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December 22, 2016
VIA E-FILING

Kimberly D. Bose, Secretary
Federal Energy Regulatory Commission
888 First Street, N. E.
Washington, DC 20426

Ellsworth Hydroelectric Project FERC No. 2727-086
Study Status: Atlantic Salmon Smolt Downstream Passage Study; Tributary Access Study; Adult American Eel Downstream Passage Study

Dear Secretary Bose:

Black Bear Hydro Partners, licensee for the Ellsworth Hydroelectric Project (Project), filed an Application for New License (Application) for the Project on December 30, 2015. The Application detailed the plan and timeline for conducting several continuing studies that are necessary to inform the Commission's license decision.[1] This filing includes the status of, and as appropriate, the study reports for, the following studies;

- Atlantic Salmon Smolt Downstream Passage Study (including the final 2016 study report and a proposal to conduct an additional year of study);
- Tributary Access Study (including the final 2016 study report);
- Adult American Eel Downstream Passage Study (year two status update).

The status of these studies is as follows.

Atlantic Salmon Smolt Downstream Passage Study – The final study plan for the smolt study was submitted to the Commission on March 31, 2015. Black Bear conducted the study in May 2016 using approximately 240 smolts that were tagged, released and evaluated using either radio-telemetry or hydro-acoustic technology. A draft report was circulated on October 19, 2016 for agency review and two fisheries management agencies provided comments, the National Marine Fisheries Service (NMFS) and the Maine Department of Marine Resources (MDMR); the final report for the 2016 study addresses the agency comments and is attached hereto.

The results of the smolt study were somewhat unexpected in that there was a low incidence of successful smolt passage at the Graham Lake dam which is a storage dam with no

[1] This relicensing is being conducted under the Commission's Integrated Licensing Process. During the course of reviewing and commenting on the Updated Study Report and Draft License Application, and in its Determination on Requested Study Modifications (December 8, 2015) the Commission authorized, or required the continuance of, several studies post-filing of the Application. The Commission required the filing of any resulting study reports by December 31, 2016.

generating units. Additionally, at the Ellsworth Dam generating station, successful passage was lower than expected through the generating units although passage through the existing downstream passage system was highly successful for those fish that used the system. The results were discussed at length in an October 4, 2016 agency meeting, with Black Bear and the Maine Department of Environmental Protection (MDEP), US Fish and Wildlife Service (USFWS), NMFS in attendance. The consensus conclusion from the meeting was that at least one additional year of study would be necessary to determine in particular what factors are causing the hesitancy of smolts to utilize the existing fish passage weir to pass the Graham Lake Dam. Black Bear subsequently prepared, and distributed for agency review (November 11, 2016), a proposed study plan for a second year of study to assess smolt passage at the Project. The draft study plan proposed to install an Alden weir at the existing Graham Lake fish passage weir to improve hydraulic conditions and attraction to, and utilization of, the weir.[2] Additionally, Black Bear proposed to modify potential passage conditions at the Ellsworth Dam by removing a section of flashboards adjacent to the existing fish passage weir at that dam to provide additional spill and route of passage for the study. The NMFS provided written comments on the draft plan and met with Black Bear on December 21, 2016 via conference call to discuss the study plan. Black Bear plans to continue study plan consultation with the fisheries agencies and to submit a final study plan for Commission approval in early 2017.

The conduct of an additional year of study for smolt passage at the Project is essential to informing the licensee, the fisheries agencies, and the Commission on the appropriate proposal(s) for inclusion in the license and in the Species Protection Plan that will be prepared for the management of the ESA listed Atlantic salmon as part of the relicensing process for the Ellsworth Project.

Tributary Access Study – The report for the tributary access study conducted in October, 2014 was submitted as part of the Updated Study Report (August 21, 2015) for the Project. The Commission however, in its December 8, 2015 Study Plan Determination, required Licensee to conduct additional agency consultation and field study to supplement the original work. Black Bear conducted the additional consultation with the agencies and concurred on a scope of work to fulfill the Commission requirements. The field study was completed in October, 2016 and a draft report was circulated on December 1, 2016 for agency review. Three agencies commented on the report, the Maine Department of Inland Fisheries and Wildlife (MDIFW), MDMR, and NMFS; the final report for the 2016 study addresses the agency comments and is attached hereto.

[2] Black Bear conducted a site visit with NMFS and discussed the potential use of an Alden weir. Black Bear subsequently, on December 9, 2016 provided supplemental information to the agencies in the form of design drawings prepared by Alden Labs. Black Bear is in the process of costing and bidding the fabrication and construction of the Alden weir in anticipation of installing the weir prior to the year two study in May of 2017, but, considering winter conditions, cannot guarantee that there will be a suitable period of weather for installation.

Adult American Eel Downstream Passage Study – The final study plan for the downstream eel passage study was submitted to the Commission on September 14, 2015. The study plan included provisions for a year-one study using radio-telemetry techniques to evaluate passage routes and success. The study, using 50 tagged eels, was conducted in fall 2015 and the study report was included in the December 30, 2015 filing of the final license application. The study plan also allowed for the possibility of a second year of study, using alternative techniques, as appropriate after further consultation with the fisheries agencies. Black Bear presented the downstream eel study results at the annual Union River Fisheries Coordinating Committee meeting held February 26, 2016. The findings were discussed with the fishery agencies in attendance (MDMR, USFWS and NMFS) and there was consensus that the year-one study provided sufficient information regarding use of available passage routes and relative success of passage through the existing routes, and that there would be little value to retesting the same conditions as were tested in 2015. The related consensus was also formed that Black Bear should wait until after any modified passage measures were implemented at the Ellsworth development such that further testing would evaluate any changes that may be implemented. As noted in the final license application, Black Bear proposes to, based on the results of the 2015 study, consult with the fisheries management agencies on the need for and design of downstream eel passage measures.

In summary, Black Bear Hydro 1) attaches the final 2016 smolt study report and proposes to conduct at least one more year of study (a final study plan will be filed in early 2016) in order to develop sufficient information for the project license and the Species Protection Plan, 2) attaches the final 2016 tributary access report, and 3) summarizes the status of the downstream eel passage study and continues to propose to consult with the fisheries management agencies on the need for and design of downstream eel passage measures.

If you have any questions regarding this filing, please contact me by phone at (207) 755-5603 or by email at Frank.Dunlap@BrookfieldRenewable.com.

Sincerely,

Frank H. Dunlap
Licensing Specialist
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Attachments:

2016 Evaluation of Atlantic salmon Smolt Passage Study Report
2016 Tributary Access Study Report

cc: Distribution List
K. Maloney, Brookfield Renewable
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CERTIFICATE OF SERVICE
Ellsworth Hydroelectric Project (FERC No. 2727)
2016 Study Reports

I, Frank H. Dunlap, Licensing Specialist, Brookfield Renewable Group, hereby certify that a link to the foregoing document on the Commission website has been transmitted to the following parties on December 22, 2016.

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Ellsworth Project, FERC No. 2727
Evaluation of Atlantic Salmon Smolt Passage
Spring 2016

Prepared For:
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December 2016

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Table of Contents

List of Figures

Page

List of Tables

Page

1.0 Introduction and Background

Black Bear Hydro Partners, LLC (BBHP or Black Bear) owns and operates the Ellsworth Hydroelectric Project (Federal Energy Regulatory Commission [FERC] No. 2727) (Ellsworth Project or Project) on the Union River pursuant to the license issued by FERC on December 28, 1987. Black Bear is in the process of relicensing the existing Ellsworth Project. On December 30, 2014, FERC issued a determination on requests for study modifications and new studies for the Ellsworth Project. In that determination, FERC recommended that Black Bear conduct a field study to evaluate downstream Atlantic salmon smolt passage at the Project. As requested, Black Bear developed a study plan, in consultation with the resource agencies, to evaluate the effectiveness of downstream passage of Atlantic salmon smolts. The final study plan was filed with FERC on March 31, 2015. A draft report, providing a summary of the methods and results of the 2016 Atlantic salmon smolt evaluation at Ellsworth was submitted to the National Marine Fisheries Service (NMFS), United States Fish and Wildlife Service (USFWS), Maine Department of Marine Resources (MDMR), and the Maine Department of Inland Fisheries and Wildlife (MDIFW) on October 19, 2016. A supplemental examination of downstream passage events at Graham Lake Dam was provided to the resource agencies on November 9, 2016 (see Appendix D of this document). The transmittal correspondence along with the written comments received from NMFS and MDMR are included in Appendix E. Responses to each comment are provided in Appendix F and where appropriate, the study report has been updated to reflect the content of those comments.

1.1 Study Objectives

The objective of this study was to evaluate smolt passage at the Ellsworth Project, including at Graham Lake and Ellsworth Dams. Specifically, the study evaluated the passage and survival of smolts through the Project area, including routes utilized for passage through the Project facilities. Migration timing (duration) was also evaluated as part of this study.

1.2 Project Description

The Ellsworth Project is located on the lower reach of the Union River in the City of Ellsworth and the towns of Waltham and Mariaville in Hancock County, Maine. The project consists of an upper dam with a large storage reservoir (Graham Lake) and a lower dam (Ellsworth Dam) located about 4 miles downstream, with a small reservoir (Leonard Lake). The Graham Lake Dam consists of three 20-foot-wide tainter gates, and an 8-foot-wide bay with a 4-foot-wide overflow weir (controlled with stoplogs) used for downstream fish passage. This weir empties into a plunge pool which subsequently discharges into the river below the dam structure. The Ellsworth Dam consists of an integral dam and intake structure with four short penstocks; the spillway of the dam is approximately 275 feet long. The existing downstream fish passage system at Ellsworth consists of three downstream passage surface weirs that deliver migrants to the sluice located on the western end of the spillway adjacent to the powerhouse. The Ellsworth Dam forms the upper limit of the tidal influence of the Union River. The Union River flows into the Union River Bay approximately 3.5 miles downstream from the project.

Ellsworth Dam is approximately 377 feet long, including a 275-foot-long spillway, and is 65 feet high with 26-inch-high flashboards on the spillway. Leonard Lake extends approximately 1 mile upstream of Ellsworth Dam and has a surface area of 90 acres at normal water surface elevation 66.67' USGS datum. The Ellsworth powerhouse contains four turbines which have a total rated capacity of 8,900 kW. Units 1 and 4 are vertical shaft propeller turbines, and Units 2 and 3 are vertical shaft Kaplan turbines. Ellsworth Dam is equipped with a vertical slot upstream fishway and trap. The downstream fish passage facilities consist of stop-log-controlled surface weirs and a transport pipe and sluice leading to a plunge pool immediately downstream of the dam. The downstream fishway is operated from April 1 to December 31 each year, as river conditions allow.

Graham Lake Dam is a flood control and storage facility that does not contain a powerhouse or hydroelectric turbines. Graham Lake Dam is 30 feet high and consists of a 670-foot-long non-overflow earth dike and an 80-foot-long concrete gate structure. The concrete gate structure contains three 20-foot-wide radial gates and an eight-foot-wide bay with a four-foot-wide sluice that is used for downstream fish passage.

The Project is operated with a continuous minimum flow requirement of 105 cubic feet per second (cfs) from the Graham Lake Dam and Ellsworth Dam from July 1 through April 30, and a continuous minimum flow requirement of 250 cfs from May 1 through June 30. The flows can be temporarily modified if required by operating emergencies beyond the control of the Licensee, and for short periods upon agreement among the Licensee, the U.S. Fish and Wildlife Service (USFWS), and the Maine Department of Environmental Protection (MDEP).

2.0 Telemetry Methodology

2.1 Overview

Smolt passage during the 2016 outmigration period was assessed using a combination of radio and acoustic telemetry at the Ellsworth Project. As the Ellsworth Project is located near the confluence of the Union River and Union Bay, the influence of saltwater intrusion into the study area was unclear prior to initiation of this study. As a result, a sub-set of Atlantic salmon smolts were tagged with acoustic transmitters and released downstream of Graham Lake Dam (upstream of Ellsworth Dam). Passage through the Ellsworth facilities for those individuals was determined based on detection within the intakes/penstocks, and detections at a series of acoustic monitors downstream of Ellsworth were used to evaluate passage survival.

In addition to the acoustic-tagged smolts, radio-tagged Atlantic salmon smolts were released upstream of Ellsworth, and their routes of passage were then determined using an array of radio receivers monitoring potential passage routes. Radio telemetry monitoring stations were also installed along the Union River downstream of Ellsworth. Prior to the initiation of this study, it was unclear whether or not an adequate distance from the base of Ellsworth Dam to the downstream monitors existed to ensure the ability to differentiate between live and dead/drifting smolts passing those locations. As a result, drift patterns were evaluated for a number of freshly-dead radio-tagged trout, and salinity readings in the vicinity of the downstream monitoring stations were collected. Information from these activities was used to

inform the validity of survival estimates for the radio-tagged Atlantic salmon smolts passing Ellsworth.

Hatchery-reared Atlantic salmon smolts were obtained from the Green Lake National Fish Hatchery (GLNFH) in Ellsworth, Maine. Releases of surgically-tagged, hatchery-reared individuals were initiated in mid-May and were completed prior to water temperatures reaching 18°C. Releases were conducted at three locations (Figure 2-1):

- Release Site 1 - Upstream of Graham Lake at the Route 181 boat landing;
- Release Site 2 - Upstream of Graham Lake Dam at a point along the western shoreline approximately 0.75 miles upstream of the dam; and
- Release Site 3 - Downstream of Graham Lake Dam at a point along the eastern shoreline approximately 120 feet downstream of Graham Lake Dam.

A total of four release events were conducted during the study. Each release event consisted of 60 radio-tagged study smolts, including 15 each released upstream of Graham Lake, upstream of Graham Lake Dam, and downstream of Graham Lake Dam, as well as 15 acoustic-tagged individuals released downstream of Graham Lake Dam.

The downstream progression of radio-tagged smolts was monitored via a series of stationary telemetry stations installed at selected locations to inform on passage rates and passage success through Graham Lake, Graham Lake Dam, Leonard Lake, and Ellsworth Dam. In addition to the stationary telemetry data collected during the study period, mobile tracking was conducted following the smolt passage period in an effort to determine the final location of radio-transmitters not passing the entire array.

2.2 Telemetry Equipment

The presence of radio-tagged outmigrating Atlantic salmon smolts was recorded on the Union River using a combination of Lotek (SRX_400 and SRX_600) and Sigma Eight (Orion) radio telemetry receivers. Telemetry receivers were used in conjunction with one or more antennas dependent on the intended area of coverage. Several types of antennas were used for this study including three-element, four-element and six-element Yagi antennas, as well as custom-made underwater antennas. Aerial antennas provided directional coverage and were utilized in open areas (e.g., cross-river locations or tailrace). Custom built dropper antennas were placed at appropriate depths within structures and were used to determine points of passage (i.e., downstream bypass and turbine units).

Radio transmitters were purchased from Lotek Wireless (model NTC-3-2) and were digitally encoded on one of two unique frequencies (149.320 or 149.360 MHz). Each transmitter measured 6.0 mm x 16.0 mm, weighed 1.1 g in air, and was programmed by the manufacturer to propagate a signal once every 2.0 seconds. Transmitters used during this study had a manufacturer's warranty for battery life of 31 days.

Downstream movements of acoustic-tagged outmigrating salmon smolts were recorded upstream and downstream of Ellsworth using Vemco VR2W 69 kHz receivers. Acoustic receivers were secured to mooring blocks and deployed by boat for the duration of the study period. Normandeau installed and retrieved acoustic receivers placed in the Union River upstream of Ellsworth. The National Marine Fisheries Service (NMFS) installed and retrieved acoustic receivers placed downstream of Ellsworth in the Union River and Union River Bay.

Acoustic transmitters were purchased from Vemco (model V9-6L) and operated on a frequency of 69 kHz. Transmitters were programmed by the manufacturer for a 20-40 second ping rate for 45 days and a 60-80 second ping rate for the remainder of the operating period. Each acoustic transmitter measured 9.0 mm x 21.0 mm and weighed 2.9 g in air. Vemco V9-6L transmitters have been successfully implanted into salmon smolts with fork lengths down to 150 mm (http://vemco.com/wp-content/uploads/2014/02/v9-coded.pdf).

2.3 Monitoring Stations and Antenna Arrangements

Radio telemetry antennas and data logging receivers were installed at both Graham Lake and Ellsworth Dams, as well as at selected locations upstream and downstream of both facilities to monitor downstream passage of the radio-tagged smolts. A total of 13 stationary radio-telemetry receivers were installed on the Union River during 2016 (identified in this report as U1-U13). Two monitoring stations were associated with the Graham Lake Dam (U2-U3) and six monitoring stations with the Ellsworth Dam (U6-U11). A total of five stationary acoustic-telemetry receivers (identified in this report as U14-U18) were installed on the Union River and Bay during 2016. Two units were moored in the Ellsworth headpond and provided redundant coverage to ensure that no smolts approaching the dam were missed. Three acoustic units were installed at locations downstream of Ellsworth Dam. A description of each monitoring station is provided below, and locations are shown graphically in Figure 2-2.

Monitoring Station U1: This station was located along the western bank at the upper end of Graham Lake at a point approximately 3.4 miles downstream of the Route 181 bridge crossing. It was intended to detect radio-tagged smolts moving downstream from the upper release site and entering Graham Lake. Monitoring station U1 consisted of a single radio-receiver and an aerial antenna oriented perpendicular to the channel.

Monitoring Station U2: This station was located on the upstream face of Graham Lake Dam and was intended to detect radio-tagged smolts approaching the upstream side of the tainter and stoplog gates at that facility. Monitoring station U2 consisted of a single radio-receiver and aerial antenna.

Monitoring Station U3: This station was located on the downstream side of Graham Lake Dam and was intended to detect radio-tagged smolts having passed that facility. Monitoring station U3 consisted of a single radio-receiver and aerial antenna.

Monitoring Station U4: This station was located on the western bank of the Union River at a point approximately 2.1 miles downstream of Graham Lake Dam and was intended to provide

passage information on radio-tagged smolts moving downstream following passage at that facility. Monitoring station U4 consisted of a single radio-receiver and an aerial antenna oriented perpendicular to the river channel.

Monitoring Station U5: This station was located on the western bank of the Union River and near the upper extent of Leonard Lake. Monitoring Station U5 was located at a point approximately 2.6 miles downstream of Graham Lake Dam and 1.5 miles upstream of Ellsworth Dam. It consisted of a single radio-receiver and aerial antenna oriented perpendicular to the river channel.

Monitoring Station U6: This station was located on the eastern bank at a point approximately 200 m (656 feet) upstream of Ellsworth Dam. Monitoring Station U6 consisted of a single radio-receiver and aerial antenna, which was oriented perpendicular to the river channel. This station was intended to detect radio-tagged smolts as they entered the Ellsworth Dam area.

Monitoring Station U7: This station consisted of a single receiver and six custom-made underwater drops. Dropper antennas were positioned within Units 2, 3, and 4 at Ellsworth Station at a point inside of the trash racks and towards the upstream end of the penstocks. All six drops were combined to eliminate lost coverage time associated with a receiver switching through the antennas at each individual unit. As a result, detections of a transmitter passing through Units 2, 3, or 4 were collected as a single data set.

Monitoring Station U8: This station consisted of a single receiver and a pair of custom-made underwater drops, and it was intended to detect radio-tagged smolts passing Ellsworth Dam via one of the two surface weirs located adjacent to Units 2, 3 and 4. The two drop antennas were installed within the concrete chamber located immediately upstream of its confluence with the pipe leading to the sluice located at the western end of the spillway adjacent to Unit 1. Drop antennas were installed at this location to ensure that any radio-tagged individuals detected had committed to passage via that route and were not being detected from areas within the adjacent headpond.

Monitoring Station U9: This station consisted of a single receiver and two custom-made underwater drops. Dropper antennas were positioned within the vent tubes of Unit 1 at a point inside of the trash racks and towards the upstream end of the penstock.

Monitoring Station U10: This station consisted of a single receiver and a custom-made underwater drop antenna, and it was intended to detect radio-tagged smolts passing Ellsworth Dam via the surface weir located adjacent to Unit 1, which exits directly into the sluice located at the western end of the spillway.

Monitoring Station U11: This station was located on the western bank at a point approximately 40 m (131 feet) downstream of Ellsworth Dam. Monitoring Station U11 consisted of a single radio-receiver and aerial antenna, which was oriented perpendicular to the river channel. This station was intended to detect radio-tagged smolts as they passed Ellsworth

Dam and to provide validation of passage via the turbine and bypass routes, or to identify smolt passage via spill (if available).

Monitoring Station U12: This station was located on the eastern bank of the Union River at a point approximately 0.25 miles downstream of Ellsworth Dam. It consisted of a single radio-receiver and an aerial antenna oriented perpendicular to the river channel.

Monitoring Station U13: This station was located on the eastern bank of the Union River at a point approximately 0.4 miles downstream of Ellsworth Dam. It consisted of a single radio-receiver and an aerial antenna oriented perpendicular to the river channel.

Monitoring Stations U14/U15: This station consisted of a pair of underwater Vemco receivers located approximately 200 m (656 feet) upstream of Ellsworth Dam. Monitoring stations 14/15 were intended to detect acoustic-tagged smolts as they entered the Ellsworth Dam project area.

Monitoring Stations U16: This station consisted of an underwater Vemco receiver located approximately 0.7 miles downstream of Ellsworth Dam. Monitoring station 16 was intended to provide passage information on acoustic-tagged smolts moving downstream following passage at Ellsworth Dam. This monitoring station was installed and maintained by NMFS.

Monitoring Stations U17: This station consisted of an underwater Vemco receiver and was located approximately 1.25 miles downstream of Ellsworth Dam. Monitoring station 17 was intended to inform on downstream movements of acoustic-tagged smolts following passage at Ellsworth Dam. This monitoring station was installed and maintained by NMFS.

Monitoring Stations U18: This station consisted of an underwater Vemco receiver located approximately 1.9 miles downstream of Ellsworth Dam. Monitoring station 18 was intended to inform on downstream movements of acoustic-tagged smolts following passage at Ellsworth Dam. This monitoring station was installed and maintained by NMFS.

Each radio-telemetry monitoring station consisted of a data-logging receiver, one or more antennas, and a power source. The monitoring stations were configured to receive signals from a designated area continuously throughout the study period. During installation of each station, range testing was conducted to configure the antennas and receiving stations to maximize detection efficiencies at each of the routes and locations, while minimizing the degree of overlap among adjacent monitoring stations. The operation of the radio-telemetry system as a whole was confirmed throughout the study period by the use of beacon tags. Beacon tags were stationed at strategic locations within the detection range of either multiple or single antennas, and they were programmed to emit a signal at scheduled time intervals. These signals were detected and logged by the receivers and used to record the functionality of the system throughout the study period. Although each monitoring station was installed in a manner which limited its ability to detect transmitters from unwanted areas, the possibility of such detections did still exist. As a result, behavioral data collected in this study (i.e., duration at a specific location or passage route) was inferred based on the signal strength, duration and pattern of contacts documented across the entire detection array.

2.4 Transport, Holding, Tagging and Release Procedures

Hatchery-reared Atlantic salmon smolts were obtained from GLNFH in Ellsworth, Maine. Smolts were transported by Normandeau personnel in an oxygenated hauling tank to a holding facility installed at Ellsworth Dam. Transport personnel followed the criteria specified by GLNFH with regards to hauling densities and water quality standards. Water quality parameters were recorded at periodic intervals during transit to ensure that tank conditions were appropriate for the smolts (Appendix A). Once on site, smolts were maintained in covered 500-700 gallon tanks supplied with flow through river water. A low flow of oxygen was provided to all tanks holding smolts as a safety precaution, in the event that power was lost to the water supply pump.

Prior to tagging, the main anesthetic container and a gravity-fed drip bucket were prepared. Smolts were anesthetized using buffered tricaine methanesulfonate (MS-222) at a concentration of 80 milligram per liter (mg/L) of freshwater. The MS-222 was buffered using sodium bicarbonate in a 1:1 ratio. A gravity-fed bucket containing fresh river water was equipped with rubber tubing leading to an in-line valve. Smolts placed in the main anesthetic container were visually monitored and were removed from anesthesia 15-30 seconds following the loss of equilibrium. While immobile, the smolt was weighed to the nearest gram (g) and measured to the nearest millimeter (mm). The smolt was placed ventral side up and supported by a soft, moist towel. The gravity-fed supply line was inserted into its mouth to provide a continuous supply of fresh river water during the procedure.

Both acoustic and radio-transmitters were surgically implanted. Prior to insertion into the body cavity, the transmitter was activated and its unique ID code verified. An incision was made on the left side of the fish, adjacent to the ventral mid-line and just anterior to the pelvic girdle. For insertion of radio-tags, a catheter was inserted into the incision and was pushed through the body wall just off of the ventral mid-line, at a point posterior to the incision and between the pelvic girdle and anal fin. The radio antenna was fed through the needle and gently pulled so that the transmitter entered the body cavity. The needle was then removed from the antenna. The transmitter was positioned by pulling the antenna so that the transmitter lay directly under the incision. Acoustic transmitters did not have an antenna and were simply inserted into the body cavity. The incision was closed with two to three interrupted sutures (chromic gut with a 4-0 cutting needle) evenly spaced across the incision. A small amount of antibacterial ointment was applied to the incision site to prevent infection. The smolt was immediately transferred to an aerated freshwater holding tank for observation during a 5-minute recovery period. Following recovery from anesthesia, tagged smolts were placed in a larger holding tank and maintained in circulating river water for a minimum of 24 hours to evaluate short-term tagging effects, tag retention, and post-tagging mortality.

Radio and acoustic-tagged smolts were transported in the same holding tanks into which they were placed following tagging. Smolts were moved by truck to the selected release sites. All releases were conducted after sunset. Smolts were placed in the water directly by submerging

the holding/transport tank and allowing the smolts to volitionally exit the container. This was done to prevent any additional netting or direct handling prior to release.

2.5 Tag-life, Retention, Delayed Mortality Assessment

A group of fifteen randomly selected smolts were radio-tagged with active NTC-3-2 transmitters, placed in holding tanks with circulating river water and back-up oxygen, and held for the duration of the study in order to assess the battery life. Operational status of the transmitters in these tagged fish were checked near daily in order to determine the time span for which each of the tags remained operational. In addition to the fifteen radio-tagged smolts assessed for the tag life study, an additional fifteen smolts were tagged with dummy radio tags. This provided a total of 30 tagged smolts to evaluate long-term retention of the radio tags. Incidence of tag loss and post-operative mortality were checked near daily for all 30 individuals. Smolts maintained as part of the tag-life/retention/delayed mortality assessment were handled in a manner identical to each test smolt, so as not to bias the results.

2.6 Downstream Drift Assessment

Prior to the use of downstream detection information from radio-tagged Atlantic salmon smolts to evaluate passage survival at Ellsworth Dam, it was necessary to understand the downstream settlement pattern for smolts killed during dam passage. To accomplish this, five "smolts" (Note: hatchery-reared brook trout were used as a surrogate) were internally radio-tagged following the same approach detailed in Section 2.4, killed, and released into the Ellsworth tailrace (via the downstream bypass sluice located at the western end of the spillway that discharges directly into outflow from the project turbine units). This route of introduction into the tailrace was used in order to ensure that these tagged "smolts" were injected into the project flow and did not become hung up during turbine passage. These five individuals transmitted on a separate frequency than that used for test fish, and the two downstream monitoring stations were programed to detect those tags. In addition, the stretch of the Union River downstream of Ellsworth was manually checked on a periodic basis to determine where the dead "smolts" drifted to.

2.7 Data Analysis

2.7.1 Data Collection and Processing

Data were downloaded from Project receivers on a near daily basis throughout the study period. Back-up copies of all data files were immediately saved to a dedicated flash drive and checked prior to re-initialization of the downloaded receiver. Data were stored in receivers as a single event, which included date, time, channel, code, and signal strength.

Downloaded data files were processed using custom programs developed in-house at Normandeau using SAS (statistical analysis software, Version 9.2; SAS Institute Inc., Cary, North Carolina). Tag detections in each downloaded data file were validated and filtered based on a series of site-specific and logical criteria: These criteria included:

1. Power threshold level of the signal,

2. Frequency of the radio-tag signals per unit of time, and
3. Spatial and temporal distribution of the radio signals detected at monitoring stations both at and between the dams.

Information related to the power threshold for a valid tag signal versus power levels associated with background noise were determined at each monitoring station prior to the release of any radio-tagged smolts. These "false" signals were typically at relatively low power levels and were removed from the analysis using a series of data filters. The frequency of the signal detections for an individual radio-tag was examined at each monitoring station, such that over a period of time adequate number of detections were available to rule out an isolated false detection (e.g., at least 3 detections within 1 minute). Finally, the spatial and temporal distributions of detections across multiple monitoring stations for each individual smolt were examined to verify that the pattern of detections was not unreasonable (i.e., for a fish to have relocated within the time between the detections).

In addition to the telemetry data collections, information on river flow and project operational data was obtained for Graham Lake and Ellsworth Dams. Water temperature in the Union River was collected using a HOBO data logger installed in the headpond above Ellsworth Dam and set to record at one hour intervals for the duration of the study.

2.7.2 Determination of Passage Route, Travel Times and Movement Rates

Following the completion of file processing using SAS, a complete record of all valid detections for each tagged salmon smolt was generated. The time series of detections for individual smolts equipped with radio-tags were evaluated to determine a route of passage at Ellsworth Dam. An arrival time into the area above the dam was determined based on detections recorded by Monitoring Station U6; the subsequent pattern of detections was then reviewed and the time and route of passage determined. In instances where a route could not be clearly determined from the collected data, the passage event for that particular smolt was classified as unknown.

Where data were available, residence times in the nearfield area upstream of Graham Lake and Ellsworth Dams, as well as downstream transit times, were calculated for smolts. Residence times were calculated as the duration of time from the initial upstream (Monitoring Station U2 at Graham Lake Dam and Monitoring Station U6 at Ellsworth Dam) until the final detection at one of the monitored passage routes (e.g., bypass, turbine). Residence times were calculated only for radio-tagged smolts at Graham Lake Dam, and for both radio and acoustic-tagged smolts at Ellsworth Dam. Downstream transit times were calculated as the duration of time from the peak signal strength of detection at an upstream location to the peak signal strength of detection at a downstream location.

