and sensitive ecosystems in forested landscapes. Following the management guidelines provided below (modified from Elliott 1999) will help conserve the biodiversity values associated with these critical ecosystems:

✓ Establish fixed (by stream order or wetland type) or variable (based on slope, floodplain size, and other local features) riparian management zones along stream, rivers, ponds, and wetlands that exceed the minimum standards required by LURC and DEP statutes. Riparian management zones have been recently developed by several prominent ecological forestry-based initiatives in Maine and elsewhere, and are summarized in Table 1.

✓ Employ forest management systems, such as single-tree or small-group selection cuts, that retain relatively continuous forest canopy cover (>70%) in riparian management zones.

✓ Consider a limited no-cut zone (25-100 ft is often recommended) immediately adjacent to the stream or wetland shoreline, particularly in areas containing steep slopes and shallow or poorly drained soils.

✓ Avoid forest management actions that lead to semi-permanent or permanent conversion of the natural vegetation within riparian management zones including placement of log landings, logging roads, and plantations.

✓ Use streams as stand boundaries to reduce the need for stream crossings. When stream crossings are unavoidable conform to Maine Forest Service's BMP's for erosion control.

✓ Bridges and culverts should be large enough to pass peak flows (from 100-year storm events) without damage to the structure and should not constrict the stream channel. Culverts, preferably with flat bottoms, should be installed at the level of the original streambed to provide fish, amphibian, and invertebrate passage at all flows.

✓ Retain snags, trees with cavities or extensive rot, downed logs, and large super-canopy trees to the greatest extent possible in the riparian management zone.

✓ Avoid using fertilizers, pesticides, and chemicals within riparian management zones and, if applied aerially, institute wide spray buffers (>1/4 mile) to prevent drift.

✓ Apply special precautions to riparian management zones in aquatic systems hosting rare, threatened, or endangered species and natural communities. Consult with MDIFW and MNAP biologists for standards -- e.g. riparian management zone width, extent, and canopy closure -- when operating in the vicinity of these elements.

Table 1. Recommended width of riparian management zones as presented by various ecological forestry-based initiatives.

Aquatic System	TNC (2000) St. John River Watershed[1]	Champion International[2]	Maine Council on SFM (1996)	NH Forest Sustainability Standards (1997)	Maine Forester's Guide (1988)[3]	MDIFW's ET Forester's Guide (1999)
1st & 2nd-order streams	50-250 ft. (50ft. no-cut)	100 ft.	75 ft.[4]	100 ft.		75-100 ft. (25 ft. no-cut)
3rd-order streams	100-500 ft. (100ft. no-cut)	330 ft.	250 ft.	300 ft. (25 ft. no-cut)	100-330 ft.	250-330 ft. (25 ft. no-cut)
4th-order streams	1000 ft. (no-cut)	660 ft.	250 ft.	600 ft. (25 ft. no-cut)	100-330 ft.	250-600 ft. (25 ft. no-cut)
Ponds < 10 acres	125 ft. (no-cut)			100 ft.		75-100 ft. (25 ft. no-cut)
Ponds > 10 acres	250 ft. (no-cut)			300 ft. (25 ft. no-cut)	100-330 ft.	250-300 ft. (75 ft. no-cut)
Permanent Wetlands	50-125 ft. (no-cut)			100-300 ft. (0-25 ft. no-cut)		75-330 ft. (25 ft. no-cut)
High Value Vernal Pools	50-125 ft. (no-cut)			200 ft. (50 ft. low-cut)		400ft (100 ft. low-cut)

[1] No-cut zones are expanded up to 250 ft. in areas where wind-throw hazards, saturated soils, or steep slopes make soil compaction or scarification possible. Additional riparian protection is provided by inclusion of "expansion areas" (300-600-acre blocks designed to support forest interior birds and several pine marten ranges) spaced at ~1-2 mile intervals along stream corridors.

[2] Guidelines were developed by Champion International Corp. whose lands are now managed by International Paper and others.

[3] 100 ft. is recommended for watercourses draining <50 mi^2 and 330 ft. is recommended for watercourses draining >50 mi^2.

[4] Recommend no clearcutting within 250 ft.

deMaynadier, P., T. Hodgman, and B. Vickery. 2007. Forest Management Recommendations for Maine's Riparian Ecosystems. Technical report submitted to the Maine Department of Inland Fisheries and Wildlife, Bangor, ME.

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Group 4
Exhibit 7-JR

Reardon Exhibit 7:

<u>Riparian Buffer and Watershed Management Recommendations for Brook Trout Habitat Conservation. Focus: Mountainous Brook Trout Watersheds of Maine and Northern New Hampshire.</u>

TROUT UNLIMITED

Augusta, Maine

RIPARIAN BUFFER AND WATERSHED MANAGEMENT RECOMMENDATIONS FOR BROOK TROUT HABITAT CONSERVATION

FOCUS:

MOUNTAINOUS BROOK TROUT WATERSHEDS OF WESTERN MAINE AND NORTHERN NEW HAMPSHIRE

MARCH 2005

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I. INTRODUCTION AND OBJECTIVES

This report describes recommended riparian buffer and watershed management standards protective of instream brook trout (*Salvelinus fontinalis)* habitat. The riparian management standards are designed to be applicable to all coldwater (trout and salmon) habitat in northern New England. However, the immediate focus of the recommendations is on river systems in the mountainous terrain of western Maine and northern New Hampshire with high quality brook trout habitat, and in areas where commercial forestry is the dominant land use. The primary emphasis of the recommendations is on riverine (streams and rivers) systems; however the majority of the concepts and recommendations in this report apply equally well to ponds and lakes.

To provide for analysis of actual, rather than hypothetical landscapes, this report includes analysis of buffer requirements for 3 important river systems in Western Maine—the Magalloway, Little Magalloway, and Kennebago Rivers.

Although the three rivers themselves are, in places, flanked by riparian zones characterized by deep, glacial-outwash-derived soils and flat to gently sloping topography, the majority of the contributing watersheds of these river systems are characterized by rugged topography and thin (shallow-to-bedrock) soils that are sensitive to erosion. The small, headwater streams that feed these rivers originate in and flow through this same rugged topography and thin soils. These characteristics, which are typical of streams in western Maine and northeastern New Hampshire, tend to increase the importance of sufficient riparian buffers and Best Management Practices (BMPs) for forestry (and other land uses), to prevent erosion and sedimentation, and other impacts to instream habitat.

Brook trout require clean, cool (commonly groundwater-fed), well-oxygenated streams and rivers to maintain vigorous, naturally-reproducing populations. Brook trout make frequent use of shallow headwater streams for spawning, and also find temporary refuge in spring-fed sections during the late summer. They are sensitive to sedimentation, stream warming, and the quantity and quality of macro invertebrate populations. Brook trout are therefore sensitive to watershed and riparian buffer changes, and serve as an "indicator" of water quality and ecosystem health. Macro invertebrates, for example, use large woody debris and leaf litter for habitat structure and as food. Timber harvesting or any other land use that affects these organic matter inputs will automatically affect brook trout habitat quality. Although the objective of this report is to protect brook trout habitat, the management strategies and recommendations also benefit non-target species in the larger riparian forest and in-stream community, including macro-invertebrates, cavity-nesting birds (*e.g.,* wood duck, barred owl), and riparian forest specialists or species with a preference for riparian habitat (*e.g.,* mink, river otter, red-shouldered hawk, and beaver). With appropriate adjustments to take into account local conditions and objectives, this report is intended to be useful for salmonid habitat conservation throughout northern New England, New York, and Canada.

The subject watersheds are sparsely populated and contain high quality to exceptional brook trout habitat. Nevertheless, these watersheds have been affected by historic timber removal operations. Large scale forest removal may have affected the depth, width and sinuosity of streams, as a result of altered hydrology and sediment load, as well as changes in shoreline vegetation. This is especially true when large cuts occurred over short periods of time so that a large percentage of the watershed was cut or in young growth at a single time. Log drives on the larger streams required that in-stream and shoreline obstacles such as large woody debris, boulders, and rocky riffles be removed by axe, pick, and dynamite to facilitate driving logs downstream during high flows. This undoubtedly had a significant effect on the morphology of certain streams, and resulted in the loss of in-stream and stream bank habitat complexity. Logging today likely continues to impact habitat quality by contributing sediment to these streams, affecting the timing and magnitude of woody debris inputs, and even by impeding fish passage in those cases where haul road and skidder trail stream crossings are not installed properly. Large areas of northern Maine are rapidly changing hands, and the future management and stewardship of wild brook trout waters is uncertain, elevating the importance of developing protective standards (Trout Unlimited, 2004). Increasingly in Maine, liquidation harvesting practices (where large blocks of woodlands are harvested to the limits of the law, often with little regard for subsequent harvests or sustainable forestry principals, and subdivided into numerous lots) threaten brook trout habitat quality. Similarly, large private timber companies are increasingly planning to develop shoreline areas, historically managed as industrial forests, into camp and home lots. One large industrial landowner in Maine, Plum Creek, has recently unveiled development plans that would radically change the pattern of land use in the Moosehead Lake region, which is ecologically and economically similar to the region analyzed here.

