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April 14, 2017

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

**Re: TransCanada Hydro Northeast Inc.'s March 30, 2017 Updated Study Results Meeting Summary**
**Project Nos. 1892-026, 1855-045, and 1904-073**

Dear Secretary Bose:

TransCanada Hydro Northeast Inc. ("TransCanada") is the owner and licensee of the Wilder Hydroelectric Project (FERC No. 1892), the Bellows Falls Hydroelectric Project (FERC No. 1855), and the Vernon Hydroelectric Project (FERC No. 1904). The current licenses for these projects each expire on April 30, 2019. On October 31, 2012, TransCanada initiated the Integrated Licensing Process by filing with the Federal Energy Regulatory Commission ("FERC" or "Commission") its Notice of Intent to seek new licenses for each project, along with a separate Pre-Application Document for each project.

With this filing, TransCanada submits its March 30, 2017 Updated Study Results Meeting Summary for the three projects, as required by 18 C.F.R. §5.15(c)(3) and the Commission's current Process Plan and Schedule (dated February 22, 2017). The meeting for the Updated Study Reports filed between November 30, 2016 and March 22, 2017 was held at the Fairfield Inn in White River Junction, Vermont, with WebEx and call-in capability for participants who could not attend in person.

The attached meeting summary includes meeting notes, points of discussion, the list of meeting attendees, and a copy of the presentation slides used during the meeting. According to the current Process Plan and Schedule, the comment period for these studies will end on May 14, 2017.

As part of this filing, and at the request of New Hampshire Fish and Game Department, TransCanada is filing a revised Study 19 Appendix F (in Excel format) which includes telemetry detections of American Eels at the Stebbins Island monitoring station in Appendix F-3 that was not included in the previously filed Appendix F.

TransCanada also wishes to inform the Commission and stakeholders that we plan to conduct additional surveys at the Vernon Project in 2017 as part of Study 18 – American Eel Upstream Passage Assessment that will include weekly nighttime visual surveys and re-installation and monitoring of the temporary eel ramp trap. Secondly, as a result of the revised downstream passage telemetry data processing we agree with agency concerns that the numbers of shad for which a passage route was determined was extremely low, to the point where conclusions could not be reasonably made. As such an additional downstream passage assessment of radio-tagged adult American Shad will be conducted in 2017 for Study 21 – American Shad Telemetry Study in which we will release a larger (100 fish) study group of radio-tagged shad above Vernon dam. We intend to discuss this further with stakeholders but in the meantime we have pre-ordered the necessary radio tags to perform the study in 2017.

If there are any questions regarding the information provided in this filing or the process, please contact John Ragonese at 603-498-2851 or by emailing john_ragonese@transcanada.com.

Sincerely,

John L. Ragonese
FERC License Manager

Attachment: March 30, 2017 Updated Study Results Meeting Summary
Study 19 – American Eel Downstream Passage Assessment, Revised Appendix F

cc: Interested Parties List (distribution through email notification of availability and download from TransCanada's relicensing web site www.transcanada-relicensing.com).

UNITED STATES OF AMERICA

BEFORE THE

FEDERAL ENERGY REGULATORY COMMISSION

**TRANSCANADA HYDRO NORTHEAST INC.**

**Wilder Hydroelectric Project (FERC Project No. 1892-026)**
**Bellows Falls Hydroelectric Project (FERC Project No. 1855-045)**
**Vernon Hydroelectric Project (FERC Project No. 1904-073)**

# March 30, 2017 Updated Study Results Meeting Summary

**April 14, 2017**

**TRANSCANADA HYDRO NORTHEAST INC.**
**UPDATED STUDY RESULTS MEETING**
**MARCH 30, 2016**

The Updated Study Results meeting for study reports and report supplements filed between November 30, 2016 and March 22, 2017 was held on March 30, 2016 at the Fairfield Inn and Suites in White River Junction, VT. Presentation slides follow these notes.

Meeting attendees in person or identified on the telephone:

| Name | Affiliation if Known | Name | Affiliation if Known |
|---|---|---|---|
| Bill Connelly | FERC | Roger Longtoe Sheehan | Elnu Abenaki |
| Brandon Cherry | FERC | Rich Holschuh | representing Elnu Abenaki |
| John Baummer | FERC | Paul Pouliot | Cowasuck Band of the Pennacook- Abenaki People |
| Steve Kartalia | FERC | Denise Pouliot | Cowasuck Band of the Pennacook- Abenaki People |
| Nick Palso | FERC | Adair Mulligan | Hanover Conservancy |
| Nick Ettema | FERC | Bill Lipfert | Landowner |
| Harold Peterson | USBIA | John Mudge | Landowner |
| Julienne Rosset | FWS | John Bennett | |
| Melissa Grader | FWS | Erin Kimsey | |
| Ken Sprankle | FWS | Mark Wamser | Gomez & Sullivan |
| John Warner | FWS | John Ragonese | TransCanada |
| Alex Haro | USGS | Jen Griffin | TransCanada |
| Ted Castro-Santos | USGS | Matthew Cole | TransCanada |
| Gregg Comstock | NHDES | Edwin Nason | TransCanada |
| Matt Carpenter | NHFGD | Drew Trested | Normandeau |
| Jeff Crocker | VDEC | Sarah Allen | Normandeau |
| Eric Davis | VDEC | Ben Griffith | Normandeau |
| Lael Will | VFWD | Steve Eggers | Normandeau |
| Scott Dillon | VTSHPO | Mark Allen | Normandeau |
| Andrea Donelon | CRWC | Jen Kennedy | Normandeau |
| Chris Yurek | CRWC | Maryalice Fischer | Normandeau |
| Tom Christopher | NE FLOW | Steve Olausen | PAL |
| Norman Sims | AMC | Suzanne Cherau | PAL |
| Bob Nasdor | American Whitewater | Semiu Lawal | Hatch |
| Katie Kennedy | TNC | Bernward Hay | Louis Berger |
| Lisa Murphy | SW Regional Planning Commission | Matt Burak | Louis Berger |
| Jim McClammer | CRJC | Ethan Nedeau | Biodrawversity |

**Study 27 Floodplain, Wetland, Riparian, and Littoral Vegetation Habitats**
**Study 30 Recreation Facility Inventory, Use and Needs Assessment**
**Study 10 Fish Assemblage**

Maryalice Fischer summarized corrections and errata to three study reports that had been previously filed, as reported in supplements to those studies filed 11/30/16 (Study 27, 10) and 12/15/16 (Study 30).

No questions.

**Study 6 Water Quality**

Matt Burak summarized the overall study and presented the report updates filed 12/15/16 in the revised final report.

Question (Q): Was there a way to quantify difference in temperature that the impoundment causes vs. if there was no impoundment?
Answer (A): We did not model that. The comment related to that came as part of comments on the Preliminary Licensing Proposal (PLP, filed 12/01/16) that we will address in the Final License Applications (FLAs).

**Study 25 Dragonfly and Damselfly Inventory and Assessment**

Sarah Allen summarized the revised report filed 12/15/16.

Q: The 8-inch rise in water surface elevation (WSE) was over what period of time?
A: 8-inch rise over 30 minutes, and we only saw that at four riverine sites and one impoundment site just above Wilder dam.

Q: For horizontal travel, only S. Spiniceps had multiple observations?
A: We observed a few for other species but mostly for S. Spiniceps.

Q: So you did not have many direct observations of odonates leaving the water?
A: We saw quite a few but they weren't necessarily at the study transects.

Q: What was the timeframe analyzed in the WSE analysis?
A: Water level logger (HOBO) data was collected and used from May 15 - August 31.

Q: Are the HOBO data and model data consistent?
A: They both compare well, but you should rely on the model data for the rate of WSE change which would align better with elevation. HOBO data is more variable.

Q: Were rapid rises related to boat wakes?
A: We did see some rapid rises that might have exceeded 8 inches in 30 minutes, but not related to boat wakes specifically. There can also be some rising between changes in operations (i.e., not related to operations) at some locations.

Q: HOBOs measure at 15 minutes, so a 30-minute rise is only 2 data points and you could miss something, and then maybe underestimate the potential impact.
A: That is true, but in terms of project operations, you won't see a fluctuation that rapid except possibly in the forebay areas at the face of the dams where there may be an unusual rapid drop in elevation because the WSE gage is right in front of the generating units. But you don't see that in other locations upstream and downstream of the dams related to project operations.

Q: You said there were some mortalities observed?
A: We did see some that seemed they would not make it to flight, but unrelated to flow – damaged wings, predation, possibly boat wakes. We also saw larvae repeatedly get knocked by boat wakes but move back up, and similarly for tenerals.

## Study 33 Phase II Archeological Survey – Vermont

Suzanne Cherau summarized the Phase II report filed 12/01/16 for Wilder and Vernon Projects in Vermont.

Comment: The VTSHPO will be submitting formal comments and are in concurrence with determination of effect for these 6 sites. VT will want to see mitigation in addition to monitoring. Several sites are on eroding scarps. HPMP should address this.
Q: VTSHPO will outline that in written comments too, correct?
A: That is correct.

Q: Is this the end of the planned archaeological investigations for the purpose of relicensing?
A: Yes, it is the end of what we can accomplish before filing license applications by May 1 2017, but it does not mean there will not be future investigations, as we assess potential archaeological impacts whenever we dig into the ground. We also were not able to obtain landowner permission for all sites and will continue to attempt that and will address these things in the Historic Properties Management Plan (HPMP).

Comment from VTSHPO: The agreement documents that will come out of the process will contain an ongoing level of investigation including continued efforts to gain landowner permission and continue to do inventory, investigation, and mitigation. This is not the end, it is really the beginning, and how does it get phased over the life of the new licenses via the HPMP.

Comment from TC: A new site might also be identified later as well and is part of the ongoing process.

## Study 17 Upstream Passage of Riverine Fish Species

Maryalice Fischer summarized substantive revisions in the 11/30/16 final report.

Q: Why was the fish ladder shut down at night?
A: The fish ladder itself was not shut down, just the attraction flow was turned off at night in 2015 as in previous years which has been a long-standing procedure, an artifact that [TC suggests] may be from historical agency fish counting protocols in which counting at the Vernon ladder was either performed by individuals observing movement past the counting window or other means requiring visible daylight. By shutting down the attraction flow at night, there was a belief that fish would be less likely to locate the entrance to the ladder during the non-count, non-daylight periods. The fish ladder attraction flow remained on continually in 2016 during the passage season.

Q: Did you look at time of passage in 2016?
A: No, and there were differences in how Salmonsoft was set up in 2016 by VDFW versus how TransCanada did it in 2015. The way the software was set up in 2016, data capture did not allow for accurate recording of time of day although the total number of detections each day was accurate (see page 80 of the final report filed 11/30/16).

## Study 18 American Eel Upstream Passage

Jen Griffin summarized the 11/30/16 report supplement for 2016 surveys.

Q: Were the observed eels climbing?
A: A limited number of eels were observed exhibiting climbing or route seeking behavior at the rocks below the stations, where there is some leakage, but at the flood gates they seemed to be hiding, resting.

Q: When the ladder was operational, were eels observed there?
A: VFDW counted eels in 2016. We have data in Study 17 from 2015. The PLP also contains that information (in 2016, eel passage at Vernon detected by Salmonsoft resulted in a net downstream passage of 920 eels).

Q: The eel ramp was installed and then modified, but when in relation to that was the eel collected?
A: The eel was collected after the modifications were made.

Comment: We know that the numbers of observations at the dam were similar in both years.

A: There were smaller numbers in 2016, but 2015 had a longer season and we may have missed a good portion of that in 2016 by starting late. We plan to install the ramp in 2017 for additional study.

Comment: The jury is still out on the last bullet of slide 44 (Study 18 conclusions: "The results of Study 18 in both years indicate that a small number of eels may attempt to migrate upstream past Vernon, and in the absence of the release in 2014 of nearly 6,000 eels upstream of Turners Falls dam substantial numbers of eels do not appear to use the Vernon fish ladder either".) since there are lots of routes that eels can get by without being detected by Salmonsoft. The fish ladder may still be a viable route, but how good it is, is still unknown. We should not discount the ladder as a viable route and/or permanent passage.
A: We just don't have the data to determine that yet. We're not trying to skew anything, but based that conclusion on what the available data does imply.

Q: Has anyone looked at passage with reduced flows at the ladder?
A: We can reduce the overall flow in the ladder but we haven't looked at that yet.

Comment: At Cabot (Turners Falls) they put traps inside the fishway after the fishway was closed. You'd still have to run attraction flow. At Vernon the location is very tricky, where the ramp is now is okay but not great, but it is the only place really except for putting a ramp inside the fishway. If you ran the fishway at half flow or something it might not be better than at 100% flow. At Cabot, eels can get up at full fishway flows.

Q: Did you observe eels at night and full moon?
A: Yes, all the surveys were done at night and weekly so covered the different moon phases. Observations seem to be more correlated with flows.

TC Comment: We intend to install the ramp again in 2017 and the plan is the same as what we did in 2016 - put the ramp in as soon as possible in the same location and conduct weekly surveys. The current ramp location seems to be the best we have for now and we want to see how it functions over a longer period. The night time surveys will help identify if eels are congregating at other locations.

**Drew Trested summarized the reprocessing of telemetry data for studies 19, 21, and 22. Then he summarized the revised reports for those studies.**

Q: How were the records logged for Orion receivers with CRTO
A: The CRTO function records data lines representing an individual fish (i.e., a unique frequency – ID combination). The first detection logs as the "start date and time". The last detection in the specified period logs as the "end date and time. The end date and time represents the last detection within up to a 2 minute (user specified) time interval.

Q: Was the issue related only to the Orions?
A: Yes, the issue did not affect the Lotek receivers.

## Study 19 American Eel Downstream Passage Study

Q: The final report mentions Stebbins Island but those detections weren't included in the initial report and final report.
A: We can provide that information.
**Post-meeting note**: A revised Study 19 Appendix F is being filed with this meeting summary which includes the Stebbins Island detections in Appendix F-3.

Comment: I wonder about fish that were detected in the tailrace for 24 hours or more. Where do you draw the line as to when a fish might be dead in the tailrace?

Q: A potential route at Vernon was through the fishway but it wasn't operating?
A: It was operating in 2015 for Study 17 so it was possible for eels to pass via that route.

## Study 21 Adult American Shad Telemetry Study - Vernon

Q: The executive Summary talks about PIT tagged fish detected "downstream" but we know PIT tags could only be detected within the fishway. It wasn't clear in the Executive Summary but then made clear in the report itself.
A: We will look at that.

**Post-meeting notes**:
1. The Executive Summary reads "*The sample size of tagged and released adult fish detected in the study area immediately downstream of Vernon was 129, and 96 of those (74.4%) were later detected at the entry to the fish ladder*." The sentence could be made clearer by deleting "immediately downstream", and "later". In the case of PIT-tagged shad, the upstream passage study area includes the fishway entrance to the fishway exit only. In the case of dual-tagged shad, the study area includes the reach from Stebbins Island to the tailrace, the tailrace, fishway, and forebay.
2. The report's Executive Summary and Section 6.1 incorrectly report the nearfield attraction rate. Section 5.3 and Table 5.3.6 correctly report the rate as 58.6%.

Q: Slide 60 Tailrace Residency. Why do some horizontal lines have gaps in the timing?
A: Every horizontal line is one fish and every break is the period when that fish moved back downstream from the tailrace to Stebbins Island.

Q: You had an aerial antenna with a detection area of only 30 feet? In other studies the dropper in the fishway detected outside the fishway as well.
A: There is definitely overlap or potential error on the external antenna, we have more confidence in the dropper receiver inside the fishway entrance.

Q: When you calculated entrance efficiency what was that based on if some fish can pop in and pop out of the ladder? If you had one fish with 10 forays, how did that affect the entrance efficiency?
A: Entrance efficiency was calculated on an individual fish basis, 25 of 34 ultimately entered the ladder and therefore made at least one foray into the ladder. Forays into the ladder were also assessed on an individual fish basis, the total number of forays for each tagged individual ranged from a high of 10 to a low of 1 (mean = 1.6; median = 1).

Q: At the dropper that scanned frequencies, how long was each frequency scanned? The dropper may provide a conservative estimate.
A: Tags were set to about a 3-second burst rate, and with 4 antennas would result in 15 seconds or so.

Q: What is the nearfield area?
A: The nearfield is the area directly outside of the fishway entrance where the attraction flow is located.
Q: Once they approached, how fast did they enter and did operations change in the meantime?
A: Generally it was very quick, maybe 15 minutes or so.

Comment: You may be underestimating performance based on PIT tags. You could look at FirstLight's PIT-tagged fish that had already passed Turners. You could look at initial detection data for each foray and look at the percentage of forays that had initial detection records at the entrance for both radio and PIT receivers. (Since that radio receiver at the entrance used not only the CRTO but also had an antenna switcher on it to toggle between aerial coverage of attraction flow area and drop coverage of inside entrance the period of time the dropper covered a particular frequency was reduced.) You should look for evidence of that and report also on count data for 2015.
A: The PIT reader at the entrance had its own issues. As reported (in Section 4.3 of the report), that reader had relatively poor detection due to the entrance configuration, which is why we relied also on the reader at the first bend inside the fish ladder. I'm not sure we'd get any better information by looking at the PIT data.

Comment: For fish with known downstream passage residency times available, we (agency) plotted by individual fish and note that 14 of 39 fish arriving spent greater than 55 hours of time in the forebay.

Comment: Route selection sample size was small to begin with, and with the revised report most shad went downstream by spill or unknown. There is nothing you could have done to change that, but it is a concern for us since in June 2015 spill occurred more frequently than normal, so how representative is the data?

Q: How did you decide on an unknown route of passage?
A: We needed definitive detections in the forebay, at passage routes, and in the tailrace to identify a specific passage route otherwise we called them "unknown". In this study route determination may have been confounded by the Lotek CRTO records. Unknowns could have been anywhere in the forebay.

Q: Did you use that same determination if it was last seen in front of the spillway?
A: Yes, for the spillway, we had a series of antennas versus the series of antennas at the intakes. To be classified as a "spill" fish, the time series of detections needed to have a series of detections indicating arrival into the area upstream of the dam. The final detections on the upstream side were recorded on the series of antennas we had facing upstream along the spill area and was followed quickly by detection on the series of antennas mounted on the downstream side of the dam in the spill area. Operations at the determined time of passage were reviewed to ensure that spill conditions were present at the time.

Q: But can you say that unknowns were unlikely to go through the spillway?
A: Perhaps yes, we can say they likely went through the powerhouse, but we cannot distinguish between routes within the powerhouse.

Q: The fish pulled off the trash racks, did you look at the distribution of times when they were collected on the racks?
A: I'm not sure if that was recorded.

**Post-meeting note**: All 9 rack mortalities had initially passed upstream via the fish ladder. Appendix B of the final study report includes the dates/times of fish ladder exit and then dates/times of subsequent forebay detection.

Comment: It would be helpful to have manual tracking and motion sensing discussed in the report, and information on how long the tags were being detected.

**Post meeting note**: Report sections 4.2.1 and 4.4.2 include information on tracking and tags including motion sensors. Figure 5.3-14 and Appendix C-3 identifies all manual tracking detections throughout the study period.

Q: On the shad with unknown passage route, did you look at which units were operating then?
A: Yes, there is a table in the report (Table 5.4-2). In most cases there were multiple passage options available.

Comment from TC: We'd like to point out that the 17,100 cfs maximum station flow capacity is defined as the total sum of each of the unit maximum flow capacities under optimal conditions specific to each unit. It overstates the total flow through the station when all units are running. The major factor that reduces flow capacity in the all-unit operation is the reduction in net head (headwater elevation behind the trashracks minus tailwater elevation). Net head is significantly reduced during all-unit operation with higher tailwater WSE accounting for most of the loss of head. The more realistic maximum station capacity is really somewhere around or slightly below 15,000 cfs.

Comment: The high flows in 2015 make it difficult to get to project effects in a more typical year. Again it creates a small sample size for route selection.

Comment: For project effects on spawning, there is a timing component when flows are within operational control that couldn't be considered given the 2015 flows. In the report there is no tieback to the AWS curves shown in the report.
A: There is a significant amount of habitat and shad can move around to find that habitat if needed. The habitat can be affected by project operations but is not limited by operations. As a note, AWS curves were included in this report for reference only. That aspect wasn't analyzed since it is included in Study 9.

**Study 22 Downstream Migration of Juvenile American Shad - Vernon**

Q: Table 4.1.3-4: forebay detections by passing and non-passing shad. Why do all forebay detections add up to 100?
A: The percentages presented in that table were based on the cumulative total number of telemetry records for all individual fish combined. The percentages by monitoring station were calculated for individuals determined to have passed and those that did not. Values for the forebay/spillway areas were greater than for specific passage routes (e.g., fish tube or units) as the forebay/spillway receivers covered a larger area where fish were present for greater periods of time than in the more limited detection areas associated with the specific passage routes. As the percentages were based on the final number of detections the total summed to 100%.

Q: Why are units 5-8 the most common route of passage?
A: If the fish ladder is not running, units 5-8 are the priority units since they are more efficient. When the fish ladder is operating, unit 10 is the priority unit followed by units 5-8.

Q: Non-passing fish were last detected in the spillway area. Why might that be?
A: Generally, when we tag and release upstream, the longer it takes them to arrive, the more likely they were to suffer predation and may end up over there.

Q: Did the sluiceway have a receiver?
A: Yes.

### Study 23 Fish Impingement, Entrainment, and Survival Study

Q: For adult shad, the desktop estimate of total project survival presented in the report did not include individuals classified as either “no pass” or “dead on rack”. Individuals determined to be alive and in the forebay but did not pass downstream could be included as losses due to the project and included in the number of fish used to estimate total project survival.
A: Those shad would have a downstream detection (i.e., survival) of 0%. To include the individuals classified as “dead on racks” in the total project calculation we would need to know the exact time/date of removal from the racks and then look at the detection history prior to removal. This might provide some insight into whether or not the fish moved into the forebay alive and subsequently died while searching for downstream passage or was dead prior to arrival in forebay and simply drifted downstream and into project area.

Q: So you did this (estimated project survival) for the fish pipe and other routes?
A: Yes, where we had detections for those.

### Study 2/3 Riverbank Transect and Riverbank Erosion

John Field summarized the erosion studies in general and the revised study 2/3 report filed 02/04/17.

Q: (from Mr. Mudge about the survey he had done versus the one done in this study, and the location of the pin used to measure in both cases).
A (with post-meeting note): We put the survey pin 8 feet back from the top of bank which, based on the licensed surveyor’s report is the same pin that was measured from in that survey, not at the top of the bank.

Q: For the statistical model variables, is the analysis combined over impoundments and riverine sections? What is statistically significant?
A: Slide 131 is showing deviance across the entire study area. The analysis shows only weak correlation for all the variables analyzed.

**Post meeting note**: Relative to statistical significance, we had estimates of the response variable and all of the predictor variables on a foot-by-foot basis for the entire study area. As stated in the report, there was no sampling. Therefore, we were not making inference from a sample to a larger universe, which is where a significance determination would be applied.

Q: It seems like bank height is not strongly correlated.
A: Correct, bank height seems to be the most correlated, but even that variable is not correlated strongly.

Q: Coarse grained vs. fine grained soil wasn't compared.
A: Bank height gets to that, lower banks would normally be floodplain loamy soils, and higher banks are more resistant to erosion (coarser or more indurated/compact glacial till or lacustrine clay, which are primarily composed of fine particles).

Q: In Section 6 of the report you had some flow velocities that were measured out in the field.
A: Yes, those measurements came from another study (Study 9) and were taken with an acoustic Doppler current profiler (ADCP).

Q: How do you know the velocity threshold is reached at the bank versus at mid-channel.
A: We are not suggesting that there would not be a difference between velocities in the mid-channel versus at the bank interface. We are saying we were able to evaluate channel average velocities and those averages at times would suggest that sediment entrainment is likely in the channel on the whole, versus other times during lower flows when it is unlikely to occur. This supports our position that under sustained high flows significant erosion, enough to remove beaches and stabilizing submerged banks can occur, thus continuing the cycle of erosion. Project operations do not appear to have that capability.

Q: So did you calculate or estimate velocity at the bank?
A: No. We were trying to give a range of what operational flows and velocities occur. We were not trying to estimate shear stress at that WSE at any site, but rather to determine the primary driver that will remove soils and carry downstream. In general it is not operational flows that are removing soils and carrying sediments downstream.

Q: But you have data from the ADCP that could show near bank velocity.
A: We did the ADCP for habitat work for the instream flow study and to compare to the hydraulic model but that measurement is an average vertical measurement.

**Post meeting note**: ADCP measurements shown in Tables 6.1-1 and 6.1-2 were taken at points across the channel including near the banks. The data is the average of those values across the ADCP transect.

Q: Historic trends in operations impoundment WSE exceedance curves (slide 139) include a midnight reading for each day. But the question people had is - has the daily pool height changed over the years?
A: This graph does show that, we haven't changed, say at Wilder from the 5-ft range that we could operate in and normally operate within a narrower range than

that. The graph shows that the fluctuation at the full 5-ft range occurs less frequently now than it did historically.

Q: If peaking operations caused pool height fluctuations and peaking is different than it was before, would the midnight reading still be realistic? Could you look at the daily delta values?
A: It would be the same basic flattening in the graph (decreased slope in the graph), but we don't have the historic hourly data except in old log books. We don't operate the full range as much as we used to.

Q: Did you say that erosion was correlated with WSE fluctuation of 1-5 ft but not lower or higher? So within that range is where you find the greater erosion?
A: Statistical analysis and the erosion ratio showed a slight propensity for erosion within the 1-3 ft (not 1-5 ft) range, across all three projects and we equate this to simply where the water line is under most situations It doesn't mean cause and effect, just where on the bank notching is occurring. We're not saying that the greatest erosion occurs under those conditions. For instance you could have erosion on a 20-ft bank even with only 1 ft of WSE fluctuation.

Q: That's why the question is really about erosive forces. What is creating the notching – it may be the WSE fluctuation and also the frequency of fluctuation each day.
A: The analysis was based on the median daily WSE fluctuation so that half of the days it would be higher and half of the days it would be lower but still within the overall operational range. The median occurs most frequently and cumulatively would have the greatest impact on the banks. If the WSE was stable and flow was going past that bank and creating a notch, would the notch be caused by WSE? No. Notching would not occur at 20 ft in the air or 20 ft down below the water level, it happens at the water surface. We say in the report that WSE fluctuation is one of many causes of notching. Notching itself is not erosion, however. More importantly, erosion is caused and perpetuated by the natural high flows that remove the material that would otherwise lead to stabilization.

Q: Do you have references related to WSE?
A: The revised report has some new references but they might be more about hydraulic gradient which would be associated with WSE fluctuation range. The greater the gradient, the greater the seepage forces that can lead to overhanging or undercutting.

### Study 14/15 Resident Fish Spawning in Impoundments and Riverine Sections

Mark Allen summarized the revised analysis and the revised report filed 11/30/2016.

No questions.

### Study 24 Co-occurring Mussel HSC Report

Mark Allen summarized work to date and reports related to Study 24 – Dwarf Wedgemussel and Co-occurring Mussel Study. The report being discussed focused on development of habitat suitability criteria (HSE) for the co-occurring mussel species, and was filed 03/22/17.

Q: Slides 163 -166 (showing mussel density at different flows). If the studies weren't conducted at 33,000 cfs (slide 166) how do you get to those velocities?
A: On slide 163 it shows the low flows that Ethan sampled at. We estimated the velocity at the quadrats from the 2D model, at the different flow values. The counts of mussels on the left axis of each graph are the same, but mussels are immobile so the quadrat that had the most elliptio (25) will experience many different flows over time.

Q: You based your values on the Delphi panel responses?
A: We asked the Delphi panel two questions: how far back should we look (they indicated 3-5 years); and what range of flow exceedance would best define the extreme ranges and a common flow range. We're not saying these are "good" or "bad" flows for mussels, but those that allow the expression of a reasonable range of flows for the population observed.

Q: What about for substrate?
A: There is not a flow variable because depth, velocity, and shear stress change with flow but with substrate is relatively stable most of the time. Slide 167 actually shows 300 circles representing all the quadrats but they are stacked behind each other so there is more data that went into developing that curve than there seems from the graph. Mussels will experience generally the same substrate over time no matter the flow level.

### Study 9 Instream Flow Study

Steve Eggers presented the summary of the final report filed 03/22/17.

Comment from TC: We will continue this discussion so that the working group has more time to review the report and ask questions. The stakeholder comment period has a deadline but we'll be working on this after that time and a lot more discussion will be needed. This is a key study to talk about flows, future operational alternatives.

Q: How does this analysis of static flows compare to variable flows, when the river actually changes constantly (for instance in a natural flow regime)?
A: The dual flow analysis looks at different flows and can provide a basis for looking at an operational series like a baseline (current operations) and what habitat opportunities are available for species, compared to other types of operations, but we are not comparing current operations with an unregulated river.

Q: I'm concerned that these studies would look only at steady state conditions that are beneficial for all species.
A: There may be a lot of ways to look at this, if the goal is to optimize all species that won't be possible but if say 80% of the habitat improves versus current operations, then that might be something to look at.

Q: Question for FERC, the comment deadline for these studies is the same even though the reports came out a week late?
A: (From Bill Connelly of FERC) will need to check with Brandon Cherry, to clarify comment deadlines.

Comment from TC: You might want to focus your written comments for now on what you need FERC to weigh in on. Our expectation is that the aquatics working group will get together to schedule a meeting for further discussion. We will meet when most convenient for the working group.

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**Post meeting slide corrections and clarifications were made in the attached slides and are bolded below:**

Study 25:

- Slide 23: We observed full eclosion process for **18** (not 8) *Stylurus spiniceps.*
- Slide 26: A total of **754** (not 528) exuviae were found in a variety of substrates.
- Slide 30: Clarified that the 2% frequency of 8-inch water rise in 30 minutes observed **"did not correlate well with either project operations or storms".**

Study 17:

- Slide 36: Section 4.1.1, 4.2.1, 4.3.1 - Cumulative passage data separated out for all species **combined,** diadromous species, and resident species.
- Slide 37: 100% net passage first occurred by May 14, but additional upstream and downstream movements continued past that date and after May 31.

Study 18:

- Slide 42: Clarified that the fish ladder entrance **(Site No. 13)** and **below fish ladder (Site No. 14)** had fewer (15.7%) observations.

Study 21:

- Slide 61: Corrected nearfield attraction rage (**58.6% not 56.3%**) were detected within 30 ft of the ladder.

