FINAL 2019 ULTRASOUND ARRAY CONTROL STUDY (UPDATED)

1.0 INTRODUCTION AND OBJECTIVES

This study plan builds on knowledge gained in 2016 and 2018 and furthers the investigation into whether the use of ultrasound technology would be an effective method to minimize shad attraction to the Cabot Station fish ladder while allowing shad to continue migrating up the bypass channel toward the Turners Falls Dam (TFD). In 2016, air entrainment from the Cabot Station turbine discharge and fish ladder attraction flow significantly increased the attenuation and scattering of the expected sound field, effectively reducing sound pressure levels below thresholds that would elicit strong and prolonged avoidance reactions from adult shad unless fish were within the immediate vicinity of the transducers including at the fish ladder entrance (Figure 1-1). In the 2016 study, there were three transducers with different horizontal orientations mounted to a pole that was located on the fish ladder wall near the entrance and two transducers, with different horizontal orientations, mounted on a pole installed approximately at the midpoint on the back of the powerhouse. Using the new data from sound measurements collected on November 15, 2017 and from the results of sound modeling, transducer locations, numbers, and orientations for the 2018 study were designed to minimize interference from air entrainment and optimize signal strength in an attempt to produce a continuous sound field spanning across the edge of the tailrace and with sound pressure levels (SPLs) greater than the 190 dB (Figure 1-2). Results of the 2018 study indicated that of the 112 adult American Shad that arrived at the Cabot Station tailrace, 85 fish (76%) moved upstream into the bypass reach entrance.

Since two elements (additional flow in the bypass reach and the ultrasound array) were added as part of the previous studies, it is not possible to ascertain which contributed to the increased number of fish moving upstream past Cabot Station and into the bypass reach. To determine if increased bypass flow or the ultrasound array or a combination of the two contributed to 76% of the tagged fish moving upstream to the bypass reach, it is proposed to conduct a movement study in 2019 with flow in the bypass reach, but without an ultrasound array in place and the Cabot Station fish ladder operating as normal.

In addition, the 2018 study revealed that Rock Dam and the channels around Rawson Island create physical and velocity barriers, respectively, which obstructed shad migration to the fishway at TFD. The 2019 study will be designed to collect additional information in these two areas of the bypass reach.

The goal of this 2019 study is to determine if the magnitude of the bypass reach flow or the ultrasound array is primarily responsible for adult American Shad moving upstream to the bypass reach. The study objectives are:

- To determine if a similar proportion of tagged migrating adult shad will migrate upstream of Cabot Station and into the bypass reach without the ultrasound array in place;
- To investigate adult shad migration in the area of Rawson Island and Rock Dam.
- To determine if adult shad migrate by the Station No .1 tailrace under a flow split of 50% spill from the TFD and 50% from Station No. 1. The 2018 study used a flow split of 67% spill from the TFD and 33% from Station No. 1, which appeared successful in terms of moving adult shad by Station No. 1 and toward the TFD. For the 2019 study both the 67%/33% and 50%/50% flow splits will be tested for flow scenario 4,400 cfs.

In addition to the objectives associated with upstream migrants, FirstLight also plans to investigate the rates of immediate and latent survival for emigrating post-spawn shad that pass through the Cabot Station turbines as they move back downstream.

2.0 MATERIALS AND METHODS

Upstream Movement Evaluation

FirstLight proposes to collect and radio tag a total of 240 early migrating adult shad at Holyoke Dam and monitor the movements of the tagged fish with a combination of Orion and Lotek receivers. The adult shad tagged at Holyoke Dam will be returned to the Connecticut River just upstream of Holyoke Dam. The monitoring equipment will be deployed and calibrated to inform on the effects of migration routes and behavior. The monitoring equipment will be deployed prior to the arrival of adult shad at Cabot Station. The study is planned for an approximate 4-week period encompassing the peak migration period, the month of May; however, the schedule may be adjusted based on river conditions and the timing of the adult shad run in 2019. Shad passage at the Holyoke Dam, located downstream of the study area, will be monitored to determine the exact timing of the 2019 study.

As shown in Figure 2-1, FirstLight proposes to release three bypass flow scenarios from the TFD, spillway fishway/attraction flow[1], and Station No. 1[2] for three consecutive days throughout the month of May. Since the bypass reach flow is proposed to only change 2,200 cfs throughout the study period, the change will be made slowly over the nighttime period when the shad are not migrating so ramp days will not be needed for this study. However, some flexibility will be needed to make bypass flow changes "on-the-fly" based on the hydrologic conditions present.

Figure 2-1: Proposed Bypass Release Schedule during Ultrasound Array Control Study

MAY

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
28	29	30	1	2	3	4
5	6	7	8	9	10	11
12	13	14	15	16	17	18
19	20	21	22	23	24	25
26	27	28	29	30	31	1

	4,400 cfs with 3,000 cfs (68%) from TFD and 1,400 cfs (32%) via Station No. 1
	4,400 cfs with 2,190 cfs (50%) from TFD and 2,210 cfs (50%) via Station No. 1
	6,500 cfs with 4,290 cfs (66%) from TFD and 2,210 cfs (34%) via Station No. 1

[1] In Figure 2-1, the TFD flow is the sum of spill plus the Spillway ladder flow and attraction flow.
[2] The full hydraulic capacity of Station No. 1 is 2,210 cfs

Assuming flows are within the control of FirstLight's facilities (Cabot = 13,728 cfs and Station No. 1 = 2,210 cfs), there will be a flow split between the magnitude of flow passed "upstream of Station No. 1" and from Station No. 1 itself. Per current water use agreements, TF Hydro and PaperLogic (other users of Turners Falls canal water) currently only operate when the hydraulic capacities of Cabot Station and Station No. 1 (collectively 15,938 cfs) are exceeded. Consideration was given to having these two facilities provide a portion (approximately 402 cfs collectively) of any future bypass flows upstream of Station No. 1. However, for purposes of the 2019 study, TF Hydro and PaperLogic will only operate after the Cabot and Station No. 1 discharge capacity is exceeded, thus they will not provide any portion of the flow above Station No. 1. In addition, another flow source upstream of Station No. 1 is the Fall River. Because there currently is no United States Geological Survey (USGS) gage or equivalent on the Fall River, we have assumed for purposes of the 2019 study that it will not contribute to the flow upstream of Station No. 1. Thus, the main two sources of flow upstream of Station No. 1 will be provided from the Spillway Ladder fishway flow/attraction flow (equates to ~ 320 cfs) and from spill over Bascule Gate No. 1. If flows exceed the hydraulic capacities of the Cabot Station and Station No. 1 (and TF Hydro and PaperLogic), then the additional flow will be passed at Bascule Gate No. 1, followed by other conveyance structures if the flows continue to rise.