In addition to travel times, rates of movement (ROM) for tagged smolts moving through river segments between monitoring stations were calculated using the formula:

$$ROM_{ab} = D_{ab} / (T_b - T_a)$$

where: ROM_{ab} = the rate of movement between stations *a* and *b*

D_{ab} = the distance (miles) between stations *a* and *b*

T_b = the date/time detected at station *b*

T_a = the date/time detected at station *a*

Rates of movement were calculated for radio-tagged Atlantic salmon smolts within the following study reaches (approximate distance):

Release Site 1 to Monitoring Station U1 (3.4 miles)
Monitoring Station U1 to Graham Lake Dam (11.3 miles)
Release Site 2 to Graham Lake Dam (0.75 miles)
Graham Lake Dam to Monitoring Station U4 (2.1 miles)
Monitoring Station U4 to Monitoring Station U5 (0.5 miles)
Monitoring Station U5 to Ellsworth Dam (1.5 miles)
Ellsworth Dam to Monitoring Station U12 (0.25 miles)
Monitoring Station U12 to Monitoring Station U13 (0.15 miles)

Rates of movement were calculated for acoustic-tagged Atlantic salmon smolts within the following study reaches (approximate distance):

Release Site 3 to Ellsworth Dam (4.1 miles)
Ellsworth Dam to Monitoring Station U16 (0.7 miles)
Monitoring Station U16 to Monitoring Station U17 (0.55 miles)
Monitoring Station U17 to Monitoring Station U18 (0.65 miles)

2.7.3 Determination of Project Dam Passage Survival Estimates

As noted in the March 31, 2015 study plan, monitoring data collected from tagged Atlantic salmon smolts were used to determine passage survival at both Graham Lake and Ellsworth Dams. Due to release at some distance upstream of the two Project dams, smolts from release locations 1, 2, and 3 may have been exposed to additional sources of mortality in the reservoir(s) unrelated to passage at the dam(s). In order to differentiate these reservoir effects, smolts that were determined to have approached within 200 meters (656 feet) of a dam were selected to comprise a 'virtual release group' in the subsequent dam survival analysis. Members of this virtual release group were determined to have survived passage at the Project dams if they were detected at downstream locations. At Graham Lake Dam, passage survival was estimated for the 'virtual' subset of radio-tagged smolts from releases conducted at release locations 1 and 2 (upstream of Graham Lake dam). At Ellsworth Dam, passage survival was estimated for the 'virtual' subset of acoustic-tagged smolts from releases conducted at release location 3 (downstream of Graham Lake dam). Following review of the draft evaluation for fresh-killed "smolts" at Ellsworth Dam (see Section 2.6 above), the dam passage survival estimates for Ellsworth Dam were supplemented with information collected from radio-tagged smolts released at locations 1, 2, and 3. Using a bootstrap sampling procedure (25,000 bootstrap

samples randomly drawn with replacement), a 95% confidence interval (CI) was calculated for each dam passage survival estimate.

2.7.4 Determination of "Timely" Project Dam Passage

As part of separate ongoing Atlantic salmon smolt dam passage survival studies on the Kennebec, Androscoggin and Penobscot Rivers, the participating resource agencies (NMFS, Maine Department of Marine Resources (MDMR), U.S. Fish and Wildlife Service (USFWS)) have requested that the potential impact of extended residence times be examined. This same "timely" passage criteria (an upstream residence duration of ≤ 24 hours) was evaluated at the Graham Lake and Ellsworth Dams, based on its application at other hydroelectric projects within the defined critical habitat. An estimate of dam passage success was calculated and considered individuals which (1) suffered mortality during passage or (2) demonstrated an upstream residence time of ≤ 24 hours. Using a bootstrap sampling procedure (25,000 bootstrap samples randomly drawn with replacement), a 95% CI was calculated for each dam passage success estimate.

2.7.5 Determination of Reach-Specific Survival and Detection Probabilities

In addition to the calculation of dam passage survival, survivorship (*Phi*) and detection (*p*) probabilities were estimated between monitoring locations through a series of Cormack-Jolly Seber (CJS) models constructed using Program MARK (White and Burnham 1999). Parameter estimates for *Phi* and *p* were obtained using the individual encounter histories constructed for each smolt. For this analysis, a suite of CJS models were evaluated based on whether survival, recapture (i.e., detection), or both vary or are constant among stations. These models included:

- *Phi*(t) *p*(t): survival and recapture may vary between receiver stations;
- *Phi*(t)*p*(.): survival may vary between stations; recapture is constant between stations;
- *Phi*(.)*p*(t): survival is constant between stations; recapture may vary between stations; and
- *Phi*(.)*p*(.): survival and recapture are constant between stations.

Where;

- *Phi* = probability of survival
- *p* = probability of detection
- (t) = parameter varies
- (.) = parameter is constant

Akaike's Information Criterion (AIC) was used to rank the models as to how well they fit the observed mark-recapture data. Lower AIC values denote a more explanatory yet parsimonious fit than higher AIC values. Assuming the assumptions of the model with the lowest AIC value were reasonable with regards to this study, it was selected for the purposes of generating MARK-derived reach-specific survival estimates. Survivorship estimates (*Phi*) were determined for radio-tagged smolts moving through the following reaches:

- Monitoring Station U1 to upstream of Graham Lake Dam
- Upstream of Graham Lake Dam (Stn U2) to downstream of Graham Lake Dam (Stn U3)
- Downstream of Graham Lake Dam (Stn U3) to Monitoring Station U4

- Monitoring Station U4 to Monitoring Station U5
- Monitoring Station U5 to Monitoring Station U6
- Monitoring Station U6 to Ellsworth Dam
- Ellsworth Dam to Monitoring Station U12

Survivorship estimates (*Phi*) were determined for acoustic-tagged smolts moving through the following reaches:

- Release Site 3 to Ellsworth headpond (4.1 miles)
- Ellsworth headpond to Monitoring Station U16 (0.7 miles)
- Monitoring Station U16 to Monitoring Station U17 (0.55 miles)

Detection probabilities (*p*) were determined for radio-tagged smolts passing the following locations:

- Monitoring Station U2
- Monitoring Station U3
- Monitoring Station U4
- Monitoring Station U5
- Monitoring Station U6
- Ellsworth Dam
- Monitoring Station U12

Detection probabilities (*p*) were determined for acoustic-tagged smolts passing the following locations:

- Ellsworth headpond (Stns U14/U15)
- Monitoring Station U16
- Monitoring Station U17

Asymmetric ranges of the 95% and 75% CIs around the survivorship probabilities were calculated. The 95% CIs around mean parameter estimates resultant from CJS models in MARK are based on the assumption of an asymptotically normal distribution on the logit scale. By default, MARK uses α=0.05 for calculation of CIs. As a result, the 95% CIs were calculated as:

$$\beta_i \pm 1.96(SE)$$

where β_i is the mean parameter estimate on the logit scale, SE is the standard error of $\bar{x}$, and 1.96 is the critical t-value containing 95% of a normal distribution.

After the calculation of the upper and lower 95% confidence limits, all estimates were back transformed from the logit scale to the original scale of the data (0.00-1.00). The mean and confidence limits were back transformed from the logit scale as:

$$\bar{x} = Logit(\beta_i)^{-1} = \frac{e^{\beta_i}}{1 + e^{\beta_i}}$$

where $\bar{x}$ is the mean parameter estimate or the confidence limit on the original scale of the data, and β_i is the mean parameter estimate or confidence limit on the logit scale. The back-transformed values are referred to as "real parameter estimates" in MARK. In order to calculate the 75% CI for survival estimates in MARK, the same procedure was used. The only difference between the calculations of 95% and 75% CI values is that the critical t-value used for calculating 75% CIs on the logit scale is 1.15 (the critical t-value containing 75% of a normal distribution).

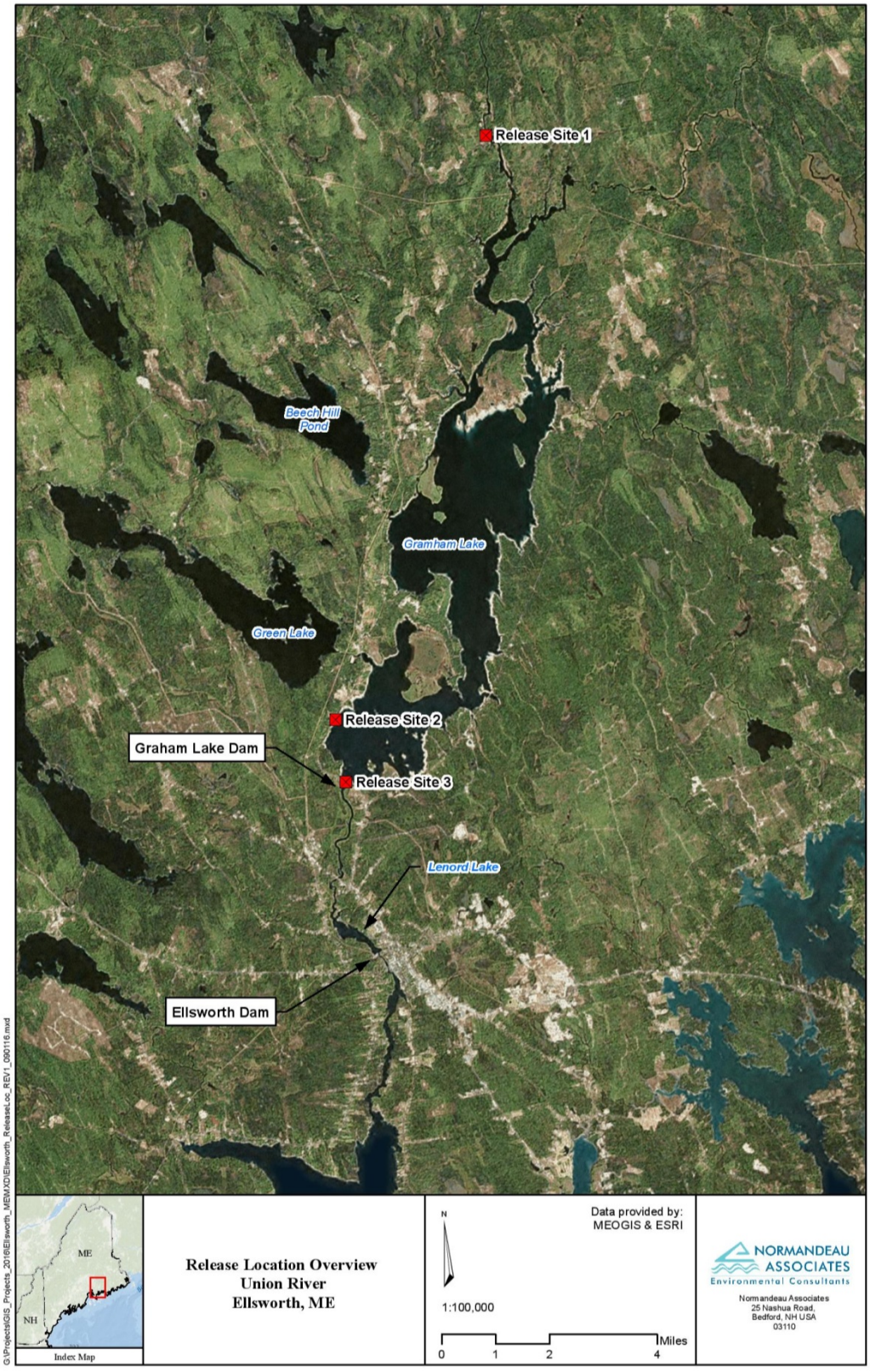

Figure 2–1. 2016 Ellsworth Project Atlantic salmon smolt release locations.

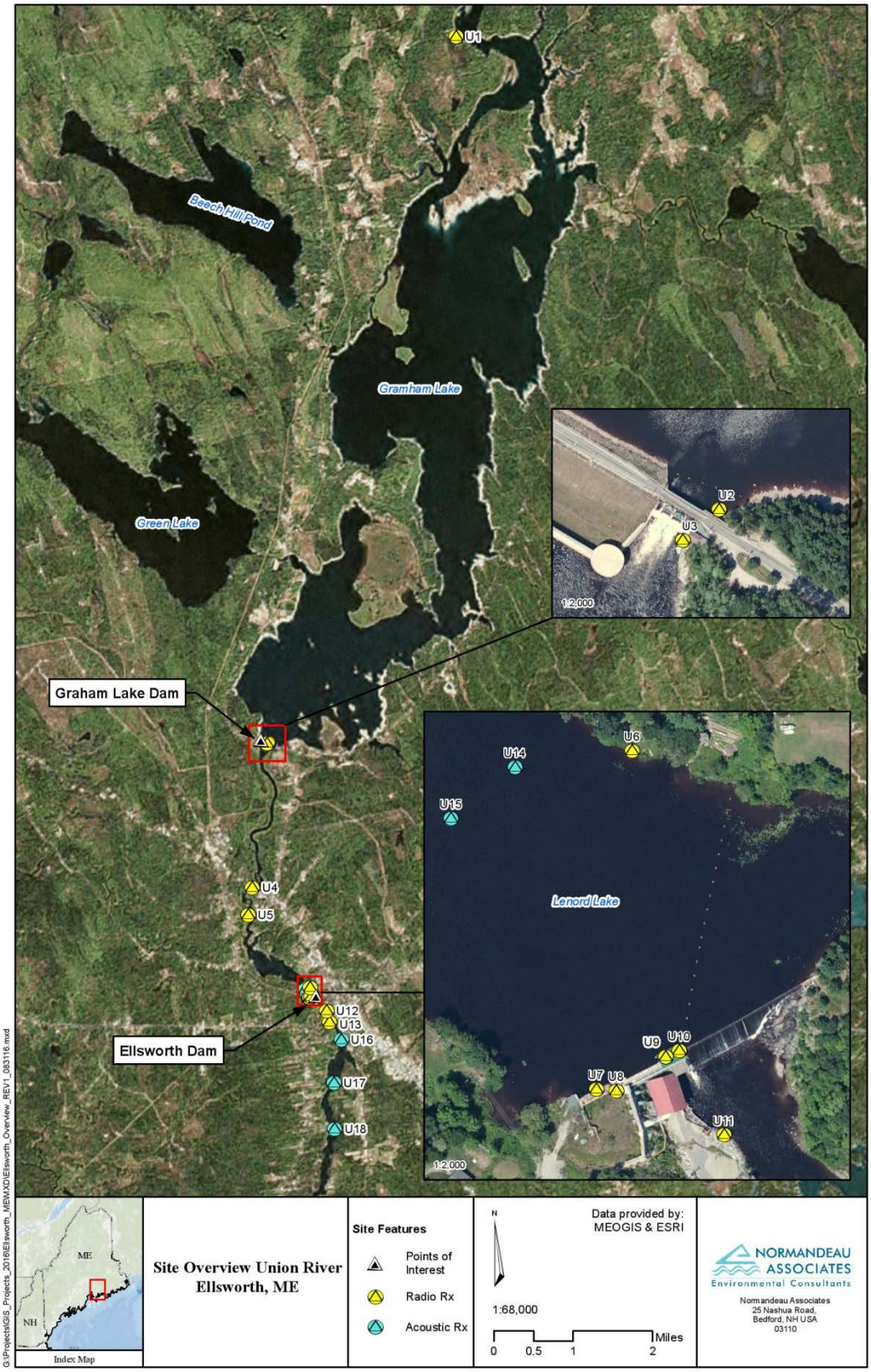

Figure 2–2. 2016 Ellsworth Project radio and acoustic-telemetry monitoring stations.

3.0 Tag-life, Retention, Delayed Mortality Assessment

3.1 In-River Test Smolts

All salmon smolts tagged for release at Ellsworth during 2016 were held for a minimum of 24 hours to assess tag retention and handling-induced mortality. Following radio-tagging, smolts (n=181) were held an average of 33.4 hours (range = 29.7-35.0 hours). Atlantic salmon smolts receiving acoustic transmitters (n=60) were held for an average of 30.1 hours (range = 28.2-31.2 hours) prior to release downstream of Graham Lake Dam. There were no observed mortality events among radio or acoustic-tagged smolts during the post tagging evaluation at Ellsworth.

3.2 In-Tank Test Smolts

In addition to assessing tag retention and 24-hour mortality of surgically-tagged smolts prior to release into the Union River, an additional group of smolts were surgically tagged and maintained in holding tanks at Ellsworth to assess long-term effects. A total of fifteen randomly selected smolts were radio-tagged with active NTC-3-2 transmitters, and an additional fifteen smolts were radio-tagged with dummy NTC-3-2 transmitters (Table 3-1). Tagging took place on May 10, 2016.

All tank test smolts were maintained at Ellsworth for a total of 12 days. Checks on transmitter operation throughout the course of the study indicated that 100% of the NTC-3-2 transmitters were still operating properly (i.e., battery was active, and signal was being broadcast every 2.0 seconds) for the duration of the holding test. In addition, tag retention was 100%, and the observed delayed mortality rate was 0% for smolts tagged and maintained in the Ellsworth holding tank. Given the battery effectiveness, tag retention, and survival rates of 100% at 12 days, battery failure, tag expulsion, and mortality due to handling/surgery were not expected to significantly bias survival rates calculated at Ellsworth during 2016.

3.3 Downstream Drift Assessment

Hatchery-reared brook trout were obtained for use in evaluating downstream drift patterns of dead “smolts” at the Ellsworth Dam. A total of five individuals (mean FL = 187 g; mean W = 123 g) were killed, radio-tagged, and then released into the Ellsworth Dam tailrace. Releases took place between 0800 and 0900 on May 21, 2016. Operations at the time of release included Unit 3 as well as the downstream bypass system. Each of the five “smolts” was confirmed to have entered the tailrace, and their tags were active immediately following release. There were no detections for any of the five dead trout at Monitoring Stations U12 or U13 for the period of time from release until receivers were removed from those two locations on June 1, 2016. Each of the five transmitters was confirmed as present in the immediate tailrace area below Ellsworth Dam on June 1, 2016. In addition, salinity readings collected along the shoreline in the vicinity of Monitoring stations U12 and U13 were zero on all dates sampled. As a result, downstream drift of “smolts” killed during passage at Ellsworth Dam was considered to be minimal under the flow conditions observed during the 2016 study.

Table 3-1. Summary of tag dates and biological information (fork length, weight) for Atlantic salmon smolts surgically tagged and maintained for evaluation of delayed survival, tag retention, and transmitter operation during 2016

Tag Date	Release Date	Transmitter		Fork Length (mm)			Weight (g)		
		Type	Number	Mean	Min	Max	Mean	Min	Max
10-May	21-May	Active	15	194	170	215	72	53	98
10-May	21-May	Dummy	15	197	169	218	75	50	100

4.0 2016 Study Findings

4.1 Ellsworth Operations and Union River Conditions

Hourly Union River discharge values at Ellsworth Dam are presented graphically in Figure 4-1. The mean Union River discharge for the entire study period (May 11 – May 31, 2016) was 478 cfs. Based on the long-term monthly flow duration curve (Figure 4-2), the normal monthly median flow for the site is approximately 900 cfs during May. Relative to the May long-term flow duration curve for the Union River at Ellsworth, river flows observed during the 2016 study period were low.

Flow discharges through Units 1-4 are presented in Figure 4-3. These values were obtained using recorded megawatt (MW) values for each unit and a station conversion factor. Units 1 and 4 (vertical shaft propeller turbines) were offline for the duration of the 2016 smolt study. Units 2 and 3 (vertical shaft Kaplan turbines) operated intermittently during the study period, with Unit 2 operating approximately 46% of the study period and Unit 3 operating approximately 88% of the study period. Non-unit discharge at Ellsworth was provided via three stoplog-controlled surface weirs leading to a common sluice passing downstream on the western side of the spillway. Discharge via this route was near constant at 60 cfs for the duration of the study period (Figure 4-4). There was no spill over the spillway section for the duration of the monitoring period.

Downstream passage at Graham Lake Dam is provided via a 4-foot wide overflow weir controlled by stoplogs. The Graham Lake Dam downstream sluice was open full (i.e., all stop logs removed) for the duration of the 2016 smolt monitoring period. The crest elevation for that sluice is 96.7′,the long-term average pond elevation for the study period is approximately 104.16′ and the licensed full pond elevation of Graham Lake is 104.2′. Figure 4-5 presents hourly lake level values for Graham Lake along with the calculated depth of spill through the downstream sluice. The lake level in Graham Lake was approximately 1.5 feet lower than the long-term average elevation or licensed full pond elevation for the study period. Spill depths through the downstream sluice ranged between 5.5 to 6.5 feet (approximately 150 and 200 cfs, respectively). In addition to the downstream sluice, one of the bottom opening radial gates at Graham Lake Dam was partially opened to provide the required minimum flow for the duration of the study (Figure 4-6).

Union River water temperatures were recorded at Ellsworth for the duration of the study and are presented in Figure 4-1. Mean daily water temperature ranged between 11.6 and 20.6°C

during the study period May 11 to May 31, and between 12.5 and 15.6°C for smolt release events.

4.2 Monitoring Coverage

Figure 4-7 presents the coverage provided by each of the thirteen stationary radio-telemetry receivers installed in the vicinity of Graham Lake and Ellsworth Dams during 2016. Station coverage was determined by beacon transmitter detections, and by field personnel observations while conducting the near daily receiver checks and data downloads. Each of the thirteen monitoring stations operated with no issues for the duration of the study. Minor breaks in coverage occurred during offload of data from the receivers by Normandeau personnel during the study. These periods were recorded in the log sheet maintained for each receiver station.

4.3 Transport, Tagging, and Release

A total of 294 Atlantic salmon smolts were obtained from GLNFH between May 9 and 14, 2016 and were transported to the holding facilities located at Ellsworth (Table 4-1). Smolts were surgically tagged at that location, and were then transported by truck to upstream release sites. A total of 181 radio-tagged and 60 acoustic-tagged smolts were released over four dates (241 total tagged smolts; May 11, 14, 18, and 22). Each release consisted of 15 radio-tagged smolts at release location 1 (i.e., the upper end of Graham Lake), 15 radio-tagged smolts at release location 2 (i.e., point located upstream of Graham Lake Dam), and 15 radio and 15 acoustic-tagged smolts at release location 3 (i.e., point located immediately downstream of Graham Lake Dam).

Fork length for hatchery-reared Atlantic salmon smolts released at Ellsworth in 2016 ranged between 163 - 229 mm (mean = 195 mm), and their weight ranged between 40 - 111 g (mean = 72 g; Table 4-2).

4.4 Smolt Movements and Passage

Stationary telemetry data collected at radio-telemetry stations U1-U13 and acoustic-telemetry stations U14-U18 were used to identify travel times and rates of movement through various river reaches, as well as to provide passage route information at Ellsworth Dam.

4.4.1 Graham Lake Passage

A total of 60 radio-tagged Atlantic salmon smolts were released at the upper end of Graham Lake (release location 1) over the duration of the study period (Table 4-2). Of those individuals, 47 (78%) were determined to have passed Monitoring Station U1. A total of 13 radio-tagged smolts were lost in the 3.4 mile stretch of Union River from the release site to the first downstream receiver. Losses here were likely a combination of tagging effects as well as predation. Of those 47 smolts reaching Monitoring Station U1, 41 (87%) were detected at Monitoring Station U2, indicating that they located the outlet at the downstream end of Graham Lake. The percentage of radio-tagged smolts successfully transiting Graham Lake varied among release groups; 92% (11 of 12 smolts) for release group 1, 100% (13 of 13 smolts) for release group 2, 70% (7 of 10 smolts) for release group 3, and 83% (10 of 12 smolts) for release group 4. Overall, 87% (41 of 47 smolts) detected at Monitoring Station U1 reached Graham Lake Dam.

Table 4-3 presents the minimum, maximum, mean and median transit times for radio-tagged smolts released at the upper end of Graham Lake to travel from the release location to Monitoring Station U1 (a distance of 3.1 miles), and from Monitoring Station U1 to arrival at the upstream side of Graham Lake Dam (Monitoring Station U2; a straight line distance of approximately 11.3 miles). When smolts from all four release groups are considered, the median travel time from release to Monitoring Station U1 was 24.8 hours, while median travel time from that point until arrival at the upstream side of Graham Lake Dam was 123.3 hours (approximately 5.1 days). The frequency distribution for transit times for radio-tagged smolts from release location 1 to Monitoring Station U1 and from Monitoring Station U1 to arrival at Graham Lake Dam are presented in Figures 4-8 and 4-9, respectively.

4.4.2 Graham Lake Dam Passage

Passage through Graham Lake Dam was assessed using (1) the subset of radio-tagged smolts successfully transiting Graham Lake from release location 1, and (2) an additional 60 radio-tagged smolts released into lower Graham Lake at release location 2, approximately 0.75 miles upstream of the dam. Of the 60 radio-tagged smolts stocked at release location 2, 59 (98%) were determined to have arrived at Graham Lake Dam based on detection at Monitoring Station U2. The minimum, maximum, mean and median transit times for radio-tagged smolts from release location 2 to arrival at Graham Lake Dam are presented in Table 4-4. The majority of individuals from release location 2 were detected at the upstream side of Graham Lake Dam within 70 hours of release (Figure 4-10).

Residence time at Graham Lake Dam was calculated for radio-tagged smolts as the duration from their initial time of arrival (Monitoring Station U2) to their determined time of downstream passage (Monitoring Station U3). When all radio-tagged smolts arriving at and passing Graham Lake Dam were considered, the median residence time was 79.8 hours (Table 4-5; range 2.1 – 287.4 hours). Residence time from arrival to passage was greater than 24 hours for the majority of radio-tagged smolts at Graham Lake Dam (Figure 4-11).

Figure 4-11a presents the timing (by hour of the day) of smolt passage at Graham Lake Dam by release group. Although likely limited by sample size (n = 22), the timing of downstream passage events at Graham Lake Dam did not appear to be influenced by time of day as events occurred across the full range of day and night time hours. However, when passage success of radio-tagged smolts moving downstream of Graham Lake Dam is examined (Figure 11b), all individuals passing Graham Lake Dam and failing to reach the first downstream monitoring station occurred during daylight hours.

4.4.3 Union River and Leonard Lake Passage

Passage of Atlantic salmon smolts moving downstream from the Graham Lake Dam tailrace and approaching the Ellsworth Dam was monitored for both radio and acoustically-tagged individuals. Movement of radio-tagged smolts through the Union River reach downstream of Graham Lake Dam and Lake Leonard was evaluated for (1) the subset of smolts from release location 1 which successfully transited Graham Lake and passed at Graham Lake Dam, (2) the subset of smolts from release location 2 which successfully passed at Graham Lake Dam, and (3) an additional 61 smolts released immediately below Graham Lake Dam.

The minimum, maximum, mean and median transit times for radio-tagged smolts from those three groups between Monitoring Station U3/release location 3 (i.e., Graham Lake Dam tailrace) to Monitoring Station U4, Monitoring Station U4 to U5, and Monitoring Station U5 to U6 (i.e., Ellsworth Dam headpond) are presented in Table 4-6. When radio-tagged smolts from all three release locations are considered, transit times through the three reaches downstream of Graham Lake Dam and delineated by stationary radio-telemetry equipment were relatively quick. The majority of radio-tagged smolts moved from the Graham Lake Dam tailrace to Monitoring Station U4 in under 7.5 hours, from Monitoring Station U4 to U5 in under 2.5 hours, and from Monitoring Station U5 to Ellsworth Dam in under 7.5 hours (Figures 4-12, 4-13, and 4-14, respectively).

Movement of acoustic-tagged smolts through the Union River reach downstream of Graham Lake Dam and Lake Leonard was evaluated for a total of 60 smolts released immediately below Graham Lake Dam. Of the 60 acoustic-tagged smolts stocked at release location 3, 57 (95%) of those were determined to have arrived at Ellsworth Dam based on their detection at Monitoring Stations U14/U15. The minimum, maximum, mean and median transit times for acoustic-tagged smolts from the Graham Lake Dam tailrace to the Ellsworth Dam are presented in Table 4-7. The median transit time for an acoustically-tagged smolt to move from the Graham Lake Dam tailrace to a point just upstream of Ellsworth Dam (a distance of ~ 4.1 miles) was 26.1 hours. The frequency distribution of transit times from Graham Lake Dam to Ellsworth for the set of acoustic-tagged smolts is presented in Figure 4-15.

4.4.4 Ellsworth Dam Passage

Upstream residence time and passage at Ellsworth Dam were examined using (1) the subsets of radio-tagged smolts arriving at Ellsworth dam from release locations 1, 2, and 3, and (2) the subset of acoustic-tagged smolts from release location 3. Of the radio-tagged smolts released upstream, 7% (4 of the 60) stocked at release location 1, 13% (8 of the 60) stocked at release location 2, and 97% (59 of the 61) stocked at release location 3 reached Ellsworth Dam (Table 4-8). Of the acoustic-tagged smolts released upstream, 95% (57 of the 60) reached Ellsworth Dam (Table 4-8).

Residence time at Ellsworth Dam was calculated for radio-tagged smolts as the duration from their initial time of arrival (Monitoring Station U6) to their determined time of downstream passage. For acoustic-tagged smolts, the residence time was the time duration from their initial to final detections at Monitoring Stations U14 and U15. When all radio-tagged smolts arriving at Ellsworth Dam were considered, the median residence time was 17.9 hours (Table 4-9; range = 0.6 – 213.0 hours), while for acoustic-tagged smolts the median residence time was 21.9 hours (range = 0.1 – 355.7 hours). Residence time from arrival to passage was less than 20 hours for the majority of radio-tagged smolts, and less than 30 hours for the majority of acoustic-tagged smolts at Ellsworth Dam (Figures 4-16 and 4-17, respectively).

A total of 71 radio-tagged individuals were available for the evaluation of passage route selection at Ellsworth. Table 4-10 presents the observed distribution of route selection among individuals approaching Ellsworth. It is important to note that Units 1 and 4 were not operated and there was no spill over the Ellsworth Dam spillway throughout the study period. As a result, passage was limited to the downstream fishway and Units 2 and 3. Of the radio-tagged smolts determined to have approached Ellsworth Dam, 93% (66 of the 71) passed the dam. Of

the 66 individuals passing, 59% (39 of the 66) passed via Units 2/3, 30% (20 of the 66) passed via the downstream fishway bypass entrances adjacent to Units 2/4, 8% (5 of the 66) passed via the downstream bypass entrance adjacent to the spillway, and 3% (2 of the 66) passed via an unknown route. The percentage of radio-tagged smolts passing Ellsworth via the downstream bypass increased during releases 3 and 4 (Table 4-10) which coincided with operation of a single unit (Unit 3; Figure 4-3).

Figure 4-18 presents the timing (by hour of the day) of smolt passage at Ellsworth Dam by release group. The majority of passage events at Ellsworth took place during the late evening and early morning hours.

4.4.5 Lower Union River Passage

Passage of Atlantic salmon smolts moving downstream from the Ellsworth Dam was monitored for both radio and acoustically-tagged individuals. Movement of radio-tagged smolts through the Union River reach downstream of Ellsworth Dam was examined using both the subset of radio-tagged smolts originating at release locations 1, 2, and 3 and the subset of acoustic-tagged smolts originating at release location 3 which successfully passed the Project. The minimum, maximum, mean and median transit times for radio-tagged smolts following passage at Ellsworth Dam to Monitoring Station U12 and between Monitoring Stations U12 and U13 are presented in Table 4-11. The median transit time following passage at Ellsworth Dam to reach Monitoring Station U12 (located approximately 0.25 miles downstream) was 0.2 hours when radio-tagged smolts from all release groups were considered. Similarly, the median transit time for radio-tagged smolts from all release groups was 0.1 hours to move between Monitoring Stations U12 and U13, a distance of approximately 0.15 miles. Frequency distributions for the observed transit times for both of these reaches are presented in Figures 4-19 and 4-20, respectively.

The minimum, maximum, mean and median transit times for acoustic-tagged smolts following their final detection upstream of Ellsworth Dam to Monitoring Station U16, between Monitoring Stations U16 and U17, and between Monitoring Stations U17 and U18, are presented in Table 4-12. Median transit times for acoustic-tagged smolts moving downstream through the comparable reach lengths between the Ellsworth Dam nearfield approach and Monitoring Station U16, Monitoring Stations U16 and U17, and Monitoring Stations U17 and U18 were comparable, 0.7, 0.9, and 0.9 hours, respectively. Frequency distributions for the full set of observed transit times for acoustic-tagged smolts for these three reaches are presented in Figures 4-21, 4-22 and 4-23.

4.4.6 Rate of Movement

In addition to the transit time information presented in Sections 4.4.1 through 4.4.5 above, rates of movement (ROM) were calculated for radio and acoustic-tagged salmon smolts moving through defined reaches (See Section 2.7.2). Appendix B provides the minimum, maximum, mean and median ROM for surgically-tagged smolts out-migrating through the Union River and Ellsworth Project area.

