TRANSCANADA HYDRO NORTHEAST INC.

ILP Study 19
American Eel Downstream Passage Assessment

Final Study Report

In support of Federal Energy Regulatory Commission Relicensing of:

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)

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EXECUTIVE SUMMARY

The goal of this study was to assess whether operations at the Wilder, Bellows Falls, and Vernon Projects affect the safe and timely passage of adult silver phase American Eels (*Anguilla rostrata*) emigrating out of the Connecticut River. The objectives of this study were to quantify the movement rates, timing, and relative proportion of silver eels passing via various routes at the projects including through the turbines, the Bellows Falls bypassed reach, downstream passage facilities, and spillways; and to assess the instantaneous and latent mortality and injury of silver eels passed through each different turbine type at each project.

This final study report incorporates revised route selection telemetry data processing, analysis and results; additional data presentation in response to stakeholder comments on the initial study report filed May 16, 2016 and on FERC's September 12, 2016 Study Plan Determination; and adds clarifications as summarized in TransCanada's August 15, 2016 Response to Comments on the initial study report.

The study was conducted in the fall of 2015. Eels used in this study were procured from a source in Newfoundland, Canada and underwent pathology testing prior to importation. As a result of delays in fish collection and testing, the field portion of the study was delayed from August/September to late October.

Route Selection and Residency

This study was carried out between October 27, 2015 and January 22, 2016. A total of 170 radio-tagged silver American Eels were released in five groups from October 27 – November 5, 2015. Each project received 50 radio-tagged eels released in their impoundment (approximately 3 miles upstream of project). Due to two separate spill events occurring at Bellows Falls during the study an additional 20 eels were released into the Bellows Falls power canal. All releases were conducted in the afternoon and evening hours (13:40 - 20:05) and eel length ranged from 363 to 1,025 mm with an average of 795 mm.

Table ES-1 provides a summary of the study's passage data as described in the subsections below.

Table ES-1. Summary of silver American Eel passage through the Wilder, Bellows Falls, and Vernon projects, 2015.

Release Location:	Wilder Imp.	Bellows Falls Canal	Bellows Falls Imp.	Vernon Imp.	Total	
Project Passage Summary:						
Wilder	50				50	**No. released**
	48				48	**No. in study area**
	45 Units 1-2: 33 Unit 3: 7[a]/5 Sluice:2 Unknown: 5				**47[a]/45** Units 1-2: 33 Unit 3: 7[a]/5 Sluice: 2 Unknown: 5	**No. passed**
Bellows Falls		20	50		70	**No. released**
	29	20	49		98	**No. in study area**
	29 Units 1-3: 21 Sluice: 6 Spillway: 2	**20** Units 1-3: 19 Sluice: 1 Spillway: 0	**47** Units 1-3: 37 Sluice: 6 Spillway: 4		**96** Units 1-3: 77 Sluice: 13 Spillway: 6	**No. passed**
Vernon				50	50	**No. released**
	25	10	35	44	114	**No. in study area**
	25 Units 1-4: 4 Units 5-8: 9 Units 9-10: 6 Sluice: 0 Fish Pipe: 1 Fish Tube: 0 Fish Ladder: 0 Unknown: 5	**10** Units 1-4: 2 Units 5-8: 5 Units 9-10: 3 Sluice: 0 Fish Pipe: 0 Fish Tube: 0 Fish Ladder: 0 Unknown: 0	**34** Units 1-4: 4 Units 5-8: 15 Units 9-10: 10 Sluice: 1 Fish Pipe: 1 Fish Tube: 0 Fish Ladder: 0 Unknown: 3	**43** Units 1-4: 4 Units 5-8: 24 Units 9-10: 7 Sluice: 1 Fish Pipe: 2 Fish Tube: 1 Fish Ladder: 1 Unknown: 3	**112** Units 1-4: 14 Units 5-8: 53 Units 9-10: 26 Sluice: 2 Fish Pipe: 4 Fish Tube: 1 Fish Ladder: 1 Unknown: 11	**No. passed**

a. Two eels that entered Unit 3 were not later detected in the tailrace.

Wilder

Forty-eight of the 50 radio-tagged eels released at Wilder (96%) moved downstream and were detected in the Wilder forebay. Approximately 38% were detected in the forebay within eight hours following release and another 27% were detected the following evening, within approximately 24 hours after release. Forebay residency time ranged from less than 0.1 hour to over 16 days with an overall median of 0.2 hour. Forebay residency for eels that passed downstream ranged from less than 0.1 hour to 39.6 hours with the majority (79%) passing in four or fewer hours after initial detection. There were no statistically significant differences among mean forebay residency times for different passage routes.

Forty-seven of the 48 eels detected in the Wilder forebay entered passage routes and 45 ultimately passed downstream of the project (Table ES-1). The majority of those that passed used Units 1 and 2 (73.3%). Five individuals (11.1%) passed Unit 3 (two others that entered Unit 3 were not later detected in the tailrace), two (4.4%) used the trash/ice sluice, and five (11.1%) passed via unknown routes. Approximately 69% of eels that passed were detected within the Wilder tailrace for 8 or fewer hours following downstream passage. The majority passed downstream of Wilder during the evening and early night hours of 17:00 to 22:00. The remainder of passage events occurred during the early morning. Individuals did not necessarily pass downstream via the route with the greatest proportion of total project discharge at that time.

Bellows Falls

Twenty-nine eels that successfully passed Wilder reached the Bellows Falls study area and all subsequently passed Bellows Falls. Of the 50 eels released into the Bellows Falls impoundment, 49 (98%) reached the study area, with 50% present within eight hours following release. Forty-seven Bellows Falls impoundment releases (94%) passed the project (Table ES-1). All 20 eels released into the Bellows Falls power canal passed the project. For the majority of eels (84%) with known power canal residency duration and that subsequently passed, residency in the power canal was less than 3 hours.

A majority (80.2%) of the 96 eels that passed the project used the turbine units, 13.5% used the trash/ice sluice, and 6.3% used the dam spillway. Five of six eels that used the dam spillway did not pass during a spill event and it is suspected that leakage at the dam, largely as a result of damaged seals at the base or sill of the gate may have been sufficient for emigrating eels to navigate. There was no statistically significant difference between the mean power canal residency time for eels passing via the turbine units or via the trash/ice sluice. The median tailrace residency duration for eels that passed the project via the power canal was 0.1 hour and approximately 83% were detected within the Bellows Falls tailrace for 4 or fewer hours following downstream passage.

Three eels were detected in the Bellows Falls tailrace for a minimum of 46 days after passage and not later detected at Vernon. All three had passed downstream via the turbine units and were likely killed during passage equating to less than 4% turbine-related mortality. For eels that passed via the spillway, the median duration those individuals were present within the bypassed reach was 50.7 hours. One individual with a bypassed reach residency duration over 69 days, was still present in the reach at the conclusion of the study, and was likely a mortality. Excluding that individual median bypassed reach residency duration was 46.8 hours. The majority of eels passed Bellows Falls during the evening and early morning hours of 17:00 to 04:00. Passage via the downstream route with the greatest proportion of flow at the time of passage (primarily the turbine units) occurred 80.2% of the time; however, two eels passed via the spillway when spill flows were approximately equal to turbine flows. Overall, project operations at the determined time of passage for eels using the trash/ice sluice and dam spillway did not always coincide with significant discharge at those locations. It is suspected that there may have been enough leakage flow (not registered in flow monitoring data) to allow passage at times with recorded zero flow.

Vernon

A total of 112 eels passed Vernon (Table ES-1). Twenty-five Wilder released eels that successfully passed both Wilder and Bellows Falls reached the Vernon study area and all subsequently passed the project. Forty-five Bellows Falls released eels that successfully passed Bellows Falls reached the Vernon study area and 44 subsequently passed. Of the 50 eels released in the Vernon impoundment, 44 (88%) reached the study area and all but one subsequently passed.
Units 5 – 8 were the primary route of passage (47.3%). Twenty six (23.2%) eels passed via Units 9 and 10. Fourteen eels passed via Units 1 - 4 (12.5%). Four eels used the fish pipe, two used the trash/ice sluice, and one eel each used the fish tube and fish ladder exit. Forebay residency time ranged from less than 0.1 hour to over 34 days with an overall median of 0.2 hour. For the majority of eels (89%) that passed downstream of Vernon, forebay residency duration was less than 4 hours. There were no statistically significant differences between the mean forebay residency time for eels passing via different turbine routes (sample sizes for other routes were too small to analyze).

Approximately 69% of eels were detected in the Vernon tailrace for 4 or fewer hours following downstream passage. Six of the 112 passed eels were detected in the Vernon tailrace for 70 days or more after passage and were not subsequently detected downstream at Stebbins Island. These eels had passed downstream via the turbine units and were likely mortalities. Ten eels that passed via the turbine units had tailrace residency times between 2 and 49 days but were detected at Stebbins Island following that period. Project operations at the determined time of passage for eels using the trash/ice sluice did not coincide with significant discharge there. It is suspected that there may have been enough leakage flow (not registered in flow monitoring data) to allow passage at those times. Individuals did not necessarily pass downstream via the route with the greatest proportion of total project discharge at the time of passage. Passage via the downstream route with the greatest proportion of flow at the time of passage occurred 61.4% of the time.

Turbine Survival

Direct relative turbine survival and injury (at 1-hour and 48-hour) for silver American Eel were estimated in passage through Unit 2 at both the Wilder and Bellows Falls projects, and through Units 4, 8, and 9 at the Vernon project using the HI-Z tag fish recapture methodology. Units were selected to represent the variety of turbine types found at all three projects. Fish tagging, release, and recapture techniques were similar to those used for adult fish in previous studies at other projects. Fifty eels were used for each treatment condition along with 40 controls. Treatment eels were released through Kaplan turbines at Wilder Unit 2 and Vernon Unit 8, and Francis turbines at Wilder Unit 3, Bellows Falls Unit 2, and Vernon Units 4 and 9. Two treatment conditions (discharge rates) were tested at Vernon Unit 8, one treatment condition was tested at each of the other units. Wilder Unit 3 testing was curtailed due to poor recovery results and further investigation indicated that passage into the tailrace was blocked by the grating which serves to diffuse flow into the fish ladder. Discharge from Unit 3 serves as attraction water for the fish ladder. No results or further analysis is presented for Wilder Unit 3 in this report.

Recapture rates for the treatment eels ranged from 93.8% to 100%. All but one control eel was recaptured. The estimated immediate (1-hour) survivals were 80.0% (Wilder Unit 2), 100.0% (Bellows Falls Unit 2), 97.8% (Vernon Unit 4), 89.6% (Vernon Unit 8 at 1,000 cfs), 78.0% (Vernon Unit 8 at 1,700 cfs), and 97.9% (Vernon Unit 9). For all Vernon units combined, the estimated immediate (1- hour) survival was 91.1%. The estimated 48-hour survival values ranged from 62.0% (Wilder Unit 2) to 98% (Bellows Falls Unit 2) and for Vernon: 93.5% (Vernon Unit 4), 87.5% (Vernon Unit 8 at 1,000 cfs), 74.0% (Vernon Unit 8 at 1,700 cfs), and 97.9% (Vernon Unit 9). For all Vernon units combined, the estimated 48-hour survival was 88.0%.

Forty eight hour survival estimates were also calculated with only recaptured fish. These estimated 48-hour survival values ranged from 66.0% (Wilder Unit 2) to 98.0% (Bellows Falls Unit 2) and from 91.3% to 100% at the different Vernon units. This estimated 48-hour survival for all Vernon units was 92.8%.

All recaptured treatment fish were examined for injuries. The number of treatment fish that had visible injuries ranged from four (8.7%) for Vernon Unit 9, to 20 (42.6%) for Wilder Unit 2. One eel (2.2%) at Vernon Unit 8 (1,000 cfs) and one eel (2.3%) at Vernon Unit 8 (1,700 cfs) had visible injuries. Two eels displayed only loss of equilibrium (LOE), both for Vernon Unit 8. Two (5.3%) control fish had visible injuries and none displayed LOE. Fish free of visible injuries, having less than 20% scale loss per side and free of loss of equilibrium were designated with a malady-free status. Malady-free estimate rates were adjusted by any maladies incurred by control fish. The malady-free estimate for recaptured fish was 60.6% at Wilder Unit 2, 90.8% at Bellows Falls Unit 2, and 96.4% at Vernon Unit 9. The malady-free estimate for recaptured fish at all Vernon units combined was 78.2%.

The results of this survival study show that eels fare better passing through the tested Francis turbines compared with the tested Kaplan (propeller type) turbines. As such, eels passing the Francis units at Bellows Falls and the larger Francis units (Units 9 and 10) at Vernon should provide safe passage to most eels. The smaller Francis units (Units 1-4) at Vernon should also provide relatively high survival but would inflict some bruising. Lower passage survival is expected for eels passing the Wilder project and the Kaplan units at Vernon (units 5-8); of the two discharge rates tested at the Vernon Kaplan units, the lower showed greater survival.

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CI	Confidence Interval
CRWC	Connecticut River Watershed Council
FERC	Federal Energy Regulatory Commission
FirstLight	FirstLight Power Resources
FWS	U.S. Department of the Interior – Fish and Wildlife Service
NHDES	New Hampshire Department of Environmental Services
NHFGD	New Hampshire Fish and Game Department
RSP	Revised Study Plan
SE	Standard Error
TransCanada	TransCanada Hydro Northeast Inc.
TU	Trout Unlimited
USR	Updated Study Report
VANR	Vermont Agency of Natural Resources
VDEC	Vermont Department of Environmental Conservation
VFWD	Vermont Fish and Wildlife Department

1.0 INTRODUCTION

This final study report presents the findings of the 2015 assessment of American Eel Downstream Passage (ILP Study 19) conducted in support of Federal Energy Regulatory Commission (FERC) relicensing efforts by TransCanada Hydro Northeast Inc. (TransCanada) for the Wilder Hydroelectric Project (FERC Project No. 1892), Bellows Falls Hydroelectric Project (FERC No. 1855), and the Vernon Hydroelectric Project (FERC No. 1904).

This final study report incorporates revised route selection telemetry data processing, analysis and results; additional data presentation in response to stakeholder comments on the initial study report filed May 16, 2016 and on FERC's September 12, 2016 Study Plan Determination; and adds clarifications as summarized in TransCanada's August 15, 2016 Response to Comments on the initial study report.

Adult, or silver phase American Eels (*Anguilla rostrata*) emigrate during the mid-summer through late fall; a time of year when river flows are generally within the operating capacities of the Wilder, Bellows Falls, and Vernon projects except during high water events. Therefore, eels would likely pass the projects through the turbines, open fish passage facilities or spill gates (if open). Because silver eels are known to be present upstream of the Vernon and Bellows Falls projects, and potentially in the Wilder project, it is necessary to understand how they move downstream through the projects and to assess what level of injury or mortality may be caused by passage during emigration. In their study requests, U.S. Department of the Interior-Fish and Wildlife Service (FWS), New Hampshire Department of Environmental Services (NHDES), New Hampshire Fish and Game Department (NHFGD), Vermont Agency of Natural Resources (VANR), Trout Unlimited (TU) and Connecticut River Watershed Council (CRWC) identified these issues and requested a field study to identify project effects on emigrating silver phase American Eels.

The Revised Study Plan (RSP) was approved without modification (except to delay the study until 2015) in FERC's February 21, 2014 Study Plan Determination.

2.0 STUDY GOALS AND OBJECTIVES

TransCanada conducted this study in the fall of 2015 to assess whether Wilder, Bellows Falls or Vernon project operations affect the safe and timely passage of emigrating silver phase American Eels. The specific objectives of this study were to:

- quantify the movement rates, timing, and relative proportion of silver eels passing via various routes at the projects including through the turbines, the Bellows Falls bypassed reach, downstream passage facilities, and spillways; and

- assess instantaneous and latent mortality and injury of silver eels passed through each turbine type. This study was designed to estimate the direct (1-hour and 48-hour) survival and malady-free rates (eels without visible injuries and no loss of equilibrium) of adult American eels passing the Wilder, Bellows Falls, and Vernon projects using the HI-Z Turb'N (HI-Z) tag (Heisey et al., 1992) recapture technique. Survival and malady-free estimates were to be within ± 10%, 90% of the time. Survival and malady-free estimates were to be obtained near the settings the units are operating at most of the time to evaluate typical conditions.

3.0 STUDY AREA

The study area associated with assessing American Eel movement rates and passage encompassed the Wilder, Bellows Falls, and Vernon Project forebays, tailraces, turbines, downstream fish bypass routes, and spillways as shown in Figure 3.1 (upstream release locations for radio-tagged eels are shown as triangles in the figure).

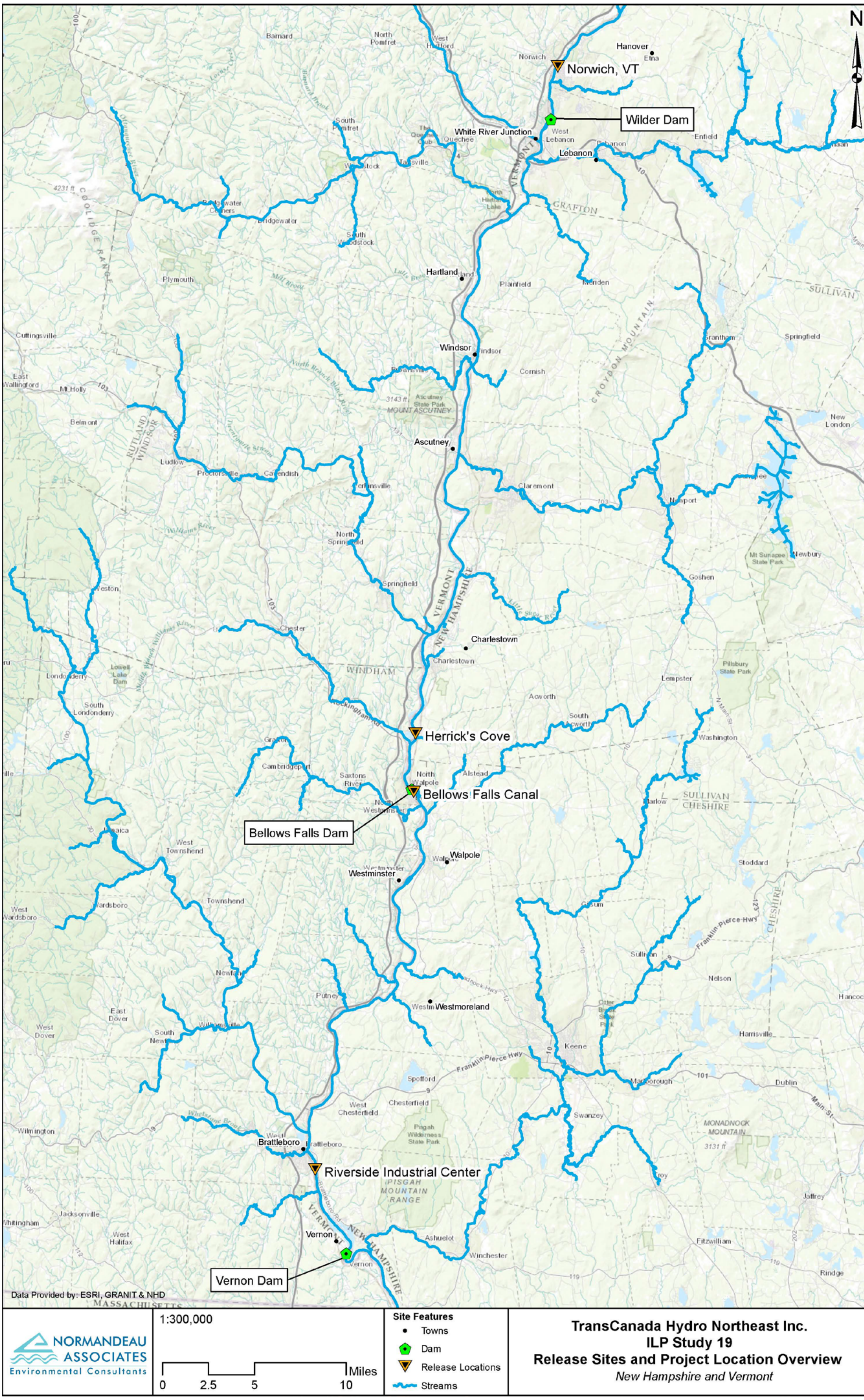

Figure 3.1. Study area.

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4.0 METHODS

American Eel downstream passage was assessed by radio tagging and systematically monitoring fish movements and passage through each of the routes through each of the projects. Downstream turbine passage survival and injury was assessed by using HI-Z mark/recapture methodology used on adult eels at other hydroelectric power stations (Normandeau, 2010; 2011a; and 2011b).

4.1 Source of Eels

The RSP anticipated collection of eels at either the Turners Falls or Holyoke bypass samplers as suggested by the resource agencies, or from out-of–basin if needed to meet the sample size requirements. On February 5, 2015, Normandeau staff on behalf of TransCanada notified NHFGD and Vermont Fish and Wildlife Department (VFWD) via email of concerns over collection of the needed number of in-basin eels as specified in the RSP. The only reliable source to collect the needed number of silver-phase American Eels in the Connecticut River Basin is the Holyoke Canal bypass sampler. Due to the large number of silver-phase American Eels needed to fulfill the requirements of relicensing studies for the TransCanada projects and FirstLight projects (Turners Falls, Northfield Mountain), and Conte Lab research, it was determined that no in-basin source would be sufficient. As a result, TransCanada and FirstLight proposed to import eels from out-of-basin sources and submit a sample for fish disease assessment prior to release into the Connecticut River. This issue was discussed in more detail at a working group consultation conference call on February 10, 2015 and comments and recommendations were provided by VFWD and NHFGD on March 25, 2015 and April 9, 2015, respectively.

TransCanada and FirstLight consultants jointly prepared and submitted to NHFGD, VFWD, and Massachusetts Department of Fish and Wildlife (MDFW) a “Plan for Implementation of Adult American Eels to the Connecticut River Basin in 2015” (Normandeau and Kleinschmidt, 2015) which proposed to procure eels from a source in Newfoundland, Canada that was likely to collect sufficient numbers, and proposed a series of pathogens tests and testing protocols. NHFGD and VFWD provided comments on the plan and additional recommendations on June 4, 2015, and Normandeau provided additional information in response on July 16, 2015 (to NHFGD) and July 17, 2015 (to VFWD). Kleinschmidt had similar interaction and communications with MDFW. All related documents and communications were included in Appendix C of the Updated Study Report (USR) filed on September 14, 2015.

All pathology tests conducted as part of eel importation had acceptable results and both states issued import permits after review of the pathology test reports (Appendix A). However, due to the need to import eels and the timing of their receipt, the study included a variance from the RSP in that route selection was delayed until late October rather than the expected start of the study in late August. Once pathology reports were received, fish were flown then trucked within 24 hours to the sites, where they received one or more days of onsite acclimation prior to the start of tagging and release. It does not appear that this delay compromised the study or study results in any meaningful way.

4.2 Route Selection and Residency Methodology

Proportional route selection, travel time, and forebay residency time for silver eel downstream passage was assessed by radio tagging and systematically monitoring tagged eel movement and passage through each of the three projects. Radio tags were surgically implanted into each specimen. Sigma Eight Inc. model TXPSC-1-450 tags were used for this study. Each tag was approximately 8.24 g in air, 62 mm in length, and 10 mm in height with a 12-inch whip antenna that propagated a signal. The tags used were calibrated for a 2.0-second burst rate and had a life expectancy of 361 days. Three radio frequencies were used and each release contained a proportionate number of tags in frequencies 150.340 MHz, 150.360 MHz, and 150.380 MHz. Each transmitter contained a unique pulse code to allow for individual fish identification.

Each of the three projects received 50 eels in five release groups of 10 eels each. Each group release occurred on the same day at all three projects (October 27, 29, and 31, November 3 and 5). All eels were released approximately 3 miles upstream of their respective project. In accordance with the RSP, since spill occurred at Bellows Falls during the study, an additional 20 eels were released in two groups directly into the Bellows Falls power canal on October 29 and 31. A total of 170 eels were used in the study.

Eels were selected for tagging by dip netting each individual from the holding tank (see Section 4.4 for details on holding procedures) to a tagging container filled with an anesthetic bath. After an appropriate exposure to the anesthetic the specimen was placed into a restraint for surgical implantation of the radio tag. An approximate 15-mm incision was made with a scalpel approximately 3-5 inches forward of the vent. Following an appropriate incision the sterilized radio tag was inserted and a cannula was used to fix the antenna into place through the abdomen wall. Following the insertion of the radio tag and antenna the incision site was then sutured. Once all sutures were completed the eel was placed into holding for 2-3 hours for recovery.

4.2.1 Wilder

Remote telemetry monitoring occurred at the Wilder forebay, fish ladder exit, trash/ice sluice, turbines, tailrace, and spillway (Figure 4.2-1). Radio receivers capable of monitoring multiple radio channels simultaneously at each location were coupled with appropriate antennas and calibrated to ensure adequate coverage of the individual sites monitored while minimizing overlap between the sites.

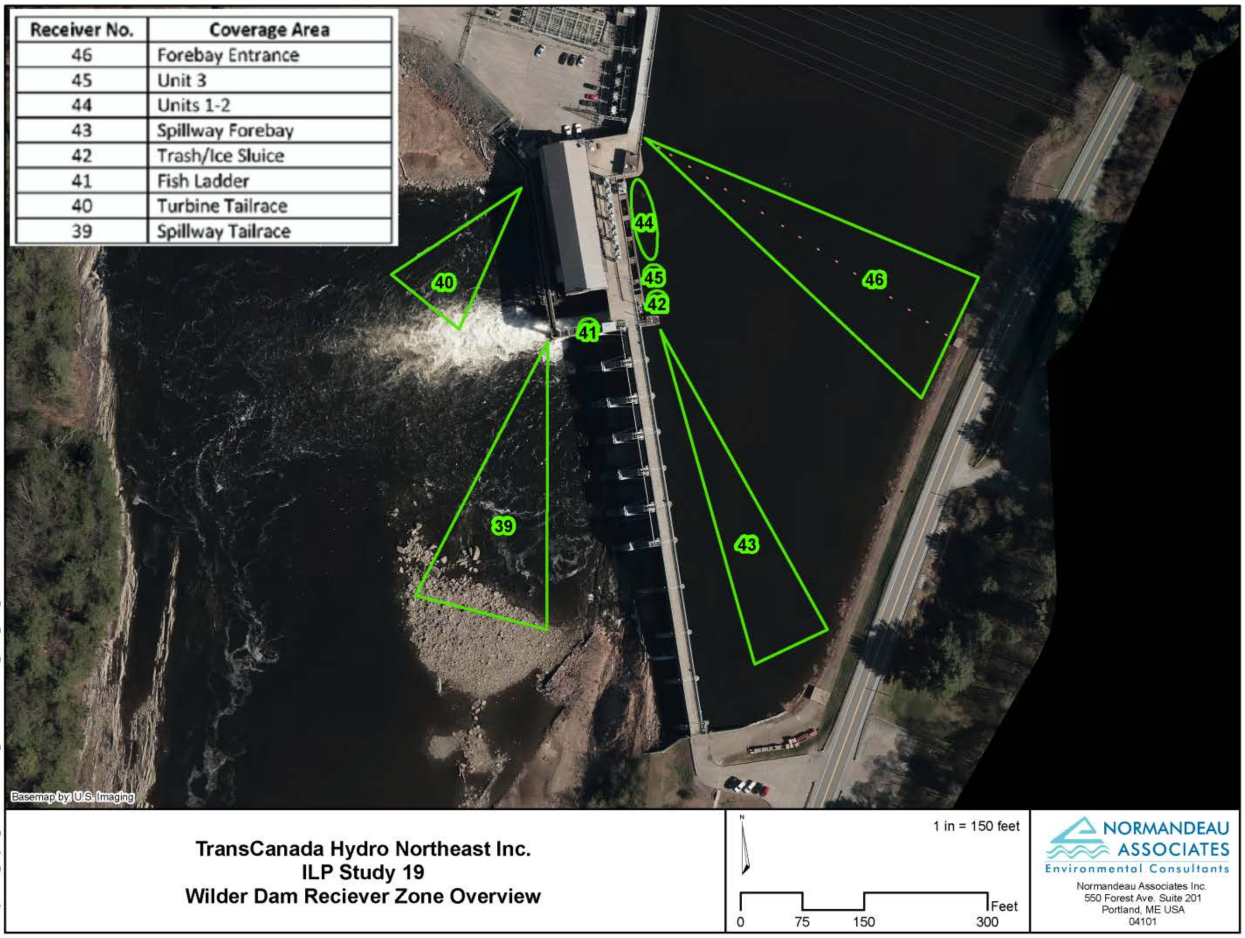


Figure 4.2-1. Wilder telemetry layout.

4.2.2 Bellows Falls

Remote telemetry monitoring occurred at the Bellows Falls power canal entrance, station forebay, turbines, fish ladder, and tailrace, and at the spillway dam and bypassed reach (Figure 4.2-2). Radio receivers capable of monitoring multiple radio channels simultaneously at each location were coupled with appropriate antennas and calibrated to ensure adequate coverage of the individual sites monitored while minimizing overlap between the sites.

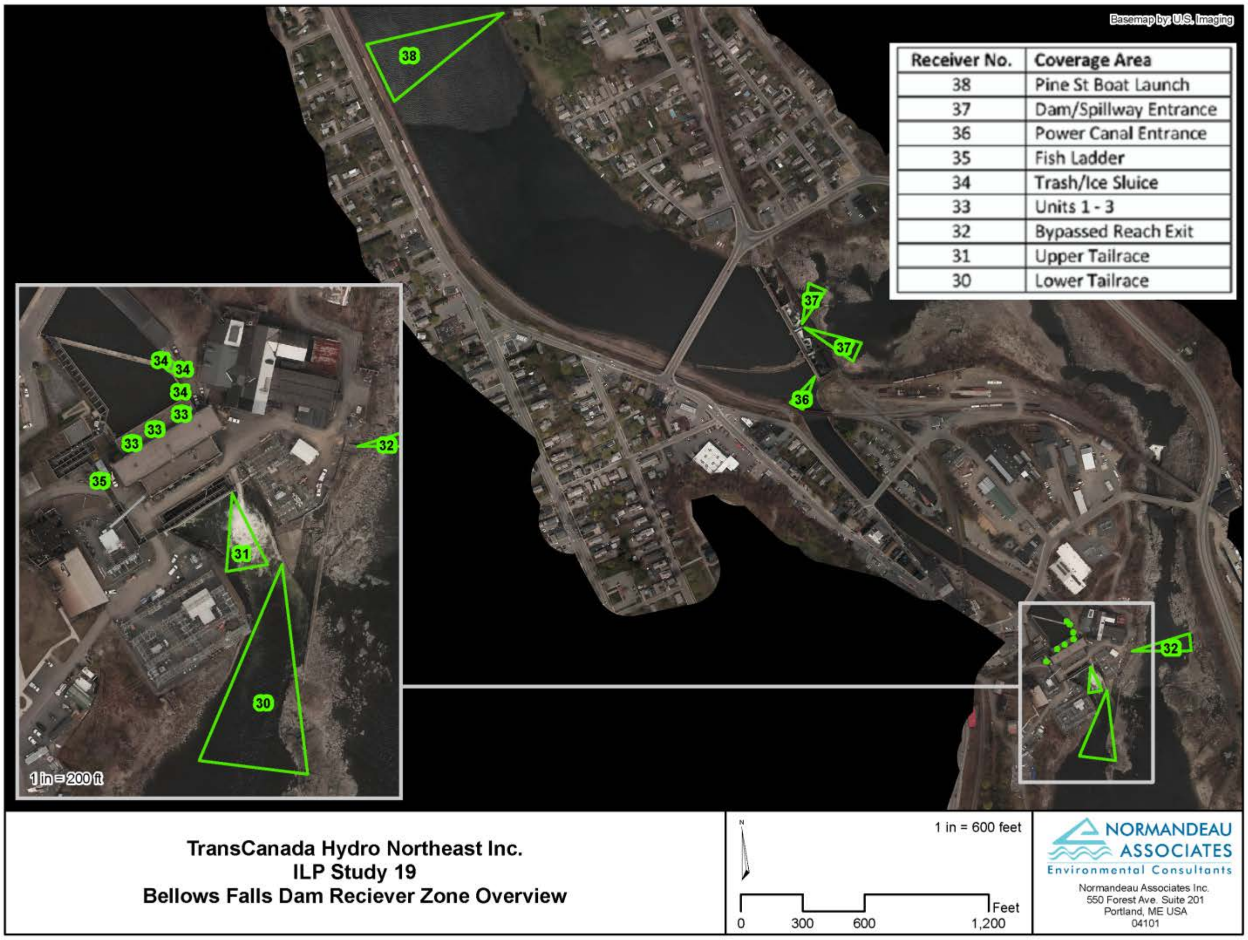


Figure 4.2-2. Bellows Falls telemetry layout.

4.2.3 Vernon

Remote telemetry monitoring occurred at the Vernon forebay, log boom and diversion boom, fish pipe, fish tube, fish ladder exit, turbines, tailrace, and spillway (Figure 4.2-3). Radio receivers capable of monitoring multiple radio channels simultaneously at each location were coupled with appropriate antennas and calibrated to ensure adequate coverage of the individual sites monitored while minimizing overlap between the sites.

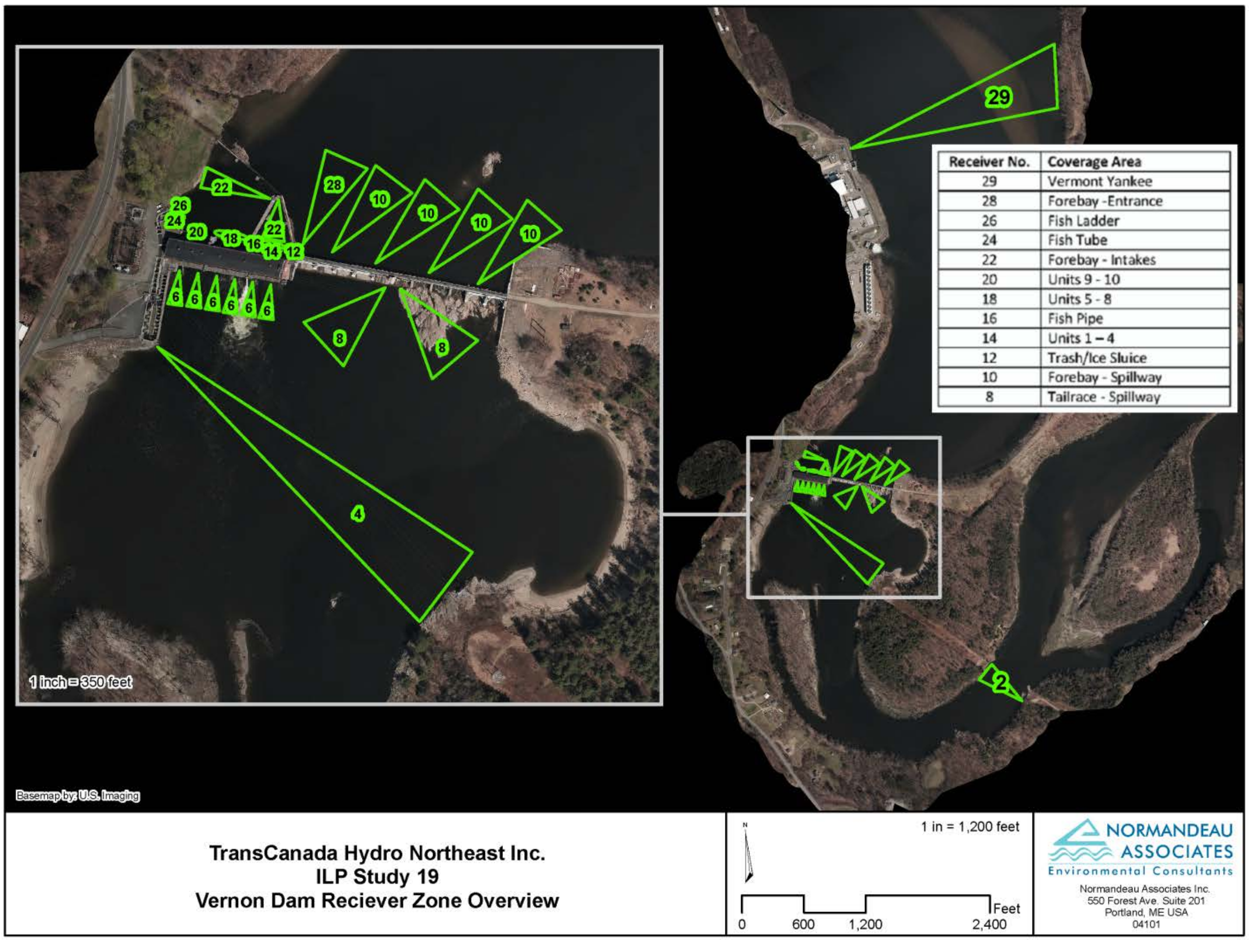


Figure 4.2-3. Vernon telemetry layout.

4.3 Turbine Survival (HI-Z Tag) Methodology

4.3.1 Procedures

To test adult American Eel survival through the projects, eels were released into the intakes of each type of turbine at each of the three projects. At Wilder, Units 2 and 3 were tested; Units 1 and 2 are similar Kaplan units, and Unit 3 is a smaller Francis unit. Bellows Falls has three similar Francis units and Unit 2 was tested. The ten units at Vernon are distinguished by type and size, Units 1 through 4 are smaller Francis units, 5 through 8 are Kaplan units, and 9 and 10 are larger Francis units. Vernon Units 4, 8, and 9 were tested. The Wilder Unit 3 test was suspended due to low recapture rates and the remaining eels used to test a second discharge rate at Vernon Unit 8. This unit was chosen because Vernon is likely to pass more eels since it is the most downstream of the three projects and Units 5 through 8 are generally first-on, last-off (see Section 4.4). Eels were captured after passage and the condition of each was examined. At the end of the 48-hour holding period, all alive and uninjured eels were released to the river. Survival and malady-free rates were estimated for each passage location with the exception of Wilder Unit 3. Descriptions of the observed injuries were recorded to help assess the probable causal mechanisms for injury/mortality (see Section 5.2, Tables 5.2.1-1 through 5.2.1-2, and 5.2.1-6).

The physical parameters of the turbine units are shown in Table 4.3.1-1. Operational parameters measured during the release of treatment adult eels through the designated units and control eels into the tailrace are presented in Table 4.3.1-2. No spill occurred at any project during turbine testing, although average project discharge includes upstream and downstream passage flows.

Table 4.3.1-1. Characteristics of turbines tested.

Project / Unit #	Turbine Type	Max discharge (cfs)	Discharge (cfs) at best efficiency	No. blades / buckets	RPM	Head (ft)	Runner diameter (ft)
Wilder Unit 2	Kaplan, adjustable blade, single runner	5,650	3,353	5 blades	112.5	49	15
Wilder Unit 3	Vertical Francis, single runner	825	745	14 buckets	212	58	6
Bellows Falls Unit 2	Vertical Francis, single runner	3,850	3,175	15 buckets	85.7	57	14.5
Vernon Unit 4	Vertical Francis, single runner	1,092	1,092	13 buckets	133.3	35	5.208
Vernon Unit 8	Vertical Kaplan, axial flow	1,860	1,178	5 blades	144	32	10.171
Vernon Unit 9	Vertical Francis, single runner	2,060	1,573	12 buckets	75	34	9.167

Table 4.3.1-2. Project operations during turbine survival testing.

Date	Average Project Discharge (cfs)[a, b]	Average Discharge from all Turbines (cfs)[a]	Average Discharge through tested Unit (cfs)[a]	Forebay Elevation (ft) (NVGD29)	Tailrace Elevation (ft) (NVGD29)	Gross Head (ft)
Vernon Unit 8 (test A)						
26-Oct	3,483	2,931	1,236	219.67	182.65	37.02
Vernon Unit 9						
27-Oct	2,629	2,093	1,308	219.66	182.45	37.22
Vernon Unit 4						
28-Oct	2,373	1,597	0,992	219.79	182.07	37.72
Vernon Unit 8 (test B)						
3-Nov	7,506	6,843	1,681	219.56	184.05	35.51
Bellows Falls Unit 2						
30-Oct	9,348	9,331	3,229	290.38	229.80	60.58
Wilder Unit 2						
1-Nov	5,495	5,468	4,748	383.15	329.75	53.40

a. Calculated from the daily start and end time of fish releases.
b. Includes discharges related to upstream and downstream fish passage only.
No spill occurred during testing at any unit.

4.3.2 Sample Size Calculations

Prior to initiating the turbine survival study, the sample size requirement was determined to fulfill the primary objective of obtaining survival estimates and malady-free rates within a pre-specified precision (ε) level. The sample size is a function of the recapture rate (P_A), expected passage survival ($\hat{\tau}$) or mortality (1-$\hat{\tau}$), survival of control eels (S), and the desired precision (ε) at a given probability of significance (α). In general, sample size requirements decrease with an increase in control eels surviving and being malady-free, and an increase in recapture rates (Mathur *et al*. 1996, 2000). Only precision and the probability of significance level can be strictly controlled by an investigator. Results of other turbine direct survival studies on adult eels (Normandeau 2010; 2011a; 2011b) indicate a sample size of approximately 60 (50 treatment and 10 control) eels should be sufficient to attain survival estimates within ± 10%, 90% of the time, for the selected operating condition of the selected turbines at each project. This number assumes close to 100% control survival, a recapture rate of 95%, and expected passage survival and malady-free rates greater than 85% for a specific study.

At Wilder and Bellows Falls, 50 treatment eels were released within the project's Unit 2 intake and 10 control eels were released into the tailrace. At Vernon, a total of 194 treatment eels were released within the turbine intakes (48 at Unit 4; 48 at

Unit 8 at 1,000 cfs; 50 at Unit 8 at 1,700 cfs; and 48 at Unit 9) along with 19 control eels released into the tailrace (Tables 4.3.2-1 and 4.3.2-2).

Table 4.3.2-1. Required sample sizes for treatment and control fish releases for various combinations of control survival (S), recapture probability (PA), and turbine related mortality (1- $\hat{\tau}$) to obtain a precision (ε) of ≤±0.10 at 1-α =0.90.

Control Survival (S)[a]	Recapture Rate (P_A)	Turbine Mortality (1- $\hat{\tau}$)	Number of Fish
1.00	0.99	0.05	18
		0.10	29
		0.15	39
		0.25	55
	0.95	0.05	39
		0.10	49
		0.15	57
		0.25	70
	0.90	0.05	69
		0.10	76
		0.15	82
		0.25	90
0.95	0.99	0.05	45
		0.10	54
		0.15	107
		0.25	111

a. Table values also applicable for malady-free estimates.

Table 4.3.2-2. Schedule of released adult eels, October-November 2015. Combined controls released into the tailrace downstream of the three stations.

Lot No.	Date	Water Temp (°C)	Vernon				Bellows Falls	Wilder		Combined Controls	Actual Treatment Release[a]
			Unit 4	Unit 8 @ 1000 cfs	Unit 8 @ 1700 cfs	Unit 9	Unit 2	Unit 2	Unit 3[a]		
1E	10/26	8.4		48							50
2E	10/27	8.0				48				10	50
3E	10/28	8.3	48							9	50
4E	10/30	7.7					50			10	53
5E	10/30	7.7							10		10
6E	11/01	7.5						50		10	50
7E	11/03	9.1			50						50
Total			**48**	**48**	**50**	**48**	**50**	**50**	**10**	**39**	**313**

a. Wilder Unit 3 eels not used in analysis.

4.3.3 Tagging and Release

Procedures for handling, tagging, release, and recapture of eels were similar for treatment and control groups. Eels were randomly selected from the holding tanks (see Section 4.4 for details on holding) located on the intake deck using dip nets and transported in pails or tubs to the tagging site.

In order to bring large adult eels to the surface for rapid recapture, three to six HI-Z balloon tags were attached with a small cable tie through the musculature at two or three locations along the eel's back via a curved cannula needle. Radio tags were attached in combination with one of the HI-Z tags to aid in tracking released eels. Specially designed eel restraint devices developed and built by Normandeau aided in tagging treatment and control eels (Figures 4.3.3-1 and 4.3.3-2).

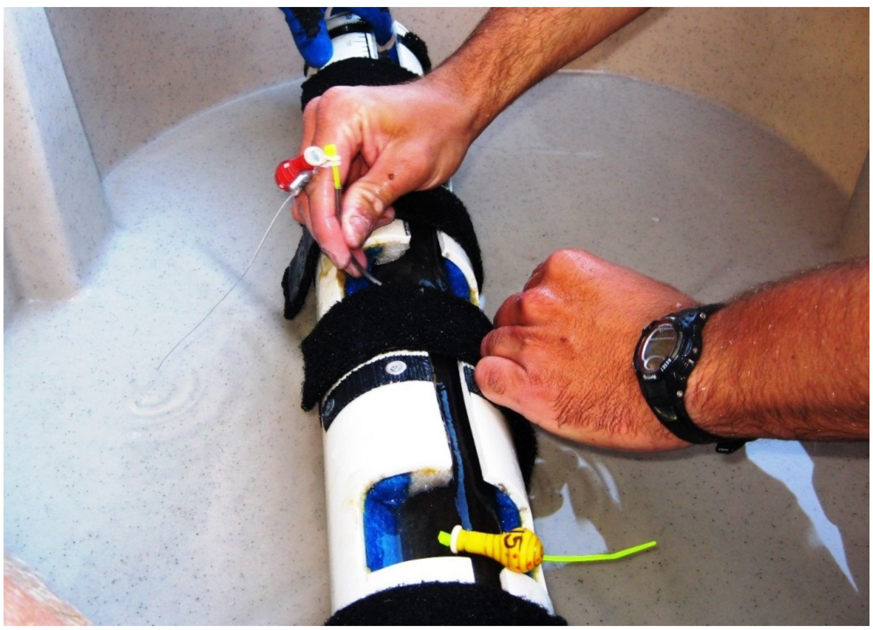


Figure 4.3.3-1. Cannula used to attach HI-Z tags and radio tags to adult American Eels.