Relative to the flow split (i.e., the percentage of the total bypass flow provided by Station No. 1 versus the Spillway Ladder fishway flow/attraction flow and spill from Bascule Gate No. 1), in the 2018 study approximately 33% of the bypass flow came from Station No. 1 and the remaining 67% from the Spillway Ladder fishway flow/attraction flow and spill from Bascule Gate No. 1 Results of the 2018 ultrasound study demonstrated that the 2:1 flow split was successful at moving fish to the Spillway Ladder. In 2019, FirstLight will test flow splits of 2 (spill):1 (Station No. 1) for different total bypass flows (4,400 and 6,500 cfs) and 1 (spill): 1 (Station No. 1) for different total bypass flow of 4,400 cfs in accordance with the schedule in Figure 2-1.

At the end of the study, FirstLight will provide the following hourly data: total naturally routed flow[3], TFD spill (and from which gate), Station No. 1 generation (to be converted to cfs), and Cabot Station generation (to be converted to cfs) and emergency gate spill if and when it occurs. Having this information will inform parties if the 33%/67% and 50%/50% flow splits are achieved when flows are within the operational capacity of the Project.

As a frame of reference, the estimated May flows at the TFD over the period of record in 10% exceedance increments are shown in Table 2-1.

Table 2-1: Estimated Turners Falls Dam Flows in May in 10% Exceedance Intervals

Exceedance Interval	10%	20%	30%	40%	50%	60%	70%	80%	90%
Flow (cfs)	42,000	32,000	27,000	22,000	19,000	17,000	14,000	11,000	9,000

A total of 240 adult shad will be collected from the Holyoke Dam fish lift; tagged and released upstream of the Holyoke Dam. These 240 shad will be released in five batches of 48 fish in early May.

Each test shad will be tagged with a radio tag. The radio tags will be appropriate for esophageal implantation and sized approximately as follows: 26 mm length, 9.6 mm diameter, and 4 g weight.

Radio tags are anticipated to transmit on several frequencies within the 148 to 151-megahertz band. The transmitters will employ a motion sensor and be configured such that the 3-second burst interval will shift

[3] Naturally routed flow includes: Vernon discharge + Ashuelot River USGS Gage Flow + Millers River USGS gage flow.

randomly to minimize repeated collision of tags on the same frequency. After m30 minutes of no movement the tag burst rate will change from 3-second bursts to 11-seconf bursts. The tag life will be no less than 90 days. Care will be taken to reduce the amount of time spent handling shad. Previous studies have shown that prolonged morphometric checks and measurements increase the probability that a tagged fish will fall back. At this time, FirstLight does not propose to sex or take any morphometric measurements of the fish used in the movement analysis, we will only determine if the fish is free of injury. Study fish will be captured, tagged, and returned to receiving waters immediately after tagging. To understand sex ratios and morphometric characteristics of the spawning population, FirstLight will collect a separate representative sample of shad to observe and record individual's sex, length, weight, and overall condition.

Tagged shad will be monitored using a combination of aerial Yagi antennas, in-water antennas (e.g., dipoles or stripped coaxial cable antennas) and mobile tracking. Antenna type and size will vary depending on site-specific constraints. Telemetry antennas will be deployed as either a singular antenna or grouped together. Prior to the anticipated tagging of American Shad, monitoring equipment will be deployed at the Project and calibrated.

Data-logging receivers will be connected to either a single antenna or antenna arrays as necessary. Date, time of day, tag frequency (i.e., channel), tag pulse code (unique to each tag), signal strength, and detection location (i.e., antenna number) will be stored for each signal reception. Data will be downloaded from receivers weekly.

Twenty-five monitoring stations are proposed for this study (Table 2-2) as shown in Figures 2-2, 2-3, and 2-4 (note Station T23, located at a bridge downstream from the Project, is not depicted on the figures).

Table 2-2. The proposed radio telemetry monitoring stations for the 2019 shad movement evaluation at the Turners Falls Project.

Monitoring Station ID	Location
T01	**Montague Wastewater Treatment Plant (Yagi)**
T02	**Entrance to the Deerfield River (Yagi)**
T03E	**Downstream End, East Channel of Smead Island (Yagi)**
T03W	**Downstream End, West Channel of Smead Island (Yagi)**
T04	**Left Side of the Cabot Station Tailrace (Yagi)**
T05	**Right Side of the Cabot Station Tailrace (Yagi)**
T06	**Cabot Ladder Entrance (Dipole)**
T07	**Cabot Station Far Field (Yagi)**
T08	**Conte Discharge Area (Yagi)**
T09	**Rock Dam (Yagi)**
T10	**Lower Left Channel Rawson Island (Yagi)**
T11	**Middle Channel at Rawson Island (Dipole)**
T12	**Left Channel at Rawson Island (Dipole)**
T13	**Bypass Reach, Upstream of Rawson Island (Yagi)**
T14	**Bypass Reach, Downstream of Station No. 1 (Yagi)**
T15	**Bypass Reach Upstream of Station 1 (Yagi)**
T16	**Spillway Ladder Entrance (Dipole)**
T17	**Spillway Ladder Vicinity (Yagi)**

Monitoring Station ID	Location
T18	**Cabot Station Forebay (Yagi)**
T19	**Log Sluice (Dipole)**
T20	**Copley Tunnel (where canal widens – Yagi)**
T21	**Nourse Farms Greenfield (Yagi)**
T22	**Hatfield Wastewater Treatment Plant (Yagi)**
T23	**Route 202 Bridge Holyoke, MA (Yagi)**
T24	**Upstream of Rock Dam (Yagi)**

Downstream Movement Assessment

FirstLight proposes to tag 190 American Shad at the exit of Cabot Ladder in May and release them in the canal. The downstream directed movements of all tagged fish (Holyoke and Cabot releases) as they approach, and pass Cabot Station will be monitored and assessed with a combination of mark-recapture methods and time-to-event modeling. Fish that were captured and tagged at the Cabot Ladder exit to return days or weeks later will more than likely have spawned and will be emigrating. Another group of 40 euthanized fish will be tagged and released either through the Cabot turbine with an injection tube or via the log sluice during a high and low Cabot operating scenario and their movements tracked downstream. FirstLight intends to track this specific cohort of dead fish to track their float downstream because we are ensured they were dead upon tagging and of their starting location. Mobile tracking to recover all or most dead fish to assess immediate and latent mortality will occur in the stretch of river once per week between Hatfield WWTP and the entrance of the bypass reach at the Cabot Station discharge. In addition, just after each release of dead tagged shad mobile tracking will occur.

In 2015, FirstLight tagged 100 fish during their migration at the exit of Cabot Ladder and found that 17 immediately fell back. Of the 83 remaining Cabot released fish, 36 were recaptured trying to emigrate from the Cabot Canal. Of those 36 fish, 12 exited through the powerhouse, 21 via the sluiceway, 1 did not escape, and 2 escaped via unknown routes. Overall, 77 fish escaped the canal in 2015 from 3 different release locations, 39% escaped through the powerhouse, 45% through the log sluice, 5% did not escape and 10% escaped via unknown routes. Overall, we should expect approximately 1/3 of the tagged fish released at Cabot to eventually escape the Cabot canal via the Cabot powerhouse. Based on previous work about 1/3 of the fish are expected to return to Cabot Station; therefore, out of a sample of 200 fish we should expect 66 fish to return.