# Wilder, Bellows Falls, and Vernon Project Relicensing

Updated Study Results Meeting: March 30, 2017

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## Agenda

| Study No. | Study Title | Study Lead |
|---|---|---|
| 27, 30, 10 | Minor supplements to Study Reports:<br>Study 27 - Terrestrial Vegetation Habitats Study<br>Study 30 - Recreation Inventory<br>Study 10 - Fish Assemblage | various |
| 6 | Water Quality Study | Bernward Hay, Matt Burak |
| 25 | Dragonfly and Damselfly Inventory | Sarah Allen, Ben Griffith |
| 33 | Cultural and Historic Study – Vermont Phase II Survey | Suzanne Cherau, Steve Olausen |
| 17 | Upstream Passage of Riverine Fish | Steve Leach |
| 18 | American Eel Upstream Passage | Steve Leach |
| Break | | |
| 19 | American Eel Downstream Passage | Drew Trested |
| 21 | Adult American Shad Study – Vernon | |
| 22 | Downstream Migration of Juvenile Shad – Vernon | |
| 23 | Fish Impingement, Entrainment, and Survival | |
| Lunch | | |

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## Agenda

| Study No. | Study Title | Study Lead |
|---|---|---|
| Lunch | | |
| 2/3 | Riverbank Transect and Erosion Studies | John Field |
| 14/15 | Resident Fish Spawning Studies | Mark Allen |
| 24 | Dwarf Wedgemussel and Co-occurring Mussel Study | Mark Allen, Ethan Nedeau |
| 9 | Instream Flow Study | Steve Eggers |

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# Study 27

## Floodplain, Wetland, Riparian, and Littoral Vegetation Habitats Study

## "Terrestrial Study"

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## Study 27 – Terrestrial Study

### Reporting:

- Initial Report 09/14/2015
- Final Report 08/01/16
- Supplement filed 11/30/16 with corrections discovered during development of the PLP

Table 5.1-2 contained some minor rounding errors and some incorrectly calculated total values for wetlands cover type totals, but overall acreages were correct:

| Wetlands Cover Type Totals | Wilder | Wilder Riverine | Bellows Falls | Bellows Falls Riverine | Vernon | Total | % of Total |
|---|---|---|---|---|---|---|---|
| Report Original: | 383.5 | 17.4 | 478.9 | 0.7 | 330.4 | 1211.0 | 23.10% |
| Supplement Revised: | **701.7** | **17.4** | **737.3** | **0.7** | **657.3** | **2114.3** | **23.1%** |

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# Study 30

# Recreation Facility Inventory and Use and Needs Assessment

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## Study 30 – Recreation Study

**Reporting:**

- Report 03/01/16
- Supplement filed 12/15/16 with corrections discovered during development of the PLP

- "Fisherman Access Area" located upstream of Vernon dam at the Cersosimo Lumber property, not a Vernon Project Recreation site, resulting in minor changes in Table 5.2-8, number of safety ratings for Vernon Project sites; and in Figure 5.2-6, safety ratings.
- Table 5.3-1: minor rounding errors, corrections and text changes related to satisfaction with site conditions.
- Tables 6.2-2, 6.2-3, and 6.2-4: satisfaction with the number of public recreation areas, incorrectly presented the Likert scores in reverse order from the scale defined in the approved Study Plan

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# Study 10
# Fish Assemblage Study

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## Study 10 – Fish Assemblage Study

### Reporting:

- Initial Report 03/01/16
- Final Report 08/01/16
- Supplement filed 11/30/16 with corrections discovered during development of the PLP

- Request to graph data differently in Figure 5.4-2 (Percent composition by species and river reach for all seasons and sampling gears). No way to do that easily or make it clearer, so the data was provided in Excel that was used to create Table 5.0-1, Figure 5.4-2, and Figure 5.4-3 in the Final Study Report.
- Minor corrections to titles for Tables 5.1-2, 5.1-3, and 5.1-4.
- Minor corrections to Table 5.6-1shows monthly precipitation in 2015 and for the 10-year average. Values for “% of 10-YR Ave” should be multiplied by 100 to correctly state percentages.
- Section 6.0 Study Conclusions, the last full sentence on page 141 changed to: *Tessellated Darter and Fallfish were among the most abundant species in the Wilder and Bellows Falls ~~impoundments~~ **riverine reaches**.*

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# Study 6
# Water Quality Study

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## Study 6 – Water Quality Study

### Study Objectives

**Characterize:**

- Temperature in the river, impoundments, Bellows Falls bypass reach, forebays, tailraces, and the main tributaries
- Dissolved oxygen, conductivity, turbidity, and pH at river stations, including during a 10-day low-flow period
- Nutrient and chlorophyll concentrations at forebay stations

**Assess:**

- Potential effects of Wilder, Bellows Falls and Vernon Projects on water quality and temperature in the Connecticut River
- Compliance with VT and NH surface water quality standards

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## Study 6 – Water Quality Study

### Field Activities

| | Station ID | Wilder | Bellows F. | Vernon | Location | Date of fisrt deployment | Mar-May Cont. Temp. sonde | Jun-Sep Continuous Temp. Sonde | Jun-Sep Continuous Temp. Transect | Jun-Sep Continuous Multi-Sonde | Jun-Sep Instantaneous Vertical profile | Jun-Sep Instantaneous Water Sample Core | Oct-Nov Cont. Temp. sonde |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Connecticut River | 06-W-04 | ■ | | | upstream | 1-May | ● | ● | 7Q10 | 7Q10 | ● | | ● |
| | 06-W-03 | ■ | | | upper imp. | 1-May | ● | ● | | | ● | | ● |
| | 06-W-02 | ■ | | | mid-imp. | 1-May | ● | ● | | | ● | | ● |
| | 06-W-01 | ■ | | | lower imp. | 7-May | ● | | | ● | ● | ● | ● |
| | 06-W-TR | ■ | | | tailrace | 7-May | ● | | | ● | ● | | ● |
| | 06-BF-04 | | ■ | | upstream | 29-Apr | ● | ● | 7Q10 | 7Q10 | ● | | ● |
| | 06-BF-03 | | ■ | | upper imp. | 29-Apr | ● | ● | | | ● | | ● |
| | 06-BF-02 | | ■ | | mid-imp. | 29-Apr | ● | ● | | | ● | | ● |
| | 06-BF-01 | | ■ | | lower imp. | 8-May | ● | | | ● | ● | ● | ● |
| | 06-BF-BR | | ■ | | bypassed reach | 13-May | ● | | | ● | | | ● |
| | 06-BF-TR | | ■ | | tailrace | 21-May | ● | | | ● | ● | | ● |
| | 06-V-04 | | | ■ | upstream | 30-Apr | ● | ● | 7Q10 | 7Q10 | ● | | ● |
| | 06-V-03 | | | ■ | upper imp. | 30-Apr | ● | ● | | | ● | | ● |
| | 06-V-02 | | | ■ | mid-imp. | 30-Apr | ● | ● | | | ● | | ● |
| | 06-V-01 | | | ■ | lower imp. | 13-May | ● | | | ● | ● | ● | ● |
| | 06-V-TR | | | ■ | tailrace | 6-May | ● | | | ● | ● | | ● |
| Tributaries | 06-W-T02 | ● | | | Waits R. | 25-Mar | ● | ● | | | | | ● |
| | 06-W-T01 | ● | | | Ompomp. R. | 7-Apr | ● | ● | | | | | ● |
| | 06-BF-T05 | | ● | | White R. | 7-Apr | ● | ● | | | | | ● |
| | 06-BF-T04 | | ● | | Mascoma R. | 25-Mar | ● | ● | | | | | ● |
| | 06-BF-T03 | | ● | | Sugar R. | 7-Apr | ● | ● | | | | | ● |
| | 06-BF-T02 | | ● | | Black R. | 25-Mar | ● | ● | | | | | ● |
| | 06-BF-T01 | | ● | | Williams R. | 26-Mar | ● | ● | | | | | ● |
| | 06-V-T03 | | | ● | Saxton R. | 24-Mar | ● | ● | | | | | ● |
| | 06-V-T02 | | | ● | Cold R. | 24-Mar | ● | ● | | | | | ● |
| | 06-V-T01 | | | ● | West R. | 23-Apr | ● | ● | | | | | ● |

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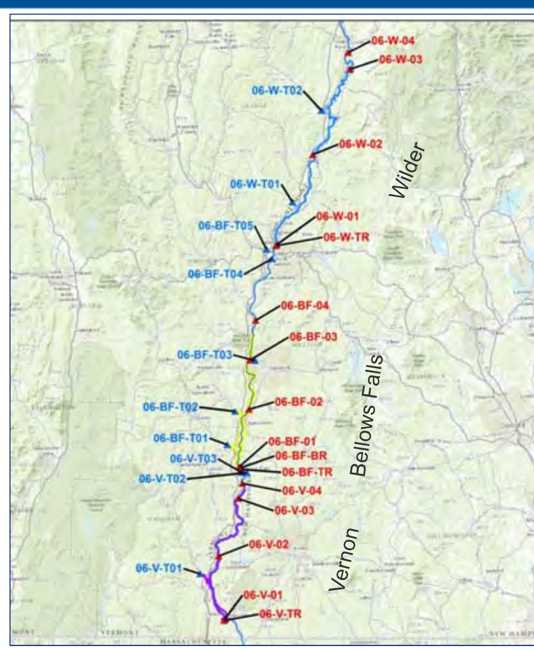
## Study 6 – Water Quality Study

### Stations

- ▲ Connecticut River (n=16)
- ▲ Tributaries (n=10)

➢ Approximately 120 river miles.

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## Study 6 – Water Quality Study

### December 15 Report - *What's New*

- **Addition of Water Surface Elevation Duration Curves (Section 5.1 Weather, Flow, and Operations)**
  - Provide a context of water level change within the impoundments over the duration of the study
  - Observations incorporated into the main body text
- **Addition of Appendices O and P**
  - Appendix O shows the 15-minute water temperature data at each station with water surface elevation
  - Appendix P shows the 15-minute water temperature data with mean daily air temperature from area NOAA weather stations
  - Observations incorporated into the main body text
- **Other Main Body Text Revisions**
  - Revisions to the Executive Summary, Section 5.5.1 – New Hampshire Water Quality Standards, and Section 6.0 – Assessment of Project Effects

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## Study 6 – Water Quality Study

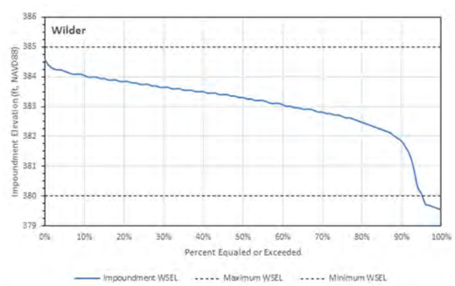
### Water Surface Elevations (Section 5.1)

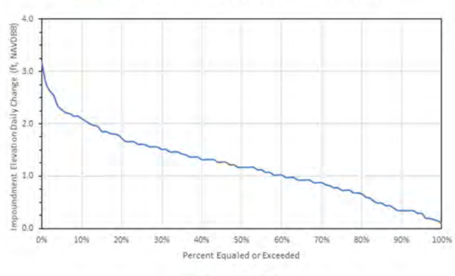
***April 1 through November 15***

**Wilder:**
*Elevation Range*: 381.8 to 384.6 ft; 90% of the time
*Daily Fluctuation*: 0.1 to 3.2 ft

**Bellows Falls:**
*Elevation Range*: 288.6 to 291.1 ft; 100% of the time
*Daily Fluctuation*: 0.1 to 1.7 ft

**Vernon:**
*Elevation Range*: 217.9 to 219.6 ft; 100% of the time
*Daily Fluctuation*: between 0.1 to 1.3 ft

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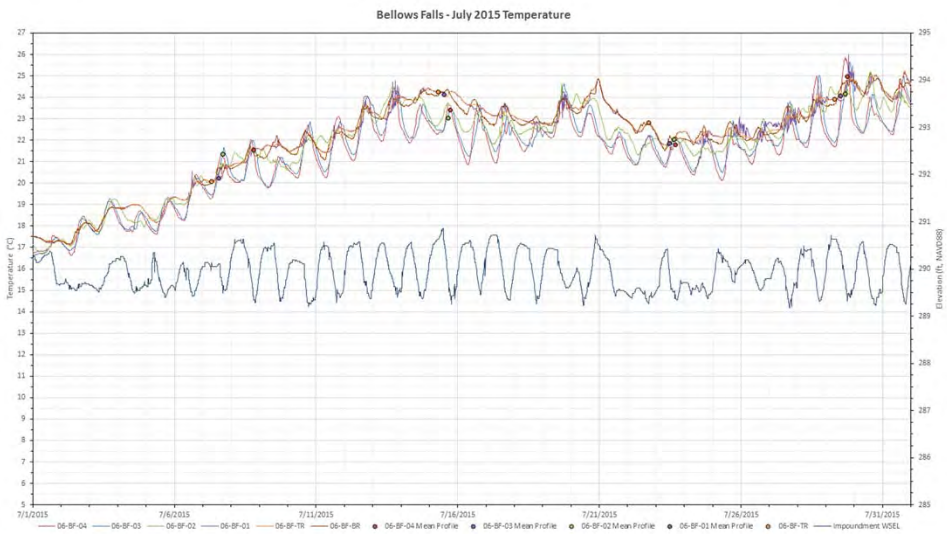
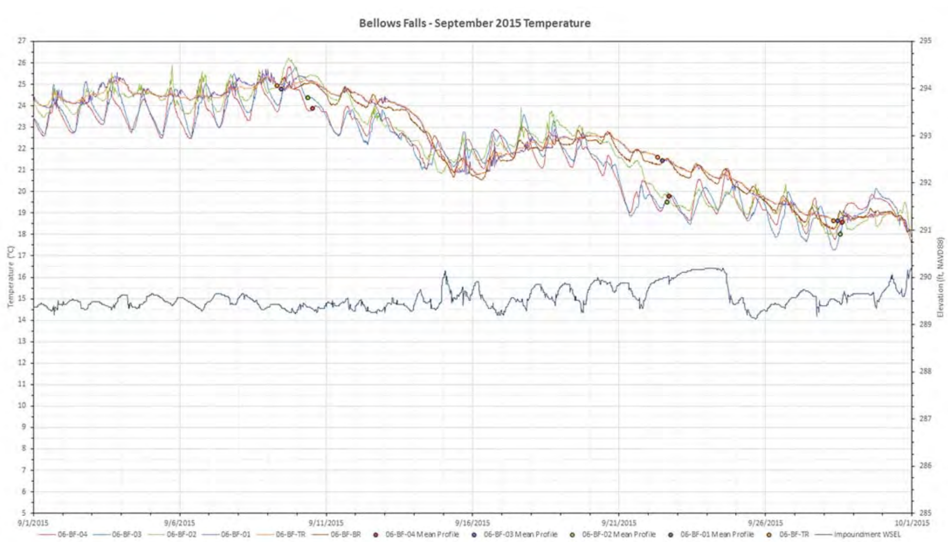
## Study 6 – Water Quality Study

### Appendix O - Water Temperature and Water Surface Elevations



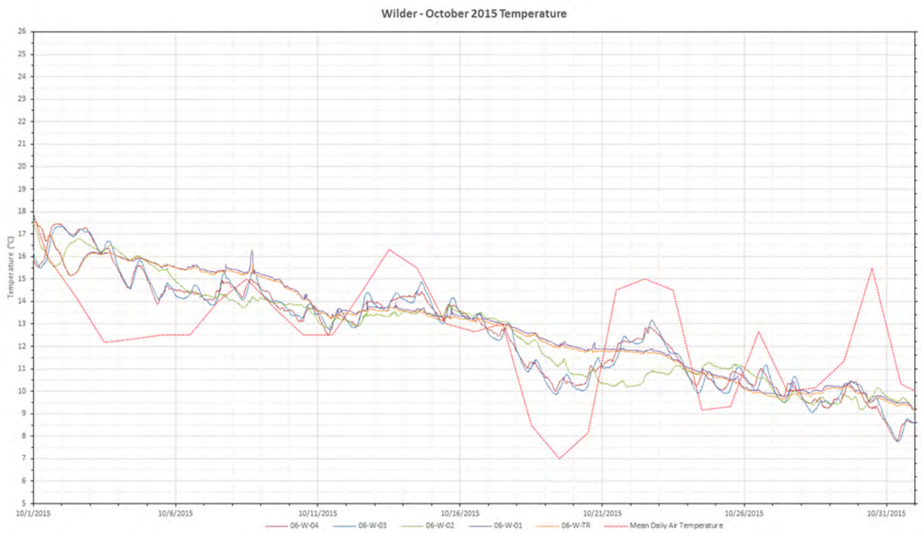

## Study 6 – Water Quality Study

### Appendix O - Water Temperature and Water Surface Elevations



## Study 6 – Water Quality Study

### Appendix P - Water Temperature and Air Temperature




## Study 25
## Dragonfly and Damselfly
## Inventory and Assessment

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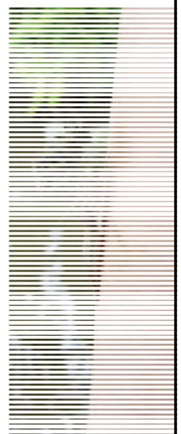
## Study 25 – Dragonfly and Damselfly Inventory and Assessment

### Study Summary

- Eleven sites were selected to cover geographic extent of the project area and a variety of hydrologic and habitat conditions
- Six visits during June and July, 2015 to all eleven sites
- Searched five 3-meter wide transects at each site for dragonfly larvae, exuviae, and tenerals (pre-flight adults)
- Recorded water levels using HOBO dataloggers
- Over 750 observations of 19 species, with at least 1 observation at each study site
- Six of the eight target listed odonates were observed throughout the Projects
- Multiple larvae were observed from emergence to eclosure to flight
- Critical period for emergence is approximately 30 minutes during eclosure



Arrow clubtail (*Stylurus spiniceps*) eclosing on observer's leg

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## Study 25 – Dragonfly and Damselfly Inventory and Assessment

### Assessment of Project Effects

- Two potential effects from normal project operations
  - Loss of habitat due to inundation
    - Operations Model (Study 5) data used to analyze the timing, frequency, and duration of high water events
  - Mortality due to rapid water level rises during eclosure
    - Water level logger data used to analyze the frequency of rapid rises
- No effect on odonates due to habitat loss from inundation
- No mortality of odonates due to rapid water level rises in impoundments
- Low mortality of odonates due to rapid water level rises in riverine reaches

Teneral of Rapids clubtail (*Gomphus quadricolor*) Wilder impoundment

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## Study 25 – Dragonfly and Damselfly Inventory and Assessment

### VANR Comment 1

Analyze the vertical and horizontal distances travelled by each species

- Vertical range of exuviae was from 0 – 204 inches from the water surface at time of observation

| Species | Site Types | Height Above Water (inches) |
|---|---|---|
| *Gomphus abbreviatus* | Impoundment | 25 |
| *Gomphus quadricolor* | Impoundment | 18 |
| *Gomphus vastus* | Impoundment, Riverine | 52 |
| *Ophiogomphus rupinsulensis* | Riverine | 31 |
| *Stylurus amnicola* | Impoundment, Riverine | 11 |
| *Stylurus scudderi* | Impoundment, Riverine | 26 |

- Not truly representative (overestimate) because we don't know water levels at time of eclosure
- We observed full eclosion process for 18 *Stylurus spiniceps* - average height above water 12", range 8-16"
  - Average height above water based on all exuviae for that species, 20"

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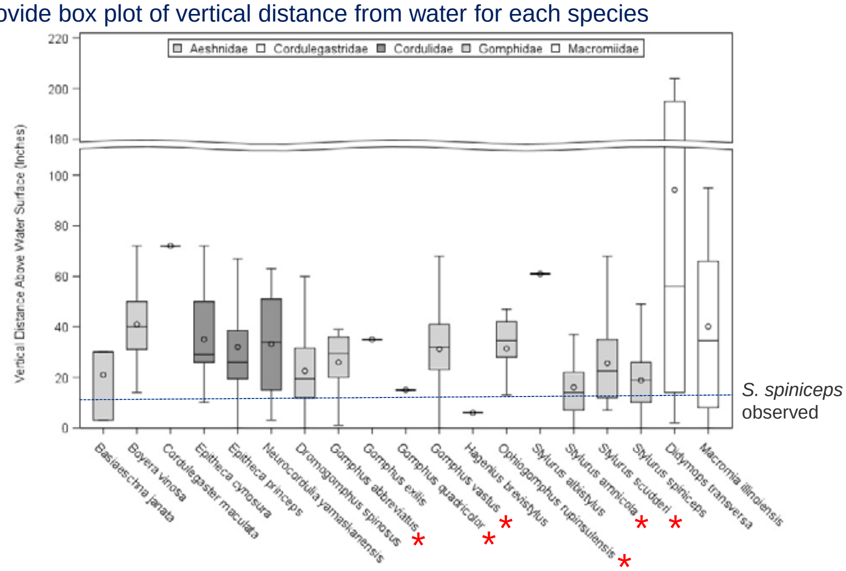
## Study 25 – Dragonfly and Damselfly Inventory and Assessment

### VANR Comment 4

Provide box plot of vertical distance from water for each species



## Study 25 – Dragonfly and Damselfly Inventory and Assessment

### VANR Comment 5

Compare observed horizontal distance traveled to other studies

Non-uniform bank topography makes horizontal distance inconsistent between studies

- Our method: Perpendicular horizontal/vertical distance for eclosing larvae only
- Martin method: Perpendicular horizontal/vertical distance for exuviae and larvae with no distinction
- Morrison method: Distance along bank surface for larvae only (stated the use of Exuviae is inappropriate for this measurement.).

Our results: Significant sample only for *Stylurus spiniceps* (mean:18", range: 0-120"). Other species observed on single individuals

*Didymops transversa*: 79";
*Gomphus vastus:* 44";
*Dromogomphus spinosus:* 3";
*Macromia illinoiensis:* 76";
*Stylurus scudderi*: 11".

Larva of Arrow clubtail (*Stylurus spiniceps*)

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## Study 25 – Dragonfly and Damselfly Inventory and Assessment

### VANR Comment 2

Analyze eclosion substrates

A total of 754 exuviae were found in a variety of substrates

| Substrate Type | Count | Percent |
|---|---|---|
| Soil | 203 | 27% |
| Leafy vegetation | 177 | 23% |
| Dislodged | 118 | 16% |
| Woody Vegetation | 73 | 9% |
| Leaf Litter | 77 | 10% |
| Roots | 95 | 13% |
| Other | 11 | 2% |
| Total | 754 | 100% |

Relatively homogeneous distribution by species

- More exuviae were found on soils, but may have been related to easier visibility

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## Study 25 – Dragonfly and Damselfly Inventory and Assessment

### VANR Comment 3 - Summarize habitat parameters measured

Field data included :

- Bank characteristics: bank height, slope, relative stability
- Type and percent cover of ground substrates: roots, woody vegetation, leafy vegetation, soil, cobble/gravel, boulder/bedrock, leaf litter/dead vegetation, other
- Percent canopy cover
- Elevation of toe of slope and top of slope
- Distance from water's edge to bank
- Site-specific water elevations and time stamp

Cobra clubtail (Gomphus vastus) teneral 3 m above its exuvia

- No clear relationship between odonate abundance and specific habitat characteristics. In general, transects with relatively high numbers of odonates (>30) had:
  - 30% or less exposed substrates
  - 50% or more cover of coarse woody debris
  - No apparent relationship to canopy cover
- Relatively homogeneous distribution by species - More exuviae were found on soils, but may have been related to easy visibility

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## Study 25 – Dragonfly and Damselfly Inventory and Assessment

### VANR Comment 6

Provide more detail on definitions of minimum and maximum elevations of available habitat, why habitat was used to assess project effects, and analysis of how other variables (substrate and vertical height) are affected by project operations.

We identified two potential direct adverse effects of Project Operations

- Inundation of eclosure habitat
- Direct mortality from rising water levels

Utilized the rating curves developed for the hydraulic model cross-sections

Exuvia of spine-crowned clubtail (*Gomphus abbreviatus*)


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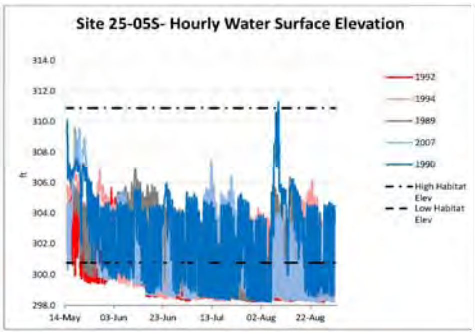
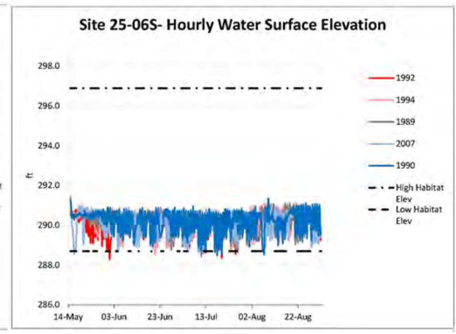
## Study 25 – Dragonfly and Damselfly Inventory and Assessment

### VANR Comment 6 (cont)

Inundation of eclosure habitat

- Assumed steep banks are beneficial because odonates can get further from the water for the same distance travelled
- Assumed critical emergence time was between May 15 and Aug 31, from 04:00 to 21:00
- Utilized the rating curves developed for the hydraulic model cross-sections to look at hourly water surface elevations
    - Determine if the steep portion of the bank fell within the range of normal project operations




## Study 25 – Dragonfly and Damselfly Inventory and Assessment

### VANR Comment 6 (cont)

Direct mortality from rising water levels

- Assumed eclosion stage is the critical time during odonate emergence
    - Supported in the literature
    - Larvae can withstand inundation, tenerals were observed to resume climbing
    - Takes approximately 30 minutes
- Evaluated rates of water level rise between May 15 and Aug 31, from 04:00 to 21:00
    - Used site specific data loggers
- Used *Stylurus spiniceps* which was observed eclosing 8”-16” above WSE, average 12”

8” rises in WSE were recorded at low frequency (<2%) at the four riverine sites, and the lower Wilder impoundment

No apparent relationship between rapid river rise and project operations OR storm events (clarified: the 2% observed did not correlate well with either project ops or storms)

Exuviae of 3 *Stylurus* species:
*S. amnicola*
*S. spiniceps*
*S. scudderi*

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## Study 25 – Dragonfly and Damselfly Inventory and Assessment

### Conclusions

- Direct mortality from Project Operations in impoundments is unlikely
- Direct mortality from Project Operations in riverine habitats is low (<2%) and unlikely to have a substantial impact to odonate populations

Teneral of Riverine clubtail (Stylurus amnicola)

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## Study 33
## Cultural and Historic Resources Study

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## Study 33 – Historic and Cultural Resources

**Completed Archaeological Investigations**

- Vernon - Phase 1A Archaeological Reconnaissance Survey Report 04/10/2008 (filed with SHPOs only).
- Wilder and Bellows Falls - Phase 1A Archaeological Reconnaissance Survey Reports 07/01/2013.
- Vernon - Phase 1A Archaeological Reconnaissance Survey Update 12/23/2014.
- Wilder, Bellows Falls, and Vernon - Phase IB Archaeological Identification Survey 03/23/2016.
- Wilder - Phase II Archaeological Determination of Eligibility Lampshire Meadow Site, 08/01/2016.
- Wilder and Vernon (Vermont) - Phase II Archaeological Site Evaluation Surveys 12/01/2016.

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## Study 33 – Historic and Cultural Resources

**Phase II Archaeological Site Evaluations –**
**Wilder and Vernon Projects in Vermont:**

- 6 pre-contact sites underwent Phase II investigations to evaluate their eligibility for listing in the National Register (NR) of Historic Places.
- VT SHPO provided stamped concurrence on Phase II site investigations field methodology (within the APE) on April 20, 2016.
- Phase II survey fieldwork, mapping, data analyses, and report preparation from April to November 2016.
- PAL recommends all four of the Wilder sites as NR eligible: Late Archaic and Woodland Period settlement in CT River valley.
- One of the Vernon sites recommended NR eligible within the APE; the other site could contain significant deposits outside of the APE, but none identified within the shoreline Project APE.
- Program of archaeological monitoring for all six site areas; mitigation measures for any impacts identified through the monitoring program to be established in the forthcoming Historic Property Management Plans.

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# Study 17
# Upstream Passage of Riverine Fish Species

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## Study 17 – Upstream Passage of Riverine Fish Species

**Reporting**

- Initial Report 05/16/16
- Final Report 11/30/16
  - Clarifications and additional presentation of data in response to stakeholder comments.
    - Section 4.1.1, 4.2.1, 4.3.1 - Cumulative passage data separated out for all species combined, diadromous species, and resident species
    - Sections 4.1.3, 4.2.3,4.3.3 – Diel periodicity figures changed net passage values on line rather than bar in initial report
    - “Net upstream passage” was changed to “net passage” except where needed for clarity.
    - Section 4.4 – New data presentation comparing ladder use during normal fish ladder operating season and the 2015 extended study season .
  - Results from review of 2016 Salmonsoft videos recorded by VFWD at Vernon.

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## Study 17 – Upstream Passage of Riverine Fish Species

2016 Salmonsoft review of Walleye and White Sucker at Vernon

- Reviewed April 15 – May 31, 2016 videos
- Ladder opened later in 2015 (May 5) with both species present at that time

| Vernon – From Ladder Open to May 31 | 2015 | 2016 |
|---|---|---|
| Ladder Open | May 5 | April 15 |
| **Walleye** | | |
| First Net Passage | May 5 | April 17 |
| 100% Net Passage | > May 31 (79% by May 31) | May 17 |
| **Total Net Passage** | **46** | **7** |
| **White Sucker** | | |
| First Net Passage | May 5 | April 16 |
| 100% Net Passage | 100% initially by May 14, but additional passage (up and downstream) occurred later | May 23 |
| **Total Net Passage** | **326** | **148** |

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## Study 17 – Upstream Passage of Riverine Fish Species

This information is not in the final report, but based on PLP comments

- In 2016, net passage of both species was completed before May 31.
- In 2015 both continued to pass upstream in small numbers after May 31.
- In 2016, water temperature at the beginning of passage was lower than 2015.
- In both years, flows during the passage period (through May 31) were comparable.

| Ladder Open to May 31 | 2015 | 2016 |
|---|---|---|
| Ladder Open | May 5 | April 15 |
| **Walleye** | | |
| Temp at Passage (ºC) | 11.9 – 15.0 | 7.0 – 15.1 |
| Flow During Passage Period (cfs) | 1,850 – 19,300 | 2,595 – 20,649 |
| **White Sucker** | | |
| Temp at Passage (ºC) | 11.9 – 13.3 | 7.0 – 15.3 |
| Flow During Passage Period (cfs) | 1,850 – 19,300 | 2,595 – 20,649 |

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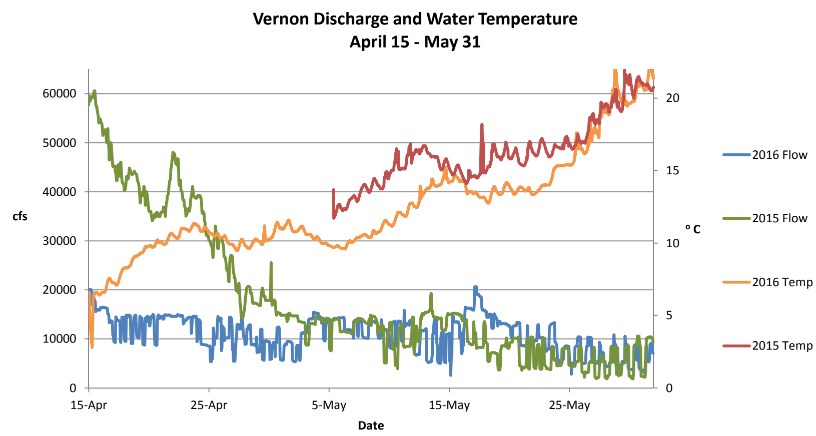
## Study 17 – Upstream Passage of Riverine Fish Species

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# Study 18

# American Eel Upstream Passage Assessment

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## Study 18 – American Eel Upstream Passage Assessment

### Reporting

- Report 03/01/16
- Report Supplement of 2016 additional study results 11/30/16
  - 2016 additional surveys similar to 2015 were conducted from July 28 to October 20
  - Fabrication and installation of a temporary eel ramp and trap near the fish ladder entrance.
    - Designed in consultation with the aquatics working group, which visited the site to determine ramp location, angle of incline, and needed water flows.
    - Time needed for consultation, design, fabrication resulted in delayed opening of ramp to September 6.
    - Ramp operated through November 4.