The riparian buffer zone and watershed management prescriptions in this report are recommendations, not regulations. This report is intended to be a guidance-level resource for government agencies and NGOs that are: developing land management plans or river corridor management plans, negotiating or developing conservation easement terms, developing permit conditions, or developing management guidelines for working forests. It is hoped that the recommendations will also be useful to private landowners, including the forest industry and small woodlot owners, who wish to manage their lands in a way that protects the ecological integrity of the riparian, wetland, riverine (streams and rivers), lacustrine (ponds and lakes), and upland resources on their property and downstream.

II. METHODS AND APPROACH

A literature search was carried out to identify up-to-date scientific information on riparian buffer characteristics and forested watershed management prescriptions that optimize important brook trout habitat elements (see Section 3.3).

Appropriate buffer widths and management prescriptions were determined by a review of scientific literature that describes the relationship between buffer and watershed characteristics and buffer and watershed function. The following specific steps were taken during method development, largely by researching the existing science-base as reported in the literature:

1. Determine riparian and watershed buffer functions important for salmonid habitat protection.
2. Identify dominant and regionally unique characteristics of target protection areas (*e.g.*, soil characteristics, disturbance regimes, vegetative structure, topography).

3. Determine buffer attributes (such as buffer width) and management approaches (such as specific BMPs) that promote buffer effectiveness and habitat optimization for the functions identified in step 1.

The science-base for the recommendations in this report was developed primarily for forested regions of the northern United States and Canada. To the extent possible, data specific to northern New England and adjacent Canada was utilized. However area-specific data was insufficient to be solely relied upon. The scientific literature provided ranges of buffer widths required for effective buffer function (both for specific functions, such as sediment filtering, and for a suite of related functions). The literature also provided the most recent scientific information with respect to forestry BMPs to protect soils, streams, rivers, ponds, and wetlands.

A watershed approach was used to develop the recommendations. It is essential that analysis of proper buffer management include both the immediate shoreline and adjacent upland areas. If the analysis were limited to the immediate riparian buffer zone, important habitat protection issues would be missed. For example, headwater areas, including small intermittent streams and wetlands, may play a particularly important role in downstream water quality. In fact, habitat quality in a particular stream reach may be affected more by what happens adjacent to an intermittent stream or headwater wetland two miles upstream than by what happens 100 ft away in its immediate riparian zone. Similarly, harvest management at the watershed scale can influence instream processes such as bank erosion and stream geomorphology by changing the annual hydrograph. For example, annual harvests that exceed a certain percentage of the contributing watershed tend to increase peak discharge and result in an increase in bankfull flow and channel width (see Section 4.3). Lastly, cumulative effects at the watershed scale are an important consideration. For example, a stream crossing that eliminates the forested riparian buffer zone on both sides of the stream may be acceptable as long as BMPs are followed, and as long as the vast majority of the forested riparian buffers in the watershed are left intact (*i.e.,* isolated cases of riparian forest buffer removal or thinning will not have a significant impact as long as the vast majority of the buffer remains intact). However, multiple such crossings in close proximity to each other, even if each of them complies with BMPs, may have substantial impacts.

III. SETTING AND BACKGROUND

- Environmental Setting

The Magalloway, Little Magalloway, and Kennebago River subwatersheds are located in extreme northern Oxford and Franklin Counties in the mountains of western Maine and include a small portion of northeastern Coos County in New Hampshire (Figure 3.1-1). Population density is very sparse with 0-1 people/square mile over the majority of the area, and 1-10 people/square mile over remaining areas (Publicover and Weihrauch, 2003). The mountainous topography and infertile soils have limited the development of agriculture in the area, and left timber harvesting as the primary land use. The area was heavily logged beginning in about the 1850s, and the bed and banks of many streams were impacted from log drives, altered hydrology (higher peak flows from heavily cut areas), and erosion and sedimentation (Publicover and Weihrauch, 2003). Instream structure (large woody debris and boulders) was removed from some stream sections to

Insert Figure 3 (separate file)

facilitate log drives. To this day, it is likely that the quantity of large woody debris in and adjacent to the streams in the area is less than it would be if the only disturbance regimes in the watershed were natural (wind, fire, and disease events separated by hundreds of years on average). Some large woody debris takes decades to decompose. The young forests that follow harvests in stream riparian zones do not supply the same degree of large woody debris inputs for many decades following the harvest. Further, large-scale timber removal or other watershed-scale land use changes, and removal of large woody debris and other structure from the channel, can have long-lasting effects on stream geomorphology (Verry and Dolloff, 2000; Sweeney et al, 2004). Effects from historic logging on the streams in the subject watersheds, as well as other parts of the northeast, likely included geomorphic responses that may have negatively affected brook trout habitat. Such responses include but are not limited to stream narrowing and/or widening, alterations to sinuosity, and simplification of in-stream and shoreline structure important for habitat.

The Magalloway and Little Magalloway Rivers are free-flowing systems without dams from Aziscohos Lake to their headwaters. The Kennebago River is undammed and unregulated above Kennebago Lake. A dam at Kennebago Lake raised the level of Kennebago Lake, and is currently used to produce hydropower, but has little overall impact on annual run-off patterns due to limited storage volume. Each of these drainages is located in the headwaters of the Upper Androscoggin watershed. The northern boundary of the Magalloway subwatershed (inclusive of the Little Magalloway) coincides with the border between the United States (Maine and New Hampshire) and Quebec, Canada, as this international boundary was established along watershed divides. The northern boundary of the Kennebago subwatershed coincides with the border between Maine and Quebec for part of its length, and is within the State of Maine in remaining sections. The mountains that make-up this region are known as the Boundary Mountains in Maine. They are part of the Connecticut Lakes subsection of the White Mountain Ecoregion, as defined by US Forest Service and the Nature Conservancy classification systems (Publicover and Weihrauch, 2003).

The subwatersheds draining to these river systems are characterized by extensive areas of rugged topography including large areas of thin (shallow-to-bedrock) soils that are sensitive to erosion (U.S.D.A. Soil Conservation Service, 1995). The small, headwater streams that feed these rivers originate in and flow through this same rugged topography and thin soils. By contrast, the valleys containing the larger streams, which occupy the lowest elevations in the subwatersheds, typically include areas of deep, coarse-textured soils (U.S.D.A. Soil Conservation Service, 1995). The majority of the land in these subwatersheds is characterized by slopes that are >10%, and slopes of >25% are common (Publicover and Weihrauch, 2003). Slopes of <10% tend to occur in the valley bottoms, adjacent to the larger streams. Bedrock is somewhat variable but is dominated by acidic metasedimentary and metavolcanic rocks formed from the Cambrian to the Devonian Periods.

The majority of the lands in the subject subwatersheds contain soils derived from glacial till (Ferwerda, et al., 1997). Till-derived soils tend to occur in the middle and upper portions of the landscape in moderately to steeply sloping areas (*i.e.,* slopes >10%). Till-derived soils include areas that are very shallow-to-bedrock (*i.e.,* bedrock located 20 inches or less below the soil surface), as well as some areas of moderate soil depth (bedrock at 20-40 inches), and areas of deeper soils (depth to bedrock of >40 inches). Till-derived areas include both basal tills and loose or ablation tills, with the former being more common in the subject subwatersheds

(Ferwerda, et al., 1997). Basal tills have a compact glacial till layer (typically at about 2 ft beneath the surface) that formed beneath the ice. This compact layer tends to be very slowly permeable and results in perched runoff, so that basal till soils are similar to shallow-to-bedrock soils from a runoff perspective. Loose or ablation tills, by contrast, are much more permeable and less dense.

The lower portions of the landscape (*i.e.,* valley bottoms) contain areas of deep soils derived from ice-contact glaciofluvial deposits (material moved by glaciers and subsequently moved and sorted by glacial meltwaters). These soils are typically relatively coarse textured (sandy or gravelly) and include glacial features such as kames (stratified glacial drift, sometimes against the base of a hill) and eskers (winding ridge of gravelly or sandy drift deposited by a stream flowing in a tunnel beneath a glacier). The valleys containing the larger streams also include deep soils derived from recent alluvium (sediments deposited by streams on floodplains).

The landscape is forested except for areas of open water, non-forested wetlands (*e.g.,* marshes, bogs, and shrub swamps), and some minor areas of exposed bedrock. At any given time, some percentage of the area is recently cut forest in early succession. Forest age classes range from recent cuts to mature forest. Forest types include northern hardwood, spruce-fir, and mixed hardwood-softwood, fairly evenly interspersed through the subject subwatersheds (Publicover and Weihrauch, 2003). Dominant species are red spruce, balsam fir, sugar maple, red maple, white birch, white pine and yellow birch. Typical site potential tree heights for the region range from around 35-50 ft (or less near tree line) in spruce-fir forests on exposed mountain slopes with shallow soils, to around 60-80 ft in birch-maple forests in the protected valley bottoms where soils are deeper and more fertile.