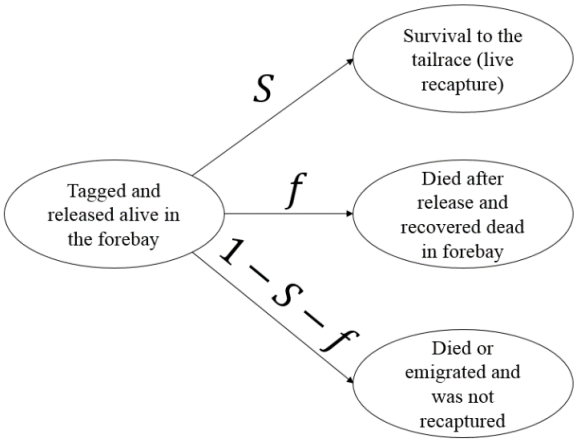
3.0 DATA ANALYSIS AND REPORTING

Radio telemetry data and fishway counts will be analyzed to determine the proportion of shad that continue past Cabot Station and up the bypass reach. It is not our intention to conduct a time series analysis of the fishway data. The telemetry data will allow for a quantitative assessment of the behavior of shad if assessed within a competing risks framework using Cox Proportional Hazards (CoxPH) regression to understand what conditions make transition from one state to the next more likely. Within a competing risks framework, movement always occurs from a central location or spoke. A series of CoxPH models will assess movement within the Cabot Station tailrace, Cabot Station forebay, and choice of route at Rawson Island. Time-dependent covariates include the bypass flow (sum of Station No. 1 discharge and spill over TFD, TFD

spillway fishway flow/attraction flow, the Fall River[4] and other discharges along the canal), Cabot Station discharge (cfs), diurnal (day/night), and water temperature.

The proportion of fish expected to arrive at the Spillway Ladder will be assessed with a Cormack Jolly Seber (CJS) mark recapture model. The proportion of fish expected to survive downstream passage through Cabot Forebay will be assessed with a live-recapture dead-recovery model. Live-recapture models, like the CJS, quantify the probability of an individual being detected (i.e., live-recapture) at a sampling location, and are determined with two parameters: the probability that the animal survives until the next sampling location, and the probability that it is alive and is recaptured at another location[5]. However, if a fish was not recovered, we are not sure of its final state; the fish may have emigrated from the study area without detection or it could have died. Live-recapture dead-recovery models differ from live-recapture models because they incorporate information from fish known to be dead. Fish are recovered in a dead-state with fixed and mobile tracking methods that use coded mortality radio-signals to identify dead fish.

The software MARK employs the live-recapture dead-recovery method using the Brownie parameterization. To demonstrate, consider a fish that is tagged and released alive upstream of the Cabot forebay. The fish may experience 1 of 3 fates: (1) it can survive passage through Cabot Station and to the next downstream station with some probability S; (2) it can die and be recovered and reported dead via combination of mobile and stationary telemetry in the forebay with probability f; or (3) it can die or emigrate through the study area undetected with probability $1 - S - f$. Recovery data supplies information directly about those fish which die without passing through Cabot Station. The following diagram depicts the possible fates of a fish up to the first live recapture location:



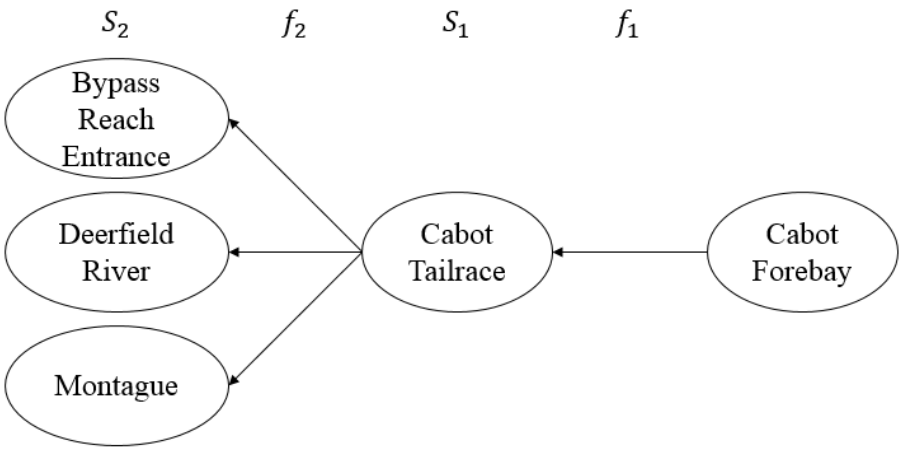
Where S is the probability of surviving from location (i) to location (j), and f is the recovery rate, which is the probability of dying, being retrieved via telemetry, and reported. So, f combines the mortality event with two other events (retrieval and reporting). We will always report fish that died as long as we can retrieve them; therefore, the reporting probability is always 1.0. Thus, the higher the retrieval rate, the better our estimate of initial forebay-mortality. Recovering dead fish between receiver detection zones with mobile tracking is paramount, as the higher the recovery rate, the better our estimate of true survival S. FirstLight will also optimize fixed stations to maximize detection ranges and minimize the potential for

[4] Flows on the Fall River will be estimated using a nearby USGS gage and adjusting the flows by a ratio of drainage area to represent the Fall River.

[5] Cooch, E., & White, G. (2001). Using MARK: a gentle introduction. Ithaca, NY: Cornell University.

receiver outages. FirstLight will construct a separate live-recapture dead-recovery model for those fish that pass through the turbines and those that pass via the log sluice.

FirstLight will assess immediate survival to the next live-recapture location in the telemetry network, which is given with:



Where f_1 is the probability of a fish dying in forebay, being recovered with mobile or fixed telemetry equipment and being reported; S_1 is the probability of surviving until the next downstream station (which happens to be the Cabot tailrace); f_2 is the probability of dying within the stretch of river between Cabot tailrace and the next telemetered reach, being recovered via mobile or fixed telemetry equipment and being reported; and S_2 is the probability of surviving and being recaptured alive at the next telemetry station in the telemetry network, whether that be at the Conte discharge, the Deerfield River, or downstream at Montague. Latent mortality will be assessed in the stretch of river from Montague to Hatfield where f_3 is the probability of dying within the stretch of river between Montague and Hatfield and S_3 is the probability of being recaptured alive at the southern end of Hatfield (Monitoring Station T22, Hatfield WWTP).

With this method, latent mortality will be assessed within the stretch of river between the tailrace and the next telemetered reach in the telemetry network (Hatfield). After tagging, this study method tracks fish via passive measures; whereas traditional turbine passage survival studies with balloon tags require extra capture and handling effort be placed on the fish, including removing the fish from the water, assessing condition, and placing them in a tank for observation. Given the delicate nature of the fish, extra handling pressure may cause undue mortality, biasing our estimate of latent mortality.