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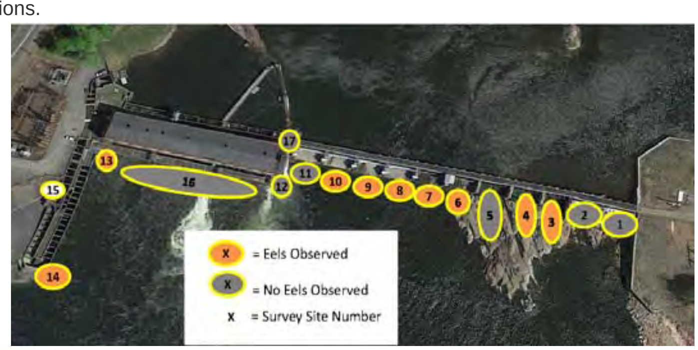
## Study 18 – American Eel Upstream Passage Assessment

- 70 eels were observed in 2016 during weekly surveys over 13 weeks.
- 80 eels had been observed in 2015 over a longer season (May – October).
- A majority (51.4%) of all observations occurred in 2 weekly surveys on August 18 and August 25.
- Site No. 3 (rocks below stanchions) and No. 10 (floodgate) had the most frequent observations (27%, and 24%).
- Fish ladder entrance (Site No. 13) and below fish ladder (Site No. 14) had fewer (15.7%) observations.

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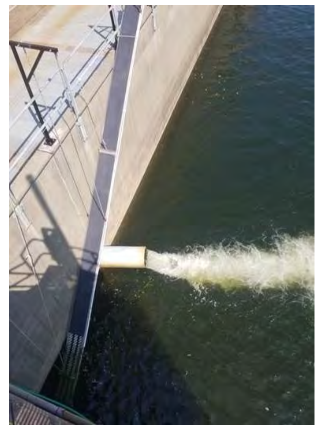
## Study 18 – American Eel Upstream Passage Assessment

- One 10.9-inch eel was collected at the ramp tank on September 23.
- During the period of ramp operation, only eight eels were observed in seven weekly nighttime observations, with 89% of eels surveyed prior to ramp opening.
- It is possible that most eel upstream migratory activity had occurred earlier in the season.



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## Study 18 – American Eel Upstream Passage Assessment

### Study Conclusions

- No large aggregations of eels staging in pools or attempting to ascend wetted structures of the dam.
- At most, 7 eels were observed in any one survey period at any one site.
- Eels observed in the rock outcrop most closely represented migratory behavior since they had ascended wetted surfaces to arrive from the tailwater elevation.
- Eels observed at the floodgates appeared to exhibit resting/hiding behavior, not necessarily migratory behavior.
- The one eel collected at the ramp represented 12.5% of all eels observed during the period of ramp operation.
- The results of Study 18 in both years indicate that a small number of eels may attempt to migrate upstream past Vernon, and in the absence of the release in 2014 of nearly 6,000 eels upstream of Turners Falls dam substantial numbers of eels do not appear to use the Vernon fish ladder either.

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# Break

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## Studies 19, 21, 22, 23

- **Study 19 – American Eel Downstream Passage Assessment**
- **Study 21 – Adult American Shad Telemetry Study**
- **Study 22 – Downstream Migration of Juvenile American Shad**
- **Study 23 – Fish Impingement, Entrainment, and Survival Study**

### Re-processed downstream passage telemetry data:

- Some original telemetry detection records were inadvertently "compressed" during data processing. This resulted in lower resolution of detections and potential masking or misidentification of passage route selection results and some passage time/residency results.
- Not a data collection error, only affected data from Orion receivers, not Lotek receivers.
- We reprocessed and reanalyzed all downstream Orion data in study reports filed Jan 17 (Study 22) and Feb 28 (Studies 19, 21) with revised route selection results.
- This also affected total project survival (Section 7) of Study 23. Report supplement filed Feb 28 (prior to the supplement, a revised report had been filed Nov 30).

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# Study 19
# American Eel
# Downstream Passage Assessment

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## Study 19 – American Eel Downstream Passage Assessment

### Study Report Revisions

Initial report filed 05/16/16, final report filed 02/28/17

- Reprocessed telemetry data for route selection.
- Additional data presentation per FERC 09/12/16 study plan determination and 08/15/16 response to comments.
- Turbine Survival – no changes.

This presentation is limited to route selection only, with only minor changes in route selection from reprocessed data.

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## Study 19 – Route Selection Results

**Wilder**

- 38% of eels were detected in the forebay within 8 hours of release and another 27% were detected within 24 hours after release
- Forebay residency ranged from less than 0.1 hour to 16.7 days (median = 0.2 hour), and no significant differences in residency between passage routes.
- 5 eels did not approach or pass the project (* including 2 that entered Unit 3 but were not detected in the tailrace)
- Most eels that passed used the turbine intakes.

| Passage Route | No. | % of all passed | % of all released |
|---|---|---|---|
| Turbine Units 1-2 | 33 | 73.3 | 66.0 |
| Turbine Unit 3 | 5* | 11.1 | 10.0 |
| Trash/ice sluice | 2 | 4.4 | 4.0 |
| Unknown | 5 | 11.1 | 10.0 |
| Total Passed | 45 | 100.0 | 90.0 |
| Did not pass | 3* | | 6.0 |
| Did not approach | 2 | | 4.0 |
| Total Released | 50 | | 100.0 |

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## Study 19 – Route Selection Results

**Bellows Falls**

- 50% of eels released in the Bellows Falls impoundment were present within the study area (Pine St Boat Launch) within 8 hours of release
- Approach duration ranged from approximately 0.6 hour to over 36 days (median = 16.0 hours)
- Power canal residency ranged from 0.1 hour to 12.8 days (median = 0.2 hour) and no significant differences in residency between powerhouse passage routes
- 84% of eels that passed the project had a power canal residency less than 3 hours

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## Study 19 – Route Selection Results – Bellows Falls

- The majority of eels passing Bellows Falls entered the power canal and passed via the turbine units
- The spillway passed 5 eels during leakage flows and 1 passed late in the season during spill
- 2 of the 98 eels arriving at Bellows Falls did not pass the project
- 21 of the 22 eels that did not approach were Wilder releases
- All canal released eels (20) passed

| Passage Route | No. | % of all passed | % of all released |
|---|---|---|---|
| All Upstream Released Eels | | | |
| Turbine Units 1-3 | 77 | 80.2 | 64.2 |
| Trash/ice sluice | 13 | 13.5 | 10.8 |
| Dam spillway | 6 | 6.3 | 5.0 |
| Total Passed | 96 | 100.0 | 80.0 |
| Did not pass | 2 | | 1.7 |
| Did not approach | 22 | | 18.3 |
| Total Released above Bellows Falls | 120 | | 100.0 |

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## Study 19 – Route Selection Results - Vernon

**Vernon**

- Approach duration for Vernon released eels ranged from 4.3 hours to 22.15 (median= 49.5 hours), slower than observed at the upstream projects.
- 36% of Vernon released eels were present within the study area within 24 hours following release
- Forebay residency for all eels ranged from <0.1 hour to 34.6 days (median = 0.2 hour), 89% passed in under 4 hours after arrival
- There were no significant differences among the mean forebay residency times for different passage routes (those with sufficient sample size)
- Most eels passed via turbine units 5-8, followed by units 9-10, then units 1-4

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## Study 19 – Route Selection Results - Vernon

| Passage Route | No. | % of all passed | % of all released |
|---|---|---|---|
| **Vernon Released Fish** | | | |
| Turbine intake 5-8 | 24 | 55.8 | 48.0 |
| Turbine intake 9-10 | 7 | 16.3 | 14.0 |
| Turbine intake 1-4 | 4 | 9.3 | 8.0 |
| Fish pipe | 2 | 4.7 | 4.0 |
| Trash/Ice sluice | 1 | 2.3 | 2.0 |
| Fish tube | 1 | 2.3 | 2.0 |
| Fish ladder | 1 | 2.3 | 2.0 |
| Unknown | 3 | 7.0 | 6.0 |
| Total Passed | 43 | 100.0 | 86.0 |
| Did not pass | 1 | | 2.0 |
| Did not approach | 6 | | 12.0 |
| Total Released | 50 | | 100.0 |

| Passage Route | No. | % of all passed | % of all released |
|---|---|---|---|
| **Combined Wilder, Bellows Falls, and Vernon Released Fish** | | | |
| Turbine intake 5-8 | 53 | 47.3 | 31.2 |
| Turbine intake 9-10 | 26 | 23.2 | 15.3 |
| Turbine intake 1-4 | 14 | 12.5 | 8.2 |
| Fish pipe | 4 | 3.6 | 2.4 |
| Trash/Ice sluice | 2 | 1.8 | 1.2 |
| Fish tube | 1 | 0.9 | 0.6 |
| Fish ladder | 1 | 0.9 | 0.6 |
| Unknown | 11 | 9.8 | 6.5 |
| Total Passed | 112 | 100.0 | 65.9 |
| Did not pass | 2 | | 1.2 |
| Did not approach | 56 | | 32.9 |
| Total Released | 170 | | 100.0 |

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## Study 19 – Downstream Passage Summary

Data reprocessing resulted in relatively minor changes to passage route selection at Wilder and Bellows Falls, more so at Vernon.

**Wilder**

| Passage Route | Initial Report No. | Revised Report No. |
|---|---|---|
| Turbine Units 1-2 | 32 | 33 |
| Turbine Unit 3 | 10 | 5 |
| Trash/ice sluice | 3 | 2 |
| Unknown | - | 5 |
| Total Passed | 45 | 45 |
| Did not pass | 5 | 3 |
| Did not approach | - | 2 |
| Total Released | 50 | 50 |

**Bellows Falls**

| Passage Route | Initial Report No. | Revised Report No. |
|---|---|---|
| Turbine Units 1-3 | 76 | 77 |
| Trash/ice sluice | 12 | 13 |
| Dam spillway | 5 | 6 |
| Total Passed | 93 | 96 |
| Did not pass | 5 | 2 |
| Did not approach | 22 | 22 |
| Total Released above Bellows Falls | 120 | 120 |

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## Study 19 – Downstream Passage Summary

- Data reprocessing resulted in more passage route revisions at Vernon due to the greater number of potential passage routes available

**Vernon**

| Passage Route | Initial Report No. | Revised Report No. |
|---|---|---|
| Turbine intake 1-4 | 7 | 14 |
| Turbine intake 5-8 | 48 | 53 |
| Turbine intake 9-10 | 31 | 26 |
| Trash/Ice sluice | 3 | 2 |
| Fish pipe | 21 | 4 |
| Fish tube | 1 | 1 |
| Fishway | 1 | 1 |
| Unknown | - | 11 |
| Total Passed | 112 | 112 |
| Did not pass | 6 | 2 |
| Did not approach | 52 | 56 |
| Total Released | 170 | 170 |

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## Study 19 – Downstream Passage Summary

- Once detected at the intended project study area, passage occurred for 93.8% of eels at Wilder, 98.0% at Bellows Falls, and 98.2% at Vernon.
- The majority of eels passed their intended project in 4 hours or less after detection in the forebay (79% at Wilder, 84% at Bellows Falls, 89% at Vernon).
- Some eels seemed to exhibit potential route searching behavior prior to passage; however, the majority of eels exhibited minimal wandering behavior prior to passage.
- Most eels passed via the turbine routes at all three projects (84.4% at Wilder, 93.7% at Bellows Falls, 83.0% at Vernon).
- Overall, 112 (65.9%) of the 170 eels released at all projects ultimately passed Vernon.

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# Study 21
# American Shad Telemetry Study

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Study 21 – American Shad Telemetry Study

## Study Report Revisions

Initial report filed 08/01/16, final report filed 02/28/17

- Reprocessed telemetry data for downstream route selection
- Re-analysis of fish ladder foray data
- Additional analysis of spawning related data
- Additional data presentation per 10/31/16 response to comments and FERC 11/29/16 study plan determination

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## Study 21 – American Shad Telemetry Study

**Upstream Passage – Entrance into "Study Area"**

- 129 individuals entered the Vernon study area and were "available" for fish ladder performance metrics.
  - 36 of 100 TC releases, 93 of 793 FL releases arrived
  - 58 dual-tag, 71 PIT tag shad arrived
- Travel duration from release to 1st detection at Vernon ranged from just over 1 day to just over 22 days.
- Median tailrace residence time for dual-tagged shad was < 2 days.
- No statistically significant difference between mean tailrace residence time for dual-tagged shad that successfully passed upstream of Vernon versus those that did not pass.

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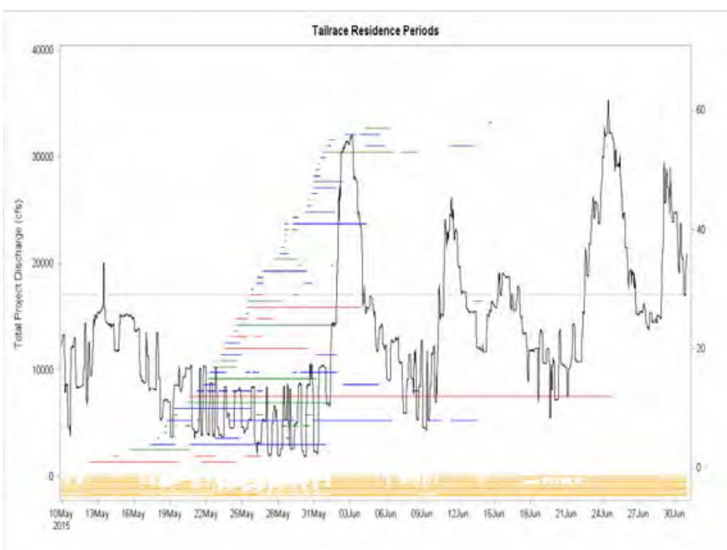
## Study 21 – American Shad Telemetry Study

**Upstream Passage – Tailrace Residency**




Black line = Project discharge (cfs), Dashed blue line = station capacity,

Red lines = downstream residence events resulting in successful passage,

Green lines = downstream residence events which included at least one attempted foray but no passage,

Blue lines = downstream residence events with no attempted fish ladder forays,

Orange lines = operational status of Units 1 (upper) through 10 (lower) where orange = unit on and blank = unit off.

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## Study 21 – American Shad Telemetry Study

### Upstream Passage – Approach Events and Nearfield Attraction

- **Approach event**: defined based on detection of a radio-tagged shad on the aerial antenna associated with the discharge area downstream of the fishway entrance
- Approach events were initiated from May 16 to June 14 with over half between May 25 and May 29
- The majority of approach events (93%) were initiated when fish ladder attraction flow was provided (between sunrise and sunset and supplying approximately 200 cfs).

- **Nearfield attraction:** defined as the proportion of dual-tagged shad in the Vernon study area detected within the immediate vicinity of the fish ladder.
  - 34 of 58 available dual-tag shad (**58.6%**) were detected within 30 ft of the ladder.
  - This value is higher than initial report (51.4%) and within the broad range of attraction effectiveness values (11.0-73.0%) observed at other facilities.

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## Study 21 – American Shad Telemetry Study

### Upstream Passage –Forays and Entrance Efficiency

- **"Foray" = a single passage attempt by a dual- or radio-tagged shad to ascend the fish ladder.**
  - Foray was considered initiated using only detections from the underwater radio antenna or PIT reader at entrance
  - Definition was revised from that used in the initial report.

- **Entrance Efficiency** = proportion of dual-tag shad in nearfield that entered fishway = **73.5%** (25 of 34; higher than initial report, 67.3%)
  - 96 shad (25 dual, 71 PIT) were detected at fishway entrance (or first bend).
  - 137 individual forays were identified
  - Number of forays for each individual ranged from a 1 to 10 (mean = 1.6; median = 1).
  - Duration of individual successful passage attempts ranged from 0.9 hours to 99.6 hours (median = 3.4 hr).
  - Duration of individual unsuccessful passage attempts ranged from <0.1 to 152.9 hours (median = 1.1 hr).

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## Study 21 – American Shad Telemetry Study

### Upstream Passage –Forays

- Average number of forays for individuals failing to pass was 1.8 (range = 1 to 10).
- Average number of forays for individuals successfully passing was 1.3 (range = 1 to 3).
- The majority of approach events and corresponding fish ladder forays occurred during flow conditions between 2,500-12,500 cfs.
  - Total discharge ranged from 2,002 to 14,990 cfs (mean = 5,373 cfs) at the time of approach events resulting in successful upstream forays.
  - Total discharge ranged from 2,123 to 22,227 cfs (mean = 6,780 cfs) at the time of approach events resulting in unsuccessful upstream forays.

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## Study 21 – American Shad Telemetry Study

### Upstream Passage –Internal Efficiency

**Internal Efficiency** = proportion of all shad entering the fish ladder and subsequently exiting the upstream end and remaining upstream of Vernon dam for more than 48 hours = **55.2%** (53 of 96 shad that entered, higher than initial report 51.0%).

| Tag Type | No. Shad Detected Entering Fish Ladder[a] | No. Shad Detected Exiting Fish Ladder[b] | Internal Efficiency Rate (%) |
|---|---|---|---|
| Dual | 25 | 11 | 44.0 |
| PIT | 71 | 42 | 59.2 |
| Total | 96 | 53 | 55.2 |

- Fish ladder residency ranged from less than 1 minute to 6 days, 8 hours, 54 minutes.

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## Study 21 – American Shad Telemetry Study

### Upstream Passage - Internal Efficiency

- For successful passage, median time from the entrance to the counting window was approximately 1.1 hours and from the counting window to the exit was approximately 1.4 hours.
  - Lower median time for unsuccessful in lower ladder
  - Higher median time for unsuccessful in upper ladder
- The majority of unsuccessful forays terminated at points either between the fish ladder entrance and the first bend, or between the points downstream and upstream of the counting window where the fish ladder transitions to a vertical slot configuration.

| Foray Type | No. Forays | Min | Max | Median | Mean |
|---|---|---|---|---|---|
| **Lower Fish Ladder** | | | | | |
| Successful | 52[a] | 0.1 | 97.3 | 1.1 | 4.1 |
| Unsuccessful | 84 | <0.1 | 152.9 | 0.3 | 5.8 |
| All | 136 | <0.1 | 152.9 | 0.8 | 5.2 |
| **Upper Fish Ladder** | | | | | |
| Successful | 52[a] | 0.5 | 93.5 | 1.4 | 4.8 |
| Unsuccessful | 19 | <0.1 | 64.2 | 4.4 | 13.0 |
| All | 71 | <0.1 | 93.5 | 1.7 | 7.0 |

a. Date-time of presence at the counting window was not recorded for one of the 53 that successfully passed.

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## Study 21 – American Shad Telemetry Study

### Post-Passage Upstream Migration and Return

- 65 radio-tagged shad were monitored upstream of Vernon dam.
  - 28% reached the Bellows Falls tailrace.
  - Median travel time from Vernon to the Bellows Falls tailrace was approximately 5.5 days.
- 91% returned to the Vernon forebay following a period of time upstream of the dam
  - The majority of return events occurred during June with minor peaks of return coinciding with peaks in the mean daily project discharge.

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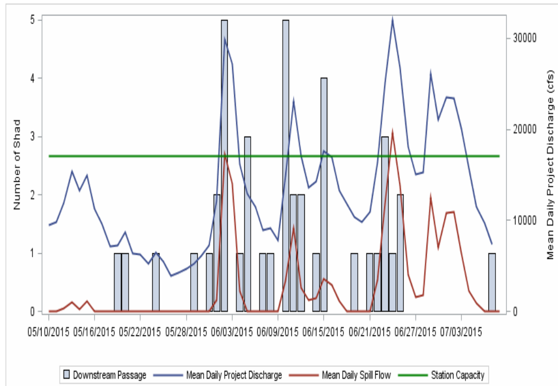
# Study 21 – American Shad Telemetry Study

## Study Results – Downstream Passage

- Median forebay residency times varied among individuals using different downstream passage routes
- Those with relatively short forebay residence times (i.e., ≤12 hrs) were generally associated with periods when flows exceeded maximum station generating capacity (during spill).

| Downstream Passage Route | Median Forebay Residency |
|---|---|
| Fish Pipe | 36m |
| Spill | 11h 56m |
| Units 5-8 | 17h 49m |
| Units 9-10 | 1d 4h 11m |
| Unknown | 1d 18h 53m |
| All | 11h 56m |

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# Study 21 – American Shad Telemetry Study

## Downstream Passage – Route Selection

| Final Disposition | Downstream Passage Route | Initial Report No. | Revised Report No. | Revised % of Number Passed |
|---|---|---|---|---|
| Did not return from upstream | - | 2 | 6 | - |
| Approached but did not pass | - | 10 | 7 | - |
| Mortality on trash racks | - | 9 | 9 | - |
| Excluded due to data conflicts | - | 0 | 1 | - |
| Passed downstream of Vernon | Turbine Units 1-4 | 7 | 0 | 0.0 |
| | Turbine Units 5-8 | 9 | 3 | 7.1 |
| | Turbine Units 9-10 | 3 | 2 | 4.8 |
| | Fish tube | 0 | 0 | 0.0 |
| | Fish pipe | 11 | 8 | 19.0 |
| | Spillway | 9 | 15 | 35.7 |
| | Unknown | 5 | 14 | 33.3 |
| Subtotal (approaching Vernon) | | 54 | 59 | - |
| Subtotal (passing Vernon) | | 44 | 42 | - |
| Total Released or Passed Upstream | | 65 | 65 | - |

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## Study 21 – American Shad Telemetry Study

**Migration Downstream of Vernon**

"Survival" through Vernon is potentially influenced by factors including: injury and mortality associated with dam passage, natural mortality (i.e., predation, post-spawn effects, and body condition), and incidental tag loss.

| Passage Route | No. Passing Vernon | Stebbins Island | | Northfield Mountain | | Turners Falls | |
|---|---|---|---|---|---|---|---|
| | | No. | Percent Detected (%) | No. | Percent Detected (%) | No. | Percent Detected (%) |
| Fish Pipe | 8 | 7 | 88 | 6 | 75 | 6 | 75 |
| Spill | 15 | 14 | 93 | 10 | 67 | 9 | 60 |
| Units 5-8 | 3 | 1 | 33 | 1 | 33 | 1 | 33 |
| Units 9-10 | 2 | 2 | 100 | 2 | 100 | 2 | 100 |
| Unknown | 14 | 9 | 64 | 6 | 43 | 5 | 36 |
| Total | 42 | 33 | 79 | 25 | 60 | 23 | 55 |

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## Study 21 – American Shad Telemetry Study

**Spawning Study Results – effort and catch**

- 60 sampling events and 120 individual ichthyoplankton net samples were collected on 30 nights (May 26 – July 2, 2015).
- Eggs were collected throughout the study area (DS of Bellows Falls to DS of Vernon) with concentrations in the riverine reaches.
- Higher gradient (tributary gravel/cobble bars) were observed to hold more shad during spawning and staging.
- 792 shad eggs and larvae were collected in 46 of 120 samples.
    - 774 (98%) were eggs
    - 9 (1%) were yolk sac larvae (YSL)
    - 9 (1%) were post yolk sac larvae (PYSL)

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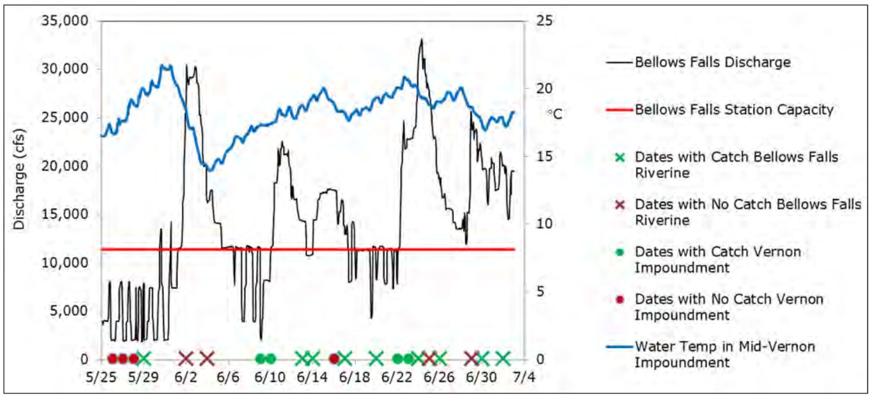
## Study 21 – American Shad Telemetry Study

Sampling and egg catch occurred over a range of station operating conditions and spill conditions

**Bellows Falls dam to Vernon dam**

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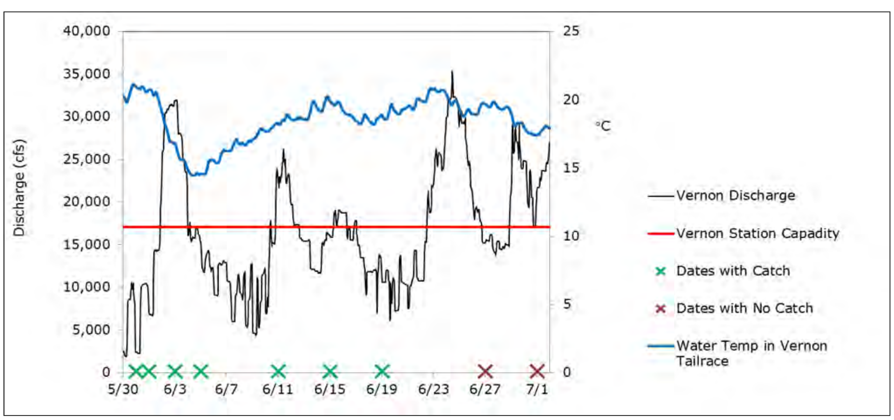
## Study 21 – American Shad Telemetry Study

**Vernon Riverine Reach**

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## Study 21 – American Shad Telemetry Study

**Spawning Study Results – ID of spawning locations**

Little splashing or active spawning behavior was observed so an alternative method was used which:

1. Determined developmental stage of eggs in lab

2. Utilized river velocity at time of egg collection (Stage 1 eggs only) and the estimated spawn time (based on available stage duration information for shad) to back-calculate an upstream distance to presumed general spawn areas

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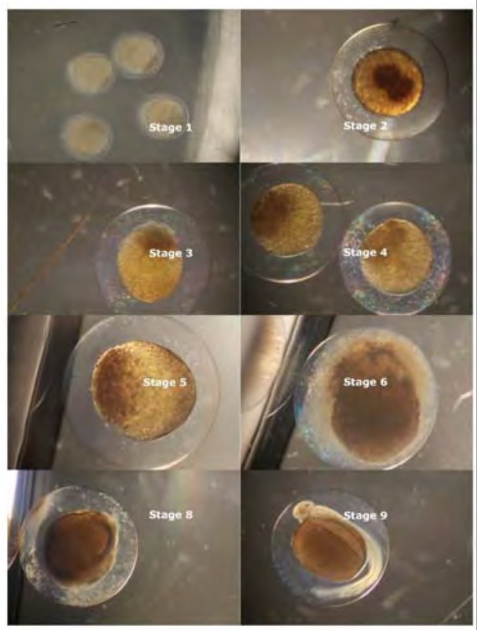
## Study 21 – American Shad Telemetry Study

| Developmental Stage | Description | Time Since Spawn (hrs) |
|---|---|---|
| 1 | Blastodisk | 0.5 |
| 2 | 2 cell stage | 1.5 |
| 3 | 4 cell stage | 2.0 |
| 4 | 8 cell stage | 2.5 |
| 5 | 16 cell stage | 3.0 |
| 6 | Morula | 4 - 6 |
| 7 | Blastopore | 6.0 |
| 8 | Early embryo | 38.0 |
| 9 | Detached tail embryo | 48.0 |

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## Study 21 – American Shad Telemetry Study

### Study Results - Spawning

- It was already assumed that American Shad used the area downstream of Vernon to spawn.
- This study provided the first concerted effort to identify unique spawning areas from Vernon tailwater upstream to Bellows Falls.
- 6 general locations were identified and included:
  - 3 within the Bellows Falls riverine reach:
    - Bellows Falls tailrace to downstream of Saxtons River
    - Cold River to upstream of Mad Brook
    - Vicinity of Mad Brook confluence
  - 2 within the Vernon impoundment:
    - Vicinity of Mill Brook confluence
    - Vicinity of Route 119 Bridge
  - The area downstream of Vernon dam to Stebbins Island

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## Study 21 – American Shad Telemetry Study

### Study Results - Spawning

| | Number of Individuals | | | | | |
|---|---|---|---|---|---|---|
| | Bellows Falls Riverine | | | Vernon Impoundment | | Vernon Riverine |
| Developmental Egg Stage | Tailrace - DS of Saxtons River | Cold River - US of Mad Brook | Mad Brook Area | Mill Brook Area | Rt 119 Bridge | Tailrace to Stebbins Island |
| Stage 1 | 269 | 23 | 8 | 2 | 1 | 305 |
| Stage 2 | 2 | 0 | 0 | 0 | 0 | 0 |
| Stage 3 | 50 | 2 | 0 | 0 | 0 | 3 |
| Stage 4 | 31 | 1 | 0 | 0 | 0 | 0 |
| Stage 5 | 0 | 0 | 13 | 0 | 0 | 0 |
| Stage 6 | 3 | 0 | 1 | 0 | 0 | 11 |
| Stage 7 | 0 | 1 | 0 | 0 | 0 | 3 |
| Stage 8 | 1 | 1 | 1 | 0 | 5 | 23 |
| Stage 9 | 0 | 0 | 0 | 0 | 0 | 13 |
| YSL | 0 | 2 | 0 | 0 | 0 | 6 |
| PYSL | 0 | 0 | 1 | 0 | 0 | 4 |
| Total | 356 | 30 | 24 | 2 | 6 | 368 |

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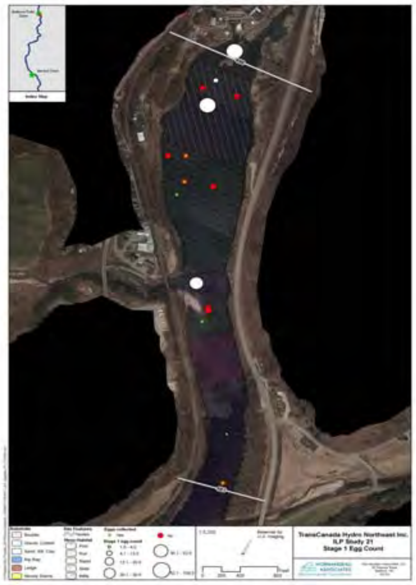
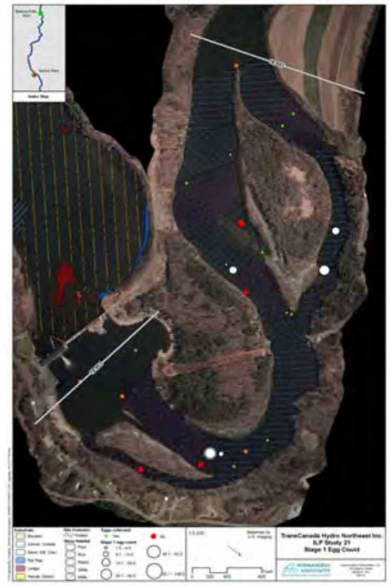
## Study 21 – American Shad Telemetry Study

Bellows Falls to Saxtons River



Vernon Riverine



## Study 21 – American Shad Telemetry Study

**Study Results - Spawning**

- Direct assessment of operational changes on actively spawning shad was not possible due to the lack of an observable response variable (i.e., if splash counts were to be used as a proxy for spawning activity, would need to have an established baseline of count frequency under a certain condition by which to compare other conditions).
- Therefore, potential impact of project effects on shad spawning was evaluated via modeled effects of project operations on mean channel velocity, channel width, and thalweg depth in the 6 identified spawning reaches.
- Minimum flow to spill flows (including flows at which back-calculated spawning occurred) were evaluated for each general spawning location.