4.5 Project Dam Passage Survival and Passage Success Estimates

4.5.1 Graham Lake Dam

When smolts from release locations 1 and 2 are considered, a total of 100 radio-tagged individuals approached Graham Lake Dam and were determined to be present within the area immediately upstream of the facility. Only 23%, or 23 of the 100 radio-tagged smolts determined to have reached Graham Lake Dam passed the facility.

When considering the 23 radio-tagged smolts that passed the Graham Lake Dam, 14 or 61% survived passage at the dam. When radio-tagged smolts which approached but did not pass are included as mortalities, a dam passage survival rate of 14.0% (95% CI = 8.0-21.0%) was calculated for Graham Lake Dam during 2016 (Table 4-13). When adjusted for prolonged residence times (defined as those greater than 24 hours), a dam passage success estimate of 2.0% (95% CI = 0.0-7.0%) was calculated for Graham Lake Dam during 2016 (Table 4-14).

4.5.2 Ellsworth Dam

A total of 60 Atlantic salmon smolts were tagged with acoustic transmitters for the primary purpose of determining passage survival at Ellsworth Dam. Of that total, 57 individuals approached Ellsworth Dam and were determined to be within the area immediately upstream of that facility. As determined based on downstream detection, a dam passage survival rate of 73.7 (95% CI = 61.4-84.2%) of acoustic-tagged smolts was calculated for Ellsworth Dam (Table 4-15). When adjusted for prolonged residence times (defined as those greater than 24 hours), a dam passage success estimate of 45.6% (95% CI = 33.3-59.6%) was calculated for acoustic-tagged smolts at Ellsworth Dam during 2016 (Table 4-16).

Following determination that "smolts" killed during passage at Ellsworth Dam did not drift downstream to Monitoring Stations U12 and U13 (See Section 3.3), dam passage survival was also calculated for the subset of radio-tagged Atlantic salmon smolts which approached the facility. A total of 71 radio-tagged individuals approached Ellsworth Dam and were available for use in the evaluation of dam survival (Table 4-17). As determined based on downstream detection, a dam passage survival rate of 74.6% (95% CI = 64.8-84.5%) of radio-tagged smolts was calculated for Ellsworth Dam (Table 4-17). When adjusted for prolonged residence times (defined as those greater than 24 hours), a dam passage success estimate of 53.5% (95% CI = 47.8-70.4%) was calculated for radio-tagged smolts at Ellsworth Dam during 2016 (Table 4-18).

Where information was available, dam passage survival for radio-tagged smolts passing Ellsworth Dam was evaluated by passage route (Table 4-19). When all release groups are considered, passage survival at Ellsworth Dam was 96% for smolts passing via the downstream bypass system and 69% for smolts passing via Units 2 and 3.

4.6 Reach Specific Survival Estimates and Detection Probabilities

Table 4-20 presents the results from the suite of CJS models run to evaluate detection probability and reach survival estimates using Program MARK for radio-tagged smolts released in the Union River during the 2016 study. Detection probabilities (Table 4-21) and reach survival estimates (Table 4-22) for radio-tagged smolts were derived from the model with the lowest AIC value. The asymmetric ranges for the 95% and 75% CIs around the survivorship probabilities were also calculated and are presented in Table 4-23 for the full set of radio-tagged

Atlantic salmon smolts. Calculated detection probabilities (release groups E1-E4 pooled) ranged from 93-100% among the seven locations evaluated for radio-tagged smolts. When all release groups are considered, individual reach survival estimates were highest for radio-tagged smolts passing through upper Lake Leonard (99%) and the adjacent section of the Union River immediately upstream (97%). Individual reach survival estimates were lowest for passage at Graham Lake Dam (23%), the 2.1 mile reach of the Union River immediately downstream of Graham Lake Dam (59%), and the 0.25 mile reach of the Union River immediately downstream of Ellsworth Dam (80%). The reach survival estimate for radio-tagged smolts traveling through Graham Lake was 86%. A cumulative estimate of survival for the reach as a whole (i.e., from the upper reach of Graham Lake downstream to a point approximately 0.25 miles below Ellsworth Dam) for radio-tagged smolts during 2016 was 8.3%; this cumulative survival estimate was determined by calculating the product of each individual reach estimate.

Table 4-24 presents the results from the suite of CJS models run to evaluate detection probability and reach survival estimates using Program MARK for acoustic-tagged smolts released during the 2016 study. Detection probabilities (Table 4-25) and reach survival estimates (Table 4-26) for acoustic-tagged smolts were derived from the model with the lowest AIC value. The asymmetric ranges for the 95% and 75% CIs around the survivorship probabilities were also calculated and are presented in Table 4-27 for the full set of acoustic-tagged Atlantic salmon smolts. The calculated detection probabilities were 100% for each of the installed acoustic receivers. When all release groups are considered, individual reach survival estimates were highest for acoustic-tagged smolts passing through the lower Union River (100%) and from the Graham Lake Dam tailrace to Ellsworth Dam (95%). The reach survival estimate from just above the Ellsworth Dam to the first downstream acoustic monitoring station (U16) was 73%. A cumulative estimate of survival for the reach as a whole (i.e., from the Graham Lake Dam tailrace downstream to a point approximately 1.9 miles below Ellsworth Dam) for acoustic-tagged smolts during 2016 was 69.4%, the product of each individual reach estimate.

Encounter histories used in the generation of detection and survivorship probabilities for radio and acoustic-tagged smolts released at Ellsworth can be found in Appendix C.

4.7 Additional Movement Data

In addition to the stationary telemetry data, manual tracking was conducted following the 2016 stationary monitoring period in an effort to identify the final disposition of radio-tagged smolts which did not fully pass the study area. Manual tracking consisted of land-based (i.e., foot and truck) and boat tracking. Tracking covered the reach from release location 1, at the Route 181 bridge crossing upstream of Graham Lake, downstream to Monitoring Station U13, approximately 0.4 miles downstream of Ellsworth Dam. Manual searches of the study area took place on June 1-2 and June 7-8, 2016. Table 4-28 presents the release group, release location, and last known manually confirmed location recorded for radio-tagged smolts determined to have not reached stationary receivers located downstream of Ellsworth Dam. A total of 23 radio-transmitters were detected during manual tracking efforts. Last known manually confirmed locations for radio-tagged smolts identified during tracking were in agreement with the encounter history assembled for each individual based on detections at dams and associated downstream monitoring stations. A total of sixteen radio-transmitters were detected within

Graham Lake at locations between 8.9-<0.1 miles upstream of the facility. Each of those radio-tagged smolts was determined to have spent a period of residence immediately upstream of Graham Lake Dam prior to departing or being predated. Similarly, the three radio-tagged smolts detected between 0.9 and 1.2 miles upstream of Ellsworth Dam were confirmed to have approached the dam.

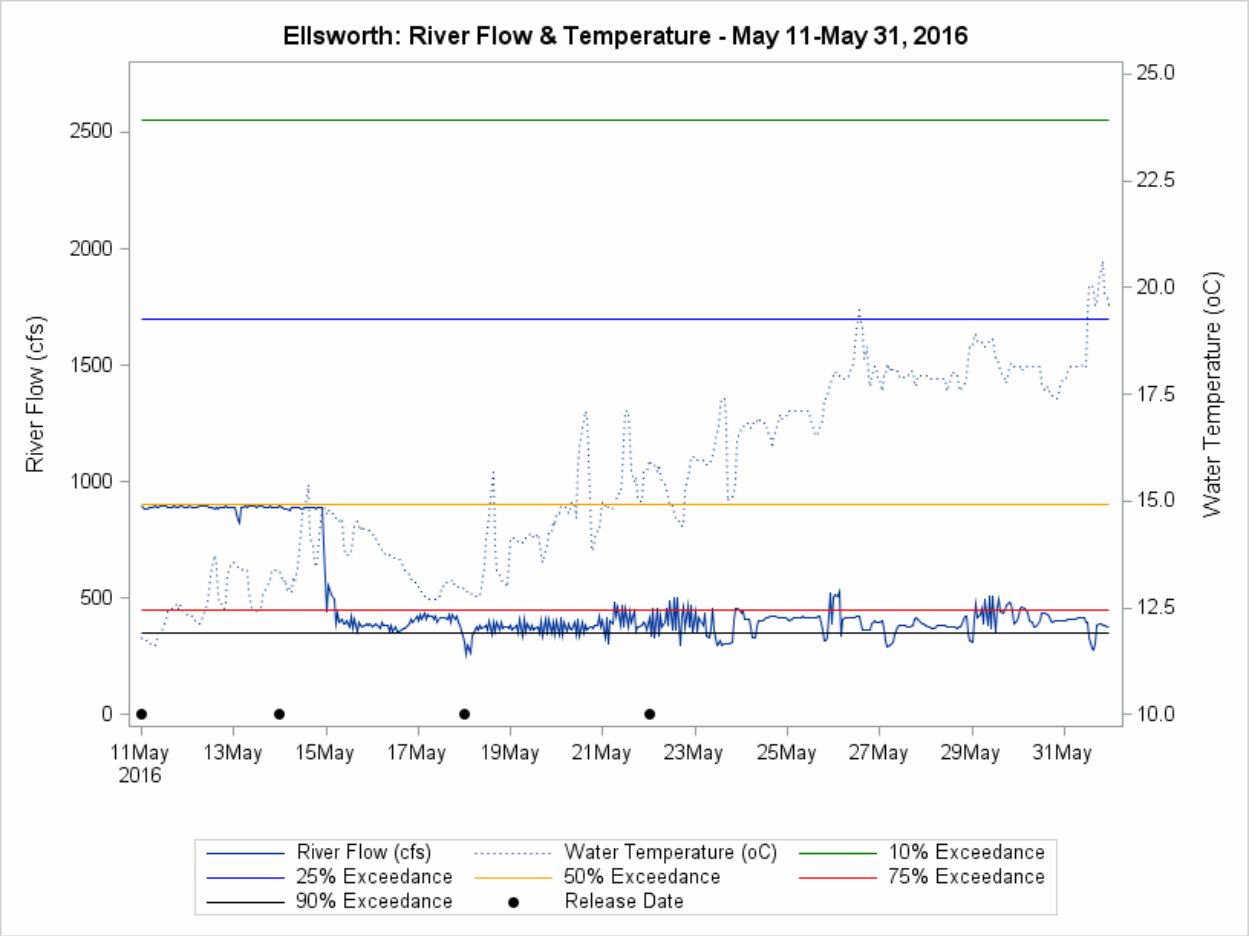

Figure 4–1. Hourly Union River flow (cfs) and daily water temperature (°C) as measured at Ellsworth for the time period May 11-May 31, 2016. The 10, 25, 50, 75, and 90% flow exceedance conditions based on historic Union River flow data (for May) as well as tagged fish release dates are included for reference.

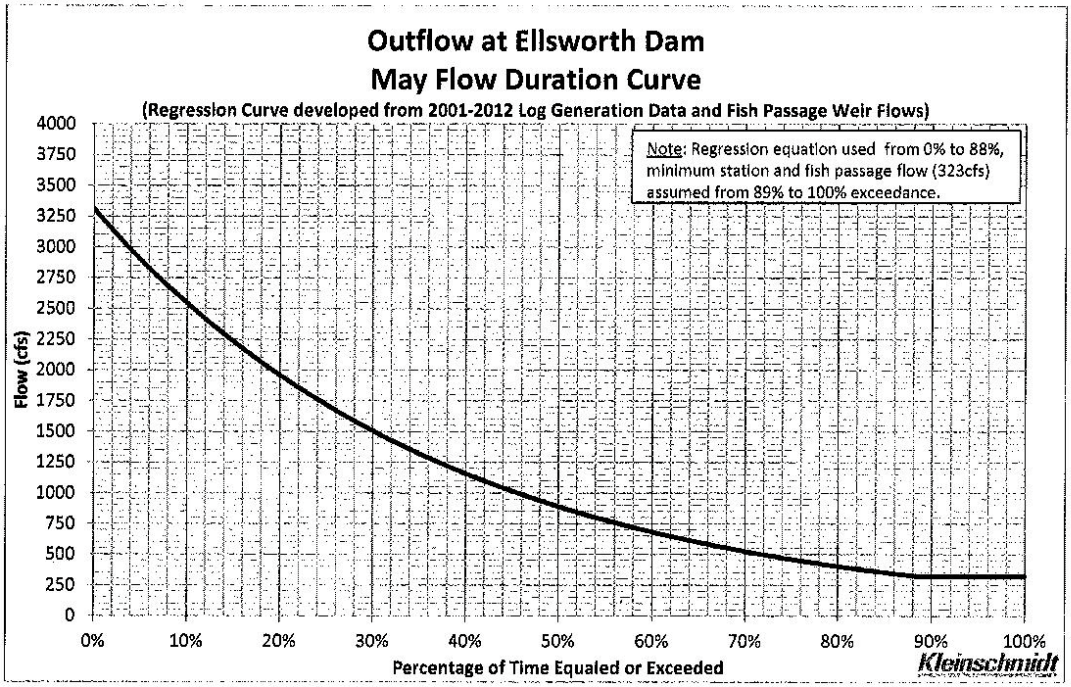

Figure 4–2. Long-term flow duration curve for May at Ellsworth Dam.

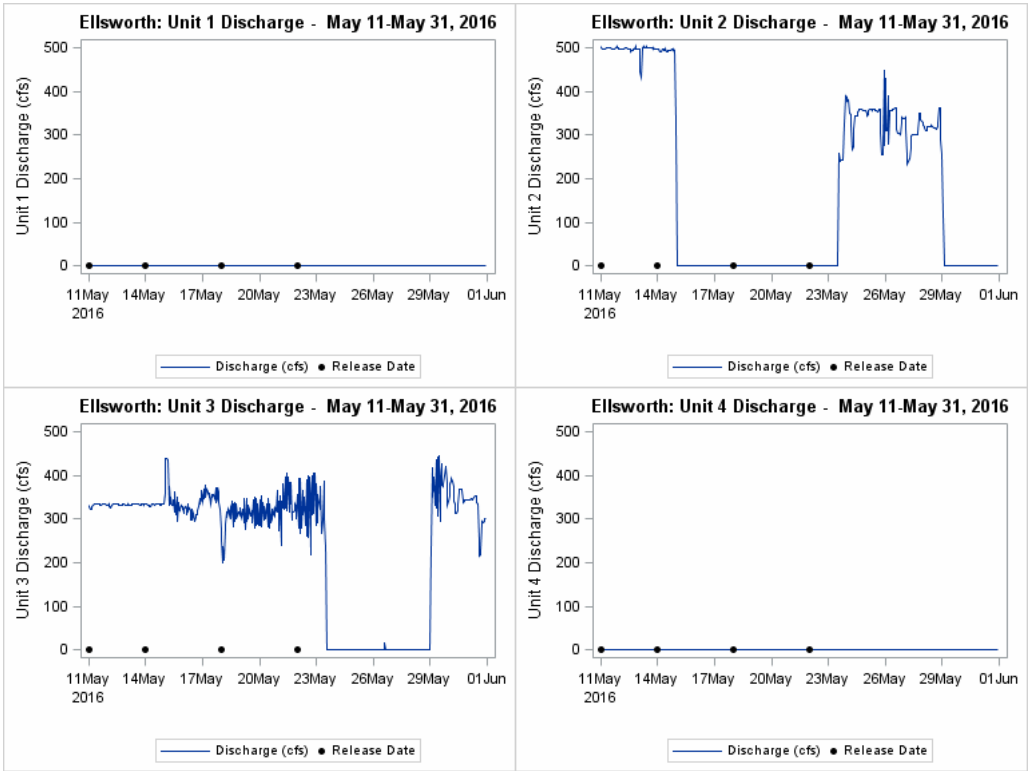

Figure 4–3. Ellsworth unit discharges (cfs) for the time period May 11-May 31, 2016. Tagged fish release dates included for reference.

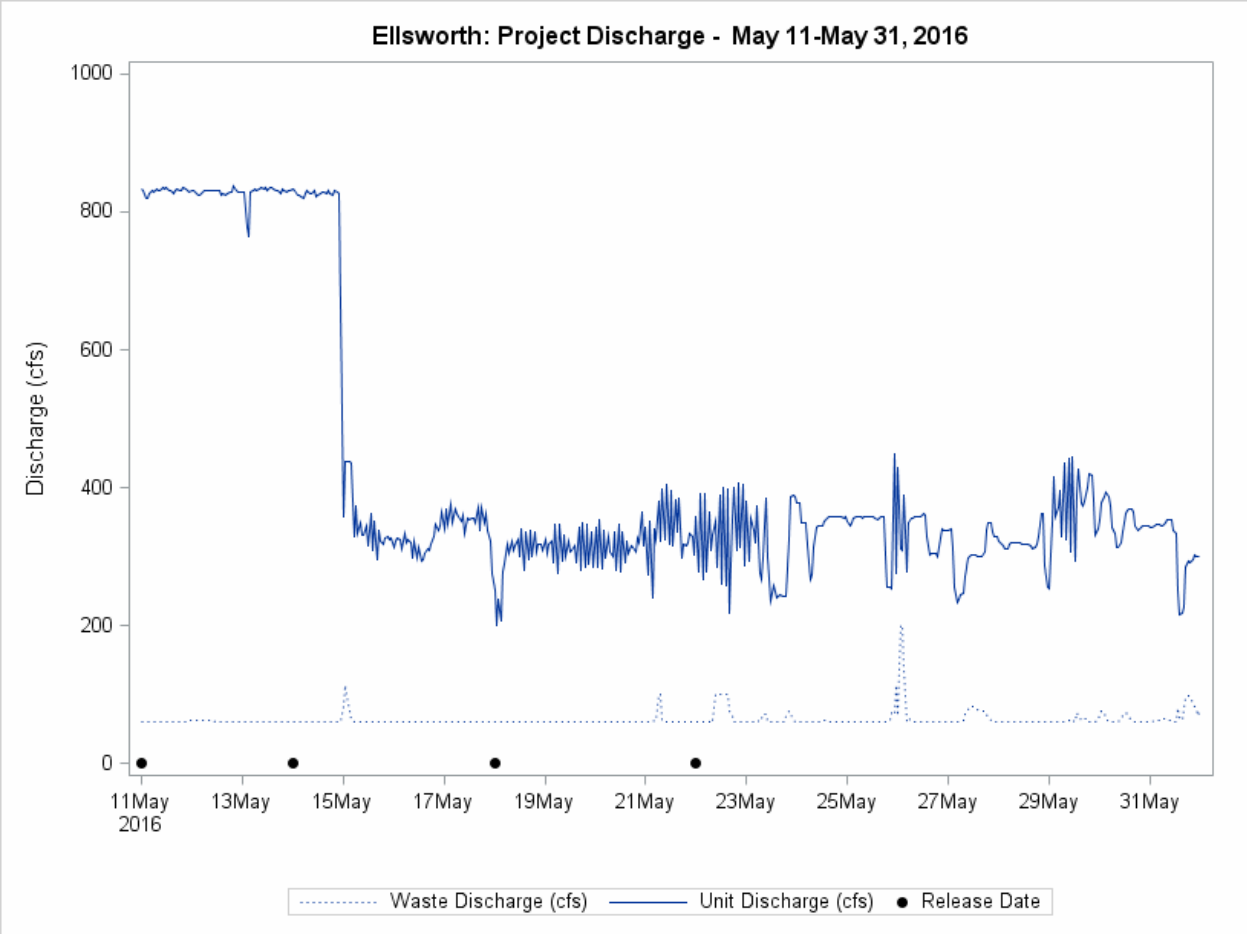

Figure 4–4. Ellsworth project discharge (generation and non-generation values; cfs) for the time period May 11-May 31, 2016. Tagged fish release dates included for reference.

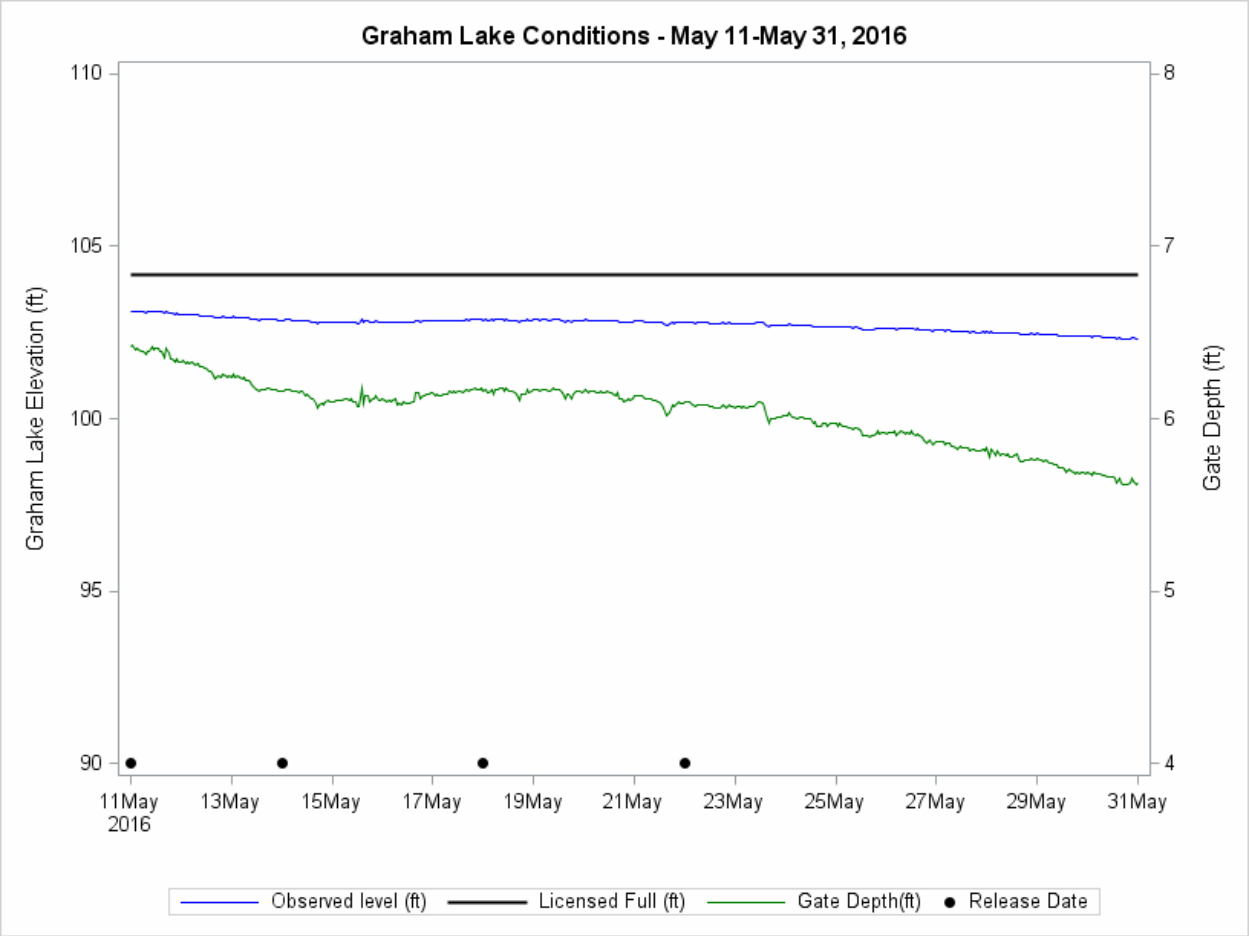

Figure 4-5. Graham Lake elevation levels and calculated spill depth through the Graham Lake Dam downstream bypass gate for the time period May 11-May 31, 2016. Normal full lake elevation and tagged fish release dates included for reference.

Figure 4–6. Downstream bypass sluice with stop logs removed and bottom opening radial gate at Graham Lake Dam during the study period May 11-May 31, 2016.

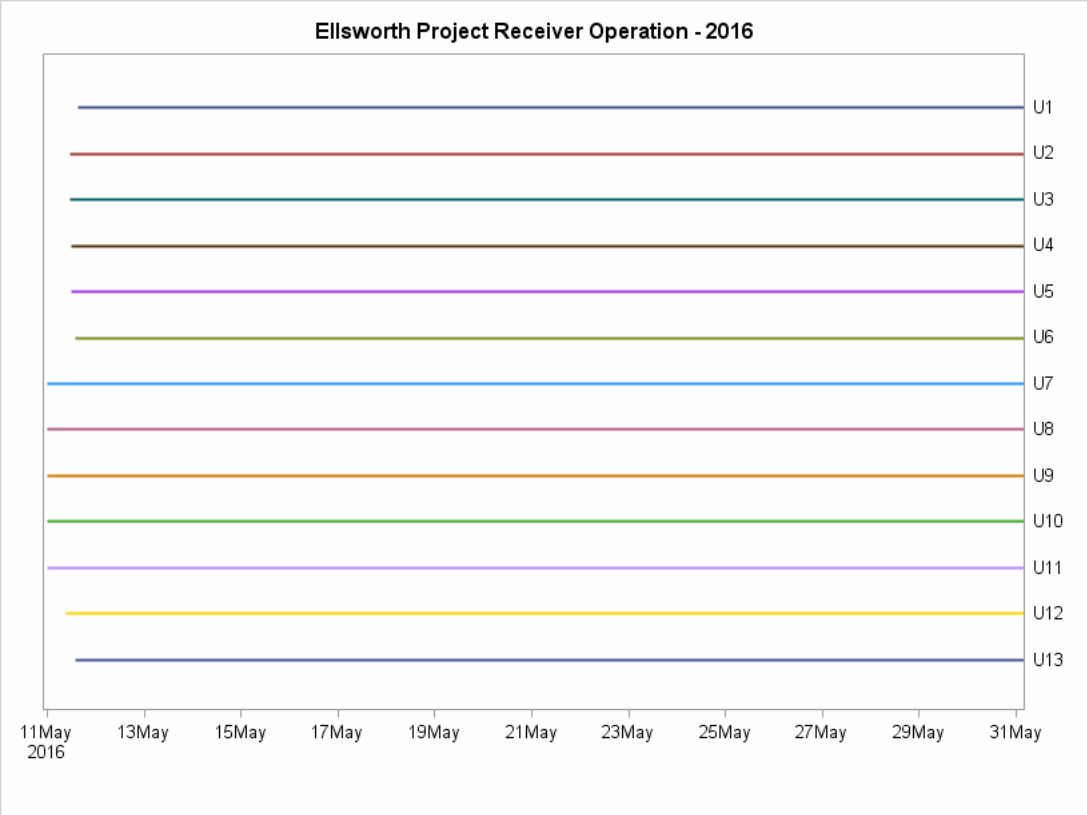

Figure 4–7. Receiver coverage for radio-telemetry monitoring stations U1 through U13 located from the upper extent of Graham Lake downstream to a point 0.4 miles below Ellsworth Dam, May 11–31, 2016.

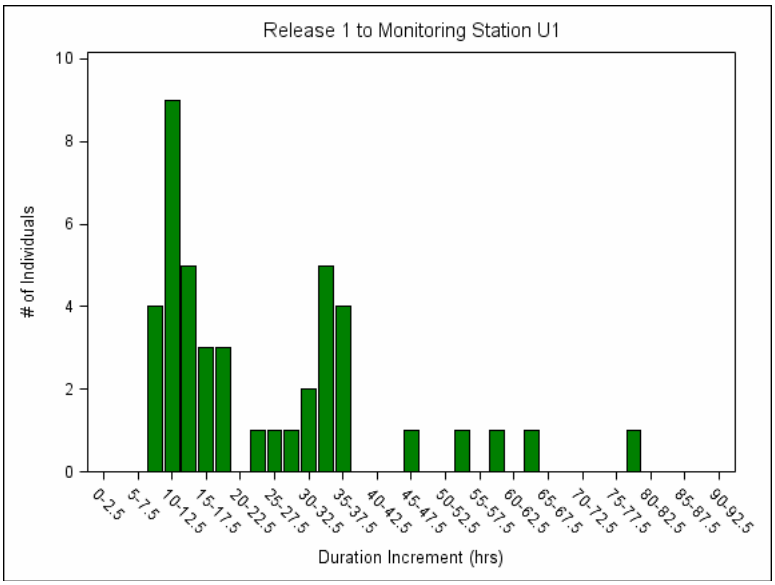

Figure 4–8. Frequency distribution of travel times (hrs) for radio-tagged smolts to move from release location 1 to Monitoring Station U1, a distance of approximately 3.4 miles.

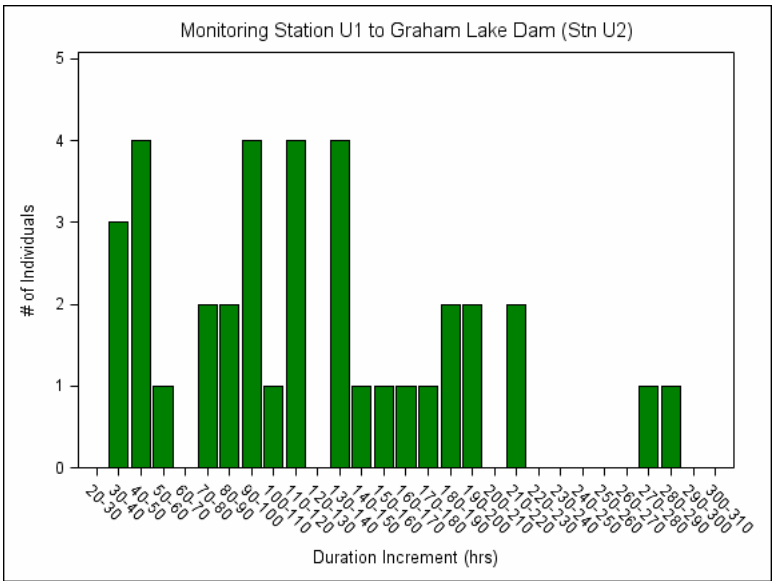

Figure 4–9. Frequency distribution of travel times (hrs) for radio-tagged smolts to move from Monitoring Station U1 to the upstream side of Graham Lake Dam, a distance of approximately 11.3 miles.

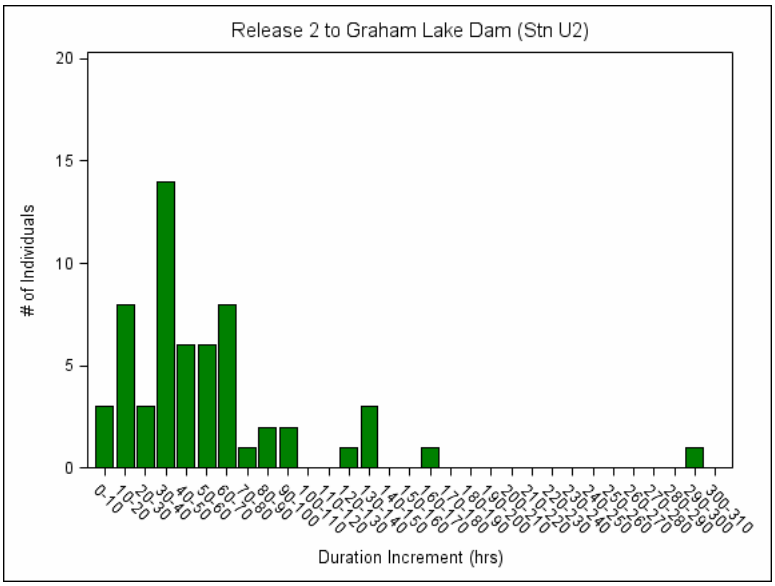

Figure 4–10. Frequency distribution of travel times (hrs) for radio-tagged smolts to move from release location 2 to the upstream side of Graham Lake Dam, a distance of approximately 0.75 miles.