Thus, number of fish assessed will more than likely be less than 200 tagged at the exit to Cabot Ladder as it is assumed this population is still migrating upstream to spawn and not all will survive to emigrate. The first recapture occasion will be within the immediate Cabot Station tailrace and is intended to ascertain true survival through Cabot Station. The second recapture occasion will be the set of receivers that make up the immediate neighbor of the tailrace receiver (bypass reach entrance, Deerfield River, and Montague wastewater), immediate mortality is assessed between the tailrace and these receivers. The third live-recapture occasion will be the Hatfield WWTP, and latent mortality will be assessed in the stretch of river from here to Montague.

A report will be prepared detailing methods, results, a discussion and conclusions. The report will be completed by October 15, 2019.

Figures

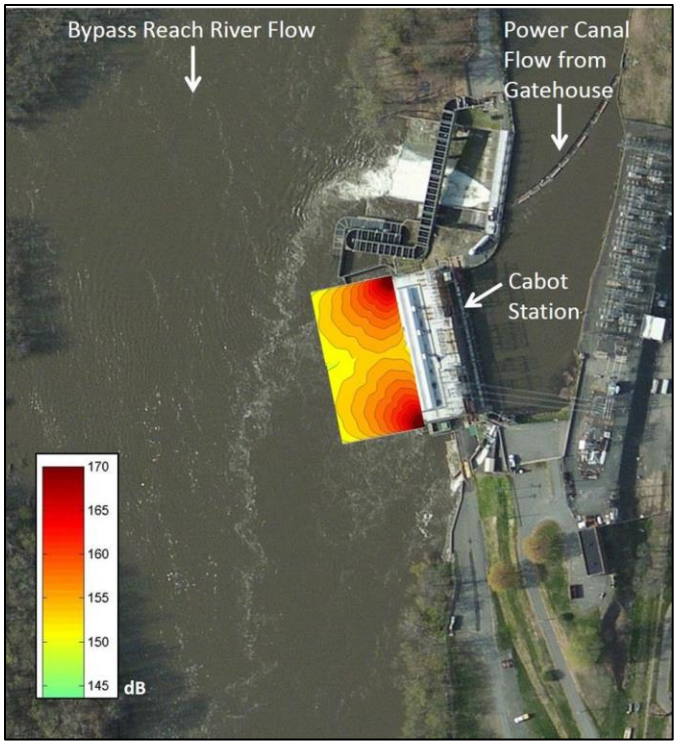


Figure 1-1. Sound field from the 2016 Ultrasound Study.

Figure 1-2. Sound field from the 2018 Ultrasound Study.

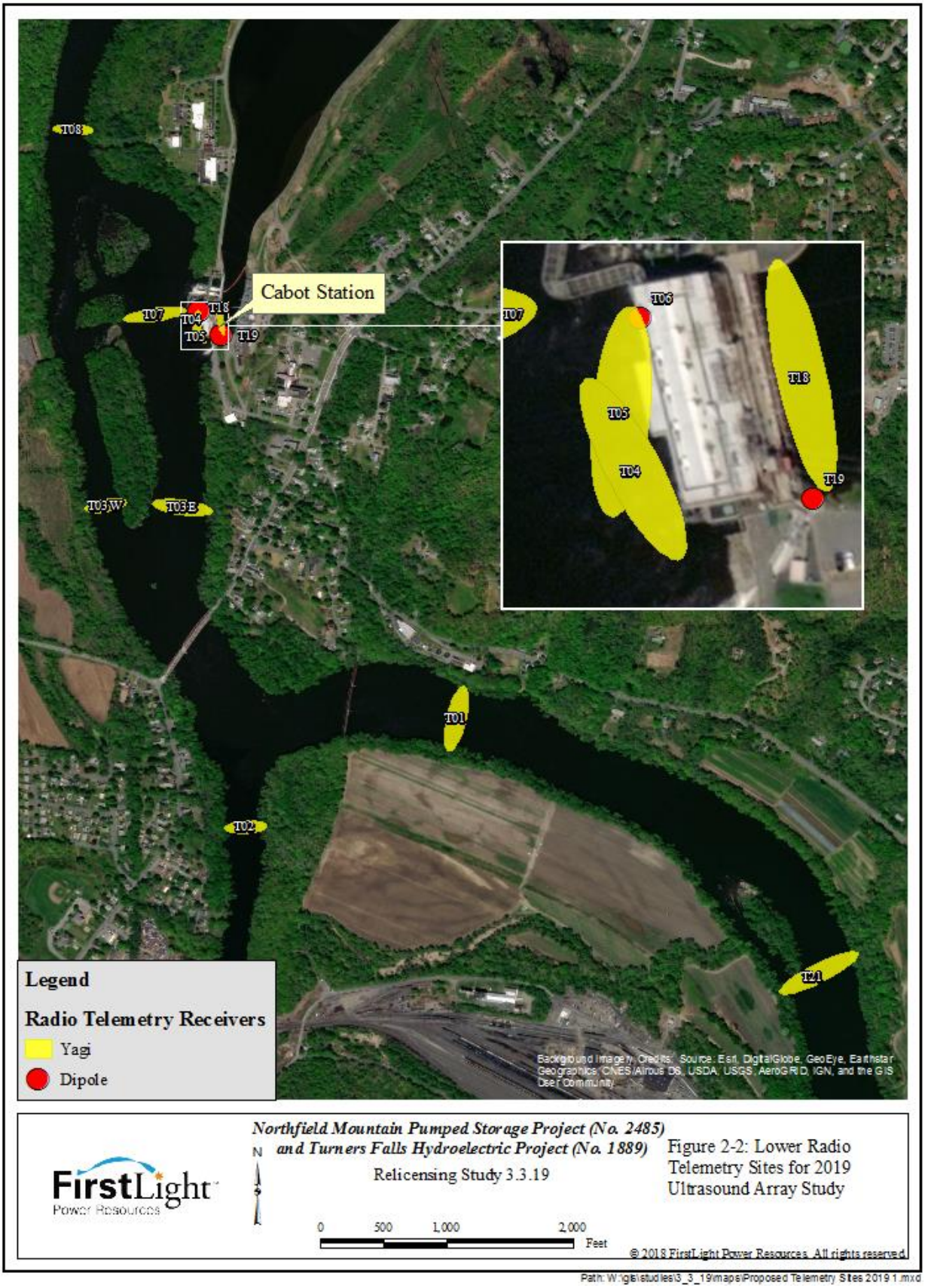
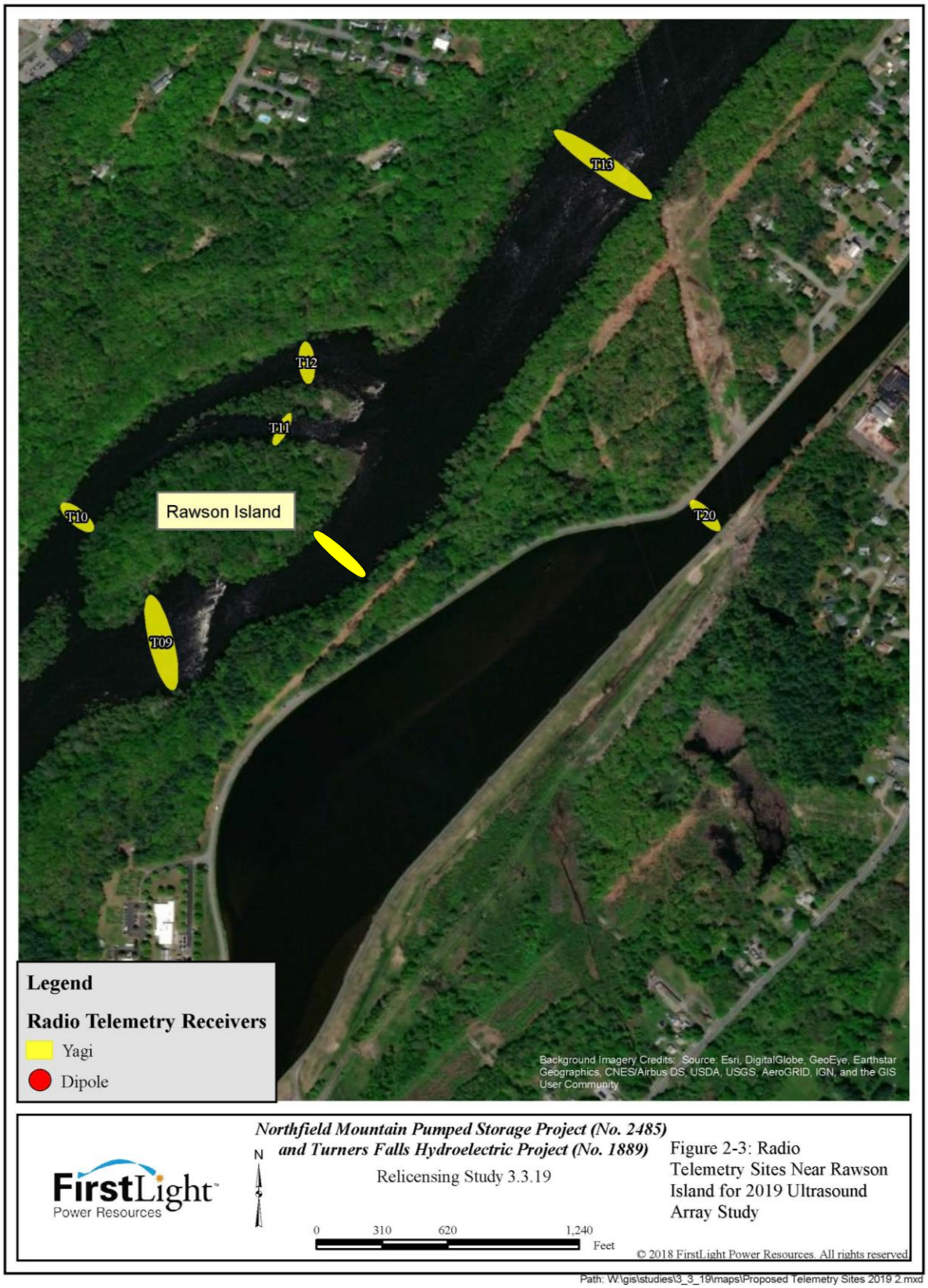