Historically (prior to settlement), it is estimated that more than 50% of the forest landscape of northern Maine was more than 150 years old at any given time on average, and that more than 25% of the forested landscape was more than 300 years old (Lorimer, 1977). Local strains of brook trout evolved in forest streams flanked by these mature and old growth forests. Today, in the northern portion of the Upper Androscoggin Watershed, probably no more than 1% of the riparian stands are more than 150 years old. Undoubtedly, this has an effect on the micro and macro-habitat conditions found in brook trout streams. For example, the maximum and average diameters of large woody debris (LWD) inputs to brook trout streams would have been larger historically.

As a result of being in the upper portion of the Androscoggin watershed, with elevations generally in excess of 1,500 ft, the subject streams are not able to rely to a large degree on upstream inputs of carbon (*e.g.,* leaves, twigs, LWD). The Androscoggin River itself, for example, likely receives enough organic matter input from upstream so that even if it completely lacked a forested riparian buffer along a particular stretch, instream leaves and wood (acting as structure and food for macroinvertebrates) would be plentiful. If a high elevation, headwater area were cut heavily, however, recruitment of LWD and fine organic matter would be impacted more significantly. A high grading approach to harvests on some parcels, or repeated heavy harvesting in general, can lead to deficient quantities of LWD (important for brook trout) as well as snags and cavity trees important for other species such as owls (Bryan, 2003).

Photo 3.1-1. Photo showing an old log across a brook trout stream that has influenced the riffle-pool sequence and stream morphology.

Photo by Alan Haberstock

- Brook Trout Natural History

The brook trout is a coldwater species whose native range extends throughout Maine, from the Western mountains to the lowlands of Downeast. Brook trout inhabit both lentic (ponds and lakes) and lotic (streams and rivers) water bodies that are characterized by cold, well oxygenated waters (Raleigh, 1982). First and second order streams are used for year-round habitat; seasonal refugia from high flows, turbidity, or high water temperatures; and spawning by trout inhabiting adjacent lakes, ponds, rivers, or larger streams (Scott and Crossman, 1973).

Brook trout spawning occurs in the fall, October and November, when water temperatures range between 4.5 and 10°C, with females digging redds in gravel. Redd construction typically occurs at the downstream end of riffles, in the tail section of pools or at upwellings of groundwater in gravel. Low gradient (<5%) sections of tributary or 1st order streams are frequently used. Eggs incubate over winter in gravel interstices, with hatching occurring in the late winter/early spring (February to April). After hatching alevin remain buried in the gravel until the yolk sac is depleted. Juvenile trout then leave the protection of the gravel to feed on a variety of invertebrates drifting in the water column and inhabiting the benthos. The preferred water temperature range for juvenile and adult brook trout is 11 to 16°C with temperatures above 20°C detrimental to growth and survival (Scott and Crossman, 1973). Preferred dissolved oxygen levels for all life stages are $\geq$7mg/l at temperatures $\leq$15°C and $\geq$9mg/l at temperatures $\geq$ 15°C (Raleigh, 1982).

Scientists have developed habitat suitability criteria for brook trout (Raleigh, 1982) that point to the specific riparian buffer functions that influence trout habitat (see Section 3.3). The growth of trout is affected by a variety of micro and macro-habitat parameters, including food availability, interspecific and intraspecific competition, channel morphology, substrate, cover, and water depth, clarity, temperature, dissolved oxygen, and velocity.

Naturally vegetated riparian areas are an important aspect of brook trout habitat. Human disturbance that significantly alters riparian buffer areas adjacent to or upstream of brook trout streams can result in degradation of critical habitat. Since brook trout lay their eggs in gravel nests in areas exposed to flowing waters, any land use that results in sedimentation can fill-in gravel beds. This can reduce suitable breeding substrate and smother trout eggs as well as the many invertebrate species that inhabit the interstices between gravel and serve as important forage items for trout. Increased turbidity (over background rates) associated with increased erosion and sedimentation can also injure the gills of trout in all life stages and limit foraging success since this species hunts by sight. Water quantity is important with respect to suitable breeding and rearing habitat. Cool, well-oxygenated water maintained by canopy shading is another important aspect of trout habitat. Trees, coarse woody debris, and leaf litter inputs to trout streams help create and maintain habitat and provide food items for invertebrates as well as provide instream cover which all life stages of brook trout require (Raleigh, 1982). Such woody debris inputs also help to create pools and riffles by influencing flow patterns and provide diverse structural habitat important for trout.

- Forested Riparian Buffer Functions that Promote Brook Trout Habitat

Forested riparian buffer functions that are important with respect to brook trout habitat protection, as identified in the literature, are:

- ***Water quality protection***. Buffers filter sediment and pollutants from upslope areas. Mature forests promote infiltration relative to open cover types, and over time develop a complex microtopography (*i.e.,* pit and mound topography, dead-and-down wood) that traps runoff and promotes sediment settling (many pollutants like phosphorous are sediment-bound) and force runoff to infiltrate into the root zone. Through a process called "denitrification," bacteria in the riparian forest floor convert nitrate from runoff to nitrogen gas, which is then harmlessly released into the air.
- ***Stream bank stabilization***. Forested riparian buffers stabilize stream banks through large roots at the stream edge and peak flow attenuation.
- ***Shading and temperature regulation***. Canopy cover helps maintain cool temperatures during the summer, and promotes a detritus-based (as opposed to algal-based) system, which supports the types of macroinvertebrates important for brook trout. Overhanging canopies also help northern streams (especially streams small enough that the canopy is continuous across the stream) retain warmth in the winter.
- ***Regulation of streamflows***. Forested buffers attenuate peak flows and maintain base flows through the storage and slow release of runoff.
- ***Large woody debris and other organic matter inputs***. Forested buffers provide wood inputs that are important for salmonid habitat structure/cover. Large-diameter wood from fallen trees promotes instream structure and habitat complexity by promoting the formation of

riffle-pool-run complexes. Litter inputs are also an important energy source for the detritus-based community of aquatic macro-invertebrates and the entire aquatic food chain.

Riparian buffers provide the entire influence on in-stream habitat functions such as shading and organic matter inputs, whereas functions such as stream flow regulation and water quality protection are provided by the entire watershed (*i.e.,* not just the immediate buffer). Therefore, an overall watershed management approach is required. Note too that effects are cumulative. For example, overall water temperature through a river system is influenced by percent canopy cover over the entire riparian system, not just the specific buffer being evaluated (Spence *et al.,* 1996).

- <u>Buffer Attributes that Affect Buffer Function</u>

The effectiveness of forested riparian buffers is related to a range of biotic and abiotic variables including topography, vegetation, soils, hydrology, and landscape position (Haberstock, *et al.,* 2000). Specific factors affecting buffer effectiveness include slope, percent canopy closure, hydrologic soil group (this grouping reflects the runoff-producing characteristics of the soils or the ability of the soils to permit infiltration), surface water features, surface roughness (*e.g.,* the degree to which certain features such as large wood, boulders and pit-and-mound topography occur on the landscape), groundwater seepage/springs, sand and gravel aquifers, floodplains and wetlands, and stream order. All else being equal, wider buffers are more effective at performing desired functions than narrower buffers, and the width of a buffer necessary to achieve a certain degree of effectiveness for a given function is affected by attributes such as those listed above.

As slope increases, the width of a given buffer must increase in order to realize a given level of buffer effectiveness. Slope has a strong relationship with erosion potential and other water quality factors such as retention or conversion of nutrients and chemical pollutants (US ACOE, 1991; Phillips, et al., 2000). Factors related to erosion such as elevated sedimentation and reduced water quality decrease the quality of salmonid habitat. Among all variables, slope has one of the most important influences on the width required for a given level of buffer effectiveness.

A high degree of canopy closure adjacent to streams is necessary for buffers to function at optimal levels. A high degree of canopy closure is associated with several functions important for salmonid habitat including shading and organic matter inputs, nutrient and sediment retention, and wind-firm conditions (Chesapeake Bay Program, 1995; Spence *et al.*, 1996; Mitchell, 1996; Kahl, 1996; Correll, 1997; Jacobson *et al.*, 1997). Cut forests with disturbed duff layers are not able to perform these functions as well. Effective buffer width and percent canopy closure are, therefore, inversely related. For example, a 20 ft buffer along a stream margin with 100% canopy closure may perform shading and LWD recruitment functions similar to a 30 ft buffer with 70% canopy closure. Forest age-class is an additional forest characteristic that relates to functional capacity (*i.e.,* mature forests are responsible for more/different LWD inputs than very young, early-successional forests).

Wooded buffers with a high degree of canopy closure, intact duff layers, and well developed shrub and herb strata generally provide greater uptake or retention of runoff and associated pollutants than do systems which have been selectively cut or disturbed (ME DEP, 1992; Sweeney, 1992; Chesapeake Bay Program, 1995; Kahl, 1996; Jacobson *et al.*, 1997).