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## Study 21 – American Shad Telemetry Study

**Study Results - Spawning**

- All 6 general spawning areas contained areas with adequate depth and velocity to support shad spawning.
- In no case did modeled thalweg depth drop below the literature reported range of water depths for shad spawning activity (i.e., 3-19 ft), even under minimum flow conditions.
- The difference in modeled wetted channel width decreased from 1 to 39% between the maximum discharges when spawning was observed, to minimum flow conditions
- Minimum flows at both projects typically occur less than 1% of the time during May and June so minimum wetted channel width estimate and related potential project effects is considered to be very conservative.

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# Study 22
# Downstream Migration of
# Juvenile American Shad - Vernon

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## Study 22 – Downstream Migration of Juvenile American Shad

### Study Report Revisions

Initial report filed 05/16/16, final report filed 02/28/17

- Reprocessed telemetry data for route selection.
- Additional data presentation per 10/31/16 response to comments and FERC 09/12/16 study plan determination.
- Turbine survival – minor clarifications per 08/15/16 response to comments.
- Hydroacoustics – no changes.

This presentation is limited to route selection only.

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## Study 22 – Route Selection Results

### Release, Approach, and Forebay Residence

- 310 radio-tagged juvenile shad were released in 15 groups from September 25 – October 30, 2015
- Approach duration ranged from 0.1 hours to 2.95 days (median=1.9 hours)
- 68% of individuals were present within the Vernon forebay within four hours following release
- Forebay residency time ranged from <0.1 hours to 9.9 days (median=0.7 hours) and forebay residency time was significantly longer for individuals that did not pass (median= 18.4 hours) relative to those that did pass (median=36 minutes)
- The highest median forebay residency time occurred during release 1 (39.5 hours) which was conducted on September 25 (report typo says Oct 3). The extended residency time indicates that fish spent a greater amount of time milling upstream of the project than later release groups. 38% of release group 1 that approached Vernon did not successfully pass the project.

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## Study 22 – Route Selection Results

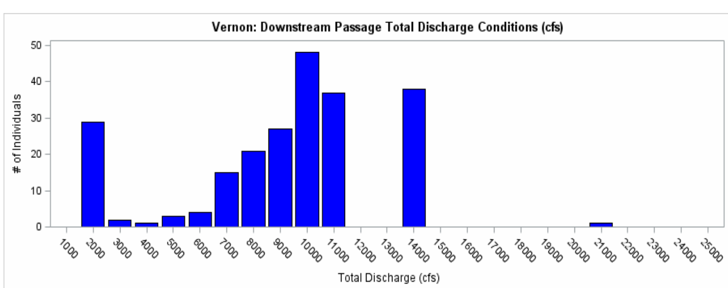
- 65% passed through turbines, 8.8% used downstream fish bypasses
- Nearly 25% passed via unknown routes since the pattern of detections needs to demonstrate a clear and definitive sequence to determine passage route – Forebay:Route:Tailrace – otherwise classified as unknown

| Passage Route | Initial Report No. | Revised Report No. | % of Total | % of those with Known Passage Route |
|---|---|---|---|---|
| Units 1-4 | 31 | 22 | 9.7 | 12.9 |
| Units 5-8 | 102 | 90 | 39.8 | 52.9 |
| Units 9-10 | 48 | 35 | 15.5 | 20.6 |
| Trash/Ice Sluice | 22 | 2 | 0.9 | 1.2 |
| Fish Pipe | 21 | 17 | 7.5 | 10 |
| Fish Tube | 5 | 1 | 0.4 | 0.6 |
| Fish Ladder | 1 | 2 | 0.9 | 1.2 |
| Attraction flow pipe | 3 | 0 | 0 | 0 |
| Spill | 0 | 1 | 0.4 | 0.6 |
| Unknown | 8 | 56 | 24.8 | n/a |
| Total | 241 | 226 | 100 | 100 |

83

## Study 22 – Route Selection Results

- Most juvenile shad passed during evening (17:00 – 22:00)
- 1 passed via the spillway during spill conditions
- 12.8% passed at approximate minimum flow
- 59% passed at flows between approximately 8,000 and 11,000 cfs
- Passage via the downstream route with the greatest proportion of flow at the time of passage occurred only 53.5% of the time.

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## Study 22 – Route Selection Results

**Downstream Detection after Passage**

- 70.4% of juvenile shad passing downstream of Vernon were subsequently detected at the Stebbins Island monitoring station

| Passage Route | No. Passing Vernon | No. Detected at Stebbins | % Detected at Stebbins Island |
|---|---|---|---|
| Units 5-8 | 90 | 68 | 75.6 |
| Units 9-10 | 35 | 23 | 65.7 |
| Units 1-4 | 22 | 13 | 59.1 |
| Fish Pipe | 17 | 14 | 82.4 |
| Fish Ladder | 2 | 0 | 0.0 |
| Trash/Ice Sluice | 2 | 0 | 0.0 |
| Fish Tube | 1 | 1 | 100.0 |
| Spill | 1 | 1 | 100.0 |
| Unknown | 56 | 39 | 69.6 |
| Total | 226 | 159 | 70.4 |

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## Study 22 – Route Selection Summary

### Summary

- 83.7% of juvenile shad detected in the forebay passed downstream .
- Residency time in the forebay was short (median=36 minutes) for passed fish, but longer for fish that did not pass (median =18.4 hours).
- The dominant route of passage was via the turbines (65% of all passed fish) with Units 5-8 being the primary turbine route (39.8%) of all passed fish, followed by Units 9-10 (15.5%), and Units 1-4 (9.7%).
- Individuals with known passage routes did not necessarily pass downstream via the route with the greatest proportion of total project discharge.
- 70.4% of juvenile shad passing downstream of Vernon were subsequently detected at the Stebbins Island monitoring station.
- Given these results, the Vernon project and its operations do not appear to limit the ability of juvenile shad to quickly locate downstream routes through the Vernon project.

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# Study 23
# Fish Impingement, Entrainment, and Survival Study



## Study 23 – Fish Impingement, Entrainment, and Survival

### Study Report Revisions

Initial report filed 05/16/16, final report filed 11/30/16, report supplement filed 02/28/17

- Revised blade strike calculations using multiple turbine discharges and efficiencies, per 08/15/16 response to comments.
- Revised total project survival estimates from reprocessed telemetry data for route selection – in report supplement filed 02/28/17.
- Minor corrections and clarifications to the initial report, per 08/15/16 response to comments.

This presentation is limited to substantive changes only.

## Study 23 – Fish Impingement, Entrainment, and Survival

### Results - Wilder

- Under typical full load (higher than the discharge at peak unit efficiency) for Unit Nos. 1 and 2, survival estimates ranged from:
  - 95 to 99 percent for small (4- to 8-inch) fish
  - 86 to 95 percent for 15-inch fish
  - 45 to 91 percent for 30-inch fish
- At Unit No. 3 under minimum flow only (because that is typical operation for the unit), survival estimates ranged from:
  - 72 to 93 percent for small (4- to 8-inch) fish
  - 47 to 73 percent for 15-inch fish
  - 0 to 47 percent for 30-inch fish

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## Study 23 – Fish Impingement, Entrainment, and Survival

### Results – Bellows Falls

- Blade strike potential and estimated survival rates were calculated for the 3 vertical Francis units at maximum unit discharge, at peak unit efficiency, and at minimum flow.
- Under all scenarios, survival estimates ranged from:
  - 87 to 97 percent for small (4- to 8-inch) fish
  - 52 to 88 percent for larger (15- and 30-inch) fish

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## Study 23 – Fish Impingement, Entrainment, and Survival

### Results – Vernon

- Blade strike potential and estimated survival rates were calculated at maximum unit discharge, at peak unit efficiency, and at minimum flow (Unit Nos. 5–8 and No. 10 only, since those are the units used for minimum flow).
- Under all scenarios for the Kaplan turbine Units 5-8, survival estimates ranged from:
  - 78 to 98 percent for small (4- to 8-inch) fish
  - 59 to 83 percent for 15-inch fish
  - 18 to 86 percent for 30-inch fish
- Survival estimates for the Francis turbine Units 1-4, 9-10 ranged from:
  - 80 to 96 percent for small (4- to 8-inch)
  - 62 to 85 percent for 15-inch fish
  - 24 to 71 percent for 30-inch fish

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## Study 23 – Fish Impingement, Entrainment, and Survival

### Total Project Survival

- "Estimate total project survival considering all passage routes".
- Revised analysis is included in the report supplement filed 02/28/17.

**NOTES**:

- Radio-tagged fish were not intended to inform on project survival in Studies 19, 21, or 22.
- Estimates of survival based on radio telemetry are for general comparison purposes with calculated Franke survival estimates and HI-Z direct turbine testing and survival data from Studies 19 and 22, and to provide a proxy for survival through non-turbine passage routes.
- Survival estimates from telemetry data are calculated as the proportion of radio-tagged fish detected at the next downstream project (or at Stebbins Island for Vernon) relative to the number of radio-tagged fish detected passing the project.
- Survival estimates based on radio telemetry must be considered conservative.

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## Study 23 – Fish Impingement, Entrainment, and Survival

### Total Project Survival - Eels

**Wilder:** Telemetry alone estimate = 59.6%
Applying both the HI-Z tag and Franke turbine survival estimates to the proportion of eels passing via turbines along with the telemetry estimates for non-turbine routes, total project survival ranges from 44.1% to 76.4%.

Franke formula calculated at typical full load for Units 1-2, and at minimum flow for Unit 3. Results are similar at other discharges/efficiencies.

| Passage Route | No. | Proportion | Estimated and Predicted Survival Rates (%) | | |
|---|---|---|---|---|---|
| | | | HI-Z (48-hr) | Conservative Radio Telemetry - Estimate | Franke Formula (30-inch fish) |
| Unit 1 - 2 | 33 | .702 | 62.0 | 66.7 | 44.6 – 90.6 |
| Unit 3 | 7 | .149 | n/a | 28.6 | 0.0 – 46.9 |
| Trash/ice sluice | 2 | .043 | n/a | 50.0 | n/a |
| Unknown | 5 | .106 | n/a | 60.0 | n/a |
| Total | 47 | 1.0 | | 59.6 | |

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## Study 23 – Fish Impingement, Entrainment, and Survival

### Total Project Survival - Eels

**Bellows Falls:** Telemetry alone estimate = 75.0%

Applying both the HI-Z tag and Franke turbine survival estimates to the proportion of eels passing via turbines along with the telemetry estimates for non-turbine routes, total project survival ranges from 57.8% to 93.2%.

Franke formula calculated at typical full load (min flow and max discharge are slightly lower).

| Passage Route | No. | Proportion | Estimated and Predicted Survival Rates (%) | | |
|---|---|---|---|---|---|
| | | | HI-Z (48-hr) | Conservative Radio Telemetry - Estimate | Franke Formula (30-inch fish) |
| Units 1-3 | 77 | 0.802 | 98.0 | 75.3 | 53.9 – 77.0 |
| Trash/ice sluice | 13 | 0.135 | n/a | 76.9 | n/a |
| Spillway | 6 | 0.063 | n/a | 66.7 | n/a |
| Unknown | 0 | 0 | n/a | n/a | n/a |
| Total | 96 | 1.0 | | 75.0 | |

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## Study 23 – Fish Impingement, Entrainment, and Survival

### Total Project Survival - Eels

**Vernon:** Telemetry alone estimate = 89.3%
Applying both the HI-Z tag and Franke turbine survival estimates to the proportion of eels passing via turbines along with the telemetry estimates for non-turbine routes, total project survival ranges from 39.9% to 88.7%.

Franke formula calculated at typical turbine operating conditions: max discharge/peak efficiency for Units 1-4, max discharge for Units 5-8, and at minimum flow for Units 9-10.

| Passage Route | No. | Proportion | Estimated and Predicted Survival Rates (%) | | |
|---|---|---|---|---|---|
| | | | HI-Z (48-hr) | Conservative Radio Telemetry - Estimate | Franke Formula (30-inch fish) |
| Units 1-4 | 14 | .125 | 93.5 | 92.9 | 24.4 – 65.1 |
| Units 5-8 | 53 | .473 | 80.8 | 84.9 | 17.4 – 82.4 |
| Units 9-10 | 26 | .232 | 97.9 | 92.3 | 53.8 – 76.9 |
| Fish pipe | 4 | .036 | n/a | 100.0 | n/a |
| Fish tube | 1 | .009 | n/a | 100.0 | n/a |
| Trash/ice sluice | 2 | .018 | n/a | 100.0 | n/a |
| Fish ladder | 1 | .009 | n/a | 100.0 | n/a |
| Unknown | 11 | .098 | n/a | 90.9 | n/a |
| Total | 43 | 1.0 | | 89.3 | |

## Study 23 – Fish Impingement, Entrainment, and Survival

### Total Project Survival – Adult Shad

**Vernon:** Telemetry alone estimate = 78.6% based on detections at Stebbins Island, 59.5% at NMPS, and 54.8% at Turners Falls.

Applying Franke turbine survival estimates to the proportion of adult shad passing via turbines along with telemetry estimates for non-turbine routes, total project survival is:
- 79.3 to 82.2% at Stebbins Island
- 60.2 to 63.1% at Northfield Mountain
- 55.5 to 58.3% at Turners Falls

Franke formula calculated at typical turbine operating conditions

| Passage Route | No. | Proportion | Estimated and Predicted Survival Rates | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | Franke Formula (15-inch fish) | Stebbins Island | | Northfield Mountain | | Turners Falls | |
| | | | | No. | Survival Rate (%) | No. | Survival Rate (%) | No. | Survival Rate (%) |
| Units 1-4 | 0 | 0 | 62.2–82.6 | 0 | n/a | 0 | n/a | 0 | n/a |
| Units 5-8 | 3 | 0.071 | 58.7-91.2 | 1 | 33.3 | 1 | 33.3 | 1 | 33.3 |
| Units 9-10 | 2 | 0.048 | 76.9-88.5 | 2 | 100 | 2 | 100.0 | 2 | 100.0 |
| Fish Pipe | 8 | 0.190 | n/a | 7 | 87.5 | 6 | 75.0 | 6 | 75.0 |
| Spill | 15 | 0.357 | n/a | 14 | 93.3 | 10 | 66.7 | 9 | 60.0 |
| Unknown | 14 | 0.333 | n/a | 9 | 64.3 | 6 | 42.9 | 5 | 35.7 |
| Total | 42 | 1.0 | n/a | 33 | 78.6 | 25 | 59.5 | 23 | 54.8 |

## Study 23 – Fish Impingement, Entrainment, and Survival

### Total Project Survival – Juvenile Shad

**Vernon:** Telemetry alone estimate = 70.4%

Applying both the HI-Z tag and Franke turbine survival estimates to the proportion of juvenile shad passing via turbines along with telemetry estimates for non-turbine routes, total project survival ranges from 83.1% to 87.5%.

Franke formula calculated at typical turbine operating conditions.

| Passage Route | No. | Proportion | Estimated and Predicted Survival Rates (%) | | |
|---|---|---|---|---|---|
| | | | HI-Z (1-hr) | Conservative Radio Telemetry - Estimate | Franke Formula (4-inch fish)[a] |
| Units 1-4 | 22 | 0.097 | 91.7 | 59.1 | 89.9 – 95.4 |
| Units 5-8 | 90 | 0.398 | 95.2 | 75.6 | 89.0 – 97.7 |
| Units 9-10 | 35 | 0.155 | 94.7 | 65.7 | 93.8 – 96.9 |
| Fish Pipe | 17 | 0.075 | n/a | 82.4 | n/a |
| Fish Tube | 1 | 0.004 | n/a | 100 | n/a |
| Trash/Ice Sluice | 2 | 0.009 | n/a | 0 | n/a |
| Fish Ladder | 2 | 0.009 | n/a | 0 | n/a |
| Spill | 1 | 0.004 | n/a | 100 | n/a |
| Unknown | 56 | 0.248 | n/a | 69.6 | n/a |
| Total | 226 | 1.000 | | 70.4 | |

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# Lunch

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## Studies 2 and 3

**Riverbank Transect Study**
**Riverbank Erosion Study**

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## Studies 2 and 3 – Riverbank Transect and Riverbank Erosion

**How does erosion occur?**
**Where and how much erosion is occurring?**
**What is the rate of erosion?**
**How has erosion changed through time?**
**What are the causes of erosion?**

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## Studies 2 and 3 – Riverbank Transect and Riverbank Erosion

### How does erosion occur?

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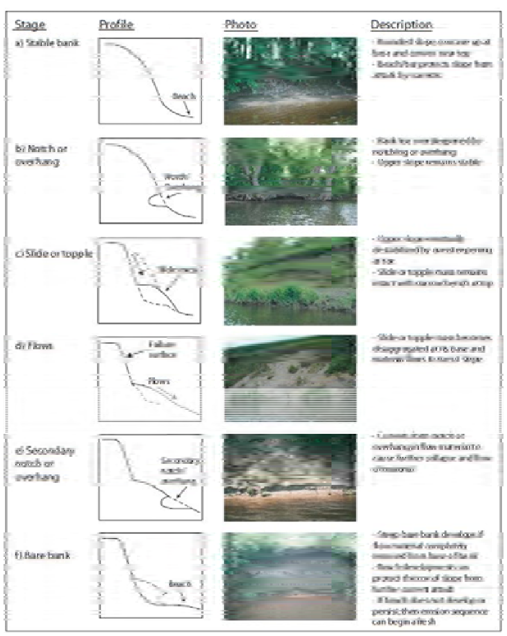
## Study 3 – Riverbank Erosion Study

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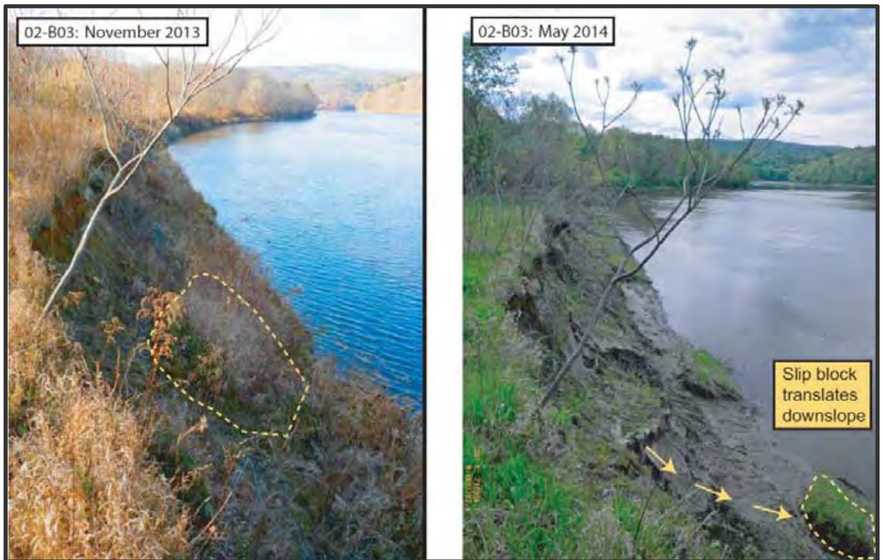
## Study 2 –Riverbank Transect Study

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## Studies 2 and 3 – Riverbank Transect and Riverbank Erosion

**Where and how much erosion is occurring?**

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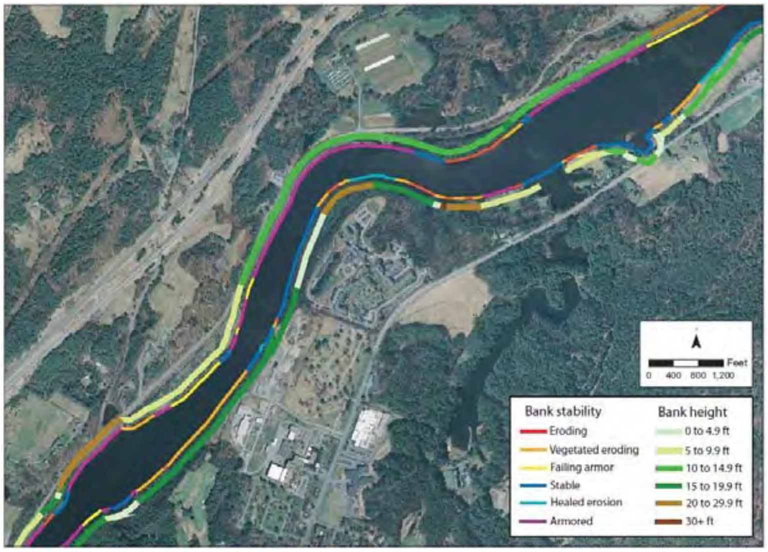
## Study 3 – Riverbank Erosion Study

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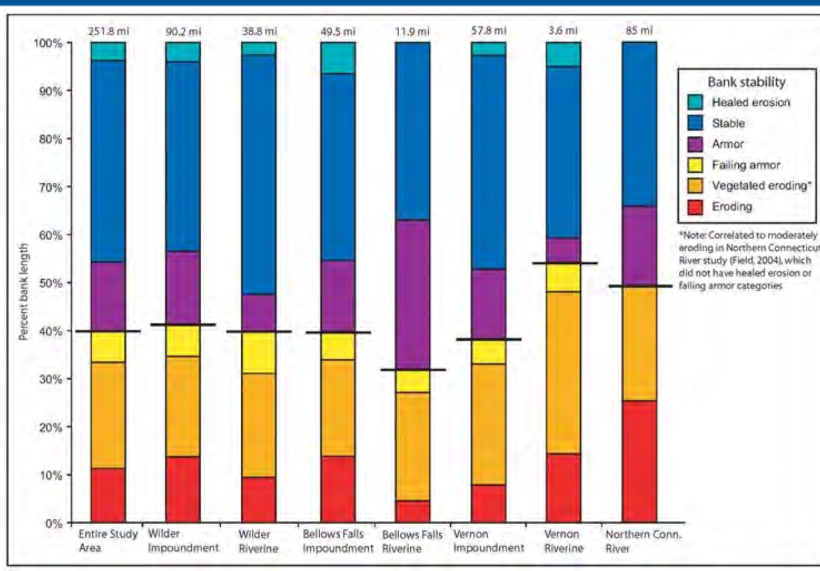
**Erosion locations can be compared to other conditions like bank height**

105

## Study 3 – Riverbank Erosion Study

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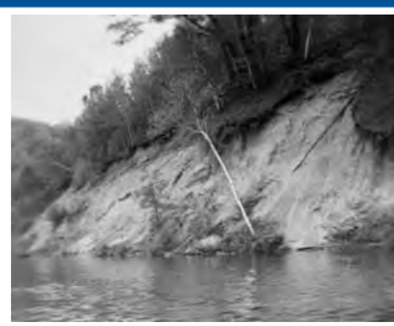
**Levels of unstable banks similar among study reaches and also elsewhere on the CT River with limited dam control**

## Study 3 – Riverbank Erosion Study

## Study 3 – Riverbank Erosion Study




## Studies 2 and 3 – Riverbank Transect and Riverbank Erosion

### What is the rate of erosion?

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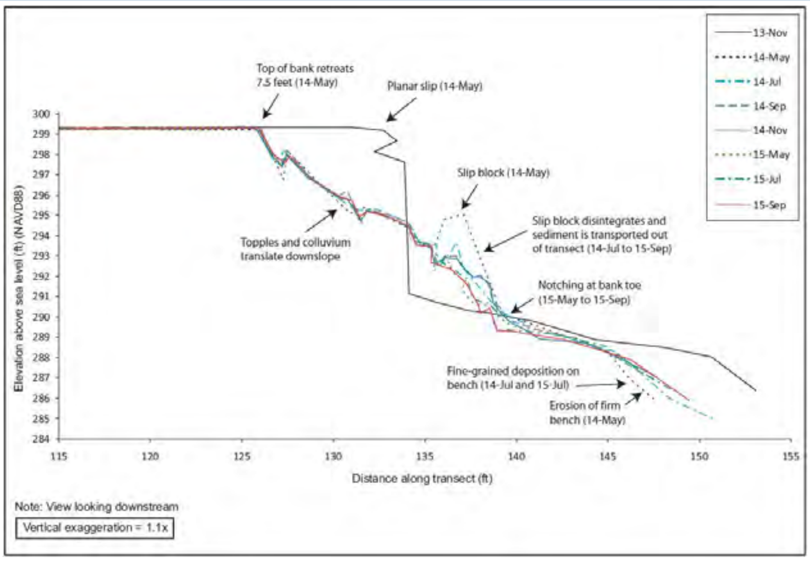
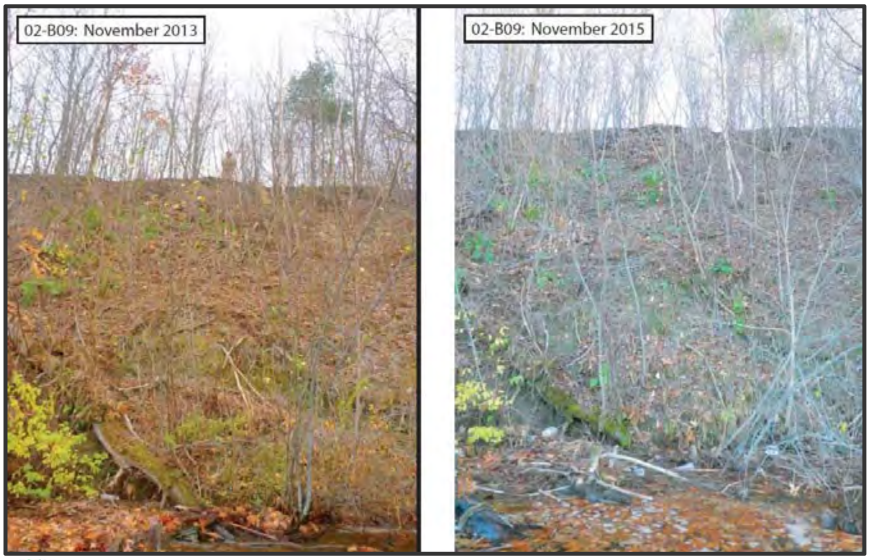
## Study 2 –Riverbank Transect Study



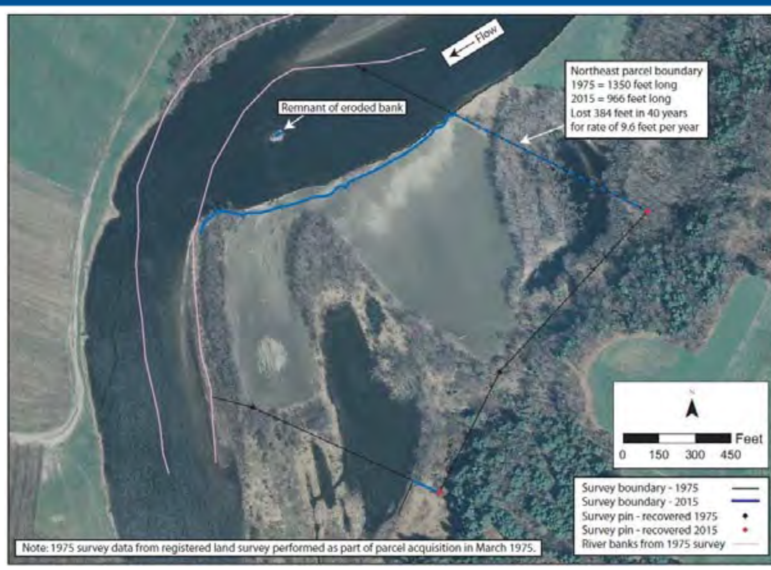

TransCanada Site 02-B07 Charlestown, NH (Charlestown Site) 110

## Study 2 –Riverbank Transect Study



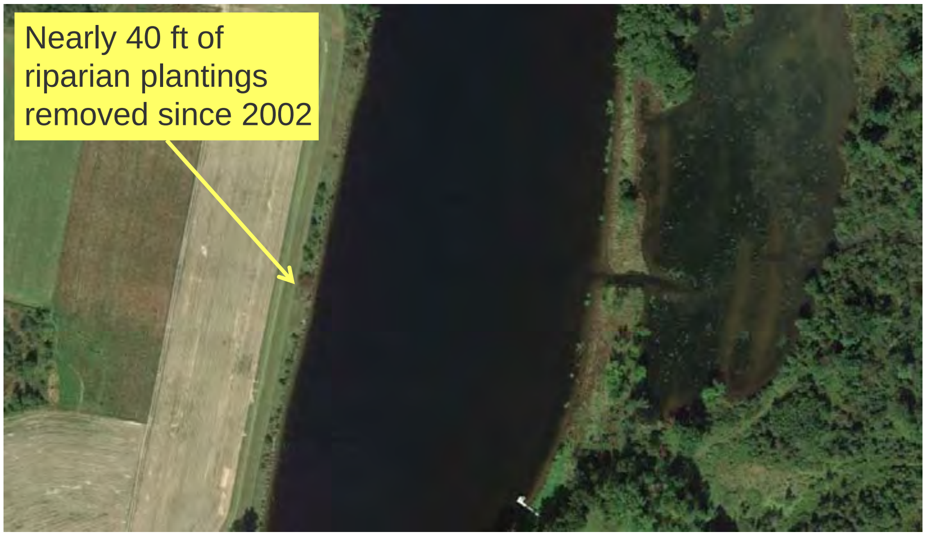

TransCanada Site 02-B09 North Walpole site 111

## Study 3 – Riverbank Erosion Study



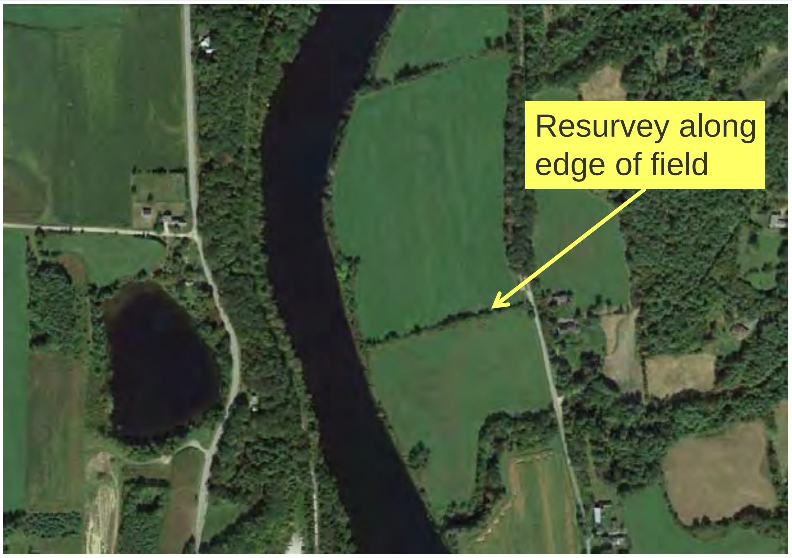

TransCanada **Just upstream of that meander, study monitoring indicates erosion rate of 9.6 ft/yr between 1975 and 2015 (Lewis site)**

## Study 3 – Riverbank Erosion Study




TransCanada **Erosion rate = 3 ft/yr, Fairlee VT** 113

## Study 3 – Riverbank Erosion Study




TransCanada **Erosion rate was 0.9 ft/yr from 1961-1989, and only 0.3 ft/yr since, at Site 02-W09 Lyme, NH (Mudge Site)**