Figure 4.3.3-2. Restraining device used to aid in HI-Z tagging with eel ready for release through the induction system.

Eels were individually marked and identified with small numbered Floy tags. The tubular Floy tags were inserted into musculature near the anterior region of the dorsal fin. Just prior to release, the HI-Z tags were activated by injecting a small amount of water into each HI-Z tag, which causes the tags to inflate in approximately 2 to 4 minutes. Tags were activated while the eel was still in the restraining device (Figure 4.3.3-3).

Figure 4.3.3-3. Injecting catalyst into a HI-Z tag attached to an adult American Eel.

All treatment eels were released through an induction apparatus. The induction apparatus was connected to 4-inch diameter hoses which allowed the eels to pass freely to the desired release points for treatment eels at each project. The release hose was lowered behind the trash racks to a point below the ceiling of the intake to ensure the eels passed through the turbine. The induction system and each release hose had a continuous supply of river water supplied by a 3-inch trash pump to ensure eels were transported quickly to the desired release point. Control eels were released through an identical induction apparatus attached to a 4-inch diameter flexible hose approximately 50 feet long that released eels into the tailrace (Figures 4.3.3-4 – 4.3.3-8).

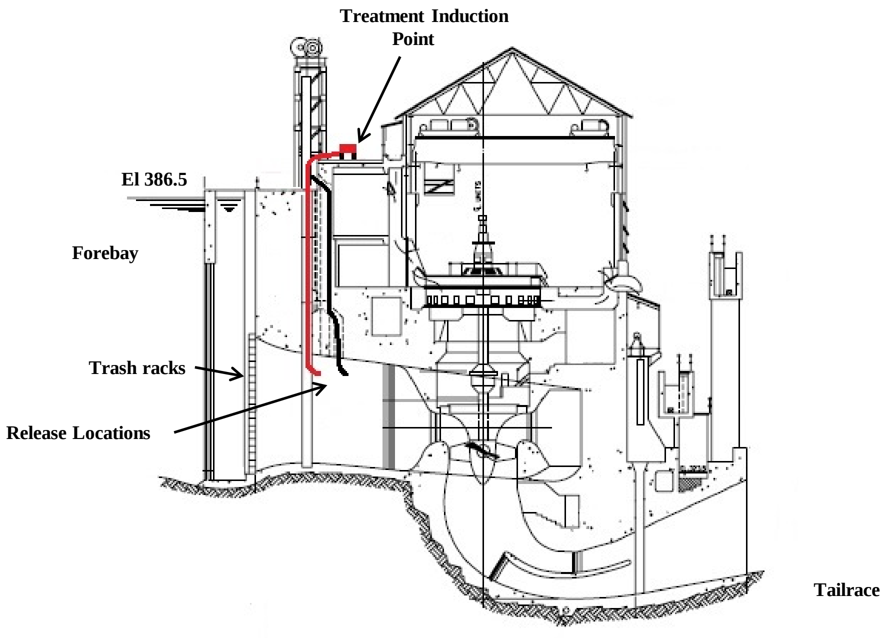


Figure 4.3.3-4. Schematic of Wilder Unit 2 showing approximate location of the treatment induction system and the terminus of the release hose (red line) and the release hose deployment configuration through a vent pipe for Unit 3 (black line).

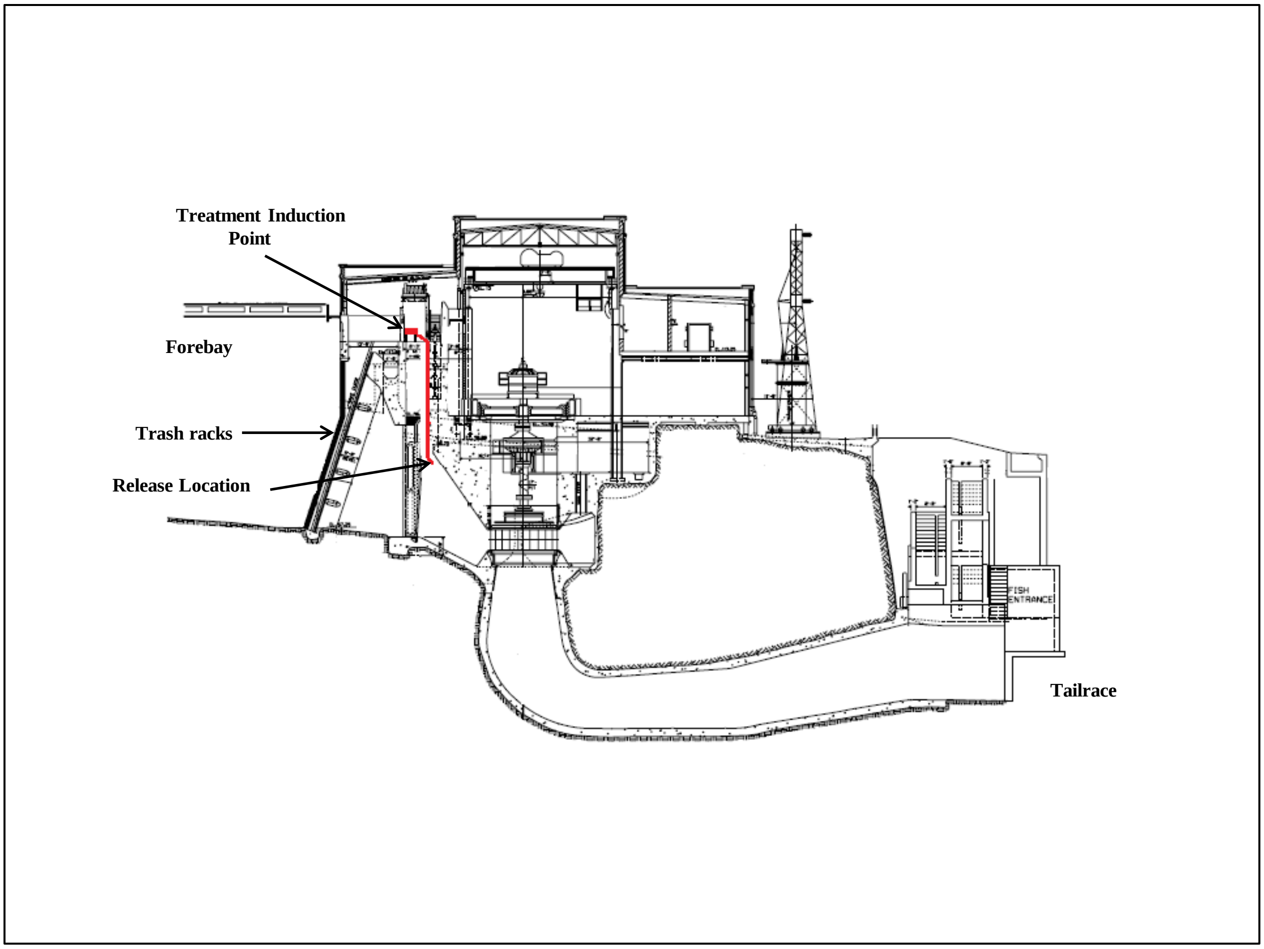


Figure 4.3.3-5. Schematic of Bellows Falls Unit 2 showing approximate location of the treatment induction system and the terminus of the release hose (red line).

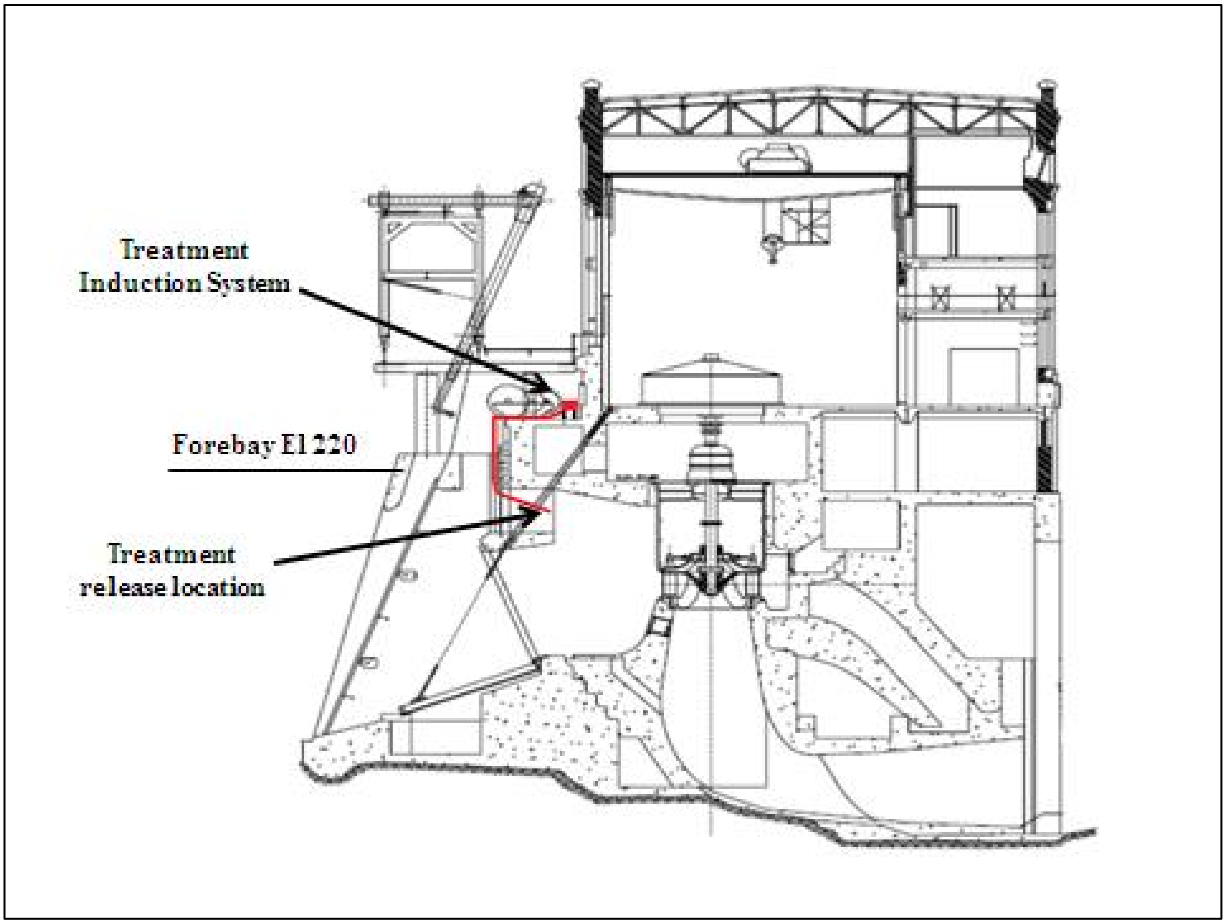


Figure 4.3.3-6. Schematic of Vernon Unit 4 showing approximate locations of the treatment induction system and the terminus of the release hose (red line).

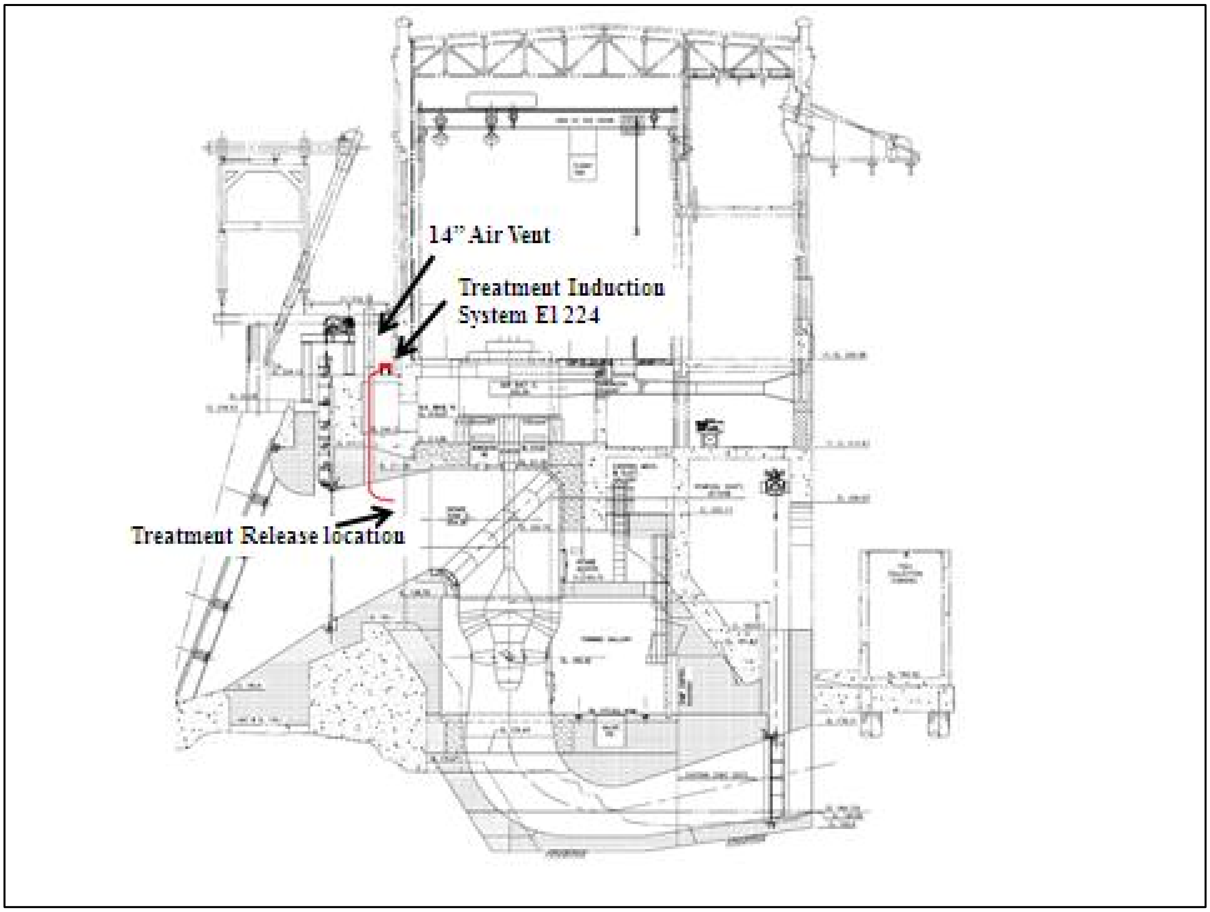


Figure 4.3.3-7. Schematic of Vernon Unit 8 showing approximate locations of the treatment induction system and the terminus of the release hose (red line).

Figure 4.3.3-8. Control induction system and release hose used to release HI-Z tagged adult American Eels.

4.3.4 Recapture Methods

After release (either as treatment or control), the eels were tracked by radio telemetry and then retrieved when buoyed to the surface downstream of the projects by one of three recapture boat crews. Boat crews were notified of the radio tag frequency of each eel upon its release. Radio signals were received on a loop antenna coupled to an Advanced Telemetry System receiver. The radio signal transmission (48 or 49 MHz) enabled the boat crews to follow the movement of each eel after passage and position the boats downstream for retrieval when eels were buoyed to the surface. Recaptured eels were placed into an on-board holding facility, and all tags were removed with the exception of the Floy tag. Each eel was immediately examined for maladies consisting of visible injuries and loss of equilibrium, and assigned appropriate condition codes. Tagging and data recording personnel were notified via a two-way radio system of each eel's recapture time and condition (Figure 4.3.4-1, Table 4.3.4-1).

Recaptured eels were transported to shore and held in 900-gal holding tanks to monitor delayed effects of tagging and turbine passage. The eels were held for 48 hours based on the protocol established for HI-Z tag assessment (Heisey et al., 1992) and laboratory studies conducted to assess shear effects on fish (Neitzel et al., 2000). Tanks were continuously supplied with ambient river water by two redundant pump systems connected to different electrical circuits. Water levels in the tanks were maintained at a minimum of 20 inches below the top of the tanks and the tanks were covered with netting or tarps to prevent eel escapement or predation. Eels that were alive at 48 hours and free of major injuries were released into the river (Figure 4.3.4-2).

Figure 4.3.4-1. Boat crew retrieving a HI-Z tagged adult eel. HI-Z tagged eel with balloons inflated can be seen in front of the boat.

Figure 4.3.4-2. Delayed assessment tanks used to monitor the 48-hour period following recapture of HI-Z tagged adult eels.

Table 4.3.4-1. Condition codes assigned to fish and dislodged HI-Z tags for fish passage survival studies.

Status Codes	Description
*	Turbine/passage-related malady
4	Damaged gill(s): hemorrhaged, torn or inverted
5	Major scale loss, >20%
6	Severed body or nearly severed
7	Decapitated or nearly decapitated
8	Damaged eye: hemorrhaged, bulged, ruptured or missing, blown pupil
9	Damaged operculum: torn, bent, inverted, bruised, abraded
A	No visible marks on fish
B	Flesh tear at tag site(s)
C	Minor scale loss, <20%
E	Laceration(s): tear(s) on body or head (not severed)
F	Torn isthmus
G	Hemorrhaged, bruised head or body
H	Loss of Equilibrium (LOE)
J	Major
K	Failed to enter system
L	Fish likely preyed on (telemetry, circumstances relative to recapture)
M	Minor
P	Predator marks
Q	Other information
S	Special describe as needed
R	Removed from sample
T	Trapped in the rocks/recovered from shore
V	Fins displaced, or hemorrhaged (ripped, torn, or pulled) from origin
W	Abrasion / Scrape

Status Codes	Description
Survival Codes	
1	Recovered alive
2	Recovered dead
3	Unrecovered – tag & pin only
4	Unrecovered – no information or brief radio telemetry signal
5	Unrecovered – trackable radio telemetry signal or other information
Dissection Codes	
1	Shear
2	Mechanical
3	Pressure
4	Undetermined
5	Mechanical/Shear
6	Mechanical/Pressure
7	Shear/Pressure
B	Swim bladder ruptured or expanded
D	Kidneys damaged (hemorrhaged)
E	Broken bones obvious
F	Hemorrhaged internally
J	Major
L	Organ displacement
M	Minor
N	Heart damage, rupture, hemorrhaged
O	Liver damage, rupture, hemorrhaged
R	Necropsied, no obvious injuries
S	Necropsied, internal injuries
T	Tagging/Release
U	Undetermined
W	Head removed; i.e., otolith

4.3.5 Classification of Recaptured Adult Eels

As in previous investigations, (Mathur et al., 1996; 2000; Normandeau, 2010; 2011a; 2011b; Normandeau and Skalski, 1998; 2005; North/South Consultants Inc. and Normandeau, 2007; 2009) the immediate post-passage status of an individual recaptured eel and recovery of inflated tags dislodged from eel were designated as either alive, dead, or unknown. The following criteria were used to make these designations: (1) alive—recaptured alive and remaining so for 1 hour; (2) alive—eel did not surface but radio signals indicated movement patterns (an un-recaptured eel was also classified as alive if no HI-Z tags were recaptured, and based on telemetry information the eel appeared to have moved into underwater structures that prevented the HI-Z tags from buoying it to the surface); (3) dead—recaptured dead or dead within 1 hour of release; (4) dead—only inflated dislodged tag(s) were recovered, and telemetric tracking or the manner in which inflated tags surfaced was not indicative of a live eel; and (5) unknown—no eels or dislodged tags were recaptured, or radio signals were received only briefly, and the subsequent status could not be ascertained.

Per the RSP eels that were not recovered (criteria 2, 4 and 5) were to be censored from the data set.

Mortalities of recaptured eels occurring after 1 hour were assigned 48-hour post-passage effects although eels were observed at approximately 12-hour intervals during the 48-hour delayed holding period. Dead eels were examined for maladies, and those that died without obvious injuries were necropsied to determine the probable cause of death. Additionally, all specimens alive at 48 hours were closely examined for injury. An initial examination of the eels when captured allowed detection of some injuries, such as bleeding and minor bruising that may not be evident after 48 hours due to natural healing processes (Figure 4.3.5-1).

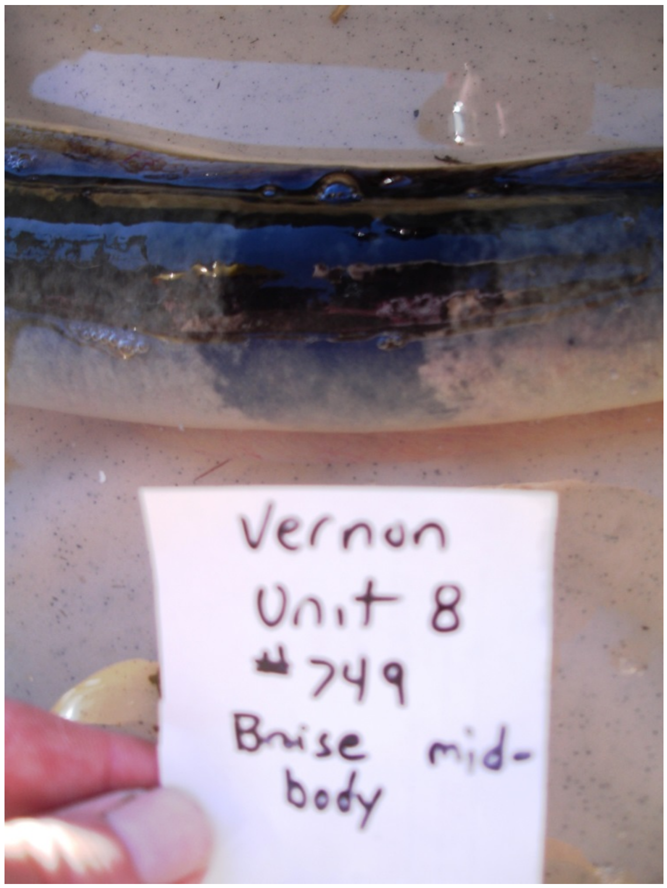


Figure 4.3.5-1. Eel with minor bruising after passing through Vernon Unit 8.

4.3.6 Assessment of Injuries

All recaptured eels, dead or alive, were examined for the type and extent of external injuries. Dead eels were also necropsied and examined for internal injuries when there were no apparent external injuries. Injuries were categorized by type, extent, and area of body. Eels without visible injuries that were not actively swimming or were swimming erratically at recapture were classified as having loss of equilibrium (LOE). This condition has been noted in most past HI-Z tag direct survival/injury studies and often disappears within 10 to 15 minutes after recapture if the eels are not injured. Visible injuries and LOE were categorized as minor or major. The criteria for this determination were based primarily on field staff's previous field observations (Tables 4.3.4-1 and 4.3.6-1).

A malady classification was established to include eels with visible injuries, and or LOE. Eels without maladies were designated "malady-free". The malady-free metric is established to provide a standard way to depict a specific passage route's effects on the condition of entrained eels (Normandeau and Skalski, 2005). The malady-free metric is based solely on eels physically recaptured and examined. Additionally, the malady-free metric in concert with site-specific hydraulic and physical data may provide insight into what passage conditions and locations provide safer eels passage.

Table 4.3.6-1. Guidelines for major and minor injury classifications for fish passage survival studies using the HI-Z Tags.

A fish with only Loss of Equilibrium (LOE) is classified as major if the fish dies within 1 hour. If it survives or dies beyond 1 hour it is classified as minor.
A fish with no visible external or internal maladies is classified as a passage related major injury if the fish dies within 1 hour. If it dies beyond 1 hour it is classified as a non-passage related minor injury.
Any minor injury that leads to death within 1 hour is classified as a major injury. If it lives or dies after 1 hour it remains a minor injury.
Hemorrhaged eye: minor if less than 50%. Major if 50% or more
Deformed pupil(s) are a: major injury.
Bulged eye: major unless one eye is only slightly bulged. Minor if slight.
Bruises are size-dependent. Major if 10% or more of fish body per side. Otherwise minor.
Inverted or bleeding gills or gill arches is major
Operculum tear at dorsal insertion is: major if it is 5 % of the fish or greater. Otherwise minor.
Operculum folded under or torn off is a major injury
Scale loss: major if 20% or more of fish per side. Otherwise minor
Scraping (damage to epidermis): major if 10% or more per side of fish. Otherwise minor.
Cuts and lacerations are generally classified as major injuries. Small flaps of skin or skinned up snouts are: minor.
Internal hemorrhage or rupture of kidney, heart or other internal organs that results in death at 1 to 48 hours is a major injury.
Multiple injuries: use the worst injury

4.3.7 Survival and Malady-Free Estimation

In order to obtain the survival estimate comparable to other HI-Z tag direct survival studies and to follow the guidelines of the RSP, survival estimates were calculated for all eels (including criteria 2, 4 and 5, see Section 4.3.5) and also with only recaptured eels. All controls were combined from the three projects for the survival and injury analysis, the typical procedure unless there are differences in survival rates for control fish released at different locations for a given study.

The release and recapture data were analyzed by a likelihood ratio test to determine whether recapture probabilities were similar for dead (P_D) and alive (P_A) fish (Mathur et al., 1996). The statistic tested the null hypothesis of the simplified model (Ho: P_A=P_D) versus the alternative generalized model (Ha: $P_A \neq P_D$). The simplified model has three parameters (P, S, τ) with three minimum sufficient statistics (a_c, a_T, d_T) while the alternative generalized model (recapture probabilities of alive and dead fish are unequal) has four parameters (P_A, P_D, S, τ) and four minimum sufficient statistics (a_c, a_T, $d_{c,}$ d_T). If homogeneity ($P > 0.05$) was revealed by the chi-square test, turbine passage survival can be estimated by the simplified model with increased precision. Appendix B also provides the definition of terms, derivation of likelihood estimates, and assumptions of the likelihood model. The maximum likelihood estimators associated with the model are:

$$\hat{\tau} = \frac{a_T R_C}{R_T a_C}$$

$$\hat{S} = \frac{R_T d_C a_C - R_C d_T a_C}{R_C d_C a_T - R_C d_T a_C}$$

$$\hat{P}_A = \frac{d_C a_T - d_T a_C}{R_T d_C - R_C d_T}$$

$$\hat{P}_D = \frac{d_C a_T - d_T a_C}{R_C a_T - R_T a_C}$$

The variance (Var) and standard error (SE) of the estimated passage mortality ($1-\hat{\tau}$) or survival ($\hat{\tau}$) are:

$$Var(1-\hat{\tau}) = Var(\hat{\tau}) = \frac{\tau}{SP_A}\left[\frac{(1-S\tau P_{A)}}{R_T} + \frac{(1-SP_A)\tau}{R_C}\right]$$

$$SE(1-\hat{\tau}) = SE(\hat{\tau}) = \sqrt{Var(1-\hat{\tau})} \ .$$

Separate survival probabilities (1 and 48 h) and malady-free rates and their associated standard errors were estimated using the likelihood model given in Mathur *et al*. (1996) and Normandeau Associates Inc. and Skalski 1998 (Appendix B). The formulas follow:

Direct Survival, 1 and 48 h

Where:

$$\hat{\tau}_i = \frac{a_{Ti} R_c}{R_{Ti} a_c},$$

R_{Ti} = Number of eels released for the ith treatment condition (i = 1,..., 9);

a_{Ti} = Number of eels alive for the ith treatment condition (i = 1,...,9);

R_c = Number of control eels released;

a_c = Number of control eels alive;

Malady-Free (MF) Eels

Where:

$$MF_i = \frac{c_{Ti} R_c}{R_{Ti} c_c},$$

C_{Ti} = Total number of eels without maladies for treatment i (i = 1,...,9);

R_{Ti} = Number of eels recovered that were examined for maladies for treatment i

(i = 1,...,9);

C_c = Number of control eels recovered without maladies;

R_c = Number of control eels recovered that were examined for maladies.

Eels that were still alive at 48 hours but had injuries that would eventually lead to death or prevent them from migrating to the ocean (e.g., tail severed, multiple backbone fractures) were considered functionally dead when calculating the 48-hour survival estimates (Figure 4.3.7-1).

Figure 4.3.7-1. American Eel considered functionally dead. Eel was alive at 48 hours, but had a completely severed tail.

4.3.8 Assignment of Probable Sources of Injury

Limited controlled experiments (Neitzel et al., 2000; Pacific Northwest National Laboratory et al., 2001) to replicate and correlate each injury type/characteristic to a specific causative mechanism provide some indication of the cause of observed injuries in the field. However, these experiments were conducted primarily on salmonids and not eels. Some injury symptoms can be manifested by two different sources that may lessen the probability of accurate delineation of a cause and effect relationship (Eicher Associates, 1987). Only probable causal mechanisms of injury were assigned for this study.

Some injuries (e.g., sliced bodies) may be assigned to a specific causative source with greater certainty (Normandeau et al., 1995). Injuries likely to be associated with direct contact with turbine runner blades or structural components are classified as mechanical and include: bruise, laceration, and severance of the eel's body (Figure 4.3.8-1) (Dadswell et al., 1986; Eicher Associates, 1987; Normandeau, 2010; 2011a; 2011b). Passage through gaps between the runner blades and the hub or at the blade tips may result in pinched bodies (Normandeau et al., 1995). Contact with the turbine structural components may result in bruising. Injuries likely to be attributed to shear forces for salmonids are decapitation, torn or flared opercula, and hemorrhaged eyes (Dadswell et al., 1986). However, shear induced injuries in eels are not well documented. The probable pressure-related effects are manifested as hemorrhaged internal organs and emboli in fins. Pressure-related forces can also cause bulging and hemorrhaged eyes. Statistical analyses are provided in Appendix B; daily tag-recapture data in Appendix C; and daily injury data in Appendix D.

Figure 4.3.8-1. American Eel with severed body after passing through Vernon Unit 8 (1,000 cfs).

4.4 Methods Specific to Each Project

4.4.1 Wilder

Eels were transported in a tank by truck from a holding tank at Vernon and delivered to a 900-gal holding tank at Wilder. The tank was located upstream on the head works of the dam to hold the eels prior to testing. An additional similarly-sized tank was located nearby to hold the eels after testing runs. Only eels determined to be in good physical condition were used. A continual supply of ambient river water was supplied to each tank and all eels were held for a minimum of 12-24 hours prior to tagging which allowed them time to recover from transport and handling stress.

Treatment eels were released through Kaplan Unit 2 and Francis Unit 3 (the minimum flow unit) approximately 5 ft below the ceiling of the turbine intake. Unit 2 eels were released through a head gate slot and Unit 3 eels were released through a vent pipe (Figure 4.3.3-4). Testing at Unit 3 was curtailed after the release of 10 eels when it was determined that most of the discharge from this unit was directed into the fish ladder and the features within the fish ladder prevented the recapture of seven of the ten eels. After consultation with TransCanada personnel, it was deemed that the egress pattern at Unit 3 would not permit the determination of reliable survival/injury estimates. The aquatics working group was notified of this RSP variance on November 13, 2015. The 50 treatment eels released to Unit 2 ranged in length from 710 to 1,005 mm, with an average of 821 mm. The 39 combined control eels released at Wilder, Bellows Falls, and Vernon ranged in length from 660 to 880 mm, with an average of 798 mm (Figure 4.4.1-1).

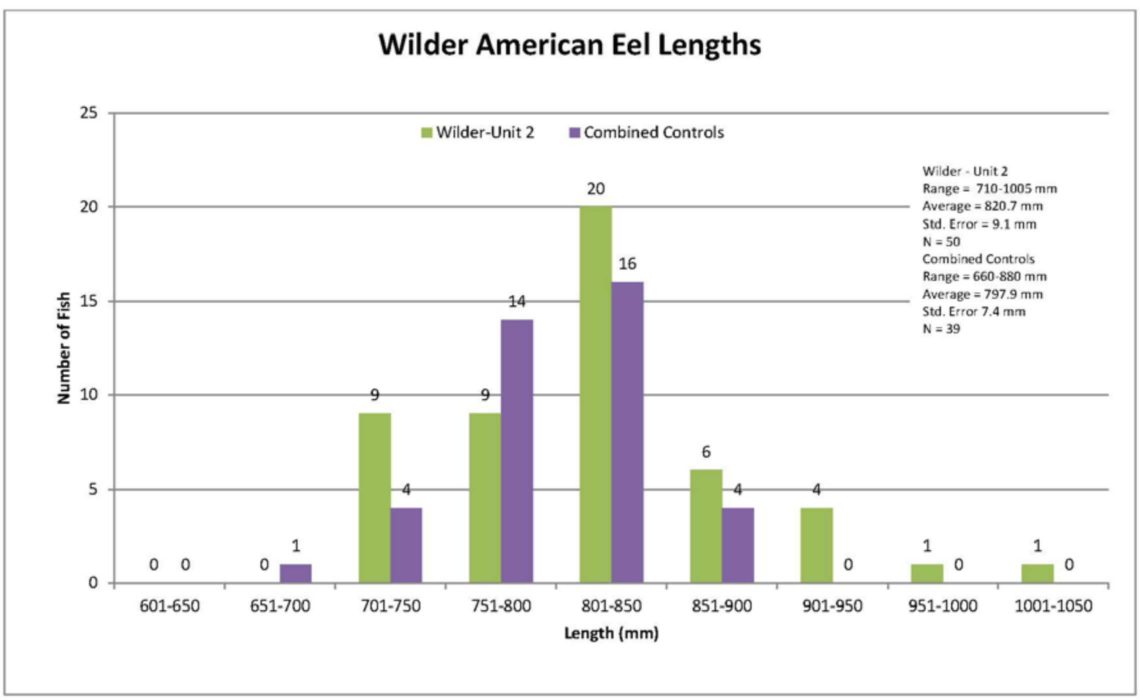


Figure 4.4.1-1. Length frequency for HI-Z tagged adult American Eels released at Wilder Station. Combined controls released at the three projects.

4.4.2 Bellows Falls

Eels were transported in a 100-gal tank by truck from Vernon and delivered to Bellows Falls the day of the test. The eels were taken directly from the transport truck to the tagging site throughout the day as needed. The transport/holding tank was supplied with aeration. A 900-gal holding tank was located on the downstream side of the power house to hold the eels for the 48-hour delayed assessment period. This tank was continuously supplied with ambient river water. The 50 treatment eels released ranged in length from 680 to 995 mm, with an average of 816 mm (Figure 4.4.2-1).

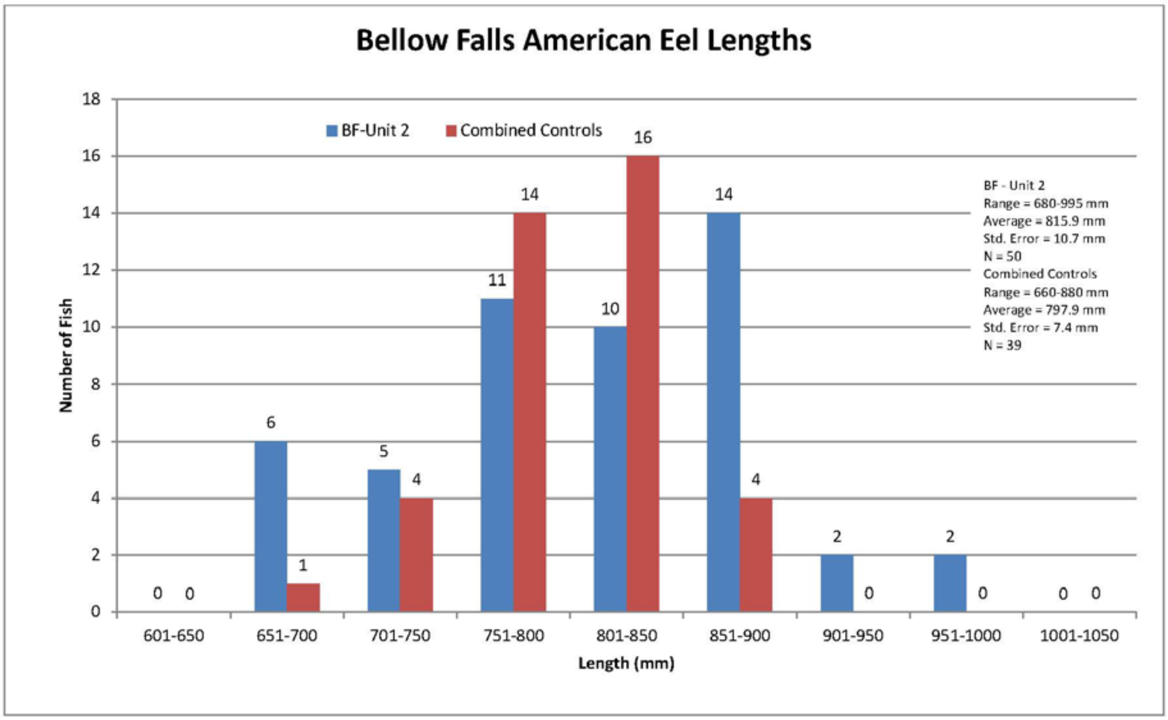


Figure 4.4.2-1. Length frequency for HI-Z tagged adult American Eels released at Bellows Falls Station. Combined controls released at the three projects.

4.4.3 Vernon

Eels were stocked in two approximately 900-gal holding tanks at Vernon. Details on the source of the eels and method of transport are described in Section 4.1. The eels tested at Wilder and Bellow Falls were subsequently removed from these two tanks at Vernon. The tanks were located upstream near the head works of the dam to hold the eels prior to testing. Two additional tanks were located on the tailrace deck to hold eels for the 48-hour delayed assessment after turbine passage. A continual supply of ambient river water was supplied to each tank and all eels were held for a minimum of 12-24 hours prior to tagging.

The 48-hour treatment eels released through Unit 4 ranged in length from 700 to 960 mm, with an average of 818 mm. At Unit 8 discharging 1,000 cfs, 48 treatment eels were released and ranged in length from 680 to 1,040 mm with an average of 813 mm. At Unit 8 discharging 1,700 cfs, 50 treatment eels were released and ranged in length from 700 to 950 mm with an average of 795 mm. The 48 treatment eels released through Unit 9 ranged in length from 650 to 930 mm, with an average of 796 mm (Figure 4.4.3-1).

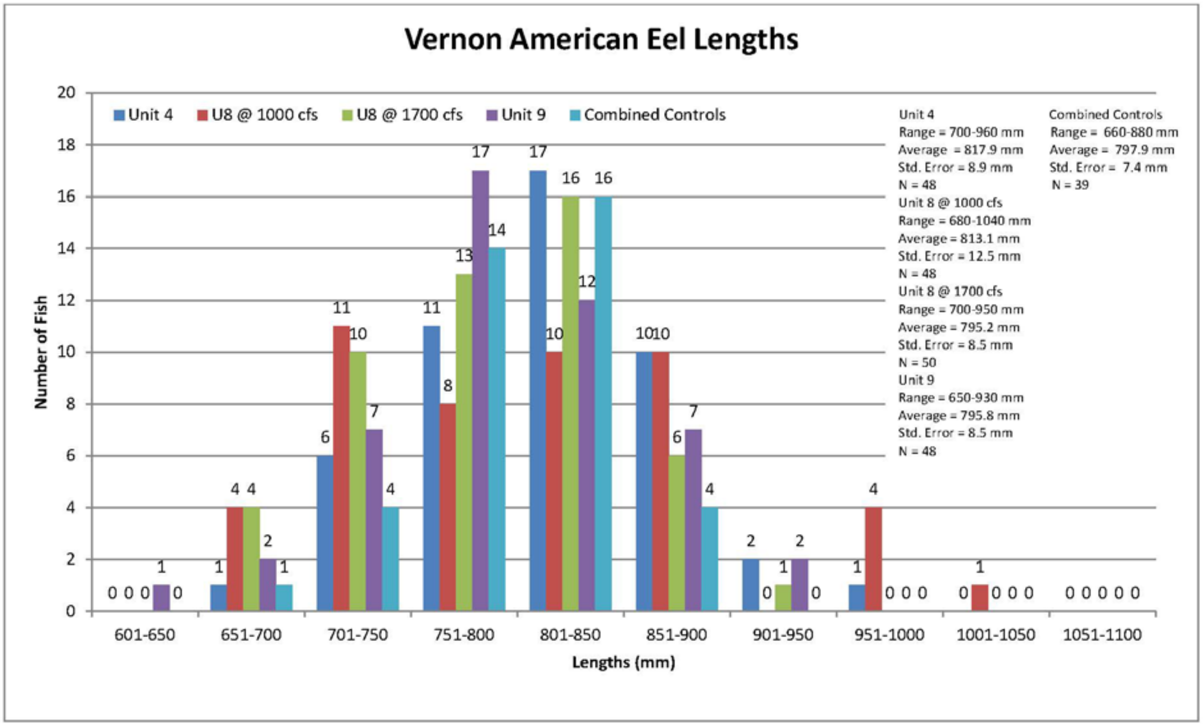


Figure 4.4.3-1. Length frequency for HI-Z tagged adult American Eels released at Vernon Station. Combined controls released at the three projects.

5.0 RESULTS AND DISCUSSION

5.1 Route Selection and Residency

A total of 170 silver eels were surgically implanted with radio tags and released upstream of Wilder, Bellows Falls, and Vernon dams on five occasions during a ten-day period between October 27 and November 5, 2015 (Table 5.1-1). Fish were tagged and released in groups of ten approximately three miles upstream of each project (0.4 miles upstream of Ledyard Free Bridge in Norwich, VT for Wilder; Herricks Cove, Rockingham, VT and Depot Street Bridge in Bellows Falls, VT for Bellows Falls; and Riverside industrial complex, Brattleboro, VT for Vernon) (Figure 3.1).

Table 5.1-1. Summary of eel tagging and releases, fall 2015.

Release Groups										
	1		2		3		4		5	
	October 27		October 29		October 31		November 3		November 5	
	Tag Freq.	No.	Tag Freq.	No.	Tag Freq.	No.	Tag Freq.	No.	Tag Freq.	No.
Vernon	150.340	3	150.340	4	150.340	3	150.340	4	150.340	3
	150.360	4	150.360	3	150.360	3	150.360	3	150.360	3
	150.380	3	150.380	3	150.380	4	150.380	3	150.380	4
Bellows Falls	150.340	4	150.340	3	150.340	4	150.340	4	150.340	3
	150.360	3	150.360	4	150.360	3	150.360	2	150.360	4
	150.380	3	150.380	3	150.380	3	150.380	4	150.380	3
Wilder	150.340	3	150.340	3	150.340	3	150.340	4	150.340	4
	150.360	3	150.360	3	150.360	4	150.360	3	150.360	3
	150.380	4	150.380	4	150.380	3	150.380	3	150.380	3
TOTAL		**30**		**30**		**30**		**30**		**30**
Bellows Falls Power Canal			150.340	3	150.340	3				
			150.360	3	150.360	3				
			150.380	4	150.380	4				
TOTAL				**10**		**10**				
N=170										

5.1.1 Wilder

Releases and Passage Route Selection

Fifty radio-tagged eels were released approximately three miles upstream of the dam into the Wilder impoundment. Of that total, 96% (N=48) moved downstream and were detected in the Wilder forebay. Of those, 45 subsequently passed downstream of the project. The majority (73.3%; N=33) passed via Units 1 and 2. Seven individuals (14.9%) entered Unit 3 and five of those (11.1% of the 45) were later detected in the tailrace, and two individuals (4.4%) passed via the trash/ice sluice. Five (11.1%) passed via an unknown route (Table 5.1.1-1).

The trash/ice sluice was opened seasonally on November 3, and one of the two eels that passed via that route did so when it was operating. There may have been enough leakage flow (not registered in flow monitoring data) through the trash/ice sluice to allow passage for the other individual.

Table 5.1.1-1. Eel passage routes at Wilder, 2015.

Passage Route	No.	% of all passed	% of all released
Turbine Units 1-2	33	73.3	66.0
Turbine Unit 3	5[a]	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[a]		6.0
Did not approach	2		4.0
Total Released	**50**		**100.0**

a. Two eels that entered Unit 3 were not later detected in the tailrace, and assumed to be mortalities.

Downstream Movement and Timing

Where data were available, approach duration, forebay residency time, tailrace residency time, and total time in the Wilder study area was calculated for each individual. Approach times were calculated as the duration of time from release into the river until initial detection at the forebay monitoring stations. Forebay residency times were calculated as the duration of time from initial detection at the forebay monitoring stations until final detection at either a confirmed passage route receiver (for individuals passing by a known route) or the last forebay monitoring station (for individuals passing by an unknown route). Tailrace residency times were calculated as the duration of time from initial to final detections at monitoring areas immediately downstream of Wilder. Finally, a total project time was calculated as the sum of forebay and tailrace residency.

Approach Duration:

Valid detection information was available to determine the approach duration for all 48 eels that entered the forebay area. Approach duration ranged from approximately 1.7 hours to 194.5 hours (8 days, 2 hours, 30 min) with a median duration of 25.1 hours (Table 5.1.1-2). Approximately 38% of individuals were detected in the forebay within eight hours following release and another 27% were detected the following evening, approximately 24 hours after release (Figure 5.1.1-1).

Table 5.1.1-2. Minimum, maximum, mean, and median approach duration (hrs) for Wilder release groups 1 through 5 of radio-tagged adult silver eels at Wilder, fall 2015.