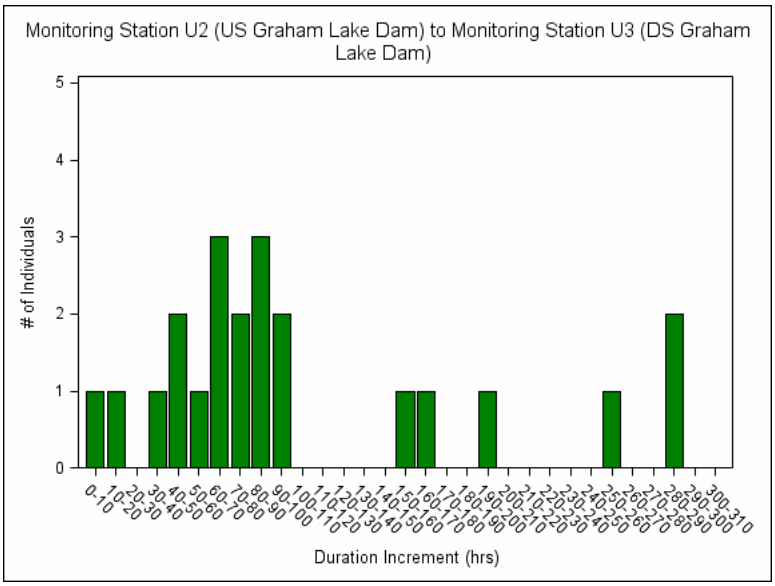

Figure 4–11. Frequency distribution of residence time (hrs) for radio-tagged smolts prior to downstream passage at Graham Lake Dam.

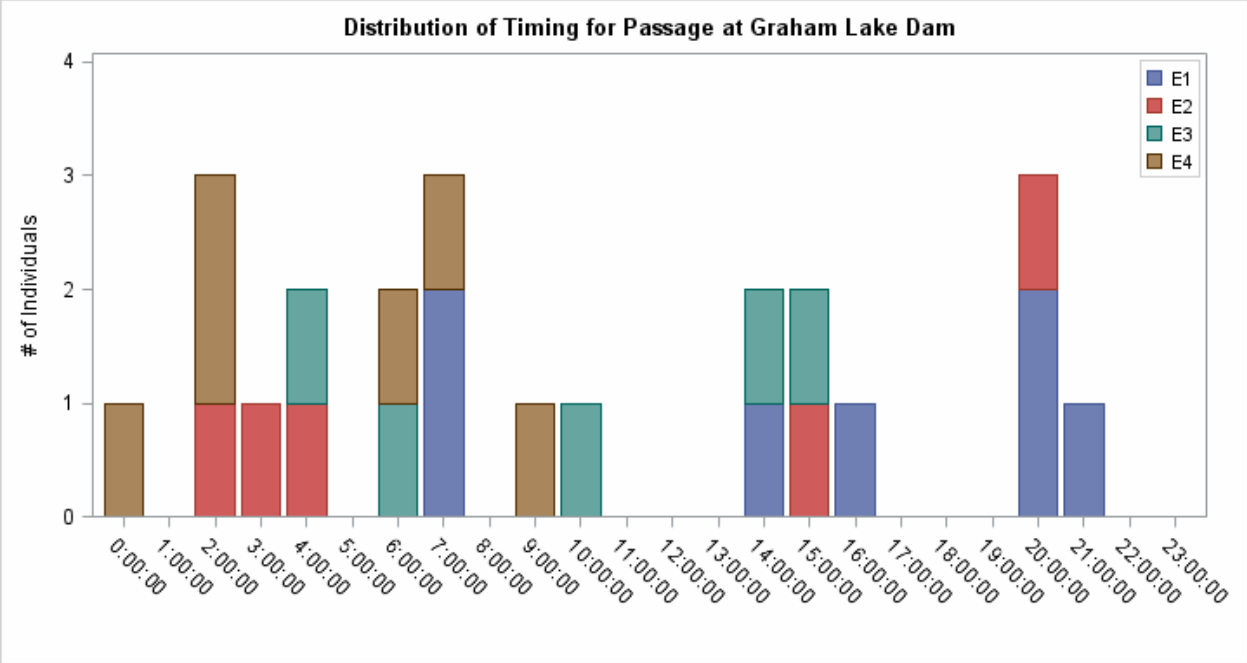

Figure 4–11a. Distribution of passage times (by release group) for radio-tagged smolts at Graham Lake Dam.

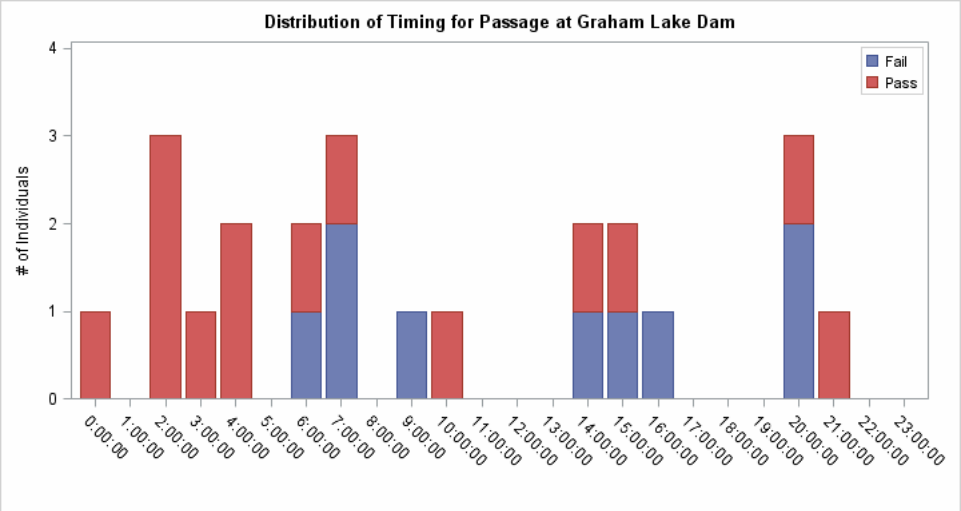

Figure 4–11b. Distribution of passage times for radio-tagged smolts determined to have successfully (pass) or unsuccessfully (fail) reached the Monitoring Station U4 located 2.1 miles downstream of Graham Lake Dam.

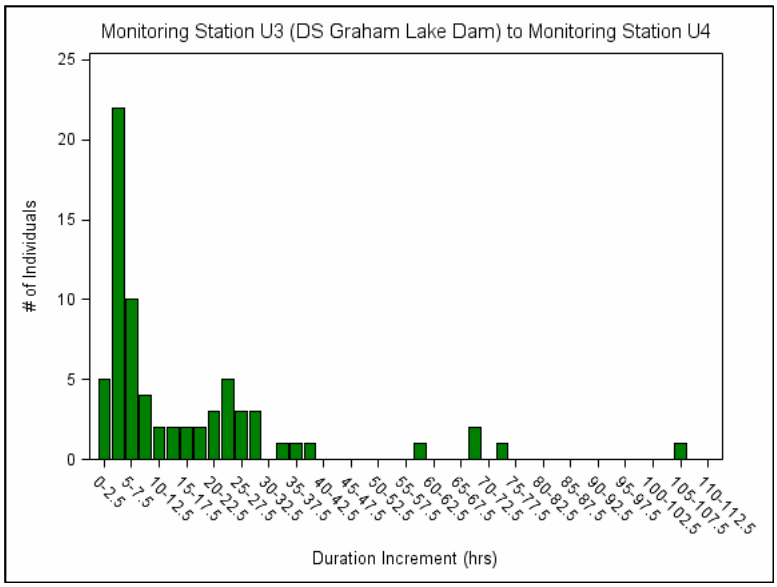

Figure 4–12. Frequency distribution of travel time (hrs) for radio-tagged smolts to move from the Graham Lake Dam tailrace to Monitoring Station U4, a distance of approximately 2.1 miles.

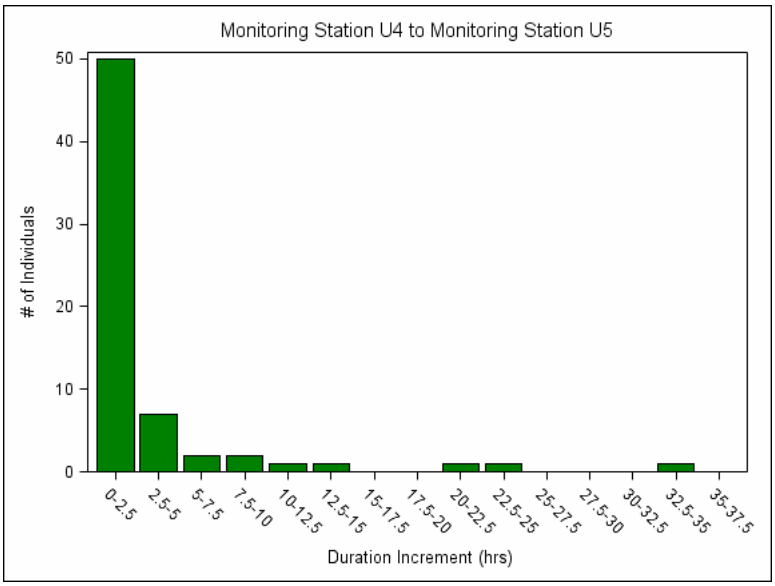

Figure 4–13. Frequency distribution of travel time (hrs) for radio-tagged smolts to move from Monitoring Station U4 to Monitoring Station U5, a distance of approximately 0.5 miles.

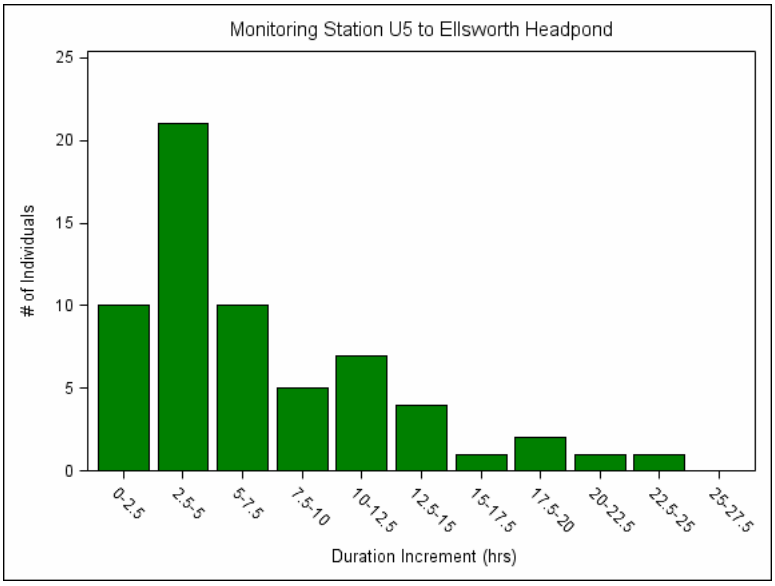

Figure 4–14. Frequency distribution of travel time (hrs) for radio-tagged smolts to move from Monitoring Station U5 to the Ellsworth Dam, a distance of approximately 1.5 miles.

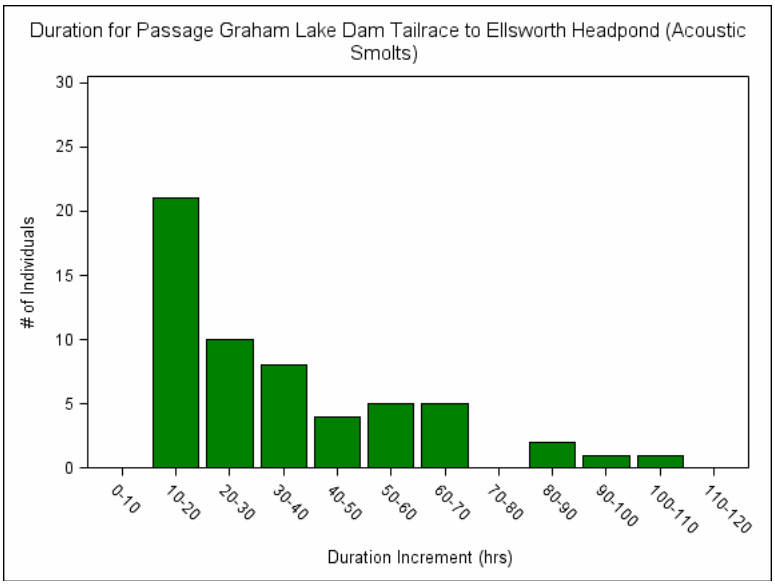

Figure 4–15. Frequency distribution of travel time (hrs) for acoustic-tagged smolts to move from release location 3 to the Ellsworth Dam, a distance of approximately 4.1 miles.

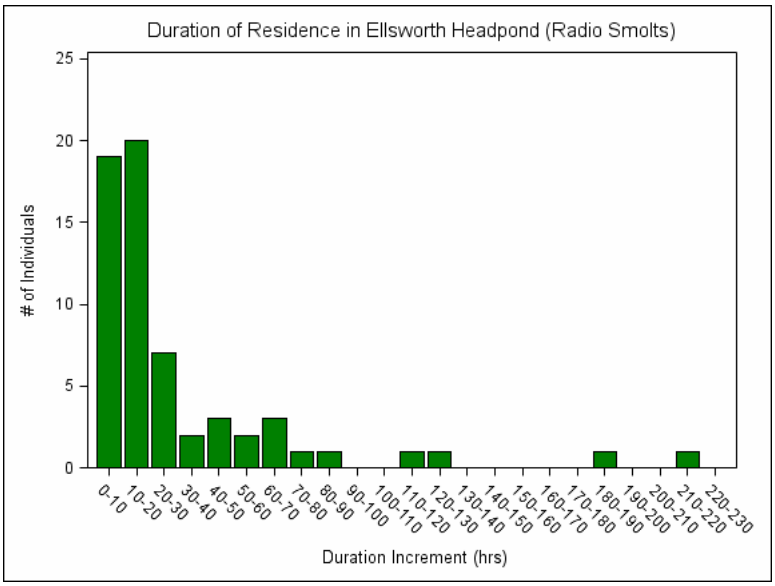

Figure 4–16. Frequency distribution of residence time (hrs) for radio-tagged smolts prior to downstream passage at Ellsworth Dam.

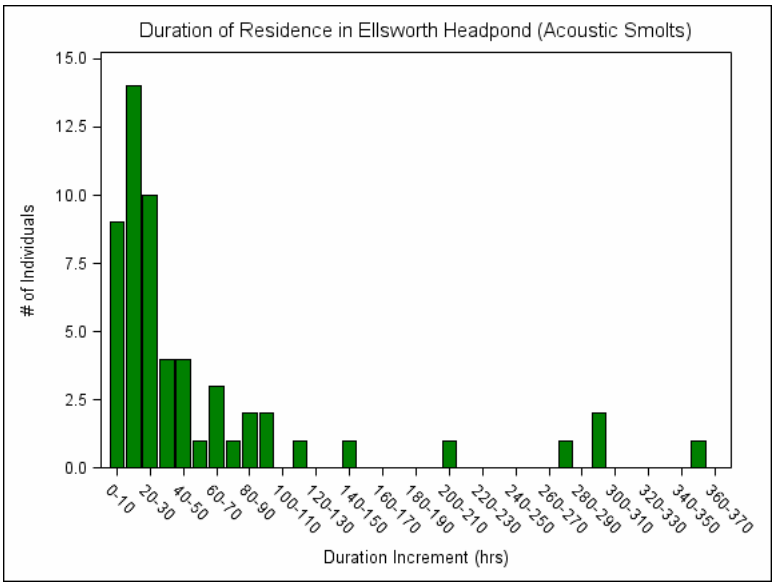

Figure 4–17. Frequency distribution of residence time (hrs) for acoustic-tagged smolts prior to downstream passage at Ellsworth Dam.

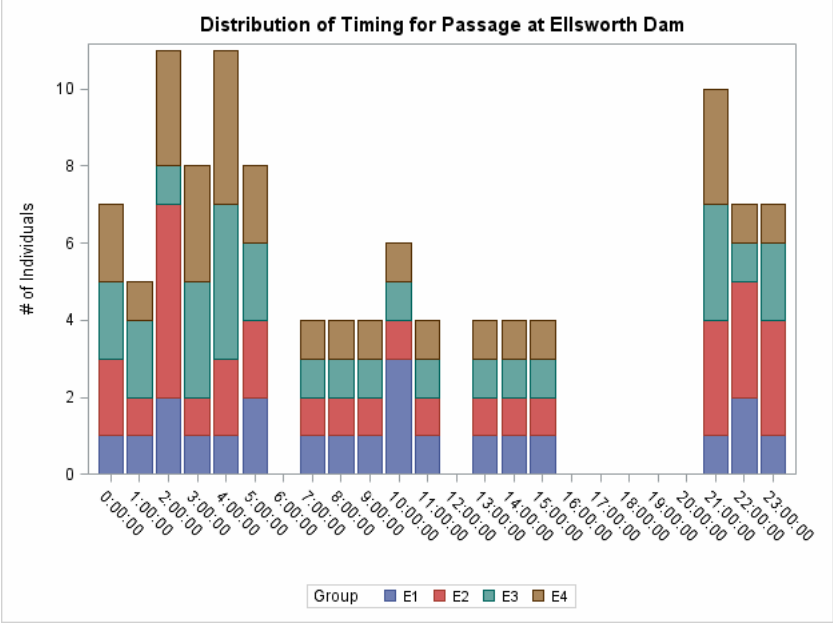

Figure 4–18. Distribution of passage times (by release group) for radio-tagged smolts at Ellsworth Dam.

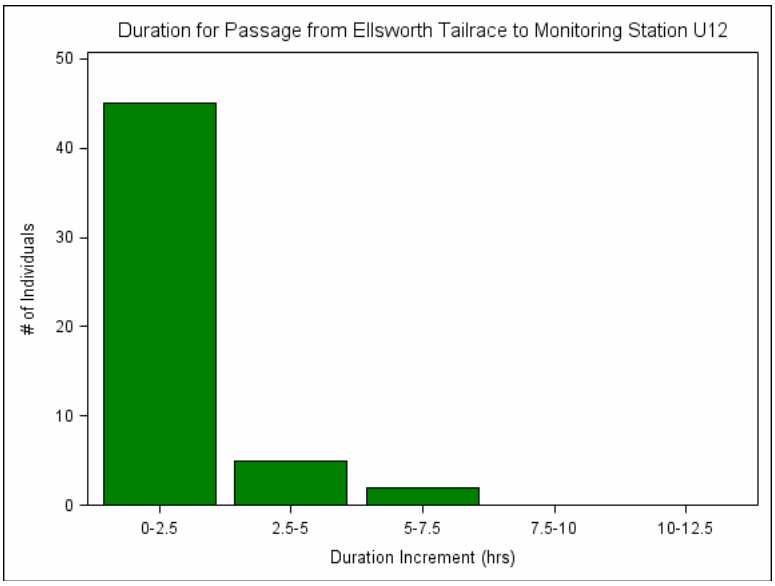

Figure 4–19. Frequency distribution of travel time (hrs) for radio-tagged smolts to move from the Ellsworth Dam tailrace to Monitoring Station U12, a distance of approximately 0.25 miles.

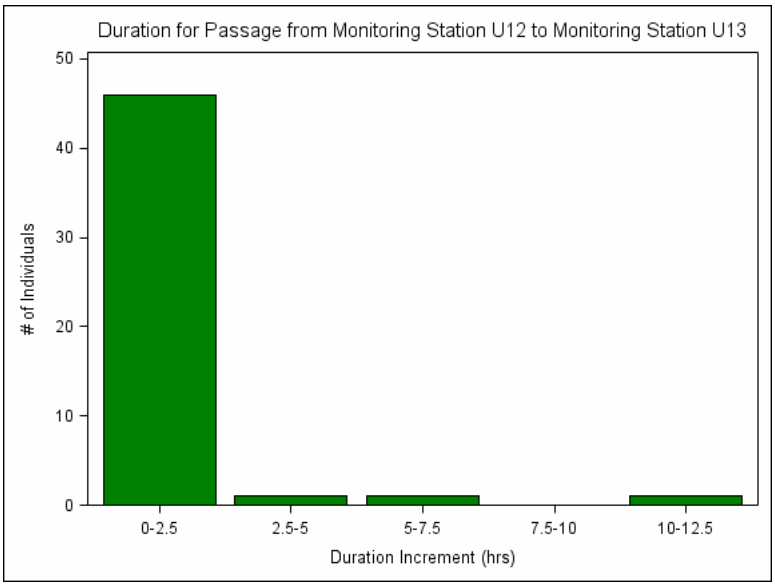

Figure 4–20. Frequency distribution of travel time (hrs) for radio-tagged smolts to move from Monitoring Station U12 to Monitoring Station U13, a distance of approximately 0.15 miles.

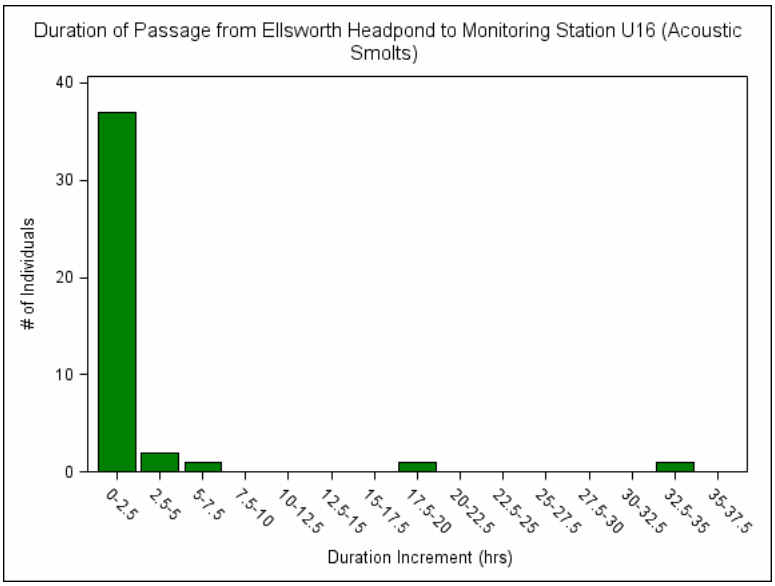

Figure 4–21. Frequency distribution of travel time (hrs) for acoustic-tagged smolts to move from the Ellsworth headpond to Monitoring Station U16, a distance of approximately 0.7 miles.

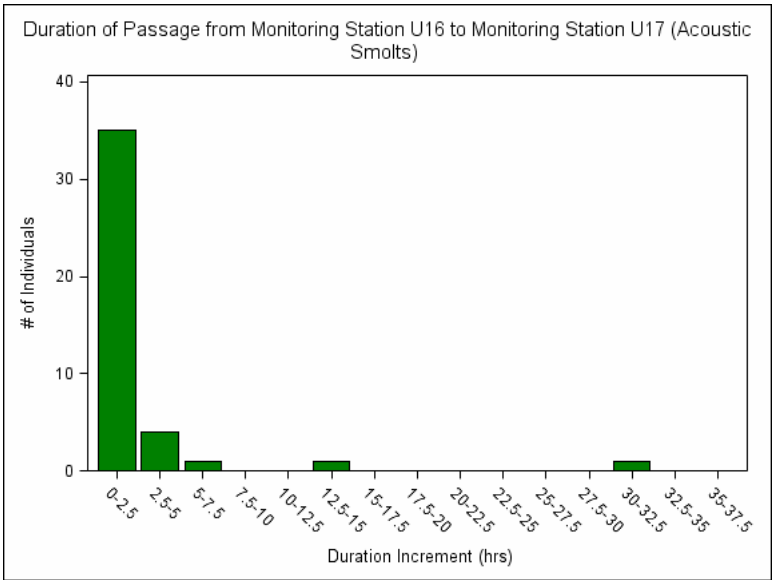

Figure 4–22. Frequency distribution of travel time (hrs) for acoustic-tagged smolts to move from Monitoring Station U16 to Monitoring Station U17, a distance of approximately 0.55 miles.

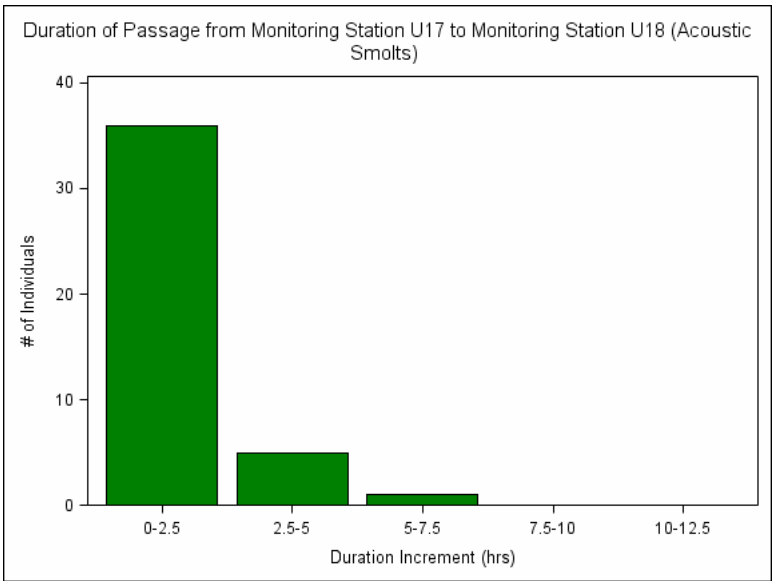

Figure 4–23. Frequency distribution of travel time (hrs) for acoustic-tagged smolts to move from Monitoring Station U17 to Monitoring Station U18, a distance of approximately 0.65 miles.

Table 4-1. Dates of transport, numbers of fish moved and mortality incidence for Atlantic salmon smolts taken from Green Lake NFH to Ellsworth by Normandeau, May 2016

Date	Origin	Destination	# Individuals	Transport Mortalities
5/9/16	GLNFH	Ellsworth	180	0
5/14/16	GLNFH	Ellsworth	114	0

Table 4-2. Summary of releases and biological information (fork length, weight) for Atlantic salmon smolts surgically tagged and released in the vicinity of the Ellsworth Project during May, 2016

Group	Location	Type	# Smolts	Date	Fork Length (mm)			Weight (g)		
					Min	Max	Mean	Min	Max	Mean
E1	1	radio	15	11-May	163	220	194	40	104	73
	2	radio	15		181	220	194	61	111	76
	3	radio	15		170	215	199	49	93	73
	3	acoustic	15		176	212	197	59	100	76
E2	1	radio	15	14-May	183	214	198	59	105	78
	2	radio	15		182	211	193	58	88	69
	3	radio	15		176	203	188	52	84	66
	3	acoustic	15		186	212	196	63	106	75
E3	1	radio	15	18-May	181	211	192	54	91	69
	2	radio	15		177	221	195	54	93	69
	3	radio	15		181	229	198	42	93	69
	3	acoustic	15		174	228	199	51	106	76
E4	1	radio	15	22-May	168	212	195	46	85	70
	2	radio	15		177	221	195	54	93	69
	3	radio	16		177	223	195	55	107	72
	3	acoustic	15		185	219	200	52	96	74
All Releases			241		163	229	195	40	111	72

Table 4-3. Minimum, maximum, mean, and median transit times for radio-tagged Atlantic salmon Smolts in release groups E1-E4 from release location 1 to Monitoring Station U1 and from U1 to arrival at Graham Lake Dam

River Reach	Release Group	Release Location	Transit Time (hr)			
			Minimum	Maximum	Mean	Median
Release Location 1 to Monitoring Station U1 (~ 3.4 miles)	E1	1	10.0	79.7	27.5	24.8
	E2	1	9.4	59.4	27.9	18.4
	E3	1	8.4	63.5	23.9	17.3
	E4	1	10.0	35.7	19.8	12.8
	All		**8.4**	**79.7**	**24.8**	**17.5**
Monitoring Station U1 to Monitoring Station U2 (i.e., Graham Lake Dam arrival; ~ 11.3 miles)	E1	1	45.8	288.9	150.5	137.5
	E2	1	35.1	187.8	106.9	97.1
	E3	1	33.7	273.6	95.2	76.9
	E4	1	30.4	210.3	134.8	117.8
	All		**30.4**	**288.9**	**123.3**	**117.8**

Table 4-4. Minimum, maximum, mean, and median transit times for radio-tagged Atlantic salmon Smolts in release groups E1-E4 from release location 2 to arrival at Graham Lake Dam

River Reach	Release Group	Release Location	Transit Time (hr)			
			Minimum	Maximum	Mean	Median
Release Location 2 to Monitoring Station U2 (~ 0.75 miles)	E1	2	10.5	135.7	61.1	61.9
	E2	2	10.7	298.4	77.5	58.3
	E3	2	3.1	99.2	37.4	37.0
	E4	2	5.0	133.6	43.7	35.5
	All		**3.1**	**298.4**	**55.1**	**41.1**

Table 4-5. Minimum, maximum, mean, and median residence times for radio-tagged Atlantic salmon Smolts in release groups E1-E4 from release locations 1 and 2 at Graham Lake Dam

Release Group	Release Location	Residence Time (hr)			
		Minimum	Maximum	Mean	Median
E1	1	78.7	79.5	79.1	79.1
	2	2.1	287.4	148.2	88.9
E2	1	15.3	95.2	55.3	55.3
	2	42.1	156.2	84.6	55.6
E3	1	90.5	165.2	127.9	127.9
	2	68.3	257.7	174.7	198.2
E4	1	38.6	65.4	48.7	42.0
	2	63.9	89.0	76.4	76.4
All		**2.1**	**287.4**	**106.5**	**79.8**

Table 4-6. Minimum, maximum, mean, and median transit times for radio-tagged Atlantic salmon Smolts in release groups E1-E4 from the Graham Lake Dam tailrace to Monitoring Station U4, between Monitoring Stations U4 and U5 and from Monitoring Station U5 to Ellsworth Dam.

River Reach	Release Group	Release Location	Transit Time (hr)			
			Minimum	Maximum	Mean	Median
Graham Lake Dam Tailrace to Monitoring Station U4 (~2.1 miles)	E1	1	69.2	69.2	69.2	69.2
		2	1.7	6.9	5.0	6.4
		3	3.4	106.0	29.4	23.8
	E2	1	2.3	3.1	2.7	2.7
		2	2.7	3.7	3.2	3.2
		3	2.3	29.3	13.2	9.6
	E3	1	3.5	3.5	3.5	3.5
		2	2.6	2.6	2.6	2.6
		3	3.4	37.8	14.8	6.1
	E4	1	3.5	4.1	3.8	3.8
		2	3.5	3.5	3.5	3.5
		3	3.0	67.8	14.6	10.0
	All		**1.7**	**106.0**	**16.0**	**6.4**
Monitoring Station U4 to Monitoring Station U5 (~0.5 miles)	E1	1	.	.	.	.
		2	0.3	0.7	0.5	0.5
		3	0.3	33.4	7.6	1.1
	E2	1	0.3	2.9	1.6	1.6
		2	0.6	1.2	0.9	0.9
		3	0.3	9.7	2.4	0.9
	E3	1	.	.	.	.
		2	0.8	0.8	0.8	0.8
		3	0.3	2.6	0.9	0.7
	E4	1	.	.	.	.
		2	0.6	3.9	2.3	2.3
		3	0.3	12.6	2.4	1.2
	All		**0.3**	**33.4**	**2.9**	**0.8**
Monitoring Station U5 to Monitoring Station U6 (i.e., Ellsworth arrival; ~ 1.5 miles)	E1	1	.	.	.	.
		2	6.4	15.0	10.7	10.7
		3	1.5	28.3	11.9	12.4
	E2	1	23.7	23.7	23.7	23.7
		2	2.8	3.8	3.3	3.3
		3	1.8	19.8	7.8	5.4
	E3	1	.	.	.	.
		2	1.2	1.2	1.2	1.2
		3	1.4	10.9	5.8	6.5
	E4	1	.	.	.	.
		2	1.2	3.0	2.1	2.1
		3	1.0	12.8	4.4	2.9
	All		**1.0**	**28.3**	**7.2**	**5.3**

Table 4-7. Minimum, maximum, mean, and median transit times for acoustic-tagged Atlantic salmon Smolts in release groups E1-E4 from the Graham Lake Dam tailrace to Ellsworth Dam.