## Studies 2 and 3 – Riverbank Transect and Riverbank Erosion

**How has erosion changed through time?**

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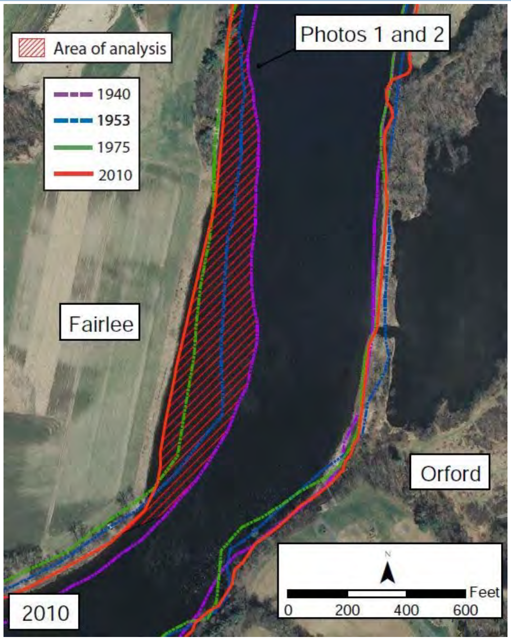
## Study 1 – Historical Riverbank Position and Erosion Study

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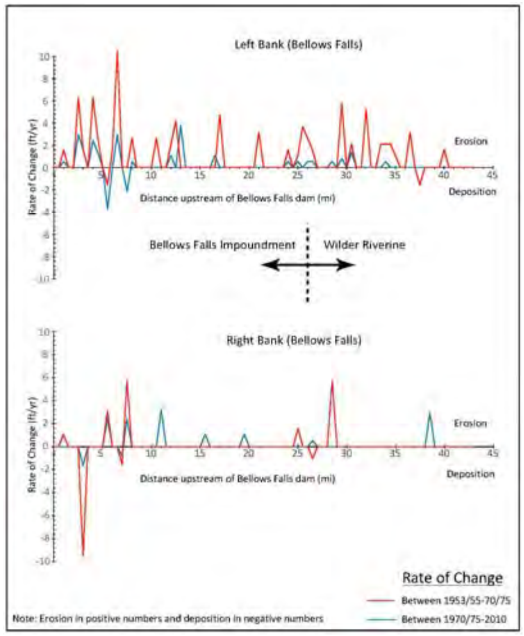
## Study 1 – Historical Riverbank Position and Erosion Study

**Changes in erosion over time with distance upstream from Bellows Falls dam**

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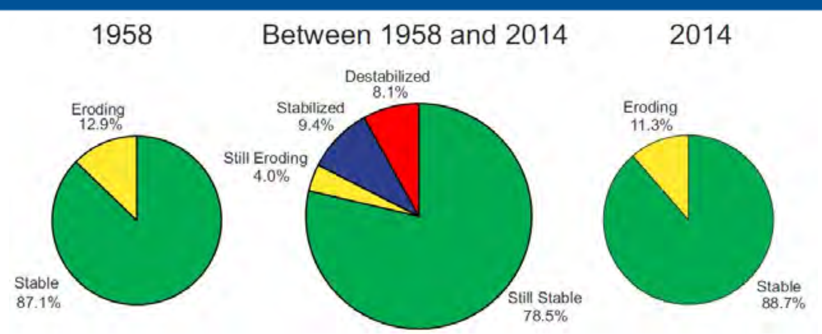
## Study 3 – Riverbank Erosion Study




Vegetated eroding bank

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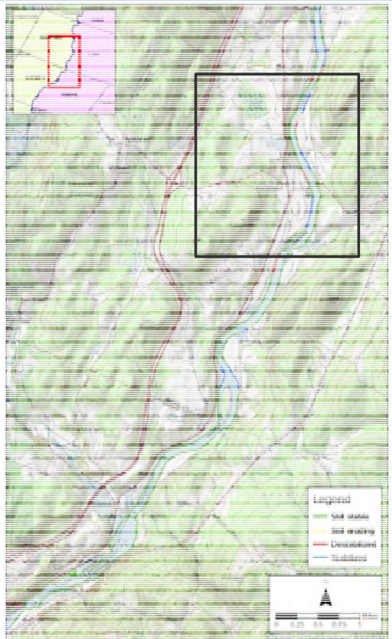
## Study 3 – Riverbank Erosion Study



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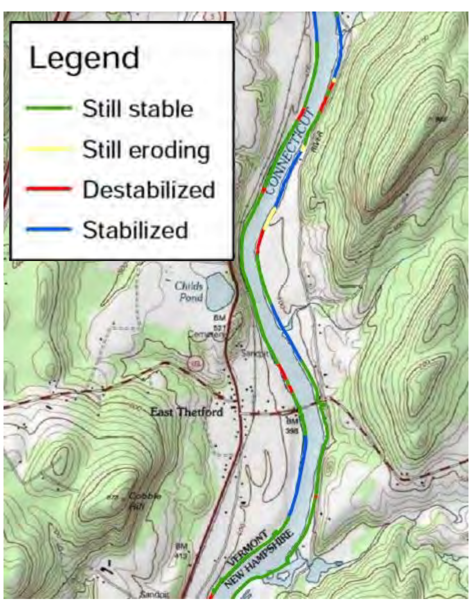
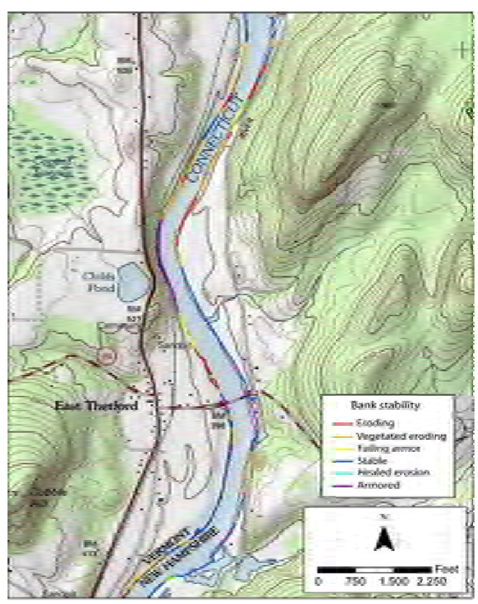
## Study 3 – Riverbank Erosion Study



## Study 3 – Riverbank Erosion Study

| Study Reach | Time period | Bank Length (miles) | Still Stable (miles) | % | Still Eroding (miles) | % | Stabilized (miles) | % | Destabilized (miles) | % |
|---|---|---|---|---|---|---|---|---|---|---|
| Entire Study Area | 1958 to 2014 | 210.2 | 164.9 | 78.5 | 8.3 | 4.0 | 19.8 | 9.4 | 17.1 | 8.1 |
| | 1958 to 1978 | 217.4 | 162.9 | 74.9 | 5.8 | 2.7 | 22.4 | 10.3 | 26.3 | 12.1 |
| | 1978 to 2014 | 210.0 | 159.8 | 76.1 | 7.4 | 3.5 | 24.8 | 11.8 | 18.0 | 8.6 |
| Wilder Impoundment | 1958 to 2014 | 90.3 | 74.8 | 82.9 | 1.8 | 2.0 | 3.0 | 3.4 | 10.6 | 11.8 |
| | 1958 to 1978 | 93.5 | 72.7 | 77.8 | 1.2 | 1.3 | 3.6 | 3.8 | 15.9 | 17.1 |
| | 1978 to 2014 | 90.2 | 65.3 | 72.4 | 4.7 | 5.2 | 12.5 | 13.9 | 7.6 | 8.4 |
| Wilder Riverine | 1958 to 2014 | 5.5 | 3.6 | 65.5 | 0.1 | 2.1 | 0.8 | 14.8 | 1.0 | 17.5 |
| | 1958 to 1978 | 5.5 | 4.3 | 78.1 | 0.0 | 0.0 | 0.9 | 17.0 | 0.3 | 4.9 |
| | 1978 to 2014 | 5.5 | 4.3 | 77.9 | 0.2 | 3.3 | 0.1 | 1.6 | 1.0 | 17.1 |
| Bellows Falls Impoundment | 1958 to 2014 | 49.8 | 32.6 | 65.5 | 4.8 | 9.6 | 10.0 | 20.1 | 2.4 | 4.8 |
| | 1958 to 1978 | 51.1 | 34.0 | 66.4 | 1.4 | 2.8 | 13.4 | 26.2 | 2.4 | 4.6 |
| | 1978 to 2014 | 49.5 | 40.0 | 80.8 | 1.2 | 2.4 | 2.6 | 5.3 | 5.7 | 11.5 |
| Bellows Falls Riverine | 1958 to 2014 | 7.0 | 5.7 | 80.2 | 0.1 | 1.7 | 0.8 | 11.8 | 0.4 | 6.3 |
| | 1958 to 1978 | 8.0 | 6.5 | 80.5 | 0.6 | 7.1 | 0.4 | 4.8 | 0.6 | 7.7 |
| | 1978 to 2014 | 7.1 | 5.4 | 76.4 | 0.1 | 1.2 | 1.1 | 15.6 | 0.5 | 6.8 |
| Vernon Impoundment | 1958 to 2014 | 57.8 | 48.2 | 83.4 | 1.6 | 2.7 | 5.1 | 8.9 | 2.9 | 5.0 |
| | 1958 to 1978 | 60.3 | 46.5 | 77.1 | 2.6 | 4.3 | 4.1 | 6.8 | 7.1 | 11.8 |
| | 1978 to 2014 | 57.7 | 44.8 | 77.5 | 1.3 | 2.2 | 8.4 | 14.6 | 3.3 | 5.7 |

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## Studies 2 and 3 – Riverbank Transect and Riverbank Erosion

### What are the causes of erosion?

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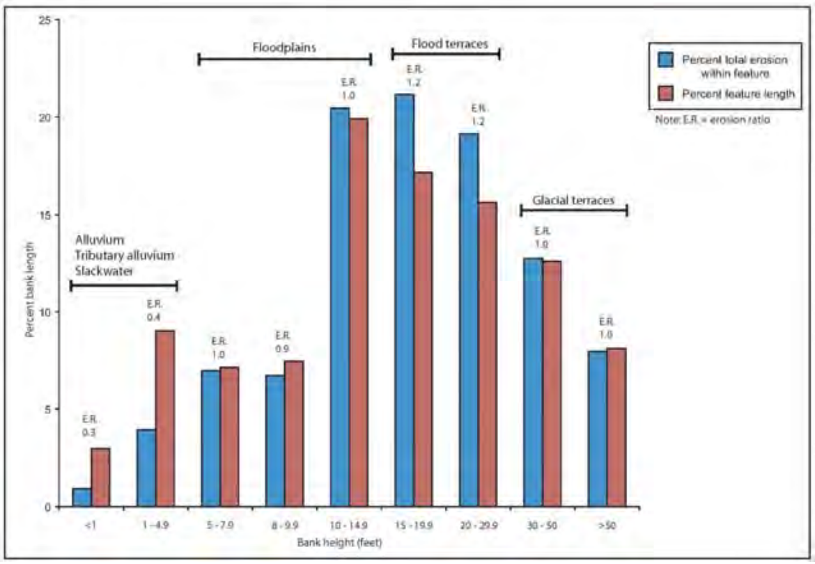
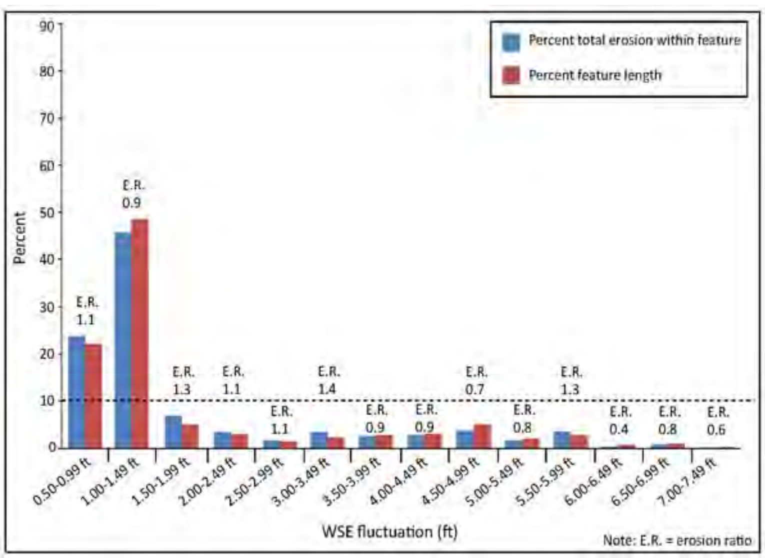
## Study 3 – Riverbank Erosion Study




TransCanada Erosion ratios by bank height

123

## Study 3 – Riverbank Erosion Study




TransCanada % erosion and erosion ratio by water level fluctuation across the entire study area

## Study 3 – Riverbank Erosion Study

**Selected comments regarding erosion ratio and causation study**

- Erosion ratio vs distance from dam does not show how WSE range varies with distance
- Erosion ratio not accepted scientific approach
- Analysis needed of erosion relative to shear stress

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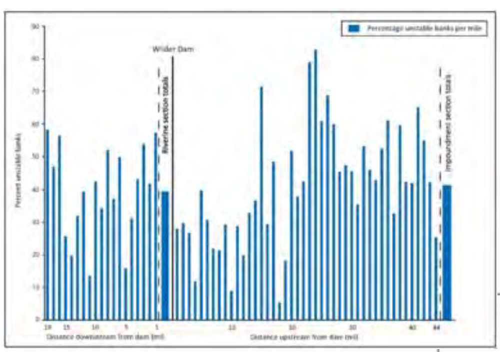
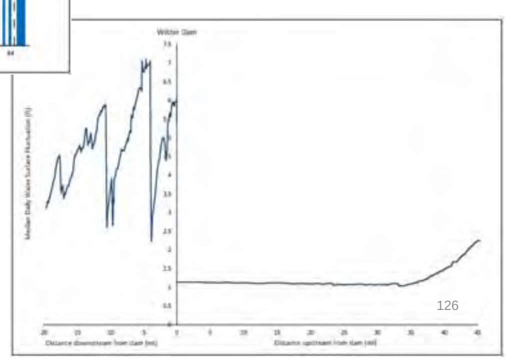
## Study 3 – Riverbank Erosion Study

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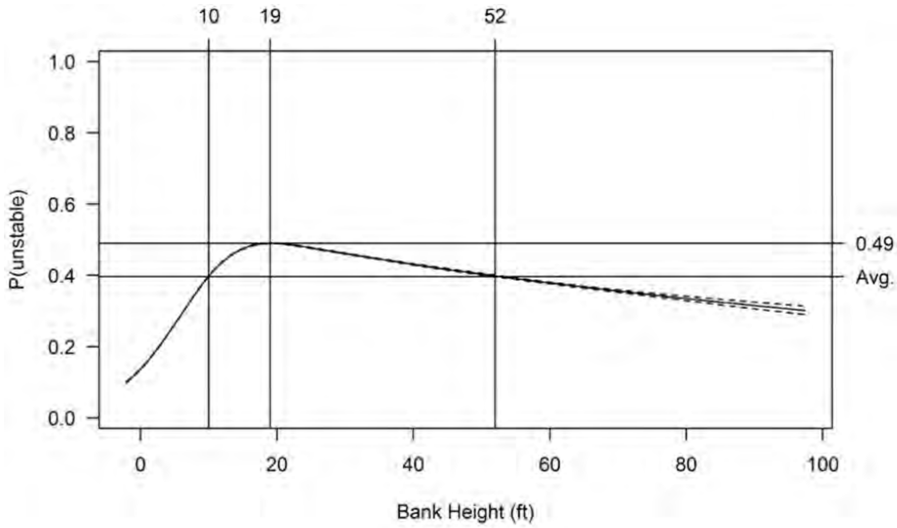
## Study 3 – Riverbank Erosion Study

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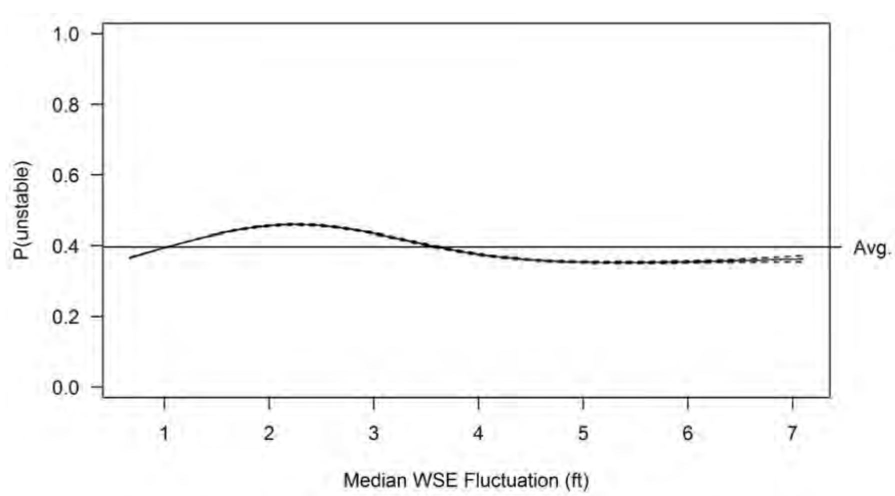
## Study 3 – Riverbank Erosion Study

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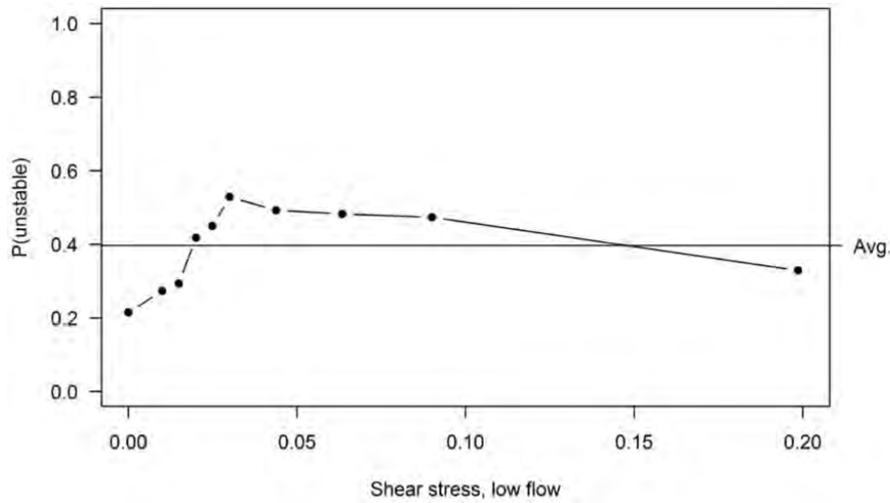
## Study 3 – Riverbank Erosion Study

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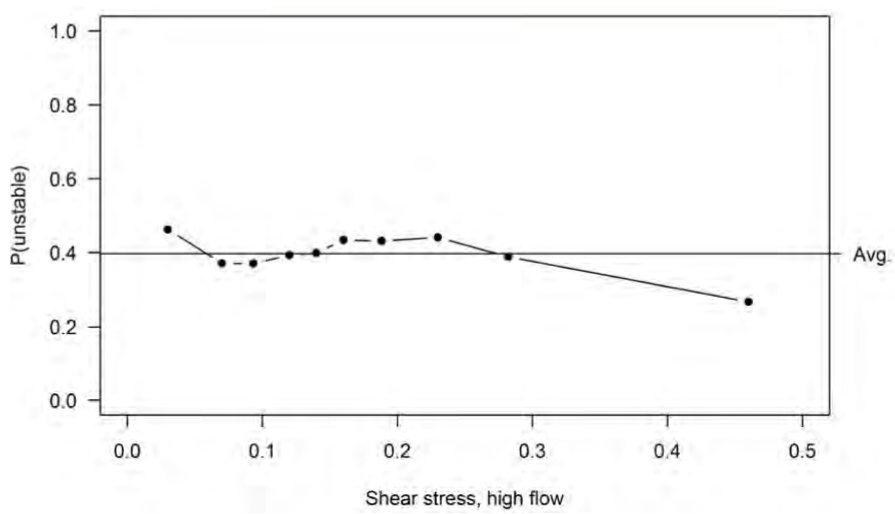
## Study 3 – Riverbank Erosion Study

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## Study 3 – Riverbank Erosion Study

| Model | % deviance explained |
|---|---|
| (intercept) | NA |
| Bank height (bins) | 3.525 |
| Shear stress, low flow (bins) | 3.337 |
| Fluctuation (bins) | 1.133 |
| Shear stress, high flow (bins) | 0.893 |
| Armored | 0.683 |
| Bend geometry | 0.243 |
| Project | 0.089 |
| Forested | 0.029 |

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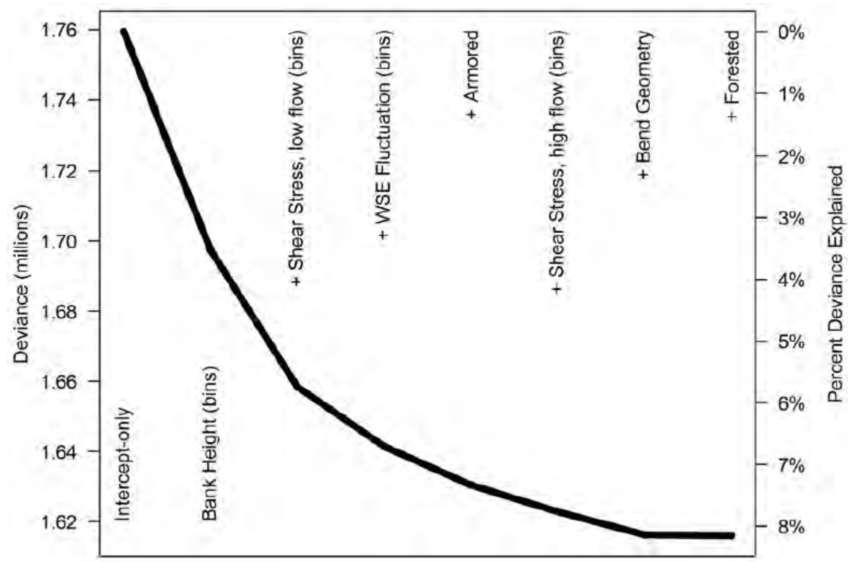
## Study 3 – Riverbank Erosion Study

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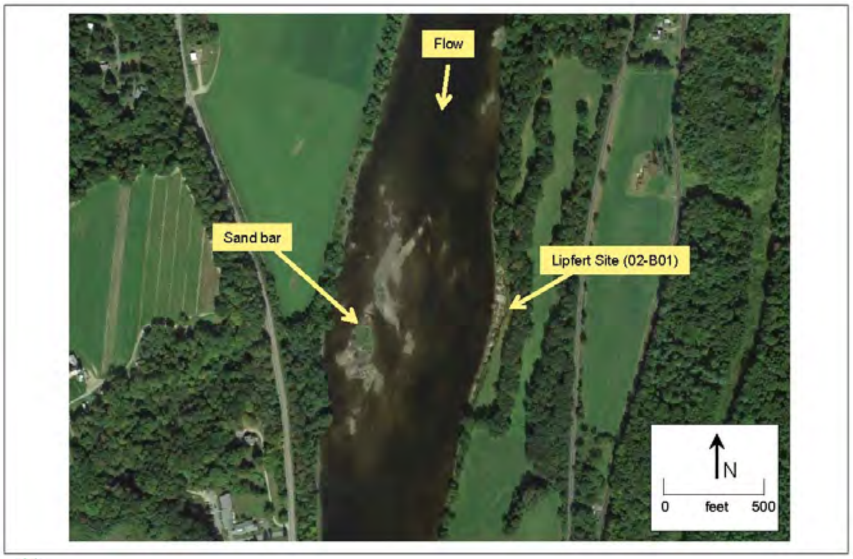
## Study 2 –Riverbank Transect Study

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**Flow deflection around sandbar toward bank at Lipfert Site (02-B01) may be a cause of erosion**

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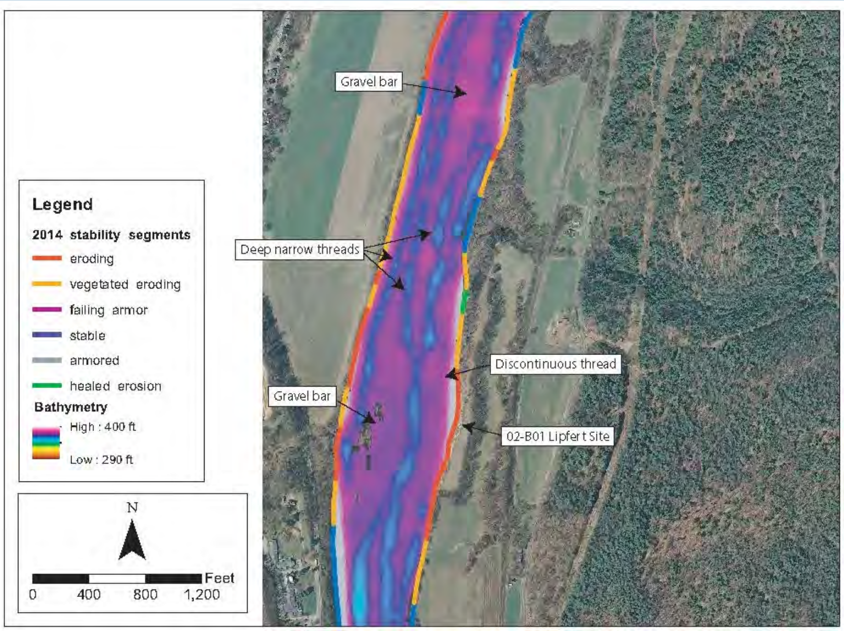
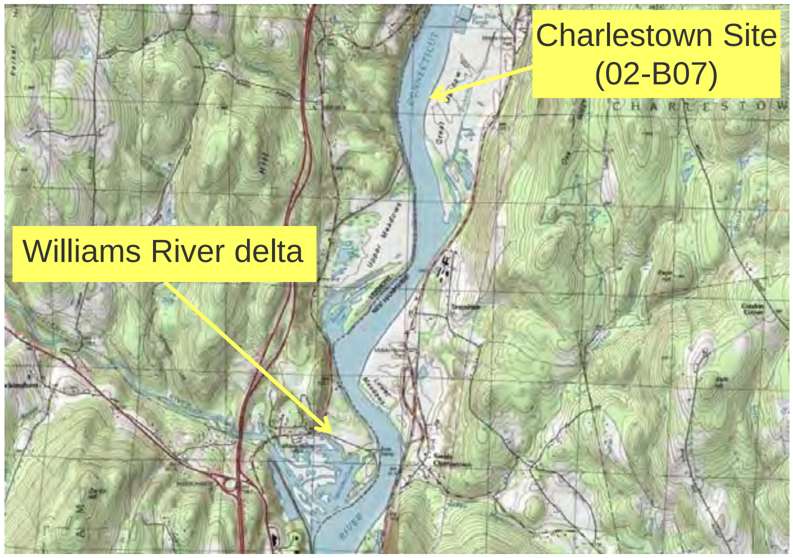
## Study 2 –Riverbank Transect Study



## Study 2 –Riverbank Transect Study

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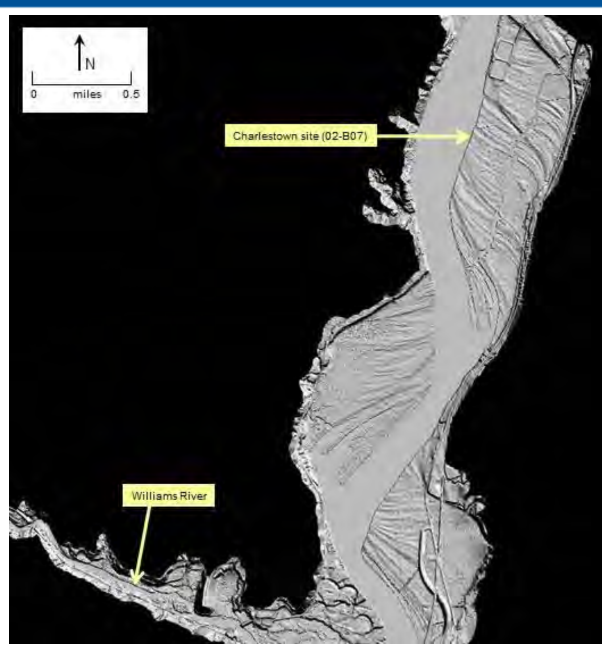
**…backwatering upstream of Williams River delta** 135

## Study 2 –Riverbank Transect Study

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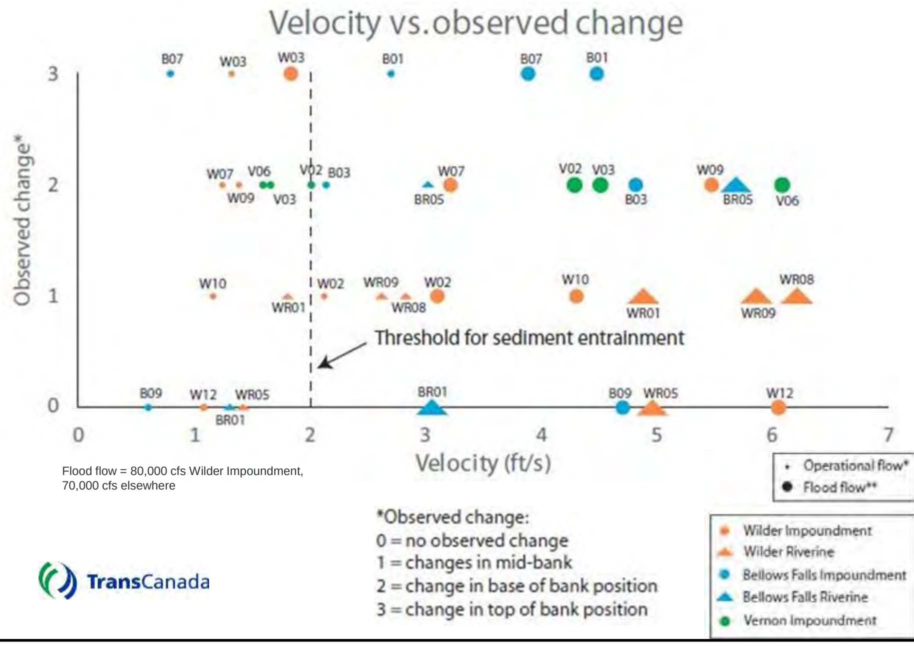
## Study 2 –Riverbank Transect Study

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## Studies 2 and 3 – Riverbank Transect and Riverbank Erosion

### Study Conclusions

Project operations contribute to erosion (one process forming notches and overhangs), but are not a major cause since:

- The levels of erosion are similar to free-flowing reaches
- The levels of erosion vary significantly with distance from dams while WSE fluctuation range remains largely constant
- Erosion levels are largely same between projects despite variations in WSE fluctuation range
- Flow velocities during normal project operations are largely insufficient to remove sediment accumulating at base of bank
- Rates and amount of erosion have varied throughout study area with little change in the WSE fluctuation range