Release Group	Approach Duration (hours)				
	Min	**Max**	**Mean**	**Median**	**No.**
1	2.4	97.4	34.4	24.2	10
2	2.6	194.5	34.1	14.8	10
3	1.7	25.6	11.3	3.6	8
4	4.1	78.4	52.6	73.9	10
5	3.1	178.8	40.9	15.4	10
All	1.7	194.5	35.6	25.1	48

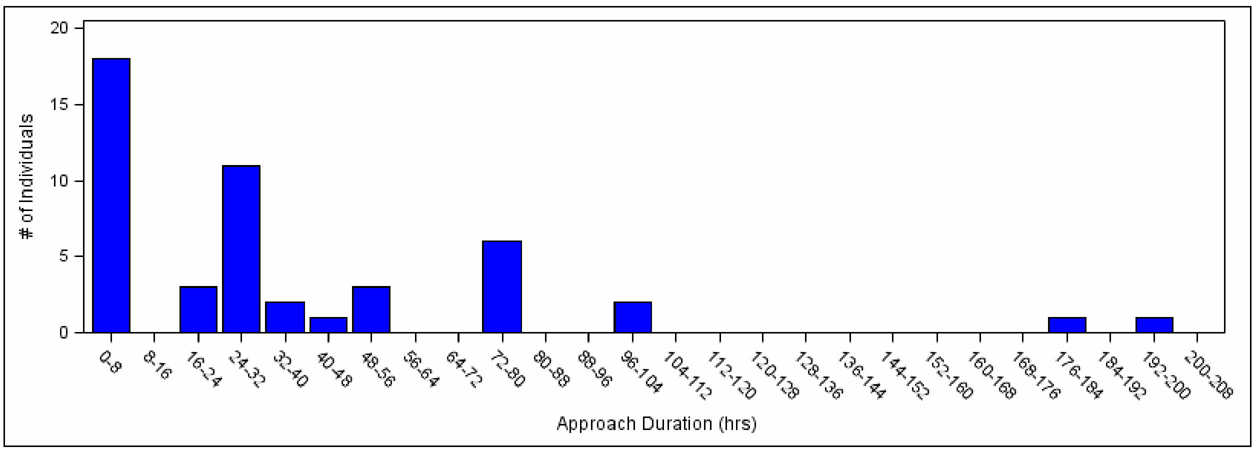


Figure 5.1.1-1. Frequency distribution of approach duration (in hours) for radio-tagged silver eels from Wilder release groups 1-5 from the upstream release site to Wilder forebay.

Forebay Residency Duration:

Valid detection information was available to determine the forebay residency time for all 48 radio-tagged silver eels known to have entered the Wilder forebay area. Forebay residency time ranged from less than 0.1 hour to 400.6 hours (16 days, 16 hours, 36 minutes) with a median of 0.2 hour (Table 5.1.1-3). Forebay residency times for eels that entered a passage route (N=47, including the two that did not ultimately pass via Unit 3) ranged from less than 0.1 hour to 39.6 hours (1 day, 15 hours, 36 minutes) with the majority of those (79%; 37 out of 47 individuals) passing in 4 or fewer hours after initial detection (Figure 5.1.1-2). There were no statistically significant differences among mean forebay residency times for different passage routes (Kruskal Wallis test; χ^2 = 4.145; *df* = 3; *p* = 0.2462) (Table 5.1.1-3).

Table 5.1.1-3. Minimum, maximum, mean, and median forebay residency duration (hrs) by release group (Wilder groups 1-5) and movement status (pass or no pass) at Wilder fall 2015.

Release Group	Forebay Residency Duration (hours)				
	Min	Max	Mean	Median	No.
1	0.1	7.5	1.0	0.3	10
2	0.1	30.0	7.9	0.3	10
3	0.1	20.2	5.2	0.3	8
4	<0.1	20.5	2.3	0.2	10
5	<0.1	400.6	46.4	0.1	10
Movement Status	**Min**	**Max**	**Mean**	**Median**	**No.**
Pass	<0.1	39.6	4.6	0.2	47
No Pass	400.6	400.6	400.6	400.6	1
All	**<0.1**	**400.6**	**12.9**	**0.2**	**48**

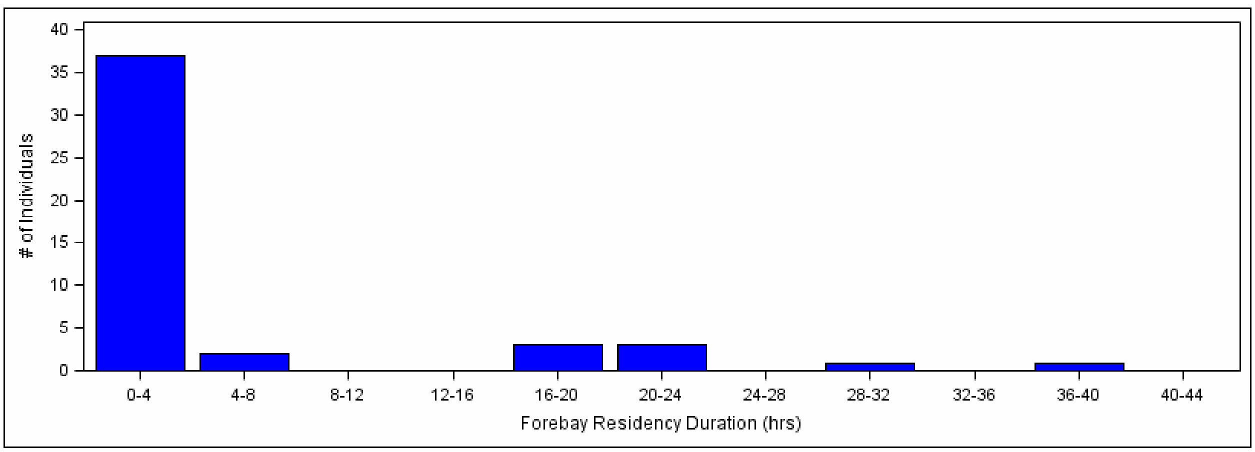


Figure 5.1.1-2. Frequency distribution of forebay residency duration (in hours) for radio-tagged silver eels from Wilder release groups 1-5 which passed from the forebay to downstream.

Table 5.1.1-4. Minimum, maximum, mean, and median forebay residency duration (hrs) by downstream passage route at Wilder, fall 2015.

Passage Route	Forebay Residency Duration (hours)				
	Min	Max	Mean	Median	No.
Units 1-2	<0.1	39.6	4.7	0.2	33
Unit 3	0.1	7.5	1.5	0.3	7
Trash/Ice Sluice	0.4	30.0	15.2	15.2	2
Unknown	<0.1	20.5	4.2	0.1	5
No Pass	400.6	400.6	400.6	400.6	1

Tailrace Residency Duration:

Valid detection information was available to determine a tailrace residency time for the 45 radio-tagged eels that successfully passed Wilder. The two individuals determined to have entered Unit 3 were not detected in the tailrace (as determined by lack of upstream or downstream detections following what appeared to be a valid entry into the unit[1]). Tailrace residency ranged from 0.1 hour to 217.8 hours (9 days, 1 hour, 48 minutes) (Table 5.1.1-5). Approximately 69% of eels were detected within the Wilder tailrace for 8 or fewer hours following downstream passage (Figure 5.1.1-3).

Table 5.1.1-5. Minimum, maximum, mean, and median tailrace residency duration (hrs) by release group at Wilder, fall 2015.

Release Group	Tailrace Residency Duration (hours)				
	Min	Max	Mean	Median	No.
1	0.2	193.6	53.2	22.4	10
2	0.2	35.3	7.8	0.5	10
3	0.1	4.5	1.2	0.5	7
4	0.1	81.7	16.4	0.8	9
5	0.2	217.8	30.2	1.4	9
All	**0.1**	**217.8**	**23.0**	**0.8**	**45**

[1] Support for this conclusion is provided by observations of eel passage out of Unit 3 during the Hi-Z tag portion of this study (see Section 4.4.1).

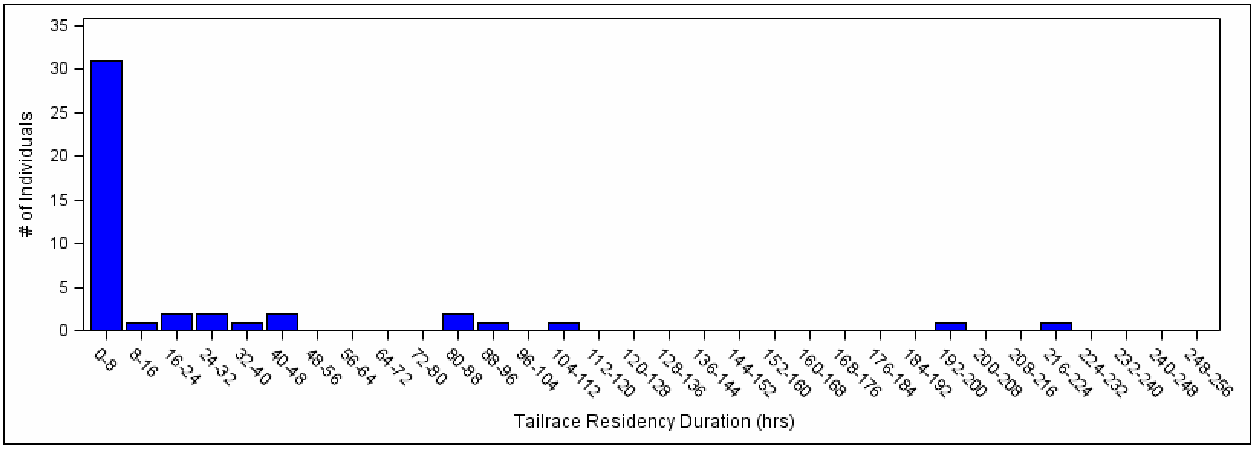


Figure 5.1.1-3. Frequency distribution of tailrace residency duration (in hours) for radio-tagged silver eels from Wilder release groups 1-5 following passage downstream of the dam.

The minimum, maximum, median, and mean tailrace residency duration for eels documented as passing downstream are provided in Table 5.1.1-6. There were no statistically significant differences detected among the mean tailrace residency times between downstream routes (Kruskal Wallis test; χ^2 = 6.1987; *df* = 3; *p* = 0.1023).

Table 5.1.1-6. Minimum, maximum, mean, and median tailrace residency duration (hrs) by downstream passage route at Wilder, fall 2015.

Downstream Route	**Tailrace Residency Duration (hours)**				
	Min	**Max**	**Mean**	**Median**	**No.**
Units 1-2	0.1	217.8	18.4	0.5	33
Unit 3	1.9	193.6	65.0	43.2	5
Trash/Ice Sluice	0.4	13.5	6.9	6.9	2
Unknown	0.1	86.8	18.0	1.4	5

Total Project Residency Duration:

Table 5.1.1-7 presents the total project residence duration for the 45 eels documented as passing downstream and entering the Wilder tailrace. Total project residence duration ranged from 0.1 hour to 240.8 hours (10 days, 48 minutes) (median = 1.7 hours) and approximately 75% of eels arrived and departed the Wilder dam area in less than 24 hours (Figure 5.1.1-4).

Table 5.1.1-7. Minimum, maximum, mean, and median total project residency duration (hrs) by release group at Wilder, fall 2015.

Release Group	Total Project Duration (hours)				
	Min	Max	Mean	Median	No.
1	0.4	194.1	54.2	26.2	10
2	0.4	43.5	15.6	10.3	10
3	0.3	21.4	6.9	1.9	7
4	0.1	81.8	18.9	1.6	9
5	0.2	240.8	37.3	1.5	9
All	**0.1**	**240.8**	**27.8**	**1.7**	**45**

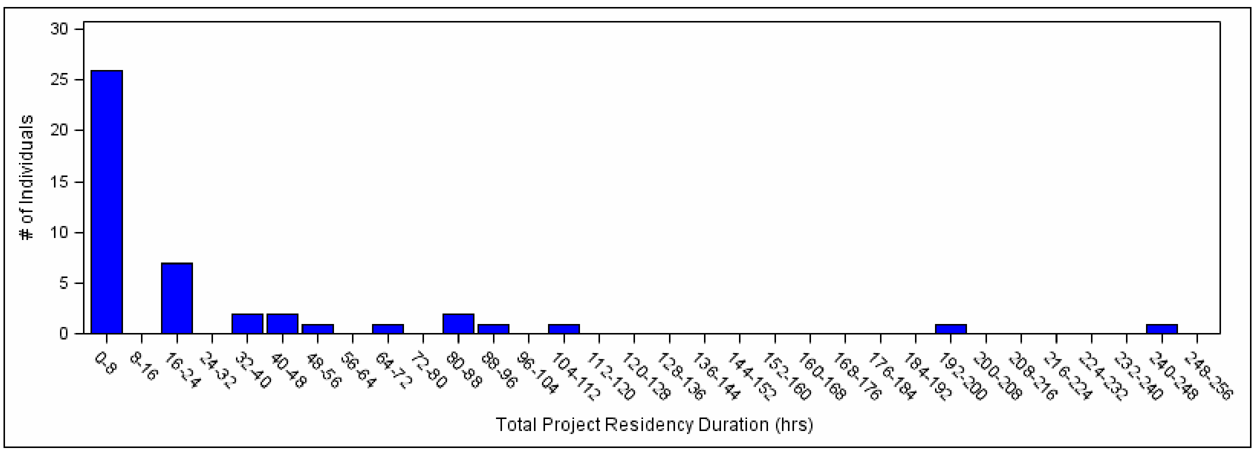


Figure 5.1.1-4. Frequency distribution of total Wilder project residency duration (in hours) for radio-tagged silver eels from Wilder release groups 1-5, fall 2015.

Temporal Distribution of Downstream Passage Events

The temporal distribution of downstream passage events for radio-tagged silver eels released upstream of Wilder is presented on an hourly basis in Figure 5.1.1-5 and on a daily basis in Figure 5.1.1-6. The majority passed during the evening and early night hours of 17:00 to 22:00. The remainder of passage events occurred during the early morning. Eels passed the project starting on the date after the first release (October 28, 2015) with the latest downstream passage event occurring on November 14, 2015.

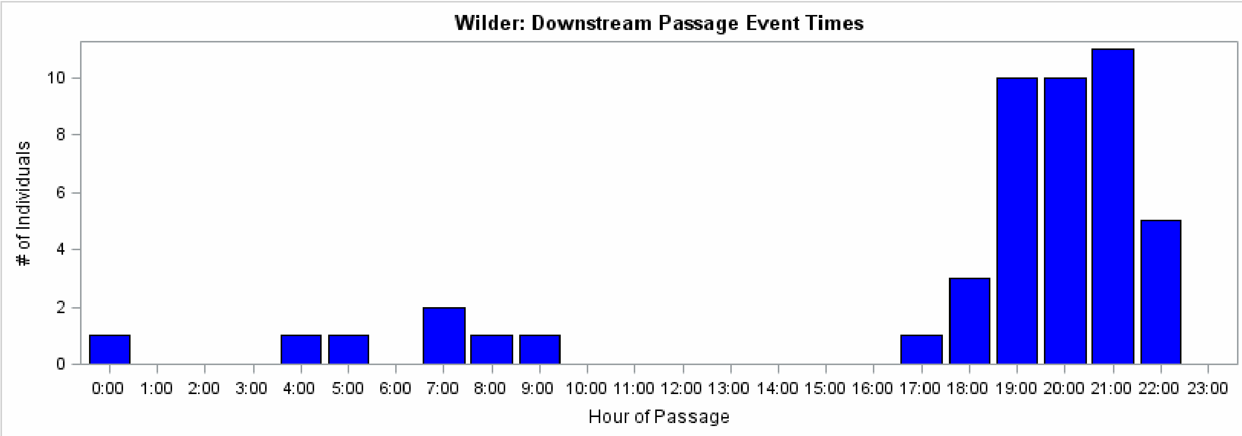
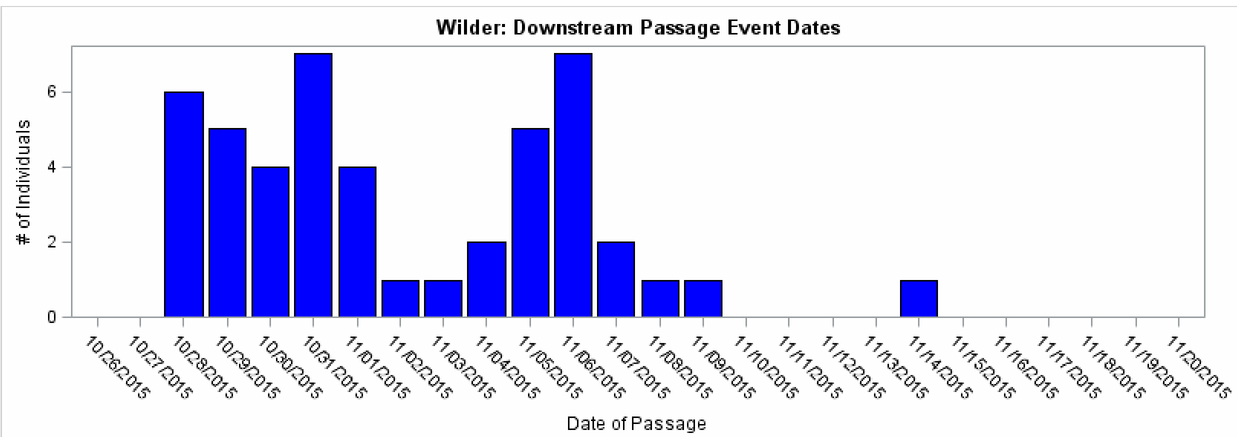


Figure 5.1.1-5. Passage of radio-tagged silver eels by time of day at Wilder, fall 2015.



Note: Eels were released on 10/27, 10/29, 10/31, 11/03, and 11/05.

Figure 5.1.1-6. Passage of radio-tagged silver eels by date at Wilder, fall 2015.

Downstream Passage and Wilder Operations

A summary of proportional route discharge conditions at the time of downstream passage is provided in Table 5.1.1-8. The majority of eel passage at Wilder occurred via the turbine units (70.2% through Units 1 and 2, and 14.9% through Unit 3). Discharge through the units at the time of downstream passage ranged from non-reported to 9,018 cfs (mean = 7,024 cfs) at Unit 1 and from 703 to 743 cfs (mean = 718) at Unit 3. The average proportion of total project flow passing via the determined downstream passage route was 81.5% for Units 1 and 2, 39.6% for Unit 3, and 20.9% for the trash/ice sluice. Individuals did not necessarily pass downstream via the route with the greatest proportion of total project discharge at that time. Passage via the downstream route with the greatest proportion of flow at the time of passage occurred 78.6% of the time.

The trash/ice sluice, a surface oriented flow conduit historically operated to facilitate downstream passage of Atlantic Salmon, was opened briefly on October 27 and then for the rest of the study duration on the afternoon of November 3. During that period 27 eels (57.4% of 47) entered the forebay, and two were last detected in the forebay prior to passage near the trash/ice sluice. Both subsequently passed the project, one via the trash/ice sluice and one via an unknown route. While the trash/ice sluice was not available as a passage route for more than half of all passage events, one eel passed via that route once it was open and there may have been enough leakage flow (not registered in flow monitoring data) through the trash/ice sluice to allow passage for the other individual.

A full listing of route discharge for radio-tagged silver eels passing Wilder is provided along with a listing of arrival and passage information in Appendix F-1 (filed separately in Excel format).

Table 5.1.1-8. Summary of radio-tagged silver eel passage and proportion of flow at Wilder, fall 2015.

Passage Route	No. Using Route	Route Discharge at Time of Passage						Non-route Discharge at Time of Passage					
		cfs			% of Total Available Discharge			cfs			% of Total Available Discharge		
		Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean
Turbine Units 1-2	33	0	9,018	7,024	0	92.6	81.5	716	1,395	926	7.4	100	18.5
Turbine Unit 3	7	703	743	718	7.3	97.3	39.6	20	8,988	5,001	2.7	92.7	60.4
Trash/ice sluice	2	0	571	286	0	41.8	20.9	762	796	779	58.2	100	79.1
Unknown	5	-	-	-	-	-	-	-	-	-	-	-	-
Total	47												

Nearfield Movement Patterns

The use of 3D acoustic telemetry has shown that the initial response of silver eels encountering the trash racks associated with a hydroelectric project is to pass directly through the turbines, sound, reverse direction, swim laterally, swim back upstream, or some combination of all of these behaviors (Brown et al., 2009). The conventional telemetry approach employed during this study does not provide the three-dimensional results necessary to evaluate individual swim pathways but the combination of the length of forebay residency duration and the sequence of detections on receivers within the detection array at each project can be used to identify individuals that may have demonstrated a greater degree of searching or wandering behavior prior to downstream passage. Specific criteria to define a forebay residency time which may suggest impacts from the project on continued downstream success are not available for eels. At the present time, National Marine Fisheries Service has identified a period of 24 hours project residence time upstream of a hydroelectric project to be detrimental for federally endangered Atlantic Salmon smolts in critical habitat in Maine rivers. In this study, the proportion of eels exhibiting back and forth patterns between stationary receivers and forebay residence times greater than 8 and 24 hours were identified as a proxy for potential project impacts due to wandering or potential searching behavior.

Based on analysis of telemetry data and detections at radio receivers, two eels (fish ids [Release Group/Channel/Code]: W5-138-151, W2-38-159) that subsequently passed the project were present in the forebay for more than 24 hours prior to passage and both were detected multiple times between the forebay entrance and potential downstream routes. Another six eels were present in the forebay area for between 8 and 24 hours prior to passage and most were detected at multiple potential downstream routes (example shown in Figure 5.1.1-7). The remaining 37 eels (82.2%) that passed the project did so in less than eight hours, and 34 of those (75.6% of all passed eels) passed in less than one hour regardless of demonstrating potential searching behavior.

Appendix E includes maps for all successfully passed eels. It should be noted that approach paths are generalized based on detection through the receiver detection zone only, and not necessarily the exact location of approach path (e.g., river right, left, or center).

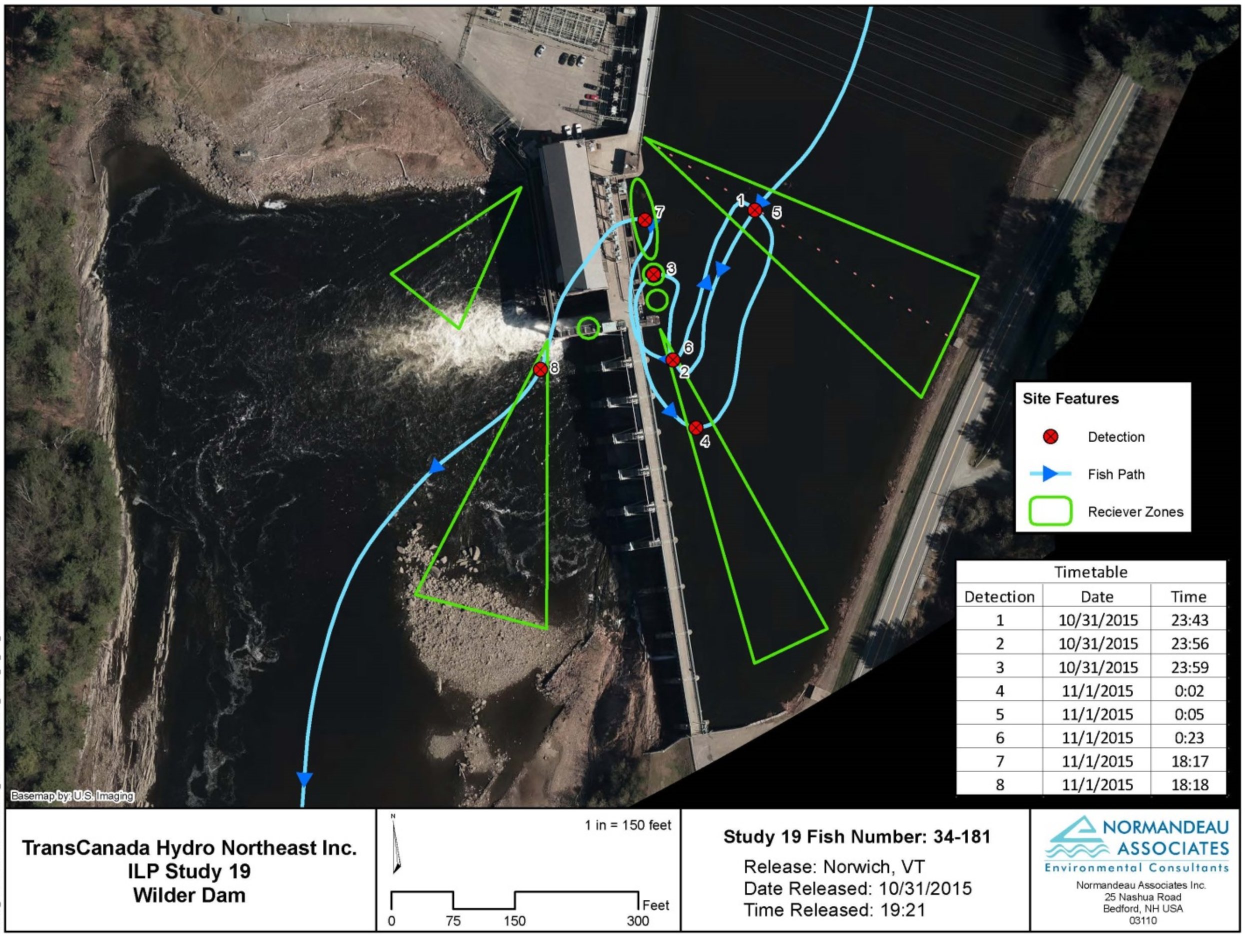


Figure 5.1.1-7. Example map showing eel wandering pattern prior to passage at Wilder, 2015.

5.1.2 Bellows Falls

Releases and Passage Route Selection

Fifty radio-tagged adult eels were released approximately three miles upstream into the Bellows Falls impoundment. Of those, 98% (N=49) were determined to have moved downstream and were detected in the Bellows Falls study area (Table 5.1.2-1). One individual remained upstream and two individuals were determined to have entered the power canal but did not pass further downstream. Of the 47 available eels, 78.7% (N=37) passed via turbine Units 1 – 3, 12.8% (N = 6) passed via the trash/ice sluice, and 8.5% (N=4) passed via the spillway into the bypassed reach.

Twenty radio-tagged eels were released into the Bellows Falls power canal during two spill events. Ten eels were released during the 2^{nd} release and during the 3^{rd} release into the canal and all passed downstream of the project. Nineteen eels (95%) released into the power canal passed via turbine Units 1 – 3 and one eel (5%) passed via the trash/ice sluice (Table 5.1.2-1).

In addition to the 70 eels released into the Bellows Falls impoundment and power canal, 29 individuals originally released into the Wilder impoundment were detected within the Bellows Falls study area and all passed the project (Table 5.1.2-1). Of these, 21 (72.4%) passed via the turbines, six (20.7%) passed via the trash/ice sluice, and two (6.9%) passed via the spillway into the bypassed reach.

Of all individuals released into the Wilder impoundment, Bellows Falls impoundment, and the Bellows Falls power canal (N=120), 96 individuals (80%) were determined to have passed the project (Table 5.1.2-1). Review of overall passage through the project indicated that 80.2% (N=77) passed via the turbine units, 13.5% (N=13) passed via the trash/ice sluice and 6.3% (N=6) passed via the spillway. The trash/ice sluice was opened seasonally on November 2, and 11 of the 13 eels that passed via that route did so when it was operating. There may have been enough leakage flow (not registered in flow monitoring data) through the trash/ice sluice to allow passage for those two eels on other dates. Five of the six eels that used the dam spillway did not pass during a spill event and it is suspected that leakage at the dam may be sufficient for emigrating eels to navigate.

Table 5.1.2-1. Passage routes for all eels approaching the Bellows Falls project (from Wilder and Bellows Falls release groups), 2015.

Passage Route	No.	% of all passed	% of all released
Bellows Falls Impoundment Released Eels			
Turbine Units 1-3	37	78.7	74.0
Trash/ice sluice	6	12.8	12.0
Dam spillway	4	8.5	8.0
Total Passed	**47**	**100.0**	**94.0**
Did not pass	2		4.0
Did not approach	1		2.0
Total Released	**50**		**100.0**
Bellows Falls Power Canal Released Eels			
Turbine Units 1-3	19	95.0	95.0
Trash/ice sluice	1	5.0	5.0
Dam spillway	0	0.0	0.0
Total Passed	**20**	**100.0**	**100.0**
Did not pass	0		0.0
Did not approach	0		0.0
Total Released	**20**		**100.0**
Wilder Impoundment Released Eels			
Turbine Units 1-3	21	72.4	42.0
Trash/ice sluice	6	20.7	12.0
Dam spillway	2	6.9	4.0
Total Passed	**29**	**100.0**	**58.0**
Did not pass	0		0.0
Did not approach	21		42.0
Total Released	**50**		**100.0**
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	**120**		**100.0**

Downstream Movement and Timing

Where data were available, approach duration, power canal residency time, tailrace residency time, bypassed reach residency time, and total time in the Bellows Falls study area was calculated for each individual. Approach times were calculated for eels originally released into the Bellows Falls impoundment as the duration of time from release to initial detection at the upstream approach monitoring station at the Pine Street boat launch (located approximately 0.3 miles upstream of the entrance to the power canal and spill sections on dam). Power canal residency times were calculated for eels originally released into the Wilder and Bellows falls impoundments as the duration of time from initial detection at the upper power canal monitoring station until the final detection at either a confirmed passage route receiver (for individuals passing by a known route) or at a forebay monitoring station (for individuals passing by an unknown route). Power canal residency times were calculated for eels originally released into the power canal as the duration of time from release to final detection at either a confirmed passage route or a forebay monitoring station.

For individuals originally released into the Wilder or Bellows Falls impoundments that passed via the spillway, a bypassed reach residency time was calculated as the duration from initial detection at the spillway monitoring station to final detection at the bypassed reach exit monitoring station. Tailrace residency times were calculated for eels passing via the powerhouse passage routes as the duration of time from the initial detection to final detection at monitoring stations immediately downstream of Bellows Falls. Finally, a total project time was calculated as the duration from initial detection at the upper-most approach monitoring station until final detection among tailrace monitoring stations (for eels passing via the power canal) or final detection at the downstream end of the bypassed reach (for eels passing via spill).

Approach Duration:

Valid detection information was available to determine the approach duration for 46 of the 49 individuals that were detected at Bellows Falls. Three individuals released into the Bellows Falls impoundment were not detected at the upstream approach monitoring station and as a result, approach duration for those individuals was not calculated[2]. Approach duration ranged from approximately 0.6 hour to 867.2 hours (36 days, 3 hours and 12 min) with an overall median duration of 16.0 hours (Table 5.1.2-2). Approximately 50% of radio-tagged eels released in the Bellows Falls impoundment were present within the Bellows Falls study area within eight hours following release (Figure 5.1.2-1).

[2] Release group B2 (channel 36, code 146), release group B4 (channel 36, code 120), release group B5 (channel 34, code 150).

Table 5.1.2-2. Minimum, maximum, mean, and median approach duration (hrs) for Bellows Falls impoundment release groups B1 through B5 of radio-tagged adult silver eels at Bellows Falls, fall 2015.

Release Group	Approach Duration (hours)				
	Min	Max	Mean	Median	No.
B1	0.6	127.6	34.8	26.1	9
B2	2.1	244.2	35.0	3.7	9
B3	2.0	223.0	47.8	18.0	10
B4	3.8	431.4	90.2	74.5	9
B5	3.4	867.2	141.7	5.8	9
All	**0.6**	**867.2**	**69.4**	**16.0**	**46**

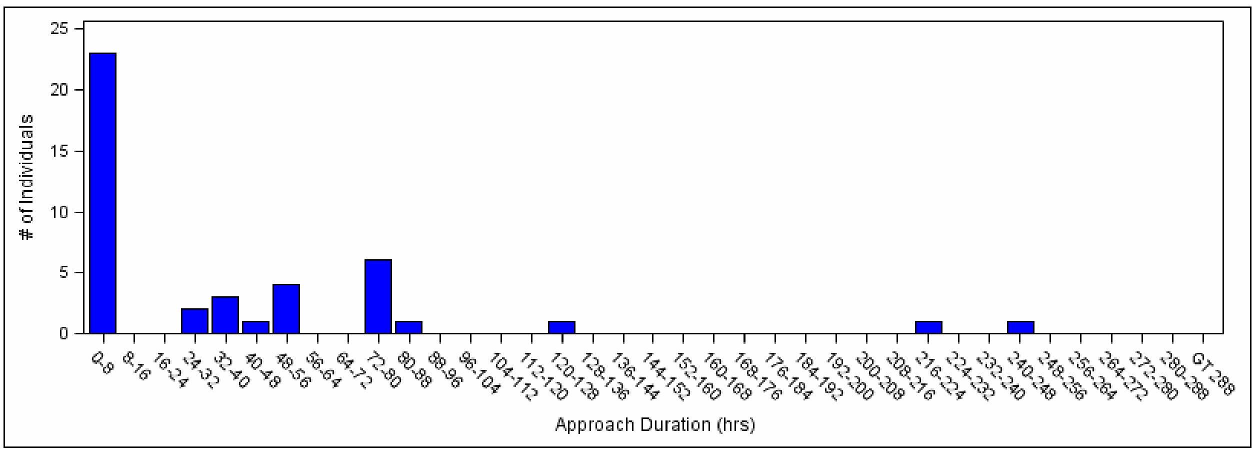


Figure 5.1.2-1. Frequency distribution of approach duration (in hours) for radio-tagged silver eels from Bellows Falls impoundment release groups B1-B5 from the upstream release site to the Bellows Falls approach receiver.

Power Canal Residency Duration:

Including individuals who approached but did not pass the project, 78 eels released into the Wilder and Bellows Falls impoundments were available to have entered the power canal (Table 5.1.2-1). An additional 20 eels were released directly into the power canal and of those, 6 individuals (originally released into the Bellows Falls impoundment (N=4) or the Wilder impoundment (N=2)) moved downstream through the bypassed reach rather than the power canal. Of the 72 individuals originating in project impoundments and confirmed as entering the canal, valid detection information was available to determine a power canal residency time for 70 of them, as well as for all 20 of the radio-tagged silver eels released directly into the power canal. Two individuals released upstream of Bellows Falls were not detected at the monitoring station covering the power canal entry and as a result, power canal residency duration for those individuals was not calculated[3]. Power canal residency time ranged from 0.1 hour to 307.1 hours (12 days, 19 hours, 6 minutes) with an overall median of 0.2 hour (Table 5.1.2-3). For the majority of eels that passed the project (84%; 74 of the 88 that passed downstream and had a known power canal residency duration), the duration of residency in the power canal was less than 3 hours (Figure 5.1.2-2). When examined by eventual passage route (Table 5.1.2-4) there was no statistically significant difference between the mean power canal residency time for eels passing via the turbine units or via the trash/ice sluice (Mann-Whitney test; z =-1.1612 p = 0.2456).

Table 5.1.2-3. Minimum, maximum, mean, and median power canal residency duration (hrs) for radio-tagged adult silver eels from Bellows Falls impoundment release groups B1-B5, power canal release groups C1 and C2, and Wilder impoundment release groups W1-W5, fall 2015.

Release Group	Canal Residency Duration (hours)				
	Min	Max	Mean	Median	No.
B1	0.1	45.6	5.4	0.1	9
B2	0.1	22.1	2.5	0.1	9
B3	0.1	18.4	2.4	0.1	8
B4	0.1	65.6	12.3	0.2	9
B5	0.1	307.1	36.5	0.4	9
C1	0.1	88.1	12.3	1.6	10
C2	0.1	293.3	52.0	1.9	10
W1	0.1	0.1	0.1	0.1	2
W2	0.1	7.2	1.2	0.2	7
W3	0.1	0.3	0.2	0.1	7
W4	0.1	0.2	0.1	0.1	6
W5	0.1	0.2	0.1	0.1	4
All	**0.1**	**307.1**	**13.2**	**0.2**	**90**

Table 5.1.2-4. Minimum, maximum, mean, and median Bellows Falls power canal residency duration (hrs) by downstream passage route, fall 2015.

Passage Route	Canal Residency Duration (hours)				
	Min	Max	Mean	Median	N
Units	0.1	307.1	14.0	0.2	76
Trash/Ice Sluice	0.1	122.4	10.3	0.1	12
No Pass	0.2	0.3	0.2	0.2	2
All	**0.1**	**307.1**	**13.2**	**0.2**	**90**

[3] Release group W1 (channel 34, code 122), release group B5 (channel 34, code 149).

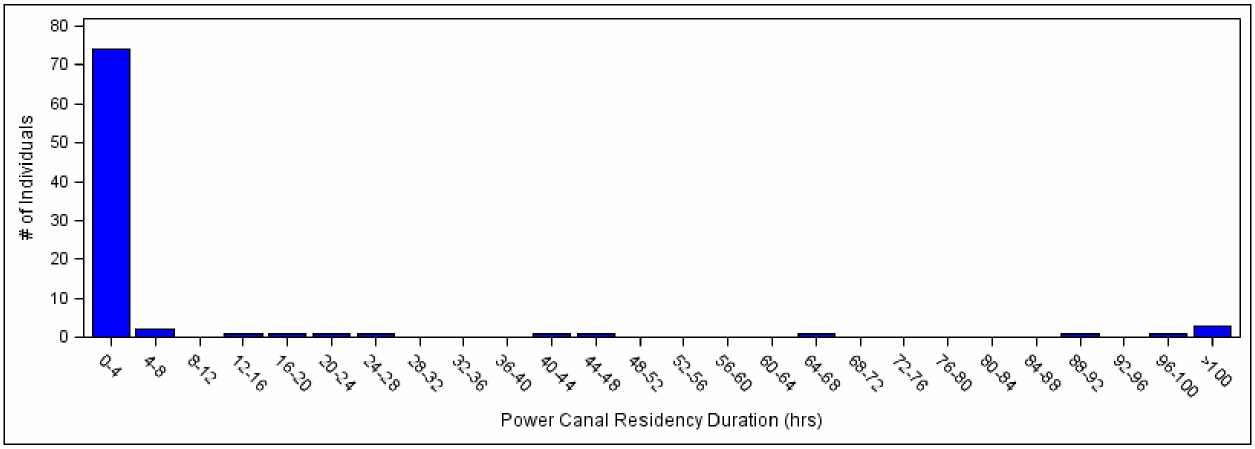


Figure 5.1.2-2. Frequency distribution of Bellows Falls power canal residency duration (in hours) for radio-tagged silver eels from Bellows Falls impoundment release groups B1-B5, power canal release groups C1 and C2, and Wilder impoundment release groups W1-W5, fall 2015.

Tailrace Residency Duration:

Valid detection information was available to determine a tailrace residency time for all 90 eels that passed Bellows Falls via available powerhouse routes. When individuals from all release groups (Bellows Falls impoundment, Bellows Falls power canal, Wilder impoundment) are considered, tailrace residency ranged from <0.1 hour to 1,879.1 hours (78 days, 7 hours, 6 minutes) (Table 5.1.2-5). Approximately 83% of passed eels were detected within the tailrace for 4 or fewer hours following downstream passage (Figure 5.1.2-3); however, three individuals were detected in the Bellows Falls tailrace for a minimum of 46 days after passage and were not later detected at Vernon. All three passed downstream via the turbine units and were likely mortalities.

Table 5.1.2-5. Minimum, maximum, mean, and median tailrace residency duration (hrs) for radio-tagged adult silver eels from Bellows Falls impoundment release groups B1-B5, power canal release groups C1 and C2, and Wilder impoundment release groups W1-W5, fall 2015.

Release Group	Tailrace Residency Duration (hours)				
	Min	Max	Mean	Median	No.
B1	<0.1	154.1	21.4	0.1	8
B2	<0.1	119.8	13.4	0.1	9
B3	<0.1	4.1	0.7	<0.1	7
B4	<0.1	1,117.4	131.0	0.3	9
B5	<0.1	3.2	0.8	0.4	10
C1	<0.1	1,879.1	195.6	1.2	10
C2	<0.1	388.4	43.7	0.8	10

Release Group	Tailrace Residency Duration (hours)				
	Min	Max	Mean	Median	No.
W1	<0.1	1,842.5	614.2	0.1	3
W2	<0.1	1.9	0.5	0.1	7
W3	<0.1	21.7	3.4	0.1	7
W4	<0.1	0.9	0.3	0.2	6
W5	<0.1	0.9	0.2	<0.1	4
All	**<0.1**	**1,879.1**	**63.9**	**0.1**	**90**

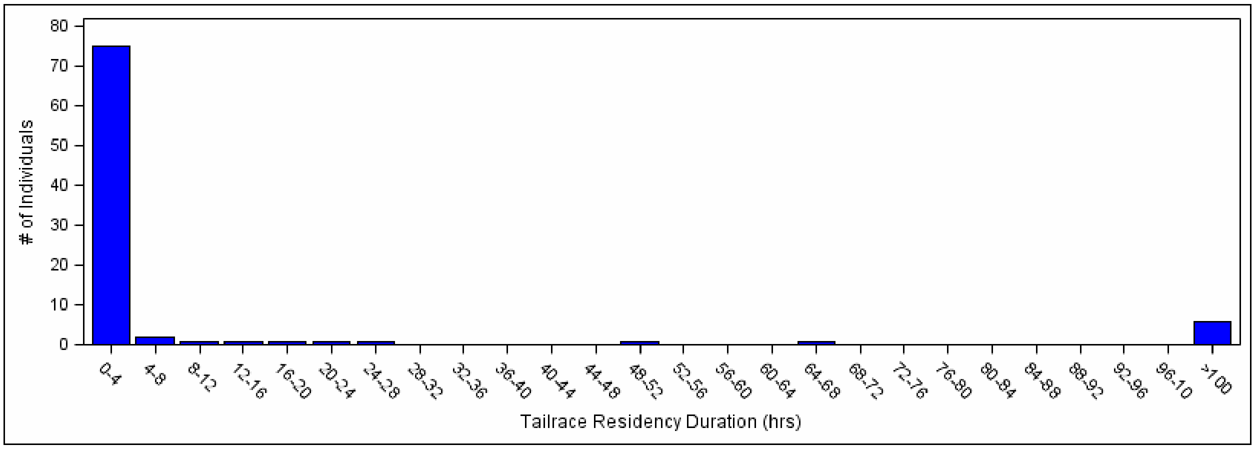


Figure 5.1.2-3. Frequency distribution of Bellows Falls tailrace residency duration (in hours) for radio-tagged silver eels from Bellows Falls impoundment release groups B1-B5, power canal release groups C1 and C2, and Wilder impoundment release groups W1-W5, fall 2015.

The minimum, maximum, median, and mean tailrace residency duration for eels from all release groups documented as passing downstream are provided by downstream passage route in Table 5.1.2-6. The mean tailrace residency duration differed significantly between eels passing via the trash/ice sluice and those passing via the turbine units (Mann-Whitney test; z =-2.7145 p = 0.0066). The longer mean tailrace duration observed for eels passing via the turbine units was driven by a number of individuals that remained stationary in the tailrace for a prolonged period of time following passage.

Table 5.1.2-6. Minimum, maximum, mean, and median Bellows Falls tailrace residency duration (hrs) by downstream passage route, fall 2015.

Passage Route	Tailrace Residency Duration (hours)				
	Min	Max	Mean	Median	No.
Units	<0.1	1,879.1	74.6	0.1	77
Trash/Ice Sluice	<0.1	0.3	0.1	<0.1	13
All	**<0.1**	**1,879.1**	**63.9**	**0.1**	**90**

Bypassed Reach Residency Duration:

Six of the radio-tagged eels released into either the Wilder impoundment or Bellows Falls impoundment passed via the spillway into the bypassed reach. The duration of time those individuals were present within the bypassed reach following their initial detection at the upstream end of the bypassed reach ranged from 13.1 hours to 1,672.9 hours (69 days, 16 hours, 54 minutes) (median = 50.7 hours) (Table 5.1.2-7). The individual from release group B3 with a bypassed reach residency duration of over 69 days was still present in the reach at the conclusion of the study and was likely a mortality, and excluding that individual the median bypassed reach residency was 46.8 hours.

Table 5.1.2-7. Minimum, maximum, mean, and median bypassed reach residency duration (hrs) for radio-tagged adult silver eels from Bellows Falls impoundment release groups B1-B5 and Wilder impoundment release groups W1-W5, fall 2015.

Release Group	Bypassed Reach Residency Duration (hours)				
	Min	Max	Mean	Median	No.
B1	.	.	.	.	0
B2	46.8	46.8	46.8	46.8	1
B3	408.7	1,672.9	1,040.8	1,040.8	2
B4	54.6	54.6	54.6	54.6	1
B5	.	.	.	.	0
W1	.	.	.	.	0
W2	.	.	.	.	0
W3	.	.	.	.	0
W4	13.0	13.0	13.0	13.0	1
W5	18.8	18.8	18.8	18.8	1
All	**13.0**	**1,672.9**	**369.1**	**50.7**	**6**

Total Project Residency Duration:

Valid detection information was available to calculate total project residency duration for 71 of the 76 eels released into either the Wilder or Bellows Falls impoundment and determined to have passed downstream of Bellows Falls. Table 5.1.2-8 presents the minimum, maximum, median, and mean total project residence duration by release group. Total project residence duration from initial upstream approach detection until final detection at the downstream tailrace or lower bypassed reach receivers ranged from 0.4 hour to 1,843.9 hours (76 days, 19 hours, 54 minutes) (median = 1.4 hours). Of the eels released into the project impoundments, approximately 80% (57 of 71 individuals) arrived and departed the Bellows Falls study area in less than 24 hours (Figure 5.1.2-4).

When only eels released directly into the power canal are considered, total project duration ranged from 0.1 hour to 1,967.2 hours (81 days, 23 hours, 12 minutes) (median = 3.5 hours) (Table 5.1.2-9). The majority of eels (70%) released into the power canal had a total project residency duration of less than 24 hours (Figure 5.1.2-5).