Figure 2-2: Lower Radio Telemetry Sites for 2019 Ultrasound Array Study


T13
T12
T11
T10
Rawson Island
T20
T09
Legend
Radio Telemetry Receivers
Yagi
Dipole
Background Imagery Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community
FirstLight Power Resources
Northfield Mountain Pumped Storage Project (No. 2485) and Turners Falls Hydroelectric Project (No. 1889)
Relicensing Study 3.3.19
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0 310 620 1,240
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Figure 2-3: Radio Telemetry Sites Near Rawson Island for 2019 Ultrasound Array Study
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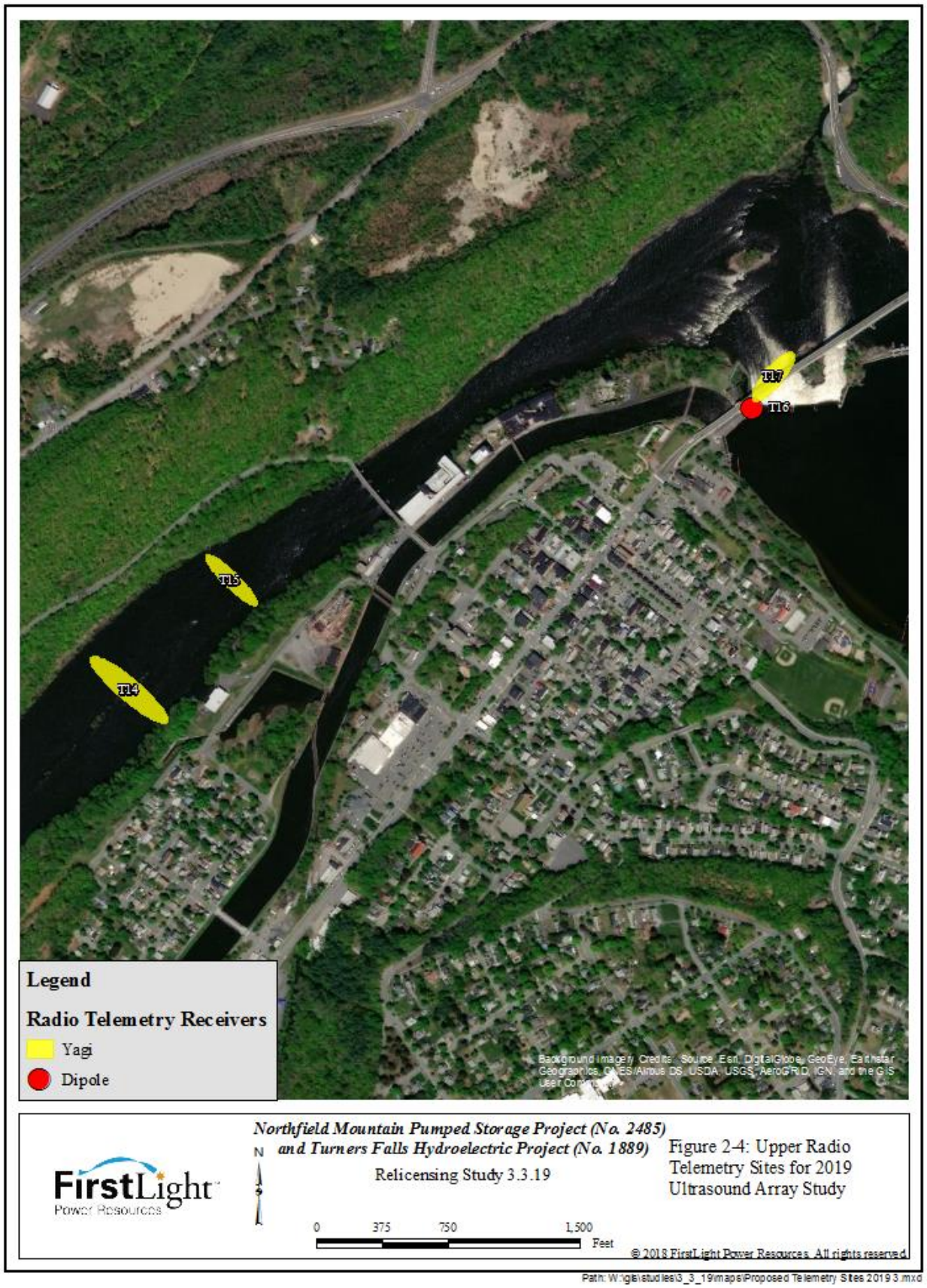