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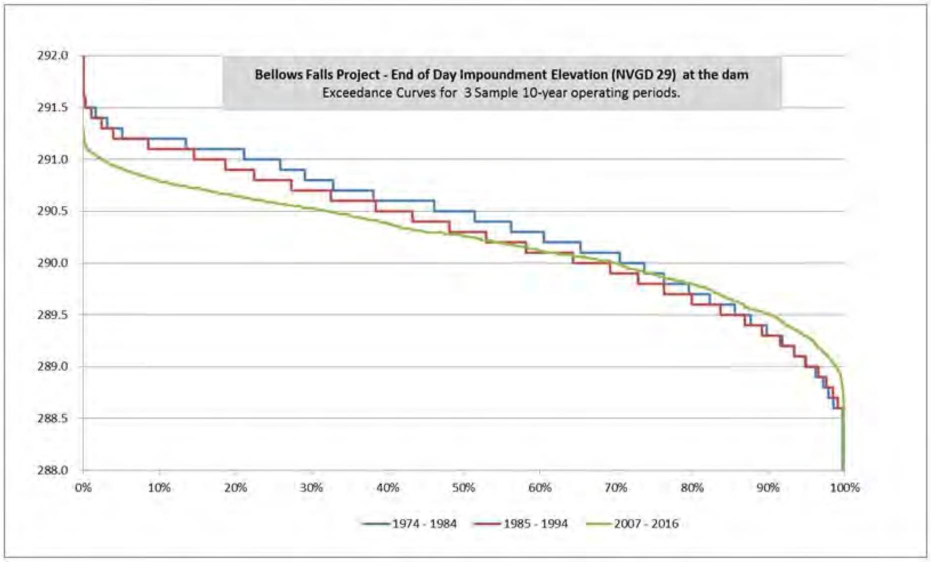
## Studies 2 and 3 – Riverbank Transect and Riverbank Erosion

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## Studies 2 and 3 – Riverbank Transect and Riverbank Erosion

**Questions?**

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# Break

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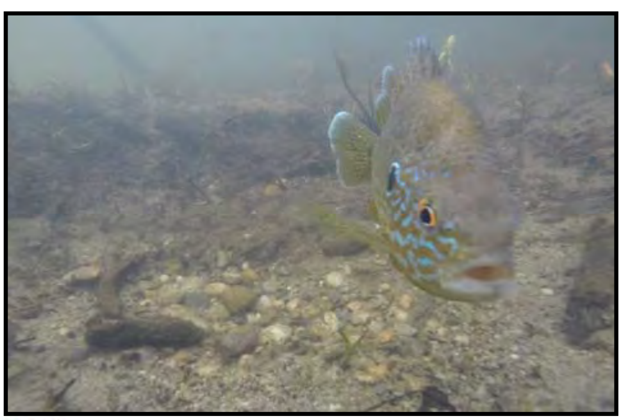
# Studies 14 and 15
# Resident Fish Spawning Studies



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## Study 14 & 15 – Resident Fish Spawning

### Recap – Resident Fish Spawning (Studies 14 & 15)

1. Draft Report filed on March 1, 2016
2. Results presented at the March 18, 2016 meeting
3. Verbal comments received at meeting and written comments received were responded to on May 31, 2016 and incorporated into the Final Report filed on August 1, 2016
4. Operations modeling results presented at August 24th, 2016 meeting
5. Written comments on Final Report received by September 30, 2016 were responded to on October 31, 2016
6. Revised Final Report filed November 30, 2016
7. This presentation highlights changes made in the Revised Final Report in response to comments

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## Study 14 & 15 – Resident Fish Spawning

### Revised Final Report Revisions

1. Treatment of egg incubation time assessments for Yellow Perch
   - Removed May 15th truncation of incubation periodicity
   - Recalculated % egg mortality (changed from mean of study site %'s to overall %)
     - *Estimate increased from 56% to 71%*
2. Treatment of Smallmouth Bass fry residence time
   - Fry residence times extended to 26 days

### Assessment of project effects based on modeling

This assessment was presented at the August 2016 meeting, and not revised in this report

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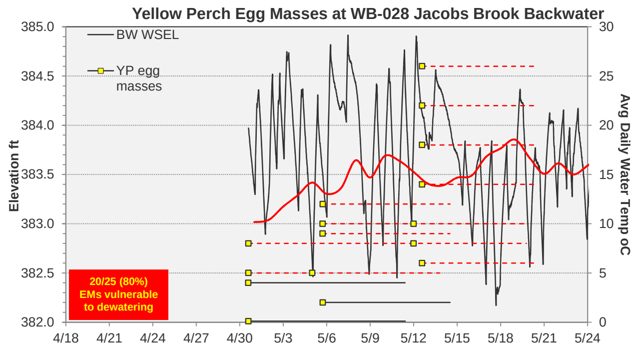
## Study 14 & 15 – Resident Fish Spawning

### 1. Treatment of Yellow Perch incubation assessment

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## Study 14 & 15 – Resident Fish Spawning

### 1. Treatment of Yellow Perch incubation assessment

| Impoundment | Study Site | Site Name | # Yellow Perch Egg Masses | Estimated # Exposed in 2015 | % Exposed | # EMs Truncated |
|---|---|---|---|---|---|---|
| Wilder | 14-WB-012 | Oxbow | 9 | N/A[1] | - | - |
| | 14-WB-016 | Waits BW | 13 | 11 | 85% | 0 |
| | 14-WB-028 | Jacobs BW | 25 | 20 | 80% | 7 (+4) |
| | 14-WB-032 | unnamed | 23 | 14 | 61% | 0 |
| | 14-WB-051 | Zebedee BW | 12 | 10 | 83% | 1 (+0) |
| | 14-WB-060 | unnamed | 143 | 64 | 45% | 2 (+1) |
| Bellows Falls | 14-BB-019 | Black BW | 305 | 304 | 100% | 0 |
| | 14-BB-030 | Williams BW | 188 | 139 | 74% | 0 |
| | 14-BB-033 | unnamed | 68 | 1 | 1% | 0 |
| Vernon | 14-VB-039 | Retreat Mdws | 30 | 16 | 53% | 0 |
| | 14-VB-045 | unnamed | 6 | 2 | 33% | 0 |
| | 14-VB-050 | unnamed | 6 | 0 | 0% | 0 |
| [1] data not available, logger malfunction | | | 828 | 581 | 71% | 10 (+5) |
| | | | | | (56%) | |

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## Study 14 & 15 – Resident Fish Spawning

### 2. Treatment of Smallmouth Bass fry residence time

- Residence times were extended for 11 nests with fry
- No additional fry or nests were dewatered due to extension

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## Study 14 & 15 – Resident Fish Spawning

### 3. Assessment of project effects (results)

- Estimated % of days the median spawning criteria were deceeded according to species periodicity, study site, and 5 modeled water years

| | | OPERATIONS UNDER NORMAL CONDITIONS | | | | |
|---|---|---|---|---|---|---|
| | | 1992 | 1989 | 1994 | 2007 | 1990 |
| Species | Reach / Habitat Type | Avg % Days Below Median | Avg % Days Below Median | Avg % Days Below Median | Avg % Days Below Median | Avg % Days Below Median |
| Yellow Perch* | Wilder BWs | 45% | 33% | 53% | 42% | 62% |
| | Bellows Falls BWs | 0% | 4% | 5% | 3% | 0% |
| | Vernon BWs | 0% | 0% | 5% | 0% | 1% |
| Sunfish | Wilder BWs | 64% | 50% | 33% | 43% | 37% |
| | Bellows Falls BWs | 22% | 17% | 2% | 23% | 14% |
| | Vernon BWs | 1% | 5% | 1% | 4% | 5% |
| Fallfish | Bellows Tribs | 0% | 0% | 0% | 0% | 0% |
| | Wilder Islands | 61% | 34% | 40% | 35% | 32% |
| | Bellows Falls Islands | 0% | 0% | 0% | 0% | 0% |
| | Vernon Islands | 14% | 0% | 5% | 5% | 0% |
| Smallmouth | Wilder Tribs | 41% | 22% | 11% | 20% | 19% |
| Bass | Bellows Falls Tribs | 7% | 6% | 0% | 6% | 5% |
| | Vernon Tribs | 0% | 0% | 0% | 0% | 0% |
| | Wilder Islands | 54% | 50% | 39% | 48% | 45% |
| | Bellows Falls Islands | 34% | 22% | 1% | 29% | 15% |
| | Vernon Islands | 34% | 16% | 9% | 22% | 13% |

* Includes high flow impoundment operations

## Study 14 & 15 – Resident Fish Spawning

### 3. Assessment of Project Effects (conclusions)

- Yellow Perch: WSE's were predicted to drop below median elevations of observed egg masses more often in the Wilder backwater habitats (30-60% of spawning days) than in the Bellows Falls or Vernon backwaters (<5%)
- Roughly 50% of days with below criteria elevations (among modeled water years) in Wilder backwaters occurred during high flow operations

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## Study 14 & 15 – Resident Fish Spawning

### 3. Assessment of Project Effects (conclusions)

- Sunfish: WSE's were predicted to drop below elevations of observed egg nests most often in Wilder backwater habitats (30-65% of days), versus 2-20% of days in Bellows Falls backwaters, and only 5% of days (or less) in Vernon backwaters
- *Note that this assumes a 40-day spawning period, not a ~5-day incubation/fry period*

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## Study 14 & 15 – Resident Fish Spawning

### 3. Assessment of Project Effects (conclusions)

- Fallfish: WSE's were predicted to drop below elevations of observed nesting mounds in 30-60% of days in Wilder island/bar habitats, but mostly <5% of days in the Bellows Falls or Vernon riverine reaches
- Smallmouth Bass: Low WSE's were predicted to drop below elevations of observed nesting in 10-40% of days in Wilder tributary habitats and in 40-55% of days in Wilder island/bar habitats;
- WSE's rarely dropped below median elevations in Bellows or Vernon tributaries, but deceeded median elevations in up to 35% of days in Bellows Falls and Vernon riverine reaches

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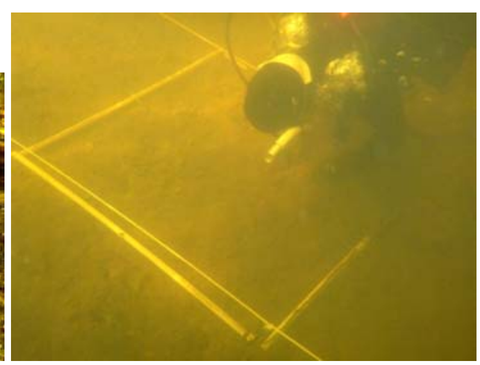
## Study 24

## Dwarf Wedgemussel and Co-occurring Mussel Study



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## Study 24 – Dwarf Wedgemussel and Co-occurring Mussels

### Recap - DWM

**2014 - 2016**

- Mussel sampling conducted in 2011 and 2013 (Phase 1) and 2014 (Phase 2)
- Abundance of DWM in project area insufficient to develop site-specific HSC, so Delphi process was used
- Delphi study plan developed and approved by FERC on January 22, 2015
- DWM Delphi panel assembled and HSC developed over 3 rounds
- HSC developed for water depth, mean column water velocity, benthic water velocity, dominant substrate, bed shear stress, dimensionless (relative) shear stress, and shear velocity (shear velocity was used but considered redundant by panelists)
- DWM Delphi report filed on May 16, 2016
- Agency and NGO comments received on July 14, 2016
- TransCanada responses to comments submitted on August 15, 2016
- FERC Determination September 12, 2016
- Modeling habitat in project-affected reaches using 1D and 2D modeling (Study 9) with Delphi HSC

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## Study 24 – Dwarf Wedgemussel and Co-occurring Mussels

### New HSC – Co-Occurring Mussels

**2014 - 2016**

- Mussel sampling conducted in 2011, 2013 and 2014 with DWM sampling
- Although DWM were rare, co-occurring mussels (especially Eastern Elliptio) were common in many survey transects and quadrats
- Elliptio were sufficiently abundant to develop site-specific HSC for riverine reaches
- Mussel sampling occurred at specific points in time and measured variables (depths and velocities) did not represent the variation in habitat under operational flows
- Co-occurring HSC were consequently developed from data collected in the Chase Island 2D study site (Wilder riverine reach) where depths and velocities could be predicted over a range of flows

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## Study 24 – Dwarf Wedgemussel and Co-occurring Mussels

### New HSC – Co-Occurring Mussels

- 300 2.25 $m^2$ quadrats were sampled within the Chase Island 2D site
- 87% of mussels in quadrats were Elliptio
- 186 Elliptio were counted in 62 quadrats (max n=25)

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## Study 24 – Dwarf Wedgemussel and Co-occurring Mussels

### New HSC – Co-Occurring Mussels

- Dominant substrates assessed at quadrats in 2014 were assumed to remain constant and used for HSC development, whereas depths, velocities, and shear variables were estimated at each quadrat location using the 2D model
- Co-occurring mussel HSC were developed for the same suite of variables used for DWM, excluding shear velocity which was considered redundant by the Delphi panelists

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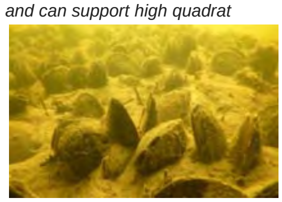
## Study 24 – Dwarf Wedgemussel and Co-occurring Mussels

### Methods – Co-Occurring Mussels

Defining Suitable vs. Unsuitable, Optimal vs. Marginal

- Assumed density of Elliptio within a quadrat was associated with habitat suitability
  - *high quadrat densities suggest optimal habitat, low densities suggest marginal habitat, zero densities suggest unsuitable habitat*
- Mussels are largely immobile, and cannot change position with rapid changes in flow (unlike fish)
- Assigned different discharges to define limits of suitable and optimal habitat
- Extreme flows were selected to define range of suitable habitat
  - *very low flows defined lower limit of tolerable depths (dewatered area expected to be devoid of mussels)*
  - *Very high flows will result in bedload movement and scouring of mussels (thus also devoid of mussels)*
- Commonly occurring flows were selected to define the range of optimal habitat
  - *range of flows where mussel survival and growth remain high and can support high quadrat densities*



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## Study 24 – Dwarf Wedgemussel and Co-occurring Mussels

### Methods – Co-Occurring Mussels

Defining Suitable vs. Unsuitable, Optimal vs. Usable

- How do we define these flow ranges?
  - *Inspect flow exceedances over a period of time when mussels were likely to have established at a specific location (quadrat)*
  - *Delphi mussel experts were asked how long should flow data be assessed prior to when the quadrat samples were taken*
  - *Suggested time range was 3-5 years - we used flow time series for 3 years prior to sampling*
  - *The channel morphology study (Study 8) was used to evaluate the selected flow ranges*

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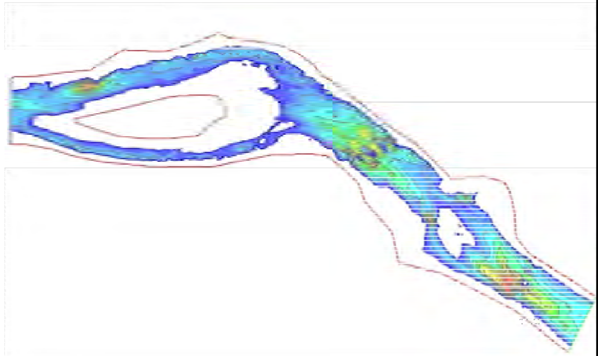
## Study 24 – Dwarf Wedgemussel and Co-occurring Mussels

### Methods – Co-Occurring Mussels

Defining Suitable vs. Unsuitable, Optimal vs. Usable

- What flow ranges might be used to represent extreme (suitable vs. unsuitable) conditions?
  - o *Delphi experts suggested that the 1% exceedance flow (33,000 cfs) might be used to represent extreme maximum flow, and the 99% exceedance flow (1,000 cfs) might represent extreme minimum flow*

Depths at ~1,000 cfs



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## Study 24 – Dwarf Wedgemussel and Co-occurring Mussels

### Methods – Co-Occurring Mussels

Defining Suitable vs. Unsuitable, Optimal vs. Usable

- What flow ranges might be used to represent optimal conditions?
  - o *Experts suggested the 20-25% and 75-80% exceedance flows might be used to represent common flows that allow the development of high mussel densities in optimal habitat*
  - o *We selected the 25% flow (~11,000 cfs) and the 75% flow (2,300 cfs) to define optimal conditions*
  - o *This range brackets the central 50% of flows, which is consistent with many HSC studies that utilize the central 50% of data to represent optimal habitat*
  - o *The Study 8 geomorphic results from 3 transects within the Chase Island study area suggested that medium gravels could be mobilized over a short range of 2,000-3,000 cfs, but then remained stable until 11,000 cfs for one transect and until 33,000 cfs for another transect*
  - o *The geomorphic study generally supported the selection of the ~2,300-11,000 cfs range to define potentially optimal conditions, and 33,000 cfs to define unsuitable conditions*

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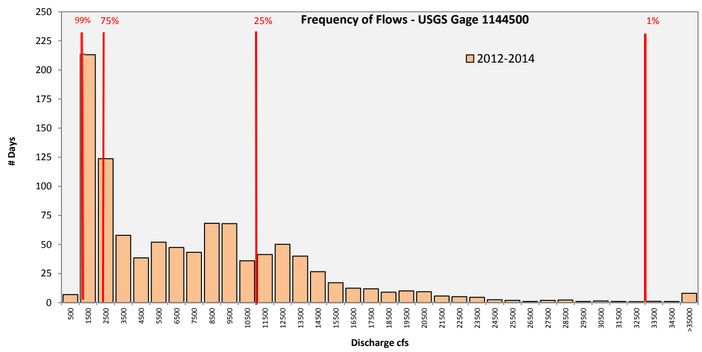
## Study 24 – Dwarf Wedgemussel and Co-occurring Mussels

### Methods – Co-Occurring Mussels

Defining Suitable vs. Unsuitable, Optimal vs. Usable

- What flow ranges might be used to represent optimal conditions?

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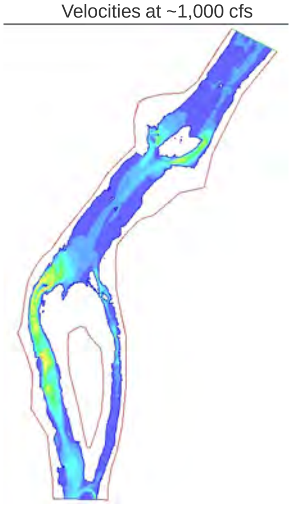
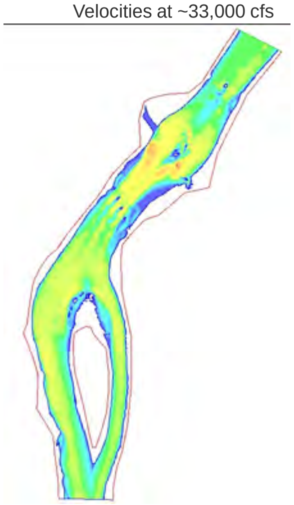
## Study 24 – Dwarf Wedgemussel and Co-occurring Mussels

### Methods – Co-Occurring Mussels

Velocities at ~1,000 cfs



Velocities at ~33,000 cfs



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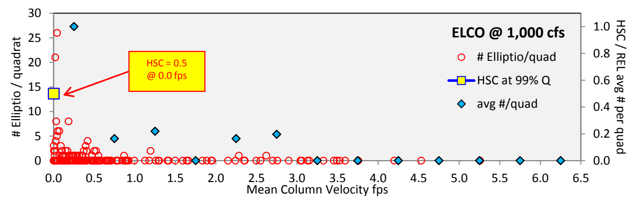
## Study 24 – Dwarf Wedgemussel and Co-occurring Mussels

### Methods – Co-Occurring Mussels

Creating HSC Curves

- Densities of Elliptio were plotted against each HSC variable at each of the 4 selected flows
- An HSC curve was fitted by eye using the 1% and 99% exceedance flows to define the range of suitable habitat, and the 25% and 75% flows to define optimal habitat
  - *At 1,000 cfs, the highest quadrat densities were in zero or near zero velocity, so HSC for zero velocity was set at 0.5*

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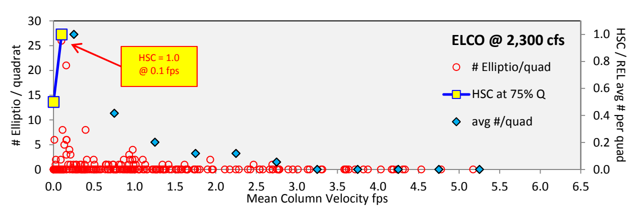
## Study 24 – Dwarf Wedgemussel and Co-occurring Mussels

### Methods – Co-Occurring Mussels

Creating HSC Curves

- Densities of Elliptio were plotted against each HSC variable at each of the 4 selected flows
- An HSC curve was fitted by eye using the 1% and 99% exceedance flows to define the range of suitable habitat, and the 25% and 75% flows to define optimal habitat
  - *At 2,300 cfs, the highest average quadrat density remained in first velocity bin with the maximum count at 0.1 fps, so HSC was set to 1.0 at 0.1 fps*

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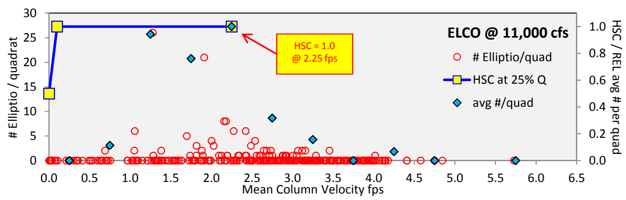
## Study 24 – Dwarf Wedgemussel and Co-occurring Mussels

### Methods – Co-Occurring Mussels

Creating HSC Curves

- Densities of Elliptio were plotted against each HSC variable at each of the 4 selected flows
- An HSC curve was fitted by eye using the 1% and 99% exceedance flows to define the range of suitable habitat, and the 25% and 75% flows to define optimal habitat
  - *At 11,000 cfs, the highest average quadrat density occurred at 2.25 fps, so HSC was set to 1.0 at that velocity*

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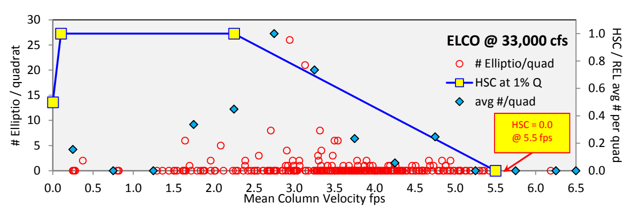
## Study 24 – Dwarf Wedgemussel and Co-occurring Mussels

### Methods – Co-Occurring Mussels

Creating HSC Curves

- Densities of Elliptio were plotted against each HSC variable at each of the 4 selected flows
- An HSC curve was fitted by eye using the 1% and 99% exceedance flows to define the range of suitable habitat, and the 25% and 75% flows to define optimal habitat
  - *At 33,000 cfs, all quadrat densities were zero after 5.5 fps, so HSC dropped to zero at that velocity*




  - *This process was repeated for the remaining 4 flow-dependent HSC variables*

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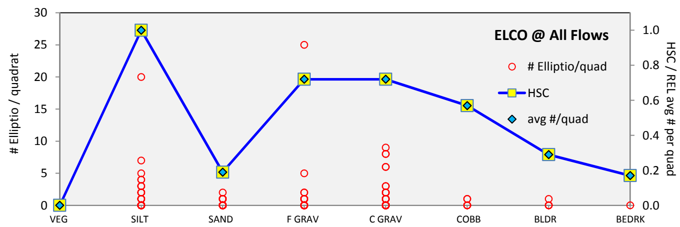
## Study 24 – Dwarf Wedgemussel and Co-occurring Mussels

### Results – Co-Occurring Mussels

HSC Curves

- Substrate was assumed to be constant and thus HSC was based on original quadrat characterization




- Co-occurring HSC were compared to DWM Delphi-based HSC curves

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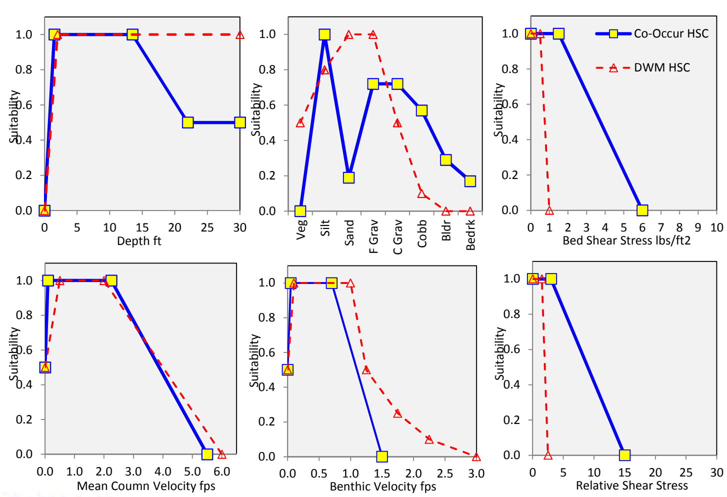
## Study 24 – Dwarf Wedgemussel and Co-occurring Mussels

### Results – Co-Occurring Mussels

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## Study 24 – Dwarf Wedgemussel and Co-occurring Mussels

### Analysis and Reporting

- The co-occurring mussel HSC were distributed in a report filed March 22, 2017
- These HSC were used in the 1D and 2D modeling in Study 9 (final report also filed March 22, 2017)

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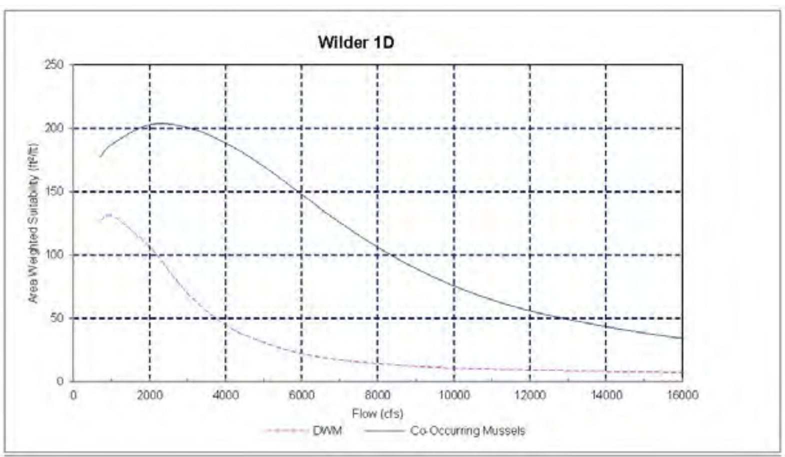
## Study 24 – Dwarf Wedgemussel and Co-occurring Mussels

### Wilder 1D AWS

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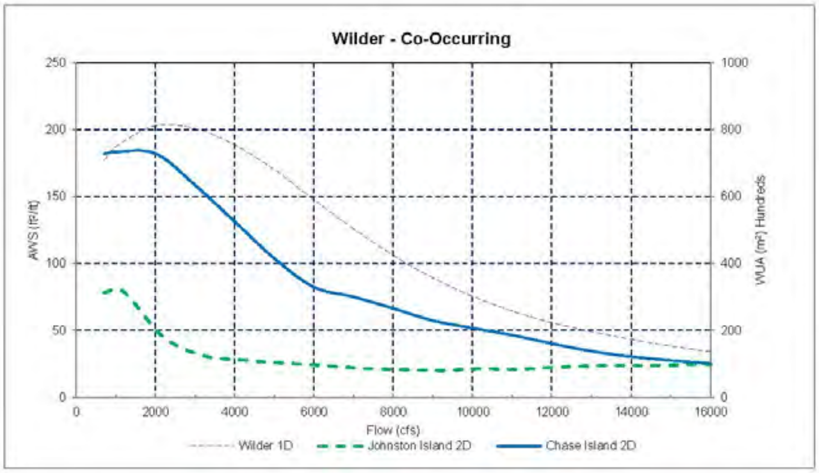
## Study 24 – Dwarf Wedgemussel and Co-occurring Mussels

### Wilder 2D AWS

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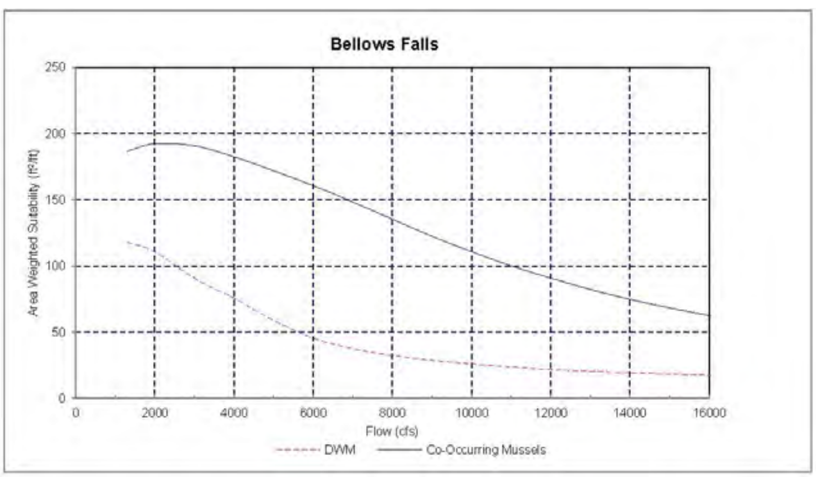
## Study 24 – Dwarf Wedgemussel and Co-occurring Mussels

### Bellows Falls AWS

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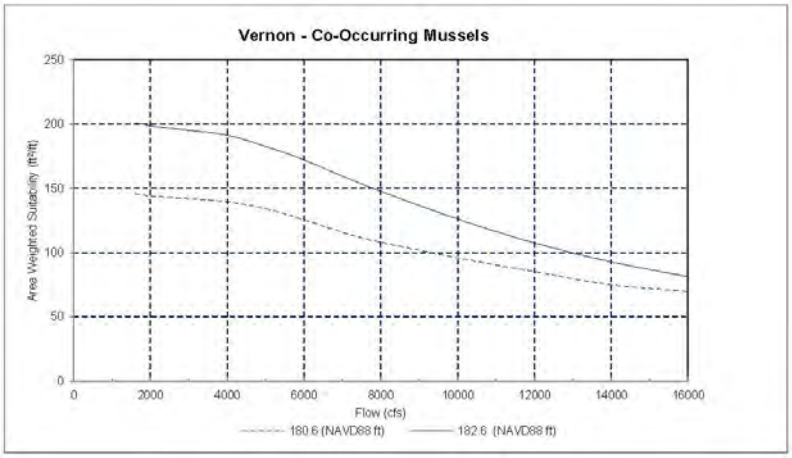
## Study 24 – Dwarf Wedgemussel and Co-occurring Mussels

### Vernon AWS

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## Study 9
## Instream Flow Study

**Final Study Report Filed March 22, 2017**

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## Study 9 – Instream Flow Study

**Additions Since Interim Report (March 1, 2016)**

- Chase Island 2D site calibration and WUA
- Critical Reach Transects
- Habitat Time Series
- Dual Flow Analysis
- Habitat modeling of DWM and Co-occurring mussels
- Sea Lamprey spawning HSC modification

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## Study 9 – Instream Flow Study

**Additions Since Interim Report (March 1, 2016)**

- Chase Island 2D site calibration and WUA
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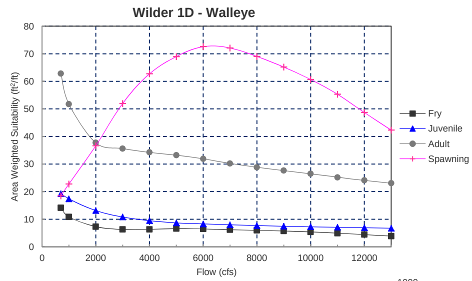
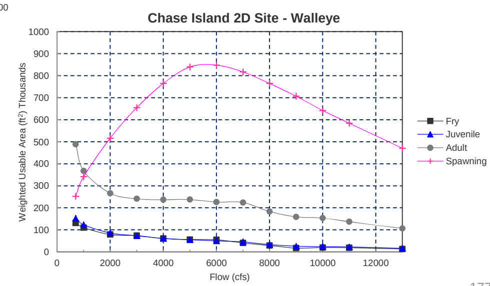
## Study 9 – Instream Flow Study

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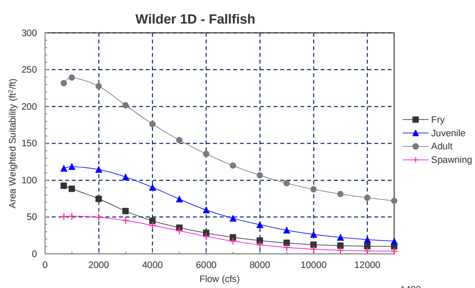
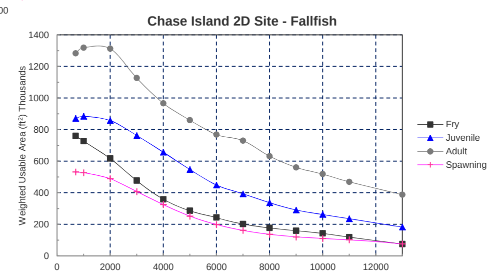
## Study 9 – Instream Flow Study

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## Study 9 – Instream Flow Study

**Additions Since Interim Report (March 1, 2016)**

- Chase Island 2D site calibration and WUA
- Critical Reach Transects
- Habitat Time Series
- Dual Flow Analysis
- Habitat modeling of DWM and Co-occurring mussels
- Sea Lamprey spawning HSC modification

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## Study 9 – Instream Flow Study: Critical Reach

- In addition to using all transects, critical reach (CR) transects were utilized in Habitat Time Series and Dual Flow Analyses
- The concept of a CR is that specific habitat types or features may be important to certain species and/or rearing and spawning life stages.
- Shallow water habitat such as riffles and runs are more dynamic than pools in terms of changes in depth and velocity relative to flow. In addition pools are typically not considered critical habitat.
- Typically transects are weighted proportionally to available habitat for modeling purposes. Pools being the dominant habitat type in the instream flow study reaches are given the most weight, while rarer habitat types such as riffles are given relatively little weight. The concern is habitat modeling results may be skewed by this difference in weighting.