River Reach	Release Group	Release Location	Transit Time (hr)			
			Minimum	Maximum	Mean	Median
Release Location 3 to Ellsworth Dam (~ 4.1 miles)	E1	3	16.6	105.2	51.5	62.9
	E2	3	12.9	88.9	37.8	36.2
	E3	3	12.1	51.5	30.5	26.1
	E4	3	15.9	37.1	22.7	18.5
	All		**12.1**	**105.2**	**36.0**	**26.1**

Table 4-8. Total number of radio and acoustic-tagged smolts from release locations 1, 2, and 3 determined to have approached Ellsworth Dam.

Release Group	Release Location			
	1	2	3	All
Radio - E1	0	3	14	17
Radio - E2	2	2	15	19
Radio - E3	0	1	14	15
Radio - E4	2	2	16	20
Radio	**4**	**8**	**59**	**71**
Acoustic - E1	-	-	15	15
Acoustic - E2	-	-	15	15
Acoustic - E3	-	-	13	13
Acoustic - E4	-	-	14	14
Acoustic	**0**	**0**	**57**	**57**

Table 4-9. Minimum, maximum, mean, and median residence times for radio and acoustic-tagged Atlantic salmon Smolts in release groups E1-E4 at Ellsworth Dam.

Release Group	Tag Type	Residence Time (hr)			
		Minimum	Maximum	Mean	Median
E1	Radio	0.6	66.2	15.7	11.7
	Acoustic	13.5	355.7	75.3	22.8
E2	Radio	2.3	63.0	21.5	18.1
	Acoustic	0.3	299.5	46.0	20.2
E3	Radio	0.8	61.5	22.0	19.1
	Acoustic	0.4	292.5	61.5	33.2
E4	Radio	1.0	213.0	54.2	18.0
	Acoustic	0.1	142.5	37.4	17.8
All	**Radio**	**0.6**	**213.0**	**29.9**	**17.9**
	Acoustic	**0.1**	**355.7**	**55.1**	**21.9**

Table 4-10. Passage routes determined for radio-tagged Atlantic salmon smolts passing Ellsworth Dam, May 2016.

Release Group	Release Date	Passage Route					
		Bypass 1	Bypass 2	Unit 2/3	Unknown	No Pass	All
E1	11-May	1	-	14	1	1	17
E2	14-May	5	2	11	-	1	19
E3	18-May	6	2	6	-	1	15
E4	22-May	8	1	8	1	2	20
All		**20**	**5**	**39**	**2**	**5**	**71**

*Bypass 1 = surface sluice entrances adjacent to Units 2 and 3; Bypass 2 = surface sluice entrance located on western end of spillway and adjacent to Unit 1

Table 4-11. Minimum, maximum, mean, and median transit times for radio-tagged Atlantic salmon Smolts in release groups E1-E4 from the Ellsworth Dam tailrace to Monitoring Station U12 and from Monitoring Station U12 to U13.

River Reach	Release Group	Release Location	Transit Time (hr)			
			Minimum	Maximum	Mean	Median
Ellsworth Tailrace to Monitoring Station U12 (~0.25 miles)	E1	all	0.1	7.0	1.4	0.2
	E2	all	0.1	3.0	0.6	0.2
	E3	all	0.1	3.6	1.1	0.3
	E4	all	0.1	3.8	0.5	0.2
	All		**0.1**	**7.0**	**0.9**	**0.2**
Monitoring Station U12 to Monitoring Station U13 (~0.15 miles)	E1	all	0.1	5.4	1.0	0.1
	E2	all	0.1	1.2	0.2	0.1
	E3	all	0.1	10.7	1.2	0.1
	E4	all	0.1	1.0	0.3	0.2
	All		**0.1**	**10.7**	**0.6**	**0.1**

Table 4-12. Minimum, maximum, mean, and median transit times for acoustic-tagged Atlantic salmon Smolts in release groups E1-E4 from their last detection in the Ellsworth Dam headpond to Monitoring Station U16, from Monitoring Station U16 to U17 and from Monitoring Station U17 to U18.

River Reach	Release Group	Transit Time (hr)			
		Minimum	Maximum	Mean	Median
Ellsworth Headpond to Monitoring Station U16 (~0.7 miles)	E1	0.4	2.2	0.8	0.6
	E2	0.5	33.6	5.2	0.7
	E3	0.5	5.0	2.2	1.6
	E4	0.4	3.8	1.2	0.7
	All	**0.4**	**33.6**	**2.3**	**0.7**
Monitoring Station U16 to Monitoring Station U17 (~0.55 miles)	E1	0.3	6.8	1.9	1.0
	E2	0.5	32.1	4.0	0.9
	E3	0.6	13.7	2.6	0.9
	E4	0.5	2.2	1.1	0.9
	All	**0.3**	**32.1**	**2.3**	**0.9**
Monitoring Station U17 to Monitoring Station U18 (~0.65 miles)	E1	0.3	3.5	1.6	1.6
	E2	0.6	4.4	1.7	1.5
	E3	0.4	6.8	1.3	0.5
	E4	0.2	2.1	0.8	0.6
	All	**0.2**	**6.8**	**1.4**	**0.9**

Table 4-13. Graham Lake Dam passage survival estimates by release group and location for radio-tagged Atlantic salmon smolts, 2016.

Release Group	Release Location	No. Released	No. Arrived	No. Passed	No. Detected Downstream	Calculated Survival
E1	1	15	11	2	1	9.1%
E2	1	15	13	2	2	15.4%
E3	1	15	7	2	1	14.3%
E4	1	15	10	3	2	20.0%
Subtotal		60	41	9	6	14.6%
E1	2	15	15	5	3	20.0%
E2	2	15	15	3	2	13.3%
E3	2	15	15	3	1	6.7%
E4	2	15	14	3	2	14.3%
Subtotal		60	59	14	8	13.6%
Total		**120**	**100**	**23**	**14**	14.0%

Table 4-14. Graham Lake Dam passage success estimates by release group and location for radio-tagged Atlantic salmon smolts, 2016.

Release Group	Release Location	No. Released	No. Passed		No. Detected Downstream*	Calculated Success
			No. Arrived	Beyond 24 hrs	Within 24 hrs		
E1	1	15	11	2	0	0	0.0%
E2	1	15	13	1	1	1	7.7%
E3	1	15	7	2	0	0	0.0%
E4	1	15	10	3	0	0	0.0%
Subtotal		60	41	8	1	1	2.4%
E1	2	15	15	4	1	1	6.7%
E2	2	15	15	3	0	0	0.0%
E3	2	15	15	3	0	0	0.0%
E4	2	15	14	3	0	0	0.0%
Subtotal		60	59	13	1	1	1.7%
Total		**120**	**100**	**21**	**2**	**2**	2.0%

*Excludes individuals passing following ≥ 24 hrs of residence time

Table 4-15. Ellsworth Dam passage survival estimates by release group and location for acoustic-tagged Atlantic salmon smolts, 2016.

Release Group	Release Location	No. Released	No. Arrived	No. Detected Downstream	Calculated Survival
E1	3	15	15	12	80.0%
E2	3	15	15	11	73.3%
E3	3	15	13	8	61.5%
E4	3	15	14	11	78.6%
Total		**60**	**57**	**42**	**73.7%**

Table 4-16. Ellsworth Dam passage success estimates by release group and location for acoustic-tagged Atlantic salmon smolts, 2016.

Release Group	Release Location	No. Released	No. Arrived	Headpond Duration		No. Detected Downstream*	Calculated Success
				Less than 24 hrs	Greater than 24 hrs		
E1	3	15	15	8	7	7	46.7%
E2	3	15	15	8	7	5	33.3%
E3	3	15	13	5	8	5	38.5%
E4	3	15	14	10	4	9	64.3%
Total		**60**	**57**	**31**	**26**	**26**	**45.6%**

*Excludes individuals passing following ≥ 24 hrs of residence time

Table 4-17. Ellsworth Dam passage survival estimates by release group and location for radio-tagged Atlantic salmon smolts, 2016.

Release Group	Release Location	No. Released	No. Arrived	No. Passed	No. Detected Downstream	Calculated Survival
E1	1	15	0	0	0	-
E2	1	15	2	2	1	50.0%
E3	1	15	0	0	0	-
E4	1	15	2	2	1	50.0%
Subtotal		60	4	4	2	50.0%
E1	2	15	3	3	3	100.0%
E2	2	15	2	2	2	100.0%
E3	2	15	1	1	0	0.0%
E4	2	15	2	2	0	0.0%
Subtotal		60	8	8	5	62.5%
E1	3	15	14	13	11	78.6%
E2	3	15	15	14	11	73.3%
E3	3	15	14	13	10	71.4%
E4	3	16	16	14	14	87.5%
Subtotal		61	59	54	46	78.0%
Total		**181**	**71**	**66**	**53**	74.6%

Table 4-18. Ellsworth Dam passage success estimates by release group and location for radio-tagged Atlantic salmon smolts, 2016.

Release Group	Release Location	No. Released	No. Arrived	Headpond Duration		No. Detected Downstream*	Calculated Success
				Less than 24 hrs	Greater than 24 hrs		
E1	3	15	0	0	0	0	-
E2	3	15	2	1	0	0	0.0%
E3	3	15	0	0	0	0	-
E4	3	15	2	0	2	0	0.0%
Subtotal		60	4	1	2	0	0.0%
E1	2	15	3	3	0	3	100.0%
E2	2	15	2	0	2	0	0.0%
E3	2	15	1	0	1	0	0.0%
E4	2	15	2	0	2	0	0.0%
Subtotal		60	8	3	5	3	37.5%
E1	3	15	14	8	2	6	42.9%
E2	3	15	15	11	3	10	66.7%
E3	3	15	14	10	3	9	64.3%
E4	3	16	16	10	4	10	62.5%
Subtotal		61	59	39	12	35	59.3%
Total		**181**	**71**	**43**	**19**	**38**	**53.5%**

*Excludes individuals passing following ≥ 24 hrs of residence time

Table 4-19. Route-specific dam passage estimates for radio-tagged Atlantic salmon smolts at Ellsworth Dam, 2016.

Passage Route	Release Group	No. Passed	No. Detected Downstream	Calculated Survival
Bypass	E1	1	1	100.0%
	E2	7	7	100.0%
	E3	8	7	87.5%
	E4	9	9	100.0%
Subtotal		25	24	96.0%
Turbine (Unit 2/3)	E1	14	12	85.7%
	E2	11	7	63.6%
	E3	6	3	50.0%
	E4	8	5	62.5%
Subtotal		39	27	69.2%

Table 4-20. Program MARK model output for radio-tagged smolts released at Ellsworth, 2016.

Release Group	Model	AICc	Δ AICc	AICc Weight	Model Likelihood	No. Parameters	Deviance
E1	*Phi*(t) *p*(t)	105.8	0.0	0.8	1.0	8	14.2
	Phi(t) *p*(.)	108.8	3.0	0.2	0.2	8	17.2
	Phi(.) *p*(t)	144.8	39.0	0.0	0.0	4	62.1
	Phi(.) *p*(.)	147.6	41.9	0.0	0.0	2	69.3
E2	*Phi*(t) *p*(.)	66.5	0.0	0.5	1.0	4	10.8
	Phi(t) *p*(t)	66.5	0.0	0.5	1.0	4	10.8
	Phi(.) *p*(t)	135.5	69.0	0.0	0.0	3	81.9
	Phi(.) *p*(.)	141.0	74.5	0.0	0.0	1	91.6
E3	*Phi*(t) *p*(.)	96.8	0.0	0.5	1.0	7	10.9
	Phi(t) *p*(t)	96.8	0.0	0.5	1.0	7	10.9
	Phi(.) *p*(t)	128.3	31.5	0.0	0.0	3	51.3
	Phi(.) *p*(.)	130.3	33.5	0.0	0.0	1	57.5
E4	*Phi*(t) *p*(t)	136.4	0.0	0.7	1.0	10	38.1
	Phi(t) *p*(.)	138.2	1.8	0.3	0.4	7	46.9
	Phi(.) *p*(t)	169.5	33.1	0.0	0.0	5	82.6
	Phi(.) *p*(.)	181.1	44.7	0.0	0.0	2	100.6
All	*Phi*(t) *p*(t)	397.0	0.0	1.0	1.0	11	50.5
	Phi(t) *p*(.)	403.0	6.0	0.0	0.0	9	60.7
	Phi(.) *p*(t)	568.2	171.1	0.0	0.0	5	234.1
	Phi(.) *p*(.)	604.0	206.7	0.0	0.0	2	276.0

*Shading indicates selected model

Table 4-21. Detection probabilities calculated in Program MARK for radio-tagged smolts released at Ellsworth, 2016.

Release Group	Detection Probability (SE)						
	MS-U2	MS-U3	MS-U4	MS-U5	MS-U6	Ellsworth	MS-U12
E1	1.00 (0.00)	1.00 (0.00)	1.00 (0.00)	0.94 (0.06)	1.00 (0.00)	1.00 (0.00)	1.00 (0.00)
E2	1.00 (0.00)	1.00 (0.00)	1.00 (0.00)	1.00 (0.00)	1.00 (0.00)	1.00 (0.00)	1.00 (0.00)
E3	1.00 (0.00)	1.00 (0.00)	1.00 (0.00)	1.00 (0.00)	1.00 (0.00)	1.00 (0.00)	1.00 (0.00)
E4	1.00 (0.00)	0.75 (0.21)	1.00 (0.00)	0.85 0.08	1.00 (0.00)	1.00 (0.00)	0.92 (0.07)
All	**1.00 (0.00)**	**0.93 (0.04)**	**1.00 (0.00)**	**0.94 (0.03)**	**1.00 (0.00)**	**1.00 (0.00)**	**0.98 (0.02)**

Table 4-22. Survivorship estimates calculated in Program MARK for radio-tagged smolts released at Ellsworth during 2016 within defined river reaches from upper Graham Lake to Union River downstream of Ellsworth Dam.

Release Group	Survivorship Probability (SE)						
	A	B	C	D	E	F	G
E1	0.91 (0.87)	0.27 (0.09)	0.57 (0.19)	0.94 (0.06)	1.00 (0.00)	0.94 (0.06)	0.88 (0.08)
E2	1.00 (0.00)	0.17 (0.07)	0.80 (0.18)	1.00 (0.00)	1.00 (0.00)	0.94 (0.05)	0.78 (0.10)
E3	0.70 (0.15)	0.23 (0.09)	0.40 (0.22)	0.94 (0.06)	0.94 (0.06)	0.94 (0.06)	0.93 (0.06)
E4	0.82 (0.11)	0.28 (0.10)	0.60 (0.22)	1.00 (0.00)	1.00 (0.00)	0.90 (0.07)	0.84 (0.09)
All	**0.86 (0.05)**	**0.23 (0.04)**	**0.59 (0.10)**	**0.97 (0.02)**	**0.99 (0.01)**	**0.93 (0.03)**	**0.80 (0.05)**

A - Monitoring Station U1 to upstream Graham Lake Dam (U2)

B - Upstream Graham Lake Dam (U2) to Downstream Graham Lake Dam

C - Downstream Graham Lake Dam (U3) to Monitoring Station U4

D - Monitoring Station U4 to Monitoring Station U5

E - Monitoring Station U5 to Monitoring Station U6 (Ellsworth headpond)

F - Monitoring Station U6 (Ellsworth headpond) to Ellsworth Passage

G - Ellsworth passage to Monitoring Station U12

Table 4-23. Asymmetrical 95% and 75% confidence intervals for reach survivorship estimates for radio-tagged smolts released at Ellsworth, 2016.

Beta Estimates from MARK						Real parameter estimates and 95% CI		
Reach	**Label**	**Estimate**	**SE**	**Lower**	**Upper**	**Estimate**	**Lower**	**Upper**
A	Phi	1.82	0.44	0.96	2.68	0.86	0.72	0.94
B	Phi	-1.17	0.24	-1.65	-0.69	0.24	0.16	0.33
C	Phi	0.37	0.43	-0.48	1.22	0.59	0.38	0.77
D	Phi	3.59	0.74	2.14	5.04	0.97	0.89	0.99
E	Phi	4.20	1.01	2.23	6.18	0.99	0.90	1.00
F	Phi	2.58	0.46	1.67	3.49	0.93	0.84	0.97
G	Phi	1.41	0.31	0.80	2.02	0.80	0.69	0.88
Beta Estimates						**Real parameter estimates and 75% CI**		
Reach (RM)	**Label**	**Estimate**	**SE**	**Lower**	**Upper**	**Estimate**	**Lower**	**Upper**
A	Phi	1.82	0.44	0.96	2.68	0.86	0.79	0.91
B	Phi	-1.17	0.24	-1.65	-0.69	0.24	0.19	0.29
C	Phi	0.37	0.43	-0.48	1.22	0.59	0.47	0.70
D	Phi	3.59	0.74	2.14	5.04	0.97	0.94	0.99
E	Phi	4.20	1.01	2.23	6.18	0.99	0.95	1.00
F	Phi	2.58	0.46	1.67	3.49	0.93	0.89	0.96
G	Phi	1.41	0.31	0.80	2.02	0.80	0.74	0.85

Table 4-24. Program MARK model output for acoustic-tagged smolts released at Ellsworth, 2016.

Release Group	Model	AICc	Δ AICc	AICc Weight	Model Likelihood	No. Parameters	Deviance
E1	*Phi*(t) *p*(t)	17.1	0.0	0.5	1.0	1	0.0
	Phi(t) *p*(.)	17.1	0.0	0.5	1.0	1	0.0
	Phi(.) *p*(.)	25.2	8.2	0.0	0.0	1	8.2
	Phi(.) *p*(t)	25.2	8.2	0.0	0.0	1	8.2
E2	*Phi*(t) *p*(t)	19.5	0.0	0.5	1.0	1	0.0
	Phi(t) *p*(.)	19.5	0.0	0.5	1.0	1	0.0
	Phi(.) *p*(t)	30.3	10.8	0.0	0.0	1	10.8
	Phi(.) *p*(.)	30.3	10.8	0.0	0.0	1	10.8
E3	*Phi*(t) *p*(t)	33.4	0.0	0.5	1.0	2	0.0
	Phi(t) *p*(.)	33.4	0.0	0.5	1.0	2	0.0
	Phi(.) *p*(.)	40.7	7.3	0.0	0.0	1	9.5
	Phi(.) *p*(t)	40.7	7.3	0.0	0.0	1	9.5
E4	*Phi*(t) *p*(t)	26.1	0.0	0.4	1.0	2	0.0
	Phi(t) *p*(.)	26.1	0.0	0.4	1.0	2	0.0
	Phi(.) *p*(t)	30.1	4.0	0.1	0.1	1	6.1
	Phi(.) *p*(.)	30.1	4.0	0.1	0.1	1	6.1
All	*Phi*(t) *p*(t)	93.6	0.0	0.5	1.0	2	0.0
	Phi(t) *p*(.)	93.6	0.0	0.5	1.0	2	0.0
	Phi(.) *p*(t)	123.2	29.6	0.0	0.0	1	31.7
	Phi(.) *p*(.)	123.2	29.6	0.0	0.0	1	31.7

*Shading indicates selected model

Table 4-25. Detection probabilities calculated in Program MARK for acoustic-tagged smolts released at Ellsworth, 2016.

Release Group	Detection Probability (SE)		
	MS-U14/15	MS-U16	MS-U17
E1	1.00 (0.00)	1.00 (0.00)	1.00 (0.00)
E2	1.00 (0.00)	1.00 (0.00)	1.00 (0.00)
E3	1.00 (0.00)	1.00 (0.00)	1.00 (0.00)
E4	1.00 (0.00)	1.00 (0.00)	1.00 (0.00)
All	**1.00 (0.00)**	**1.00 (0.00)**	**1.00 (0.00)**

Table 4-26. Survivorship estimates calculated in Program MARK for acoustic-tagged smolts released at Ellsworth during 2016 within defined river reaches from the Graham Lake Dam tailrace to Union River downstream of Ellsworth Dam.

Release Group	Survivorship Probability (SE)		
	H	I	J
E1	1.00 (0.00)	0.80 (0.10)	1.00 (0.00)
E2	1.00 (0.00)	0.73 (0.11)	1.00 (0.00)
E3	0.86 (0.09)	0.61 (0.13)	1.00 (0.00)
E4	0.93 (0.06)	0.78 (0.11)	1.00 (0.00)
All	**0.95 (0.03)**	**0.73 (0.06)**	**1.00 (0.00**

H - Release below Graham Lake Dam to Ellsworth Headpond (U14/15)

I - Ellsworth Headpond (U14/15) to Monitoring Station U16

J - Monitoring Station U16 to Monitoring Station U17

Table 4-27. Asymmetrical 95% and 75% confidence intervals for reach survivorship estimates for acoustic-tagged smolts released at Ellsworth, 2016.

Beta Estimates from MARK						Real parameter estimates and 95% CI		
Reach	Label	Estimate	SE	Lower	Upper	Estimate	Lower	Upper
H	Phi	2.94	0.59	1.78	4.11	0.95	0.86	0.98
I	Phi	1.03	0.30	0.44	1.62	0.74	0.61	0.83
J	Phi	21.48	6591.74	-12898.34	12941.30	1.00	-	-
Beta Estimates						**Real parameter estimates and 75% CI**		
Reach	Label	Estimate	SE	Lower	Upper	Estimate	Lower	Upper
H	Phi	2.94	0.59	1.78	4.11	0.95	0.91	0.97
I	Phi	1.03	0.30	0.44	1.62	0.74	0.66	0.80
J	Phi	21.48	6591.74	-12898.34	12941.30	1.00	-	-

Table 4-28. Summary of final location information for radio-tagged Atlantic salmon smolts detected during manual tracking efforts covering from release location 1 to downstream of Ellsworth Dam, June 2016.

Release Group	Release Location	Frequency	ID	Waterbody	Direction and Name of Nearest Landmark	Approximate Distance (miles)
E4	1	320	74	Union River	DS Release Location 1	0.2
E3	1	320	101	Union River	DS Release Location 1	0.3
E3	1	360	35	Union River	DS Release Location 1	0.6
E3	2	320	95	Graham Lake	US Graham Lake Dam	<0.1
E4	2	360	31	Graham Lake	US Graham Lake Dam	0.3
E3	1	320	105	Graham Lake	US Graham Lake Dam	0.5
E3	2	360	45	Graham Lake	US Graham Lake Dam	0.6
E4	1	320	75	Graham Lake	US Graham Lake Dam	0.6
E4	2	320	83	Graham Lake	US Graham Lake Dam	0.6
E4	1	360	25	Graham Lake	US Graham Lake Dam	0.7
E3	2	360	43	Graham Lake	US Graham Lake Dam	0.8
E3	1	320	104	Graham Lake	US Graham Lake Dam	1.1
E3	2	320	94	Graham Lake	US Graham Lake Dam	1.4
E3	2	360	46	Graham Lake	US Graham Lake Dam	2.6
E3	1	320	102	Graham Lake	US Graham Lake Dam	3.2
E3	2	360	48	Graham Lake	US Graham Lake Dam	3.7
E4	2	320	78	Graham Lake	US Graham Lake Dam	6.2
E3	2	360	42	Graham Lake	US Graham Lake Dam	8.9
E4	3	320	67	Leonard Lake	US Ellsworth Dam	0.9
E4	3	320	65	Leonard Lake	US Ellsworth Dam	1.1
E3	3	320	91	Leonard Lake	US Ellsworth Dam	1.2
E3	3	320	85	Union River	DS Ellsworth Dam	<0.1
E4	3	320	84	Union River	DS Ellsworth Dam	<0.1

5.0 Summary

A total of 241 hatchery-reared Atlantic salmon smolts were surgically tagged and released at three locations in the vicinity of the Ellsworth Project during May, 2016. Of that total, 60 smolts were equipped with Vemco acoustic transmitters and 181 with Lotek radio transmitters. Downstream movements of tagged smolts were monitored via a series of radio and acoustic receivers installed at fixed locations ranging from the upper end of Graham Lake to a point approximately 2.0 miles downstream of Ellsworth Dam. Releases were initiated on May 11 and completed on May 22, 2016. River flows during the study period were relatively low (478 cfs study period average vs a normal median monthly flow of approximately 900 cfs based on the Ellsworth Dam long-term flow duration curve for May). Due to the low flow conditions, excess spill at Ellsworth Dam was absent, and the two vertical shaft propeller turbines (Units 1 and 4) were not operated for the duration of the study.

Passage survival as a whole for the reach from the upper end of Graham Lake Dam to downstream of Ellsworth Dam was estimated at 8.3% for the 2016 study and was likely influenced to varying degrees by natural inflow through the system, water temperature, project operations and a suite of predatory species. The majority of radio-tagged smolts released at release location 1 (68%) and at release location 2 (98%) approached the outlet at Graham Lake Dam. However, passage at that facility was low, as only 23% of individuals determined to have entered the nearfield area upstream of Graham Lake Dam actually passed downstream. Because of this, the dam passage survival estimate for Graham Lake Dam was low, 14.0% (95% CI = 8.0-21.0%).

Nearly all radio-tagged smolts (97%) from release location 3 (downstream of Graham Lake) reached Ellsworth Dam. Passage route distribution at Ellsworth Dam during 2016 was via Units 2/3 (~60%) or the downstream fishway bypass system (~40%).[1] Downstream passage survival at Ellsworth Dam was estimated for both radio and acoustic-tagged smolts. Estimates were comparable with a dam passage survival rate of 73.7 (95% CI = 61.4-84.2%) for acoustic-tagged smolts and a dam passage survival rate of 74.6 (95% CI = 64.8-84.5%) for radio-tagged smolts. When evaluated by passage route, survival was higher for radio-tagged smolts passing Ellsworth Dam via the downstream fishway bypass system (96%) than was observed for the units in operation (69%).

[1] Note that, due to low flow conditions, Units 1 and 4 were not operated and there was no spill over the Ellsworth Dam spillway throughout the study period.

Appendix A

Summary of water quality conditions for all GLNFH Atlantic salmon smolts transported by truck in association with the Ellsworth Project.

Appendix Table A-1.

Date	Departing	Arriving	# Smolts	Time	Temp (°C)	DO (mg/L)	DO (%Sat)
5/9/2016	GLNFH	Ellsworth	180	9:42	9.4	11.22	100.1
				10:15	9.4	11.11	97.3
5/11/2016	Ellsworth	Release 1, 2, 3	60	20:10	12.7	10.34	97.4
				20:40	12.6	10.66	100.2
				21:13	12.5	10.5	98.5
5/14/2016	Ellsworth	Release 1, 2, 3	60	20:00	14.1	9.22	88.9
				20:32	14.1	9.84	96.7
				21:02	14.1	9.48	92.5
5/9/2016	GLNFH	Ellsworth	114	9:06	11.9	10.66	101.4
				9:44	11.9	10.13	95.2
5/14/2016	Ellsworth	Release 1, 2, 3	60	19:42	13.2	10.01	93.1
				20:28	13.2	9.04	86.6
				20:46	13.2	9.55	92.5
5/21/2016	Ellsworth	Lower River	63	13:48	17.9	9.63	101.7
5/22/2016	Ellsworth	Release 1, 2, 3	61	19:35	15.8	9.47	95.9
				19:48	15.8	9.25	93.8
				20:17	15.8	9.4	94.7

Appendix B

Rates of movements for radio and acoustic-tagged Atlantic salmon smolts through the Ellsworth Project area as defined by stationary telemetry equipment locations.

Appendix Table B-1. **Minimum, maximum, mean and median rate of movement for radio-tagged Atlantic salmon smolts by release group and release location for the reach between release location 1 and Monitoring Station U1.**

Release Group	Rate of Movement (mph)				
	Min	Max	Mean	Median	N
E1	0.04	0.34	0.18	0.14	11
E2	0.06	0.36	0.17	0.18	11
E3	0.05	0.4	0.21	0.2	10
E4	0.1	0.34	0.22	0.27	11
Release Location	**Rate of Movement (mph)**				
	Min	**Max**	**Mean**	**Median**	**N**
1	0.04	0.4	0.2	0.19	43
2	.	.	.	.	0
3	.	.	.	.	0
ALL	**Rate of Movement (mph)**				
	Min	**Max**	**Mean**	**Median**	**N**
	0.04	0.4	0.2	0.19	43

Appendix Table B-2. **Minimum, maximum, mean and median rate of movement for radio-tagged Atlantic salmon smolts by release group and release location for the reach between Monitoring Station U1 and upstream of Graham Lake Dam (Monitoring Station U2).**

Release Group	Rate of Movement (mph)				
	Min	Max	Mean	Median	N
E1	0.04	0.25	0.09	0.08	10
E2	0.06	0.32	0.14	0.12	11
E3	0.04	0.34	0.18	0.15	7
E4	0.05	0.37	0.12	0.1	9
Release Location	**Rate of Movement (mph)**				
	Min	**Max**	**Mean**	**Median**	**N**
1	0.04	0.37	0.13	0.1	37
2	.	.	.	.	0
3	.	.	.	.	0
ALL	**Rate of Movement (mph)**				
	Min	**Max**	**Mean**	**Median**	**N**
	0.04	0.37	0.13	0.1	37

Appendix Table B-3. **Minimum, maximum, mean and median rate of movement for radio-tagged Atlantic salmon smolts by release group and release location for the reach between release location 2 and upstream of Graham Lake Dam (Monitoring Station U2).**

Release Group	Rate of Movement (mph)				
	Min	Max	Mean	Median	N
E1	0.01	0.07	0.02	0.01	15
E2	0.01	0.07	0.02	0.01	15
E3	0.01	0.24	0.05	0.02	15
E4	0.01	0.15	0.03	0.02	14
Release Location	**Rate of Movement (mph)**				
	Min	**Max**	**Mean**	**Median**	**N**
1	.	.	.	.	0
2	0.01	0.24	0.03	0.02	59
3	.	.	.	.	0
ALL	**Rate of Movement (mph)**				
	Min	**Max**	**Mean**	**Median**	**N**
	0.01	0.24	0.03	0.02	59

Appendix Table B-4. **Minimum, maximum, mean and median rate of movement for radio-tagged Atlantic salmon smolts by release group and release location for the reach between upstream of Graham Lake Dam (Monitoring Station U2) and Monitoring Station U4.**

Release Group	Rate of Movement (mph)				
	Min	Max	Mean	Median	N
E1	0.02	1.23	0.31	0.21	17
E2	0.07	0.93	0.49	0.55	18
E3	0.06	0.81	0.33	0.37	17
E4	0.03	0.69	0.31	0.26	19
Release Location	**Rate of Movement (mph)**				
	Min	**Max**	**Mean**	**Median**	**N**
1	0.03	0.92	0.56	0.6	6
2	0.3	1.23	0.66	0.6	7
3	0.02	0.93	0.3	0.19	58
ALL	**Rate of Movement (mph)**				
	Min	**Max**	**Mean**	**Median**	**N**
	0.02	1.23	0.36	0.33	71

Appendix Table B-5. **Minimum, maximum, mean and median rate of movement for radio-tagged Atlantic salmon smolts by release group and release location for the reach between Monitoring Station U4 and Monitoring Station U5.**

Release Group	Rate of Movement (mph)				
	Min	Max	Mean	Median	N
E1	0.01	1.72	0.67	0.57	15
E2	0.05	1.85	0.74	0.57	18
E3	0.2	1.79	0.84	0.7	16
E4	0.04	1.55	0.63	0.42	17
Release Location	Rate of Movement (mph)				
	Min	Max	Mean	Median	N
1	0.17	1.67	0.92	0.92	2
2	0.13	1.72	0.74	0.73	7
3	0.01	1.85	0.71	0.62	57
ALL	Rate of Movement (mph)				
	Min	Max	Mean	Median	N
	0.01	1.85	0.72	0.65	66

Appendix Table B-6. **Minimum, maximum, mean and median rate of movement for radio-tagged Atlantic salmon smolts by release group and release location for the reach between Monitoring Station U5 and Ellsworth Dam.**

Release Group	Rate of Movement (mph)				
	Min	Max	Mean	Median	N
E1	0.05	0.99	0.24	0.12	13
E2	0.06	0.82	0.32	0.32	18
E3	0.14	1.24	0.42	0.23	15
E4	0.12	1.52	0.59	0.52	17
Release Location	Rate of Movement (mph)				
	Min	Max	Mean	Median	N
1	0.06	0.06	0.06	0.06	1
2	0.1	1.24	0.61	0.5	7
3	0.05	1.52	0.38	0.28	55
ALL	Rate of Movement (mph)				
	Min	Max	Mean	Median	N
	0.05	1.52	0.4	0.28	63

Appendix Table B-7. Minimum, maximum, mean and median rate of movement for radio-tagged Atlantic salmon smolts by release group and release location for the reach between Ellsworth Dam and Monitoring Station U12.