Northfield Mountain Pumped Storage Project (No. 2485) and Turners Falls Hydroelectric Project (No. 1889)
Relicensing Study 3.3.19

Figure 2-4: Upper Radio Telemetry Sites for 2019 Ultrasound Array Study

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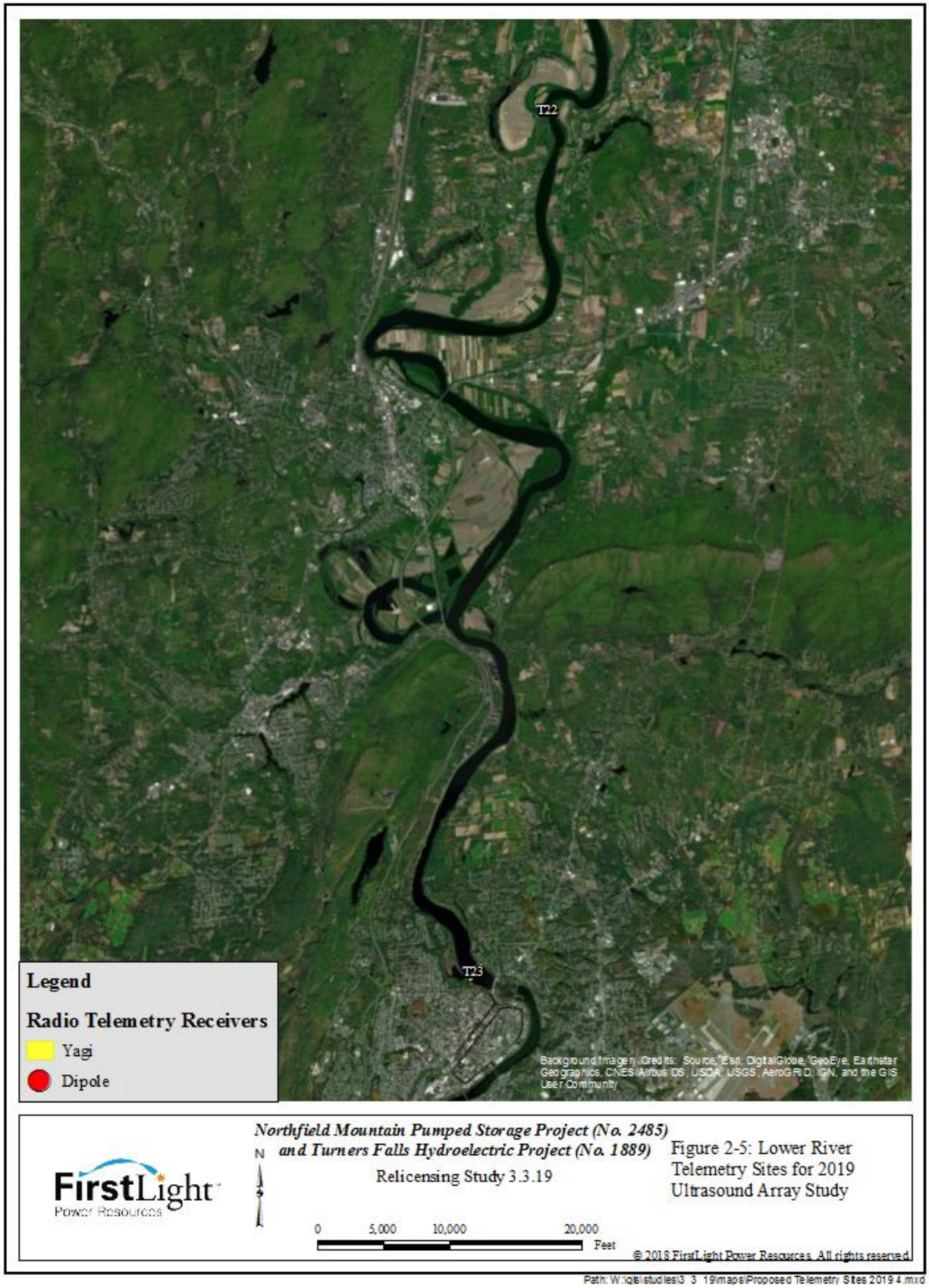
T22
T23
Legend
Radio Telemetry Receivers
Yagi
Dipole
Background Imagery Credits: Source, Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community
Northfield Mountain Pumped Storage Project (No. 2485)
and Turners Falls Hydroelectric Project (No. 1889)
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Figure 2-5: Lower River Telemetry Sites for 2019 Ultrasound Array Study
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Stakeholder Comments and Response to Comments

Hello,

Based on the information provided at last week's meeting, we offer the following recommended modifications to the methodology for the upcoming bypass flow/fish movement study at TF.

At the outset, we'd like to state that we appreciate the effort FL is making to address deficiencies identified in the previous downstream adult shad passage assessment in the current proposed study plan. However, even with the proposed modifications and adoption of recommendations contained in this message, we still believe there is inherent uncertainty in using radio telemetry to assess survival (e.g., inability to determine turbine-induced injury resulting in latent mortality). A balloon tag study (alone, or in conjunction with the proposed plan) would help reduce this uncertainty.

COMMENTS

Downstream Passage/ Dead Drift

Questions:

1. Do dead fish moving in water code as dead or alive?

The Dead Drift component of the study should answer this question. FL proposes to have the 11 second burst come on after 6 hrs. We recommend having it trigger after 30 minutes (for both alive and dead fish). This will remove uncertainty associated with detections coding as live for fish known to be dead, but within the time period prior to the "mort burst" triggering. For example if the 11 second burst comes on after 6 hrs but the fish is detected via mobile tracking 2 hrs. after release, is that fish coding as live because it was in motion or because the "mort burst" had not initiated yet?

In addition, we recommend increasing the frequency of mobile tracking. Dead fish should be tracked starting 1 hr after release and continuing through daylight hours. Daily tracking should continue the next day, with the tracking area extending down to Holyoke. If all dead test fish have been accounted for by that point, then mobile tracking of dead fish could continue on the weekly tracking schedule proposed for the downstream passage component of the study. However, if some dead test fish are still unaccounted for after those first 48 hrs, tracking should continue until all test fish have been located and confirmed stationary.