Table 5.1.2-8. Minimum, maximum, mean, and median total project residency duration (hrs) for radio-tagged adult silver eels from Bellows Falls impoundment release groups B1-B5 and Wilder impoundment release groups W1-W5, fall 2015.

Release Group	Total Project Residency Duration (hours)				
	Min	Max	Mean	Median	No.
B1	0.5	186.1	55.7	17.9	8
B2	0.5	142.4	21.5	0.5	9
B3	0.5	1,673.9	234.4	0.7	9
B4	0.6	1,174.4	274.7	2.9	9
B5	0.5	308.2	37.9	1.6	9
W1	0.4	1,843.9	922.2	922.2	2
W2	0.7	19.7	5.1	0.8	7
W3	0.4	22.2	4.5	0.7	6
W4	0.4	14.2	3.9	1.5	7
W5	0.4	39.9	12.4	1.3	5
All	**0.4**	**1,843.9**	**106.4**	**1.4**	**71**

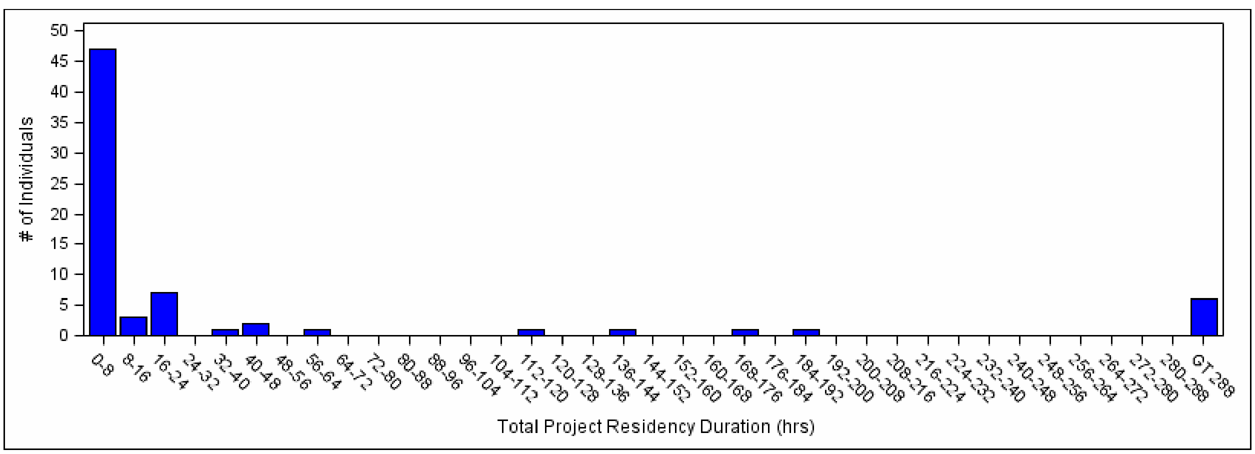


Figure 5.1.2-4. Frequency distribution of Bellows Falls total project residency duration (in hours) for radio-tagged silver eels from Bellows Falls impoundment release groups B1-B5 and Wilder impoundment release groups W1-W5, fall 2015.

Table 5.1.2-9. Minimum, maximum, mean, and median total project residency duration (hrs) for radio-tagged adult silver eels from Bellows Falls power canal release groups C1 and C2, fall 2015.

Release Group	Total Project Residency Duration (hours)				
	Min	Max	Mean	Median	No.
C1	0.1	1,967.2	208.0	3.3	10
C2	0.1	389.5	95.7	12.5	10
All	**0.1**	**1,967.2**	**151.8**	**3.5**	**20**

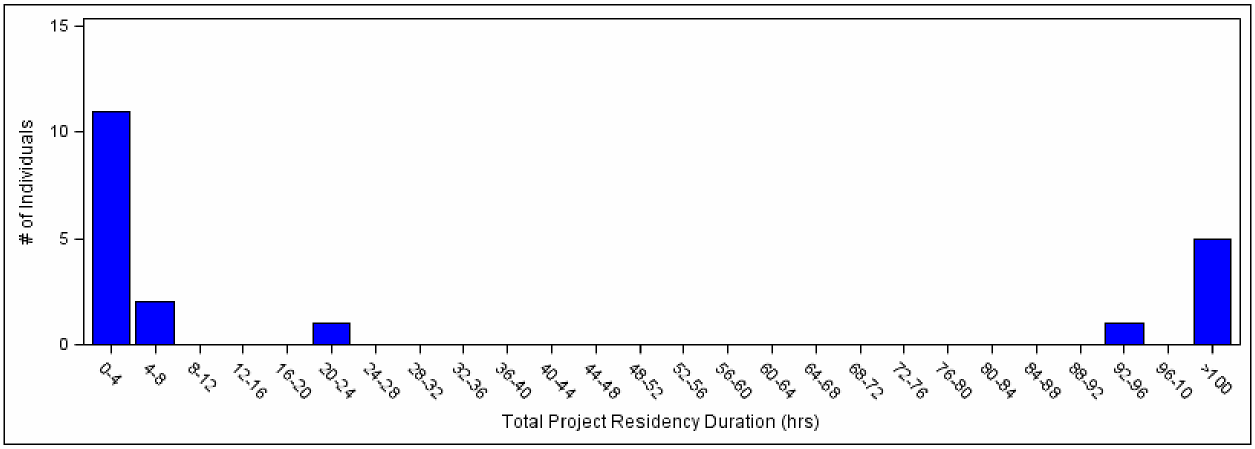


Figure 5.1.2-5. Frequency distribution of Bellows Falls total project residency duration (in hours) for radio-tagged silver eels from Bellows Falls power canal release groups C1 and C2, fall 2015.

Temporal Distribution of Downstream Passage Events

The temporal distribution of downstream passage events for eels released upstream of Bellows Falls is presented on an hourly basis in Figure 5.1.2-6 and on a daily basis in Figure 5.1.2-7. The majority passed during the evening and early morning hours from 17:00 to 04:00. Downstream passage events during the daylight hours were limited in frequency. The majority of eels (79%) released into the Bellows Falls impoundment passed the project within one day after the final release (November 5, 2015) with the latest documented passage event occurring on December 21, 2015. Ninety-five percent of eels released directly into the Bellows Falls power canal passed downstream between the initial release date on October 29, 2015 and November 5, 2015. Eels released into the Wilder impoundment passed Bellows Falls between October 30 and November 15, 2015. Downstream passage for those individuals peaked on November 2-3.

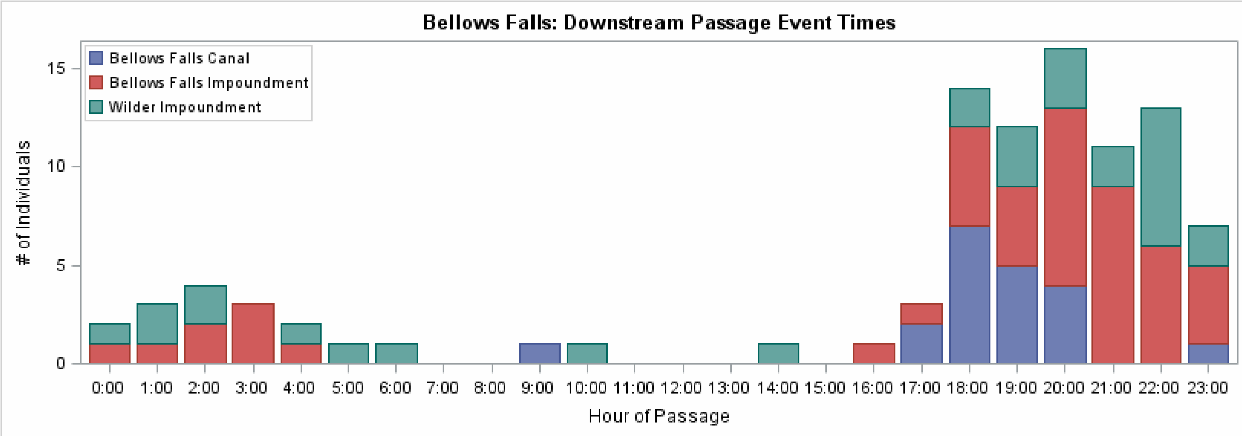
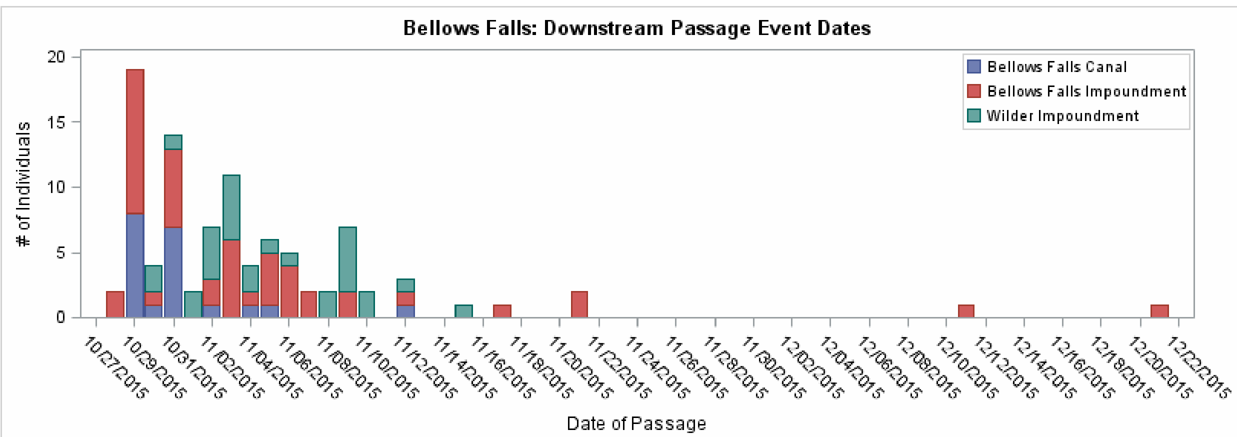


Figure 5.1.2-6. Passage of radio-tagged silver eels by time of day and release location at Bellows Falls, fall 2015.



Note: Eels were released at Bellows Falls on 10/27, 10/29, 10/31, 11/03, and 11/05.

Figure 5.1.2-7. Passage of radio-tagged silver eels by date and release location at Bellows Falls, fall 2015.

Downstream Passage and Bellows Falls Operations

A summary of proportional route discharge conditions at the time of downstream passage is provided in Table 5.1.2-10. The majority of eels passing Bellows Falls entered the power canal and passed via the turbine units (77%). Discharge through the turbine units at the time of downstream passage ranged from 1,380 to 11,186 cfs (mean = 8,867 cfs) for all units combined. The average proportion of total project flow for eels passing was 97.9% for Units 1-3, 4.3% for the dam spillway and 1.4% for the trash/ice sluice. Project operations at the determined time of passage for eels using the trash/ice sluice and dam spillway did not always coincide with significant discharge at those locations. Flows through the trash/ice sluice during the time of passage ranged from a recorded flow from 0 to 166 cfs, and through the spillway during the time of passage ranged from a recorded flow of 0 to 2,565 cfs. It is suspected that there may have been enough leakage flow (not registered in flow monitoring data) to allow passage at times with recorded zero flow. Individuals did not necessarily pass via the route with the greatest proportion of total project discharge at the time of passage. Passage via the route with the greatest proportion of flow at the time of passage occurred 80.2% of the time.

The trash/ice sluice, a surface oriented flow conduit historically operated to facilitate downstream passage of Atlantic Salmon, was opened on November 2 for the remainder of the study. Prior to opening, final pre-passage forebay detections (as opposed to final pre-passed detections at the dam) occurred for 42 (45.7%) of the 92 eels that passed via the canal and powerhouse. Eleven of the 13 eels that passed via the trash/ice sluice did so when it was operating. While the trash/ice sluice was not available as a passage route for nearly half of all passage events, there may have been enough leakage flow (not registered in flow monitoring data) through the trash/ice sluice to allow passage for the two eels that passed prior to its opening. In total, 7 of the 13 eels (53.8%) that passed via the trash/ice sluice did so when monitored trash/ice sluice flows were very low, between zero and 12 cfs.

A full listing of route discharge for radio-tagged silver eels passing Bellows Falls is provided along with a listing of arrival and passage information in Appendix F-2 (filed separately in Excel format).

Table 5.1.2-10. Summary of radio-tagged silver eel passage and proportion of flow at Bellows Falls, fall 2015.

Passage Route	No. Using Route	Route Discharge at Time of Passage						Non-route Discharge at Time of Passage					
		cfs			% of Total Available Discharge			cfs			% of Total Available Discharge		
		Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean
Turbine Units 1-3	77	1380	11,186	8,867	49.6	99.8	97.9	24	7,604	226	0.2	50.4	2.1
Trash/ice sluice	13	0	166	36	0.0	10.9	1.4	1362	11,146	7,683	89.1	100.0	98.7
Dam spillway	6	0	2,465	411	0.0	25.9	4.3	1346	11,202	4,044	74.1	100.0	95.7
Total	96												

Nearfield Movement Patterns

As described in Section 5.5.1, Nearfield Movement Patterns (Wilder), National Marine Fisheries Service has identified a period of 24 hours project residence time upstream of a hydroelectric project to be detrimental for federally endangered Atlantic Salmon smolts in critical habitat in Maine rivers. In this study, the proportion of eels exhibiting back and forth patterns between stationary receivers and forebay residence times greater than 8 and 24 hours were identified as a proxy for potential project impacts due to wandering or potential searching behavior.

Based on analysis of telemetry data and detections at radio receivers, nine eels that subsequently passed the project via the powerhouse were present in the forebay for more than 24 hours prior to passage and were detected multiple times between the forebay entrance and potential downstream routes. Another three eels were present in the forebay area for between 8 and 24 hours prior to passage and most were detected at multiple potential downstream routes (example shown in Figure 5.1.2-8). The remaining 78 eels (86.7%) of the 90 that passed via the powerhouse did so in less than eight hours, and 67 of those (74.4% of all eels that passed via the powerhouse) passed in less than one hour regardless of demonstrating potential searching behavior.

Of the six eels that passed via the spillway, only one (16.7%) exhibited potential searching behavior (Figure 5.1.2-9). Appendix E includes maps for all successfully passed eels. It should be noted that approach paths are generalized based on detection through the receiver detection zone only, and not necessarily the exact location of approach path (e.g., river right, left, or center).

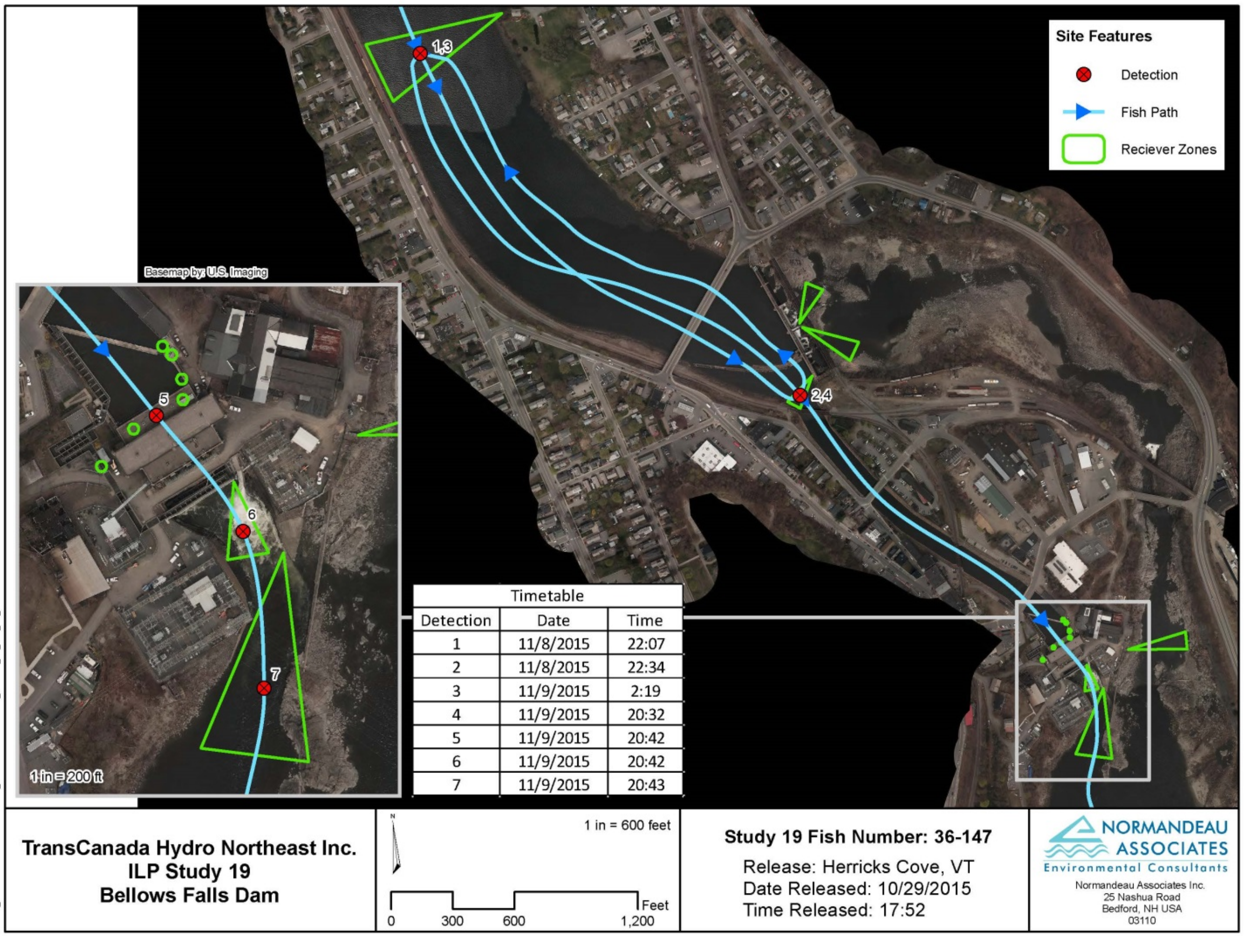
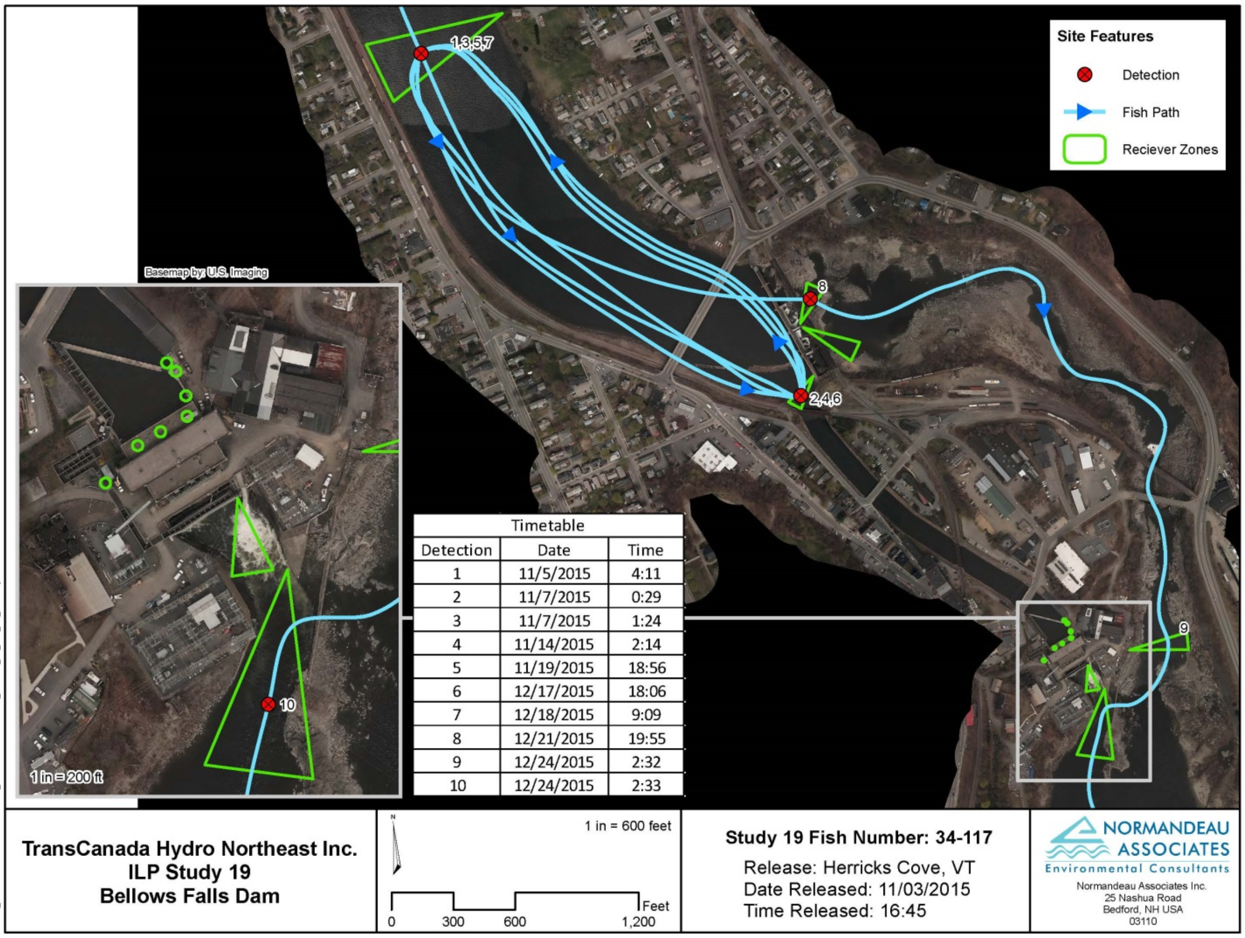


Figure 5.1.2-8. Example map showing eel wandering pattern prior to passage at Bellows Falls, 2015.



Timetable		
Detection	Date	Time
1	11/5/2015	4:11
2	11/7/2015	0:29
3	11/7/2015	1:24
4	11/14/2015	2:14
5	11/19/2015	18:56
6	12/17/2015	18:06
7	12/18/2015	9:09
8	12/21/2015	19:55
9	12/24/2015	2:32
10	12/24/2015	2:33

Figure 5.1.2-9. Example map showing eel wandering pattern prior to passage via the spillway at Bellow Falls, 2015.

5.1.3 Vernon

Releases and Passage Route Selection

Fifty radio-tagged silver eels were released into the Vernon impoundment. Of these, 86% (N=43) passed the project (Table 5.1.3-1). Six eels never approached the project and one was detected within the study area but did not pass. The passage route used most frequently by eels released into the Vernon impoundment was Units 5-8 (55.8%, 24 of 43 individuals).

Of the 70 eels released into the Bellows Falls impoundment and power canal, 67 (96%) passed the Bellows Falls project. Of those, 45 (66% of those passing Bellows Falls) were detected in the Vernon study area and 44 subsequently passed the Vernon project (Table 5.1.3-2). Twenty (45.5%) of the Bellows Falls eels passed via Units 5-8. Thirteen (29.5%) passed via Units 9-10, six (13.6%) eels passed via the Units 1–4, and one eel each passed via the fish pipe and the trash/ice sluice.

Of the 50 radio-tagged eels released into the Wilder impoundment, 25 (50%) were detected in the Vernon study area and subsequently passed the project (Table 5.1.3-3). Nine (36%) of the Wilder released eels passed via Vernon Units 5-8. Six (24%) passed via Units 9-10. Four (16%) eels passed via Units 1–4, and one eel passed via the fish pipe.

Analysis of overall eel passage (N=112) through the Vernon project indicates that 53 (47.3%) fish passed via Units 5-8. Twenty six (23.2%) eels passed via Units 9-10 and fourteen eels passed via Units 1-4 (12.5%). Four eels used the fish pipe, two used the trash/ice sluice, and one each used the fish tube and fish ladder. Table 5.1.3-4 summarizes passage routes for the full set of radio-tagged eels within the Vernon study area.

Table 5.1.3-1. Eel passage routes at Vernon for all eels released into the Vernon impoundment, fall 2015.

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**

Table 5.1.3-2. Eel passage routes at Vernon for all eels released into the Bellows Falls impoundment and Bellows Falls power canal, fall 2015.

Passage Route	No.	% of all passed	% of all released
Bellows Falls Impoundment Released Fish			
Turbine intake 5-8	15	44.1	30.0
Turbine intake 9-10	10	29.4	20.0
Turbine intake 1-4	4	11.8	8.0
Fish pipe	1	2.9	2.0
Trash/Ice sluice	1	2.9	2.0
Unknown	3	8.8	6.0
Total Impoundment Passed	**34**	**100.0**	**68.0**
Bellows Falls Canal Released Fish			
Turbine intake 5-8	5	50.0	25.0
Turbine intake 9-10	3	30.0	15.0
Turbine intake 1-4	2	20.0	10.0
Total Canal Passed	**10**	**100.0**	**50.0**
All Bellows Falls Released Fish			
Total Passed	**44**	**100.0**	**62.9**
Did not pass	1		1.4
Did not approach	25		35.7
Total Released	**70**		**100.0**

Table 5.1.3-3. Eel passage routes at Vernon for all eels released into the Wilder impoundment, fall 2015.

Passage Route	No.	% of all passed	% of all released
Wilder Released Fish			
Turbine intake 5-8	9	36.0	18.0
Turbine intake 9-10	6	24.0	12.0
Turbine intake 1-4	4	16.0	8.0
Fish pipe	1	4.0	2.0
Unknown	5	20.0	10.0
Total Passed	**25**	**100.0**	**50.0**
Did not approach	25		50.0
Total Released	**50**		**100.0**

Table 5.1.3-4. Eel passage routes at Vernon for all eels released into the Wilder, Bellows Falls or Vernon impoundments and Bellows Falls power canal, fall 2015.

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**

Downstream Movement and Timing

Where data were available, approach duration, forebay residency time, tailrace residency time, and total time in the Vernon study area was calculated for each individual. Approach times were calculated for eels originally released into the Vernon impoundment as the duration of time from release into the river until initial detection at the forebay monitoring stations. Forebay residency times were calculated for all eels as the duration of time from initial detection at the forebay monitoring stations until final detection at either a confirmed passage route receiver (for individuals passing by a known route) or a forebay monitoring station (for individuals passing by an unknown route). Tailrace residency times were calculated as the duration of time from the initial to final detections at monitoring areas immediately downstream of Vernon. Finally, a total project time was calculated as the sum of forebay and tailrace residency.

Approach Duration:

Valid detection information was available to determine the approach duration all 44 individuals released in the Vernon impoundment and detected in the forebay. Approach duration for these eels ranged from approximately 4.3 hours to 531.5 hours (22 days, 3 hours and 30 min) with an overall median duration of 49.5 hours (2 days, 1 hour, 30 min; Table 5.1.3-5). Approach from the Vernon impoundment release site to the forebay was slower than observed at the upstream projects. Approximately 36% of eels released in the Vernon impoundment were present within the Vernon study area within 24 hours following release (Figure 5.1.3-1).

Table 5.1.3-5. Minimum, maximum, mean, and median approach duration (hrs) for Vernon impoundment release groups V1 through V5 of radio-tagged adult silver eels at Vernon, fall 2015.

Release Group	Approach Duration (hours)				
	Min	Max	Mean	Median	No.
V1	4.3	531.5	103.6	49.5	10
V2	5.5	35.6	10.0	6.8	10
V3	7.5	152.5	53.0	54.8	7
V4	6.9	268.6	136.8	132.5	9
V5	7.0	197.4	67.2	67.1	8
All	**4.3**	**531.5**	**74.4**	**49.5**	**44**

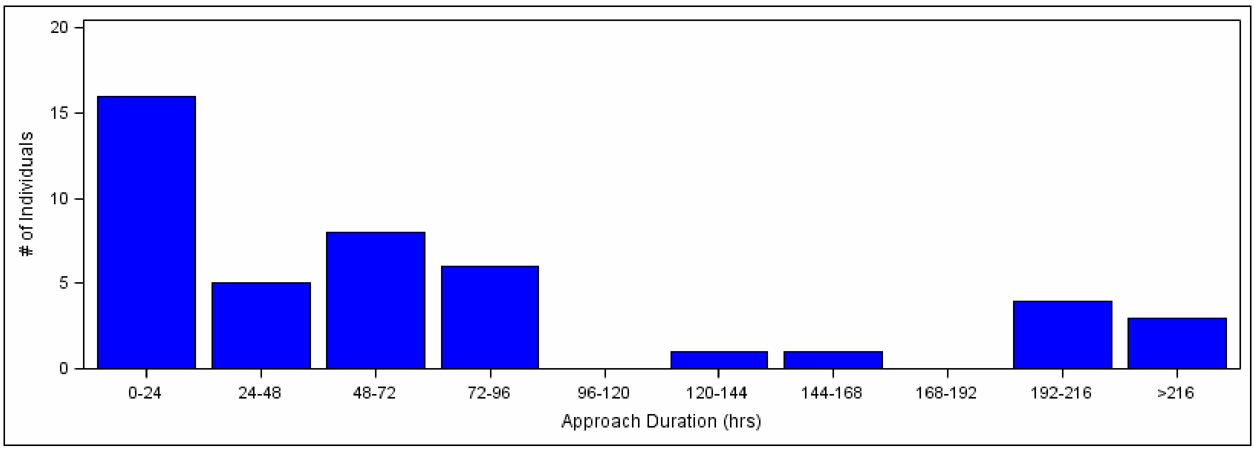


Figure 5.1.3-1. Frequency distribution of approach duration (in hours) for radio-tagged silver eels from Vernon impoundment release groups V1-V5 from the upstream release site to Vernon approach receiver.

Forebay Residency Duration:

Including individuals that did not pass Vernon, a total of 114 eels released into the Wilder or Bellows Falls impoundments, Bellows Falls power canal, or Vernon impoundment were available to pass Vernon (Tables 5.1.3-1, 5.1.3-2, 5.1.3-3). Valid detection information was available to determine the forebay residency time for each of these individuals, and ranged from less than 0.1 hour to 835 hours (34 days, 19 hours) with an overall median of 0.2 hour (Table 5.1.3-6). For the majority of eels (89%; 102 of the 114) that passed Vernon, forebay residency duration was less than 4 hours (Figure 5.1.3-2). When examined among individuals with known passage routes and an adequate sample size (i.e., greater than 5 individuals; Table 5.1.3-7) there were no statistically significant differences among the mean forebay residency times (Kruskal Wallis test; χ^2 = 2.744; *df* = 2; *p* = 0.2537).

Table 5.1.3-6. Minimum, maximum, mean, and median forebay residency duration (hrs) by release location at Vernon fall 2015.

Release Location	Release Group	Forebay Residency Duration (hours)				
		Min	Max	Mean	Median	No.
Wilder Impoundment	All	<0.1	23.2	4.0	0.1	25
Bellows Falls Impoundment	All	<0.1	835.0	24.2	0.2	35
Bellows Falls Canal	All	0.1	44.9	5.5	0.2	10
Vernon Impoundment	V1	<0.1	32.4	5.3	0.2	10
	V2	<0.1	0.3	0.1	0.1	10
	V3	0.1	0.3	0.2	0.2	7
	V4	<0.1	96.1	11.0	0.3	9
	V5	0.1	102.0	13.2	0.6	8
All		**<0.1**	**835.0**	**11.1**	**0.2**	**114**

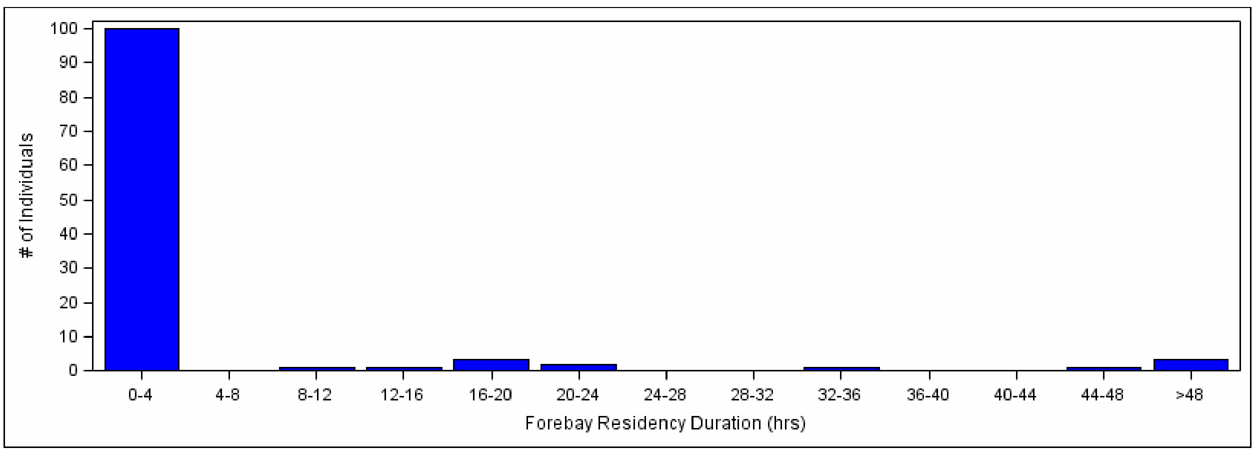


Figure 5.1.3-2. Frequency distribution of forebay residency duration (in hours) for radio-tagged silver eels from all release groups which passed from the forebay to downstream.

Table 5.1.3-7. Minimum, maximum, mean, and median forebay residency duration (hrs) by downstream passage route at Vernon fall 2015.

Passage Route	Forebay Residency Duration (hours)				
	Min	Max	Mean	Median	No.
Turbine intake 5-8	<0.1	44.9	2.8	0.2	53
Turbine intake 9-10	<0.1	835.0	34.1	0.1	26
Turbine intake 1-4	<0.1	96.1	8.5	0.2	14
Unknown	<0.1	0.1	0.1	0.1	11
Fish pipe	0.1	0.3	0.2	0.2	4
No Pass	0.5	1.7	1.1	1.1	2
Trash/Ice sluice	0.7	2.3	1.5	1.5	2
Fish tube	102.0	102.0	102.0	102.0	1
Fish ladder	0.1	0.1	0.1	0.1	1
All	**<0.1**	**835.0**	**11.1**	**0.2**	**114**

Tailrace Residency Duration:

Valid detection information was available to determine a tailrace residency time for all 112 eels that passed Vernon. When individuals from all release groups (Wilder and Bellows Falls impoundments, Bellows Falls power canal, Vernon impoundment) are considered, tailrace residency ranged from <0.1 hour to 1,961.9 hours (81 days, 17 hours, 54 minutes) (Table 5.1.3-8). Approximately 69% of eels were detected within the tailrace for 4 or fewer hours following downstream passage (Figure 5.1.3-3). Six individuals were detected in the Vernon tailrace for a minimum of 70 days after passage and were not subsequently detected downstream at Stebbins Island. All had passed downstream via the turbine units (four via Units 5-8, two via Units 9-10) and were likely mortalities. Ten eels determined to have passed via the turbine units had tailrace residency duration between 2 and 49 days, and were detected at Stebbins Island following that period.

Table 5.1.3-8. Minimum, maximum, mean, and median tailrace residency duration (hrs) by release location at Vernon fall 2015.

Release Location	Release Group	Tailrace Residency Duration (hours)				
		Min	Max	Mean	Median	No.
Wilder Impoundment	All	<0.1	1,787.4	142.5	0.5	25
Bellows Falls Impoundment	All	<0.1	1,693.8	72.1	0.6	34
Bellows Falls Canal	All	0.1	1,934.6	228.2	1.8	10
Vernon Impoundment	V1	0.2	27.7	6.6	1.4	10
	V2	0.1	1,961.9	368.8	0.2	10
	V3	0.1	782.7	175.0	1.0	7
	V4	0.6	1,835.0	386.8	7.8	8
	V5	<0.1	290.7	37.3	1.0	8
All		**<0.1**	**1961.9**	**148.8**	**0.8**	**112**

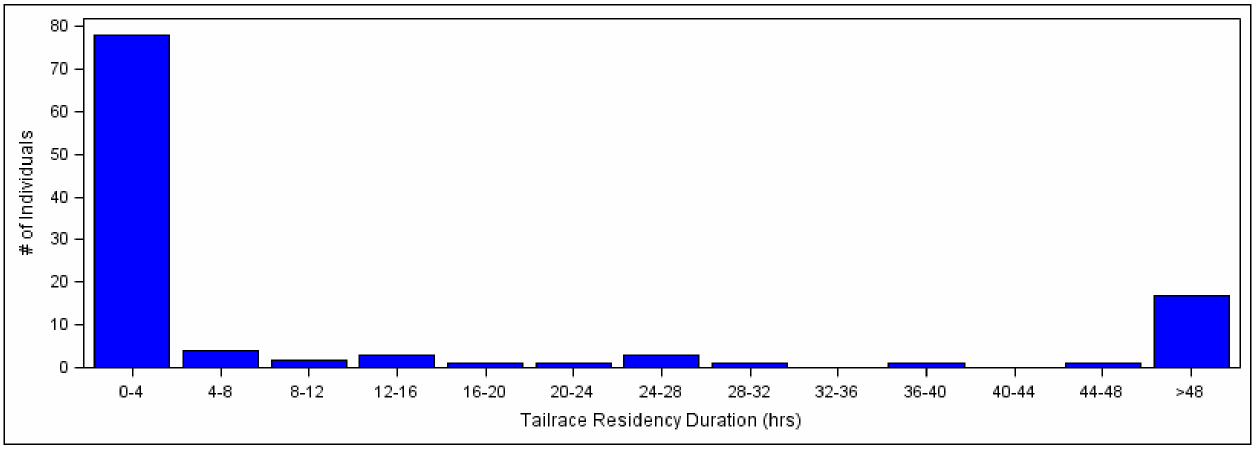


Figure 5.1.3-3. Frequency distribution of tailrace residency duration (in hours) for radio-tagged silver eels from all release groups which passed from the forebay to downstream.

The minimum, maximum, median, and mean tailrace residency duration for eels from all groups released upstream of Vernon that were documented as passing downstream are provided by passage route in Table 5.1.3-9. The mean tailrace residency duration was examined for individuals passing via Units 1-4, 5-8, and 9-10 (routes with an adequate sample size, greater than 5 individuals). Mean tailrace time did not differ significantly among eels exiting the Vernon forebay via any of the three sets of turbine units (Kruskal Wallis test; $\chi^2 = 0.412$; $df = 2$; $p = 0.8137$).

Table 5.1.3-9. Minimum, maximum, mean, and median tailrace residency duration (hrs) by downstream passage route at Vernon fall 2015.

Passage Route	Tailrace Residency Duration (hours)				
	Min	Max	Mean	Median	No.
Turbine intake 5-8	<0.1	1934.6	205.1	0.6	53
Turbine intake 9-10	<0.1	1961.9	150.0	0.9	26
Turbine intake 1-4	0.1	1034.3	80.4	0.6	14
Unknown	0.1	668.6	67.7	0.9	11
Fish pipe	0.2	0.9	0.4	0.3	4
Trash/Ice sluice	3.1	18.2	10.6	10.6	2
Fish tube	1.2	1.2	1.2	1.2	1
Fish ladder	1.5	1.5	1.5	1.5	1
All	**<0.1**	**1961.9**	**148.8**	**0.8**	**112**

Total Project Residency Duration:

Valid detection information was available to calculate total project residency duration for all 112 eels determined to have passed the project. Table 5.1.3-10 presents the minimum, maximum, median, and mean total project residence duration by release location. Total project residence duration from initial forebay detection until final detection at the downstream tailrace receivers ranged from 0.1 hour to 1,962.1 hours (81 days, 18 hours, 6 minutes) (median = 1.2 hours). Of eels that passed, approximately 76% (N=85) arrived and departed the Vernon study area in less than 24 hours (Figure 5.1.3-4).

Table 5.1.3-10. Minimum, maximum, mean, and median total project residency duration (hrs) for all radio-tagged adult silver eels passing downstream of Vernon, fall 2015.

Release Location	Release Group	Total Project Residency Duration (hours)				
		Min	Max	Mean	Median	No.
Wilder Impoundment	All	0.1	1,808.1	146.5	1.0	25
Bellows Falls Impoundment	All	0.1	1,695.6	97.0	1.0	34
Bellows Falls Canal	All	0.2	1,934.8	233.7	4.0	10
Vernon Impoundment	V1	0.2	60.1	11.9	1.8	10
	V2	0.1	1,962.1	368.9	0.4	10
	V3	0.2	782.7	175.2	1.2	7
	V4	1.1	1,835.3	399.0	34.0	8
	V5	0.5	291.4	50.5	1.9	8
All		**0.1**	**1,962.1**	**160.1**	**1.2**	**112**

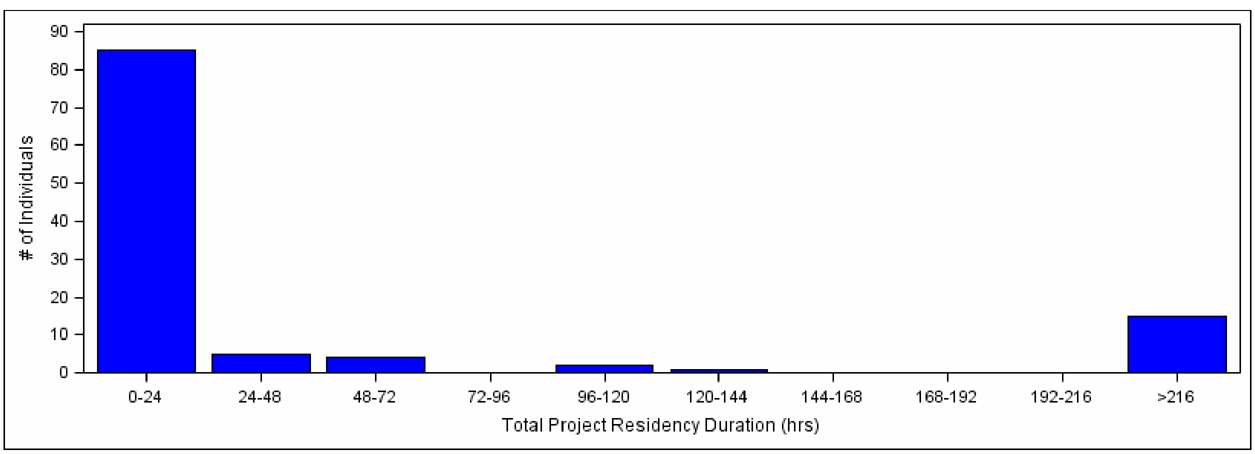


Figure 5.1.3-4. Frequency distribution of Vernon total project residency duration (in hours) for radio-tagged silver eels from all release locations, fall 2015.

Temporal Distribution of Downstream Passage Events

The temporal distribution of downstream passage events for all eels released upstream of Vernon from all release points is presented on an hourly basis in Figure 5.1.3-5 and on a daily basis in Figure 5.1.3-6. The majority passed the project during the evening and early morning hours from 17:00 to 07:00. Downstream passage events during the daylight hours were limited in frequency. The majority of eels (70%) released into the Vernon impoundment passed the project within one day after the final release on November 5, 2015 with the latest documented passage event occurring on November 20, 2015. Eels approaching from the Bellows Falls impoundment and power canal release sites passed Vernon between October 29 and December 28, 2015 with most passing during the first half of November. Eels approaching from the Wilder impoundment release site passed Vernon between November 1 and November 21, 2015.

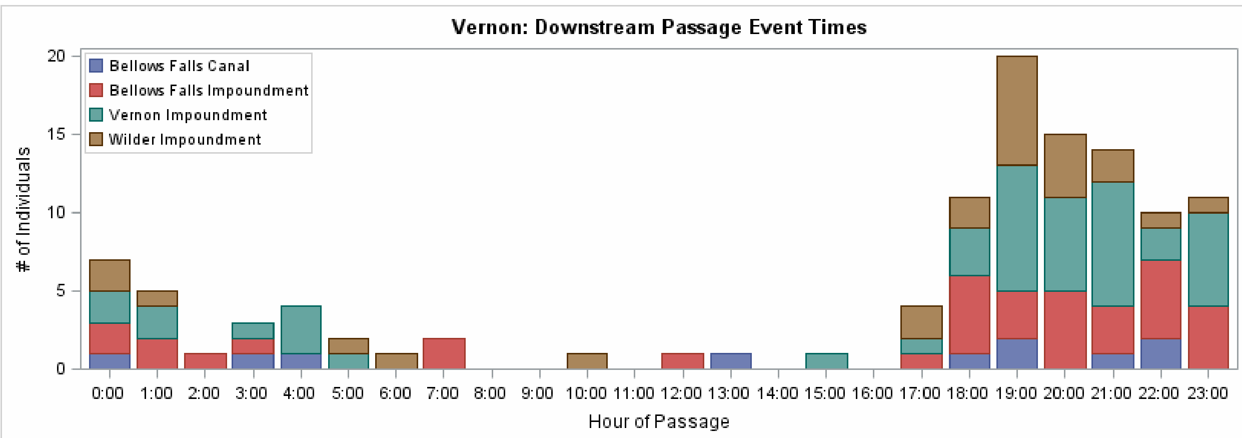
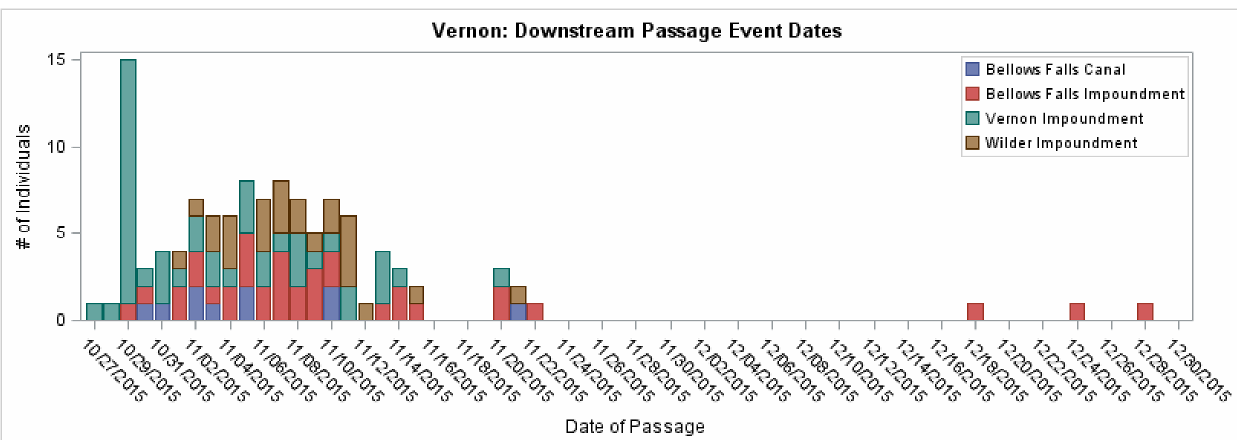


Figure 5.1.3-5. Passage of radio-tagged silver eels by time of day and release location at Vernon, fall 2015.