Release Group	Rate of Movement (mph)				
	Min	Max	Mean	Median	N
E1	0.04	2.64	1.13	1.04	14
E2	0.08	2.11	1.06	1.08	14
E3	0.07	2.11	0.91	0.86	10
E4	0.07	1.97	1.11	1.18	14
Release Location	**Rate of Movement (mph)**				
	Min	**Max**	**Mean**	**Median**	**N**
1	1.08	1.08	1.08	1.08	1
2	1.01	2.49	1.34	1.08	5
3	0.04	2.64	1.03	1.06	46
ALL	**Rate of Movement (mph)**				
	Min	**Max**	**Mean**	**Median**	**N**
	0.04	2.64	1.07	1.08	52

Appendix Table B-8. Minimum, maximum, mean and median rate of movement for radio-tagged Atlantic salmon smolts by release group and release location for the reach between Monitoring Station U12 and Monitoring Station U13.

Release Group	Rate of Movement (mph)				
	Min	Max	Mean	Median	N
E1	0.03	2.42	1.21	1.3	13
E2	0.13	2.35	1.54	1.77	14
E3	0.01	2.45	1.42	1.51	10
E4	0.15	2.13	0.99	0.91	12
Release Location	**Rate of Movement (mph)**				
	Min	**Max**	**Mean**	**Median**	**N**
1	1.66	1.66	1.66	1.66	1
2	0.62	2.06	1.48	1.7	5
3	0.01	2.45	1.26	1.3	43
ALL	**Rate of Movement (mph)**				
	Min	**Max**	**Mean**	**Median**	**N**
	0.01	2.45	1.29	1.4	49

Appendix Table B-9. Minimum, maximum, mean and median rate of movement for acoustic-tagged Atlantic salmon smolts by release group for the reach between release location 3 and Ellsworth Dam.

Release Group	Rate of Movement (mph)				
	Min	Max	Mean	Median	N
E1	0.04	0.25	0.12	0.07	15
E2	0.05	0.32	0.14	0.11	15
E3	0.08	0.34	0.16	0.16	13
E4	0.11	0.26	0.2	0.22	14
All	0.04	0.34	0.16	0.16	57

Appendix Table B-10. Minimum, maximum, mean and median rate of movement for acoustic-tagged Atlantic salmon smolts by release group for the reach between Ellsworth Dam and Monitoring Station U16.

Release Group	Rate of Movement (mph)				
	Min	Max	Mean	Median	N
E1	0.32	1.94	1.18	1.27	12
E2	0.02	1.54	0.92	1.06	11
E3	0.14	1.51	0.66	0.44	8
E4	0.18	1.73	0.94	1.00	11
All	0.02	1.94	0.95	1.03	42

Appendix Table B-11. Minimum, maximum, mean and median rate of movement for acoustic-tagged Atlantic salmon smolts by release group for the reach between Monitoring Station U16 and Monitoring Station U17.

Release Group	Rate of Movement (mph)				
	Min	Max	Mean	Median	N
E1	0.08	1.75	0.64	0.55	12
E2	0.02	1.16	0.57	0.63	11
E3	0.04	0.98	0.58	0.61	8
E4	0.26	1.16	0.66	0.61	11
All	0.02	1.75	0.61	0.59	42

Appendix Table B-12. Minimum, maximum, mean and median rate of movement for acoustic-tagged Atlantic salmon smolts by release group for the reach between Monitoring Station U17 and Monitoring Station U18.

Release Group	Rate of Movement (mph)				
	Min	Max	Mean	Median	N
E1	0.18	2.53	0.79	0.42	12
E2	0.15	1.17	0.53	0.43	11
E3	0.10	1.74	1.20	1.29	8
E4	0.30	3.38	1.28	1.03	11
All	0.10	3.38	0.93	0.70	42

Appendix C

Encounter histories of radio and acoustic-tagged Atlantic salmon smolts as input into Program MARK for reach specific survivorship estimates and monitoring station detection efficiency values.

Appendix Table C-1. Radio-tagged Atlantic salmon smolts.

Release Group	ID	Release Location	Encounter History	Release Group	ID	Release Location	Encounter History
E1	36078	1	110000000	E3	32099	1	100000000
E1	36079	1	110000000	E3	36033	1	000000000
E1	36080	1	000000000	E3	36034	1	111100000
E1	36081	1	100000000	E3	36035	1	000000000
E1	36082	1	000000000	E3	36036	1	111000000
E1	36083	1	110000000	E3	36037	1	000000000
E1	36084	1	110000000	E3	36038	1	110000000
E1	36085	1	111000000	E3	36039	1	100000000
E1	320130	1	110000000	E3	36040	1	110000000
E1	320131	1	111100000	E3	320100	1	000000000
E1	320132	1	110000000	E3	320101	1	000000000
E1	320133	1	110000000	E3	320102	1	110000000
E1	320134	1	010000000	E3	320103	1	100000000
E1	320135	1	000000000	E3	320104	1	110000000
E1	320136	1	110000000	E3	320105	1	110000000
E1	36086	2	010000000	E3	32092	2	011000000
E1	36087	2	010000000	E3	32093	2	010000000
E1	36088	2	011111111	E3	32094	2	010000000
E1	36089	2	010000000	E3	32095	2	010000000
E1	36090	2	010000000	E3	32096	2	010000000
E1	36091	2	011000000	E3	32097	2	010000000
E1	36092	2	011000000	E3	32098	2	010000000
E1	36093	2	010000000	E3	36041	2	011000000
E1	320137	2	010000000	E3	36042	2	010000000
E1	320138	2	011101111	E3	36043	2	010000000
E1	320139	2	010000000	E3	36044	2	010000000
E1	320140	2	010000000	E3	36045	2	010000000
E1	320143	2	011111111	E3	36046	2	010000000
E1	320144	2	010000000	E3	36047	2	011111100
E1	320145	2	010000000	E3	36048	2	010000000
E1	36094	3	000000000	E3	32085	3	000111100
E1	36095	3	000111100	E3	32086	3	000111111
E1	36096	3	000111111	E3	32087	3	000111100
E1	36097	3	000111111	E3	32088	3	000111111
E1	36098	3	000111110	E3	32089	3	000111111
E1	36099	3	000111111	E3	32090	3	000111111
E1	320141	3	000111000	E3	32091	3	000111000
E1	320142	3	000111111	E3	36049	3	000111111
E1	320146	3	000111100	E3	36050	3	000111111
E1	320147	3	000111111	E3	36051	3	000111111
E1	320148	3	000011111	E3	36052	3	000111111
E1	320149	3	000111111	E3	36053	3	000111111
E1	320150	3	000111111	E3	36054	3	000110000
E1	360100	3	000111111	E3	36055	3	000111100
E1	360101	3	000111111	E3	36056	3	000111111

(continued)

Appendix Table C-1. (Continued)

Release Group	ID	Release Location	Encounter History	Release Group	ID	Release Location	Encounter History
E2	36057	1	000000000	E4	32069	1	110000000
E2	36058	1	110000000	E4	32070	1	000000000
E2	36059	1	111111111	E4	32071	1	110000000
E2	36060	1	110000000	E4	32072	1	100000000
E2	36061	1	010000000	E4	32073	1	010000000
E2	36062	1	110000000	E4	32074	1	000000000
E2	36063	1	110000000	E4	32075	1	110000000
E2	320106	1	111111100	E4	32076	1	110000000
E2	320107	1	000000000	E4	36019	1	111101100
E2	320108	1	010000000	E4	36020	1	111101101
E2	320109	1	110000000	E4	36021	1	100000000
E2	320110	1	110000000	E4	36022	1	000000000
E2	320111	1	110000000	E4	36023	1	110000000
E2	320112	1	110000000	E4	36024	1	111000000
E2	320113	1	110000000	E4	36025	1	110000000
E2	36071	2	010000000	E4	32077	2	000000000
E2	36072	2	010000000	E4	32078	2	010000000
E2	36073	2	010000000	E4	32079	2	011111100
E2	36074	2	011000000	E4	32080	2	010000000
E2	36075	2	010000000	E4	32081	2	010000000
E2	36076	2	010000000	E4	32082	2	010000000
E2	36077	2	010000000	E4	32083	2	010000000
E2	320122	2	010000000	E4	32084	2	010000000
E2	320123	2	010000000	E4	36026	2	011000000
E2	320124	2	010000000	E4	36027	2	010111100
E2	320125	2	010000000	E4	36028	2	010000000
E2	320126	2	010000000	E4	36029	2	010000000
E2	320127	2	011111111	E4	36030	2	010000000
E2	320128	2	011111111	E4	36031	2	010000000
E2	320129	2	010000000	E4	36032	2	010000000
E2	36064	3	000111111	E4	32061	3	000111111
E2	36065	3	000111100	E4	32062	3	000111111
E2	36066	3	000111111	E4	32064	3	000111111
E2	36067	3	000111100	E4	32065	3	000111000
E2	36068	3	000011000	E4	32066	3	000111111
E2	36069	3	000111111	E4	32067	3	000111000
E2	36070	3	000111111	E4	32068	3	000111110
E2	320114	3	000111111	E4	36010	3	000111111
E2	320115	3	000111111	E4	36011	3	000111111
E2	320116	3	000111111	E4	36012	3	000111111
E2	320117	3	000111111	E4	36013	3	000111111
E2	320118	3	000111100	E4	36014	3	000111111
E2	320119	3	000111111	E4	36015	3	000101110
E2	320120	3	000111111	E4	36016	3	000111111
E2	320121	3	000111111	E4	36017	3	000111111
				E4	36018	3	000111111

Appendix Table C-2. Acoustic-tagged Atlantic salmon smolts.

Release Group	ID	Encounter History	Release Group	ID	Encounter History
E1	42751	11111	E3	42760	10000
E1	42752	11111	E3	42761	11000
E1	42753	11111	E3	42762	11000
E1	42754	11111	E3	42769	11111
E1	42755	11111	E3	42770	11111
E1	42756	11000	E3	42771	11111
E1	42757	11111	E3	42772	10000
E1	42758	11111	E3	42773	11111
E1	42759	11111	E3	42774	11111
E1	42763	11111	E3	42775	11000
E1	42764	11000	E3	42776	11000
E1	42765	11111	E3	42777	11111
E1	42766	11111	E3	42784	11111
E1	42767	11111	E3	42785	11000
E1	42768	11000	E3	42786	11111
E2	42796	11111	E4	42778	11111
E2	42797	11111	E4	42779	11111
E2	42798	11000	E4	42780	11111
E2	42799	11111	E4	42781	11111
E2	42800	11111	E4	42782	10000
E2	42801	11111	E4	42783	11111
E2	42802	11000	E4	42787	11111
E2	42803	11111	E4	42788	11111
E2	42804	11111	E4	42789	11111
E2	42805	11111	E4	42790	11111
E2	42806	11111	E4	42791	11000
E2	42807	11111	E4	42792	11111
E2	42808	11000	E4	42793	11000
E2	42809	11111	E4	42794	11000
E2	42810	11000	E4	42795	11111

Appendix D

Evaluation of radio-tagged Atlantic salmon smolt passage events at Graham Lake Dam.

NORMANDEAU ASSOCIATES
Environmental Consultants

November 9, 2016

Mr. Richard Dill
Brookfield Renewable
44 Davenport Street
Milford, Maine 04461

Re: Graham Lake Dam – Atlantic salmon smolt passage evaluation

Dear Mr. Dill:

As a follow up to our October 18, 2016 conference call, Normandeau Associates ("Normandeau") has conducted a more detailed analysis of the Atlantic salmon smolt detection data collected upstream of Graham Lake Dam. The objective of this analysis was to further understand movements of radio-tagged Atlantic salmon smolts relative to the upstream side of that structure. Normandeau sought to examine available signal strength data in an effort to determine the proximity and duration of residence time for radio-tagged smolts which approached but did not pass Graham Lake Dam during the May 2016 field study. Available signal strength information for smolts with confirmed downstream passage at Graham Lake Dam was used to inform decisions on the proximity of individuals which approached but did not pass[1]. The primary objectives of this additional analysis were to (1) identify the proportion of smolts detected in the upstream vicinity of Graham Lake Dam that may have been in close proximity to available downstream passage but failed to utilize and (2) examine the frequency and duration of residence periods for radio-tagged smolts upstream of Graham Lake Dam.

As described in the draft report detailing Atlantic salmon smolt passage at the Ellsworth Project during 2016, a total of 100 radio-tagged individuals approached the upstream side of Graham Lake Dam (Table 4-14; Normandeau 2016). Of that total, 23 were determined to have passed downstream. An estimate of the "time at large" upstream of Graham Lake Dam was calculated as the duration from initial detection at Monitoring Station U2 until passage (for individuals passing) or as the duration between the initial and final detections at Monitoring Station U2 (for individuals which did not pass). However, upon initial arrival at Graham Lake Dam smolts are not contained in any way and are free to move away from and return to the dam facility. As a result, the period of actual residence in the vicinity of Graham Lake Dam may be the sum of several shorter durations which represent all or a percentage of the calculated time at large. To evaluate this, the "cumulative residence duration" was determined for each individual.

[1] As discussed, the signal strength value recorded as part of each detection record is a function of more than just distance upstream. That value can also be influenced by depth of the tag, angle of approach towards the antenna, etc. For the purposes of this analysis, it was felt that the use of signal strength to examine proximity to the downstream bypass at Graham Lake Dam would provide some useful insight into the observations made there during the 2016 field study.

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The calculation of the cumulative residence duration relied on the ability to identify the breaks in the detection time series for a particular individual to indicate when that fish is or is not present in the detection field for a particular receiver. Since signal transmissions during a period of residence within the detection zone of a single receiver can go unrecorded for a variety of reasons (e.g., receiver scan time, signal collision, background interference, etc.), it is not appropriate to set a threshold interval between detections equal to the transmission rate of the tags (Castro-Santos and Perry 2012). To determine the appropriate threshold interval for Monitoring Station U2, the intervals between all successive detections for each individual at that location were calculated. In theory, sequential detections within a particular zone should be some multiple of the burst rate for the transmitters being used with longer intervals decreasing in frequency of occurrence. For Monitoring Station U2, a threshold interval for determining continued presence was identified as the 95th percentile of the observed set of interval durations (Figure A-1) and was determined to be 46 seconds. This threshold value was used to delineate when each period of residence was started and completed for a tagged individual. The departure of a tagged fish from the area upstream of Graham Lake Dam was determined when the time interval between successive detections exceeded the threshold interval for that zone.

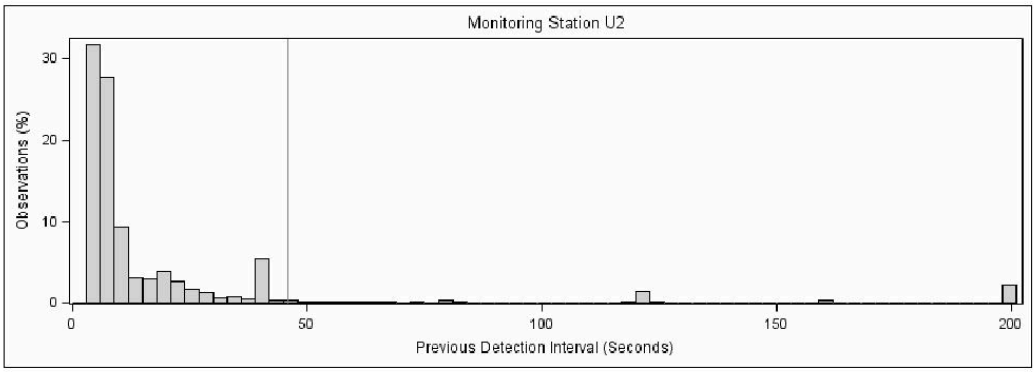

Figure A-1. Frequency distribution (%) of intervals since last detection for radio-tagged Atlantic salmon smolts transmitting in the detection zone of Monitoring Station U2. The vertical line represents the unique threshold value used to delineate new periods of residence transmitting in the detection zone upstream of Graham Lake Dam.

The duration of values calculated for time at large for radio-tagged Atlantic salmon smolts are presented in Table A-1 and ranged between 0.24 and 335.92 hours (mean = 151.61 hours). When examined for individuals which passed or did not pass at Graham Lake Dam (Table A-2), there was no significant difference between the average time at large ($t = 1.88$; $p = 0.0633$). Following refinement using the site-specific threshold value determined for Monitoring Station U2, the mean, maximum and minimum cumulative residence durations for radio-tagged smolts were determined and ranged between 0.01 and 184.94 hours (mean = 4.97 hours) (Table A-3). Similar to the comparison for average time at large, individuals which passed or did not pass at Graham Lake Dam (Table A-4) did not demonstrate a significant difference in average cumulative residence duration ($t = 0.47$; $p = 0.6367$).

When the cumulative residence duration was expressed as a percentage of the overall time at large following initial detection upstream of Graham Lake Dam, the average value for all radio-tagged smolts was approximately 8.5% (Table A-5). The average percentage of the overall time at large following initial detection upstream of Graham Lake Dam did not differ between radio-tagged smolts passing or not passing at that location ($t = 0.07$; $p = 0.9448$).

Table A-1. Minimum, maximum and mean "time at large" durations for Atlantic salmon smolts following initial detection at Monitoring Station U2 indicating arrival in the vicinity of Graham Lake Dam (by release group and location).

Release Group	Release Location	Graham Lake Dam - Time at Large (hrs)			
		No. Individuals	Minimum	Maximum	Mean
E1	1	11	0.60	256.96	127.00
E2	1	13	15.40	243.62	154.10
E3	1	7	0.03	221.25	144.90
E4	1	10	0.01	213.36	62.30
Subtotal		41	0.01	256.96	121.43
E1	2	15	2.12	335.92	209.90
E2	2	15	1.86	292.72	173.50
E3	2	15	18.70	316.98	202.50
E4	2	14	0.24	198.69	101.70
Subtotal		59	0.24	335.92	173.09
Total		**100**	**0.01**	**335.92**	**151.61**

Table A-2. Minimum, maximum and mean "time at large" durations for Atlantic salmon smolts following initial detection at Monitoring Station U2 indicating arrival in the vicinity of Graham Lake Dam (by eventual passage success).

Graham Lake Dam Passage	Graham Lake Dam - Time at Large (hrs)			
	No. Individuals	Minimum	Maximum	Mean
Successful	23	1.86	287.37	117.86
Unsuccessful	77	0.01	335.92	161.56
Total	**100**	**0.01**	**335.92**	**151.61**

Table A-3. Minimum, maximum and mean "cumulative residence duration" for Atlantic salmon smolts within the field of detection at Monitoring Station U2 indicating presence at Graham Lake Dam (by release group and location).

Release Group	Release Location	Graham Lake Dam - Cumulative Residence Duration (hrs)			
		No. Individuals	Minimum	Maximum	Mean
E1	1	11	0.25	6.43	2.99
E2	1	13	0.84	8.39	3.45
E3	1	7	0.01	6.91	3.62
E4	1	10	0.01	18.17	3.38
Subtotal		41	0.01	18.17	3.33
E1	2	15	0.58	11.29	3.20
E2	2	15	0.48	184.94	15.34
E3	2	15	1.30	7.33	3.37
E4	2	14	0.24	5.66	2.25
Subtotal		59	0.24	184.94	6.11
Total		**100**	**0.01**	**184.94**	**4.97**

Table A-4. Minimum, maximum and mean "cumulative residence duration" for Atlantic salmon smolts within the field of detection at Monitoring Station U2 indicating presence at Graham Lake Dam (by eventual passage success).

Graham Lake Dam Passage	Graham Lake Dam - Cumulative Residence Duration (hrs)			
	No. Individuals	Minimum	Maximum	Mean
Successful	23	0.77	18.17	4.05
Unsuccessful	77	0.01	184.94	5.25
Total	**100**	**0.01**	**184.94**	**4.97**

Table A-5. Minimum, maximum and mean percentage of the time at large represented by cumulative residence duration for radio-tagged Atlantic salmon smolts representing presence within the field of detection at Monitoring Station U2 located upstream of Graham Lake Dam (by eventual passage success).

Graham Lake Dam Passage	% of Time at Large Represented by Cumulative Residence Duration			
	No. Individuals	Minimum	Maximum	Mean
Successful	23	1.21%	63.44%	8.23%
Unsuccessful	77	0.25%	100.00%	8.55%
Total	**100**	**0.25%**	**100.00%**	**8.48%**

The cumulative residence time presented above represents the sum of all time periods where an individual salmon smolt was present within the entire detection zone of Monitoring Station U2. Based on the low passage rate observed at Graham Lake Dam during the 2016 study, it was of interest to determine the percentage of smolts which approached Graham Lake Dam close enough to have had an opportunity to pass but did not. To evaluate this Normandeau examined the signal strength information collected for smolts known to have passed downstream of Graham Lake Dam and determined a threshold value which would distinguish telemetry detections for a radio-tagged smolt in close proximity to the dam versus further out in the receiver detection zone. A full set of upstream and downstream detections (i.e., Monitoring Stations U2 and U3) were available for 20 of the 23 radio-tagged salmon smolts[2]. For each of those individuals, the sub-set of detections upstream of Graham Lake Dam during the two minutes prior to downstream passage were identified and the signal strength values associated with those records were considered representative of an individual in the nearfield area immediately upstream of the downstream bypass. The range and average signal strength value for each individual radio-tagged smolt known to have passed Graham Lake Dam is presented in Table A-6.

Table A-6. Minimum, maximum and mean signal strength values recorded at Monitoring Station U2 during the two minutes proceeding downstream passage at Graham Lake Dam for individual radio-tagged Atlantic salmon smolts.

	Signal Strength			
Fish ID	No. Detections	Minimum	Maximum	Mean
320-79	21	97	228	188
320-92	11	145	235	216
320-106	13	175	230	205
320-127	9	200	236	224
320-128	11	197	238	222
320-131	16	105	236	188
320-138	11	141	236	201
320-143	12	169	223	200
360-19	4	148	188	174
360-20	16	68	237	199
360-26	12	102	194	163
360-34	15	171	236	216
360-36	10	166	234	205
360-41	20	143	235	196
360-47	13	79	211	181
360-59	17	159	238	216
360-74	12	194	237	213
360-85	8	140	230	189
360-88	20	119	238	195
360-91	17	81	210	152

[2] Note: adequate detection data was unavailable for 3 of the 23 radio-tagged Atlantic salmon smolts passing Graham Lake Dam. As a result they were excluded from the evaluation of signal strength indicating presence in vicinity of the downstream bypass. Passage of these individuals at Graham Lake Dam was determined based on subsequent detections at downstream stations and Ellsworth Dam.

When the detections for all 20 radio-tagged smolts known to pass are pooled, signal strengths recorded during the 2-minutes prior to downstream passage ranged between 68 and 238 (mean = 196; 95% CI = 192 – 201). Based on signal strength information collected for smolts immediately prior to known passage events, a value of 192 (representing the lower 95% CI around the mean value) was selected as the threshold value indicating the presence of a radio-tagged smolt in the near vicinity of the downstream bypass at Graham Lake Dam.

Signal strength information associated with the full time series of detection information for each of the 77 radio-tagged smolts which approached but did not pass Graham Lake Dam was visually evaluated relative to the threshold value determined from known passage events (value = 192). For each individual it was determined (a) if that individual resided in close proximity to passage options at Graham Lake Dam and (b) on how many occasions one of these "approach events" occurred. The proportional contribution of detections with signal strength readings greater than the 192 threshold value to the overall total number of detections was used to approximate the percentage of the cumulative residence time spent in close proximity to passage options at Graham Lake Dam for each individual smolt. Figure A-2 provides two examples of a plotted time series of signal strength information for radio-tagged smolts 360-31 and 320-112 which made 4 and 6 approach events, respectively, during their time at large above Graham Lake Dam but failed to pass.

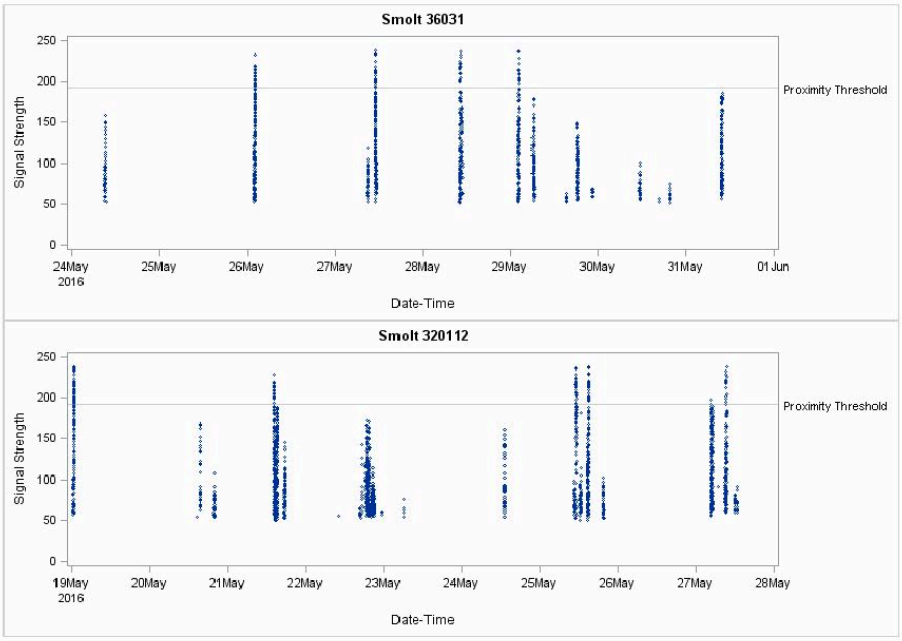

Figure A-2. Time series plots of recorded signal strength information for two radio-tagged Atlantic salmon smolts upstream of Graham Lake Dam relative to the estimated approach threshold value.

Of the 77 radio-tagged smolts which were recorded within the Monitoring Station U2 detection zone, 96% (74 of the 77) were determined to have made at least one approach event during their time at large upstream of Graham Lake Dam. The number of approach events ranged between 1 and 11 (mean = 4.7) for those individuals (Table A-7). Smolts exhibiting successful passage at Graham Lake Dam also attempted multiple approach events prior to moving downstream (range = 1-17; mean = 5.5). There was no significant difference between the average number of approach events for individuals which did or did not pass Graham Lake Dam (t = 1.26; p = 0.2109).

Table A-7. Minimum, maximum and mean number of approach events for radio-tagged Atlantic salmon smolts as determined during review of Monitoring Station U2 detection data (by eventual passage success).

Graham Lake Dam Passage	Number of Approach Events			
	No. Individuals*	Minimum	Maximum	Mean
Successful	23	1	17	5.5
Unsuccessful	74	1	11	4.7
Total	**97**	**1**	**17**	**4.9**

* three individuals made no approach events and were only recorded away from Graham Lake Dam

The product of the cumulative residence duration (Tables A-3 and A-4) and the proportional contribution of signal strength readings greater than the approach threshold value were used to estimate the total amount of time spent in close proximity to downstream passage options on an individual basis at Graham Lake Dam. The minimum, maximum and mean "cumulative proximity duration" values are presented in Table A-8. When all smolts are considered, cumulative proximity duration ranged between < 1 to 120 minutes (mean = 16.8 min). The average cumulative proximity duration did not differ between smolts which did or did not pass at Graham Lake Dam (t = 1.54; p = 0.1262).

Table A-8. Minimum, maximum and mean cumulative proximity duration for radio-tagged Atlantic salmon smolts in the vicinity of downstream passage route at Graham Lake Dam (by eventual passage success).

Graham Lake Dam Passage	Cumulative Proximity Duration (minutes)			
	No. Individuals	Minimum	Maximum	Mean
Successful	23	1.9	52.8	21.2
Unsuccessful	74	0.1	119.7	15.4
Total	**97**	**0.1**	**119.7**	**16.8**

In summary, the majority (96%; 74 of the 77) of the radio-tagged Atlantic salmon smolts reported to have been in the vicinity of Graham Lake Dam but failing to pass did in fact approach within close proximity to downstream passage options. These individuals made on average 5 approach events which cumulatively added to approximately 15 minutes of residence time in the vicinity of passage

options. These values did not differ significantly from Atlantic salmon smolts known to have passed at Graham Lake Dam. Based upon this review, it appears as if radio-tagged Atlantic salmon smolts during 2016 were successful in locating the vicinity of downstream passage at Graham Lake Dam but the majority of those individuals (76%; 74 of the 97 approaching) opted to remain upstream.

Should you have any additional questions related to this analysis, please do not hesitate to call (603.319.5310) or email (dtrested@normandeau.com).

Sincerely,

Drew Trested
Fisheries Biologist
Normandeau Associates, Inc.

Appendix E

Correspondence related to agency review of draft report (October19/November 9 2016)

From:	Dunlap, Frank
To:	jeff.murphy@noaa.gov; Donald.Dow@noaa.gov; Steven_Shepard (Steven_Shepard@fws.gov); Antonio Bentivoglio (antonio_bentivoglio@fws.gov); Dan.Tierney@noaa.gov; nicholas.palso@ferc.gov; William_Connelly; Cox, Oliver N; Burr, Gregory; john.perry@maine.gov
Cc:	Maloney, Kelly; Dill, Richard; Bernier, Kevin
Subject:	Ellsworth 2016 Smolt Study - Agency Review
Attachments:	2016-10-13 Ellsworth 2016 Smolt Study Agency Draft_Normandeau.pdf

All

Attached is the review draft of the 2016 Evaluation of Atlantic Salmon Smolt Passage conducted at the Ellsworth Project. Please review the study report and provide your comments to me by Friday, November 18, 2016.