Lastly, we request that FL consider using a shorter burst interval to identify "motionless" fish. As currently proposed, a "dead fish" burst interval would be set to 11 seconds (though it is our understanding that this interval may be increased to 13 seconds). Because Lotek receivers will have to scan through a number of frequencies, the mobile tracking boat will have to move very slowly while scanning for dead code tags (a minimum of 11 seconds multiplied by 5 frequencies, or nearly 1 minute at a given location) in order to be confident that a non-detection is due to the fish not being there versus the fish being missed because the boat was going too fast. Ways to overcome this problem are to (1) shorten the burst interval for a motionless tag to, for example, 7 seconds, or (2) have multiple Lotek antennas each set to a single frequency on the boat(s). This would increase tag detection and allow for more river miles to be surveyed.

2. Does release location influence rate of transport?

Again, the Dead Drift component can answer this with the following modifications to the current proposal:

- Have a minimum of 4 treatments: Cabot tailrace releases under a "total high river flow" condition and "total low river flow" condition, as well as Alden weir releases and low and high total river flow conditions. At least 10 fish per treatment, for a total of 40 dead fish. The high river flow should strive to be at (or near) full Cabot generation plus a bypass flow of 6500 cfs or 4400 cfs and the low river flow should strive to be at near min. turbine discharge plus 6500 cfs or 4400 cfs bypass flow.

While we see benefit in having 2 additional treatments at a "mid river flow" condition, we understand there is a tradeoff between the info to be gained from that component and the loss of info from taking those test fish away from the upstream passage movement component. As we noted at the meeting, given the presumed difference in bathymetry between the downstream bypass outfall and Cabot tailrace, we want to know if those channel morphology and hydraulic differences affect residence time at the outfall/tailrace and rate of movement downstream from those locations.

Our preference is to release fish directly into the turbine. If that is not possible, then our next preference is to release them in the forebay. However, we realize this may be problematic; the fish may become impinged on the rack, not go down at all, or may be delayed such that immediate tracking would miss them. Only with an injection system similar to the balloon test could immediate turbine passage be assured. If this also is not possible then they should be released into the tailrace as close to the powerhouse as possible.

Our concern is that there may be a difference in how long a fish resides in the turbine boil depending on if they are released at the surface or down deep. If there is a difference then potentially results of the dead drift component would not be truly reflective of transit rates for turbine-passed fish.

3. Detection in D/S Bypass
In order to more clearly determine route of passage through the canal, we recommend installing multiple droppers in the downstream bypass.

Upstream Movement
1. Receiver Locations
As currently configured, there would be an Orion receiver in the middle channel at Rawson Island. If possible, we recommend installing dipole(s) there instead. This potentially would eliminate some of the likely overlap with fish in the larger channel and at Rock Dam if an aerial antenna is used.

2. Bypass Flow Release Schedule
We support modifying the flow release schedule per Don Pugh's recommendations. In general, the goal should be to lengthen each treatment and reduce the number of transitions between treatments.

Data Analysis
We request that separate bypass sluice and Cabot unit survival models be developed.

Regards,

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Changes in flow below Rawson = 2: 7-9 and 19-20. The proposed schedule has 5 changes.

Sunday	Monday	Tuesday	Wednesd	Thursday	Friday	Saturday
			1	2	3	4
5	6	7	8	9	10	11
12	13	14	15	16	17	18
19	20	21	22	23	24	25
26	27	28	29	30	31	1

Additional comments on study plan:
If it is possible to monitor fish in the middle channel at Rawson Island with dipole(s) since it is so narrow, it would seem to eliminate some of the likely overlap with fish in the larger channel and at Rock Dam if a yagi is used.

Dead drift test – immediate mobile tracking and follow-up the next day. Local drift will be influenced by Cabot discharge but total drift will likely be more influenced by total river flow than just Cabot generation. Release days should consider both Cabot and total river discharge with the emphasis on total river discharge.

Bypass sluice survival model as well as the Cabot unit model.

Please update my e-mail address to:
don.pugh@outlook.com

Hello,

I want to concur with the comments (*reiterated below as "forward"*) contributed by Melissa Grader on behalf of the US Fish & Wildlife Service.

My Comments:

UPSTREAM Movements: respecting monitoring of Upstream Movements, I again state that it would be valuable to have Water Level Loggers in place to record changing depths and passage routes in **both** the Rock Dam pool, and the pool immediately above RD during test flows. This would provide further information about the impacts of flow released either from the TF dam or ***Station 1***—whose releases are the closest, and in the most direct line to the nearby RD.

We know the shad are there, and it will be valuable to know at what level the several notches at Rock Dam allow them passage. I would suggest two loggers in the RD pool itself—one River Left at the **main,**

near-shore notch. And, another would be placed closer to the several significant notches **nearer Rawson** Island.

Just a single logger would suffice in **Upstream Pool**, since the RD is in most ways a very uniform precipice. Place it perhaps at the halfway point.

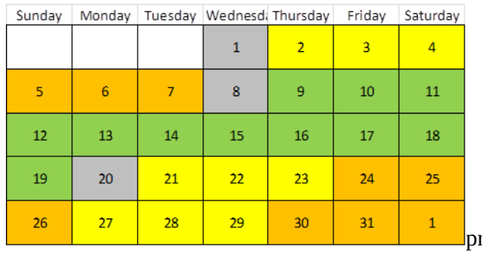
Canal Emergency Spillway: ALSO, as requested, please include data on number **Canal Emergency Spillway gates** open, and the volumes and opening-apertures of each gate.

By Pass Releases: Lastly, please use the **flow release schedule** worked out by Don Pugh.

Thank you,
Karl Meyer

Responses to Stakeholder Comments on the Proposed 2019 Ultrasound Array Control Study