Note: Eels were released at Vernon on 10/27, 10/29, 10/31, 11/03, and 11/05.

Figure 5.1.3-6. Passage of radio-tagged silver eels by date and release location at Vernon, fall 2015.

Downstream Passage and Vernon Operations

A summary of proportional route discharge conditions at the time of downstream passage at Vernon is provided in Table 5.1.3-11. The majority of eels passing Vernon did so via the turbine units (12.5% via Units 1-4, 47.3% via Units 5-8, and 23.2% via Units 9-10; Table 5.1.3-4). Discharge through the units at the time of passage ranged from non-reported to 4,028 cfs (mean = 1,102 cfs) for Units 1-4; 748 to 7,042 cfs (mean = 6,065) for Units 5-8; and from 1,280 to 3,261 (mean = 1,871) for Units 9-10. The average proportion of total project flow at the determined downstream passage routes was 59.9% for Units 5-8; 40.1% for Units 9-10; 8.7% for Units 1-4; 7.6% for the fish pipe, and less than 5% for all other routes.

Project operations at the determined time of passage for eels using the trash/ice sluice did not coincide with significant discharge there. It is suspected that there may have been enough leakage flow (not registered in flow monitoring data) to allow passage at those times. Individuals did not necessarily pass downstream via the route with the greatest proportion of total project discharge at the time of passage. Passage via the downstream route with the greatest proportion of flow at the time of passage occurred 61.4% of the time. A full listing of route discharge for radio-tagged silver eels passing Vernon is provided along with a listing of arrival and passage information in Appendix F-3 (filed separately in Excel format).

Table 5.1.3-11. Summary of radio-tagged silver eel passage and proportion of flow at Vernon, fall 2015.

Passage Route	No. Using Route	Route Discharge at Time of Passage						Non-route Discharge at Time of Passage					
		cfs			% of Total Available Discharge			cfs			% of Total Available Discharge		
		Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean
Turbine intake 5-8	53	748	7,042	6,065	29.5	77.6	59.9	1,739	7,878	4,378	22.4	70.5	40.1
Turbine intake 9-10	26	1,280	3,261	1,871	11.8	80.5	40.1	455	19,997	4,834	19.5	88.2	59.9
Turbine intake 1-4	14	0	4,028	1,102	0.0	31.2	8.7	1,916	9,803	7,721	68.8	100.0	91.3
Unknown	11	-	-	-	-	-	-	-	-	-	-	-	-
Fish pipe	4	350	350	350	2.6	18.4	7.6	1,552	13,149	7,186	81.6	97.4	92.4
Trash/Ice sluice	2	0	0	0	0.0	0.0	0.0	1,933	8,513	5,223	100.0	100.0	100.0
Fish tube	1	40	40	40	2.0	2.0	2.0	1,953	1,953	1,953	98.0	98.0	98.0
Fish ladder	1	65	65	65	1.1	1.1	1.1	5,742	5,742	5,742	98.9	98.9	98.9
Total	112												

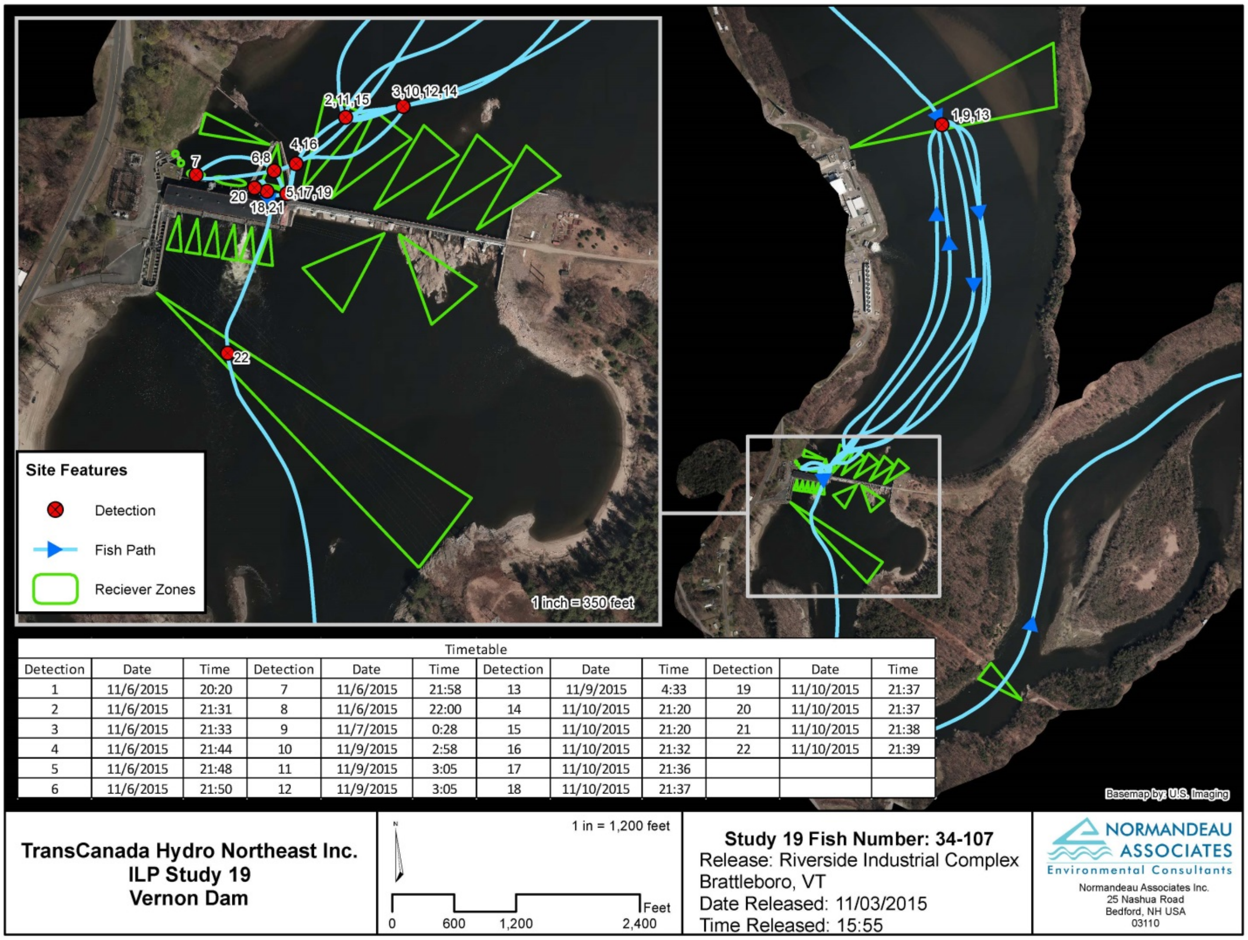
Nearfield Movement Patterns

As described in Section 5.5.1, Nearfield Movement Patterns (Wilder), National Marine Fisheries Service has identified a period of 24 hours project residence time upstream of a hydroelectric project to be detrimental for federally endangered Atlantic Salmon smolts in critical habitat in Maine rivers. In this study, the proportion of eels exhibiting back and forth patterns between stationary receivers and forebay residence times greater than 8 and 24 hours were identified as a proxy for potential project impacts due to wandering or potential searching behavior.

Based on analysis of telemetry data and detections at radio receivers, five of the 112 eels that subsequently passed the project (4.5%) were present in the forebay for more than 24 hours prior to passage and were detected multiple times between the forebay entrance and potential downstream routes (example shown in Figure 5.1.3-7). Another seven eels (6.3%) were present in the forebay area for between 8 and 24 hours prior to passage and all but one were detected at multiple potential downstream routes.

The remaining 100 eels (89.3%) that passed the project did so in less than eight hours, and 67 of those (74.4% of all eels that passed) passed in less than one hour regardless of demonstrating potential searching behavior.

Appendix E includes maps for all successfully passed eels. It should be noted that approach paths are generalized based on detection through the receiver detection zone only, and not necessarily the exact location of approach path (e.g., river right, left, or center).



Timetable

Detection	Date	Time	Detection	Date	Time	Detection	Date	Time	Detection	Date	Time
1	11/6/2015	20:20	7	11/6/2015	21:58	13	11/9/2015	4:33	19	11/10/2015	21:37
2	11/6/2015	21:31	8	11/6/2015	22:00	14	11/10/2015	21:20	20	11/10/2015	21:37
3	11/6/2015	21:33	9	11/7/2015	0:28	15	11/10/2015	21:20	21	11/10/2015	21:38
4	11/6/2015	21:44	10	11/9/2015	2:58	16	11/10/2015	21:32	22	11/10/2015	21:39
5	11/6/2015	21:48	11	11/9/2015	3:05	17	11/10/2015	21:36			
6	11/6/2015	21:50	12	11/9/2015	3:05	18	11/10/2015	21:37			

Figure 5.1.3-7. Example map showing eel wandering pattern prior to passage at Vernon, 2015.

5.1.4 Downstream Travel between Projects

The duration of time for radio-tagged silver eels to move between: 1) the Wilder tailrace and initial approach at Bellows Falls, 2) Bellows Falls tailrace and Vernon forebay, and 3) Vernon tailrace and Stebbins Island are presented in Table 5.1.4-1.

Of the 50 eels released upstream of Wilder, 29 (58%) were determined to have reached and passed downstream of Bellows Falls (Table 5.1.2-1). Of those, detection information was available for 27 individuals to evaluate transit time between the Wilder tailrace and the monitoring station immediately upstream of the Bellows Falls bypassed reach/power canal area (a distance of approximately 44 river miles). Transit through that reach ranged from 26 hours to 169.9 hours (7 days, 1 hour, 54 minutes) (median = 53.5 hours).

Of the 96 eels (representing individuals released into Wilder and Bellows Falls impoundments and Bellows Falls power canal) that were determined to have passed downstream of Bellows Falls, 69 (72%) were determined to have reached and passed downstream of Vernon (Tables 5.1.3-2 and 5.1.3-3). Of those, detection information was available for 62 individuals to evaluate transit time between the Bellows Falls tailrace and the monitoring station immediately upstream of Vernon (a distance of approximately 31 river miles). Transit through that reach ranged from 16.2 hours to 437.5 hours (18 days, 5 hours, 30 minutes) (median = 62.4 hours).

Of the 112 eels (representing individuals released from all upstream release sites that were determined to have passed downstream of Vernon (Tables 5.1.3-2 and 5.1.3-3), detection information was available for 102 individuals to evaluate transit time between the Vernon tailrace and the Stebbins Island monitoring station (a distance of 0.75 river miles). Transit through that reach ranged from <0.1 hour to 657.3 hours (27 days, 9 hours, 18 minutes) (median = 0.1 hour).

Table 5.1.4-1. Minimum, maximum, mean, and median downstream transit times (hours) for radio-tagged silver eels downstream of Wilder, Bellows Falls and Vernon projects, fall 2015.

Release Location	**Transit Time (hours)**				
	Min	**Max**	**Mean**	**Median**	**No.**
Wilder Tailrace to Bellows Falls Project					
Wilder impoundment	26.0	169.9	65.7	53.5	27
Bellows Falls Tailrace to Vernon Project					
Wilder impoundment	16.2	159.6	48.7	43.3	22
Bellows Falls impoundment	28.9	437.5	129.3	88.8	31
Bellows Falls power canal	24.1	141.5	69.4	52.8	9
All	16.2	437.5	92.0	62.4	62
Vernon Tailrace to Stebbins Island					
Wilder impoundment	<0.1	10.1	0.6	0.1	24
Bellows Falls impoundment	<0.1	657.3	21.4	0.1	31
Bellows Falls power canal	0.1	17.5	2.6	0.2	9
Vernon impoundment	<0.1	95.6	4.9	0.1	38
All	**<0.1**	**657.3**	**8.7**	**0.1**	**102**

The NHFGD July 14, 2016 comments on the initial study report filed May 16, 2016 suggested that “better understanding of the cumulative effects of the three dams on downstream eel passage required a closer look at the eels which were documented as passing multiple dams” and requested a summary of downstream passage routes at each project for eels within each of the four categories listed below.

FERC’s September 12, 2016 Study Plan Determination stated: “The telemetry portion of the study was not designed to track the eels passing multiple dams, instead it was designed to determine the movement rates, timing, and route selection of eels at each dam by releasing tagged eels upstream of a dam and tracking the eels until they were detected downstream of that dam. However, because the study was being conducted simultaneously at all three dams, some eels (i.e., those categorized by New Hampshire FGD) were incidentally detected at multiple dams. While the study was not intended to evaluate cumulative survival or passage through multiple dams…[this analysis] could provide information that helps describe the relationship between an eel's passage route and its likelihood of successfully passing multiple dams."

NHFGD suggested four categories of eels that could be evaluated in this manner:

1. Category 1: Eels originally released into the Wilder impoundment that passed downstream of Wilder, Bellows Falls and Vernon;
2. Category 2: Eels originally released into the Wilder impoundment that passed downstream of Wilder and Bellows Falls but did not pass Vernon;
3. Category 3: Eels originally released into the Bellows Falls impoundment or power canal that passed downstream of Bellows Falls and Vernon; and
4. Category 4: Eels originally released into the Bellows Falls impoundment or power canal that passed downstream of Bellows Falls but did not pass Vernon.

As requested, the distribution between downstream passage routes at each project for the four NHFGD categories is presented in Tables 5.1.4-2 through 5.1.4-5. In addition, the minimum, maximum, median, and mean project residency or downstream travel durations for each project or downstream reach passed are included in the tables.

Table 5.1.4-2. Downstream passage route, project residency and downstream travel duration information for radio-tagged silver eels in NHFGD's Category 1 - Wilder released eels that passed Bellows Falls and Vernon.

Passage Route			No.	%
WILDER	Units 1-2		18	72
	Unknown		3	12
	Unit 3		2	8
	Trash/Ice Sluice		2	8
	Total		**25**	**100**
BELLOWS FALLS	Units 1-3		18	72
	Trash/Ice Sluice		5	20
	Spill		2	8
	Total		**25**	**100**
VERNON	Units 5-8		9	36
	Units 9-10		6	24
	Unknown		5	20
	Units 1-4		4	16
	Fish Pipe		1	4
	Total		**25**	**100**
Duration (hours)	**Min**	**Max**	**Mean**	**Median**
Wilder Project Residency	0.1	43.5	5.8	0.9
Wilder Tailrace to Upstream Bellows Falls	30.3	169.9	64.6	53.5
Bellows Falls Project Residency	0.4	39.9	6.5	1.3
Bellows Falls Tailrace to Upstream Vernon	16.2	159.6	48.7	43.3
Vernon Project Residency	0.1	1,808.2	146.6	1.0

Table 5.1.4-3. Downstream passage route, project residency and downstream travel duration information for radio-tagged silver eels in NHFGD's Category 2 - Wilder released eels that only passed Bellows Falls.

Passage Route			No.	%
WILDER	Units 1-2		4	100
	Total		**4**	**100**
BELLOWS FALLS	Units 1-3		3	75
	Trash/Ice Sluice		1	25
	Total		**4**	**100**
Duration (hours)	**Min**	**Max**	**Mean**	**Median**
Wilder Project Residency	0.4	19.5	5.3	0.6
Wilder Tailrace to Upstream Bellows Falls	26.0	144.8	72.3	59.2
Bellows Falls Project Residency	0.4	1,843.9	461.6	1.0

Table 5.1.4-4. Downstream passage route, project residency and downstream travel duration information for radio-tagged silver eels in NHFGD's Category 3 - Bellows Falls released eels that passed Vernon.

Passage Route			No.	%
BELLOWS FALLS	Units		37	84
	Trash/Ice Sluice		5	11
	Spill		2	5
	Total		**44**	**100**
VERNON	Units 5-8		20	45
	Units 9-10		13	30
	Units 1-4		6	14
	Unknown		3	7
	Trash/Ice Sluice		1	2
	Fish Pipe		1	2
	Total		**44**	**100**
Duration (hours)	**Min**	**Max**	**Mean**	**Median**
Bellows Falls Project Residency	0.1	1,174.4	58.7	1.6
Bellows Falls Tailrace to Upstream Vernon	24.1	437.5	116.9	77.7
Vernon Project Residency	0.1	1,934.9	128.1	1.2

Table 5.1.4-5. Downstream passage route, project residency and downstream travel duration information for radio-tagged silver eels in NHFGD's Category 4 - Bellows Falls released eels that did not pass Vernon.

Passage Route			No.	%
BELLOWS FALLS	Units 1-3		19	83
	Trash/Ice Sluice		2	9
	Spill		2	9
	Total		**23**	**100**
Duration (hours)	**Min**	**Max**	**Mean**	**Median**
Bellows Falls Project Residency	0.1	1,967.2	269.2	4.3

Of the 50 eels released above Wilder, 29 subsequently passed Bellows Falls (Table 5.1.2-1) and 25 also passed Vernon (Table 5.1.3-3). Those that passed all three projects (Category 1, N=25) predominately used the turbines at each project with 80%, 72%, and 76% passing via turbines at Wilder, Bellows Falls, and Vernon, respectively (Table 5.1.4-2). For Wilder-released eels that passed Bellows Falls but not Vernon (Category 2, N=4), 100% passed Wilder via turbine units 1-2, and 75% subsequently passed via Bellows Falls turbines, similar to Category 1 eel passage routes at the projects downstream of Wilder (Table 5.1.4-3). Statistical comparison between mean Wilder project residency duration and transit times from the Wilder tailrace to upstream of Bellows Falls were not reasonable given the small sample size of Category 2 eels. However, the mean and median values for both durations were comparable between the two categories. Median Bellows Falls project residency also appeared similar for both categories (Category 1 = 1.3 hr, Category

2 = 1.0 hr); however, mean Bellows Falls project residency appeared longer for Category 2 eels (461.6 hrs versus 6.5 hrs for Category 1), although the higher value is skewed by the contribution from a single Category 2 eel.

Of the 70 Bellows Falls-released eels, 67 passed Bellows Falls (Table 5.1.2-1) and 44 of those also passed Vernon (Table 5.1.3-2). These two groups of eels showed a similar pattern as Wilder-released eels where 84% of Category 3 eels (those released at Bellows Falls that also passed Vernon, N=44) used the Bellows Falls turbines (Table 5.1.4-4) compared to 83% of Category 4 eels (Bellows Falls released eels that did not pass Vernon, N=23) (Table 5.1.4-5). There was no statistically significant difference between the mean Bellows Falls project residency durations for Category 3 eels than for Category 4 eels (Wilcoxon; z = 1.1473; p = 0.2512). Based on the limited observations of eels with multiple dam passage events during this study, there were no apparent patterns as to whether or not an individual would reach the next downstream project when examining downstream passage route or project residency duration. The majority of individuals that did and did not reach the next downstream project predominantly passed by turbines and in general, did not show great differences in residence times at the projects.

5.2 Turbine Survival

5.2.1 Recapture Rates

The HI-Z tag recapture technique performed satisfactorily with high recapture rates (physical retrieval of live and dead eels), with the exception of Wilder Unit 3. Details are provided in Table 5.2.1-1 and Appendix C for the three projects.

As discussed in Section 4.4.1, eels were released at Wilder Unit 3 on October 30, 2015. In the initial test group, ten eels were released into the unit and three emerged in the tailrace, resulting in the loss of seven eels as well as the seven radio tags they were carrying (radio tags were used on more than one fish during this study, averaging about 10 fish per tag and loss of many radio tags could have impacted the ability to continue the evaluation). With the 70% loss of fish, the Unit 3 study was suspended and the aquatics working group was notified via email of this study plan variance.

Eels were released through Unit 2 at Wilder on November 1, 2015. Of the 50 treatment eels released, 40 (80%) were recaptured alive and seven (14%) were retrieved dead. Only inflated HI-Z tags were retrieved on 3 (6%) treatment eels. The eels with only the HI-Z tags recaptured were assigned a dead status. The recapture rate for the combined controls was 97.4%. This rate was also used for Bellows Falls, and Vernon.

At Bellows Falls eels were released through Unit 2 on October 30, 2015 with a high recapture rate of 100% for both treatment and control eels.

Eels were released on four days at Vernon: through Unit 4 on October 28, Unit 8 (discharging 1,000 cfs) on October 26, Unit 8 (discharging 1,700 cfs) on November 3, and Unit 9 on October 27. Control eels were released on October 27 and 28. Recapture rate was high at 93.8% (Unit 4), 95.8% (Unit 8 at 1,000 cfs), 88.0%

(Unit 8 at 1,700 cfs), and 95.8% (Unit 9). Inflated, dislodged HI-Z tags were retrieved on one eel at Unit 4, two at Unit 8 at 1,000cfs, and four at Unit 8 at 1,700 cfs. Released eels with only the HI-Z tags recovered were assigned a dead status.

Table 5.2.1-1. Tag-recapture data and estimated 1-hour and 48-hour survival for adult eels.

	Vernon Unit 4		Vernon Unit 8 @ 1,000 cfs		Vernon Unit 8 @ 1,700 cfs		Vernon Unit 9		Vernon Units Combined		Bellows Falls Unit 2		Wilder Unit 2		Combined Controls [c]	
No. Released[a]	**48**	**%**	**48**	**%**	**50**	**%**	**48**	**%**	**194**	**%**	**50**	**%**	**50**	**%**	**39**	**%**
No. Alive	45	94	43	90	39	78	46	96	173	89	50	100	40	80	38	97
No. Recaptured Dead	0		3	6	5	10	0		8	4	0		7	14	0	
No. Assigned Alive[b]	0		0		0		0		0		0		0		1	3
No. Assigned Dead	1	2	2	4	6	12	1	2	10	5	0		3	6	0	
Tags Only	1		2		4		0		7		0		3		0	
Stationary Signal	0		0		2		1		3		0		0		0	
No. Unknown	2	4	0		0		1	2	3	2	0		0		0	
Survival at 1 hour (%)	97.8%		89.6%		78.0%		97.9%		91.1%		100.0%		80.0%			
Std Error (%)	2.2%		4.4%		5.9%		2.1%		2.1%		N/A		5.7%			
No. Held	45		43		39		46		173		50		40		38	
Died in Holding	2		1		2		0		5		1		9		0	
Alive at 48 hours	43		42		37		46		168		49		31		38	
Survival at 48 hours (%)	93.5%		87.5%		74.0%		97.9%		88.0%		98.0%		62.0%			
Std Error (%)	3.6%		4.8%		6.2%		2.1%		2.4%		2.0%		6.9%			
90% CI (%)	6.0%		7.8%		10.2%		3.5%		3.8%		3.2%		11.3%			

a. Analytical sample; some eels were removed from analysis due to unrecoverable conditions (i.e., trapped in tailrace).

b. Eels assigned alive status based on telemetry and visual observation.

c. Combined controls released into the tailrace downstream of the three stations.

5.2.2 Recapture Times

Recapture times (the time interval between eel release and subsequent recapture) for the eels released through Wilder Unit 2 ranged from 1 to 16 minutes and averaged 3.3 minutes. Almost all the eels were recaptured within eight minutes; however, one eel was recaptured 16 minutes after being released. This eel was alive, and had no injuries attributable to turbine passage (Figure 5.2.2-1). The average time for the combined control recapture at Wilder, Bellows Falls, and Vernon was 21.1 minutes. This recapture time was also used for Bellows Falls and Vernon.

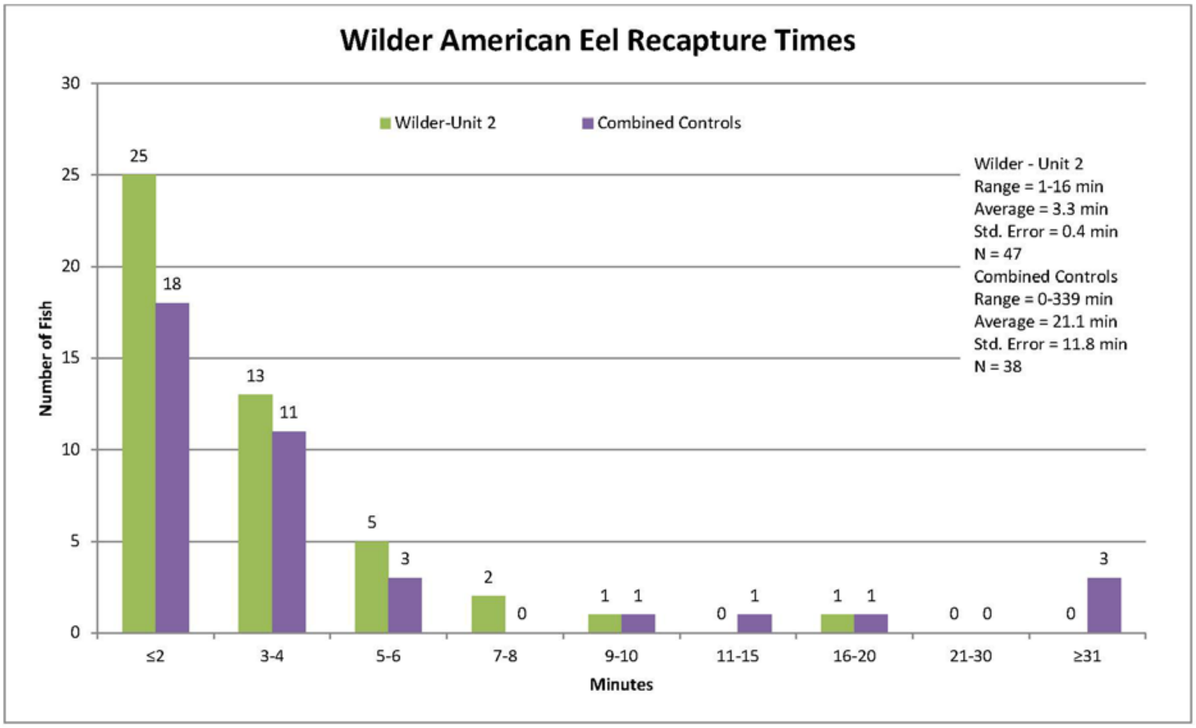


Figure 5.2.2-1. Recapture times for HI-Z tagged adult American Eels released at Wilder Station. Combined controls released at the three projects.

At Bellows Falls, recapture times (the time interval between eel release and subsequent recapture) for the eels released through Unit 2 ranged from 1 to 73 minutes and averaged 9.3 minutes. All but five of the eels were recaptured within fifteen minutes; however, three eels were recaptured more than 30 minutes after being released. Many of the eels that took longer to recapture surfaced along the downstream face of the power house and had to be captured with a drop net from shore near the downstream fish passage exit flume (Figure 5.2.2-2).

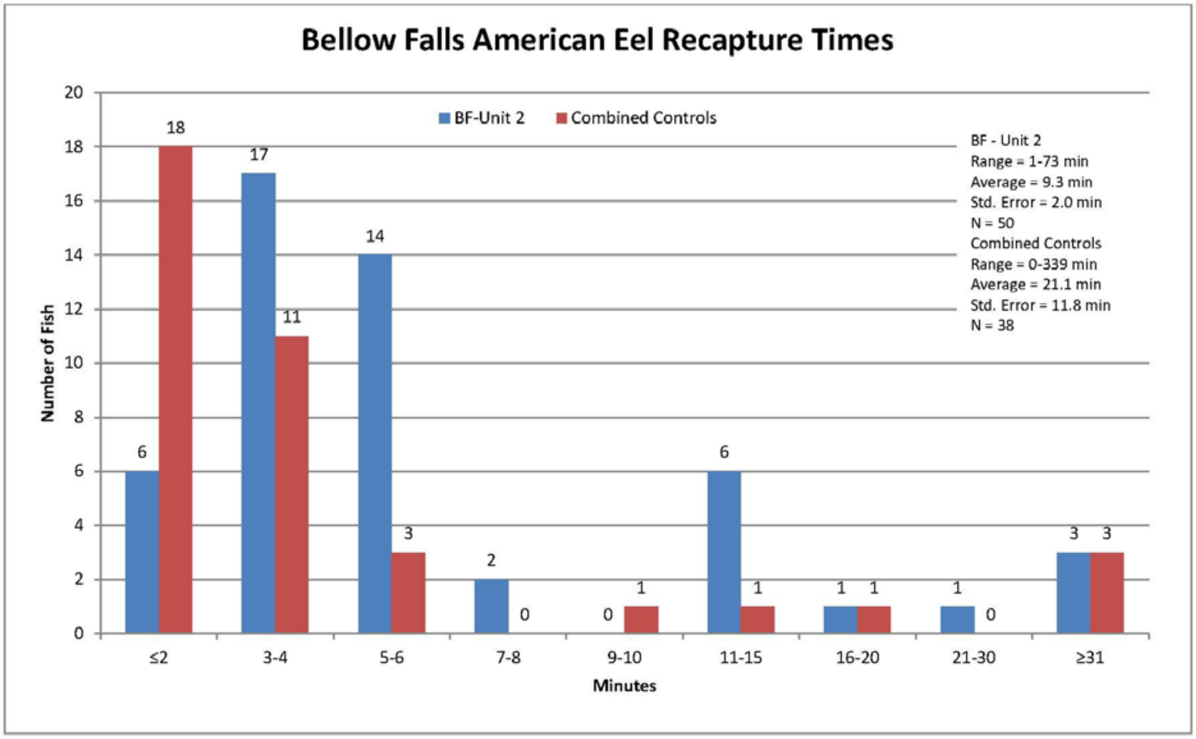


Figure 5.2.2-2: Recapture times for HI-Z tagged adult American Eels released at Bellows Falls Station. Combined controls released at the three projects.

At Vernon, recapture times (the time interval between eel release and subsequent recapture) for the eels released through Unit 4 ranged from 2 to 325 minutes (5.4 hours) and averaged 14.9 minutes. All but three of the eels were recaptured within 25 minutes; however, three eels had recapture times >30 minutes. The one that was recaptured alive 325 minutes after release had no injuries attributable to turbine passage (Figure 5.2.2-3).

Recapture times for eels released through Vernon Unit 8 discharging at 1,000 and 1,700 cfs ranged from 1 to 255 minutes (4.25 hours), and 2 to 126 minutes (2.1 hours), respectively. Average recapture times were 10.6 minutes for Unit 8 eels released at 1,000 cfs and 11.5 minutes for Unit 8 eels released at 1,700 cfs. All but two of the eels were recaptured within 30 minutes of release at 1,000 cfs. Only three of 50 eels were recaptured after 30 minutes at release at 1,700 cfs.

At Vernon Unit 9, eel recapture times ranged from 1 to 237 minutes (3.95 hours) and averaged 24.6 minutes. All but seven eels were recaptured within 15 minutes with recapture times for those seven >59 minutes. All seven of these eels were recaptured alive and had no injuries attributable to turbine passage. Most of the long recapture times were for eels that appeared to hold up for extended periods in underwater structures before the HI-Z tags could buoy them to the surface. There were also indications that some of these eels were able to dislodge some of their tags by spinning while in crevices in boulders.

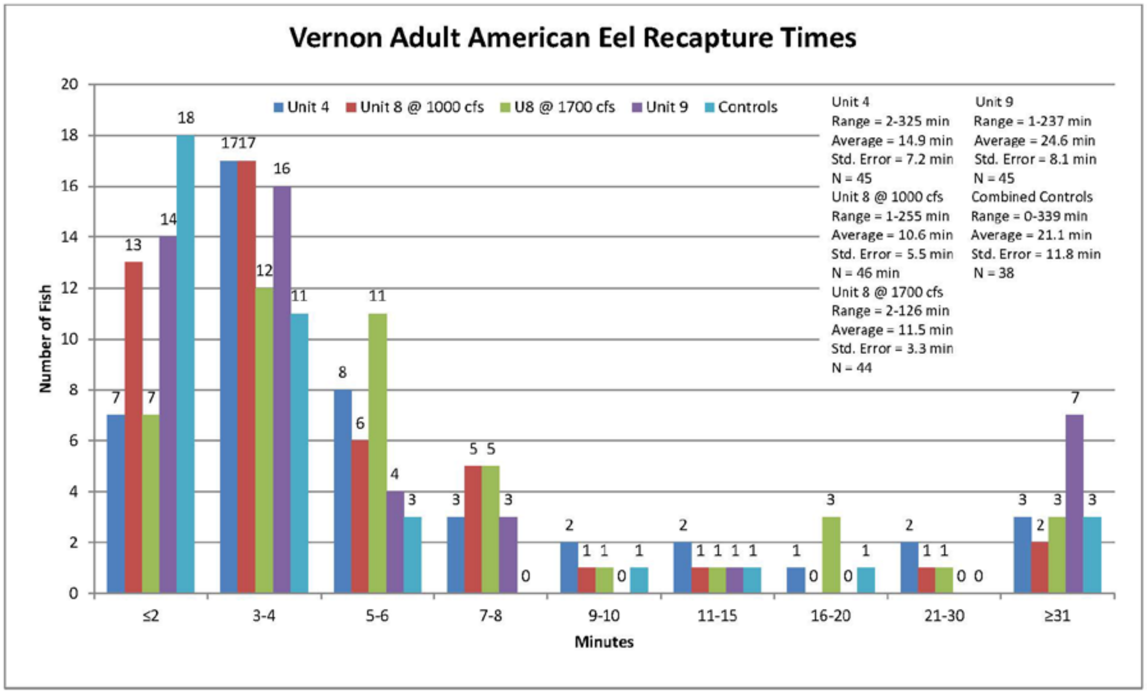


Figure 5.2.2-3. Recapture times for HI-Z tagged adult American Eels released at Vernon Station. Combined controls released at the three projects.

5.2.3 Survival Estimates

All Fish

Survival estimates for all fish are provided in Table 5.2.1-1 above for each of the three projects.

At Wilder the 1-hour direct survival was 80%. Survival at 48 hours was 62.0%. The 48-hour survival estimate was adjusted downward by one eel that was alive at 48 ours but classified as functionally dead (severely injured). The precision of the 48-hour survival estimates for the Unit 2 eels was within ± 11.3%, 90% of the time. The target precision of ≤ ± 10.0%, 90% of the time for the Unit 2 survival estimate was not attained primarily because of the relatively low survival estimate.

At Bellows Falls the 1-hour direct survival was 100.0%. Survival at 48 hours was 98.0%. The precision of the 48-hour survival estimates for the Unit 2 eels was within ± 3.2%, 90% of the time.

At Vernon the 1-hour direct survival was 97.8% (Unit 4), 89.6% (Unit 8 at 1,000 cfs), 78.0% (Unit 8 at 1,700 cfs), and 97.9% (Unit 9). Survival at 48 hours was 93.5%, 87.5%, 74.0%, and 97.9% for the Unit 4, Unit 8 at 1,000 cfs, Unit 8 at 1,700 cfs, and Unit 9 releases, respectively. These survival estimates excluded three eels still alive at 48 hours that were considered functionally dead (severely injured). The precisions of the 48-hour survival estimates for Unit 4, Unit 8 at 1,000 cfs, and Unit 9 releases were all within ± 7.8%, 90% of the time, and the precision for Unit 8 at 1,700 cfs was ±10.2%, 90% of the time. The 1- and 48-

hour direct survival estimates for the combined Vernon units were 91.1% and 88.0%, respectively. The precision of the 1- and 48-hour survival estimates were both within ± 3.8%, 90% of the time.

Only Recaptured Fish

Following the RSP, survival estimates were also calculated with only recaptured eels (Table 5.2.3-1). At Wilder the estimated 1-hour immediate survival was 85.1% and the 48-hour survival estimate was 66.0% (CI ±11.4%). Since all eels at Bellows Falls were recaptured, the estimated 1-hour (100%) and 48-hour (98.0%) survival estimates were the same as those reported above.

At Vernon the estimated 1-hour immediate survival was 100.0% (Unit 4), 93.5% (Unit 8 at 1,000 cfs), 88.6% (Unit 8 at 1,700 cfs), and 100.0% (Unit 9). Survival at 48 hours was 95.6%, 91.3%, 84.1%, and 100% for the Unit 4, Unit 8 at 1,000 cfs, Unit 8 at 1,700 cfs, and Unit 9 releases, respectively. These estimates were also adjusted for functionally dead eels. The precision of the survival estimates (1- and 48-hour) for the Unit 4, Unit 8 at 1,000 cfs, Unit 8 at 1,700 cfs, and Unit 9 releases were all within ± 9.1%, 90% of the time. For all Vernon units combined, 1- and 48-hour direct survival was 95.6% and 92.8%, respectively. The precision of the 1- and 48-hour survival estimates were both within ± 3.2%, 90% of the time.

Table 5.2.3-1. Tag-recapture data and estimated 1-hour and 48-hour survival for only recaptured adult eels, October-November 2015.

	Vernon Unit 4		Vernon Unit 8 @ 1000 cfs		Vernon Unit 8 @ 1700 cfs		Vernon Unit 9		Vernon Units Combined		Bellows Falls Unit 2		Wilder Unit 2		Combined Controls [b]	
No. Released [a]	**48**	**%**	**48**	**%**	**50**	**%**	**48**	**%**	**194**	**%**	**50**	**%**	**50**	**%**	**39**	**%**
No. Recaptured	45	94	46	96	44	88	46	96	181	93	50	100	47	94	38	97
No. Alive	45	94	43	90	39	78	46	96	173	89	50	100	40	80	38	97
No. Dead	0	0	3	6	5	10	0	0	8	4	0	0	7	14	0	0
Survival at 1 hour (%)	100.0%		93.5%		88.6%		100.0%		95.6%		100.0%		85.1%			
Std Error (%)	N/A		3.6%		4.8%		N/A		1.5%		N/A		5.2%			
No. Held	45		43		39		46		173		50		40		38	
Died in Holding	2		1		2		0		5		1		9		0	
Alive at 48 hours	43		42		37		46		168		49		31		38	
Survival at 48 hours (%)	95.6%		91.3%		84.1%		100.0%		92.8%		98.0%		66.0%			
Std Error (%)	3.1%		4.2%		5.5%		N/A		1.9%		2.0%		6.9%			
90% CI (%)	5.1%		6.8%		9.1%		N/A		3.2%		3.3%		11.4%			

a. Analytical sample; some fish were removed from analysis due to unrecoverable conditions (i.e., trapped in tailrace).

b. Combined controls released into the tailrace downstream of the three stations.

5.2.4 Injury Rate, Types, and Probable Source

Tables 5.2.4-1, 5.2.4-2 and 5.2.4-3 below, and Appendix D provide details on injury rates, types, and probable sources for the three projects.

At Wilder the injury rate for eels released into Unit 2 was 42.6%; 20 of the 47 recaptured eels had passage-related visible injuries. The dominant injuries for eels passing through Unit 2 were severed bodies or decapitations (12.8%) and internal hemorrhaging/broken bones (17.0%). These injuries were likely inflicted mechanically by the blades and other components within the turbine. Other common injuries included gill damage (8.5%), hemorrhaged eye(s) (6.4%), scrapes or bruises on head or body (12.8%), and cuts or lacerations (2.1%). Almost all the injuries, 19 of 20 (40.4% of recaptured eels) were attributed to mechanical forces and one (2.1%) was attributed to shear forces. The cause of the two control eel injuries was undetermined and considered minor. No eels displayed only loss of equilibrium (LOE) upon recapture. Seventeen of the injuries (36.2%) were classified as major and three (6.4%) were considered minor.

At Bellows Falls seven of the 50 Unit 2 treatment eels (14.0%) and 2 of the 10 control eels (20.0%) had passage-related visible injuries. The dominant injury (8.0%) for treatment eels was scrapes and/or bruises to the head and/or body. Gill damage accounted for 4.0% of injuries and fin damage was also 4.0%. No eels displayed only LOE upon recapture. Of the injuries to control fish, one (2.6%) had bruising to the head and one (2.6%) had anal fin damage. Mechanical forces accounted for five (10.0%) of the eel injuries and shear forces were responsible for two (4.0%). The cause of the control eel injuries was undetermined. Only three (6%) of the treatment eels had an injury considered major. All other injuries (treatment and control) were classified as minor.

At Vernon sixteen of the 45 recaptured Unit 4 eels (35.6%) had passage-related injuries. The dominant injuries through Unit 4 were scrapes or bruises to the head/body (28.9%). Gill damage (8.9%), internal injuries (6.7%), cuts or lacerations (2.2%), and damage to the fins (4.4%) accounted for the remaining passage related visible injuries through Unit 4. None of the Unit 4 eels were severed.

Of the 46 recaptured eels through Vernon Unit 8 discharging at 1,000 cfs, thirteen (28.3%) had visible injuries. Scrapes and bruises accounted for 10.9%, fin damage for 8.7%, decapitation or severed body for 6.5% and internal damage for 2.2% of the remaining passage related visible injuries.

Vernon Unit 8 discharging at 1,700 cfs recaptured treatment eels had an injury rate of 27.3% (12 of 44 eels had visible injuries). Decapitation and/or severed body accounted for 11.4% of injuries; gill damage (6.8%); scrapes or bruises to the head/body (4.5%); hemorrhaged eyes (2.3%); internal damage (4.5%) and cuts or lacerations (2.3%).

Vernon Unit 9 recaptured treatment eels had an injury rate of 8.7% (4 of 46 recaptured eels). Most of the injuries were scrapes or bruises to the head/body (6.5%) with fin damage (2.2%) accounting for the remaining passage related injuries. None were severed passing Unit 9. There were no visible injuries on any of the 19 control eels released into the Vernon tailrace.

The probable cause of all 16 of the Unit 4 visibly injured eels was mechanical forces. Seven injuries were considered minor and nine major. The probable cause for 13 of 14 visibly injured eels from Unit 8 at 1,000 cfs was mechanical forces with 10 considered minor and four major. The cause of one visibly injured eel could not be determined. Of the 13 visibly injured eels from Unit 8 at 1,700 cfs, the probable cause was mechanical forces for 10 eels, shear forces for two eels, and undetermined for one eel. Three injuries were considered minor and ten major. All four of the Unit 9 treatment eels had injuries attributed to mechanical forces and all were considered minor.

Overall, 45 of 181 (24.9%) of the recaptured treatment eels had visible injuries. The dominant injury (12.7%) for eels passing the Vernon project was scrapes and bruises to the head or body. These injuries were likely mechanically inflicted by the blades and other components within the turbine.

Malady-Free Estimates (MFE)

Malady-free (MF) estimates (i.e., eels free of passage-related maladies) are presented in Table 5.2.4-4. MF rates are based only on recaptured eels and adjusted for controls. The MF estimate for Wilder Unit 2 eels was 60.6% with a 90% CI of 13.1%. The target precision for the MF estimate of ± 10.0%, 90% of the time was not attained. The MF estimate for Bellows Falls Unit 2 eels was 90.8%, with a 90% CI of 10.3%.

At Vernon the MF estimate for Unit 4 eels was 68.1%, with a 90% CI of 13.1%. The MF estimate for Unit 8 at 1,000 cfs eels was 73.4%, with a 90% CI of 12.6%. The MF estimate for the Unit 8 at 1,700 cfs eels was 74.4%, with a CI of 12.8%. The MF estimate for the Unit 9 eels was 96.4%, with a CI of 9.4%. Overall, the pooled MF estimate for all releases at Vernon was 78.2%, 90% CI of 7.5%.

Table 5.2.4-1. Summary of visible injury types and injury rates observed on recaptured adult eels, October-November 2015.

No. Released	No. Examined		Passage Related Visibly Injured		Injury Type[a]															
					Loss of Equilibrium only		Gill Damage		Hemorrhaged eye(s)		Scrape or Bruised Head/body		Broken Backbone Internal Hemorrhaging		Decapitated Severed Body		Cut or Laceration		Fin(s) Damage	
	No	%	No	%	No	%	No	%	No	%	No	%	No	%	No	%	No	%	No	%
Vernon Unit 4																				
48	45	93.8	16	35.6	0	0	4	8.9	0	0	13	28.9	3	6.7	0	0	1	2.2	2	4.4
Vernon Unit 8 @ 1000 cfs																				
48	46	95.8	13	28.3	1	2.2	0	0	0	0	5	10.9	1	2.2	3	6.5	0	0	4	8.7
Vernon Unit 8 @ 1700 cfs																				
50	44	88.0	12	27.3	1	2.3	3	6.8	1	2.3	2	4.5	2	4.5	5	11.4	1	2.3	0	0
Vernon Unit 9																				
48	46	95.8	4	8.7	0	0	0	0	0	0	3	6.5	0	0	0	0	0	0	1	2.2
Vernon Units Combined																				
194	181	93.3	45	24.9	2	1.1	7	3.9	1	0.6	23	12.7	6	3.3	8	4.4	2	1.1	7	3.9
Bellows Falls Unit 2																				
50	50	100	7	14.0	0	0	2	4.0	0	0	4	8.0	0	0	0	0	0	0	2	4.0
Wilder Unit 2																				
50	47	94.0	20	42.6	0	0	4	8.5	3	6.4	6	12.8	8	17.0	6	12.8	1	2.1	0	0
Combined Controls (released into the tailrace downstream of the three stations).																				
39	38	97.4	2	5.3	0	0	0	0	0	0	1	2.6	0	0	0	0	0	0	1	2.6

a. Some fish had multiple injury types.