Thank you

Frank

Frank H. Dunlap
Licensing Specialist
Brookfield Renewable
150 Main Street, Lewiston, Maine 04240
T 207-755-5603 **C** 207-242-6410
Frank.Dunlap@BrookfieldRenewable.com
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From: Dunlap, Frank
To: jeff.murphy@noaa.gov; Donald.Dow@noaa.gov; Steven_Shepard (Steven_Shepard@fws.gov); Antonio Bentivoglio (antonio_bentivoglio@fws.gov); Dan.Tierney@noaa.gov; nicholas.palso@ferc.gov; William Connelly; Cox, Oliver N; Burr, Gregory; john.perry@maine.gov
Cc: Maloney, Kelly; Dill, Richard; Bernier, Kevin
Subject: RE: Ellsworth 2016 Smolt Study - Agency Review
Attachments: 2016-11-09 Ellsworth Smolt Signal Strength Evaluation.pdf

All
We have had Normandeau conduct further analysis on the 2016 smolt passage data at the Ellsworth Project to evaluate the question of whether smolts approached the passage routes at Graham Lake dam in particular. Attached as a supplement to the previously distributed 2016 Evaluation of Atlantic Salmon Smolt Passage at the Ellsworth Project, is a November 9, 2016 letter report by Normandeau evaluating the smolt telemetry signal strength in the vicinity of Graham Lake Dam. Please consider this as part of your review of the overall study report.
Thank you
Frank

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Frank.Dunlap@BrookfieldRenewable.com
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From: Dunlap, Frank
Sent: Wednesday, October 19, 2016 5:18 PM
To: jeff.murphy@noaa.gov; Donald.Dow@noaa.gov; Steven Shepard (Steven_Shepard@fws.gov); Antonio Bentivoglio (antonio_bentivoglio@fws.gov) (antonio_bentivoglio@fws.gov); Dan.Tierney@noaa.gov; nicholas.palso@ferc.gov; William Connelly (William.Connelly@ferc.gov); Cox, Oliver N; Burr, Gregory (gregory.burr@maine.gov); john.perry@maine.gov
Cc: Maloney, Kelly (Kelly.Maloney@brookfieldrenewable.com); Dill, Richard (Richard.Dill@brookfieldrenewable.com); Bernier, Kevin
Subject: Ellsworth 2016 Smolt Study - Agency Review

All
Attached is the review draft of the 2016 Evaluation of Atlantic Salmon Smolt Passage conducted at the Ellsworth Project. Please review the study report and provide your comments to me by Friday, November 18, 2016.
Thank you
Frank

Frank H. Dunlap
Licensing Specialist

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UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
GREATER ATLANTIC REGIONAL FISHERIES OFFICE
55 Great Republic Drive
Gloucester, MA 01930-2276

NOV 15 2016

Frank H. Dunlap
Licensing Specialist
Brookfield Renewable
150 Main Street, Lewiston, Maine 04240

Re: Atlantic Salmon Smolt Survival Study at the Ellsworth Project (P-2727)

Dear Mr. Dunlap:

In your October 19, 2016 and November 9, 2016 e-mails, you requested that we review and comment on Brookfield's draft Atlantic salmon smolt survival study report from the May 2016 study conducted at the Ellsworth Project (FERC No. 2727) on the Union River in Ellsworth, Maine. The results, particularly the almost total loss of study fish, as well as extreme levels of migratory delay, are alarming. We encourage you to immediately take measures to improve downstream passage conditions at both the Graham Lake Dam and the Ellsworth Dam to allow for safe, timely and effective passage for juvenile Atlantic salmon and river herring.

The following are our comments on the 2016 draft study report:

This was a well designed and implemented study, and we appreciate the speed with which the results were analyzed and presented. We acknowledge the Licensee's efforts working with us and other stakeholders on the Union River to conduct the best possible assessments of Atlantic salmon. Answers to the questions highlighted below are necessary for a complete assessment of the study results.

P.17: The report states units 2 and 3 were operating 46% and 88% of time. Units 1 and 4 were not operating at all. Is it correct to assume there were periods during the study that no units were operating? Please provide hourly generation data for all units for the study period.

P. 17: For Graham Lake Dam, you indicate that "Spill depths through the downstream sluice ranged between 5.5 to 6.5 feet." What does this equate to in cubic feet per second?

P.18 4.4.1: You report that 68% of the fish that were released upriver of Graham Lake were detected at Graham Dam. Some of this mortality could have been associated with post-handling release mortality. What proportion of fish detected at Station U1 (upper end of Graham Lake) were subsequently detected at Station U2 (Graham Lake Dam)?

P.20: You state that "the majority of passage events at Ellsworth took place during the late evening and early morning hours". While true, it is worth noting that nearly a third of the fish passed during daylight hours (Fig 4-18). This is relevant in terms of whether or not nighttime shutdowns would be appropriate as a minimization measure at this project. Please provide the same information for Graham Lake Dam.

P.19-20: The cumulative migratory delay (i.e. residence time) at Graham Lake dam (median of 80 hours) and at Ellsworth dam (median of 18 hours) is approximately one hundred to one thousand times greater than the median delay estimates reported at Brookfield's dams on the Penobscot, Kennebec, and Androscoggin Rivers. For example, mean residence time at the Shawmut Project on the Kennebec was estimated to be 0.3 hours, which is 0.3% of the delay experienced at the Ellsworth Project in 2016. It is likely that this extreme level of migratory delay is a causative factor in the high mortality at both dams. We expect this delay will need to be addressed during the ongoing relicensing.

P. 21: Future studies should employ more receiver locations in Graham Lake to understand the fate of smolts. We suggest adding a camera at the dam to record predators.

Please add a graph depicting: 1) time of first detection for smolts at Graham Dam; and, 2) time of last detection of smolts at Graham Dam.

Given Downeast Salmon Federation's documentation of injuries to juvenile alewives presumably caused by barotrauma during downstream passage in October 2016, Brookfield should consider how to analyze this effect in any future smolt survival study.

Although the effects of Graham Dam (only 14% survival) are the more striking, we are also concerned with the high mortality (~25%) of smolts passing the Ellsworth Dam. As only two of the four turbines at the Project were operating in May of 2016 due to low flows, we anticipate that a larger proportion of smolts could potentially become entrained in a more typical year. Given the reported difference between bypass survival (96%) and turbine survival (69%), it seems that passage survival in higher flow years could have been even lower. As noted above, we are very concerned about the effects of the continued operation of the Ellsworth project on our trust resources, including endangered Atlantic salmon.

Lastly, the 2016 study results demonstrate the lack of utility in the desktop approach to predicting mortality of fish at hydroelectric projects. The Ellsworth Project desktop and entrainment study contained in the 2015 Draft License Application predicted 94.7 to 95.2% survival of Atlantic salmon smolts through the project area. This is in stark contrast to the 8.3% survival estimate reported in your draft report. In the future, Brookfield and the Federal Energy Regulatory Commission should demonstrate extreme prudence in relying on these types of analyses versus actual field studies.

We look forward to working with you to find solutions to the very significant issues that were revealed through this study. If you have any questions concerning these comments, please contact Dan Tierney (207-866-3755 or Dan.Tierney@noaa.gov).

Sincerely,

for Kimberly B. Damon-Randall
Assistant Regional Administrator for
Protected Resources

Cc: Oliver Cox (MDMR)
Steven Shepard (USFWS)
Julie Crocker, Sean McDermott (NMFS)

From:	Cox, Oliver N
To:	Dunlap, Frank; jeff.murphy@noaa.gov; Donald.Dow@noaa.gov; Steven Shepard (Steven_Shepard@fws.gov); Antonio Bentivoglio (antonio_bentivoglio@fws.gov) (antonio_bentivoglio@fws.gov); Dan.Tierney@noaa.gov; nicholas.palso@ferc.gov; William Connelly (William.Connelly@ferc.gov); Burr, Gregory; Perry, John
Cc:	Maloney, Kelly; Dill, Richard; Bernier, Kevin
Subject:	RE: Ellsworth 2016 Smolt Study - Agency Review
Date:	Friday, November 18, 2016 10:37:01 AM

Dear Frank,

Thank you for the opportunity to review the Atlantic Salmon Smolt Study Report for the Ellsworth Project (P-2727) that Black Bear Hydro Partners, LLC conducted in May of 2016. The Maine Department of Marine Resources (MDMR) has reviewed the draft report.

Overall, the results of the study demonstrates a serious need to improve downstream fish passage at both Graham Lake and Ellsworth dams to reduce the delay and significantly improve survival.

Graham Lake Passage:
It is beneficial to our review to know how many of the smolts released above Graham Lake at release site 1 were detected at monitoring station U1 without having to "dig" for the information? Based on Figure 4-8, it appears that 43 smolts were detected at station U1. Therefore, survival from release site 1 to monitoring station U1 was only 72% (n=60) and that survival through Graham Lake from monitoring station U1 to station U2 was 95% (n=43). In contrast, survival from release site 1 to monitoring station U2 was 68% (n=60). Please add a sentence to Section 4.4.1 that states the number of smolts detected at U1 and provide a table showing apparent survival for Graham Lake.

Graham Lake Dam:
It was surprising to see that only 61% of the smolts survived passage at Graham Lake Dam (n=23). It was also surprising to see that only 23% (n=100) of smolts arriving at Graham Lake Dam successfully passed. It is evident that something must be done to improve attraction and downstream passage success at Graham Lake Dam.

Ellsworth Dam:
Please provide more detail on when units 2 and 3 were being operated. When were both units operating at the same time? Was there a time when both units were off? It is unclear from your report what the operating conditions were when smolts were utilizing the turbines for passage versus the downstream bypass.

Smolt survival of only 75% (n=71) at the Ellsworth Dam is a discouraging result. However, it was encouraging to see that 96% (n=25) of the smolt that utilized the bypass were detected downstream. Implementing measures to increase the utilization of the downstream bypass and to eliminate passage through the turbines will benefit Atlantic salmon smolts and hopefully post-spawn alewives as well.

Project Survival:
The results indicated that only 3.3% (n=60) of the smolts successfully passed the Project (Table 4-17). Reach specific survival estimates calculated in Program MARK (Table 4 -22) indicated an overall

survival from monitoring station U1 to monitoring station U12 was 8.3%. Recovery of Atlantic salmon is highly unlikely given those results.

Please feel free to contact me with any questions you may have.

Sincerely,
Oliver

Oliver Cox
Maine Department of Marine Resources
Division of Sea Run Fisheries and Habitat
650 State Street, Bangor, Maine 04401
207.941.4487

Division Mission
To protect, conserve, restore, manage and enhance diadromous fish populations and their habitat in all waters of the State; to secure a sustainable recreational fishery for diadromous species; and to conduct and coordinate projects involving research, planning, management, restoration or propagation of diadromous fishes.

From: Dunlap, Frank [mailto:Frank.Dunlap@brookfieldrenewable.com]
Sent: Wednesday, October 19, 2016 5:20 PM
To: jeff.murphy@noaa.gov; Donald.Dow@noaa.gov; Steven Shepard (Steven_Shepard@fws.gov); Antonio Bentivoglio (antonio_bentivoglio@fws.gov) (antonio_bentivoglio@fws.gov); Dan.Tierney@noaa.gov; nicholas.palso@ferc.gov; William Connelly (William.Connelly@ferc.gov); Cox, Oliver N; Burr, Gregory; Perry, John
Cc: Maloney, Kelly; Dill, Richard; Bernier, Kevin
Subject: Ellsworth 2016 Smolt Study - Agency Review

All
Attached is the review draft of the 2016 Evaluation of Atlantic Salmon Smolt Passage conducted at the Ellsworth Project. Please review the study report and provide your comments to me by Friday, November 18, 2016.
Thank you
Frank

Frank H. Dunlap
Licensing Specialist

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Appendix F

Responses to resource agency comments

The following comments were provided by NMFS and the MDMR:

NMFS Comment 1: P.17. The report states units 2 and 3 were operating 46% and 88% of time. Units 1 and 4 were not operating at all. Is it correct to assume there were periods during the study that no units were operating? Please provide hourly generation data for all units for the study period.

Response to NMFS Comment 1: Figure 4-4 of the report provides the cumulative discharge for Units 1 through 4 for the duration of the study period. Total unit discharge ranged from a low of 200 cfs up to 838 cfs. At no point during the study period was there a period with no unit operation. Because Figures 4-3 and 4-4 show the unit generation flows they also implicitly illustrate the generation pattern of the units during the entire study period.

NMFS Comment 2: P.17. For Graham Lake Dam, you indicate that "Spill depths through the downstream sluice ranged between 5.5 and 6.5 feet". What does this equate to in cubic feet per second?

Response to NMFS Comment 2: Using the formula for a rectangular contracted weir, discharge through the Graham Lake Dam was estimated at 150 cfs for a sluice depth of 5.5 ft and 200 cfs for a sluice depth of 6.5 ft. The report was revised accordingly.

NMFS Comment 3: P.18 4.4.1: You report that 68% of the fish that were released upriver of Graham Lake were detected at Graham Lake Dam. Some of this mortality could have been associated with post-handling release mortality. What proportion of fish detected at Station U1 (upper end of Graham Lake) were subsequently detected at Station U2 (Graham Lake Dam)?

Response to NMFS Comment 3: Of the 60 smolts released upstream of Graham Lake, 47 were determined to have moved downstream of Station U1 (upper end of Graham Lake). Based on that determination, 13 radio-tagged smolts failed to move from the release site through the 3.4 mile stretch of the Union River and downstream to the first detection station. Although a proportion of those smolts may have been impacted by the tagging process, it is likely some were also predated through that reach. That stretch of the Union River can be characterized as very slow moving, low gradient habitat.

NMFS Comment 4: You state that "the majority of passage events at Ellsworth took place during the late evening and early morning hours". While true, it is worth noting that nearly a third of fish passed during daylight hours (Figure 4-18). This is relevant in terms of whether or not nighttime shutdowns would be appropriate as a minimization measure at this project. Please provide the same information for Graham Lake.

Response to NMFS Comment 4: Observations on the distribution of passage times for radio-tagged smolts at Ellsworth are noted. As requested, an additional figure (Figure 11a) has been added to the report and presents the temporal distribution of passage events for

radio-tagged smolts at Graham Lake Dam. Although limited by the small sample size, downstream passage at this location did not appear to be influenced by time of day as events occurred across the full range of day and nighttime hours. The report was revised.

NMFS Comment 5: P. 19-20: The cumulative migratory delay (i.e., residence time) at Graham Lake Dam (median of 80 hours) and at Ellsworth Dam (median of 18 hours) is approximately one hundred to one thousand times greater than the median delay estimates reported at Brookfield's dams on the Penobscot, Kennebec and Androscoggin Rivers. For example, mean residence time at the Shawmut Project on the Kennebec was estimated to be 0.3 hours, which is 0.3% of the delay experienced at the Ellsworth Project in 2016. It is likely that this extreme level of migratory delay is a causative factor in the high mortality at both dams. We expect this delay will need to be addressed during the ongoing relicensing.

Response to NMFS Comment 5: As part of the proposed 2017 downstream passage evaluation, Brookfield plans to temporarily modify the current passage measures to test whether these modifications may improve passage as well as reduce residence time. At Graham Lake Dam, the existing downstream passage weir will be modified to create an Alden weir and bell shaped approach. At Ellsworth, Black Bear plans to temporarily remove a seven-foot-wide section of flashboards adjacent to the current downstream passage weir.

NMFS Comment 6: P. 21: Future studies should employ more receiver locations in Graham Lake to understand the fate of smolts. We suggest adding a camera at the dam to record predators.

Response to NMFS Comment 6: The effectiveness of additional radio-telemetry receiver locations within Graham Lake will be severely impacted by the size of the lake. Graham Lake is 1-2+ miles wide over most of its length. The detection probability for the NTC-3-2 transmitter carried by radio-tagged smolts would be very low for shoreline stations placed along the main body of the lake. Black Bear will consider installing a camera(s) at Graham Lake Dam during the proposed 2017 smolt study to evaluate avian predation.

NMFS Comment 7: Please add a graph depicting: 1) time of first detection for smolts at Graham Lake Dam; and 2) time of last detection of smolts at Graham Lake Dam.

Response to NMFS Comment 7: Following clarification with NMFS on this request, an additional figure (Figure 11b) was prepared which summarizes the fate of radio-tagged smolts (i.e., survival to the next downstream monitoring station) based upon hour of passage. Based upon this information, all smolts passing Graham Lake Dam and failing to reach the first downstream monitoring station occurred during daylight hours. Although limited by sample size, this observation suggests that losses associated with passage at Graham Lake Dam may be less a function of the physical act of passage (which should impact smolts uniformly regardless of passage hour as gate operations are consistent day to

night) and may be more related to presence of a diurnal predator such as the cormorant or piscivorous fish species.

NMFS Comment 8: Given Downeast Salmon Federation's documentation of injuries to juvenile alewives presumably caused by barotrauma during downstream passage in October 2016, Brookfield should consider how to analyze this effect in any future smolt survival study.

Response to NMFS Comment 8:
Black Bear is actively consulting with the NMFS to establish the scope and methodologies to be used during the proposed 2017 smolt study for the Ellsworth Project.

MDMR Comment 1: Graham Lake Passage: It is beneficial to our review to know how many of the smolts released above Graham Lake at release site 1 were detected at monitoring station U1 without having to "dig" for the information. Based on Figure 4-8, it appears that 43 smolts were detected at station U1. Therefore, survival from release site 1 to monitoring station U1 was only 72% (n=60) and that survival through Graham Lake from monitoring station U1 to station U2 was 95% (n=43). In contrast, survival from release site 1 to monitoring station U2 was 68% (n=60). Please add a sentence to Section 4.4.1 that states the number of smolts detected at U1 and provide a table showing apparent survival for Graham Lake.

Response to MDMR Comment 1: As noted above in the response to NMFS comment 3, 47 of the 60 smolts (78%) released upstream of Graham Lake Dam were determined to have moved downstream of Station U1 (upper end of Graham Lake). To evaluate reach-specific survival for the complete set of radio-tagged smolts released at the upper end of Graham Lake through the 3.4 river mile reach downstream to Monitoring Station U1, an additional CJS model was constructed which incorporated an initial value of '1" for all 60 individuals representing their release into the system. Based on that model output, survival for radio-tagged smolts for the reach between release site 1 and Monitoring Station U1 was estimated at 0.794 (SE = 0.054). Reach specific estimates of survival for Graham Lake (Monitoring Station U1 to U2) are presented by release group (and for all individuals combined) in Table 4-22. The survival for the entire reach (release site 1 to Graham Lake Dam) is the product of those two reach estimates (0.794 * 0.860 = 0.683) or 68%.

MDMR Comment 2: Graham Lake Dam: It was surprising to see that only 61% of the smolts survived passage at Graham Lake Dam (n=23). It was also surprising to see that only 23% (n=100) of smolts arriving at Graham Lake Dam successfully passed. It is evident that something must be done to improve attraction and downstream passage success at Graham Lake Dam.

Response to MDMR Comment 2: Black Bear is taking steps to address the passage issues noted during the 2016 study and has prepared a draft study plan for an additional evaluation to be conducted during 2017. As noted above in the response to NMFS comment 5, structural modifications (installation of an Alden weir) are planned for Graham Lake Dam with the intent on improving downstream passage at that location.

MDMR Comment 3: Ellsworth Dam: Please provide more detail on when units 2 and 3 were being operated. When were both units operating at the same time? Was there a time when both units were off? It is unclear from your report what the operating conditions were when smolts were utilizing the turbines for passage versus the downstream bypass.

Response to MDMR Comment 3: Figures 4-3 and 4-4 of the report provide the operational status and associated discharge for independent unit operation (Figure 4-3) and cumulative operation (Figure 4-4). Although units 1 and 4 were offline for the duration of the study, either unit 2, unit 3 or both operated for the duration of the study period. Downstream passage routes were not identified to the individual turbine unit during the 2016 study. That will be conducted as part of the proposed 2017 evaluation.

MDMR Comment 4: Smolt survival of only 75% (n=71) at the Ellsworth Dam is a discouraging result. However, it was encouraging to see that 96% (n=25) of the smolt that utilized the bypass were detected downstream. Implementing measures to increase the utilization of the downstream bypass and to eliminate passage through the turbines will benefit Atlantic salmon smolts and hopefully post-spawn alewives as well.

Response to MDMR Comment 4: As noted above in the response to NMFS comment 5, modifications are scheduled to be evaluated at Ellsworth Dam with the intent on improving downstream passage at that location.

MDMR Comment 5: Project Survival: The results indicated that only 3.3% (n=60) of the smolts successfully passed the Project (Table 4-17). Reach specific survival estimates calculated in Program MARK (Table 4 -22) indicated an overall survival from monitoring station U1 to monitoring station U12 was 8.3%. Recovery of Atlantic salmon is highly unlikely given those results.

Response to MDMR Comment 5: The 3.3% referenced above refers to the two of the original 60 radio-tagged smolts released at release site 1 at the upper end of Graham Lake dam which successfully passed the receivers downstream of Ellsworth Dam. Reach-specific survival estimates from Program MARK (Table 4-22) utilized the full set of radio-tagged smolts (n = 181) and likely provide a more robust estimate of full reach survival

Ellsworth Hydroelectric Project
FERC No. 2727

Tributary Access Study

Black Bear Hydro Partners LLC
150 Main Street
Lewiston, Maine 04240

December 2016

Ellsworth Project Tributary Access Study

Background

In its December 8, 2015 Study Determination letter, FERC stated that additional information about the connectivity of Graham Lake and Lake Leonard tributaries is necessary to evaluate the effects of the Ellsworth Project (Project)operations on access to upstream fish habitat. Specifically, FERC stated that Black Bear Hydro Partners LLC (Back Bear) should provide gradient profiles for portions of tributaries to Graham Lake and Lake Leonard. In addition, FERC noted that Black Bear proposed to collect zone-of-passage information from tributaries selected in consultation with the fisheries agencies. Furthermore, FERC recommended that Black Bear collect similar information for the tributaries of the Union River between Graham Lake and Lake Leonard.

Methodology/Results

In-Office Agency Consultation Meeting

On June 29, 2016 Black Bear held a meeting in Augusta, Maine to consult with the National Marine Fisheries Service (NMFS), the Maine Department of Marine Resources (DMR), and the Maine Department of Inland Fisheries and Wildlife (IFW) to determine the scope of the study to be conducted. The U.S. Fish and Wildlife Service (USFWS) did not attend the meeting, but did e-mail their comments to Black Bear in advance of the meeting.

The tributaries discussed during the meeting, which are the same tributaries studied in the 2014 tributary access study, are:

Graham Lake	**Lake Leonard**	**Union River (between lakes)**
Hapworth Brook	Branch Lake Stream	Grey Brook
Webb Brook		Shackford Brook
East Branch of Union River		Moore Brook
West Branch of Union River		Gilpatrick Brook
Garland Brook		
Tannery Brook		
Beech Hill Pond Stream		
Reed Brook (Green Lake outlet stream)		

Prior to the meeting Black Bear distributed via e-mail a packet of information (maps and photographs) of the tributaries under consideration. Hard copies of the packet information were distributed at the meeting and photographs and Google Earth maps (including historical Google earth maps) were reviewed on screen during the meeting. In addition, NMFS provided a list of modelled (but not field verified) juvenile Atlantic salmon production units (spawning and nursery combined) for several of the tributaries.

During the meeting each of the tributaries were reviewed and discussed in depth with regard to important fish species to be considered, fish accessibility and stream conditions at various lake

levels. The result of the meeting was agreement that Graham Lake tributaries: Hapworth Brook, the West Branch of the Union River, Garland Brook, Beech Hill Pond Stream, Reed Brook (Green Lake Outlet Stream); Union River tributaries Greys Brook, Shackford Brook, Moore Brook, and Gilpatrick Brook; and the Lake Leonard tributary, Branch Lake Stream, provided adequate conditions for fish passage, even under low water, and did not require further investigation. It was also determined that it would be beneficial to conduct a site visit to the East Branch of the Union River, Webb Brook, and Tannery Brook, all tributaries of Graham Lake, in the late summer/fall during lake drawdown conditions to further evaluate/determine whether additional field investigation was necessary. A summary of the meeting is presented in Attachment 1.

Agency Site Visit

As follow-up to the consultation meeting in Augusta, a site visit was conducted on September 26, 2016 when Graham Lake was at elevation 97.11' (7.1 feet below full pond condition), near the target water level for this time of year. The site visit was attended by the NMFS, the Maine DMR, and the Maine IFW as well as personnel from Black Bear and TRC Environmental Services (TRC). The purpose of the site visit was to determine what if any, quantitative field data should be collected during lake drawdown conditions. All tributaries were approached from the landward side. A summary of the site visit is presented in Attachment 2.

Tannery Brook

Tannery Brook was investigated at three locations: at the large concrete culvert where the brook crosses under Route 181 in Mariaville approximately 1.4 miles from the confluence with Graham Lake at low water; off of Hemlock Lane approximately 1.0 mile upstream of the confluence with Graham Lake; and at the confluence to Graham Lake. Flow in the stream was through a well-defined channel in the upper reaches and was more broadly distributed at the confluence with the lake (Photo 1). Channel depths ranged from a few inches to a few feet in some pooled locations. It was agreed that tributary connectivity and fish passage at low lake levels and low stream flow is not a problem. The agency representatives stated that no measurements or other data collection was necessary. One breached, and a second beaver dam were observed on the brook. It was agreed that no additional field work is required for the study.

East Branch of the Union River

The East Branch of the Union River was investigated from its confluence with Graham Lake (at low water) in Waltham up to an approximately 10-foot high natural cascade over bedrock, a distance of approximately 0.2 miles upstream of the lake. There was considerable discussion about whether the cascade was a barrier to river herring passage and if it would be less so when Graham Lake was at near-full pond level, which it would be during their spawning migration period in May and early June. A question whether spring flows over the cascade would produce velocities that the river herring could not overcome was also raised. There does not appear to be any evidence that river herring have historically gone upstream beyond the cascade to waters higher in the watershed. It was agreed that tributary connectivity and fish passage at low lake levels and low stream flow (Photo 2) is not a problem up to the location of the cascade. The

agency representatives stated that no measurements or other data collection was necessary, and it was agreed that no additional field work is planned for the study. The agencies were, however, interested in what the cascade would look like at full pond and may visit the site on their own during the spring runoff period.

Branch Lake Stream

The group also visited the concrete dam on Branch Lake Stream at the confluence with Lake Leonard (Photo 3). TRC had previously contacted the Frenchman's Bay Conservancy and the Downeast Salmon Federation (DSF) about their plans for removing the dam. DSF is currently talking to the City of Ellsworth (owner of the dam) about the proposed removal and is writing grant applications for engineering design and funding. The Frenchman's Bay Conservancy is interested in the dam's removal, but is only playing a supportive role at this point. This activity is not related to the relicensing studies.

Photo 1 – Tannery Brook

Photo 2 – East Branch of the Union River

Photo 3 – Branch Lake Stream dam

Webb Brook

Webb Brook was investigated from the Ball Field Road bridge in Waltham downstream to the confluence with Graham Lake at low water, a distance of approximately 550 feet. Three beaver dams were observed upstream of the Ball Field Road bridge (Photos 4-7). Although the agency representatives observed no particular concerns about fish passage in this area, it was agreed that elevation measurements at three or four cross section transects would be taken at locations with the greatest potential passage limitations. In addition, a longitudinal stream gradient profile would be measured from the first beaver dam upstream of the bridge down to the lake. The agency representatives stated that no velocity measurements would be needed. Field work was completed in early October 2016, the findings are presented below.

Webb Brook Field Effort

TRC collected survey measurements at Webb Brook on October 5, 2016. Natural flows from Webb Brook on the date of the survey field measurements were very low as the area had been experiencing drought conditions throughout the summer and fall. Bottom profile elevations were collected at seven horizontal transects (Figures 1 - 7) between the lake and Ball Field Road bridge. In addition, bottom elevations were collected along a longitudinal profile following the thalweg from above the first beaver dam upstream of the Ball Field Road bridge down to the lake (elevation 96.5'; 7.7 feet below full pond condition). The gradient of Webb Brook from just downstream of the Ball Field Road bridge to the Graham Lake water surface elevation was measured to be 2.5% (5.33' elevation over 214 feet distance).

From the above mentioned beaver dam down to the lake, Webb Brook flows through an area of large boulders and bedrock substrate. The flow is often divided into multiple small channels through the boulders, but, as was determined during the agency site visit, there was always one or more channels sufficient for fish passage. Depths through the best channel at each transect were a minimum of four inches.