Some of the literature indicates, however, that non-forested systems perform better than forested systems for sediment retention and uptake and retention of sediment-bound nutrients (Welsch, 1991; Chesapeake Bay Program, 1995; Lyons, *et al.*, 2000), which is why some riparian buffer prescriptions call-for a zone of low, dense grass-dominated vegetation upgradient from forest at the stream edge (Welsch, 1991). Grass-dominated zones may make sense in some regions but are not recommended in the target region of Maine and New Hampshire because: agriculture (pasture and hay operations) are impractical due to infertile soils and rugged terrain, shallow-rooted vegetation such as spruce and fir and trees over shallow-to-bedrock soils are susceptible to wind throw when long term openings occur adjacent to them, and the surface roughness of the forest floor (boulders, pit-and-mound topography, and dead-and-down wood) likely does trap sediment as well as rough pasture.

Intact forested riparian areas also provide organic debris inputs which directly enhance brook trout habitat through the provision of in-stream structure like tree boles, root wads, and large branches, and indirectly enhance salmon habitat since wood and leaves provide food and habitat for detritus-based aquatic macroinvertebrates (Dolloff, 1998). Large woody debris inputs promote "hydraulic heterogeneity" and support the development of varied instream habitat conditions such as pools, runs, and riffles (Ohio EPA, 1994; Jacobson *et al.,* 1997). Large woody debris also provides an energy source for denitrification and provides a mechanism for increasing buffer zone surface roughness in terrestrial areas, thereby limiting concentrated surface runoff patterns and enhancing the ability of the buffer to perform optimal water quality maintenance functions (Chesapeake Bay Program, 1995; Correll, 1997).

Areas dominated by soils with low infiltration capacities and high runoff potentials (*i.e.*, hydrologic group D soils as determined by USDA NRCS soils mapping) generally require greater buffer widths for a given level of protection, than soils with high infiltration capacities and low runoff potentials (*i.e.*, group A and B soils). In general, the greater the infiltration capacity of the soils, the greater the ability of the buffer to perform water quality and water quantity functions (Welsch, 1991). Soils with a high infiltration capacity discourage concentrated, erosive flows, thereby reducing sediment and sediment-bound nutrient (*i.e.*, phosphorous) export. Such soils are also well suited to providing a flow de-synchronization function. A caveat to the benefits of infiltration capacity is that extremely permeable soils such as sand and gravel outwash can be leaky with regard to nutrients (especially nitrogen) (Chesapeake Bay Program, 1995; Grantham, 1996; Speirman *et al*, 1997) and chemical pollutants.

Where surface water features such as intermittent streams are present in the buffer of a perennial stream, these smaller drainage features should also be buffered since they can allow contaminants to quickly bypass the soils and root zone of the riparian buffer (Adamik *et al.*, 1987; Ohio EPA, 1994; Murphy, 1995; Chesapeake Bay Program, 1997; Correll, 1997). Such surface water features include intermittent streams, ditches and gullies. The presence of surface water features provides increased potential for "leaky" or ineffective buffers since they provide a potential concentrated flow path whereby sediments, dissolved nutrients and other potential pollutants can effectively circumvent the buffer. Conversely, diffuse flow (*e.g.,* sheetflow) through a buffer encourages infiltration and energy dissipation, allowing sediments and nutrients to be trapped. Intermittent streams surrounded by forested buffers are more effective at trapping sediments and pollutants, in part because coarse woody debris inputs can increase channel roughness, deflect flows to the adjacent forest, and prevent channel incision.

Buffers and watersheds with less surface roughness are more susceptible to potential impacts from tree removal or other disturbances, and therefore warrant wider buffers to achieve a given level of effectiveness with regard to water quality functions. Higher degrees of surface roughness (as function of micro-topography, coarse woody debris, herbaceous vegetation, and forest floor) encourage infiltration and discourage concentrated flows (Murphy, 1995). Features such as pit-and-mound topography, dense herbaceous vegetation, dead-and-down wood, and a thick duff layer increase surface roughness. Surface roughness is typically lacking on landscapes that were recently cultivated for crops, because plowing smoothed out the pit-and-mound topography. Similarly, repeated cutting can "starve" a forest of the large diameter trees that promote pit-and-mound topography.

Spring or groundwater discharge is a habitat characteristic important to brook trout. Springs provide important base flow inputs in the summer and help moderate stream temperatures, and can also enhance spawning habitat when located in the stream channel. Springs can indicate a close relationship between the water table and the buffer soils/vegetation. Where groundwater is near the surface as it flows through the buffer, undisturbed soils and root systems play an important role in removing nutrients and other pollutants from groundwater prior to discharge to the stream (Caswell, 1987; Sweeney, 1993; Correll, 1997; Lowrance *et al.*, 1997; Speirman *et al.*, 1997). Identifiable spring-discharge areas, both riparian and in-stream, should be mapped if possible, and stream crossings (whether permanent or temporary haul roads) should be located away from these locations.

The presence of sand and gravel aquifers may increase the sensitivity of an area to anthropogenic disturbances since these features are highly permeable and allow nutrients and other contaminants to enter the groundwater more easily than with less permeable surficial deposits such as tills (Caswell, 1987; Weddle, *et al*, 1988; Correll, 1997; Lowrance *et al.*, 1997; Speirman *et al.*, 1997). Groundwater in riparian sand and gravel deposits is assumed to discharge to the adjacent stream (USDOI, 1993). Potential water quality impacts to aquifers are associated more with residential and agricultural development than with forestry activities.

Streamside floodplains (defined as areas with alluvial soils) and open wetlands (emergent & scrub-shrub) adjacent to streams, no matter how wide, should be considered part of the stream resource being protected. The baseline for buffer width measurement should begin at their landward edge. Some streams meander over time and the main channel could potentially occupy any part of the floodplain in the future. Floodplains are of vital importance in terms of accommodating and attenuating overbank flows during high flow periods, and perform some of the same water quality and quantity functions as wetlands (Poff *et al.*, 1997). Where there are wide floodplains, large wood and fine forest litter recruitment may come from areas further than the equivalent of a mature tree height from the stream edge because wood is carried by water in addition to gravity.

Wetlands are functionally-important landscape features in riparian buffers, as well as at the watershed-scale, that are particularly sensitive to impacts from forestry and other land uses. Riparian wetlands are typically connected by surface and/or subsurface hydrology to streams, and perform important water quality functions (Chase *et al.,* 1997; Spence *et al.*, 1996; Correll, 1997; Lowrence, 1997). Wetlands typically have water tables within the root zone and are more effective than uplands at converting potentially available nitrogen to a gaseous form through denitrification. Wetlands are often effective at trapping sediments and pollutants adsorbed to sediments. Disturbance to wetland soils may compromise wetland functions. Wetland preservation in the riparian zone and in the larger watershed enhances buffer function and watershed function. Any surface water connecting the wetland and the brook trout stream (*e.g.*, wetland has intermittent stream outlet) increases the potential risk of sedimentation related to inadequate buffer width or wetland protection. Forested wetlands adjacent to streams provide important functions such as shading, and woody debris and litter inputs that are not provided by open-canopy wetlands to the same degree. In Maine, timber removal is permitted in forested wetlands as long as sediments are not mobilized.

Buffer widths or other protective management measures should not be lessened for smaller, first order streams since spawning and early life stage rearing habitat can be concentrated in smaller headwater stream reaches that are often more sensitive to water quality and quantity impacts (Davies and Sowles, 1984; Murphy, 1995; Chesapeake Bay Program, 1995; Kahl, 1996). Small streams can also serve as refuge for brook trout during floods or during warm periods (where smaller, tributary streams are cooler or groundwater fed). In most cases, smaller streams are afforded less regulatory protection than are larger streams (USFS, 1997). For many functions, such as the provision of wildlife corridors and terrestrial wildlife habitat, this makes sense. However, smaller headwater streams are typically more vulnerable to water quality and quantity impacts as they are less able to dilute or buffer impacts such as sedimentation, solar heating, nutrient loading, or base flow alterations (*e.g.* water withdrawal). One reason that smaller streams are not afforded greater buffer widths is that larger streams have a greater potential floodplain and more energy available for bank cutting, wood recruitment, and sediment and debris transport (Murphy, 1995).

- <u>Regional Considerations for Developing Recommendations</u>

Management recommendations such as buffer prescriptions and BMP recommendations should consider the unique regional conditions (Section 3.1) of the target protection area. Table 3.5-1 summarizes some factors that should be taken into account in management recommendations (Section 4).