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## Study 9 – Instream Flow Study: Critical Reach

- A CR reach does not necessarily need to comprise groups of closely spaced transects or specific study sites, and may involve single transects widely spread out within a given reach.
- During discussions with the working group a number of criteria were suggested for selecting CR transects:
  1. inclusion of all riffles
  2. include diverse habitats associated with islands, mid-channel bars or point bars
  3. include transects that encompass identified lamprey spawning areas or potential lamprey spawning areas
- In order not to diminish or increase the effect of any one transect or habitat type all CR reach transects are weighted equally.

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## Study 9 – Instream Flow Study: Critical Reach Transects

**Wilder Reach 1**


| Transect ID | Habitat Type |
|---|---|
| WR1-1 | Deep Pool |
| WR1-3 | Deep Pool |
| WR1-4 LC | Run |
| WR1-4 RC | Run |
| WR1-5 LC | Glide |
| WR1-5 RC | Run |
| WR1-6 | Deep Pool |
| WR1-7 LC | Run |
| WR1-7 RC | Run |
| WR1-8 | Run |
| WR1-9 | Deep Pool |
| WR1-10 | Glide |

Critical reach transect

Lamprey spawning location (from Study 16)

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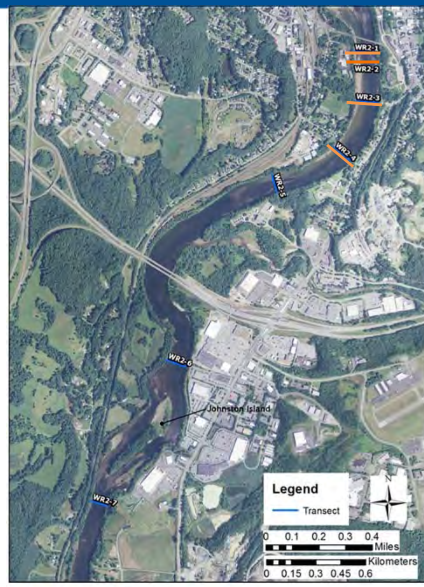
## Study 9 – Instream Flow Study: Critical Reach Transects

**Wilder Reach 2 (Upper)**




| Transect ID | Habitat Type |
|---|---|
| WR2-1 | Run |
| WR2-2 | Riffle |
| WR2-3 | Run |
| WR2-4 | Glide |
| WR2-5 | Pool |
| WR2-6 | Glide |
| WR2-7 | Deep Pool |

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Critical reach transect

Lamprey spawning location (from Study 16)

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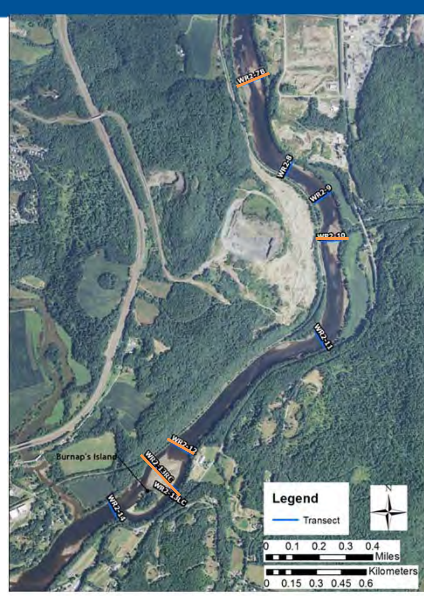
## Study 9 – Instream Flow Study: Critical Reach Transects

**Wilder Reach 2 (Lower)**




| Transect ID | Habitat Type |
|---|---|
| WR2-7b | Run |
| WR2-8 | Run |
| WR2-9 | Pool |
| WR2-10 | Run |
| WR2-11 | Deep Pool |
| WR2-12 | Glide |
| WR2-13 LC/RC | Run |
| WR2-14 | Deep Pool |

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Critical reach transect

Lamprey spawning location (from Study 16)

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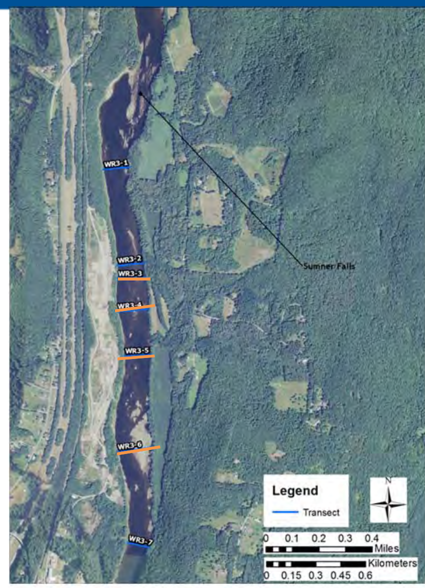
## Study 9 – Instream Flow Study: Critical Reach Transects

**Wilder Reach 3 (Upper)**




| Transect ID | Habitat Type |
|---|---|
| WR3-1 | Glide |
| WR3-2 | Pool |
| WR3-3 | Glide |
| WR3-4 | Riffle |
| WR3-5 | Run |
| WR3-6 | Run |
| WR3-7 | Glide |

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Critical reach transect

Lamprey spawning location (from Study 16)

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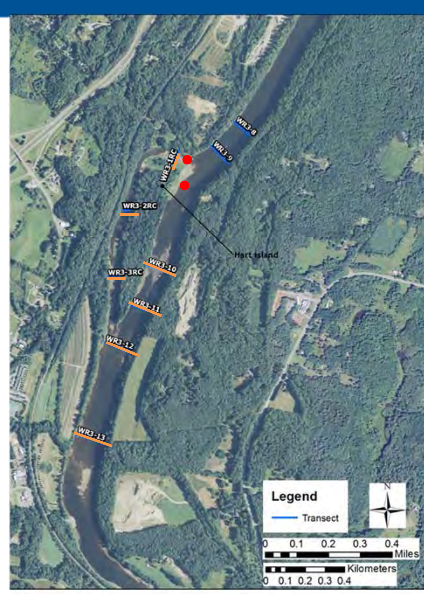
## Study 9 – Instream Flow Study: Critical Reach Transects

**Wilder Reach 3 (Lower)**




| Transect ID | Habitat Type |
|---|---|
| WR3-8 | Pool |
| WR3-9 | Glide |
| WR3-10 | Riffle |
| WR3-11 | Pool |
| WR3-12 | Riffle |
| WR3-13 | Glide |
| WR3-1 RC | Riffle |
| WR3-2 RC | Pool |
| WR3-3 RC | Riffle |

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Critical reach transect

Lamprey spawning location (from Study 16)

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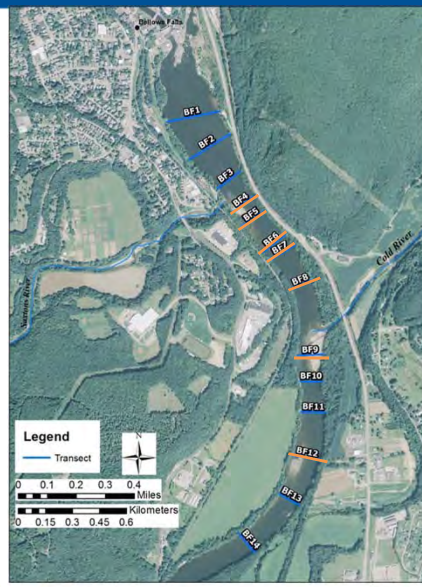
## Study 9 – Instream Flow Study: Critical Reach Transects

**Bellows Falls (Upper)**




| Transect ID | Habitat Type |
|---|---|
| BF1 | Deep Pool |
| BF2 | Glide |
| BF3 | Glide |
| BF4 | Run |
| BF5 | Glide |
| BF6 | Riffle |
| BF7 | Riffle |
| BF8 | Run |
| BF9 | Run |
| BF10 | Pool |
| BF11 | Glide |
| BF12 | Run |
| BF13 | Pool |
| BF14 | Glide |

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Critical reach transect

Lamprey spawning location (from Study 16)

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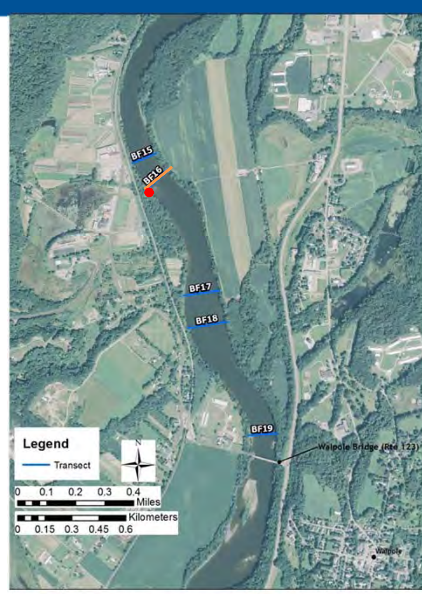
## Study 9 – Instream Flow Study: Critical Reach Transects

**Bellows Falls (Lower)**




| Transect ID | Habitat Type |
|---|---|
| BF15 | Pool |
| BF16 | Glide |
| BF17 | Pool |
| BF18 | Glide |
| BF19 | Deep Pool |

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Critical reach transect

Lamprey spawning location (from Study 16)

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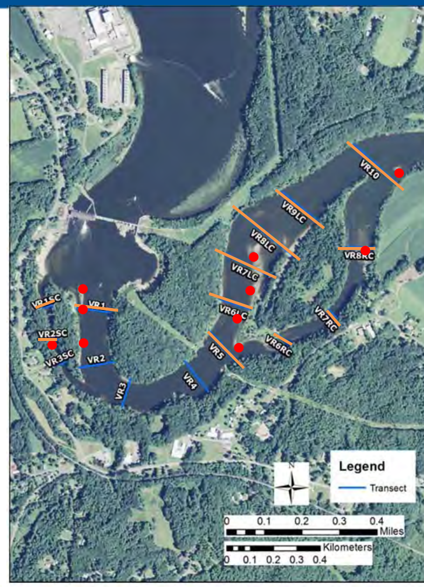
## Study 9 – Instream Flow Study: Critical Reach Transects

**Vernon**




| Transect ID | Habitat Type |
|---|---|
| VR1 | Run |
| VR2 | Run |
| VR3 | Deep Pool |
| VR4 | Deep Pool |
| VR5 | Glide |
| VR6 LC | Run |
| VR7 LC | Glide |
| VR8 LC | Run |
| VR9 LC | Glide |
| VR6 RC | Run |
| VR7 RC | Pool |
| VR8 RC | Run |
| VR10 | Pool |
| VR1 SC | Run |
| VR2 SC | Riffle |
| VR3 SC | Pool |

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Critical reach transect
Lamprey spawning location (from Study 16)

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## Study 9 – Instream Flow Study

**Additions Since Interim Report (March 1, 2016)**

- Chase Island 2D site calibration and WUA
- Critical Reach Transects
- Habitat Time Series (All target species and life stages)
- Dual Flow Analysis
- Habitat modeling of DWM and Co-occurring mussels
- Sea Lamprey spawning HSC modification

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## Study 9 – Instream Flow Study: Habitat Time Series

- Hydrology for time series from Study 5 – Operations Model
  - Based on five annual hourly scenarios of dam, powerhouse and impoundment Project operations designated by a corresponding inflow year: 1992, 1994, 1989, 2007 and 1990.
- Operations Model segmented the Project reaches based on water travel time and accretion – termed "Vista reaches"
  - Wilder riverine section divided into 7 Vista reaches
  - Bellows Falls riverine section divided into 2 Vista reaches
  - Vernon riverine section as a single reach
- Vista reach hydrology was applied to those transects located within a given reach. Results for each Vista reach were then combined to produce the final total combined reach habitat output. In the case of 2D sites, hydrology for the Vista reach in which the site is located were used.

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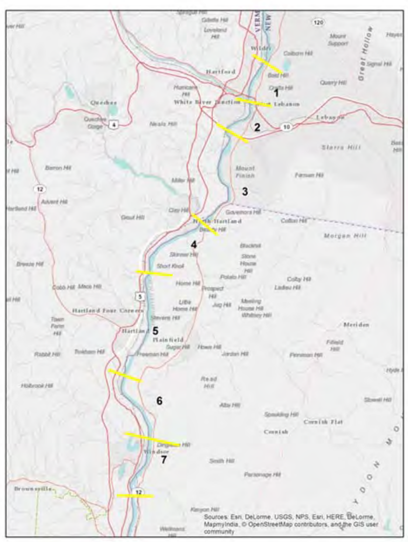
## Study 9 – Instream Flow Study: Habitat Time Series

**Wilder Vista Reaches 1-7**



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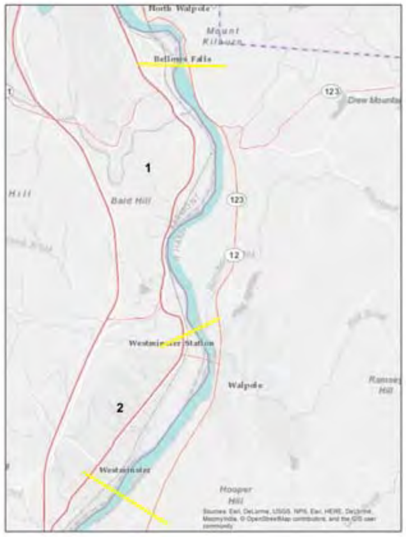
## Study 9 – Instream Flow Study: Habitat Time Series

**Bellows Falls Vista Reaches 1-2**

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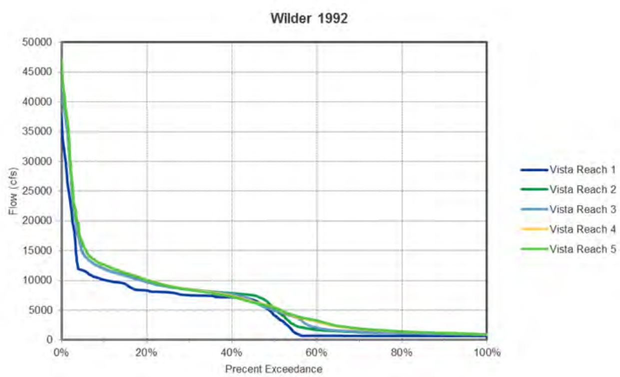
## Study 9 – Instream Flow Study: Habitat Time Series

**Wilder Vista Reach 1-5 Flow Duration**

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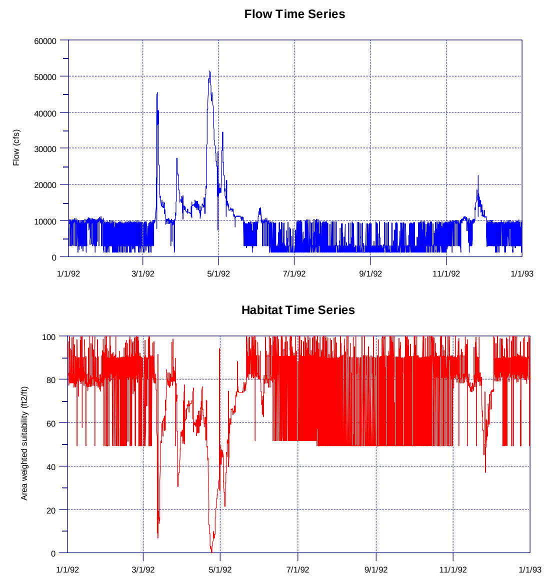
## Study 9 – Instream Flow Study: Habitat Time Series

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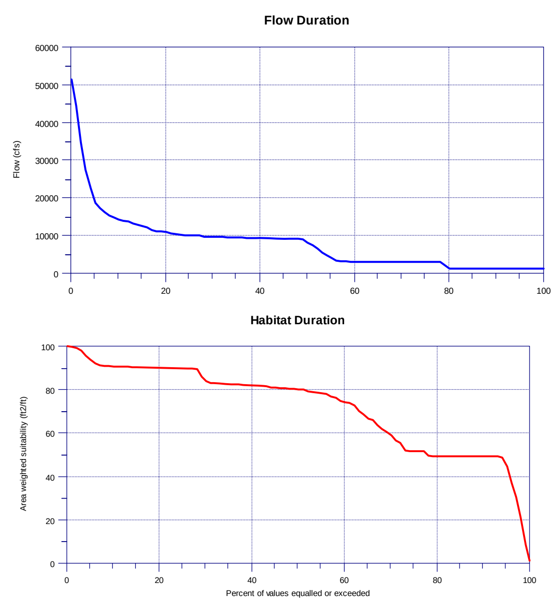
## Study 9 – Instream Flow Study: Habitat Time Series

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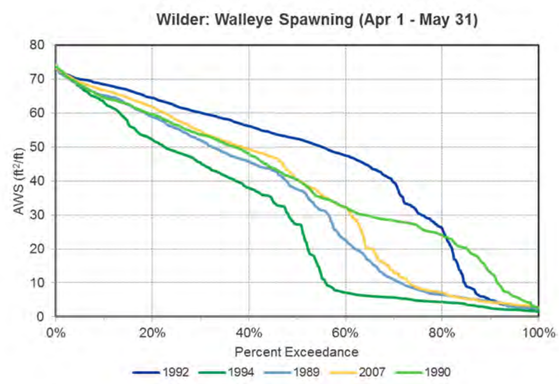
## Study 9 – Instream Flow Study: Habitat Time Series

### Habitat Duration

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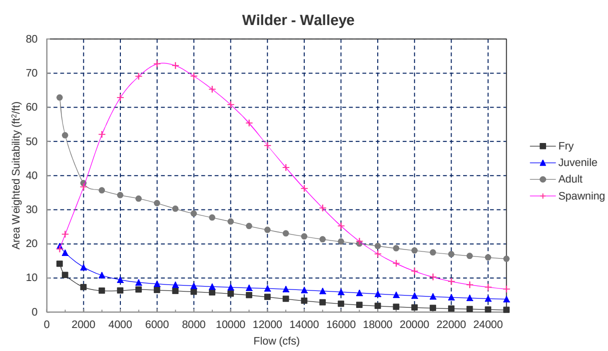
## Study 9 – Instream Flow Study: Habitat Time Series

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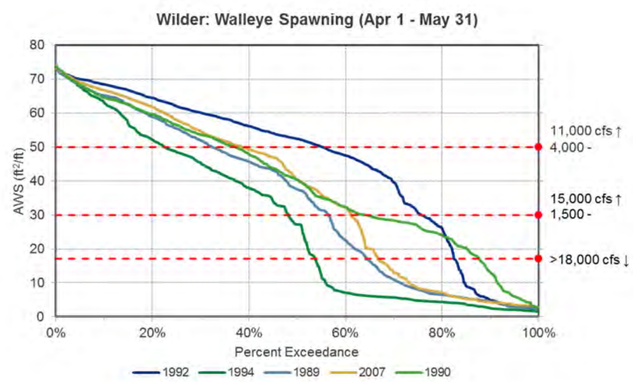
## Study 9 – Instream Flow Study: Habitat Time Series

### Habitat Duration

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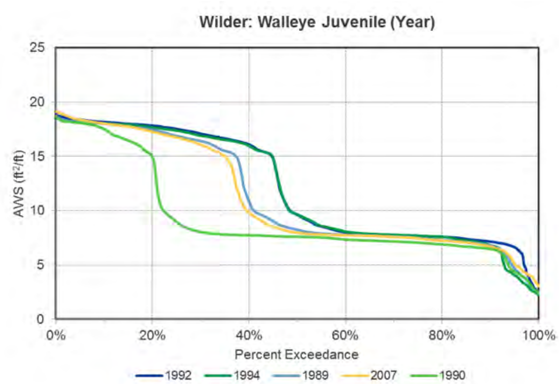
## Study 9 – Instream Flow Study: Habitat Time Series

### Habitat Duration

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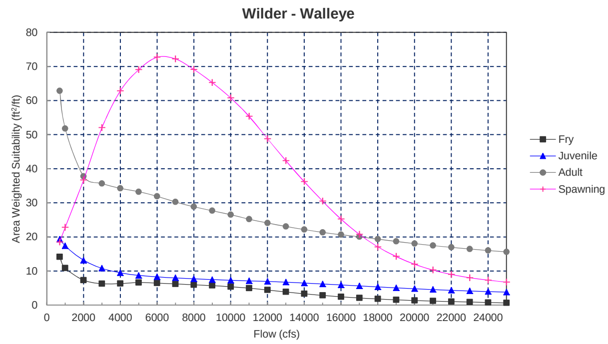
## Study 9 – Instream Flow Study: Habitat Time Series

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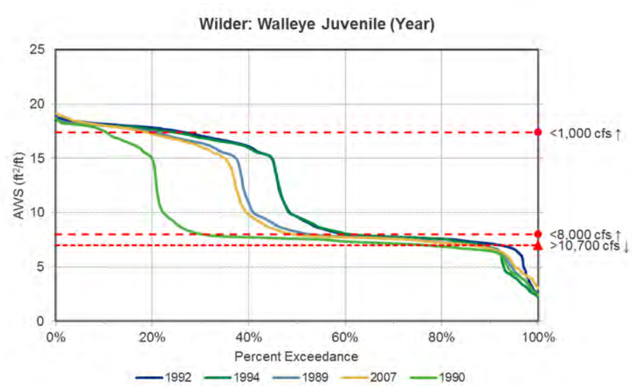
## Study 9 – Instream Flow Study: Habitat Time Series

### Habitat Duration

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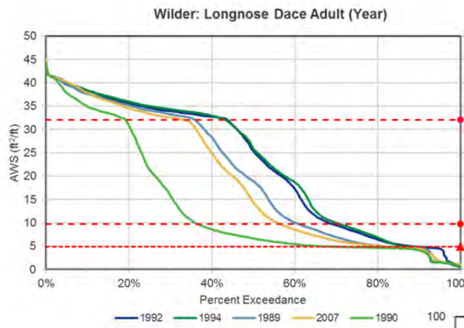
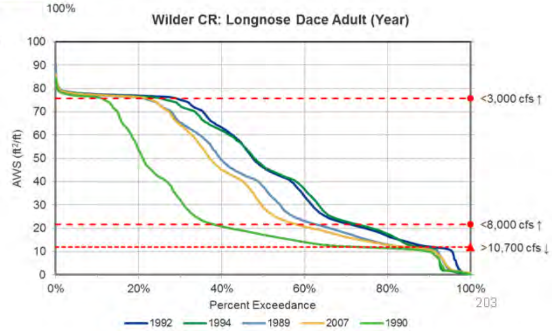
## Study 9 – Instream Flow Study: Habitat Time Series




**Longnose Dace**

- Shallow Depth – Fast Velocity




**Critical Reach**

- Higher habitat values
- No difference in habitat duration

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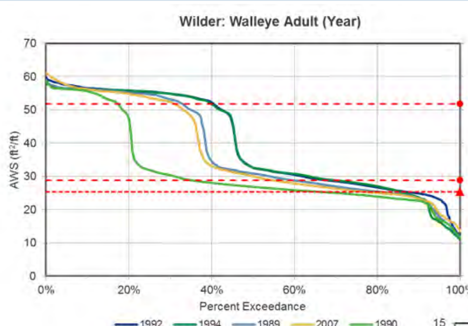
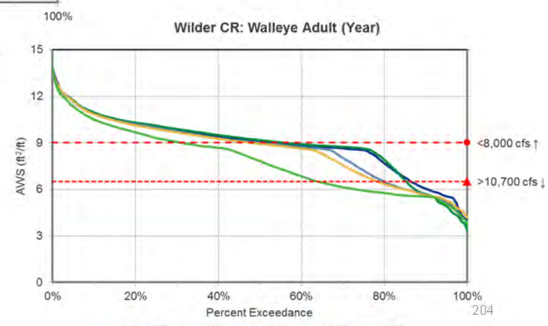
## Study 9 – Instream Flow Study: Habitat Time Series




**Walleye Adult**

- Deep Depth – Slow Velocity




**Critical Reach**

- Lower habitat values
- Noticeable difference in habitat duration

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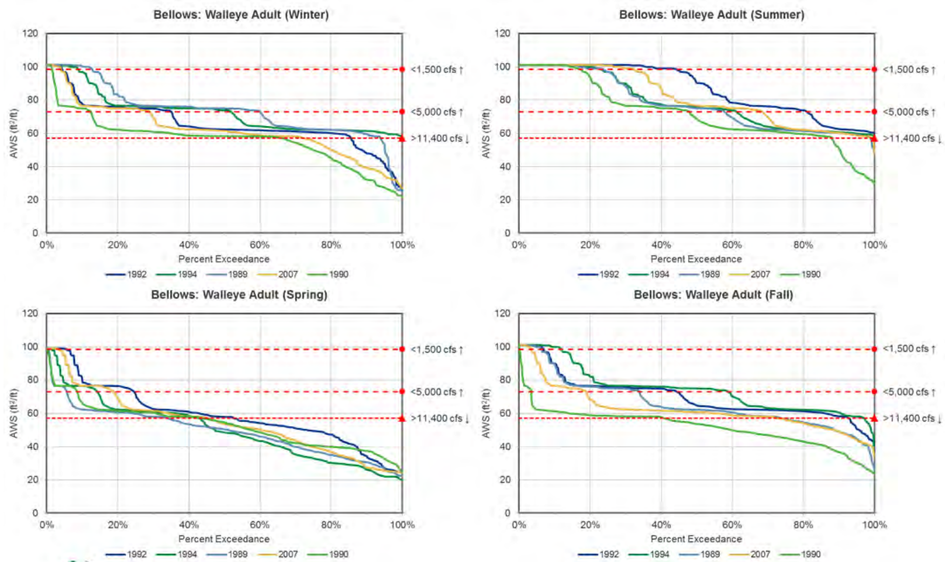
## Study 9 – Instream Flow Study: Habitat Time Series

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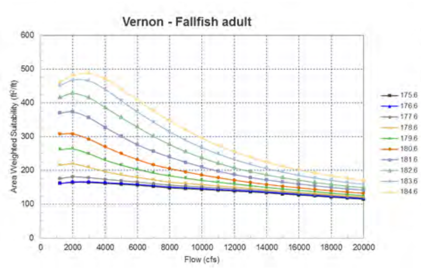
## Study 9 – Instream Flow Study: Habitat Time Series

### Vernon Reach

- Turners Falls project operations affect WSE in the Vernon reach
- As a result both WSE and flow must be accounted for in the time series




| Date:Hour Ending | Flow (cfs) | WSE (ft NAVD88) | Fallfish Adult AWS (ft²/ft) |
|---|---|---|---|
| | | | |
| 07-04-1990:01 | 2,171 | 183.3 | 437.09 |
| 07-04-1990:02 | 2,150 | 182.8 | 417.16 |
| 07-04-1990:03 | 2,150 | 182.3 | 388.95 |
| 07-04-1990:04 | 2,150 | 181.8 | 355.81 |
| 07-04-1990:05 | 2,150 | 181.2 | 317.57 |
| 07-04-1990:06 | 2,150 | 180.6 | 286.97 |
| 07-04-1990:07 | 2,150 | 180.0 | 260.97 |
| 07-04-1990:08 | 6,293 | 179.6 | 190.54 |
| 07-04-1990:09 | 8,956 | 179.7 | 171.85 |
| 07-04-1990:10 | 8,854 | 179.2 | 166.07 |
| 07-04-1990:11 | 9,563 | 179.1 | 160.83 |
| 07-04-1990:12 | 14,127 | 179.4 | 145.35 |
| 07-04-1990:13 | 14,405 | 179.8 | 146.99 |
| 07-04-1990:14 | 15,416 | 180.4 | 146.42 |
| 07-04-1990:15 | 15,673 | 180.9 | 149.64 |
| 07-04-1990:16 | 15,627 | 181.5 | 156.24 |
| 07-04-1990:17 | 15,577 | 182.1 | 163.42 |
| 07-04-1990:18 | 15,524 | 182.6 | 170.35 |
| 07-04-1990:19 | 14,295 | 183.0 | 184.18 |
| 07-04-1990:20 | 14,139 | 183.1 | 187.79 |
| 07-04-1990:21 | 14,191 | 183.2 | 189.48 |
| 07-04-1990:22 | 14,429 | 183.3 | 188.06 |
| 07-04-1990:23 | 2,150 | 183.4 | 441.70 |
| 07-04-1990:24 | 2,150 | 183.4 | 442.16 |
| 07-05-1990:01 | 2,160 | 183.1 | 431.08 |
| 07-05-1990:02 | 2,150 | 182.6 | 404.85 |
| 07-05-1990:03 | 2,150 | 182.1 | 373.80 |
| 07-05-1990:04 | 2,150 | 181.5 | 335.91 |
| 07-05-1990:05 | 2,150 | 180.8 | 299.29 |
| 07-05-1990:06 | 2,150 | 180.2 | 272.64 |

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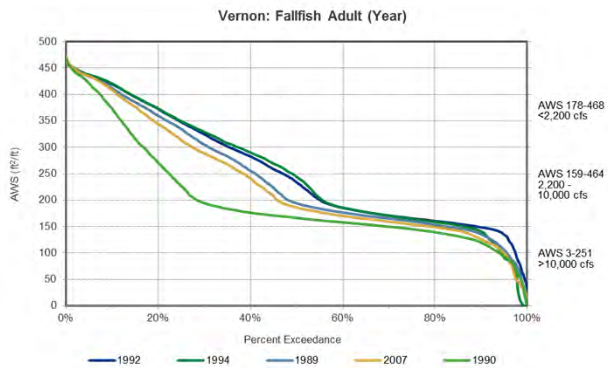
## Study 9 – Instream Flow Study: Habitat Time Series

**Habitat Duration**

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## Study 9 – Instream Flow Study

**Additions Since Interim Report (March 1, 2016)**

- Chase Island 2D site calibration and WUA
- Critical Reach Transects
- Habitat Time Series
- Dual Flow Analysis

  **Includes all target fry and spawning life stages.**
  **Plus macroinvertebrates, Tessellated Darter Adult, GHC, DWM and Co-occurring mussels**
- Habitat modeling of DWM and Co-occurring mussels
- Sea Lamprey spawning HSC modification

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## Study 9 – Instream Flow Study: Dual Flow

- Dual Flow analysis consists of comparing change in habitat between flow pairs, typically a range of minimum or base flows to a set of operational ("peaking") flows. The amount of usable habitat between flows is the minimum amount of habitat that overlaps in space with suitable locations that were available at the base flow, identified as persistent habitat.
- Flow pairs were selected in consultation with the aquatics working group through a series of meetings and memorandums. Operational flows were based primarily on permutations of typical generation flows and turbine efficiency at each project.
- Comparisons were also made based on quality habitat, which eliminated any habitat with a CSI value <0.5 from the analysis.
- Flow accretion must be taken into account in reaches with major tributary inflow.