Photo 4 – Webb Brook looking upstream from lake to Ball Field Road bridge

Photo 5 – Webb Brook looking across the Brook

Photo 6 – Webb Brook looking downstream to Graham Lake

Photo 7 – Webb Brook looking downstream from Ball Field Road bridge

Legend

Cross Section

Stream Transect

Stream Thalweg

N

0 100 200

Feet

Sources: ESRI, TRC

Figure 1
Webb Brook Transect and Thalweg Locations

TRC
14 Gabriel Drive
Augusta, ME 04330

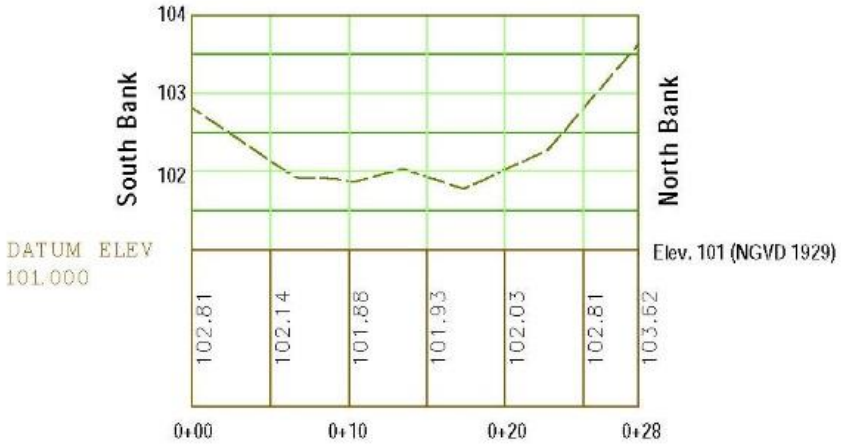
11/30/2016

V:\PROJECTS\AUGUSTA\Brookfield\Webb Brook\Webb_Brook_Salmon_Access.mxd

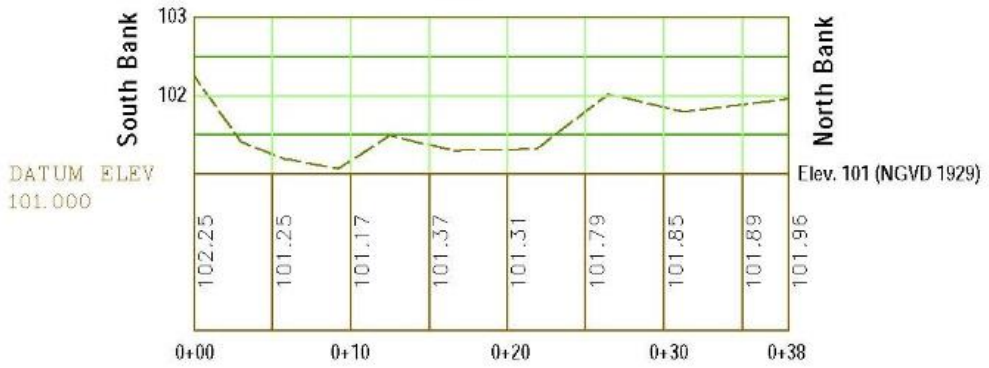
Webb Brook Transect Cross Sections

Figure 2

TS1

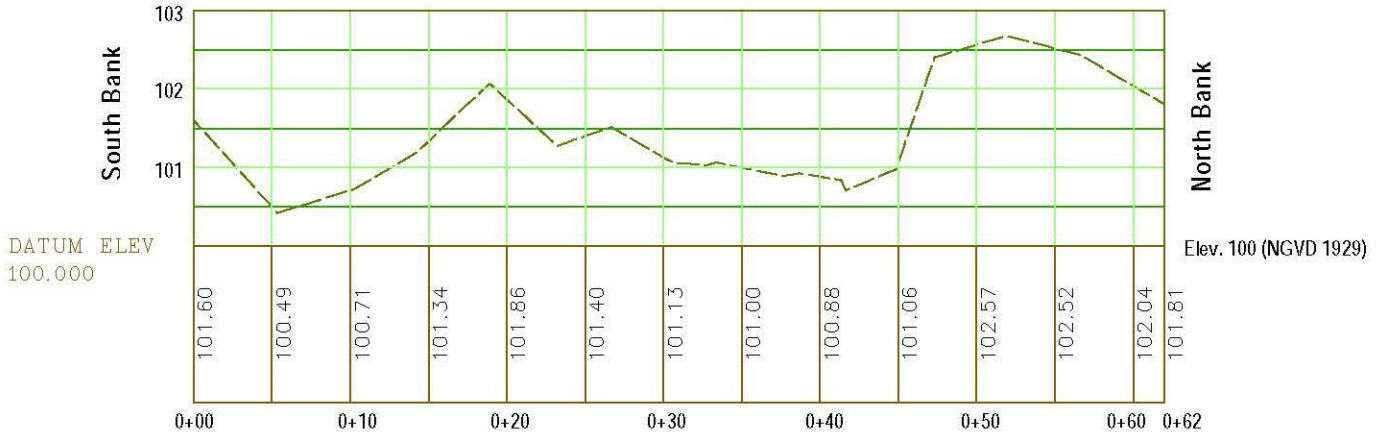


TS2



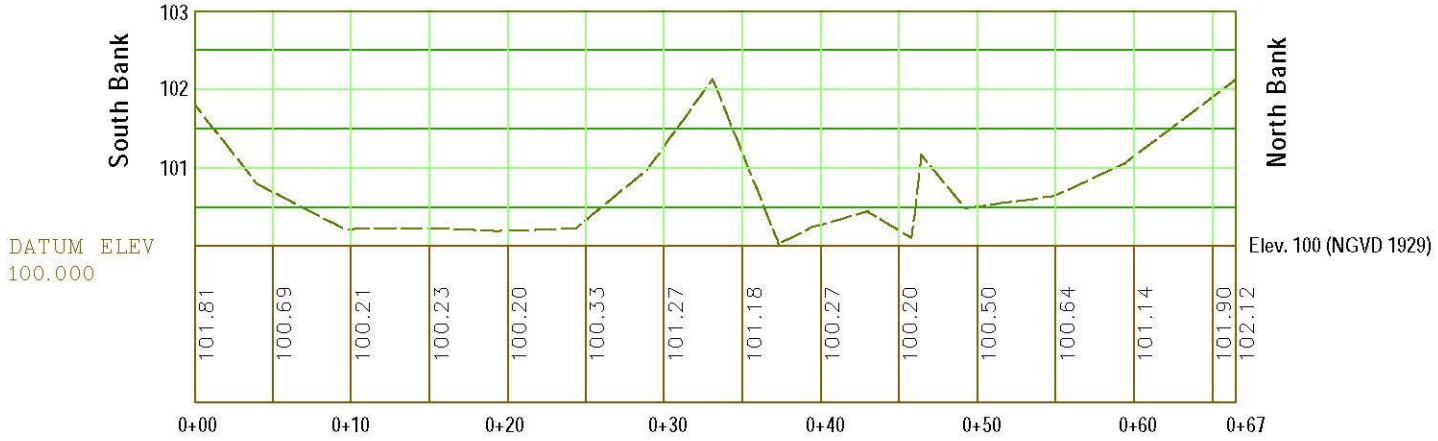
Webb Brook Transect Cross Sections

Figure 3



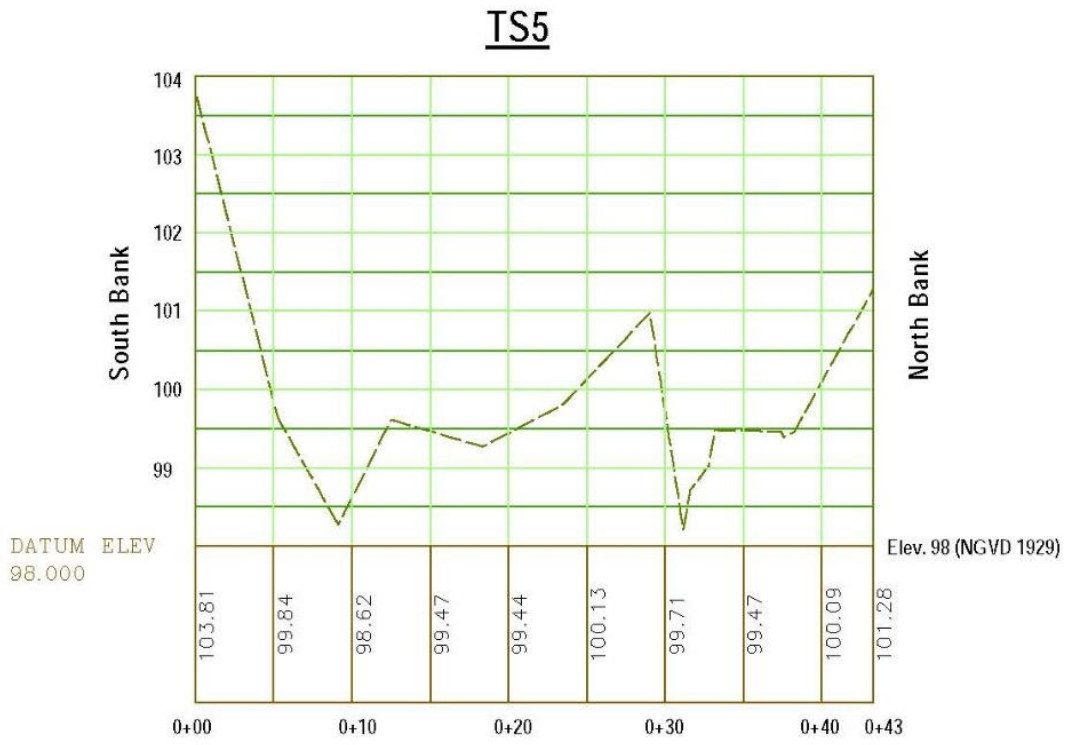
TS3

TS4



Webb Brook Transect Cross Sections

Figure 4



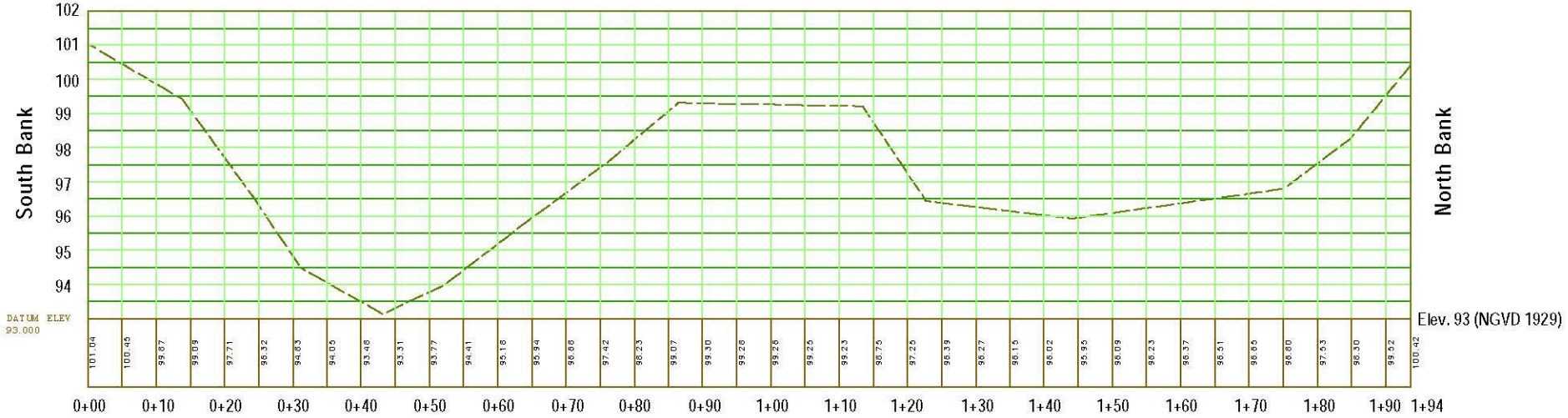
Webb Brook Transect Cross Sections

Figure 5

Webb Brook Transect Cross Sections

Figure 6

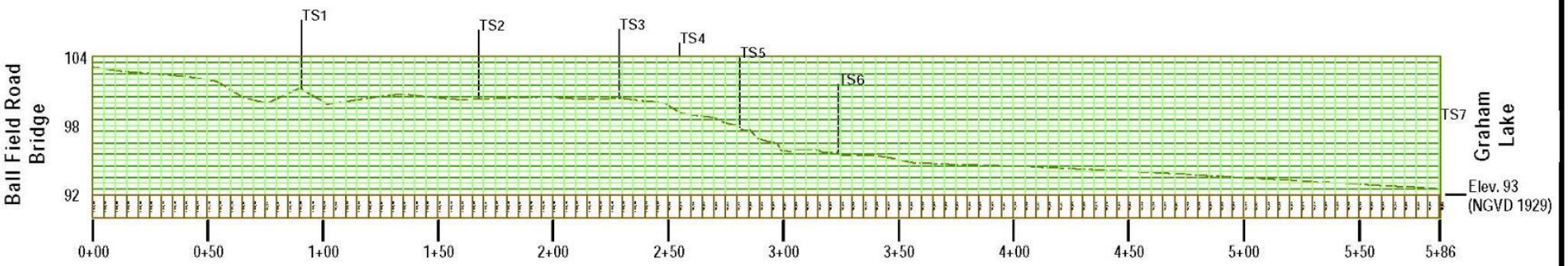
TS7



Webb Brook Transect Cross Sections

Figure 7

THALWEG



Consultation

On December 1, 2016 a consultation draft of the Tributary Access Study was sent to appropriate representatives of the Maine Department of Inland Fisheries and Wildlife (MDIFW), the Maine Department of Marine Resources (MDMR), the NOAA – National Marine Fisheries Service (NMFS) and the U.S. National Wildlife Service (USFWS) for review and comment. Comments were received from MDIFW, MDMR, and NMFS. Licensee responded to the comments by removing the table that contained modelled habitat unit numbers as requested by NMFS.

ATTACHMENT 1

CONSULTATION MEETING SUMMARY

BLACK BEAR HYDRO PARTNERS LLC
ELLSWORTH HYDROELECTRIC PROJECT (FERC NO. 2727) RELICENSING
MEETING
THURSDAY, JUNE 29, 2016

OFFICES OF BROOKFIELD AND VIA TELECONFERENCE

ATTENDEES:

Brookfield Renewable – Frank Dunlap, Richard Dill
TRC Engineers (TRC) – Dave Dominie
HDR, Inc. (HDR) – Mike Sears
National Marine Fisheries Service (NMFS/NOAA) – Jeff Murphy, Dan Tierney
Maine Department of Marine Resources (MDMR) – Oliver Cox
Maine Department of Inland Fisheries and Wildlife – Greg Burr, Joe Overlock, John Perry

In its December 8, 2016 Study Determination letter, FERC states that additional information about the connectivity of Graham Lake and Lake Leonard tributaries is necessary to evaluate the effects of project operations on access to upstream fish habitat. Specifically, FERC states that Black Bear Hydro Partners LLC (Back Bear) should provide gradient profiles for portions of the Graham Lake and Lake Leonard tributaries. In addition, FERC notes that Black Bear proposed to collect zone-of-passage information from tributaries selected in consultation with the fisheries agencies. Furthermore, FERC recommended that Black Bear collect similar information for the tributaries of the Union River between Graham Lake and Lake Leonard.

On June 29, 2016 Brookfield held a meeting in Augusta, Maine to consult with the National Marine Fisheries Service, the Maine Department of Marine Resources, and the Maine Department of Inland Fisheries and Wildlife to determine the scope of the study to be conducted. The U.S. Fish and Wildlife Service did not attend the meeting, but did e-mail their comments (attached below) to Brookfield in advance of the meeting.

The tributaries discussed during the meeting, which are the same tributaries studied in the 2014 tributary access study, are:

Graham Lake	**Lake Leonard**	**Union River**
Hapworth Brook	Branch Lake Stream	Grey Brook
Webb Brook		Shackford Brook
East Branch of Union River		Moore Brook
West Branch of Union River		Gilpatrick Brook
Garland Brook		
Tannery Brook		
Beech Hill Pond Stream		
Green Lake Hatchery outlet		

Prior to the meeting Brookfield distributed via e-mail a packet of information (maps and photographs) of the tributaries under consideration. Hard copies of the packet information were distributed at the meeting and photographs and Google Earth maps (including historical Google earth maps) were reviewed on screen during the meeting.

Discussion:

Graham Lake Tributaries

Hapworth Brook
Maine DMR stated that this brook had marginal habitat of low value. NMFS stated that they were OK with the information they had now and no more was needed. Maine DIFW stated this brook is not of concern to them. It was agreed that no further investigation is required.

Webb Brook
USFWS indicated in their written comments that this is the brook of greatest interest to them. NMFS noted that they would like to do a site visit with Brookfield at Webb Brook. Maine DMR stated this is an important brook for river herring. There was a discussion about what and how measurements should be taken. It was determined that measurements (width, depth) should be taken along 3 +/- cross sections laid out in the locations with greatest potential passage limitations. Also longitudinal stream gradient should be measured in these same areas down toward the lake. Measurements need to go above the beaver dams only if the dams would be inundated at full pond.

East Branch of the Union River
A comment was made that there is a waterfall (Great Falls) east of Route 179. MDMR stated that salmon can pass the falls under some flows. Maine DIFW stated that it is unlikely that herring can pass the falls; they have no evidence that river herring have passed Great Falls. It was determined that the site would be visited by Brookfield and the agencies to determine if further investigation is warranted as relates to salmon passage.

West Branch of the Union River
Photographs clearly showed that the West Branch is a fairly large and deep stream that does not present any barrier to fish passage up to and beyond the Ellsworth Project Boundary. It was agreed that no further investigation is required.

Garland Brook
Garland Brook has a fairly large watershed and the Google earth photos showed a clear channel from its head waters to Graham Lake. Prior investigation found that the brook is deep and passable even with Graham Lake drawn down by six feet. It was agreed that no further investigation is required.

Tannery Brook
Maine DIFW stated that this brook was the best brook trout habitat in the area and that they were not aware of any passage barriers. It was determined that the site would be visited by Brookfield and the agencies to determine if further investigation is warranted. The site visit will begin at Route 181 and then head downstream toward Graham Lake.

Beech Hill Pond Brook
This brook has a passage barrier consisting of an approx. 8-foot bedrock drop. Immediately below the drop is an old beaver dam. USFWS written comments noted that this stream has a natural falls that blocks alosine passage, but that "Maine DIFW and USFWS may work on issues on Beech Hill outlet." It was agreed that a site visit is not warranted for this brook and that no further investigation is required as part of this study.

Reed Brook (Green Lake Outlet Stream)
Maine DIFW found out that the dam on Green Lake is owned by Kleinschmidt Hydropower. It was agreed that no further investigation is required.

Union River Tributaries

Greys Brook
It was noted that at low flow there is adequate passage to the small backwater area (where juvenile alewives were seen during the 2014 investigation) at the confluence of the brook with the Union River and that there is a very limited amount of habitat further up the brook. It was agreed that no further investigation is required.

Shackford Brook
It was noted that at low flow there is adequate passage to the brook at the confluence of the brook with the Union River. Pickerelweed and arrowhead emergent vegetation dominate. It was agreed that no further investigation is required.

Moore Brook
Though shallow at the confluence with the Union River, diadromous fish could access the brook. Emergent and floating vegetation dominate the confluence area. It was agreed that no further investigation is required.

Gilpatrick Brook
This brook has a more defined channel and larger substrates than the tributaries upstream. The confluence is absent of any fish migration barriers, and it appears that there are adequate water depths for river herring and Atlantic salmon to access the brook under low flow conditions. Mane DIFW noted that brook trout do inhabit this brook. It was agreed that no further investigation is required.

Lake Leonard Tributary

Branch Lake Stream
There is a concrete dam at the confluence with the Union River. The agencies reported that the City of Ellsworth and the Frenchmens's Bay Conservancy are working on plans to take the dam out. TRC will contact Frenchman's Bay Conservancy to find out about the status of the potential removal of the dam removal. The group recommended that TRC examine the confluence elevation behind the concrete dam on at the mouth of Branch Lake Stream to see if there were any features that might obstruct fish passage once the dam is taken out.

Summary
Webb Brook, will be investigated and quantitative data collected in late summer/early fall when Graham Lake levels are down. In addition, two other tributaries, East Branch of the Union River, and Tannery Brook will be visited at the same time to determine if field measurements need to be taken. Brookfield will coordinate the site visits and will be in contact with the agencies in late summer/early fall.

From: Shepard, Steven [mailto:steven_shepard@fws.gov]
Sent: Monday, June 27, 2016 2:26 PM
To: Dominie, David <DDominie@trcsolutions.com>
Cc: Frank.Dunlap@BrookfieldRenewable.com; John Perry <John.Perry@maine.gov>; Gregg Burr <gregory.burr@maine.gov>; Oliver Cox <oliver.n.cox@maine.gov>; Sean McDermott - NOAA Federal <sean.mcdermott@noaa.gov>; Jeff Murphy <jeff.murphy@noaa.gov>
Subject: Re: FW: Ellsworth Hydroelectric Project - Tributary Access Study

Sorry Dave

I have been at a fish passage conference for the last week. Also, we have moved and our contact info has changed (see below).

I cannot make a meeting this week. Must get Williams REA done.

Re: trib access...a few points
1) there are no rainbow smelt issues (not present)
2) salmon issues are being handled by NOAA
3) the Service is mostly concerned with Alosines
4a) Alosine trib access concerns are upstream (late May to early July), and
4b) downstream (June to October)
5) in general, trib's of interest are Webb Brook, East Branch, and Beech Hill Pond outlet stream.
6) the latter two have natural falls that block alosines. However, DIFW & FWS may work on issues on Beech Hill outlet.

Thus, the greatest concern is Webb Brook.

Happy to discuss these points

Steve

Please note new address and phone
~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~
Steven Shepard, C.F.P.
U.S. Fish and Wildlife Service
P.O. Box A
306 Hatchery Road
East Orland, Maine 04431
Phone: 207-469-6701, Ext. 1116
Cell: 207-949-1288
steven_shepard@fws.gov
~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~

ATTACHMENT 2

SITE VISIT SUMMARY

BLACK BEAR HYDRO PARTNERS LLC
ELLSWORTH HYDROELECTRIC PROJECT (FERC NO. 2727) RELICENSING
TRIBUTARY SITE VISIT
MONDAY, SEPTEMBER 26, 2016

ATTENDEES:

Brookfield Renewable – Frank Dunlap, Richard Dill
TRC Engineers (TRC) – Dave Dominie
National Marine Fisheries Service (NMFS/NOAA) – Dan Tierney
Maine Department of Marine Resources (MDMR) – Ernie Atkinson
Maine Department of Inland Fisheries and Wildlife – Greg Burr

At the agency consultation meeting on June 29, 2016 it was agreed that a site visit to Tannery Brook, the East Branch of the Union River, and Webb Brook, all of which are tributaries to Graham Lake, should be conducted in late summer/fall of 2016 during lake drawdown conditions. The site visit was conducted on September 26, 2016 when Graham Lake was at elevation 97.11', (7.1 feet below full pond condition), near the target water level for this time of year.. The purpose of the site visit was to investigate each site and to determine what if any, quantitative field data should be collected during lake drawdown conditions. All tributaries were approached from the landward side.

Tannery Brook

Tannery Brook was investigated at three locations: at the large concrete culvert where the brook goes under Route 181 approximately 1.4 miles from the confluence with Graham Lake; at the end of Tannery Brook Road where the brook enters Graham Lake; and off of Hemlock Lane approximately 1.0 mile upstream of the confluence with Graham Lake. Flow in the stream was through a well-defined channel in the upper reaches and was more broadly distributed at the confluence with the lake. Channel depths ranged from a few inches to a few feet in some pooled locations. It was agreed that tributary connectivity and fish passage at low lake levels and low stream flow is not a problem. The agency representatives stated that no measurements or other data collection was necessary. One breached, and a second beaver dam were observed on the brook. It was agreed that no additional field work is planned for the study.

East Branch of the Union River

The East Branch of the Union River was investigated from its confluence with Graham Lake up to an approximately 10-foot high cascade over bedrock, a distance of approximately 0.2 miles. There was considerable discussion about whether the cascade was a barrier to river herring passage and if it would be less so when Graham Lake was at near-full pond level, which it would be during their migration period. A question whether spring flows over the cascade would produce velocities that the river herring could not overcome was also raised. There does not appear to be any evidence that river herring have historically gone upstream beyond the cascade to waters higher in the watershed. It was agreed that tributary connectivity and fish passage at low lake levels and low stream flow is not a problem up to the location of the cascade. The agency representatives stated that no measurements or other data collection was necessary, and it

was agreed that no additional field work is planned for the study. The agencies were however interested in what the cascade would look like at full pond and may visit the site on their own during the spring runoff period.

Webb Brook

Webb Brook was investigated from the Ball Field Road bridge down to the confluence with Graham Lake, a distance of approximately 550 feet. Three beaver dams were observed upstream of the Ball Field Road bridge. Although the agency representatives observed no particular concerns about fish passage in this area, it was agreed that elevation measurements at three or four cross section transects will be taken at locations with the greatest potential passage limitations. In addition, a longitudinal stream gradient will be measured from the first beaver dam upstream of the bridge down to the lake. The agency representatives stated that no velocity measurements would be needed. Field work is anticipated during early October 2016.

Branch Lake Stream

While in the vicinity, the group also stopped to look at the concrete dam on Branch Lake Stream at the confluence with Lake Leonard. Dave Dominie reported earlier in the day that he had contacted the Frenchman's Bay Conservancy and the Downeast Salmon Federation (DSF) about their plans for removing the dam. DSF is currently talking to the City of Ellsworth (owner of the dam) about the removal and is writing grant applications for engineering design and removal funding. The Frenchman's Bay Conservancy is interested in the dam's removal, but is only playing a supportive role at this point. This activity is not related to the relicensing studies.

ATTACHMENT 3

AGENCY CONSULTATION REPORT COMMENTS

From: Dominie, David <DDominie@trcsolutions.com>
Sent: Thursday, December 1, 2016 2:59 PM
To: Gregory.Burr@maine.gov; Steven Shepard (steven_shepard@fws.gov); Jeff.Murphy@noaa.gov; Cox, Oliver N
Cc: Perry, John; Dan Tiemey - NOAA Federal; Atkinson, Emie; Overlock, Joe; Dunlap, Frank; Dill, Richard
Subject: Ellsworth Hydro Project - Tributary Access Study
Attachments: 2016-12-01 Ellsworth Tributary Access Study.pdf

Group –

Attached for your review and comment is the update to the Ellsworth Hydro Project Tributary Access Study. As you know, consultation in 2016 consisted of an in-office meeting (June 29, 2016) to determine the scope of the additional work to be performed, as well as a site visit (September 26, 2016) to observe conditions in the field and determine what, if any quantitative field data should be collected. As a result of those consultations, Black Bear, through its consultant TRC collected survey information at Webb Brook. The information collected is included in the updated study.

In order to meet its December 31st FERC deadline for submittal of the study, I have spoken to Greg and Steve and left voice mail messages for Jeff and Oliver requesting an expedited review of the study. Black Bear would appreciate receiving your comments by Friday, December 16th. If you find that you do not have any comments could you please let me know so we are not waiting for something that may not be coming. Contact me if you have any questions.

Thanks for your assistance and your input during the consultation process.

Dave

David R. Dominie
Senior Environmental Specialist

TRC
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14 Gabriel Drive, Augusta, ME 04330
T: 207.620.3835 | F: 207.621.8226
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www.trcsolutions.com

From: Burr, Gregory <Gregory.Burr@maine.gov>
Sent: Thursday, December 1, 2016 3:16 PM
To: Dominie, David
Subject: RE: Ellsworth Hydro Project - Tributary Access Study

Hi Dave,

Thank you for sending this along. I have reviewed it and it looks good. No issues. Well done!

Best,

Greg

Gregory Burr
Regional Fisheries Biologist
Grand Lakes Region
Jonesboro, Maine 04648
(207) 434-5925

From: Dominie, David [mailto:DDominie@trcsolutions.com]
Sent: Thursday, December 01, 2016 2:59 PM
To: Burr, Gregory; Steven Shepard (steven_shepard@fws.gov); Jeff.Murphy@noaa.gov; Cox, Oliver N
Cc: Perry, John; Dan Tierney - NOAA Federal; Atkinson, Ernie; Overlock, Joe; 'Frank.Dunlap@BrookfieldRenewable.com'; richard.dill@brookfieldrenewable.com
Subject: Ellsworth Hydro Project - Tributary Access Study

Group –

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Dave

David R. Dominie
Senior Environmental Specialist

From: Dominie, David <DDominie@trcsolutions.com>
Sent: Monday, December 5, 2016 11:21 AM
To: Dan Tierney - NOAA Federal; Gregory.Burr@maine.gov; Jeff.Murphy@noaa.gov; Cox, Oliver N; Atkinson, Ernie; Steven Shepard (steven_shepard@fws.gov); Perry, John
Cc: Dunlap, Frank; Dill, Richard
Subject: FW: Ellsworth Hydro Project - Tributary Access Study

Dan –

As per your request, we have removed both the text reference to the modelled habitat units and the hand written table.

Dave

From: Dan Tierney - NOAA Federal [mailto:dan.tierney@noaa.gov]
Sent: Friday, December 02, 2016 5:05 PM
To: Dominie, David <DDominie@trcsolutions.com>
Subject: Re: Ellsworth Hydro Project - Tributary Access Study

Hi Dave, I only have one comment at this point. You have cited and attached the modeled habitat units that I brought to the June meeting. I calculated those units from the model you cited, but I only intended it as a reference for myself as you were going through your presentation in the meeting. As you recall, when I mentioned the numbers in the meeting it was decided that we should print a copy off for everyone. The model has been QA/QCd, but my extraction of those numbers was pretty quick and dirty and probably not publication worthy. So, as they don't appear critical to the report, could you remove those particular numbers? I would hate for anyone to put too much stock in them. The data itself is publicly available if you want to calculate the totals yourself.

Maine Stream Habitat Viewer
http://mapserver.maine.gov/streamviewer/index.html
The modelled layer of rearing habitat is located under High Interest Habitats...Atlantic salmon...Potential...Modelled Rearing Habitat

Thanks!
Dan

On Thu, Dec 1, 2016 at 2:58 PM, Dominie, David <DDominie@trcsolutions.com> wrote:

> Group –
>
> Attached for your review and comment is the update to the Ellsworth Hydro Project Tributary Access Study. As you know, consultation in 2016 consisted of an in-office meeting (June 29, 2016) to determine the scope of the additional work to be performed, as well as a site visit (September 26, 2016) to observe conditions in the field and determine what, if any quantitative field data should be collected. As a result of those consultations, Black Bear, through its consultant TRC collected survey information at Webb Brook. The information collected is included in the updated study.

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Dan Tierney
NOAA's National Marine Fisheries Service
Protected Resources Division
Maine Field Station
17 Godfrey Drive – Suite 1
Orono, Maine 04473
Ph: 207-866-3755
Fax: 207-866-7342
Email: Dan.Tierney@noaa.gov

From: Cox, Oliver N <Oliver.N.Cox@maine.gov>
Sent: Friday, December 16, 2016 9:10 AM
To: Dominie, David
Cc: Burr, Gregory; steven_shepard@fws.gov; Jeff.Murphy@noaa.gov; Perry, John; dan.tierney@noaa.gov; Atkinson, Ernie; Overlock, Joe; Dunlap, Frank; Dill, Richard
Subject: Re: Ellsworth Hydro Project - Tributary Access Study

Hi David,

I have reviewed the tributary access study and do not have any comments or edits.

Thank you,
Oliver

On Dec 1, 2016 at 2:59 PM "Dominie, David" <DDominie@trcsolutions.com> wrote:

> Group –
>
> Attached for your review and comment is the update to the Ellsworth Hydro Project Tributary Access Study. As you know, consultation in 2016 consisted of an in-office meeting (June 29, 2016) to determine the scope of the additional work to be performed, as well as a site visit (September 26, 2016) to observe conditions in the field and determine what, if any quantitative field data should be collected. As a result of those consultations, Black Bear, through its consultant TRC collected survey information at Webb Brook. The information collected is included in the updated study.
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>
> Thanks for your assistance and your input during the consultation process.
>
> Dave

From: Jeff Murphy - NOAA Federal <jeff.murphy@noaa.gov>
Sent: Monday, December 19, 2016 10:55 AM
To: Dominie, David
Cc: Frank.Dunlap@BrookfieldRenewable.com
Subject: Re: FW: Ellsworth Hydro Project - Tributary Access Study

Hi Dave - I have nothing to add. Jeff.

On Mon, Dec 19, 2016 at 10:52 AM, Dominie, David <DDominie@trcsolutions.com> wrote:

> Jeff –
>
> As follow-up to the phone message I left you earlier today, please note that Dan Tierney did provide comments on the study report (see below). If you wish to add to his comments please let me know as soon as possible.
>
> Hope you have enjoyable holiday season.
>
> Dave
>
> **From:** Dan Tierney - NOAA Federal [mailto:dan.tierney@noaa.gov]
> **Sent:** Friday, December 02, 2016 5:05 PM
> **To:** Dominie, David <DDominie@trcsolutions.com>
> **Subject:** Re: Ellsworth Hydro Project - Tributary Access Study
>
> Hi Dave, I only have one comment at this point. You have cited and attached the modeled habitat units that I brought to the June meeting. I calculated those units from the model you cited, but I only intended it as a reference for myself as you were going through your presentation in the meeting. As you recall, when I mentioned the numbers in the meeting it was decided that we should print a copy off for everyone. The model has been QA/QCd, but my extraction of those numbers was pretty quick and dirty and probably not publication worthy. So, as they don't appear critical to the report, could you remove those particular numbers? I would hate for anyone to put too much stock in them. The data itself is publicly available if you want to calculate the totals yourself.
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Thanks for your assistance and your input during the consultation process.

Dave

David R. Dominie

Senior Environmental Specialist

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