Table 3.5-1. Characteristics of the Magalloway* and Kennebago River Subwatersheds and Associated Management Considerations

Characteristic	Associated Management Consideration(s)
The area includes a large proportion of steeply sloping, hilly to mountainous terrain. The majority of the land i characterized by slopes that are >10%, and slopes of >25% are common.	All else being equal, buffers should be wider (as compared to more gently sloping landscapes), and watershed and forestry BMPs should be more rigorously pursued.
The area is typified by hydrologic group C and D soils (soils that are shallow-to-bedrock, are derived from compact basal tills, or are on wetlands). These soils have a high runoff potential and low infiltration rates.	All else being equal, buffers should be wider (as compared to landscapes dominated by hydrologic group A and B soils), and watershed and forestry BMPs should be more rigorously pursued.
Target resource (brook trout) utilizes very small 1st order streams. Plus, due to the rugged terrain, the smallest streams tend to occur on the more rugged, erodable, upper portions of the landscape (as opposed to the major stream valleys).	Apply buffer widths and BMPs on small streams at least as rigorously as on large streams.
Shallow-rooted trees are common in the area. This is because two of the dominant species (spruce and fir) are shallow-rooted, and the shallow soils and rugged topography result in many forest trees being shallow-rooted by necessity.	Maintain wind-firm conditions by limiting the size of cuts, especially near streams. Heavy cuts should not occur adjacent to forested riparian buffers, as this can result in elevated wind-throw and a "pulse" of LWD inputs to the stream (and in later decades a deficit).
Heavy logging occurred in the area beginning around 1850. Larger streams (such as the Magalloway) likely suffered from habitat simplification as large boulders and LWD were removed from the channel to accommodate log drives. In the absence of humans LWD typically enters the stream as a result of localized, natural disturbance events. Heavy logging also changes the input of LWD because it results in the removal of large boles and limits the percent of the watershed in mature growth at any given time. Heavy logging may also have left a legacy of fine sediments in some of the low gradient streams.	The best tree growth conditions and most valuable trees are concentrated in the river valleys and lower slopes. However, a no-cut zone should be maintained adjacent to streams to help sustain long term LWD recruitment, and help regain lost instream habitat complexity. Heavy logging of the valleys, even many decades ago, would still have a legacy today as instream LWD structure takes many decades to decay. LWD from a very large tree can provide important micro-habitat for macro-invertebrates for more than a century after initial recruitment.
Most of the target streams are small, 1st order headwater streams in the upper portion of the watershed. As such, they do not receive organic matter inputs from area far upstream.	Riparian forest removal along small headwater streams will directly impact organic matter inputs. The further up in the watershed a stream is the more it relies on its immediate riparian buffer instead of the larger contributing watershed to supply wood and leaves for energy (carbon) and structure. Apply buffer widths and BMPs on small streams at least as rigorously as large streams.
The area has very few residents, and there is little agriculture. The timber industry is the dominant use of the land.	At this time, buffer designs do not need to specifically protect streams from significant amounts of non-point-source pollution from farm runoff or residential/commercial development (*e.g.*, fertilizers, hydrocarbons). Forestry is the primary potential source of sediments and nutrients. So BMPs and management recommendations should be geared more to forestry than other land uses.

* Includes Little Magalloway

IV. RECOMMENDATIONS

This section outlines the riparian buffer and watershed management recommendations for the focus watersheds. Section 4.1 details a recommended 3-zone riparian buffer management approach. Section 4.2 considers stream size and type. Watershed-level recommendations are included in Section 4.3. A watershed approach is critical because even wide no-cut zones don't entirely protect the instream habitat. Forestry and stream crossing BMP recommendations are included as Sections 4.4 and 4.5 respectively. BMPs include a wide range of techniques and recommended procedures that, when used properly, will protect targeted resources.

- 4.1 Protective Riparian Buffers

In order to maintain brook trout habitat at optimal levels, while at the same time allowing for timber harvesting, a zoned management approach is recommended. Other zoned approaches have been developed and used in the northeast. Welsch (1991) of the U.S. Forest Service advocated a 3-zone approach where Zone 1 is a no-cut zone (generally about 15 ft wide), zone 2 is a managed forest zone (generally about 60 ft wide), and zone 3 is a non-forested zone where controlled haying or pasture occur. Kleinschmidt (1999) recommended a 2-Zone approach where Zone 1 is a 35 ft wide no-cut zone, and Zone 2 is a limited harvest zone of variable width where no soil disturbance is permitted. This variable-width approach results in buffers ranging from 70 ft to several hundred feet depending on buffer characteristics, but only the first 35 ft is no-cut. Lansky (2004) recommends a 3-Zone approach where Zone 1 is of variable-width (35 ft for gentle slopes and more for steep slopes), Zone 2 is a fixed width of 75 ft (based on the length of a cable on winch) in which limited harvesting can occur, and Zone 3 (all remaining areas) is a controlled harvest zone where some level of soil disturbance for haul roads and landings can occur. All of these methods apply to even the smallest 1st order streams, whereas some other unpublished methods used by the private forest industry, as well as state regulations in Maine, designate more restrictive buffers on the larger streams and have little to no buffer for small streams.

Based on the goals and objectives of this project, and the characteristics of the target region, it is recommended that a 3-Zone approach be used. The recommended zones are summarized in Table 4.1-1, along with the management recommendations for the three zones. It is recognized that no two riparian buffer zones are alike and that the width required to achieve a given level of functional effectiveness is variable from buffer to buffer depending on a variety of biotic and abiotic variables (Section 3.4). There is therefore good justification for recommending variable-width buffers. However, fixed-width buffers are much simpler to implement and more practical for applications such as regulations, easement terms, and private-sector policies. Variable width buffers also require field work to determine the width because GIS data on slope, wetlands and soils, is typically too coarse to work for an area as narrow as 75 feet. As long as fixed-width zones take into account the typical conditions of the watershed, are sufficiently wide to address the range of conditions, and have adjustments to take into account special characteristics (e.g., springs or intermittent drainage features), a fixed-width approach accomplishes the stated objective of protecting native brook trout habitat.

The recommendations in this report build upon the earlier recommendations, discussed above (Welsch, 1991; Kleinschmidt, 1999; Lansky, 2004). A comparatively wider, fixed width, no-cut zone (Zone 1) of 75 feet is recommended for this target region and objective to reflect that:

- The target resource (brook trout habitat) is extremely sensitive to the effects of sedimentation, stream warming, dissolved oxygen levels, and other in-stream and shoreline habitat characteristics.
- There are certain physical characteristics that make the subject watersheds more prone to erosion and stream damage, such as rugged terrain and thin soils.
- The science and literature base has progressed and many recent references recommend no-cut zones as wide as 100 feet or more. Because the recommendations in this report include a Zone 2 that is also 75 feet in width (totaling a 150 foot minimum width of no soil disturbance) 100 feet of no-cut was considered excessive.

The recommended width of Zone 2 is 75 feet, where no soil disturbance or pesticide use is permitted. Skidders should be kept out of this zone this zone to avoid tree damage or soil disturbance, and to permit wind-firm stocking levels. Cables or other methods can be used to carefully remove tree boles from this zone. Slash should be left in place. Guideline for minimum stocking levels are 60 sq ft of basal area for hardwoods, 80 sq ft for mixed-wood, and 100 sq ft for softwood to ensure wind-firm conditions (Lansky, 2004). No harvesting should occur in Zones 2 wetlands, springs, areas with slopes of $\geq$25%, or hydrologic group D soils. Lastly, harvesting should not occur within 25 feet of intermittent streams in this zone.

Zone 3 should be 300 ft wide, extending from 150 ft to 450 ft from the stream. Well-planned haul roads and skidder trails may occur in this zone, but to the maximum extent possible should be located outside this zone. Strict adherence to BMPs (Sections 4.4 & 4.5) here and in the remaining portions of the watershed is critical, because even wide buffers can't protect streams from inadequate BMP use. The recommended guidelines for minimum stocking levels are 50 sq ft of basal area for hardwoods, 70 sq ft for mixed-wood, and 80 sq ft for softwood. As with Zone 2, no harvesting should occur in Zones 2 or 3 in wetlands, springs, areas with slopes of $\geq$25%, or hydrologic group D soils. Again, as with Zone 2, no herbicides or insecticides should be used in this zone, and harvesting should not occur within 25 feet of intermittent streams.

Table 4.1-1. Three-Zone Riparian Management Approach

Zone	Extent	Prescription
Zone 1	Fixed 75 ft	No-cut zone. Mature and old growth forest allowed to develop over time. Only disturbance regime is natural.
Zone 2	Fixed 75 ft beyond Zone 1	No soil disturbance. No haul roads (except existing or permitted crossings). Timber may be extracted by cable only. Guidelines for minimum stocking levels are 60 sq ft of basal area for hardwoods, 80 sq ft for mixed-wood, and 100 sq ft for softwood. No harvesting should occur in Zones 2 or 3 in wetlands, springs, areas with slopes of ≥25%, or hydrologic group D soils. Further harvesting should not occur within 25 feet of intermittent streams in this zone. No herbicides or insecticides.
Zone 3	Fixed 300 ft beyond Zone 2	Well-planned skidder trails and haul roads. Strict adherence to BMPs (Sections 4.4 & 4.5). Guidelines for minimum stocking levels are 50 sq ft of basal area for hardwoods, 70 sq ft for mixed-wood, and 80 sq ft for softwood. No harvesting should occur in Zones 2 or 3 in wetlands, springs, areas with slopes of ≥25%, or hydrologic group D soils. Further harvesting should not occur within 25 feet of intermittent streams in this zone. No herbicides or insecticides.
Remaining Area	Remaining Area	Regular commercial management and harvests, with well-planned haul roads and strict adherence to BMPs (Sections 4.4 & 4.5). To the extent possible leave a 25 ft limited harvest or no-cut zone adjacent to intermittent streams.
Watershed as a Whole	Entire Watershed	No more than 20% of any subwatershed should be in age classes less than 15 years at any given time (Section 4.3).