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## Study 9 – Instream Flow Study: Dual Flow

Wilder

- Flow accretion estimates based on the average of Operations Model hydrology for Wilder reaches by season (for year round life stages) and individual fry and spawning life stage periodicity. (Flow in cfs)

| | Season | | | |
|---|---|---|---|---|
| | Winter | Spring | Sumer | Fall |
| Reach | Jan-Mar | Apr-Jun | Jul-Sep | Oct-Dec |
| Wilder 2 | 1,396 | 2,544 | 621 | 1,353 |
| Wilder 3 | 1,806 | 3,319 | 779 | 1,737 |

| | Fry | | | |
|---|---|---|---|---|
| | Walleye | Fallfish | W. Sucker | LND & SMB |
| Reach | May 1 - July 1 | June 1 - July 1 | June 1 - Sep 30 | July 1 - Sep 30 |
| Wilder 2 | 1,654 | 1,018 | 722 | 621 |
| Wilder 3 | 2,173 | 1,308 | 912 | 779 |

| | Spawning | | | |
|---|---|---|---|---|
| | Walleye | W. Sucker | Fallfish & SMB | Shad & Lamprey |
| Reach | Apr 1 - May 31 | Apr 1 - June 30 | May 1 - June 30 | May 1 - July 15 |
| Wilder 2 | 3,289 | 2,544 | 1,670 | 1,476 |
| Wilder 3 | 4,302 | 3,319 | 2,192 | 1,929 |

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## Study 9 – Instream Flow Study: Dual Flow

Tabular display of Walleye spawning dual flow (example shows Wilder flow pairs):

| Base Flows | Base Flow AWS | Persistent AWS (ft²/ft) Operational Flows | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1700 | 2500 | 3350 | 4400 | 5600 | 6700 | 7500 | 8800 | 9550 | 10700 |
| 700 | 58.74 | 52.22 | 47.13 | 41.65 | 34.82 | 28.56 | 23.77 | 20.56 | 15.99 | 13.69 | 10.57 |
| 1000 | 60.80 | 56.08 | 50.86 | 45.16 | 37.99 | 31.50 | 26.39 | 22.87 | 17.76 | 15.12 | 11.64 |
| 1250 | 62.37 | 59.27 | 53.94 | 48.07 | 40.71 | 34.02 | 28.65 | 24.83 | 19.27 | 16.42 | 12.60 |
| 1500 | 63.75 | 62.35 | 56.91 | 50.90 | 43.39 | 36.57 | 30.84 | 26.77 | 20.75 | 17.66 | 13.58 |
| 1750 | 65.21 | | 59.94 | 53.79 | 46.10 | 39.10 | 33.07 | 28.76 | 22.24 | 18.95 | 14.63 |
| 2000 | 66.72 | | 63.05 | 56.70 | 48.81 | 41.62 | 35.32 | 30.75 | 23.77 | 20.33 | 15.71 |
| 2250 | 68.09 | | 66.07 | 59.51 | 51.42 | 44.05 | 37.51 | 32.70 | 25.32 | 21.69 | 16.78 |
| 2500 | 69.14 | | 69.14 | 62.37 | 54.11 | 46.54 | 39.71 | 34.67 | 26.85 | 23.04 | 17.85 |
| 3000 | 70.44 | | | 67.50 | 58.95 | 50.92 | 43.60 | 38.24 | 29.81 | 25.66 | 19.90 |
| 3500 | 70.94 | | | | 63.40 | 54.94 | 47.21 | 41.56 | 32.70 | 28.16 | 21.70 |
| 4000 | 70.49 | | | | 67.07 | 58.25 | 50.24 | 44.37 | 35.02 | 30.20 | 23.36 |
| 5000 | 68.58 | | | | | 63.80 | 55.21 | 48.83 | 38.87 | 33.75 | 26.23 |

| Base Flows | % at Base Flow | % Loss Persistent AWS Operational Flows | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1700 | 2500 | 3350 | 4400 | 5600 | 6700 | 7500 | 8800 | 9550 | 10700 |
| 700 | 0 | 11 | 20 | 29 | 41 | 51 | 60 | 65 | 73 | 77 | 82 |
| 1000 | 0 | 8 | 16 | 26 | 38 | 48 | 57 | 62 | 71 | 75 | 81 |
| 1250 | 0 | 5 | 14 | 23 | 35 | 45 | 54 | 60 | 69 | 74 | 80 |
| 1500 | 0 | 2 | 11 | 20 | 32 | 43 | 52 | 58 | 67 | 72 | 79 |
| 1750 | 0 | | 8 | 18 | 29 | 40 | 49 | 56 | 66 | 71 | 78 |
| 2000 | 0 | | 6 | 15 | 27 | 38 | 47 | 54 | 64 | 70 | 76 |
| 2250 | 0 | | 3 | 13 | 24 | 35 | 45 | 52 | 63 | 68 | 75 |
| 2500 | 0 | | 0 | 10 | 22 | 33 | 43 | 50 | 61 | 67 | 74 |
| 3000 | 0 | | | 4 | 16 | 28 | 38 | 46 | 58 | 64 | 72 |
| 3500 | 0 | | | | 11 | 23 | 33 | 41 | 54 | 60 | 69 |
| 4000 | 0 | | | | 5 | 17 | 29 | 37 | 50 | 57 | 67 |
| 5000 | 0 | | | | | 7 | 20 | 29 | 43 | 51 | 62 |

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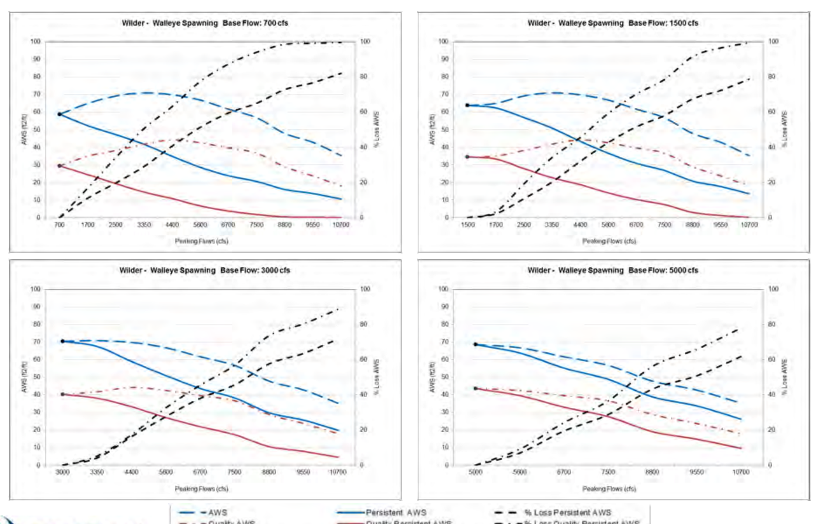
## Study 9 – Instream Flow Study: Dual Flow

Graphical display of Walleye spawning dual flow (example Wilder base flows):

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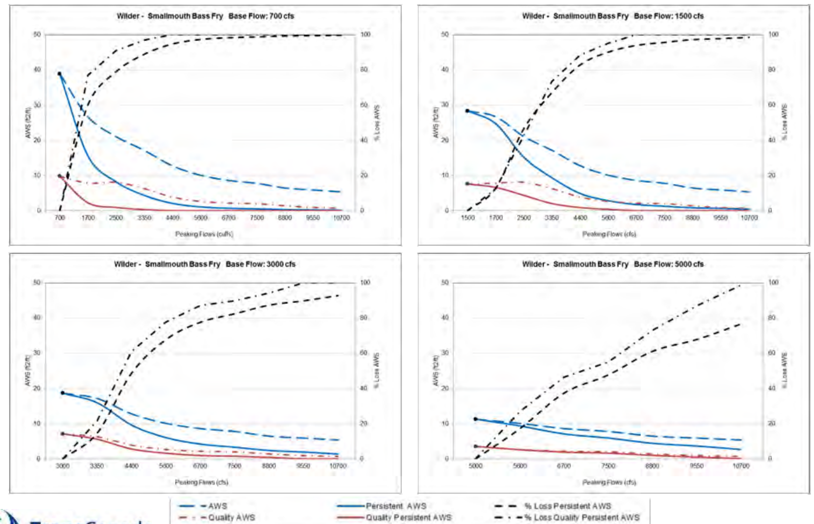
## Study 9 – Instream Flow Study: Dual Flow

Graphical display of Smallmouth Bass fry dual flow (example Wilder base flows):

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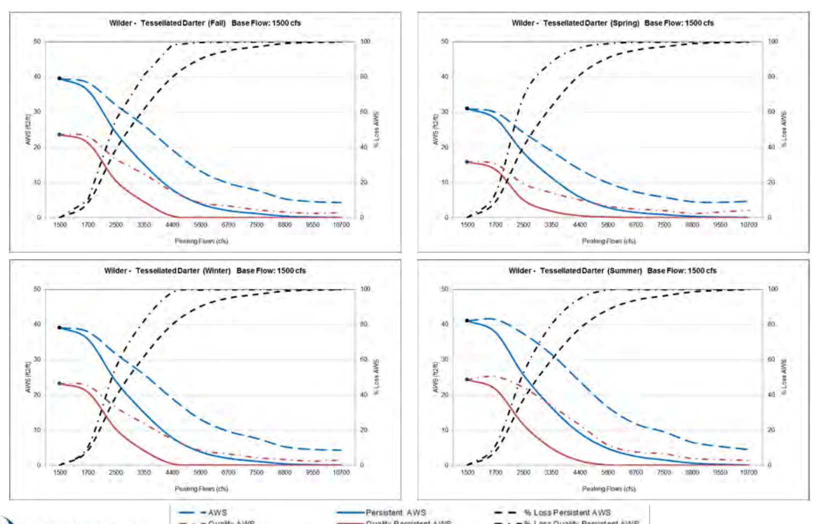
## Study 9 – Instream Flow Study: Dual Flow

Seasonal dual flow for Tessellated Darter (Wilder base flow 1,500 cfs)

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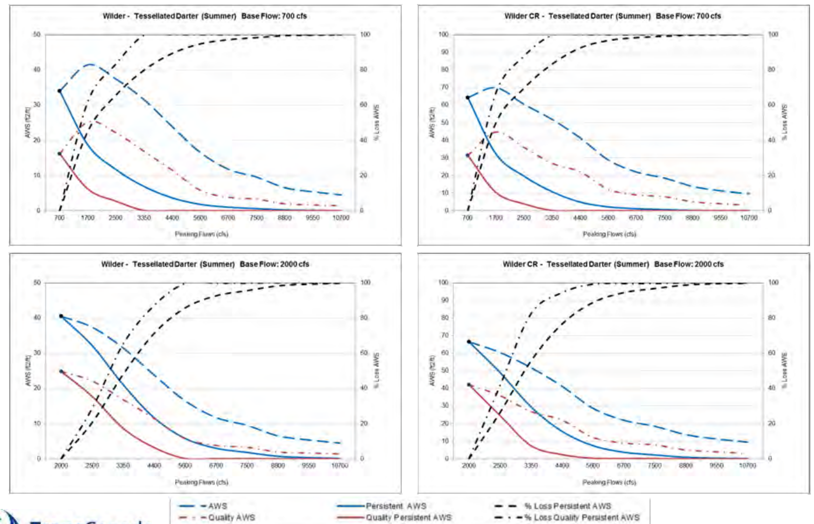
## Study 9 – Instream Flow Study: Dual Flow

Dual flow and CR dual flow for Tessellated Darter – Summer (Wilder base flows)

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## Study 9 – Instream Flow Study: Dual Flow

**Chase Island**



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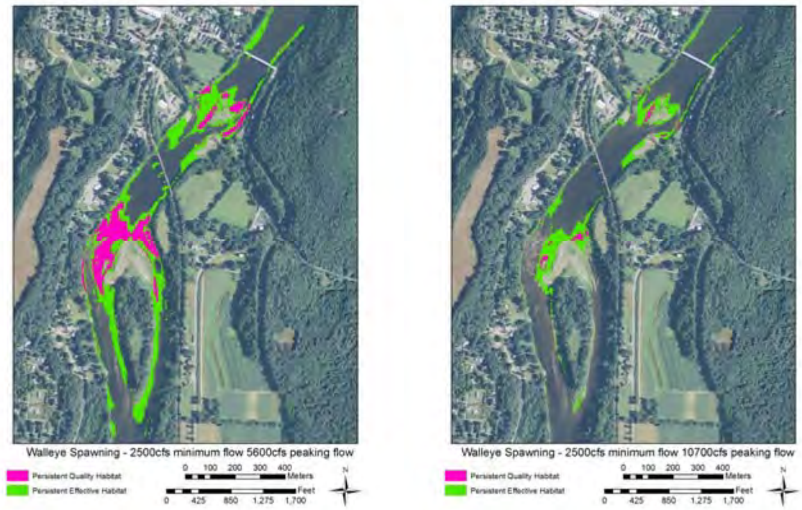
## Study 9 – Instream Flow Study: Dual Flow

**Chase Island**

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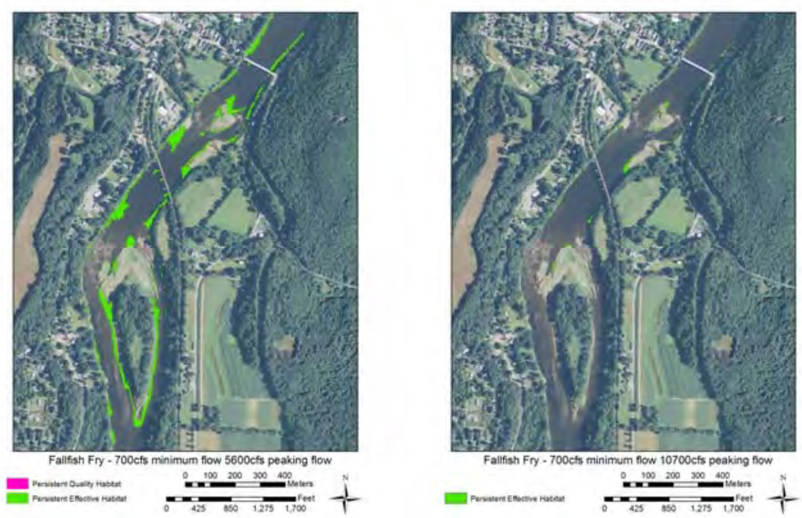
## Study 9 – Instream Flow Study: Dual Flow

**Chase Island**

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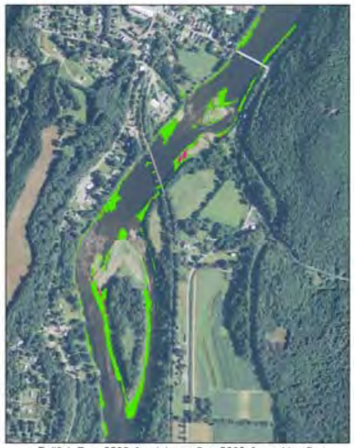
## Study 9 – Instream Flow Study: Dual Flow

**Chase Island**



Fallfish Fry - 2500cfs minimum flow 5600cfs peaking flow

Persistent Quality Habitat
Persistent Effective Habitat

Fallfish Fry - 2500cfs minimum flow 10700cfs peaking flow

Persistent Effective Habitat

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## Study 9 – Instream Flow Study

**Additions Since Interim Report (March 1, 2016)**

- Chase Island 2D site calibration and WUA
- Critical Reach Transects
- Habitat Time Series
- Dual Flow Analysis
- Habitat modeling of DWM and Co-occurring mussels
- Sea Lamprey spawning HSC modification

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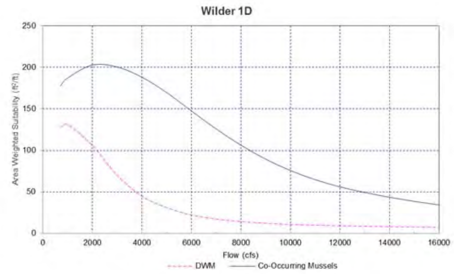
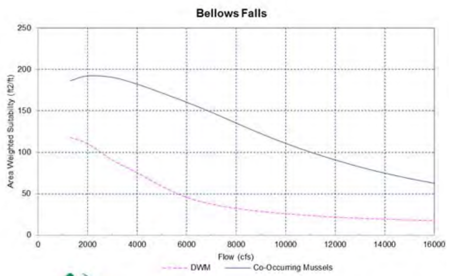
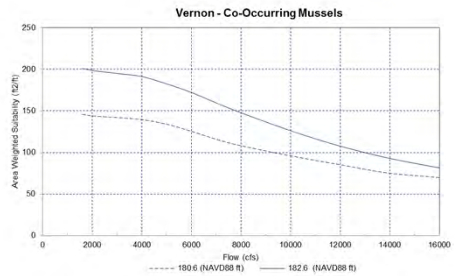
## Study 9 – Instream Flow Study: DWM and Co-occurring

**Wilder, Bellows Falls and Vernon**

- Only Co-occurring mussels run in Vernon reach

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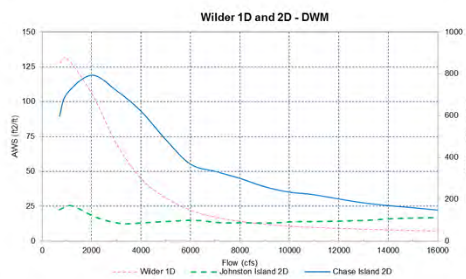
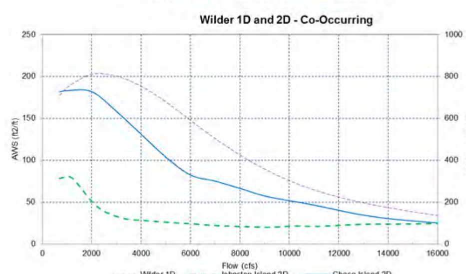
## Study 9 – Instream Flow Study: DWM and Co-occurring

**Wilder 1D and 2D**

- Note: DWM and Co-occurring mussels have relatively flat curves for the Johnston Island 2D site.

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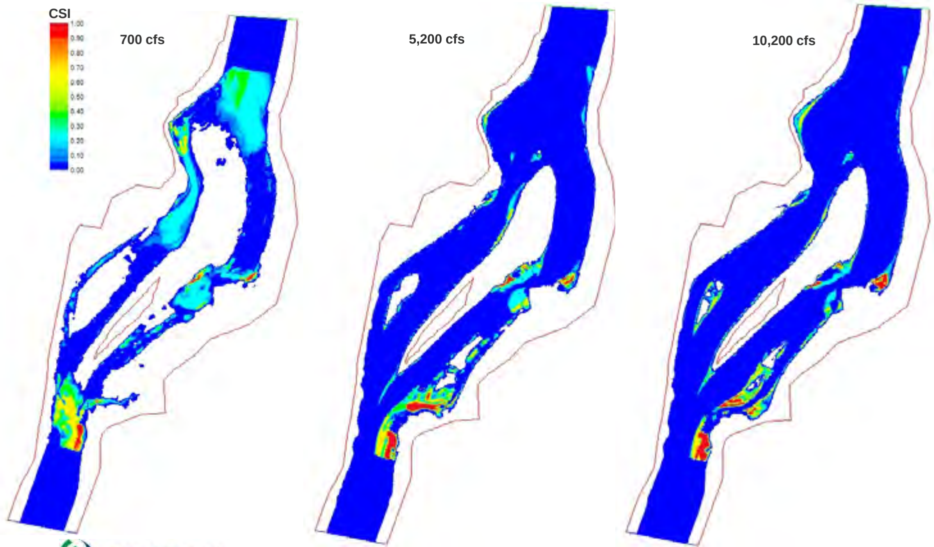
## Study 9 – Instream Flow Study: DWM and Co-occurring

**Johnston Island - DWM**

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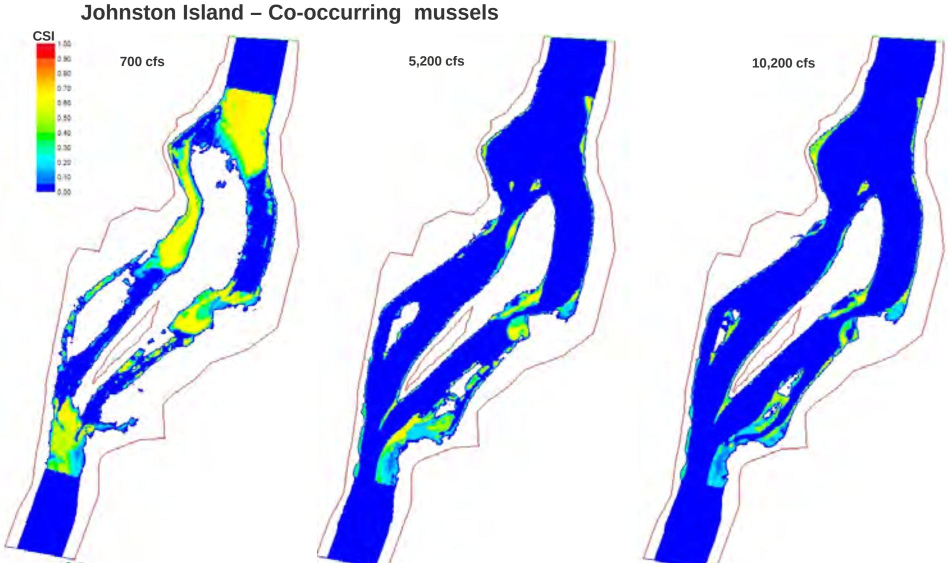
## Study 9 – Instream Flow Study: DWM and Co-occurring

**Johnston Island – Co-occurring mussels**

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## Study 9 – Instream Flow Study

**Additions Since Interim Report (March 1, 2016)**

- Chase Island 2D site calibration and WUA
- Critical Reach Transects
- Habitat Time Series
- Dual Flow Analysis
- Habitat modeling of DWM and Co-occurring mussels
- Sea Lamprey spawning HSC modification

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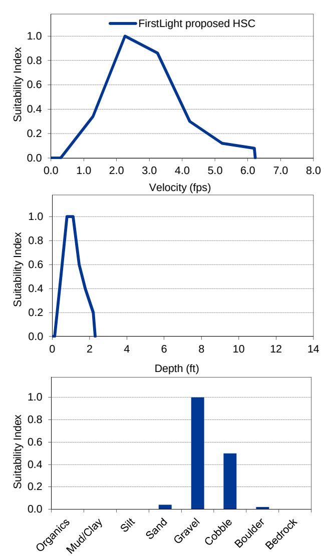
## Study 9 – Instream Flow Study

- **Evaluation of Proposed Lamprey HSC Curves**
  - FirstLight proposed HSC for Sea Lamprey spawning using pre-existing curves
  - FL curves were based on Kynard & Horgan (2013) and Yergeau (1983), as modified by FWS (2014)
  - FWS comments on FL instream flow report questioned whether the HSC based on the smaller source streams were representative of habitat suitability in the Connecticut River
  - FERC later recommended that FL modify the curves using site-specific data
  - TransCanada possessed more site-specific redd observations than FL and chose to propose modified HSC

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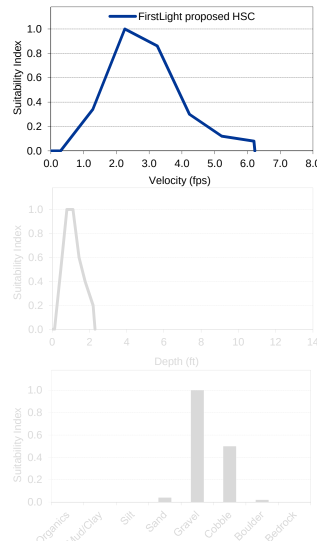
## Study 9 – Instream Flow Study

- **Evaluation of Proposed Lamprey HSC Curves**
  - Few lamprey redds were constructed at locations where velocities could be modeled over the range of flows experienced during nest building and egg incubation
  - Consequently the FL velocity HSC were not modified

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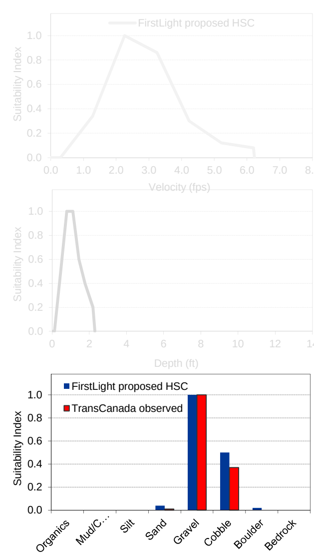
## Study 9 – Instream Flow Study

- **Evaluation of Proposed Lamprey HSC Curves**
  - Dominant substrate characterized at 49 lamprey redds in the TC study area were very similar to the FL HSC
  - Consequently the FL substrate HSC were not modified

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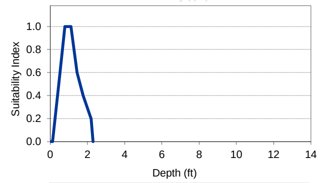
## Study 9 – Instream Flow Study

- **Evaluation of Proposed Lamprey HSC Curves**
  - o Depths at observed lamprey redds could be modeled over the period of nest building and incubation using either proximal water level loggers or HEC-RAS WSE modeling
  - o WSEs estimated using both data sources were compared to measured nest elevations to estimate depths over the expected duration of spawning and incubation (May 15-July 15)







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## Study 9 – Instream Flow Study

- **Evaluation of Proposed Lamprey HSC Curves**
  - o The location of 56 measured redds were compared to locations of proximal depth loggers and HEC-RAS nodes
  - o The relative frequency of depths over lamprey redds was assessed and compared between sources of WSE data

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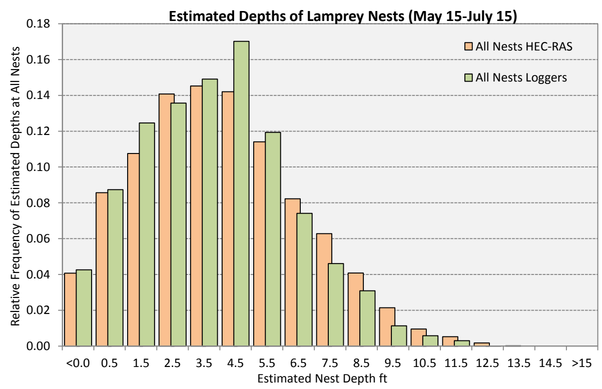
## Study 9 – Instream Flow Study

### Evaluation of Proposed Lamprey HSC Curves

- Minimal difference was observed between the two sources of WSE data

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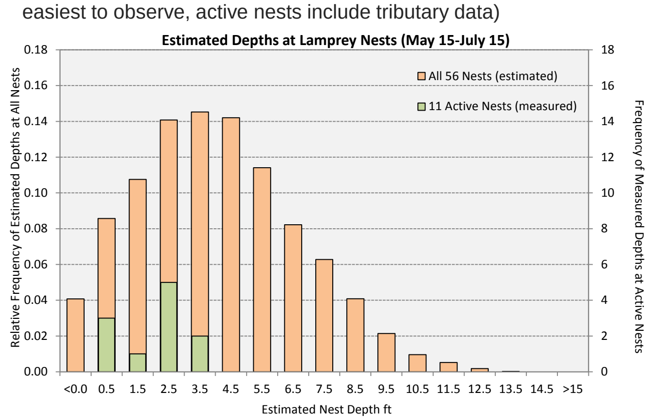
## Study 9 – Instream Flow Study

### Evaluation of Proposed Lamprey HSC Curves

- Measured depths at 11 active nests (with adult lampreys present) were shallower than modeled depths at the 56 nests (shallow nests were easiest to observe, active nests include tributary data)

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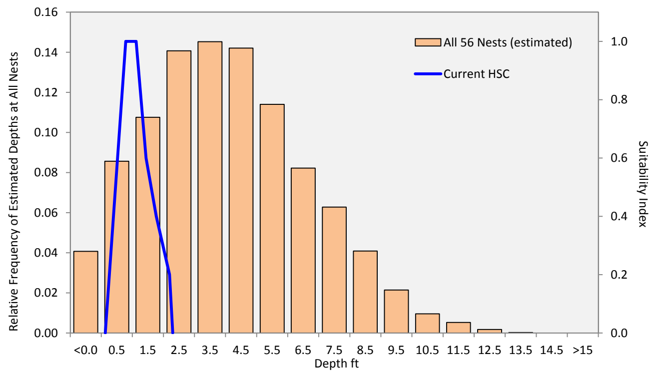
## Study 9 – Instream Flow Study

### Evaluation of Proposed Lamprey HSC Curves

- Comparison of estimated depths with the FL depth HSC showed large differences

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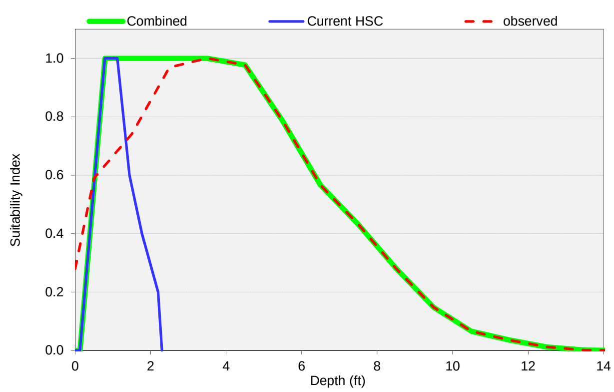
## Study 9 – Instream Flow Study

### Evaluation of Proposed Lamprey HSC Curves

- A combination of the two datasets seemed an appropriate way to represent depth suitability for lamprey spawning in the mainstem Connecticut River

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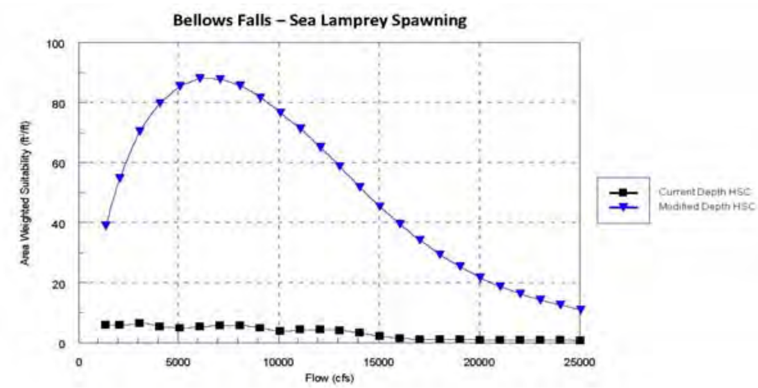
## Study 9 – Instream Flow Study: Sea Lamprey

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## Study 9 – Instream Flow Study

### Questions?

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