Table 5.2.4-2. Incidence of maladies, including injury, and temporary loss of equilibrium observed on released adult eels, October-November 2015.

Date	Test Lot	Fish ID	Alive / Dead		Maladies	Passage Malady [a]	Photo	Malady Severity	Probable Cause
Vernon Unit 4									
10/28/15	3E	967	alive		Bleeding from gills	Yes	No	Major	Mechanical
10/28/15	3E	964	alive		Bruise on right side of head	Yes	No	Minor	Mechanical
10/28/15	3E	959	alive		Bruised on right side of body	Yes	No	Minor	Mechanical
10/28/15	3E	954	alive		Part of caudal fin missing	Yes	No	Minor	Mechanical
10/28/15	3E	841	alive		Bleeding from behind pectoral fins; part of caudal fin missing	Yes	No	Major	Mechanical
10/28/15	3E	839	alive		Bleeding right side behind head	Yes	No	Major	Mechanical
10/28/15	3E	833	alive		Small cut in front of right pectoral fin; bruise on head; bleeding from gills; scrape on right side	Yes	No	Major	Mechanical
10/28/15	3E	826	dead	24h	Heart ruptured; bruising on right side of body; internal hemorrhaging	Yes	Yes	Major	Mechanical
10/28/15	3E	969	dead	24h	Necropsied, no obvious injuries	No	Yes	Major	Undetermined
10/28/15	3E	822	alive		Bleeding from gills; bruise on lower mandible	Yes	Yes	Major	Mechanical
10/28/15	3E	823	alive		Bruised on left side mid-body	Yes	No	Minor	Mechanical
10/28/15	3E	828	alive		Bruise on left side mid-body	Yes	Yes	Minor	Mechanical
10/28/15	3E	829	alive		Scrape on snout; broken backbone	Yes	Yes	Major	Mechanical
10/28/15	3E	847	alive		Bruised on head and jaw both sides	Yes	Yes	Minor	Mechanical
10/28/15	3E	951	alive		Bleeding from left gill; bruise on left side just behind pectoral fin	Yes	No	Major	Mechanical
10/28/15	3E	952	alive		Bruise on left side mid-body	Yes	Yes	Minor	Mechanical
10/28/15	3E	960	alive		Broken backbone	Yes	Yes	Major	Mechanical
Vernon Unit 8									
10/26/15	1E	732	alive		Laceration and scrape on caudal fin	Yes	No	Minor	Mechanical
10/26/15	1E	720	alive		Hemorrhaged anal fin	Yes	No	Minor	Mechanical
10/26/15	1E	722	alive		LOE	Yes	No	Minor	Undetermined
10/26/15	1E	730	alive		Laceration on anal fin; part of caudal fin missing	Yes	No	Minor	Mechanical
10/26/15	1E	738	alive		Hemorrhaged caudal fin	Yes	No	Minor	Mechanical
10/26/15	1E	702	dead	1h	Severed body; Hemorrhaged internally	Yes	Yes	Major	Mechanical
10/26/15	1E	731	dead	1h	Severed body	Yes	Yes	Major	Mechanical
10/26/15	1E	739	dead	1h	Severed body	Yes	Yes	Major	Mechanical
10/26/15	1E	723	dead	24h	Crushed left side of face, broken lower mandible; broken backbone; Internal hemorrhaging	Yes	No	Major	Mechanical
10/26/15	1E	704	alive		Bruised and scraped on the mouth	Yes	Yes	Minor	Mechanical
10/26/15	1E	705	alive		Scrapes on both sides of head	Yes	No	Minor	Mechanical

Date	Test Lot	Fish ID	Alive / Dead		Maladies	Passage Malady [a]	Photo	Malady Severity	Probable Cause
10/26/15	1E	710	alive		Bruised mid-body both sides	Yes	Yes	Minor	Mechanical
10/26/15	1E	714	alive		Bruising both sides of body near tail; scrape on tip of tail	Yes	Yes	Minor	Mechanical
10/26/15	1E	749	alive		Bruised mid-body both sides	Yes	Yes	Minor	Mechanical
Vernon Unit 8 1700 cfs									
11/3/15	7E	150	alive		Laceration on body	Yes	No	Minor	Mechanical
11/3/15	7E	112	alive		Bleeding from gills; hemorrhaged right eye	Yes	No	Major	Shear
11/3/15	7E	143	alive		LOE	Yes	No	Minor	Undetermined
11/3/15	7E	125	alive		Bruise on left side of body	Yes	No	Minor	Mechanical
11/3/15	7E	111	alive		Bleeding from gills	Yes	No	Major	Shear
11/3/15	7E	107	dead	1h	Severed body	Yes	Yes	Major	Mechanical
11/3/15	7E	118	dead	1h	Severed body	Yes	Yes	Major	Mechanical
11/3/15	7E	126	dead	1h	Decapitated	Yes	Yes	Major	Mechanical
11/3/15	7E	145	dead	24h	Some blood coming out of gills, and mouth, crushed top of skull	Yes	Yes	Major	Mechanical
11/3/15	7E	105	alive		External bruising on left side front third of fish, dorsally	Yes	No	Major	Mechanical
11/3/15	7E	106	dead	1h	Severed body	Yes	Yes	Major	Mechanical
11/3/15	7E	123	dead	48h	Broken backbone and internal hemorrhaging	Yes	Yes	Major	Mechanical
11/3/15	7E	135	dead	1h	Severed body	Yes	No	Major	Mechanical
Vernon Unit 9									
10/27/15	2E	805	alive		Small part of caudal fin missing	Yes	No	Minor	Mechanical
10/27/15	2E	767	alive		Bruised left side front of body	Yes	Yes	Minor	Mechanical
10/27/15	2E	769	alive		Bruised right side mid-body	Yes	Yes	Minor	Mechanical
10/27/15	2E	772	alive		Bruised on right and left sides body	Yes	Yes	Minor	Mechanical
Bellows Falls Unit 2									
10/30/15	4e	6	alive		Bruise on head	Yes	No	Minor	Mechanical
10/30/15	4e	27	alive		Bleeding from gills	Yes	No	Major	Shear
10/30/15	4e	38	alive		Hemorrhaged anal fin	Yes	No	Minor	Mechanical
10/30/15	4e	46	alive		Bruise on lower mandible; part of caudal fin missing	Yes	No	Minor	Mechanical
10/30/15	4e	49	alive		Bleeding from gills	Yes	No	Major	Shear
10/30/15	4e	18	alive		Bruise on head	Yes	No	Minor	Mechanical
10/30/15	4e	26	dead	24h	Bruised lower jaw and head	Yes	Yes	Major	Mechanical

Date	Test Lot	Fish ID	Alive / Dead		Maladies	Passage Malady [a]	Photo	Malady Severity	Probable Cause
Wilder Unit 2									
11/1/15	6E	117	alive		Hemorrhage on head	Yes	No	Minor	Mechanical
11/1/15	6E	106	alive		Minor bruising lower mandible	Yes	No	Minor	Mechanical
11/1/15	6E	93	alive		Hemorrhaging from left gills	Yes	No	Major	Shear
11/1/15	6E	90	dead	1h	Severed body	Yes	Yes	Major	Mechanical
11/1/15	6E	91	dead	1h	Severed body	Yes	Yes	Major	Mechanical
11/1/15	6E	110	dead	1h	Decapitated	Yes	Yes	Major	Mechanical
11/1/15	6E	116	dead	1h	Severed body	Yes	Yes	Major	Mechanical
11/1/15	6E	123	dead	1h	Severed body	Yes	No	Major	Mechanical
11/1/15	6E	125	dead	1h	Laceration on body; gills protruding; broken back bone	Yes	Yes	Major	Mechanical
11/1/15	6E	129	dead	1h	Severed body	Yes	Yes	Major	Mechanical
11/1/15	6E	86	dead	24h	Hemorrhaged left eye; bruise just behind pectoral fins	Yes	Yes	Major	Mechanical
11/1/15	6E	121	dead	24h	Massive gill bleeding, Crushed head	Yes	Yes	Major	Mechanical
11/1/15	6E	122	dead	24h	Broken back bone	Yes	Yes	Major	Mechanical
11/1/15	6E	83	alive		Hemorrhage on skin, middle third of body both sides	Yes	No	Minor	Mechanical
11/1/15	6E	84	dead	48h	Bleeding from gills; bruise on head; hemorrhaged left eye	Yes	Yes	Major	Mechanical
11/1/15	6E	89	dead	48h	Broken backbone	Yes	No	Major	Mechanical
11/1/15	6E	96	dead	48h	Hemorrhaged right eye; broken backbone	Yes	No	Major	Mechanical
11/1/15	6E	104	dead	48h	Broken backbone behind vent	Yes	No	Major	Mechanical
11/1/15	6E	108	dead	48h	Bruising behind vent both sides, swollen rib area, rigid and hard	Yes	No	Major	Mechanical
11/1/15	6E	113	dead	48h	Broken backbone	Yes	No	Major	Mechanical
Combined Controls (released into the tailrace downstream of the three stations).									
10/30/15	4e	56	alive		Minor scrape on anal fin	Yes	No	Minor	Undetermined
10/30/15	4e	63	alive		Bruise on head	Yes	No	Minor	Undetermined

a. Maladies include both visible injuries and LOE attributed to turbine passage.

Table 5.2.4-3. Probable sources and severity of maladies observed on recaptured adult eels, October-November 2015.

No. of Fish Examined	Total With Maladies[a]		Probable Cause						Severity			
			Mechanical		Shear		Undeter-mined		Minor		Major	
	No	%	No	%	No	%	No	%	No	%	No	%
Vernon Unit 4												
45	16	35.6	16	3.56	0	0	0	0	7	15.6	9	20.0
Vernon Unit 8 @ 1000 cfs												
46	14	30.4	13	28.3	0	0	1	2.2	10	21.7	4	8.7
Vernon Unit 8 @ 1700 cfs												
44	13	29.5	10	22.7	2	4.5	1	2.3	3	6.8	10	22.7
Vernon Unit 9												
46	4	8.7	4	8.7	0	0	0	0	4	8.7	0	0
Vernon Units Combined												
181	47	26.0	43	23.8	2	1.1	2	1.1	24	13.3	23	12.7
Bellows Falls Unit 2												
50	7	14.0	5	10.0	2	4.0	0	0	4	8.0	3	6.0
Wilder Unit 2												
47	20	42.6	19	40.4	1	2.1	0	0	3	6.4	17	36.2
Combined Controls (released into the tailrace downstream of the three stations)												
38	2	5.3	0	0	0	0	2	5.3	2	5.3	0	0

a. Maladies include both visible injuries and LOE attributed to turbine passage.

Table 5.2.4-4. Summary malady data and malady-free estimates for recaptured adult eels, October-November 2015.

	Vernon Unit 4		Vernon Unit 8 @ 1000 cfs		Vernon Unit 8 @ 1700 cfs		Vernon Unit 9		Vernon Units Combined		Bellows Falls Unit 2		Wilder Unit 2		Combined Controls [a]	
Number released	**48**	**%**	**48**	**%**	**50**	**%**	**48**	**%**	**194**	**%**	**50**	**%**	**50**	**%**	**39**	**%**
Number examined for maladies	45	93.8	46	95.8	44	88.0	46	95.8	181	93.3	50	100	47	94.0	38	97.4
Number with passage related maladies	16	35.6	14	30.4	13	29.5	4	8.7	47	26.0	7	14.0	20	42.6	2	5.3
Visible injuries	16	35.6	13	28.3	12	27.3	4	8.7	45	24.9	7	14.0	20	42.6	2	5.3
Loss of equilibrium only	0	0	1	2.2	1	2.3	0	0	2	1.1	0	0	0	0	0	0
Number without passage related maladies	29	64.4	32	69.6	31	70.5	42	91.3	134	74.0	43	86.0	27	57.4	36	94.7
Number without passage related maladies that died	1	2.2	0	0	0	0	0	0	1	0.6	0	0	0	0	0	0
Malady-free rate (%)	68.1%		73.4%		74.4%		96.4%		78.2%		90.8%		60.6%			
Std Error (%)	8.0%		7.7%		7.8%		5.7%		4.6%		6.2%		8.0%			
90% CI (%)	13.1%		12.6%		12.8%		9.4%		7.5%		10.3%		13.1%			

a. Combined controls released into the tailrace downstream of the three stations.

5.2.5 Survival Comparison with Other Projects

The direct survival and injury estimates for this study indicate that eels fared better passing through the larger and slower speed Francis turbines than through the Kaplan (propeller type) turbines. Survival through the Wilder Kaplan turbine (Unit 3) is lower, while survival through the Vernon Kaplan turbines is consistent with other direct survival/injury studies conducted on eels at four propeller type turbines on the Rhine and Rhone Rivers in France and on the St. Lawrence River in New York (Normandeau, 2010; 2011a; 2011b; Normandeau and Skalski, 1998) (Table 5.2.5-1). There are no as yet published studies conducted on adult eel passage through Francis units although FirstLight conducted a study in 2015 as part of the Turners Falls project relicensing, but at the time of this report that data has not been published.

The turbine passage survival (48-hour) at four large (240-262.6 inch diameter) propeller turbines in other studies (Table 5.2.5-1) ranged from 73.5-93.0%. These turbines had rotation rates close to 95 rpm. The most significant factor that affected survival for these units was the number of blades, with lower survival rates of 78.6 and 73.5% for five- and six-bladed units versus 93.0 and 92.4% for four-bladed units.

The propeller turbines tested at Wilder and Vernon were smaller than units tested at other projects (189 and 122 inches, respectively), had slightly higher runner speed (112.5 and 144 rpm, respectively), and had five blades. The survival at these smaller and slightly faster units was lower (62.0%) at the Wilder turbine, within the range (74.0%) at Vernon Unit 8 at 1,700 cfs, and higher (87.5%) at Vernon Unit 8 at 1,000 cfs than obtained at the other propeller turbines tested in other studies.

Table 5.2.5-1. Comparison of direct survival and injury of adult eels passed through Vernon, Bellows Falls, and Wilder stations with comparison to other projects and studies.

Station	Turbine Type	Unit Tested	No. of Blades/ Buckets	Runner Speed (rpm)	Runner Diameter (in)	48-hour Survival (%)	48-hour Std Error (%)	Visibly Injured (%)	Injuries Classified Major (%)	Dominant Injury
Vernon	Francis	4	13	133.3	62.5	93.5	3.6	35.6	20.0	bruises on body/ head
Vernon	Francis	9	12	75	110	97.9	2.1	8.7	0.0	bruises on body/ head
Vernon @ 1,000 cfs	Kaplan	8	5	144	122	87.5	4.8	28.3	8.7	bruises on body/ head
Vernon @ 1,700 cfs	Kaplan	8	5	144	122	74.0	6.2	27.3	22.7	severed body
Bellows Falls	Francis	2	15	85.7	174	98.0	2.0	14.0	6.0	bruises on body/ head
Wilder	Kaplan	2	5	112.5	180	62.0	6.9	42.6	36.2	severed or bruised body
Other Projects										
Beaucaire, France[a]	Bulb	n/a	4	94.0	245.7	93.0	1.5	6.5	6.5	bruised head/body
Fessenheim, France[a]	Kaplan	n/a	4	88.2	262.6	92.4	2.2	11.5	6.7	severed or nearly severed body
Ottmarsheim, France[a]	Kaplan	n/a	5	93.8	246.0	78.6	2.3	26.5	20.7	head/ body severed or nearly severed
Robert Moses [b], NY	Propeller	n/a	6	99.2	240.0	73.5	3.4	36.7	24.1 or higher	severed body

a. European Eel.

b. 48-hour survival, little mortality beyond 24 hours.

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6.0 STUDY CONCLUSIONS

6.1 Route Selection and Residency

Of the 170 eels released at all projects, nine did not approach their intended project (two at Wilder, one at Bellows Falls, and six at Vernon). Cumulatively, of all available eels upstream of each project, 22 did not approach Bellows Falls and 56 did not approach Vernon. The final fate of these fish is unknown and cannot be gleaned from any data collected in this study. It is possible that they moved into tributaries and did not migrate; their tags became dislodged; they died either before or after passage through one or more projects and settled on the river bottom; or they were preyed upon by other fish or birds.

Once detected at each project's study area, passage occurred for 93.8% of eels at Wilder, 98.0% at Bellows Falls, and 98.2% at Vernon (Table 6.1-1). Overall, 112 (65.9%) of the 170 eels released in this study ultimately passed Vernon. The majority of eels passed their intended project in 4 hours or less after their first detection in the forebay (79% at Wilder, 84% at Bellows Falls, 89% at Vernon). From analysis of telemetry data some eels seemed to exhibit potential route searching behavior prior to passage; however, the vast majority of eels in this study 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).

Table 6.1-1. Summary of silver American Eel passage through the Wilder, Bellows Falls, and Vernon projects, 2015.

Release Location:	Wilder Imp.	Bellows Falls Canal	Bellows Falls Imp.	Vernon Imp.	Total	
Project Passage Summary:						
Wilder	50				50	**No. released**
	48				48	**No. in study area**
	45 Units 1-2: 33 Unit 3: 7[a]/5 Sluice:2 Unknown: 5				**47[a]/45** Units 1-2: 33 Unit 3: 7[a]/5 Sluice: 2 Unknown: 5	**No. passed**
Bellows Falls		20	50		70	**No. released**
	29	20	49		98	**No. in study area**
	29 Units 1-3: 21 Sluice: 6 Spillway: 2	**20** Units 1-3: 19 Sluice: 1 Spillway: 0	**47** Units 1-3: 37 Sluice: 6 Spillway: 4		**96** Units 1-3: 77 Sluice: 13 Spillway: 6	**No. passed**
Vernon				50	50	**No. released**
	25	10	35	44	114	**No. in study area**
	25 Units 1-4: 4 Units 5-8: 9 Units 9-10: 6 Sluice: 0 Fish Pipe: 1 Fish Tube: 0 Fish Ladder: 0 Unknown: 5	**10** Units 1-4: 2 Units 5-8: 5 Units 9-10: 3 Sluice: 0 Fish Pipe: 0 Fish Tube: 0 Fish Ladder: 0 Unknown: 0	**34** Units 1-4: 4 Units 5-8: 15 Units 9-10: 10 Sluice: 1 Fish Pipe: 1 Fish Tube: 0 Fish Ladder: 0 Unknown: 3	**43** Units 1-4: 4 Units 5-8: 24 Units 9-10: 7 Sluice: 1 Fish Pipe: 2 Fish Tube: 1 Fish Ladder: 1 Unknown: 3	**112** Units 1-4: 14 Units 5-8: 53 Units 9-10: 26 Sluice: 2 Fish Pipe: 4 Fish Tube: 1 Fish Ladder: 1 Unknown: 11	**No. passed**

a. Two eels that entered Unit 3 were not later detected in the tailrace.

6.2 Turbine Survival

6.2.1 Wilder

The direct survival estimate of 62.2% for eels passing through Kaplan Unit 2 was lower at this unit than any of the other units tested at Bellows Falls and Vernon. Injury rate (42.6%) for the recaptured eels was also the highest observed and 36.2% of the injuries were classified as major. These injuries were primarily bruised or severed bodies. Similar survival and injury results would be expected for the untested Kaplan Unit 1 at Wilder.

The Francis turbine (Unit 3) wasn't able to be tested due to the configuration of the discharge that feeds into the fish ladder from below via an energy dissipation chamber separated from the fish ladder by a grate; however, its characteristics are similar to the Francis turbine tested at Vernon Unit 4. The small Francis turbine at Wilder has 14 buckets, a runner speed of 212 rpm, and a runner diameter of 72 inches. The turbine at Vernon Unit 4 has 13 buckets, a runner speed of 133.3 rpm, and a runner diameter of 62.5 inches. The 48-hour survival of eels passed through this turbine was 93.5%. Based on these results, eels passing through Wilder Unit 3 could have a similar survival rate.

6.2.2 Bellows Falls

The 48-hour direct survival of 98.0% for eels passing Francis Unit 2 at Bellows Falls was the highest obtained at any of the turbines tested in this study. The injury rate of 14.0% was the second lowest observed and only 6.0% of the examined eels had injuries considered major. Injuries were primarily bruises to the body. Because all the Bellows Falls units are similar, eels should incur little mortality and injury passing these turbines.

6.2.3 Vernon

The 48-hour direct survival was highest (97.9%) for eels passed through the larger Francis turbine Unit 9. This unit also had the lowest injury rate (8.7%) of any of the turbines tested in this study. Additionally none of the injuries (bruises on head and body, fin damage) were classified as major. The smaller Francis Unit 4 also had relatively high 48-hour survival of 93.5%; however, 36.5% were injured, primarily bruises to head and body, and 20% of the eels had major injuries.

The Kaplan Unit 8 had a higher 48-hour survival (87.5%) at the lower discharge tested (1,000 cfs) than at the higher discharge (1,700 cfs) where the survival was 74.0%. Injury rates were similar at 28.3% and 27.3%, respectively for the two discharge rates. Although injury rates were similar, the lower discharge inflicted fewer major injuries (8.7%) than the higher discharge (22.7%). Additionally, more fish were severed at the higher discharge. Based on these direct survival and injury results emigrating eels should incur high survival and few injuries passing the two larger Francis Units 9 and 10. Turbine passage should also be relatively high for eels passing the smaller Francis Units 1-4. Kaplan Units 5-8 effects on eel passage survival and severity of injuries appears to be partially dependent upon discharge rates with better passage conditions at lower discharges.

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APPENDIX A

Pathology Test Results

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Phone: 603-428-4960

Specimen: EEL BODY x60 Rec: 23-SEP-15
Submitted By: THREADER Sample ID: SAMPLE #1 NFLD

HISTORY: A mixture of 60 adult and juvenile American eels were submitted for gross pathology and parasitology examination. This group was Lot 1: from fisher Wally Cunard, Northern Penisula of Newfoundland. These eels were collected between Sept. 6 -12, picked up and shipped for diagnostics on Sept. 12

In addition to the gross examination, each eel was sampled for general bacteriology using a kidney swab, and eel tissues were grouped into 5 fish pools, each containing gill, spleen, heart and kidney tissues for virus isolation on 5 cell lines.

GROSS FINDINGS: (60 eels were examined)
All eels showed normal morphology, no lesions noted either externally or internally. All swim bladders were removed and opened and no parasite were noted in any of the 60 bladders.

GROSS PARASITOLOGY: No parasite, including Anguillacoides crassus, were found.

BACTERIOLOGY: All kidney samples were negative by both Aeromonas salmonicida and Yersinia ruckeri.

VIROLOGY: Virus isolation on 5 cel lines (CHSE,EPC,ASK,EK1,FHM) was negative.

MORPHOLOGIC DIAGNOSIS:
Normal eel morphology, no infectious disease of concern identified.

COMMENTS - Virology results for both groups of eels (120 in total) are reported in the lab number U23122-2015, all were negative for viruses. The bacteriology and parasitology results are split between the two submission, U23122-2015 and U23226-2015.

David Groman MSc., PhD. Fish Pathologist
Signed and dated 19-OCT-15

Please consult your veterinarian for interpretation of results.

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Specimen: EEL BODY x60 Rec: 24-SEP-15
Submitted By: THREADER Sample ID: SAMPLE #2 NFLD

HISTORY: A mixture of 60 adult and juvenile American eels were submitted for gross pathology and parasitology examination. These are Lot 2: collected by Dean Cuttler, who fished for them between Sept 9 -15, picked up September 19 at Bay St. George, and set for diagnostic testing at the AVC.

In addition to the gross examination each eel was sampled for general bacteriology using a kidney swab, and eel tissues were grouped into 5 fish pools, each containing gill, spleen, heart and kidney tissues for virus isolation on 5 cell lines.

GROSS FINDINGS: (60 eels were examined)
All eels showed normal morphology, no lesions noted either externally or internally. All swim bladders were removed and opened and no parasite were noted in any of the 60 bladders.

GROSS PARASITOLOGY: No parasite, including Anguillacoides crassus, were found.

BACTERIOLOGY: All kidney samples were negative by both Aeromonas salmonicida and Yersinia ruckeri.

VIROLOGY: Virus isolation on 5 cell lines (CHSE,EPC,ASK,EK1,FHM) was negative.

MORPHOLOGIC DIAGNOSIS:
Normal eel morphology, no infectious disease of concern identified.

COMMENTS - Virology results for both groups of eels (120 in total) are reported in the lab number U23122-2015, all were negative for viruses. The bacteriology and parasitology results are split between the two submission, U23122-2015 and U23226-2015.

David Groman MSc., PhD. Fish Pathologist
Signed and dated 19-OCT-15

Please consult your veterinarian for interpretation of results.

APPENDIX B

Turbine Survival Statistical Analysis

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DERIVATION OF PRECISION, SAMPLE SIZE, AND MAXIMUM LIKELIHOOD PARAMETERS

The statistical description below is excerpted from Normandeau Associates and Skalski (2000). For the sake of brevity, references within the text have been removed. However, interested readers can look up these citations in the report prepared by Normandeau Associates and Skalski (2000).

The estimation for the likelihood model parameters and sample size requirements discussed in the text are given herein. Additionally, the results of statistical analyses for evaluating homogeneity in recapture and survival probabilities, and in testing hypotheses of equality in parameter estimates under the simplified (H_O:P_A=P_D) versus the most generalized model (H_A:$P_A \neq P_D$) are given.

The following terms are defined for the equations and likelihood functions which follow:

R_C = Number of control fish released

R_T = Number of treatment fish released

R = R_C=R_T

n = Number of replicate estimates $\hat{\tau}_i$ (*i*=1,…,n)

a_C = Number of control fish recaptured alive

d_C = Number of control fish recaptured dead

a_T = Number of treatment fish recaptured alive

d_T = Number of treatment fish recaptured dead

S = Probability fish survive from the release point of the controls to recapture

P_A = Probability an alive fish is recaptured

P_D = Probability a dead fish is recaptured

τ = Probability a treatment fish survives to the point of the control releases (*i.e.*, passage survival)

1-τ = Passage-related mortality.

The precision of the estimate was defined as:

$$P(-\varepsilon < \hat{\tau} - \tau < \varepsilon) = 1 - \alpha$$

or equivalently

$$P(-\varepsilon <| \hat{\tau} - \tau |< \varepsilon) = 1 - \alpha$$

where the absolute errors in estimation, *i.e.*, $|\hat{\tau} - \tau|$, is <ε (1-α) 100% of the time, $\hat{\tau}$ is the estimated passage survival, and ε is the half-width of a (1-α) 100% confidence interval for $\hat{\tau}$ or 1-$\hat{\tau}$. A precision of ±10%, 95% of the time is expressed as P($|\hat{\tau} - \tau|$<0.10)=0.95.

Using the above precision definition and assuming normality of $\hat{\tau} - \tau$, the required total sample size (R) is as follows:

$$P\left(\frac{-\varepsilon}{\sqrt{Var(\hat{\tau})}} < Z < \frac{\varepsilon}{\sqrt{Var(\hat{\tau})}}\right) = 1 - \alpha$$

$$P\left(Z < \frac{-\varepsilon}{\sqrt{Var(\hat{\tau})}} \right) = \alpha / 2$$

$$\Phi\left(\frac{-\varepsilon}{\sqrt{Var(\hat{\tau})}} \right) = \alpha / 2$$

$$\frac{-\varepsilon}{\sqrt{Var(\hat{\tau})}} = Z_{\alpha/2}$$

$$Var(\hat{\tau}) = \frac{\varepsilon^2}{Z^2_{1-\frac{\alpha}{2}}}$$

$$\frac{\tau}{SP_A}\left[\frac{(1 - S\tau P_A)}{R_T} + \frac{(1 - SP_A)\tau}{R_C} \right] = \frac{\varepsilon^2}{Z^2_{1-\frac{\alpha}{2}}} \ .$$

where Z is a standard normal deviate satisfying the relationship $P(Z>Z_{1-\alpha/2})=\alpha/2$, and Φ is the cumulative distribution function for a standard normal deviate.

If data can be pooled across trials and letting $R_C=R_T=R$, the sample size for each release is

$$R = \frac{\tau}{SP_A}\left[1 + \tau - 2S\tau P_A\right]\frac{Z^2_{1-\alpha/2}}{\varepsilon^2} \ .$$

By rearranging, this equation can be solved to predetermine the anticipated precision given the available number of fish for a study. In most previous investigations (Normandeau Associates and Skalski 2000) this equation has been used to calculate sample sizes because of homogeneity between trials; in the present investigation sample size was predetermined using this equation.

If data cannot be pooled across trials the precision is based on

$$\sum_{i=1}^{n}(1 - \hat{\tau}_i)/n = 1 - \sum_{i=1}^{n}\hat{\tau}_i / n = 1 - \bar{\hat{\tau}} \ .$$

Precision is defined as

$$P(|\ \bar{\hat{\tau}} - \bar{\tau}\ | < \varepsilon) = 1 - \alpha$$

$$P(-\varepsilon < \bar{\hat{\tau}} - \bar{\tau}\ | < \varepsilon) = 1 - \alpha$$

$$P\left(\frac{-\varepsilon}{\sqrt{Var(\bar{\hat{\tau}})}} < t_{n-1} < \frac{\varepsilon}{\sqrt{Var(\bar{\hat{\tau}})}} \right) = 1 - \alpha$$

$$P\left(t_{n-1} < \frac{-\varepsilon}{\sqrt{Var(\bar{\hat{\tau}})}}\right) = \alpha/2$$

$$\Phi\left(\frac{-\varepsilon}{Var(\bar{\hat{\tau}})}\right) = \alpha/2$$

$$\frac{-\varepsilon}{\sqrt{Var(\bar{\hat{\tau}})}} = t_{\alpha/2,n-1}$$

$$Var(\bar{\hat{\tau}}) = \frac{\varepsilon^2}{t^2_{1-\alpha/2,n-1}}$$

$$\frac{\sigma^2_\tau + \frac{\tau}{SP_A}\left[\frac{(1-S\tau P_A)}{R_T} + \frac{(1-SP_A)\tau}{R_C}\right]}{n} = \frac{\varepsilon^2}{t^2_{1-\alpha/2,n-1}}$$

where σ_τ^2=natural variation in passage-related mortality.

Now letting $R_T=R_C$

$$\frac{\sigma^2_\tau + \frac{\tau}{SP_A}\left[\frac{(1-S\tau P_A)}{R} + \frac{(1-SP_A)\tau}{R}\right]}{n} = \frac{\varepsilon^2}{t^2_{1-\alpha/2,n-1}}$$

which must be iteratively solved for n given R. Or R given n where

$$R = \frac{\frac{\tau}{SP_A}\left[(1-S\tau P_A) + (1-SP_A)\tau\right]}{\left[\frac{n\varepsilon^2}{t^2_{1-\alpha/2,n-1}} - \sigma^2_\tau\right]}$$

$$R = \frac{\frac{\tau(1+\tau)}{SP_A}}{\left[\frac{n\varepsilon^2}{t^2_{1-\alpha/2,n-1}} - \sigma^2_\tau\right]}$$

$$R = \frac{\tau(1+\tau)}{SP_A}\left[\frac{t^2_{1-\alpha/2,n-1}}{n\varepsilon^2 - \sigma^2_\tau t^2_{1-\alpha/2,n-1}}\right].$$

The joint likelihood for the passage-related mortality is:

$$L\,(S,\ \tau,\ P_A,\ P_D \mid R_C,\ R_T,\ a_C,\ a_T,\ d_C,\ d_T)=$$

$$\binom{R_C}{a_c d_C}(SP_A)^{a_C}((1-S)P_D)^{d_C}(1-SP_A-(1-S)P_D)^{R_C-a_C-d_C}$$

$$\times\binom{R_T}{a_T d_T}(S\tau P_A)^{a_T}((1-S\tau)P_D)^{d_T}(1-S\tau P_A-(1-S\tau)P_D)^{R_T-a_T-d_T}\ .$$

The likelihood model is based on the following assumptions: (1) fate of each fish is independent, (2) the control and treatment fish come from the same population of inference and share that same survival probability, (3) all alive fish have the same probability, P_A, of recapture, (4) all dead fish have the same probability, P_D, of recapture, and (5) passage survival (τ) and survival (S) to the recapture point are conditionally independent. The likelihood model has four parameters (P_A, P_D, S, τ) and four minimum sufficient statistics (a_C, d_C, a_T, d_T).

Because any two treatment releases were made concurrently with a single shared control group we used the likelihood model which took into account dependencies within the study design (Normandeau Associates *et al.* 1995). For any two treatment groups (denoted T_1 and T_2), the likelihood model is as follows:

$$L(S,\tau_1,\tau_2,P_A,P_D \mid R_C,R_{T_1},R_{T_2},a_C,d_c,a_{T_1},d_{T_1},a_{T_2},d_{T_2})=$$

$$\binom{R_C}{a_c d_C}(SP_A)^{a_C}((1-S)P_D)^{d_C}(1-SP_A-(1-S)P_D)^{R_C-a_C-d_C}$$

$$\times\binom{R_{T_1}}{a_{T_1} d_{T_1}}(S\tau_1 P_A)^{a_{T_1}}((1-S\tau_1)P_D)^{d_{T_1}}(1-S\tau_1 P_A-(1-S\tau_1)P_D)^{R_{T_1}-a_{T_1}-d_{T_1}}$$

$$\times\binom{R_{T_2}}{a_{T_2} d_{T_2}}(S\tau_2 P_A)^{a_{T_2}}((1-S\tau_2)P_D)^{d_{T_2}}(1-S\tau_2 P_A-(1-S\tau_2)P_D)^{R_{T_2}-a_{T_2}-d_{T_2}}\ .$$

This likelihood model has the same assumptions as stated in Normandeau Associates and Skalski (2000) but has five estimable parameters (S, τ_1, τ_2, P_A, and P_D). The survival rate for treatment T_1 is estimated by τ_1 and for treatment T_2, by τ_2. A likelihood ratio test with 1 degree of freedom was used to test for equality in survival rates between treatments τ_1 and τ_2 based on the hypothesis H_O: $\tau_1=\tau_2$ versus H_a: $\tau_1 \neq \tau_2$.

Likelihood models are based on the following assumptions: (a) the fate of each fish is independent; (b) the control and treatment fish come from the same population of inference and share the same natural survival probability, S; (c) all alive fish have the same probability, P_A, of recapture; (d) all dead fish have the same probability, P_D, of recapture; and (e) passage survival (τ) and natural survival (S) to the recapture point are conditionally independent.

The estimators associated with the likelihood model are:

$$\hat{\tau}=\frac{a_T R_C}{R_T a_C}$$

$$\hat{S}=\frac{R_T d_C a_C - R_C d_T a_C}{R_C d_C a_T - R_C d_T a_C}$$

$$\hat{P}_A = \frac{d_C a_T - d_T a_C}{R_T d_C - R_C d_T}$$

$$\hat{P}_D = \frac{d_C a_T - d_T a_C}{R_C a_T - R_T a_C} \ .$$

The variance (Var) and standard error (SE) of the estimated passage mortality ($1 - \hat{\tau}$) or survival ($\hat{\tau}$) are:

$$Var(1-\hat{\tau}) = Var(\hat{\tau}) = \frac{\tau}{SP_A}\left[\frac{(1-S\tau P_{A)}}{R_T} + \frac{(1-SP_A)\tau}{R_C}\right]$$

$$SE(1-\hat{\tau}) = SE(\hat{\tau}) = \sqrt{Var(1-\hat{\tau})} \ .$$

DERIVATION OF VARIANCE FOR WEIGHTED AVERAGE SURVIVAL ESTIMATE

The variance of a weighted average is estimated by the formula

$$\hat{\bar{\theta}}_W = \frac{\sum_{i=1}^{n} W_i \hat{\theta}_i}{\sum_{i=1}^{n} W_i}$$

with

$$\text{Var}\left(\hat{\bar{\theta}}_W\right) = \frac{\sum_{i=1}^{n} W_i \left(\hat{\theta}_i - \hat{\bar{\theta}}_W\right)^2}{(n-1)\sum_{i=1}^{n} W_i}$$

where $\hat{\bar{\theta}}_W$ = the weighted average,

$\hat{\theta}_i$ = the parameter estimate for the *i*th replicate,

W_i = weight.

One and Forty-Eight Hour Outputs Including all Eels and Combining all Controls

One hour survival estimates for adult American Eels passed through Unit 4 and combining all controls at Vernon Station, October-November 2015.
Control: 39 released, 39 alive, 0 dead
Treatment (Unit 4): 48 released, 45 alive, 1 dead

RESULTS FOR REDUCED MODEL (EQUAL LIVE/DEAD RECOVERY)

	estim.	std.err.	
S =	1.0	N/A	Control group survival*
Pa = Pd	0.9770	(0.0161)	Recovery probability
Tau =	0.9783	(0.0215)	Unit 4 survival
1-Tau =	0.0217	(0.0215)	Unit 4 mortality

* Because of constraints in the data set, this probability is assumed equal to 1.0; not estimated.

Log-likelihood: -14.340047

Variance-Covariance matrix for estimated probabilities:
0.00026 0.00000
0.00000 0.00046

Profile likelihood intervals:

	Unit 4 survival	Unit 4 mortality
90 percent:	(0.9230, 0.9977)	(0.0023, 0.0770)
95 percent:	(0.9078, 0.9987)	(0.0013, 0.0922)
99 percent:	(0.8739, 0.9997)	(0.0003, 0.1261)

Likelihood ratio statistic for equality of recovery probabilities: 2.417010

Compare with quantiles of the chi-squared distribution with 1 d.f.:
For significance level 0.10: 2.706
For significance level 0.05: 3.841
For significance level 0.01: 6.635

Forty-eight hour survival estimates for adult American Eels passed through Unit 4 and combining all controls at Vernon Station, October-November 2015.
Control: 39 released, 39 alive, 0 dead
Treatment (Unit4): 48 released, 43 alive, 3 dead

RESULTS FOR REDUCED MODEL (EQUAL LIVE/DEAD RECOVERY)

	estim.	std.err.	
S =	1.0	N/A	Control group survival*
Pa = Pd	0.9770	(0.0161)	Recovery probability
Tau =	0.9348	(0.0364)	Unit 4 survival
1-Tau =	0.0652	(0.0364)	Unit 4 mortality

* Because of constraints in the data set, this probability is assumed equal to 1.0; not estimated.

Log-likelihood: -20.612418

Variance-Covariance matrix for estimated probabilities:
0.00026 0.00000
0.00000 0.00133

Profile likelihood intervals:

	Unit 4 survival	Unit 4 mortality
90 percent:	(0.8579, 0.9784)	(0.0216, 0.1421)
95 percent:	(0.8395, 0.9834)	(0.0166, 0.1605)
99 percent:	(0.8004, 0.9906)	(0.0094, 0.1996)

Likelihood ratio statistic for equality of recovery probabilities: 2.417010

Compare with quantiles of the chi-squared distribution with 1 d.f.:
For significance level 0.10: 2.706
For significance level 0.05: 3.841
For significance level 0.01: 6.635

One hour survival estimates for adult American Eels passed through Unit 8 (1000 cfs) and combining all controls at Vernon Station, October-November 2015.
Control: 39 released, 39 alive, 0 dead
Treatment (Unit 8-1000 cfs): 48 released, 43 alive, 5 dead

RESULTS FOR REDUCED MODEL (EQUAL LIVE/DEAD RECOVERY)

	estim.	std.err.	
S =	1.0	N/A	Control group survival*
Pa = Pd	1.0	N/A	Recovery probability*
Tau =	0.8958	(0.0441)	Unit 8 (1000 cfs) survival
1-Tau =	0.1042	(0.0441)	Unit 8 (1000 cfs) mortality

* Because of constraints in the data set, this probability is assumed equal to 1.0; not estimated.

Log-likelihood: -16.038854

Variance-Covariance matrix for estimated probabilities:
0.00194

Profile likelihood intervals:

	Unit 8-1000 cfs survival	Unit 8-1000 cfs mortality
90 percent:	(0.8740, 1.0000)	(0.0000, 0.1260)
95 percent:	(0.0000, 1.0000)	(0.0000, 1.0000)
99 percent:	(0.0000, 1.0000)	(0.0000, 1.0000)

Likelihood ratio statistic for equality of recovery probabilities: 0.000000

Compare with quantiles of the chi-squared distribution with 1 d.f.:
For significance level 0.10: 2.706
For significance level 0.05: 3.841
For significance level 0.01: 6.635

Forty-eight hour survival estimates for adult American Eels passed through Unit 8 (1000 cfs) and combining all controls at Vernon Station, October-November 2015.
Control: 39 released, 39 alive, 0 dead
Treatment (Unit 8-1000 cfs): 48 released, 42 alive, 6 dead

RESULTS FOR REDUCED MODEL (EQUAL LIVE/DEAD RECOVERY)

	estim.	std.err.	
S =	1.0	N/A	Control group survival*
Pa = Pd	1.0	N/A	Recovery probability*
Tau =	0.8750	(0.0477)	Unit 8 (1000 cfs) survival
1-Tau =	0.1250	(0.0477)	Unit 8 (1000 cfs) mortality

* Because of constraints in the data set, this probability is assumed equal to 1.0; not estimated.

Log-likelihood: -18.084968

Variance-Covariance matrix for estimated probabilities:
0.00228

Profile likelihood intervals:

	Unit 8-1000 cfs survival	Unit 8-1000 cfs mortality
90 percent:	(0.8521, 1.0000)	(0.0000, 0.1479)
95 percent:	(0.0000, 1.0000)	(0.0000, 1.0000)
99 percent:	(0.0000, 1.0000)	(0.0000, 1.0000)

Likelihood ratio statistic for equality of recovery probabilities: 0.000000

Compare with quantiles of the chi-squared distribution with 1 d.f.:
For significance level 0.10: 2.706
For significance level 0.05: 3.841
For significance level 0.01: 6.635

One hour survival estimates for adult American Eels passed through Unit 8 (1700 cfs) and combining all controls at Vernon Station, October-November 2015.
Control: 39 released, 39 alive, 0 dead
Treatment (Unit 8-1700 cfs): 50 released, 39 alive, 11 dead

RESULTS FOR REDUCED MODEL (EQUAL LIVE/DEAD RECOVERY)

	estim.	std.err.	
S =	1.0	N/A	Control group survival*
Pa = Pd	1.0	N/A	Recovery probability*
Tau =	0.7800	(0.0586)	Unit 8 (1700 cfs) survival
1-Tau =	0.2200	(0.0586)	Unit 8 (1700 cfs) mortality

* Because of constraints in the data set, this probability is assumed equal to 1.0; not estimated.

Log-likelihood: -26.345398

Variance-Covariance matrix for estimated probabilities:
0.00343

Profile likelihood intervals:

	Unit 8-1700 cfs survival	Unit 8-1700 cfs mortality
90 percent:	(0.0000, 1.0000)	(0.0000, 1.0000)
95 percent:	(0.0000, 1.0000)	(0.0000, 1.0000)
99 percent:	(0.0000, 1.0000)	(0.0000, 1.0000)

Likelihood ratio statistic for equality of recovery probabilities: 0.000000

Compare with quantiles of the chi-squared distribution with 1 d.f.:
For significance level 0.10: 2.706
For significance level 0.05: 3.841
For significance level 0.01: 6.635

Forty- eight hour survival estimates for adult American Eels passed through Unit 8 (1700 cfs) and combining all controls at Vernon Station, October-November 2015.
Control: 39, released, 39 alive, 0 dead
Treatment (Unit 8-1700 cfs): 50 released, 37 alive, 13 dead

RESULTS FOR REDUCED MODEL (EQUAL LIVE/DEAD RECOVERY)

	estim.	std.err.	
S =	1.0	N/A	Control group survival*
Pa = Pd	1.0	N/A	Recovery probability*
Tau =	0.7400	(0.0620)	Unit 8 (1700 cfs) survival
1-Tau =	0.2600	(0.0620)	Unit 8 (1700 cfs) mortality

* Because of constraints in the data set, this probability is assumed equal to 1.0; not estimated.

Log-likelihood: -28.652846

Variance-Covariance matrix for estimated probabilities:
0.00385

Profile likelihood intervals:

	Unit 8-1700 cfs survival	Unit 8-1700 cfs mortality
90 percent:	(0.0000, 1.0000)	(0.0000, 1.0000)
95 percent:	(0.0000, 1.0000)	(0.0000, 1.0000)
99 percent:	(0.0000, 1.0000)	(0.0000, 1.0000)

Likelihood ratio statistic for equality of recovery probabilities: 0.000000

Compare with quantiles of the chi-squared distribution with 1 d.f.:
For significance level 0.10: 2.706
For significance level 0.05: 3.841
For significance level 0.01: 6.635

One hour survival estimates for adult American Eels passed through Unit 9 and combining all controls at Vernon Station, October-November 2015.
Control: 39 released, 39 alive, 0 dead
Treatment (Unit 9): 48 released, 46 alive, 1 dead

RESULTS FOR REDUCED MODEL (EQUAL LIVE/DEAD RECOVERY)

	estim.	std.err.	
S =	1.0	N/A	Control group survival*
Pa = Pd	0.9885	(0.0114)	Recovery probability
Tau =	0.9787	(0.0210)	Unit 9 survival
1-Tau =	0.0213	(0.0210)	Unit 9 mortality

* Because of constraints in the data set, this probability is assumed equal to 1.0; not estimated.