The primary scientific justification or rationale for the width and the management prescriptions recommended for each zone is:

- Zone 1 should be as wide as a site potential tree height to achieve close to 100% of the potential shading and LWD inputs. 50 ft would capture the majority of these functions. However, buffers of 100 ft or more may be required to protect streams form the majority of potential water quality impacts (Kleinschmidt, 1999), and some literature shows that BMPs are not always followed (ME DOC, 2002) so that sedimentation occurs despite otherwise adequate buffers. A width of 75 ft addresses the range of conditions in the region (steep slopes, shallow soils, historic logging effects) since Zones 2 and 3 provide further protection. Some literature shows that LWD recruitment can occur beyond one site potential tree height away from the stream because of the common occurrence of one tree falling into another and knocking it in the same direction (Reid and Hilton, 1998), however, the relatively high stocking levels for Zone 2 will result in much of this potential recruiting path remaining.
- Zone 2 width is largely a function of the reach of a cable skidder and the desire to prevent any disturbance at all to the duff layer.

- The width of Zone 3 is designed to ensure wind firm conditions in Zones 1 and 2 and act as an additional filter for water quality functions while allowing forestry and some haul roads and trails to occur. Since seeps and intermittent streams do not have their own no-cut zones (Zone 1) or special harvest guidelines (Zones 2 and 3), Zone 2 and 3 will protect these resources relative to full commercial cuts and will be able to filter most sediments coming from outside Zone 3.

As detailed in Section 4.2, the target region can be divided into two basic stream corridor types. One is the small (usually 1st order), high gradient stream corridors that occur in the more mountainous terrain. The other is the larger (usually 2nd and 3rd order), low gradient stream corridors that occur in the protected valleys. There are several factors that would suggest wider buffers be applied to the smaller, high-gradient streams. However, there are also several factors that would suggest wider buffers be applied to the larger, low-gradient streams. These factors more or less cancel each other out (see Section 4.2). As such it was felt that a fixed-width 75 ft no-cut zone (Zone 1) would accomplish the functional objectives desired for the range of stream types found in the region. The recommended three-zone approach protects a riparian area that is 450 wide including: 1) no harvesting in the first 75 ft (Zone 1), 2) no soil disturbance (*i.e.,* no haul roads, skidders, or other disturbance that would expose mineral soil) in the first 150 ft (Zones 1 and 2 combined), and 3) limited harvesting and road/trial construction between 150 and 450 ft. The limited harvesting in Zones 2 and 3, if proper use of BMPs is adhered to (Sections 4.4 and 4.5), is considered consistent with maintaining healthy brook trout habitat.

The 3-zone approach should be applied to all perennial streams. Intermittent streams are protected by the use of careful BMPs, and are also further protected in those places where they flow through Zones 1-3. Zone 1 is measured from the normal high water mark of the stream if there are no streamside wetlands or floodplains. If there are wetlands or floodplains, these are considered part of the resource being protected, and the measurement begins at the landward edge of these features.

- 4.2 Stream Order

Small, 1st order, headwater streams are more sensitive to potential impacts than are larger/higher order streams (Kahl, 1996). For example, small streams are less able to handle elevated sediment inputs and warm more readily following canopy removal. Small streams also rely heavily on the adjacent riparian area for LWD and leaf litter inputs, whereas larger streams receive a large proportion of these inputs from the smaller streams that feed them. The health of large streams is directly related to the health of the small intermittent streams, 1st order streams, and wetlands in the contributing watershed (American Rivers and the Sierra Club, 2003). There are several compelling reasons to afford more protection for smaller streams (Table 4.2-1). However, there are several equally compelling reasons, pertinent to brook trout habitat, to afford more protection for larger streams. An additional reason to have more protection (wider buffers) on larger streams is that these corridors are used more extensively by wildlife such as cavity nesting birds and riparian-specific species like mink and otter that benefit from buffers that are several hundred feet wide (USDA Forest Service, 1997; Chase *et al.,* 1997). This factor is not listed in Table 4.2-1 because it is not directly relevant for brook trout habitat. The factors in Table 4.2-1 were concluded to cancel each other out to the point where a single, fixed Zone 1 buffer width of 100 ft (justification for this width in Section 4.4) would be simple to implement and would make sense scientifically.

potential (steep slopes and preponderance of shallow to bedrock soils and basal till soils), and also because the effect on they annual hydrograph from cutting is accentuated where softwoods are dominant (Kahl, 1996). Spruce and fir are very common in this region (Section 3.1).

Land uses (*e.g.,* forest clearing, soil disturbance) that occur as little as 50-100 feet from a main-stem river can sometimes have less of an effect on instream structure and function than land uses occurring a mile or more upstream affecting small, headwater streams. Therefore, watershed-wide BMPs such as summarized in Sections 4.4 and 4.5 are important.

As indicated by Table 4.3-1, individual functions are important in different parts of the watershed and at varying distances from the stream.

Table 4.3-1. Functions of Zones

Function	Zone 1	Zone 2[1]	Zone 3 and Entire Watershed
Shading and Temperature Regulation	Primary	*Secondary*	*Insignificant*
Large Woody Debris and Organic Matter Inputs	Primary	*Secondary*	*Insignificant*
Water Quality Functions (other than shading)	Primary	Primary[2]	Primary[2]
Water Quantity Functions	*Secondary*[3]	*Secondary*[3]	Primary[3]
Bank Stabilization	Primary	*Insignificant*[4]	*Secondary*[4]

[1] An additional function of Zone 2 is to provide wind-firm conditions in Zone 1.

[2] As a result of intermittent streams, wetlands, and stormwater runoff (surface and shallow subsurface), the entire watershed provides water quality functions, although Zone 1 is often the most important zone for this function.

[3] Baseflow maintenance and peak flow attenuation is provided by the entire watershed, not primarily by the immediate riparian buffer. Flood storage during overbank flows is a primary function of riparian buffers. However, this report recommends that floodplains be included as part of the resource to be buffered. Zone 1 begins at the landward edge of floodplains.

[4] The entire watershed is relevant to bank stability. Zone 3 and watershed management affects the annual hydrograph (*i.e.,* cutting a large percentage of the watershed increases peak flows), which affects bank stability.

- 4.4 Forestry BMPs (Non-Crossing)

BMPs are generally developed by state and federal government agencies such as the Maine Forest Service and the USDA Natural Resources Conservation Service and are designed to protect water quality during all stages of forestry operations. This includes pre-harvest planning, buffers (Section 4.1), watershed management (Section 4.3), streamside and wetland area management, road construction and maintenance, stream crossings (Section 4.5), timber harvesting, revegetation, and chemical management. This section briefly summarizes recommended BMPs as gleaned from several recently developed references (VDF, 2002; ME FS, 2004; PSRWG, 2004). The majority of sedimentation that occurs during and after timber harvesting operations results from improperly constructed or maintained haul roads, skid trails and landings (VDF, 2002).

Table 4.4-1 is a summary of the forestry and road crossing BMPs recommended. Section 4.5 provides greater detail regarding fish-friendly crossings.

Table 4.4-1. Recommended Forestry BMPs.