No.	Entity	Comment	Response
1	USFWS email, dated 4/2/2019	1. Do dead fish moving in water code as dead or alive? The Dead Drift component of the study should answer this question. FL proposes to have the 11 second burst come on after 6 hrs. We recommend having it trigger after 30 minutes (for both alive and dead fish). This will remove uncertainty associated with detections coding as live for fish known to be dead, but within the time period prior to the "mort burst" triggering. For example, if the 11 second burst comes on after 6 hrs but the fish is detected via mobile tracking 2 hrs. after release, is that fish coding as live because it was in motion or because the "mort burst" had not initiated yet?	The original 6-hour threshold was arbitrary, and FirstLight (FL) can lower this to 5 minutes if needed however the requested 30 minutes sounds reasonable.
2		In addition, we recommend increasing the frequency of mobile tracking. Dead fish should be tracked starting 1 hr after release and continuing through daylight hours.	FL agrees
3		Daily tracking should continue the next day	FL agrees, if needed
4		the tracking area extending down to Holyoke.	We propose to track to the Hatfield Waste Water Treatment Facility which is located in the Holyoke Impoundment.
5		If all dead test fish have been accounted for by that point, then mobile tracking of dead fish could continue on the weekly tracking schedule proposed for the downstream passage component of the study. However, if some dead test fish are still unaccounted for after those first 48 hrs, tracking should continue until all test fish have been located and confirmed stationary.	FL will not agree to tracking until all the dead fish are accounted for since radio tags could malfunction and turn off or a predator to remove the fish from the project area, however FL will agree to accounting for most of the dead fish after a reasonable amount of tracking-effort (8 to 10 hours).
6		Lastly, we request that FL consider using a shorter burst interval to identify "motionless" fish. As currently proposed, a "dead fish" burst interval would be set to 11 seconds (though it is our understanding that this interval may be increased to 13 seconds). Because Lotek receivers will have to scan through a number of frequencies, the mobile tracking boat will have to move very slowly while scanning for dead code tags (a minimum of 11 seconds multiplied by 5 frequencies, or nearly 1 minute at a given location) in order to be confident that a non-detection is due to the fish not being there versus the fish being missed because the boat was going too fast. Ways to overcome this problem are to (1) shorten the burst interval for a motionless tag to, for example, 7 seconds, or (2) have multiple Lotek antennas each set to a single frequency on the boat(s). This would increase tag detection and allow for more river miles to be surveyed.	If FL reduces the mortality pulse to 7 seconds, the risk of signal collisions increases. If FL releases 20 dead fish with short burst rates through Cabot Station and they do not drift downstream, they will remain in the tailrace. Not only will the 7 second burst rate result in superfluous data, but the chance that their signals collide with those of live fish and impact our ability to discern their movement in the tailrace will increase as well. The increase in data will mean longer run times of the algorithm and potentially increased data download rates on the receivers. The increase in signal collisions will mean sparse movement data that may impact our ability to generate significant models. Given that this a secondary objective of the study, we recommend mortality burst rates remain at large prime numbers. We recommend that when mobile tracking, technicians remain in place and hear at least two mortality pulses in sequence before searching for new fish. FL will agree to have 2 Lotek receivers on the mobile tracking boat.
7		Have a minimum of 4 treatments: Cabot tailrace releases under a "total high river flow" condition and "total low river flow" condition, as well as Alden weir releases and low and high total river flow conditions. At least 10 fish per treatment, for a total of 40 dead fish. The high river flow should strive to be at (or near) full Cabot generation plus a bypass flow of 6500 cfs or 4400 cfs and the low river flow should strive to be at near min. turbine discharge plus 6500 cfs or 4400 cfs bypass flow.	FL will agree to tagging 40 dead fish removing 10 of the radio tags previously designated for live fish from the Upstream component of the study and 10 from the Downstream component of the study. We will release these additional 20 tagged dead fish at the Cabot log sluice bypass at “high” and “low” flows.
8		Our preference is to release fish directly into the turbine. If that is not possible, then our next preference is to release them in the forebay. However, we realize this may be problematic; the fish may become impinged on the rack, not go down at all, or may be delayed such that immediate tracking would miss them. Only with an injection system similar to the balloon test could immediate turbine passage be assured. If this also is not possible then they should be released into the tailrace as close to the powerhouse as possible. Our concern is that there may be a difference in how long a fish resides in the turbine boil depending on if they are released at the surface or down deep. If there is a difference, then potentially results of the dead drift component would not be truly reflective of transit rates for turbine-passed fish.	We will release the dead fish into a Cabot turbine with an induction tube as requested.
9		In order to more clearly determine route of passage through the canal, we recommend installing multiple droppers in the downstream bypass.	Under the current plan, test fish will be detected near the bypass entrance and then in the tailwater. These two monitoring sites effectively determine passage via the bypass. The velocity in the downstream bypass is very fast and detections via droppers in the bypass sluice itself is not very effective, even at a rapid burst rate.

10		As currently configured, there would be an Orion receiver in the middle channel at Rawson Island. If possible, we recommend installing dipole(s) there instead. This potentially would eliminate some of the likely overlap with fish in the larger channel and at Rock Dam if an aerial antenna is used.	FL will deploy a dropper instead of a Yagi for the middle channel of Rawson Island to address this concern. However, we recommend the use of a Yagi antenna in the wider channel (river right looking downstream). This approach provides a logistically easier setup and the deductive logic to determine which way fish passed (i.e. only those detected by the droppers will be assigned a route in the middle channel). No overlap between the Yagi antenna monitoring the Rock Dam and other locations is envisioned based on the results of the 2015 study effort. We proposed a dipole or dropper antenna at Rock Dam in the study plan but upon further consideration we don't think that is feasible. It should be a Yagi.
11		We support modifying the flow release schedule per Don Pugh's recommendations. In general, the goal should be to lengthen each treatment and reduce the number of transitions between treatments.	FL understands there is concern that not enough 6,500 cfs flow releases would be tested under the proposed flow release schedule in the plan. However, Don Pugh's proposal over-weighs 6,500 cfs treatment during a period that historically suggests the most concentrated migration. We are concerned that such an unbalanced study design would lead to spurious correlation of treatment and response. To address this an alternative flow schedule was included in the updated study plan.
12		We request that separate bypass sluice and Cabot unit survival models be developed.	That is FL's intent
1	Don Pugh (CRC), dated 03/29/2019	 proposed alternative flow schedule from Don Pugh	See USFWS # 11 above
2		If it is possible to monitor fish in the middle channel at Rawson Island with dipole(s) since it is so narrow, it would seem to eliminate some of the likely overlap with fish in the larger channel and at Rock Dam if a yagi is used.	See USFWS # 10 above
3		Dead drift test – immediate mobile tracking and follow-up the next day. Local drift will be influenced by Cabot discharge, but total drift will likely be more influenced by total river flow than just Cabot generation. Release days should consider both Cabot and total river discharge with the emphasis on total river discharge.	See USFWS # 2 above
4		Bypass sluice survival model as well as the Cabot unit model.	See USFWS # 12 above
1	Karl Meyer email dated 4/7/2019	**UPSTREAM** Movements: respecting monitoring of Upstream Movements, I again state that it would be valuable to have Water Level Loggers in place to record changing depths and passage routes in **both** the Rock Dam pool, and the pool immediately above RD during test flows. This would provide further information about the impacts of flow released either from the TF dam or ***Station 1***—whose releases are the closest, and in the most direct line to the nearby RD. We know the shad are there, and it will be valuable to know at what level the several notches at Rock Dam allow them passage. I would suggest two loggers in the RD pool itself—one River Left at the **main, near-shore** notch. And, another would be placed closer to the several significant notches **nearer Rawson** Island. Just a single logger would suffice in **Upstream Pool**, since the RD is in most ways a very uniform precipice. Place it perhaps at the halfway point.	FL has developed a hydraulic model of the bypass reach and can model flows as needed. Thus, there is no need for water level loggers. However, to determine if shad are indeed accessing the Spillway ladder over Rock Dam, FL is proposing to include an additional telemetry receiver above Rock Dam.
2		Please include data on number **Canal Emergency Spillway gates** open, and the volumes and opening-apertures of each gate.	FL will include this information in its final report.
3		Please use the **flow release schedule** worked out by Don Pugh.	See USFWS # 11 above