Log-likelihood: -10.299572

Variance-Covariance matrix for estimated probabilities:
0.00013 -0.00000
-0.00000 0.00044

Profile likelihood intervals:

	Unit 9 survival	Unit 9 mortality
90 percent:	(0.9246, 0.9977)	(0.0023, 0.0754)
95 percent:	(0.9096, 0.9988)	(0.0012, 0.0904)
99 percent:	(0.8765, 0.9997)	(0.0003, 0.1235)

Likelihood ratio statistic for equality of recovery probabilities: 1.198855

Compare with quantiles of the chi-squared distribution with 1 d.f.:
For significance level 0.10: 2.706
For significance level 0.05: 3.841
For significance level 0.01: 6.635

Forty-eight hour survival estimates for adult American Eels passed through Unit 9 and combining all controls at Vernon Station, October-November 2015.
Control: 39 released, 39 alive, 0 dead
Treatment (Unit 9): 48 released, 46 alive, 1 dead

RESULTS FOR REDUCED MODEL (EQUAL LIVE/DEAD RECOVERY)

	estim.	std.err.	
S =	1.0	N/A	Control group survival*
Pa = Pd	0.9885	(0.0114)	Recovery probability
Tau =	0.9787	(0.0210)	Unit 9 survival
1-Tau =	0.0213	(0.0210)	Unit 9 mortality

* Because of constraints in the data set, this probability is assumed equal to 1.0; not estimated.

Log-likelihood: -10.299572

Variance-Covariance matrix for estimated probabilities:
0.00013 -0.00000
-0.00000 0.00044

Profile likelihood intervals:

	Unit9 survival	Unit 9 mortality
90 percent:	(0.9246, 0.9977)	(0.0023, 0.0754)
95 percent:	(0.9096, 0.9988)	(0.0012, 0.0904)
99 percent:	(0.8765, 0.9997)	(0.0003, 0.1235)

Likelihood ratio statistic for equality of recovery probabilities: 1.198855

Compare with quantiles of the chi-squared distribution with 1 d.f.:
For significance level 0.10: 2.706
For significance level 0.05: 3.841
For significance level 0.01: 6.635

One hour survival estimates for adult American Eels passed through combined Unit 4, Unit 8 (1000 cfs), Unit 8 (1700 cfs) and Unit 9 and combining all controls at Vernon Station, October-November 2015.
Control: 39 released, 39 alive, 0 dead
Treatment: 194 released, 173 alive, 17 dead

RESULTS FOR REDUCED MODEL (EQUAL LIVE/DEAD RECOVERY)

	estim.	std.err.	
S =	1.0	N/A	Control group survival*
Pa = Pd	0.9828	(0.0085)	Recovery probability
Tau =	0.9105	(0.0207)	Vernon Station survival
1-Tau =	0.0895	(0.0207)	Vernon Station mortality

* Because of constraints in the data set, this probability is assumed equal to 1.0; not estimated.

Log-likelihood: -77.474944

Variance-Covariance matrix for estimated probabilities:
0.00007 -0.00000
-0.00000 0.00043

Profile likelihood intervals:

	Vernon Station survival	Vernon Station mortality
90 percent:	(0.8726, 0.9407)	(0.0593, 0.1274)
95 percent:	(0.8645, 0.9456)	(0.0544, 0.1355)
99 percent:	(0.8478, 0.9544)	(0.0456, 0.1522)

Likelihood ratio statistic for equality of recovery probabilities: 1.479423

Compare with quantiles of the chi-squared distribution with 1 d.f.:
For significance level 0.10: 2.706
For significance level 0.05: 3.841
For significance level 0.01: 6.635

Forty-eight hour survival estimates for adult American Eels passed through combined Unit 4, Unit 8 (1000 cfs), Unit 8 (1700 cfs) and Unit 9 and combining all controls for Vernon Station, October-November 2015.
Control: 39 released, 39 alive, 0 dead
Treatment: 194 released, 168 alive, 23 dead

RESULTS FOR REDUCED MODEL (EQUAL LIVE/DEAD RECOVERY)

	estim.	std.err.	
S =	1.0	N/A	Control group survival*
Pa = Pd	0.9871	(0.0074)	Recovery probability
Tau =	0.8796	(0.0235)	Vernon Station survival
1-Tau =	0.1204	(0.0235)	Vernon Station mortality

* Because of constraints in the data set, this probability is assumed equal to 1.0; not estimated.

Log-likelihood: -86.279791

Variance-Covariance matrix for estimated probabilities:
0.00005 0.00000
0.00000 0.00055

Profile likelihood intervals:

	Vernon Station survival	Vernon Station mortality
90 percent:	(0.8373, 0.9147)	(0.0853, 0.1627)
95 percent:	(0.8285, 0.9206)	(0.0794, 0.1715)
99 percent:	(0.8104, 0.9314)	(0.0686, 0.1896)

Likelihood ratio statistic for equality of recovery probabilities: 1.106921

Compare with quantiles of the chi-squared distribution with 1 d.f.:
For significance level 0.10: 2.706
For significance level 0.05: 3.841
For significance level 0.01: 6.635

Forty-eight hour survival estimates on adult American Eels passed through Unit 2 and combining all controls at Bellows Falls, October-November 2015.
Control: 39 released, 39 alive, 0 dead
Treatment (Unit 2): 50 released, 31 alive, 19 dead

RESULTS FOR REDUCED MODEL (EQUAL LIVE/DEAD RECOVERY)

	estim.	std.err.	
S =	1.0	N/A	Control group survival*
Pa = Pd	1.0	N/A	Recovery probability*
Tau =	0.9800	(0.0198)	Unit 2 survival
1-Tau =	0.0200	(0.0198)	Unit 2 mortality

* Because of constraints in the data set, this probability is assumed equal to 1.0; not estimated.

Log-likelihood: -4.901956

Variance-Covariance matrix for estimated probabilities:
0.00039

Profile likelihood intervals:

	Unit 2 survival	Unit 2 mortality
90 percent:	(0.9708, 1.0000)	(0.0000, 0.0292)
95 percent:	(0.0000, 1.0000)	(0.0000, 1.0000)
99 percent:	(0.0000, 1.0000)	(0.0000, 1.0000)

Likelihood ratio statistic for equality of recovery probabilities: 0.000000

Compare with quantiles of the chi-squared distribution with 1 d.f.:
For significance level 0.10: 2.706
For significance level 0.05: 3.841
For significance level 0.01: 6.635

One hour survival estimates on adult American Eels passed through Unit 2 and combing all controls at Wilder Station, October-November 2015.
Control: 39 released, 39 alive, 0 dead
Treatment (Unit 2): 50 released, 40 alive, 10 dead

RESULTS FOR REDUCED MODEL (EQUAL LIVE/DEAD RECOVERY)

	estim.	std.err.	
S =	1.0	N/A	Control group survival*
Pa = Pd	1.0	N/A	Recovery probability*
Tau =	0.8000	(0.0566)	Unit 2 survival
1-Tau =	0.2000	(0.0566)	Unit 2 mortality

* Because of constraints in the data set, this probability is assumed equal to 1.0; not estimated.

Log-likelihood: -25.020121

Variance-Covariance matrix for estimated probabilities:
0.00320

Profile likelihood intervals:

	Unit 2 survival	Unit 2 mortality
90 percent:	(0.0000, 1.0000)	(0.0000, 1.0000)
95 percent:	(0.0000, 1.0000)	(0.0000, 1.0000)
99 percent:	(0.0000, 1.0000)	(0.0000, 1.0000)

Likelihood ratio statistic for equality of recovery probabilities: 0.000000

Compare with quantiles of the chi-squared distribution with 1 d.f.:
For significance level 0.10: 2.706
For significance level 0.05: 3.841
For significance level 0.01: 6.635

Forty-eight hour survival estimates for adult American Eels passed through Unit 2 and combing all controls at Wilder Station, October-November 2015.
Control: 39 released, 39 alive, 0 dead
Treatment (Unit 2): 50 released, 31 alive, 19 dead

RESULTS FOR REDUCED MODEL (EQUAL LIVE/DEAD RECOVERY)

	estim.	std.err.	
S =	1.0	N/A	Control group survival*
Pa = Pd	1.0	N/A	Recovery probability*
Tau =	0.6200	(0.0686)	Unit 2 survival
1-Tau =	0.3800	(0.0686)	Unit 2 mortality

* Because of constraints in the data set, this probability is assumed equal to 1.0; not estimated.

Log-likelihood: -33.203206

Variance-Covariance matrix for estimated probabilities:
0.00471

Profile likelihood intervals:

	Unit 2 survival	Unit 2 mortality
90 percent:	(0.0000, 1.0000)	(0.0000, 1.0000)
95 percent:	(0.0000, 1.0000)	(0.0000, 1.0000)
99 percent:	(0.0000, 1.0000)	(0.0000, 1.0000)

Likelihood ratio statistic for equality of recovery probabilities: 0.000000

Compare with quantiles of the chi-squared distribution with 1 d.f.:
For significance level 0.10: 2.706
For significance level 0.05: 3.841
For significance level 0.01: 6.635

Malady-Free Outputs Combining all Controls

Malady-Free estimate for adult American Eels passed through Unit 4 combining all controls, at Vernon Station, October-November 2015.

Control: 38 examined, 36 without maladies, 2 with maladies
Treatment (Unit 4): 45 examined, 29 without maladies, 16 with maladies

RESULTS FOR REDUCED MODEL (EQUAL LIVE/DEAD RECOVERY)

	estim.	std.err.	
S =	0.9474	(0.0362)	Control group survival
Pa = Pd	1.0	N/A	Recovery probability*
Tau =	0.6802	(0.0797)	Unit 4 Malady-Free Estimate
1-Tau =	0.3198	(0.0797)	Unit 4 Malady Estimate

* Because of constraints in the data set, this probability is assumed equal to 1.0; not estimated.

Log-likelihood: -37.122111

Variance-Covariance matrix for estimated probabilities:
0.00131 -0.00094
-0.00094 0.00635

Profile likelihood intervals:

	Unit 4 Malady-Free CI	Unit 4 Malady CI
90 percent:	(0.5483, 0.8121)	(0.1879, 0.4517)
95 percent:	(0.5231, 0.8388)	(0.1612, 0.4769)
99 percent:	(0.4743, 0.8948)	(0.1052, 0.5257)

Likelihood ratio statistic for equality of recovery probabilities: 0.000000

Compare with quantiles of the chi-squared distribution with 1 d.f.:
For significance level 0.10: 2.706
For significance level 0.05: 3.841
For significance level 0.01: 6.635

Malady-Free estimate for adult American Eels passed through Unit8 (1000 cfs) and combining all controls at Vernon Station, October-November 2015.
Control: 39 examined, 36 without maladies, 2 with maladies
Treatment (Unit 8-1000 cfs): 46 examined, 32 without maladies, 14 with maladies

RESULTS FOR REDUCED MODEL (EQUAL LIVE/DEAD RECOVERY)

	estim.	std.err.	
S =	0.9474	(0.0362)	Control group survival
Pa = Pd	1.0	N/A	Recovery probability*
Tau =	0.7343	(0.0769)	Unit 8-1000 cfs Malady-Free Estimate
1-Tau =	0.2657	(0.0769)	Unit 8-1000 cfs Malady Estimate

* Because of constraints in the data set, this probability is assumed equal to 1.0; not estimated.

Log-likelihood: -36.102451

Variance-Covariance matrix for estimated probabilities:
0.00131 -0.00102
-0.00102 0.00592

Profile likelihood intervals:

	Unit 8-1000 cfs Malady-Free CI	Unit 8-1000 cfs Malady CI
90 percent:	(0.6055, 0.8622)	(0.1378, 0.3945)
95 percent:	(0.5805, 0.8886)	(0.1114, 0.4195)
99 percent:	(0.5316, 0.9451)	(0.0549, 0.4684)

Likelihood ratio statistic for equality of recovery probabilities: 0.000000

Compare with quantiles of the chi-squared distribution with 1 d.f.:
For significance level 0.10: 2.706
For significance level 0.05: 3.841
For significance level 0.01: 6.635

Malady-Free estimate for adult American Eels passed through Unit 8 (1700 cfs) and combining all controls at Vernon Station, October-November 2015.
Control: 38 examined, 36 without maladies, 2 with maladies
Treatment (Unit 8-1700 cfs): 44 examined, 31 without maladies 13 with maladies

RESULTS FOR REDUCED MODEL (EQUAL LIVE/DEAD RECOVERY)

	estim.	std.err.	
S =	0.9474	(0.0362)	Control group survival
Pa = Pd	0.9880	(0.0120)	Recovery probability
Tau =	0.7437	(0.0780)	Unit 8-1700 cfs Malady-Free Estimate
1-Tau =	0.2563	(0.0780)	Unit 8-1700 cfs Malady Estimate

Log-likelihood: -39.954489

Variance-Covariance matrix for estimated probabilities:
0.00131 0.00000 -0.00103
0.00000 0.00014 -0.00000
-0.00103 -0.00000 0.00608

Profile likelihood intervals:

	Unit 8-1700 cfs Malady-Free CI	Unit 8-1700 cfs Malady CI
90 percent:	(0.6126, 0.8729)	(0.1271, 0.3874)
95 percent:	(0.5870, 0.8995)	(0.1005, 0.4130)
99 percent:	(0.5370, 0.9565)	(0.0435, 0.4630)

Likelihood ratio statistic for equality of recovery probabilities: 0.294649

Compare with quantiles of the chi-squared distribution with 1 d.f.:
For significance level 0.10: 2.706
For significance level 0.05: 3.841
For significance level 0.01: 6.635

Malady-Free estimate for adult American Eels passed through Unit 9 and combining all controls at Vernon Project, October-November 2015.
Control: 38 examined, 36 without maladies, 2 maladies
Treatment (Unit 9): 46 examined, 42 without maladies, 4 with maladies

RESULTS FOR REDUCED MODEL (EQUAL LIVE/DEAD RECOVERY)

	estim.	std.err.	
S =	0.9474	(0.0362)	Control group survival
Pa = Pd	1.0	N/A	Recovery probability*
Tau =	0.9638	(0.0573)	Unit 9 Malady-Free Estimate
1-Tau =	0.0362	(0.0573)	Unit 9 Malady Estimate

* Because of constraints in the data set, this probability is assumed equal to 1.0; not estimated.

Log-likelihood: -21.425501

Variance-Covariance matrix for estimated probabilities:
0.00131 -0.00133
-0.00133 0.00328

Profile likelihood intervals:

	Unit 9 Malady-Free CI	Unit 9 Malady CI
90 percent:	(0.8648, 1.0000)	(0.0000, 0.1352)
95 percent:	(0.8437, 1.0000)	(0.0000, 0.1563)
99 percent:	(0.8001, 1.0000)	(0.0000, 0.1999)

Likelihood ratio statistic for equality of recovery probabilities: -0.000000

Compare with quantiles of the chi-squared distribution with 1 d.f.:
For significance level 0.10: 2.706
For significance level 0.05: 3.841
For significance level 0.01: 6.635

Malady-Free estimate on adult American Eels passed through combined Unit 4, Unit 8 (1000 cfs), Unit 8 (1700 cfs), and Unit 9 and combining all controls at Vernon Station, October-November 2015.
Control: 39 examined, 38 without maladies, 2 with maladies
Treatment: 181 examined, 134 without maladies, 47 with maladies

RESULTS FOR REDUCED MODEL (EQUAL LIVE/DEAD RECOVERY)

	estim.	std.err.	
S =	0.9474	(0.0362)	Control group survival
Pa = Pd	1.0	N/A	Recovery probability*
Tau =	0.7815	(0.0456)	Vernon Station Malady-Free Estimate
1-Tau =	0.2185	(0.0456)	Vernon Station Malady Estimate

* Because of constraints in the data set, this probability is assumed equal to 1.0; not estimated.

Log-likelihood: -111.495790

Variance-Covariance matrix for estimated probabilities:
0.00131 -0.00108
-0.00108 0.00208

Profile likelihood intervals:

	Vernon Station Malady-Free CI	Vernon Station Malady CI
90 percent:	(0.7121, 0.8714)	(0.1286, 0.2879)
95 percent:	(0.6994, 0.8937)	(0.1063, 0.3006)
99 percent:	(0.6747, 0.9443)	(0.0557, 0.3253)

Likelihood ratio statistic for equality of recovery probabilities: -0.000000

Compare with quantiles of the chi-squared distribution with 1 d.f.:
For significance level 0.10: 2.706
For significance level 0.05: 3.841
For significance level 0.01: 6.635

Malady-Free estimate for adult American Eels passed through Unit 2 and combining all controls at Bellows Falls, October-November 2015.
Control: 38 examined, 36 without maladies, 2 with maladies
Treatment (Unit 2): 50 examined, 43 without maladies, 7 with maladies

RESULTS FOR REDUCED MODEL (EQUAL LIVE/DEAD RECOVERY)

	estim.	std.err.	
S =	0.9474	(0.0362)	Control group survival
Pa = Pd	1.0	N/A	Recovery probability*
Tau =	0.9078	(0.0624)	Unit 2 Malady-Free Estimate
1-Tau =	0.0922	(0.0624)	Unit 2 Malady Estimate

* Because of constraints in the data set, this probability is assumed equal to 1.0; not estimated.

Log-likelihood: -28.083472

Variance-Covariance matrix for estimated probabilities:
0.00131 -0.00126
-0.00126 0.00389

Profile likelihood intervals:

	Unit 2 Malady-Free CI	Unit 2 Malady CI
90 percent:	(0.8011, 1.0000)	(0.0000, 0.1989)
95 percent:	(0.7792, 1.0000)	(0.0000, 0.2208)
99 percent:	(0.7348, 1.0000)	(0.0000, 0.2652)

Likelihood ratio statistic for equality of recovery probabilities: 0.000000

Compare with quantiles of the chi-squared distribution with 1 d.f.:
For significance level 0.10: 2.706
For significance level 0.05: 3.841
For significance level 0.01: 6.635

Malady-Free estimate for adult American Eels passed through Unit 2 and combining all controls at Wilder Station, October-November 2015.
Control: 38 examined, 36 without maladies, 2 with maladies
Treatment (Unit 2): 47 examined, 27 without maladies, 20 with maladies

RESULTS FOR REDUCED MODEL (EQUAL LIVE/DEAD RECOVERY)

	estim.	std.err.	
S =	0.9474	(0.0362)	Control group survival
Pa = Pd	1.0	N/A	Recovery probability*
Tau =	0.6064	(0.0796)	Unit 2 Malady-Free Estimate
1-Tau =	0.3936	(0.0796)	Unit 2 Malady Estimate

* Because of constraints in the data set, this probability is assumed equal to 1.0; not estimated.

Log-likelihood: -39.889994

Variance-Covariance matrix for estimated probabilities:
0.00131 -0.00084
-0.00084 0.00633

Profile likelihood intervals:

	Unit 2 Malady-Free CI	Unit 2 Malady CI
90 percent:	(0.4769, 0.7389)	(0.2611, 0.5231)
95 percent:	(0.4527, 0.7654)	(0.2346, 0.5473)
99 percent:	(0.4065, 0.8201)	(0.1799, 0.5935)

Likelihood ratio statistic for equality of recovery probabilities: 0.000000

Compare with quantiles of the chi-squared distribution with 1 d.f.:
For significance level 0.10: 2.706
For significance level 0.05: 3.841
For significance level 0.01: 6.635

One and Forty-Eight Hour Outputs on Only Recaptured Eels and Combining all Controls

One hour survival estimates for adult American Eels passed through Unit 4 and Unit 9 at Vernon Project for <u>only recaptured eels</u> and combining all controls, October-November 2015.
Controls: 38 recaptured, 38 alive, 0 dead
Treatment Unit 4: 45 recaptured, 45 alive, 0 dead
Treatment Unit 9: 46 recaptured, 46 alive, 0 dead

RESULTS FOR REDUCED MODEL (EQUAL LIVE/DEAD RECOVERY)

	estim.	std.err.	
S1 =	1.0	N/A	Control group survival*
Pa = Pd	1.0	N/A	Recovery probability*
S2 =	1.0	N/A	Unit 4 Turbine survival*
S3 =	1.0	N/A	Unit 9 Turbine survival*

* Because of constraints in the data set, this probability is assumed equal to 1.0; not estimated.

Log-likelihood: 0.0000

Tau = 1.0000 (0.0000) Unit 4 Turbine/Control ratio
Tau = 1.0000 (0.0000) Unit 9 Turbine/Control ratio

Z statistic for the equality of equal turbine survivals: 0.0000

Compare with quantiles of the normal distribution:

	1-tailed	2-tailed
For significance level 0.10:	1.2816	1.6449
For significance level 0.05:	1.6449	1.9600
For significance level 0.01:	2.3263	2.5758

Confidence intervals:

	Unit 4 Survival	Unit 9 Survival
90 percent:	(1.0000, 1.0000)	(1.0000, 1.0000)
95 percent:	(0.9999, 1.0001)	(1.0000, 1.0000)
99 percent:	(0.9999, 1.0001)	(0.9999, 1.0001)

Likelihood ratio statistic for equality of recovery probabilities: 0.0000

Compare with quantiles of the chi-squared distribution with 1 d.f.:
For significance level 0.10: 2.706
For significance level 0.05: 3.841
For significance level 0.01: 6.635

Forty-eight hour survival estimates for adult American Eels passed through Unit 4 for <u>only recaptured eels</u> and combining all controls at Vernon Station, October-November 2015.
Control: 38 recaptured, 38 alive, 0 dead
Treatment (Unit 4): 45 recaptured, 43 alive, 2 dead

RESULTS FOR REDUCED MODEL (EQUAL LIVE/DEAD RECOVERY)

	estim.	std.err.	
S =	1.0	N/A	Control group survival*
Pa = Pd	1.0	N/A	Recovery probability*
Tau =	0.9556	(0.0307)	Unit 4 survival
1-Tau =	0.0444	(0.0307)	Unit 4 mortality

* Because of constraints in the data set, this probability is assumed equal to 1.0; not estimated.

Log-likelihood: -8.181913

Variance-Covariance matrix for estimated probabilities:
0.00094

Profile likelihood intervals:

	Unit 4 survival	Unit 4 mortality
90 percent:	(0.0000, 1.0000)	(0.0000, 1.0000)
95 percent:	(0.0000, 1.0000)	(0.0000, 1.0000)
99 percent:	(0.0000, 1.0000)	(0.0000, 1.0000)

Likelihood ratio statistic for equality of recovery probabilities: 0.000000

Compare with quantiles of the chi-squared distribution with 1 d.f.:
For significance level 0.10: 2.706
For significance level 0.05: 3.841
For significance level 0.01: 6.635

One hour survival estimates for adult American Eels passed through Unit 8 (1000 cfs) and Unit 8 (1700 cfs) for <u>only recaptured eels</u> and combining all controls at Vernon Station, October-November 2015.
Control: 38 recaptured, 38 alive, 0 dead
Treatment (Unit 8-1000 cfs): 46 recaptured, 43 alive, 3 dead
Treatment (Unit 8-1700 cfs): 44 recaptured 39 alive, 5 dead

RESULTS FOR REDUCED MODEL (EQUAL LIVE/DEAD RECOVERY)

	estim.	std.err.	
S1 =	1.0	N/A	Control group survival*
Pa = Pd	1.0	N/A	Recovery probability*
S2 =	0.9348	(0.0364)	Unit 8-1000 cfs Turbine survival
S3 =	0.8864	(0.0478)	Unit 8-1700 cfs Turbine survival

* Because of constraints in the data set, this probability is assumed equal to 1.0; not estimated.

Log-likelihood: -26.6683

Tau = 0.9348 (0.0364) Unit 8 (1000 cfs) Unit 8-1000 cfs survival/Control ratio
Tau = 0.8864 (0.0478) Unit 8 (1700 cfs) Unit 8-1700 cfs survival/Control ratio

Z statistic for the equality of equal turbine survivals: 0.8054

Compare with quantiles of the normal distribution:

	1-tailed	2-tailed
For significance level 0.10:	1.2816	1.6449
For significance level 0.05:	1.6449	1.9600
For significance level 0.01:	2.3263	2.5758

Confidence intervals:

	Unit 8-1000 cfs	Unit 8-1700 cfs
90 percent:	(0.8749, 0.9947)	(0.8077, 0.9651)
95 percent:	(0.8634, 1.0061)	(0.7926, 0.9801)
99 percent:	(0.8410, 1.0285)	(0.7632, 1.0096)

Likelihood ratio statistic for equality of recovery probabilities: 0.0000

Compare with quantiles of the chi-squared distribution with 1 d.f.:
For significance level 0.10: 2.706
For significance level 0.05: 3.841
For significance level 0.01: 6.635

Forty-eight hour survival estimates for adult American Eels passed through Unit 8 (1000 cfs) for <u>only recaptured eels</u> and combining all controls at Vernon Station, October-November 2015.
Control 38 recaptured, 38 alive, 0 dead
Treatment (Unit 8-1000 cfs): 46 recaptured, 42 alive, 4 dead

RESULTS FOR REDUCED MODEL (EQUAL LIVE/DEAD RECOVERY)

	estim.	std.err.	
S =	1.0	N/A	Control group survival*
Pa = Pd	1.0	N/A	Recovery probability*
Tau =	0.9130	(0.0415)	Unit 8-1000 cfs survival
1-Tau =	0.0870	(0.0415)	Unit 8-1000 cfs mortality

* Because of constraints in the data set, this probability is assumed equal to 1.0; not estimated.

Log-likelihood: -13.590203

Variance-Covariance matrix for estimated probabilities:
0.00173

Profile likelihood intervals:

	Unit 8-1000 cfs survival	Unit 8-1000 cfs mortality
90 percent:	(0.0000, 1.0000)	(0.0000, 1.0000)
95 percent:	(0.0000, 1.0000)	(0.0000, 1.0000)
99 percent:	(0.0000, 1.0000)	(0.0000, 1.0000)

Likelihood ratio statistic for equality of recovery probabilities: 0.000000

Compare with quantiles of the chi-squared distribution with 1 d.f.:
For significance level 0.10: 2.706
For significance level 0.05: 3.841
For significance level 0.01: 6.635

Forty-eight hour survival estimate for adult American Eels passed through Unit 8 (1700 cfs) for only recaptured eels and combining all controls at Vernon Station, October-November 2015.
Control: 38 recaptured, 38 alive, 0 dead
Treatment (Unit 8-1700 cfs): 44 recaptured, 37 alive, 7 dead

RESULTS FOR REDUCED MODEL (EQUAL LIVE/DEAD RECOVERY)

	estim.	std.err.	
S =	1.0	N/A	Control group survival*
Pa = Pd	1.0	N/A	Recovery probability*
Tau =	0.8409	(0.0551)	Unit 8-1700 cfs survival
1-Tau =	0.1591	(0.0551)	Unit 8-1700 cfs mortality

* Because of constraints in the data set, this probability is assumed equal to 1.0; not estimated.

Log-likelihood: -19.279010

Variance-Covariance matrix for estimated probabilities:
0.00304

Profile likelihood intervals:

	Unit 8-1700 cfs survival	Unit 8-1700 cfs mortality
90 percent:	(0.0000, 1.0000)	(0.0000, 1.0000)
95 percent:	(0.0000, 1.0000)	(0.0000, 1.0000)
99 percent:	(0.0000, 1.0000)	(0.0000, 1.0000)

Likelihood ratio statistic for equality of recovery probabilities: 0.000000

Compare with quantiles of the chi-squared distribution with 1 d.f.:
For significance level 0.10: 2.706
For significance level 0.05: 3.841
For significance level 0.01: 6.635

One hour survival estimates for adult American Eels passed through Unit 4, Unit 8 (1000 cfs), Unit 8 (1700 cfs), and Unit 9 for only recaptured eels and combining all controls at Vernon Station, October-November 2015.
Control: 38 recaptured, 38 alive, 0 dead
Treatment: 181 recaptured, 173, alive, 8 dead

RESULTS FOR REDUCED MODEL (EQUAL LIVE/DEAD RECOVERY)

	estim.	std.err.	
S =	1.0	N/A	Control group survival*
Pa = Pd	1.0	N/A	Recovery probability*
Tau =	0.9558	(0.0153)	Vernon Station survival
1-Tau =	0.0442	(0.0153)	Vernon Station mortality

* Because of constraints in the data set, this probability is assumed equal to 1.0; not estimated.

Log-likelihood: -32.772984

Variance-Covariance matrix for estimated probabilities:
0.00023

Profile likelihood intervals:

	Vernon Station survival	Vernon Station mortality
90 percent:	(0.0000, 1.0000)	(0.0000, 1.0000)
95 percent:	(0.0000, 1.0000)	(0.0000, 1.0000)
99 percent:	(0.0000, 1.0000)	(0.0000, 1.0000)

Likelihood ratio statistic for equality of recovery probabilities: 0.000000

Compare with quantiles of the chi-squared distribution with 1 d.f.:
For significance level 0.10: 2.706
For significance level 0.05: 3.841
For significance level 0.01: 6.635

Forty-eight hour survival estimates for adult American Eels passed through Unit 4, Unit 8(1000 cfs), Unit 8 (1700 cfs), and Unit 9 for <u>only recaptured eels</u> and all controls at Vernon Station, October-November 2015.
Control: 38 recaptured, 38 alive, 0 dead
Treatment: 181 recaptured, 168 alive, 13 dead

RESULTS FOR REDUCED MODEL (EQUAL LIVE/DEAD RECOVERY)

	estim.	std.err.	
S =	1.0	N/A	Control group survival*
Pa = Pd	1.0	N/A	Recovery probability*
Tau =	0.9282	(0.0192)	Vernon Station survival
1-Tau =	0.0718	(0.0192)	Vernon Station mortality

* Because of constraints in the data set, this probability is assumed equal to 1.0; not estimated.

Log-likelihood: -46.757672

Variance-Covariance matrix for estimated probabilities:
0.00037

Profile likelihood intervals:

	Vernon Station survival	Vernon Station mortality
90 percent:	(0.9091, 1.0000)	(0.0000, 0.0909)
95 percent:	(0.0000, 1.0000)	(0.0000, 1.0000)
99 percent:	(0.0000, 1.0000)	(0.0000, 1.0000)

Likelihood ratio statistic for equality of recovery probabilities: 0.000000

Compare with quantiles of the chi-squared distribution with 1 d.f.:
For significance level 0.10: 2.706
For significance level 0.05: 3.841
For significance level 0.01: 6.635

One hour survival estimates for adult American Eels passed through Bellows Falls Unit 2 and Wilder Unit 2 for only recaptured eels and combining all controls, October-November 2015.
Control: 38 recaptured, 38 alive, 0 dead
Treatment BF: 50 recaptured, 50, 0 dead
Treatment Wilder: 47 recaptured, 40 alive, 7 dead

RESULTS FOR REDUCED MODEL (EQUAL LIVE/DEAD RECOVERY)

	estim.	std.err.	
S1 =	1.0	N/A	Control group survival*
Pa = Pd	1.0	N/A	Recovery probability*
S2 =	1.0	N/A	Bellows Falls Unit 2 survival*
S3 =	0.8511	(0.0519)	Wilder Unit 2 survival

* Because of constraints in the data set, this probability is assumed equal to 1.0; not estimated.

Log-likelihood: -19.7804

Tau = 1.0000 (0.0000) Bellows Falls Unit 2/Control ratio
Tau = 0.8511 (0.0519) Wilder Unit 2/Control ratio

Z statistic for the equality of equal turbine survivals: 2.8679

Compare with quantiles of the normal distribution:

	1-tailed	2-tailed
For significance level 0.10:	1.2816	1.6449
For significance level 0.05:	1.6449	1.9600
For significance level 0.01:	2.3263	2.5758

Confidence intervals:

	BF Unit 2	Wilder Unit 2
90 percent:	(1.0000, 1.0000)	(0.7656, 0.9365)
95 percent:	(0.9999, 1.0001)	(0.7493, 0.9529)
99 percent:	(0.9999, 1.0001)	(0.7173, 0.9848)

Likelihood ratio statistic for equality of recovery probabilities: 0.0000

Compare with quantiles of the chi-squared distribution with 1 d.f.:
For significance level 0.10: 2.706
For significance level 0.05: 3.841
For significance level 0.01: 6.635

Forty-eight hour survival estimates for adult American Eels passed through Unit 2 at Bellows Falls for <u>only recaptured eels</u> and all combining all controls, October-November 2015.
Control: 38 recaptured, 38 alive, 0 dead
Treatment (BF Unit 2): 50 recaptured, 49 alive, 1 dead

RESULTS FOR REDUCED MODEL (EQUAL LIVE/DEAD RECOVERY)

	estim.	std.err.	
S =	1.0	N/A	Control group survival*
Pa = Pd	1.0	N/A	Recovery probability*
Tau =	0.9800	(0.0198)	Bellows Falls Unit 2 survival
1-Tau =	0.0200	(0.0198)	Bellows Falls Unit 2 mortality

* Because of constraints in the data set, this probability is assumed equal to 1.0; not estimated.

Log-likelihood: -4.901956

Variance-Covariance matrix for estimated probabilities:
0.00039

Profile likelihood intervals:

	BF Unit 2 survival	BF Unit 2 mortality
90 percent:	(0.9708, 1.0000)	(0.0000, 0.0292)
95 percent:	(0.0000, 1.0000)	(0.0000, 1.0000)
99 percent:	(0.0000, 1.0000)	(0.0000, 1.0000)

Likelihood ratio statistic for equality of recovery probabilities: 0.000000

Compare with quantiles of the chi-squared distribution with 1 d.f.:
For significance level 0.10: 2.706
For significance level 0.05: 3.841
For significance level 0.01: 6.635

Forty-eight hour survival estimates for adult American Eels passed through Unit 2 at Wilder Station for only recaptured eels and combining all controls, October-November 2015.
Control: 38 recaptured, 38 alive, 0 dead
Treatment (Wilder Unit 2): 47 recaptured, 31 alive, 16 dead

RESULTS FOR REDUCED MODEL (EQUAL LIVE/DEAD RECOVERY)

	estim.	std.err.	
S =	1.0	N/A	Control group survival*
Pa = Pd	1.0	N/A	Recovery probability*
Tau =	0.6596	(0.0691)	Wilder Unit 2 survival
1-Tau =	0.3404	(0.0691)	Wilder Unit 2 mortality

* Because of constraints in the data set, this probability is assumed equal to 1.0; not estimated.

Log-likelihood: -30.141914

Variance-Covariance matrix for estimated probabilities:
0.00478

Profile likelihood intervals:

	Wilder Unit 2 survival	Wilder Unit 2 mortality
90 percent:	(0.0000, 1.0000)	(0.0000, 1.0000)
95 percent:	(0.0000, 1.0000)	(0.0000, 1.0000)
99 percent:	(0.0000, 1.0000)	(0.0000, 1.0000)

Likelihood ratio statistic for equality of recovery probabilities: 0.000000

Compare with quantiles of the chi-squared distribution with 1 d.f.:
For significance level 0.10: 2.706
For significance level 0.05: 3.841
For significance level 0.01: 6.635

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APPENDIX C

Daily Turbine Survival Recapture Data

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Daily data for recaptured adult eels passed through Units 4, 8 (2 releases) and 9 at Vernon Station, Bellows Falls Unit 2 and Wilder Unit 2, October-November 2015. Combined controls released into the tailrace downstream of the three stations.

	Vernon Station				**Bellows Falls**	**Wilder**	
	Unit 8-1000cfs	**Unit 9**	**Unit 4**	**Unit 8-1700cfs**	**Unit 2**	**Unit 2**	
	10/26	**10/27**	**10/28**	**11/3**	**10/30**	**11/1**	**Totals**
			Treatment				
Number released	48	48	48	50	50	50	**294**
Number alive	43	46	45	39	50	40	**263**
Number recovered dead	3	0	0	5	0	7	**15**
Assigned dead	2	1	1	6	0	3	**13**
Dislodged tags	2	0	1	4	0	3	**10**
Stationary radio signals	0	1	0	2	0	0	**3**
Undetermined	0	1	2	0	0	0	**3**
Held and Alive 1 h	43	46	45	39	50	40	**263**
Alive 24 h	42	46	43	38	49	37	**255**
Alive 48 h	42	46	43	37	49	31	**248**
			Controls				
Number released		10	9		10	10	**39**
Number alive		10	9		10	9	**38**
No. Assigned Alive*		0	0		0	1	**1**
Number recovered dead		0	0		0	0	**0**
Assigned dead		0	0		0	0	**0**
Dislodged tags		0	0		0	0	**0**
Stationary radio signals		0	0		0	0	**0**
Undetermined		0	0		0	0	**0**
Held and Alive 1 h		10	9		10	9	**38**
Alive 24 h		10	9		10	9	**38**
Alive 48 h		10	9		10	9	**38**

* Eel assigned alive status based on telemetry and visual observation.

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APPENDIX D

Daily Turbine Survival Injury Data

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Daily malady data for recaptured adult eels passed through Units 4, 8 (2 releases) and 9 at Vernon Station, Bellows Falls Unit 2 and Wilder Unit 2, October-November 2015. Combined controls released into the tailrace downstream of the three stations.

	Vernon Station				Bellows Falls	Wilder	
	Unit 8-1000cfs	Unit 9	Unit 4	Unit 8-1700cfs	Unit 2	Unit 2	
	10/26	10/27	10/28	11/3	10/30	11/1	Totals
Treatment							
Number released	48	48	48	50	50	50	**294**
Number examined	46	46	45	44	50	47	**278**
Passage related maladies	14	4	16	13	7	20	**74**
Visible injuries	13	4	16	12	7	20	**72**
Loss of equilibrium only	1	0	0	1	0	0	**2**
Without maladies (passage related)	32	42	29	31	43	27	**204**
With non-passage maladies	0	0	1	0	0	0	**1**
Controls							
Number released		10	9		10	10	**39**
Number examined		10	9		10	9	**38**
Passage related maladies		0	0		2	0	**2**
Visible injuries		0	0		2	0	**2**
Loss of equilibrium only		0	0		0	0	**0**
Without maladies		10	9		8	9	**36**
Without maladies that died		0	0		0	0	**0**

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APPENDIX E

2D Maps of Eel Movement and Passage

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Timetable		
Detection	Date	Time
1	10/29/2015	20:18
2	10/29/2015	20:47
3	10/29/2015	20:58
4	10/29/2015	20:59
5	10/29/2015	20:59
6	10/29/2015	21:00

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TransCanada Hydro Northeast Inc.
ILP Study 19
Wilder Dam

1 in = 150 feet

N

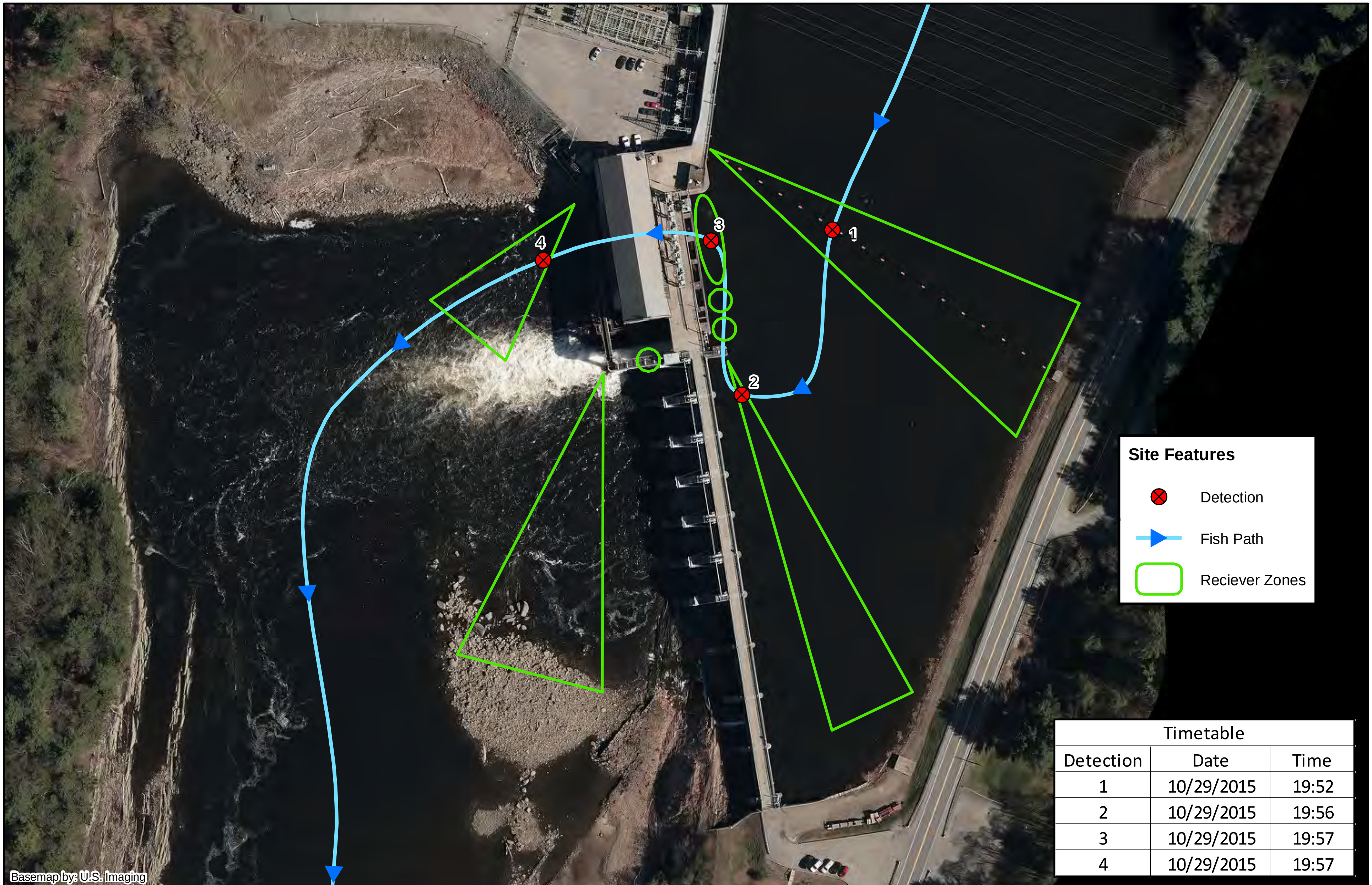
0 75 150 300 Feet

Study 19 Fish Number: 34-121

Release: Norwich, VT
Date Released: 10/27/2015
Time Released: 20:15

NORMANDEAU ASSOCIATES
Environmental Consultants

Normandeau Associates Inc.
25 Nashua Road
Bedford, NH USA
03110



Timetable		
Detection	Date	Time
1	10/29/2015	19:52
2	10/29/2015	19:56
3	10/29/2015	19:57
4	10/29/2015	19:57

TransCanada Hydro Northeast Inc.
ILP Study 19
Wilder Dam

N

1 in = 150 feet

0 75 150 300 Feet

Study 19 Fish Number: 34-122

Release: Norwich, VT
Date Released: 10/27/2015
Time Released: 20:05

NORMANDEAU ASSOCIATES
Environmental Consultants
Normandeau Associates Inc.
25 Nashua Road
Bedford, NH USA
03110

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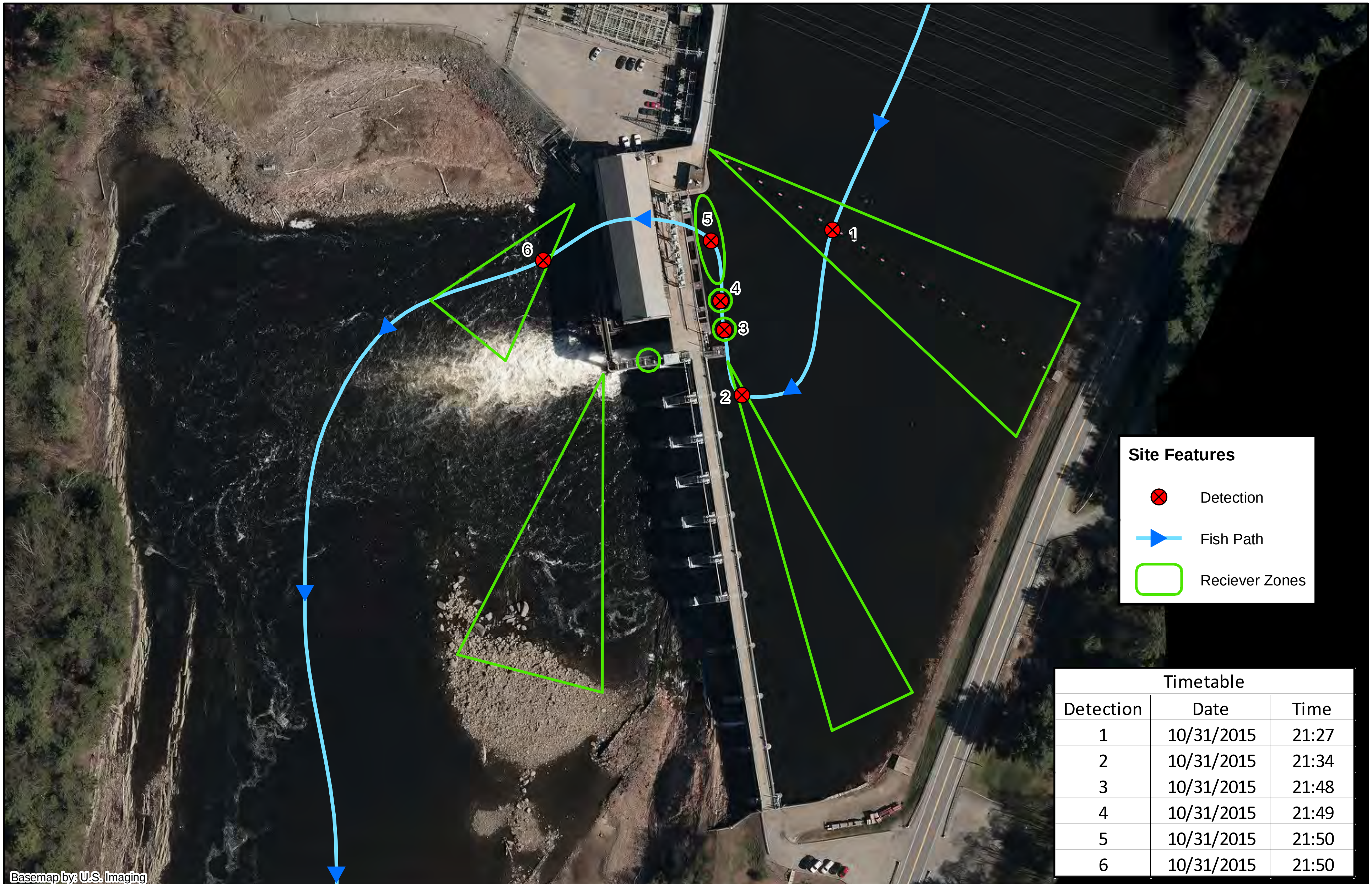