Recommendation	Rationale
A pre-harvest or **forest management plan** should be developed before each harvest operation. The pre-harvest plan should identify the BMPs that will be followed before, during and after the harvest. The plan should: clearly identify the area to be harvested, locate special areas of protection (such as wetlands), specify proper timing of forestry activities, describe the road layout, design, construction, and maintenance, and identify harvest methods and forest regeneration.	Natural drainage features, sensitive landscape features like wetlands and springs, threatened and endangered species habitat, topography, and soil types need to be considered if impacts related to haul roads, trails, and harvest areas are to be avoided or minimized.
No herbicide or insecticides in Zones 1-3	Although glyphosate-based herbicides are not thought to be toxic, the surfactant mixed with it can be toxic to aquatic organisms. Insecticides pose a more serious threat to fish and macroinvertebrates than herbicides.
No spraying anywhere when winds are >5 mph	Spraying in moderate or high winds can result in inputs to streams, and can directly or indirectly (through damage to shoreline vegetation and to the macroinvertebrate community) stress salmonids
Conduct winter harvests only, when the ground is frozen solid (generally December 1 until March 15 in northern Maine)	Winter harvests are the least damaging to forest floors and pose the least risk for erosion and sedimentation.
Use appropriate stream crossing BMPs (Section 4.5) **for even small, intermittent streams and temporary crossings** (Maine FS, 2004; PSRWG, 2004). Avoid culverts for temporary crossings. Use temporary bridges instead of fords where there is flow or potential flow (PSRWG, 2004).	Stream crossings at very small headwater streams are a primary potential source of sedimentation.
Use appropriate stream crossing BMPs (Section 4.5) **for permanent crossings or crossings of perennial streams.** Do not perch culverts, undersize culverts or otherwise create passage barriers or unstable banks (Maine FS, 2004; Kleinschmidt, 2004)	Stream crossings at very small headwater streams is a primary potential source of sedimentation

Landings should be located in dry areas with gentle slopes, well outside streamside management zones or wetlands. The number and size of landings should be planned along with the harvest road system. There should be adequate drainage on haul trails to the landing and a mechanism to divert water away from the landing. After completion of harvesting operations, landings and access roads must be stabilized and revegetated.	Poorly planned and located landings, and landings that are not stabilized after use, can impact streams in the watershed by erosion and sedimentation, including gully and sheet and rill erosion. Landings can also concentrate surface runoff through compacted soils and altered drainage patterns.
Haul roads and skid trails should be properly constructed and located. Recommended road system layout recommendations are: minimize the total road length, use existing roads where possible, avoid Zones 1-2 always and Zone 3 as much as possible, avoid changes to natural drainage patterns, avoid concentrated runoff patterns and promote diffuse runoff and infiltration, use BMPs like turnouts and broad-based dips to distribute runoff to upland areas where it can infiltrate, locate roads on uplands, the road should follow the natural contours to minimize cut and fill, keep road gradient as low as possible (the steeper the road, the greater the velocity of the runoff), if steep grades are needed for short distances, follow by gentle stretches to reduce runoff velocity, select the appropriate road surfacing material to minimize erosion and reduce maintenance costs, and use outsloped, crowned or in-sloped roads to drain water directly to forest floor depending on topography and stream locations.	Well-located, constructed, and maintained forest roads and skid trails can minimize the major source of erosion and sedimentation associated with silvicultural activities. A poorly designed road system can result in significant impacts such as increased sediment load reaching the stream, and altered and concentrated surface runoff, as well as increased maintenance costs.
Minimize and stabilize exposed soil where the duff layer has been scraped down to mineral soil using mulching and revegetation techniques.	Exposed mineral soil is far more susceptible to erosion and sedimentation than vegetated areas and areas with a thick forest floor or mulch cover.
Handle fuel and oil properly. If oil changes are necessary on-site, oil should be properly recycled. Fuel should be stored properly to prevent spills and contain spills that do occur.	Fuel or oil reaching brook trout streams can damage macroinvertebrates and water quality.
Maintain 25 ft forested **buffers along intermittent streams** as much as possible.	It is recognized that intermittent streams are too numerous to avoid crossing and harvesting along without severely impacting the economics of harvest operations,

- <u>4.5 Stream Crossing BMPs</u>

New road crossings should preferably be located in straight, stable stream sections, and away from known important spawning areas. Although new crossings should be avoided if possible, if a crossing must be developed, culverts or bridges that promote unimpeded bank to bank flow should be used. Permanent logging roads usually cross streams via culverts. If culverts are used, they must be satisfactorily sized and designed to minimize stream impacts. Culverts should accommodate flood flows and base flows, and address factors such as hydraulics and stream slope (PSRWG, 2004). This can be accomplished by calculating and designing for specific criteria such as a specific flood event, or installing a no-slope design that is as wide as the stream channel. No-bottom arch culvert designs are typically superior to conventional culverts with respect to maintaining natural substrate and accommodating flood flows. Culvert and bridge crossings should be oriented perpendicular (culverts themselves should be parallel) to flow whenever possible. Temporary crossings are not preferred and should be avoided if possible. Bridges should be designed with piers positioned above bankfull elevation to avoid debris buildup, bank erosion and downstream channel degradation.

Road and culvert construction practices must be properly timed and designed to avoid impacting brook trout or their habitat. This requires timing construction or maintenance activities to avoid times when soils are wet, loose and difficult to control and/or when spawning is occurring. Habitat characteristics (such as shading, large woody debris recruitment) should be emphasized in all BMP designs in brook trout watersheds.

When to Cross

Maine regulations (Natural Resources Protection Act) specify that stream crossings occur between July 15 and October 1 to minimize impacts to spawning or migrating fish, and to avoid work in saturated soils or during high flows. The Maine Department of Inland Fisheries and Wildlife (DIFW) reviews permit applications submitted to the Maine Department of Environmental Protection or US Army Corps of Engineers for crossings, and depending on the particular stream and region, there is some flexibility in these dates. Northern and high elevation portions of Maine, such as the subject watersheds, experience earlier brook trout spawning (Steve Timpano and Forrest Bonney, DIFW, personal communication, March 24, 2005). The cooler climate and higher elevations of the subject watersheds also result in a shorter growing season so soils stay saturated longer into the summer and become saturated again earlier in the fall. For these reasons, **it is recommended that the stream crossing window be narrowed to July 15 to September 15 in the subject watersheds** (Steve Timpano and Forrest Bonney, DIFW, personal communication with Alan Haberstock, Kleinschmidt Associates, March 24, 2005).

Where to Cross

Crossings should avoid important high density spawning areas where these are known or can be identified in advance of a crossing project (the DIFW Regional Biologist should be consulted for new crossing locations). Brook trout females are selective compared to other salmonid species with regard to where they deposit their eggs, and this selectivity may lead to a high degree of site fidelity from year to year.

Other factors that should be considered when siting a culvert or bridge crossing include: flow direction relative to culvert orientation, flow velocity, lateral stream migration potential,

potential vertical stream bed changes, bedload and debris transport dynamics, channel width and gradient, and bank characteristics (California Department of Fish and Game, IFD, 2003; PSRWG, 2004). Figure 4.5-1 illustrates a few crossing considerations.

Bridges or arch culverts are preferable to conventional culverts as long as they are constructed in such a way that flow is not affected. Because conventional culverts channel water within the stream, special care must be taken to orient and size these structures (PSRWG, 2004). The axis of a culvert should be oriented parallel to channel flow as much as possible. Roads should be as close to perpendicular to the stream as possible. Culverts that are skewed more than 30 degrees to the channel flow are not recommended since they can increase inlet turbulence at high flows, make the culvert less efficient at sediment and flood flow transport, result in bank erosion and in-channel deposition upstream, and result in downstream bank erosion and bed degradation (Washington DFW, 2003).

Potential lateral channel migration should also be considered. For example, a meander bend is a poor crossing location, and locations along relatively straight reaches with stable banks are good choices. Site specific conditions (*e.g.,* whether the subject stream is a meandering low gradient steam or a relatively straight high gradient stream) will dictate the potential to find straight and stable stream reaches. Stream crossings should be placed in sections of the waterway that are relatively straight above and below the crossing, as a general guideline. Alluvial reaches are poor locations for stream crossing locations, as they typically have floodplains, extensive areas of alluvial sediments (sediment sorted and deposited by over bank flows), oxbows, or other indications of potential lateral stream channel movement. Lastly, reaches that flow through non-cohesive soils (*e.g.,* loose sediments, such as outwash sands that do not hold together well) may be problematic with regard to lateral stream migration.

High gradient stream reaches (>4%) may cause problems for culvert crossings. Although the channel beds tend to be more stable along high gradient reaches, large debris (boulders and large woody debris) is more mobile in high gradient reaches, and debris damming at a culvert crossing may occur. In addition, high stream velocities increase the chances of structural damage and erosion, and can magnify design flaws such as undersized or misaligned culverts. Bridges and over-sized culvert designs can minimize problems with high velocities and debris jams. Many high gradient reaches are headwater streams, however, the contributing watershed is often smaller and flooding potential is often less as compared to low gradient reaches further downstream.

Culvert crossing designs along low gradient streams (<1%) with fines (*i.e.,* organics, clay, silt, and fine sand) for substrate should take into account that these are typically depositional areas. If the subject reach is prone to aggradation, culvert size should be increased to allow deposited material to pass and prevent build-up that could result in fish passage impacts such as low flow barriers, and debris dams. Flow constrictions from undersized culverts could also deepen the channel downstream and create a perched culvert during low flows (or velocity barrier during high flows).

Insert Figure 4 (separate file)

A bridge is recommended instead of a culvert crossing if the crossing is unavoidably located along steep banks (approximately >20%). Such locations increase the chances of bank erosion and sedimentation from riparian vegetation removal, road runoff, and high velocities during high flows. Moderately steep banks (>10%) also require careful planning and design with regard to stormwater management and culvert parameters. Steep banks are associated with fast-rising streams during floods and increase the chances of overtopping structures. Bedrock or well-consolidated/cohesive (*e.g.,* holds together well) bank materials provide a stable base for structure placement, whereas non-cohesive materials require more attention to bank stabilization measures and may require an oversized culvert design or bridge.

How to Cross

Permanent Crossings

Culverts and bridges should be constructed in a manner that facilitates fish passage and avoids habitat degradation. There are several organizations and references that provide detailed information and calculations for properly sizing and locating culverts and bridges, including some recently developed manuals (Maine DOT, 2002; Washington DFW, 2003; PSRWG, 2004). In addition, professional engineers can be hired to complete designs that avoid fish passage barriers or habitat degradation. Listed below are some general guidelines. Other sources, such as those listed above, should be used to determine more detailed calculations and criteria.

For bridges and culverts fish passage at a stream crossing should meet the following criteria:

- The stream crossing should be selected and placed in a manner that allows fish to swim both up and down stream. Flow velocity should not be increased by the crossing, as can occur with undersized culverts, so as to not create velocity barriers and erosion. Further, culverts should not be perched or allowed to become overly embedded.
- The stream crossing must accommodate peak flow (or flood) conditions. The stream crossing must pass the design storm as specified by applicable regulations. Agencies vary in their design storm guidance so it is necessary to contact all potentially jurisdictional agencies. For example, if the crossing is in an area where only Land Use Regulation Commission (LURC) regulations apply, this flow will likely be equal to the highest flow that would occur in a typical 10-year period (*i.e.,* Q_{10}).
- The stream crossing must maintain existing stream channel slopes above and below the stream crossing.
- Materials selected for construction of fish passage structures shall be non-toxic to fish and other aquatic life.
- Stream crossings shall not be configured such that they will change the natural geomorphic processes up and down stream of the crossing.
- Design criteria that are specific to culvert crossings include:
  - Hanging or perched culverts are not acceptable in any flow situations.
  - New culverts should be installed with the culvert bottom below streambed elevation. At a minimum, pipes less than 48 in. across should be embedded 6 in.; and pipes 48 in. across or more should be embedded 12

in. into the stream bottom. Embedded pipes should be allowed to fill with natural substrate.

- For culvert crossings with multiple pipes at the same location, the lowest pipe should be sized and located to allow fish passage during low flow periods of regular movement; size and locate the additional pipe(s) to collectively pass the design peak flows. Multi-pipe installations are prone to unintended consequences and should only be designed by experienced hydraulic engineers.
- There are many types, styles, configurations, and materials for culverts. Culverts with natural bottoms are consistent with optimal brook trout habitat. An open bottomed culvert is preferred over a solid bottom culvert since it helps ensure that a natural stream bottom will be maintained.

Photo 4.5.2-1 Example of a perched culvert; notice the upper culvert designed to accommodate higher spring flows. Perched culverts block upstream fish migration.

Photo 2.2-2 Another two-culvert design. Severe embededdness has resulted in reduced flow and passage.

Photos by Alan Haberstock

Temporary Crossings

Temporary crossing options for small (intermittent and small 1st order) streams such as pole fords, ice bridges, and slash crossings can result in little to no impact if implemented correctly, however they are often misused and do result in substantial stream damage. Temporary stream crossings have the potential to produce streamside erosion, and degrade brook trout habitat and water quality through increased turbidity and sedimentation. Further, some recommended approaches for stream fords specify that crossings should occur in the most stable, coarse-textured substrates of a stream in low gradient reaches so that bed damage and turbidity are minimized. This, however, can result in stream fords right on valuable brook trout spawning habitat (*i.e.*, gravel and cobble areas in low gradient stretches). Temporary crossings can also create passage barriers, especially if they are left in place rather than being properly removed immediately after the harvest (or other temporary access application) is complete. Temporary crossings should never be left in place for more than six months. If it is necessary to install temporary stream crossings, the number of crossings should be limited to as few as possible and the location(s) should be carefully selected.

Temporary bridges are the least intrusive temporary crossing method since they can be easily installed and easily removed and re-used with little impact to habitat if used properly. The Maine Forest Service (MFS) is a contact to obtain sources for buying, borrowing or leasing pre-manufactured, portable, temporary bridges. Large operations or large landowners typically have constant demand for them so that owning an inventory of portable bridges may be cost-effective.

Temporary bridges are most effective when a proper foundation is provided. Bridges need a log, railroad tie, or similar abutment to rest on to level the structure, minimize disturbance to the stream bank, and ease removal. Temporary bridges can be constructed of rough logs, timber, pre-manufactured metals, prestressed concrete, or other structural material. No soils disturbance should occur below the normal high water mark to install foundation materials. Temporary bridges should be removed immediately after its use has expired or six months (whichever occurs first) by removing the temporary bridge, the associated materials on the approach, and the bridge support, and immediately stabilize the exposed soil areas with hay mulch and seed.

The MFS is probably the best source for technical assistance for temporary crossing BMPs, and has recently issued a useful document on forestry BMPs including crossings (Maine Forest Service, 2004).

- <u>Forestry Certification and BMP Compliance Monitoring</u>

This report does not provide specific recommendations with regard to third-party certification programs or monitoring and enforcement of recommended BMPs. This information can be found in other references (ME DCO, 2002; Reardon, 2003). Since adequate BMPs are not routinely being implemented in the working forests of Maine or other states (ME DOC, 2002), this report does recommend that some compliance process be applied. Such "checks" are needed to ensure that regulations, easement terms, and permit conditions, which dictate BMPs and sensitive resource protection protocols, are implemented.

V. IMPLEMENTATION

The buffer and BMP recommendations outlined in this report are intended as technical recommendations. We envision that they will be implemented through a variety of means, including, but not limited to:

- Adoption into harvesting plans for forest lands owned by land trusts, government agencies, or other conservation-minded landowners for whom protection of brook trout habitat is a primary objective.
- Use as the basis for terms and conditions of conservation easements or other long-term management agreements that seek to protect brook trout habitat.
- Identification of key riparian parcels for conservation purchase (in-fee or easement).
- Evaluation of the adequacy of existing regulatory, BMP, and voluntary practices intended to protect brook trout habitat and watersheds.

GIS analysis was applied to identify the buffer recommendations in this report as they would be applied to portions of six townships adjacent to the Kennebago River, and Kennebago and Little Kennebago Lakes. This area was selected for the value of its existing brook trout fisheries, and because we believe it to be broadly representative of many similar areas in Northern New England. In addition, as a result of recent land sales and other management changes, there is growing interest in conservation within this region.

Figure 5 shows the three zones of the buffer. It should be noted that even for a medium sized watershed like Kennebago Stream, adequate protection of brook trout habitat will require application of the recommended buffers over long reaches of stream. Although these areas are, in many places, relatively narrow corridors, because they include the entire stream length, application will require coordination among multiple landowners, across several different townships, even in areas where land ownership remains in large, relatively undeveloped blocks of more or less intact forest. As the number of landowners increases, watershed scale protection will likely become exponentially more difficult to achieve.

It is also significant that in some places the inclusion of floodplain and stream-associated wetlands within Zone 1 substantially increases the protected area associated with the immediate stream bank. Conversely, not protecting these areas would open up large areas of seasonally flooded forest floor to soil disturbance and subsequent sedimentation. It would also have the potential to remove a large fraction of the large trees before they have the potential to be recruited to the stream channel as large woody debris.

Insert Figure 5

While these recommendations were developed using conditions in three particular western Maine watersheds, they are broadly applicable to protection of salmonid habitat in other regions of the northeastern United States and Canada where brook trout occur on similar landscapes—relatively undeveloped watersheds containing healthy populations of wild brook trout, where land use is dominated by timber harvest and the landscape is characterized by mixed northern forest types, steep slopes, and mountainous terrain. Even for more developed and/or less mountainous landscapes, key concepts of the buffer approach suggested here are applicable, although their relative width would likely vary with topography, stream type, and forest type. Key aspects of this approach include:

- Starting the buffer at the edge of the floodplain or any stream-associated wetlands. Regardless of width, buffers that are largely or wholly within the floodplain will not provide protection of brook trout habitat.
- Application of the buffer to all perennial streams. To protect sensitive species such as brook trout, even small first order streams must be buffered.
- A multi-zoned buffer. This should include a no disturbance Zone 1 immediately adjacent to the stream, a minimal disturbance Zone 2 that allows for limited harvest of trees, and a wider Zone 3 in which more disturbance is allowed, but such disturbance is limited and carefully planned.
- Even beyond Zone 3, activities must conform with erosion control BMPs. A healthy watershed requires a healthy forest, and no amount of buffering will compensate for harvest practices that do not pay attention to drainage patterns, erosion and sedimentation, and the overall condition of the forest and forest floor.
- Fish-friendly stream crossings. Culverts and bridges should be constructed in a manner that facilitates fish passage and avoids habitat degradation. Road and culvert construction practices must be properly timed and designed to avoid impacting brook trout or their habitat.

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