Timetable		
Detection	Date	Time
1	10/31/2015	21:27
2	10/31/2015	21:34
3	10/31/2015	21:48
4	10/31/2015	21:49
5	10/31/2015	21:50
6	10/31/2015	21:50

TransCanada Hydro Northeast Inc.
ILP Study 19
Wilder Dam

N

1 in = 150 feet

0 75 150 300 Feet

Study 19 Fish Number: 34-123

Release: Norwich, VT
Date Released: 10/27/2015
Time Released: 20:05

NORMANDEAU ASSOCIATES
Environmental Consultants

Normandeau Associates Inc.
25 Nashua Road
Bedford, NH USA
03110

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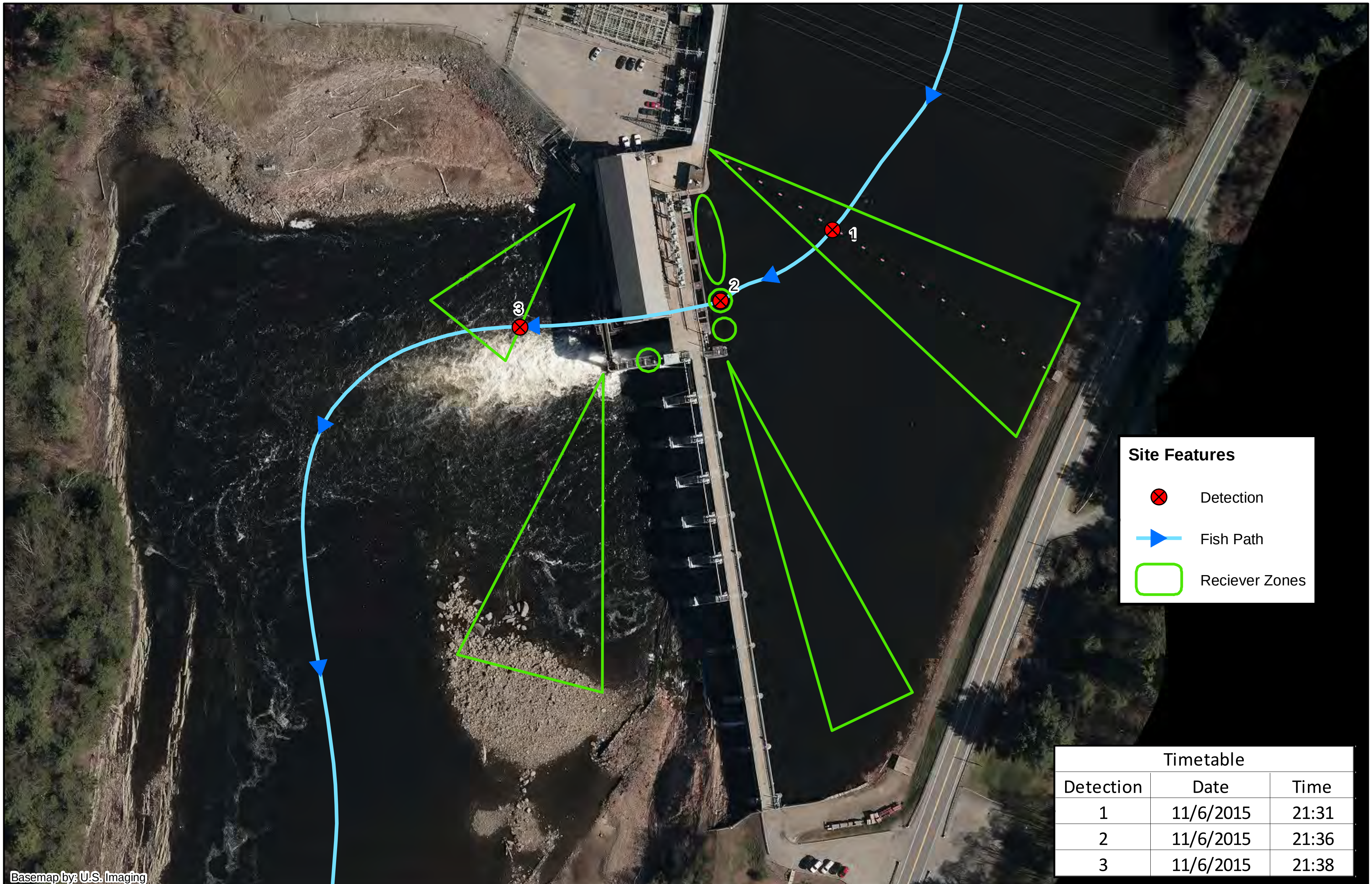

Timetable

Detection	Date	Time
1	11/6/2015	21:31
2	11/6/2015	21:36
3	11/6/2015	21:38

TransCanada Hydro Northeast Inc.
ILP Study 19
Wilder Dam

N

1 in = 150 feet

0 75 150 300 Feet

Study 19 Fish Number: 34-127

Release: Norwich, VT
Date Released: 11/03/2015
Time Released: 17:32

NORMANDEAU ASSOCIATES
Environmental Consultants

Normandeau Associates Inc.
25 Nashua Road
Bedford, NH USA
03110

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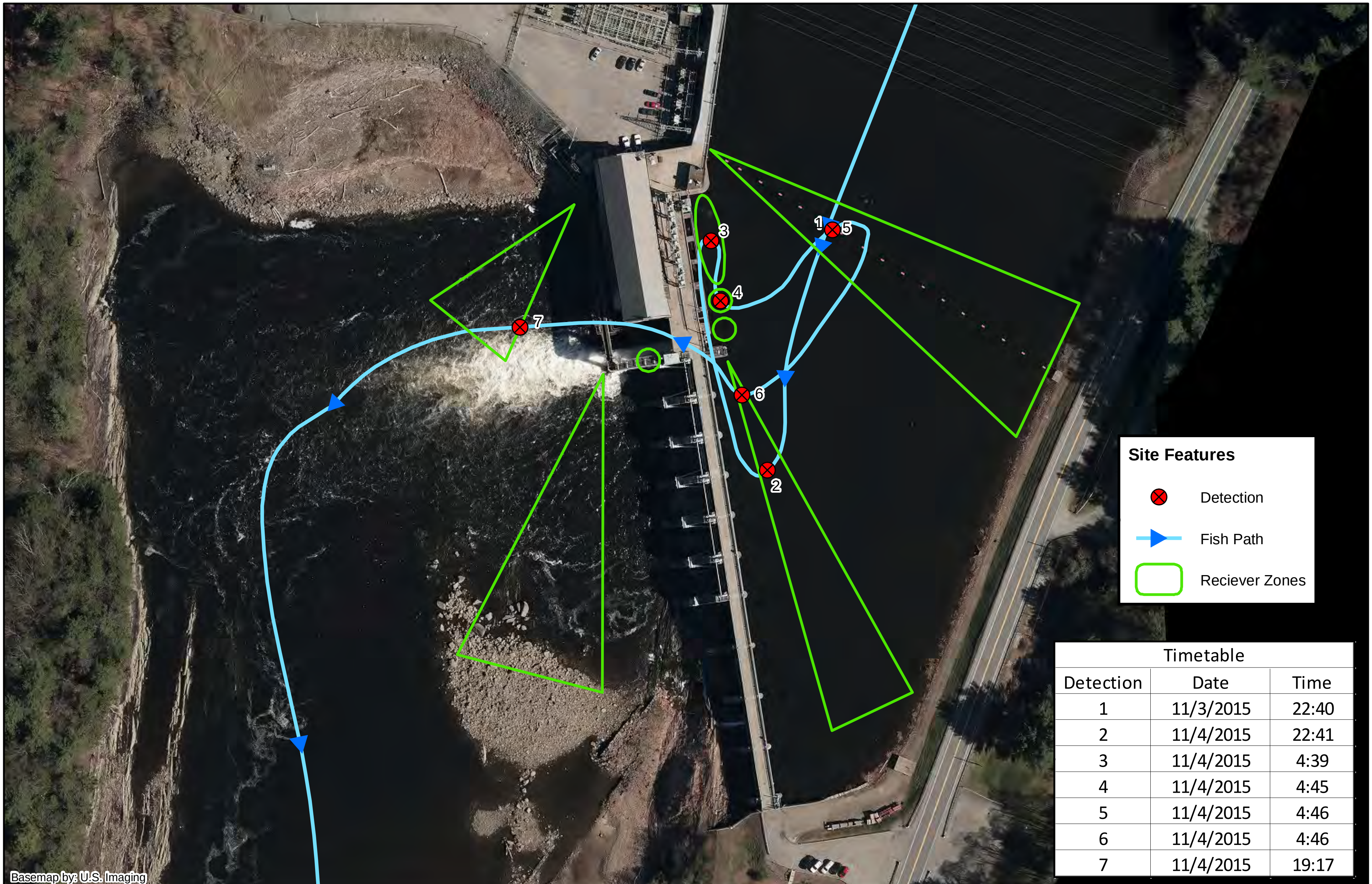

Timetable		
Detection	Date	Time
1	11/3/2015	22:40
2	11/4/2015	22:41
3	11/4/2015	4:39
4	11/4/2015	4:45
5	11/4/2015	4:46
6	11/4/2015	4:46
7	11/4/2015	19:17

TransCanada Hydro Northeast Inc.
ILP Study 19
Wilder Dam

N

1 in = 150 feet

0 75 150 300 Feet

Study 19 Fish Number: 34-128

Release: Norwich, VT
Date Released: 11/03/2015
Time Released: 17:32

NORMANDEAU ASSOCIATES
Environmental Consultants

Normandeau Associates Inc.
25 Nashua Road
Bedford, NH USA
03110

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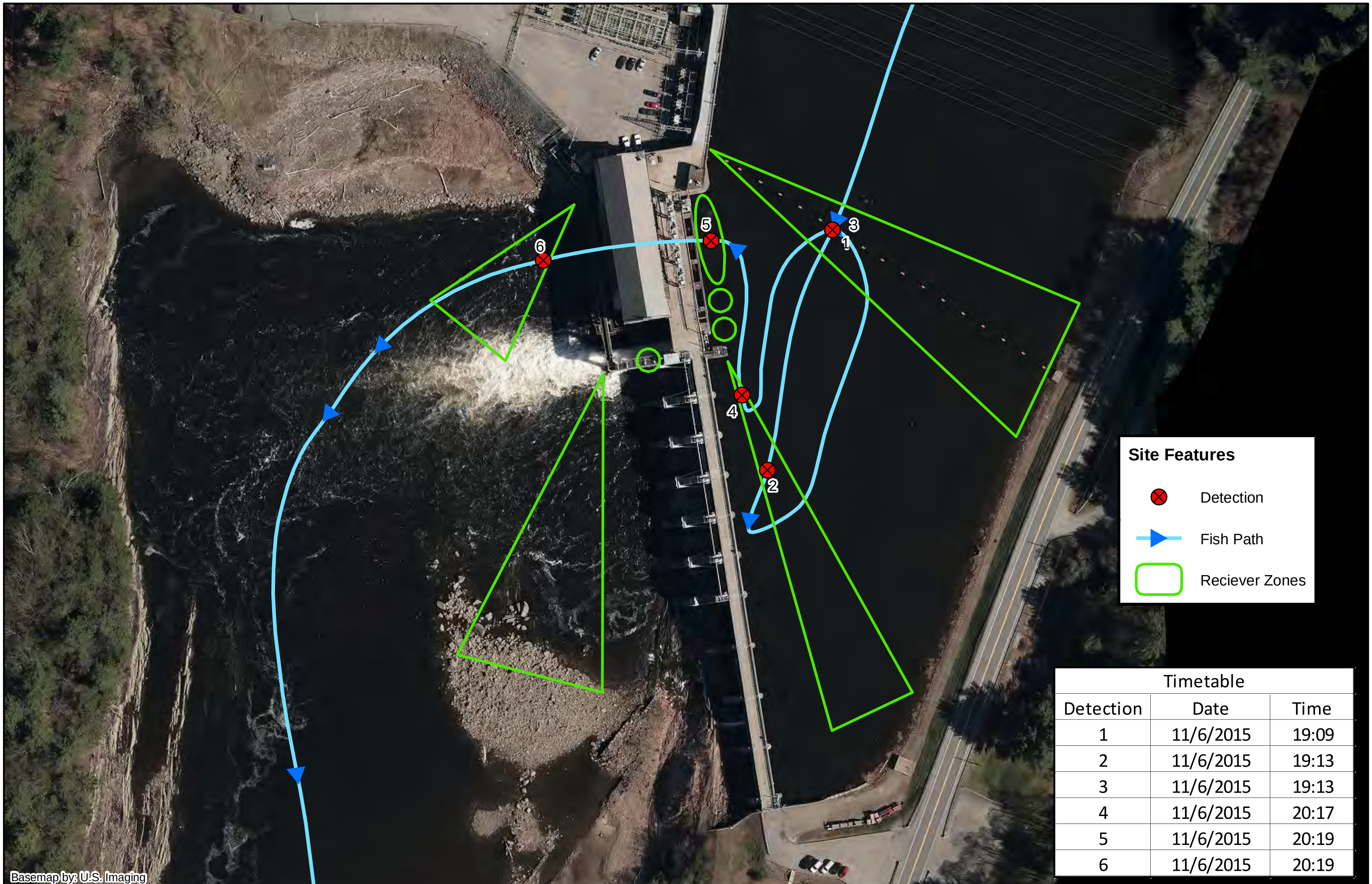

Timetable		
Detection	Date	Time
1	11/6/2015	19:09
2	11/6/2015	19:13
3	11/6/2015	19:13
4	11/6/2015	20:17
5	11/6/2015	20:19
6	11/6/2015	20:19

TransCanada Hydro Northeast Inc.
ILP Study 19
Wilder Dam

N

1 in = 150 feet

0 75 150 300 Feet

Study 19 Fish Number: 34-129

Release: Norwich, VT
Date Released: 11/03/2015
Time Released: 17:32

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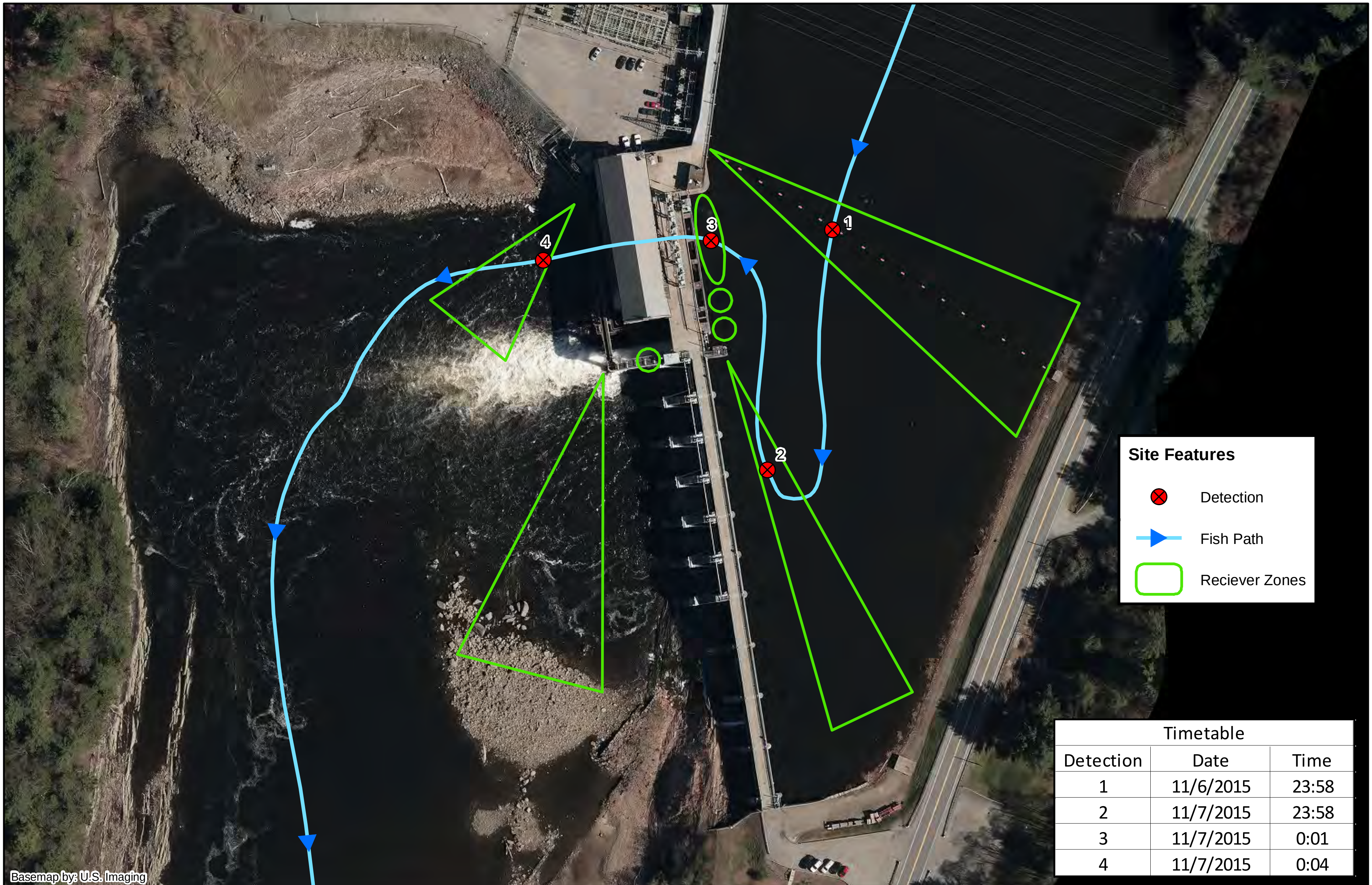
Bedford, NH USA
03110

J:\Jen_TEST\TransCanada\S19\REV_2017\Wilder\MXD\TC_Wilder_34_129_T1_020917.mxd



Timetable		
Detection	Date	Time
1	11/6/2015	23:58
2	11/7/2015	23:58
3	11/7/2015	0:01
4	11/7/2015	0:04

TransCanada Hydro Northeast Inc.
ILP Study 19
Wilder Dam

N

1 in = 150 feet

0 75 150 300 Feet

Study 19 Fish Number: 34-130

Release: Norwich, VT
Date Released: 11/03/2015
Time Released: 17:32

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Environmental Consultants

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25 Nashua Road
Bedford, NH USA
03110

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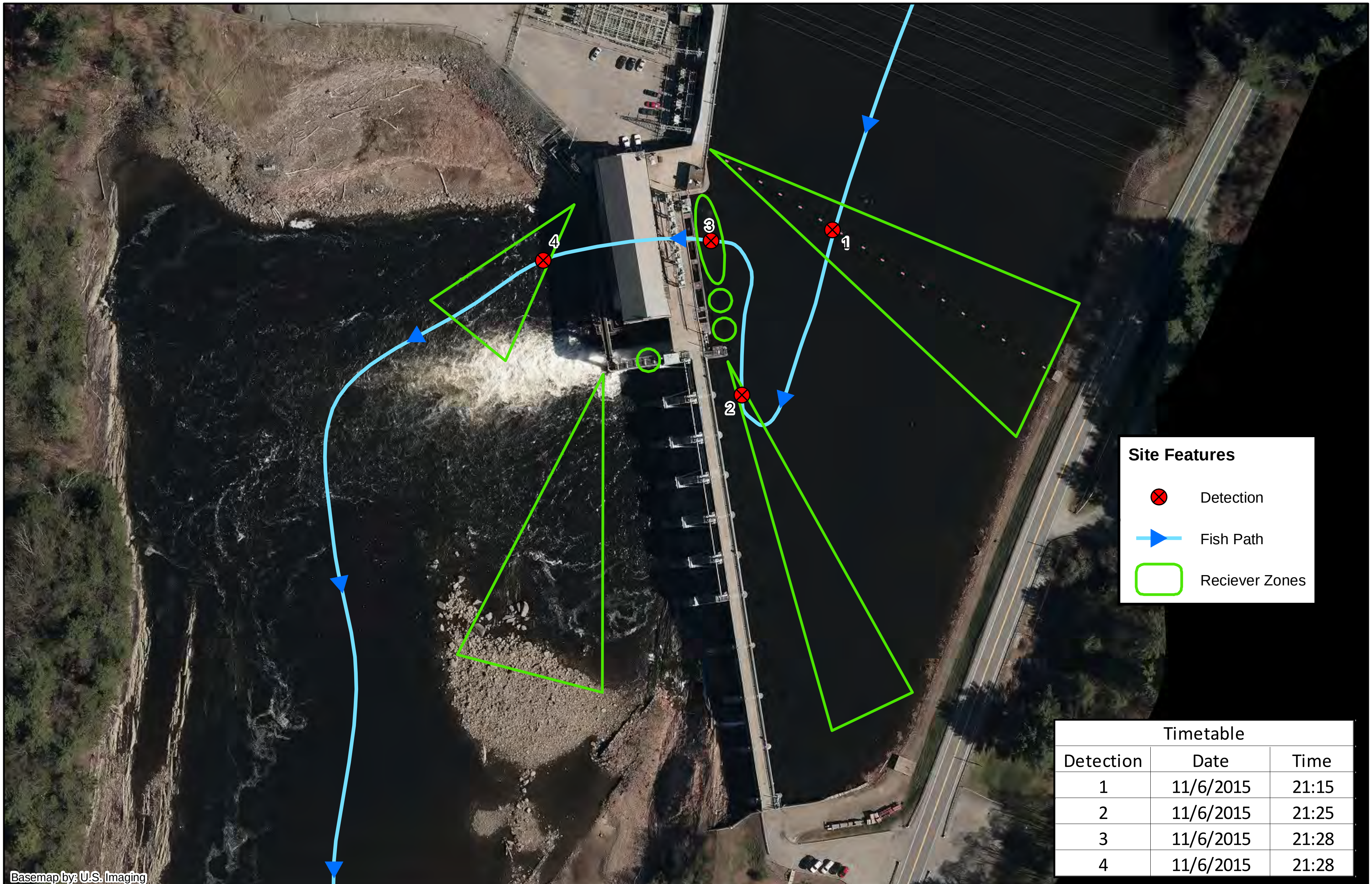

Timetable		
Detection	Date	Time
1	11/6/2015	21:15
2	11/6/2015	21:25
3	11/6/2015	21:28
4	11/6/2015	21:28

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TransCanada Hydro Northeast Inc.
ILP Study 19
Wilder Dam

N

1 in = 150 feet

0 75 150 300 Feet

Study 19 Fish Number: 34-151

Release: Norwich, VT
Date Released: 10/29/2015
Time Released: 18:43

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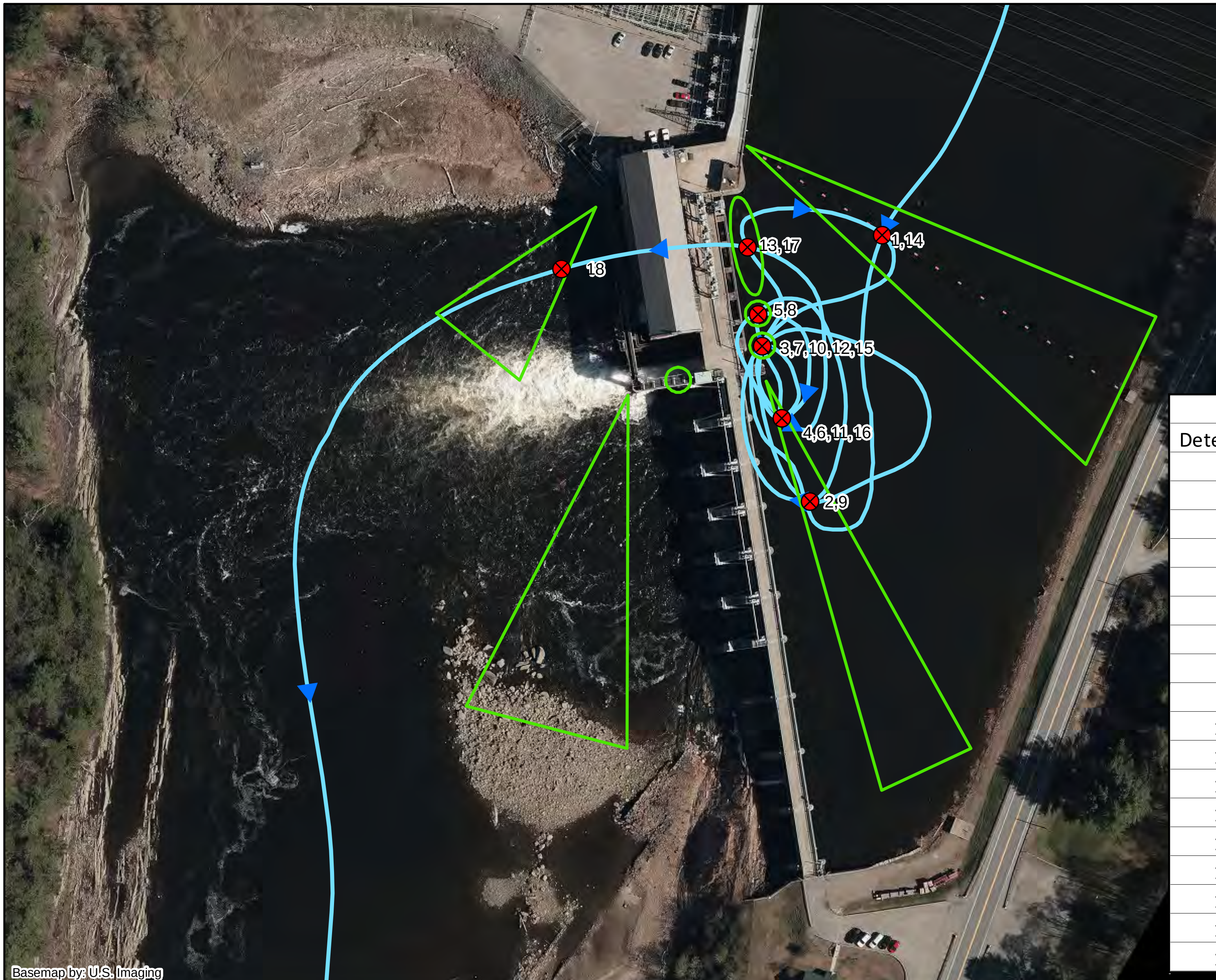

Timetable

Detection	Date	Time
1	10/29/2015	23:27
2	10/29/2015	23:34
3	10/29/2015	23:34
4	10/29/2015	23:35
5	10/29/2015	23:36
6	10/29/2015	23:36
7	10/29/2015	23:45
8	10/29/2015	23:50
9	10/29/2015	23:51
10	10/29/2015	23:51
11	10/29/2015	23:53
12	10/30/2015	0:13
13	10/30/2015	0:16
14	10/30/2015	0:16
15	10/30/2015	19:05
16	10/30/2015	19:07
17	10/30/2015	19:24
18	10/30/2015	19:24

TransCanada Hydro Northeast Inc.
ILP Study 19
Wilder Dam

N

1 in = 150 feet

0 75 150 300 Feet

Study 19 Fish Number: 34-152

Release: Norwich, VT
Date Released: 10/29/2015
Time Released: 18:43

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Environmental Consultants

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Bedford, NH USA
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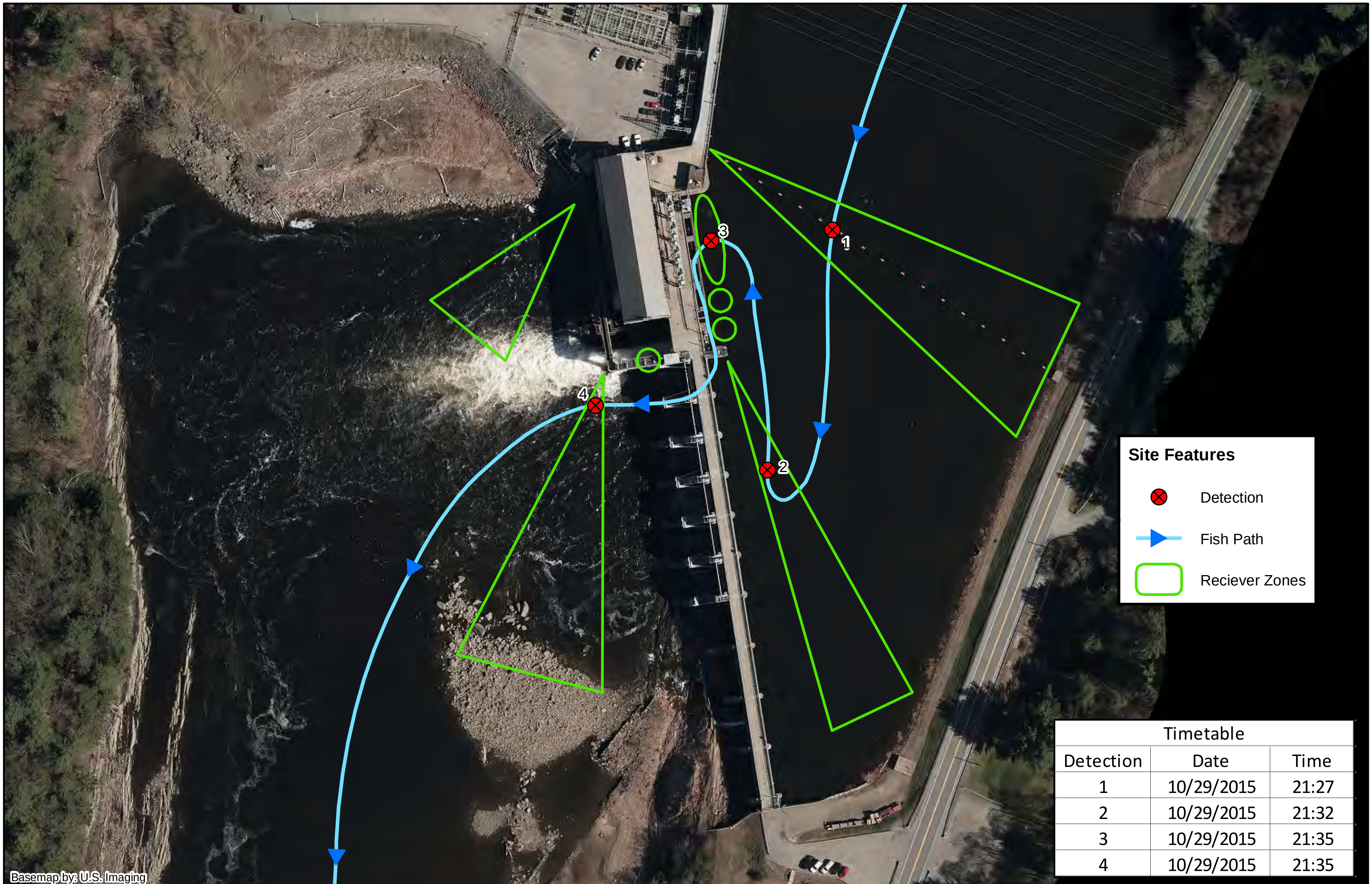
J:\Jen_TEST\TransCanada\S19\REV_2017\Wilder\MXD\TC_Wilder_34_152_021017BG.mxd



Timetable		
Detection	Date	Time
1	10/29/2015	21:27
2	10/29/2015	21:32
3	10/29/2015	21:35
4	10/29/2015	21:35

TransCanada Hydro Northeast Inc.
ILP Study 19
Wilder Dam

N

1 in = 150 feet

0 75 150 300 Feet

Study 19 Fish Number: 34-153

Release: Norwich, VT
Date Released: 10/29/2015
Time Released: 18:43

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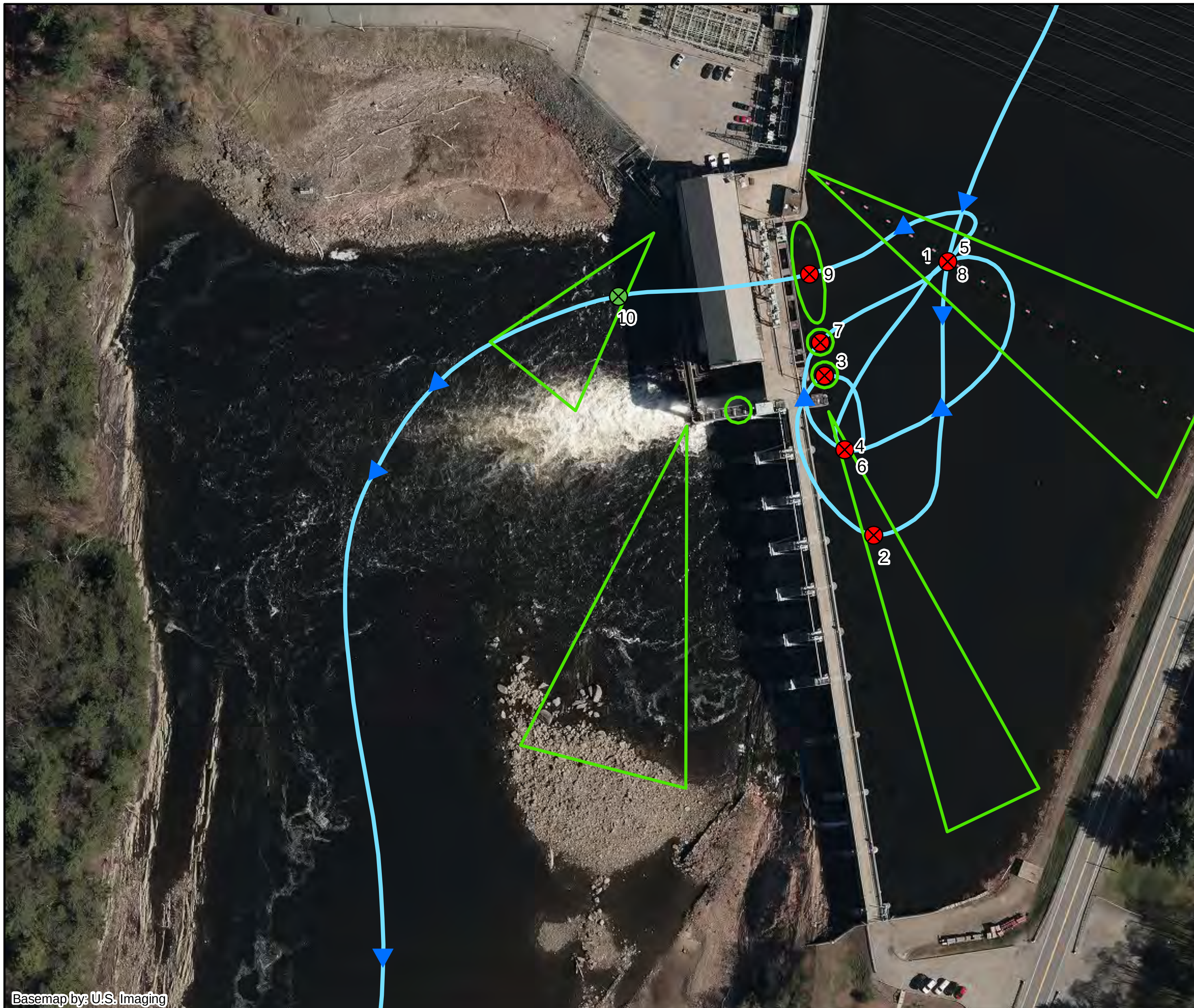
J:\Jen_TEST\TransCanada\S19\REV_2017\Wilder\MXD\TC_Wilder_34_153_021017.mxd



Timetable		
Detection	Date	Time
1	11/13/2015	3:52
2	11/13/2015	4:08
3	11/13/2015	4:11
4	11/13/2015	4:11
5	11/13/2015	4:28
6	11/14/2015	0:33
7	11/14/2015	0:41
8	11/14/2015	0:42
9	11/14/2015	2:48
10	11/14/2015	8:15

TransCanada Hydro Northeast Inc.
ILP Study 19
Wilder Dam

N

1 in = 150 feet

0 75 150 300 Feet

Study 19 Fish Number: 34-154

Release: Norwich, VT
Date Released: 11/05/2015
Time Released: 17:05

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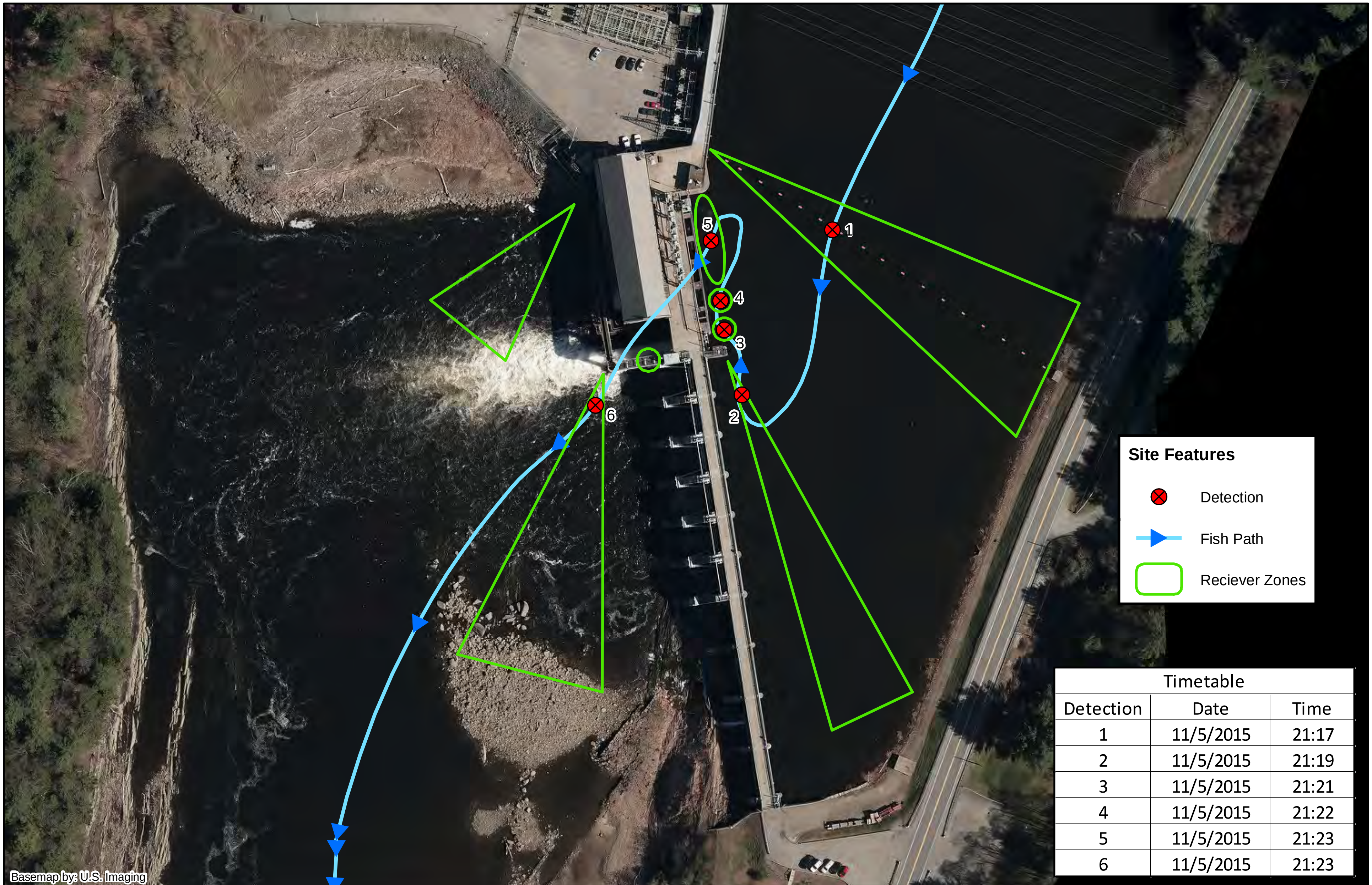

Timetable		
Detection	Date	Time
1	11/5/2015	21:17
2	11/5/2015	21:19
3	11/5/2015	21:21
4	11/5/2015	21:22
5	11/5/2015	21:23
6	11/5/2015	21:23

TransCanada Hydro Northeast Inc.
ILP Study 19
Wilder Dam

1 in = 150 feet

0 75 150 300 Feet

Study 19 Fish Number: 34-155 (T1)

Release: Norwich, VT
Date Released: 11/05/2015
Time Released: 17:05

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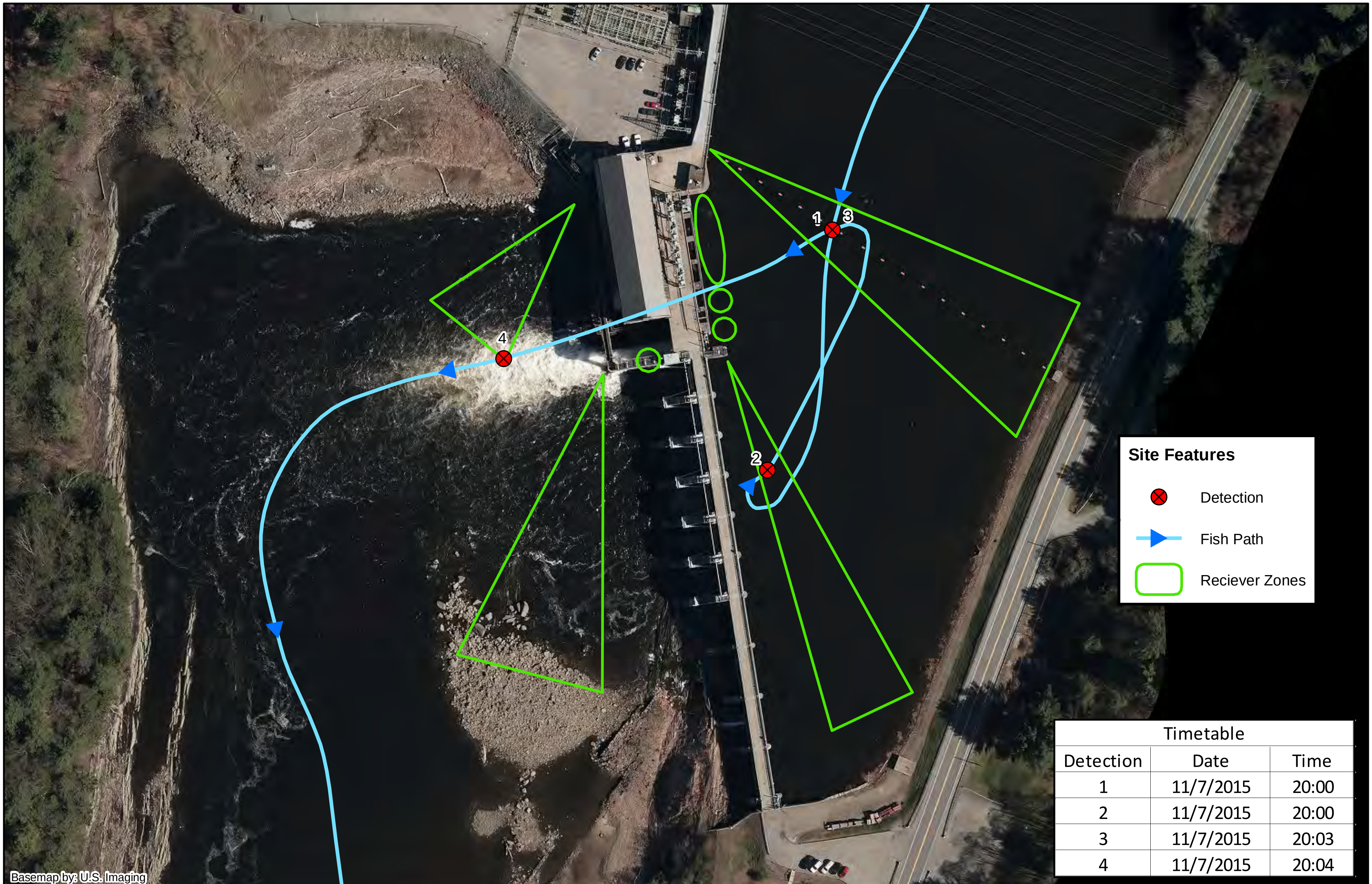

Timetable		
Detection	Date	Time
1	11/7/2015	20:00
2	11/7/2015	20:00
3	11/7/2015	20:03
4	11/7/2015	20:04

TransCanada Hydro Northeast Inc.
ILP Study 19
Wilder Dam

N

1 in = 150 feet

0 75 150 300 Feet

Study 19 Fish Number: 34-156

Release: Norwich, VT
Date Released: 11/05/2015
Time Released: 17:05

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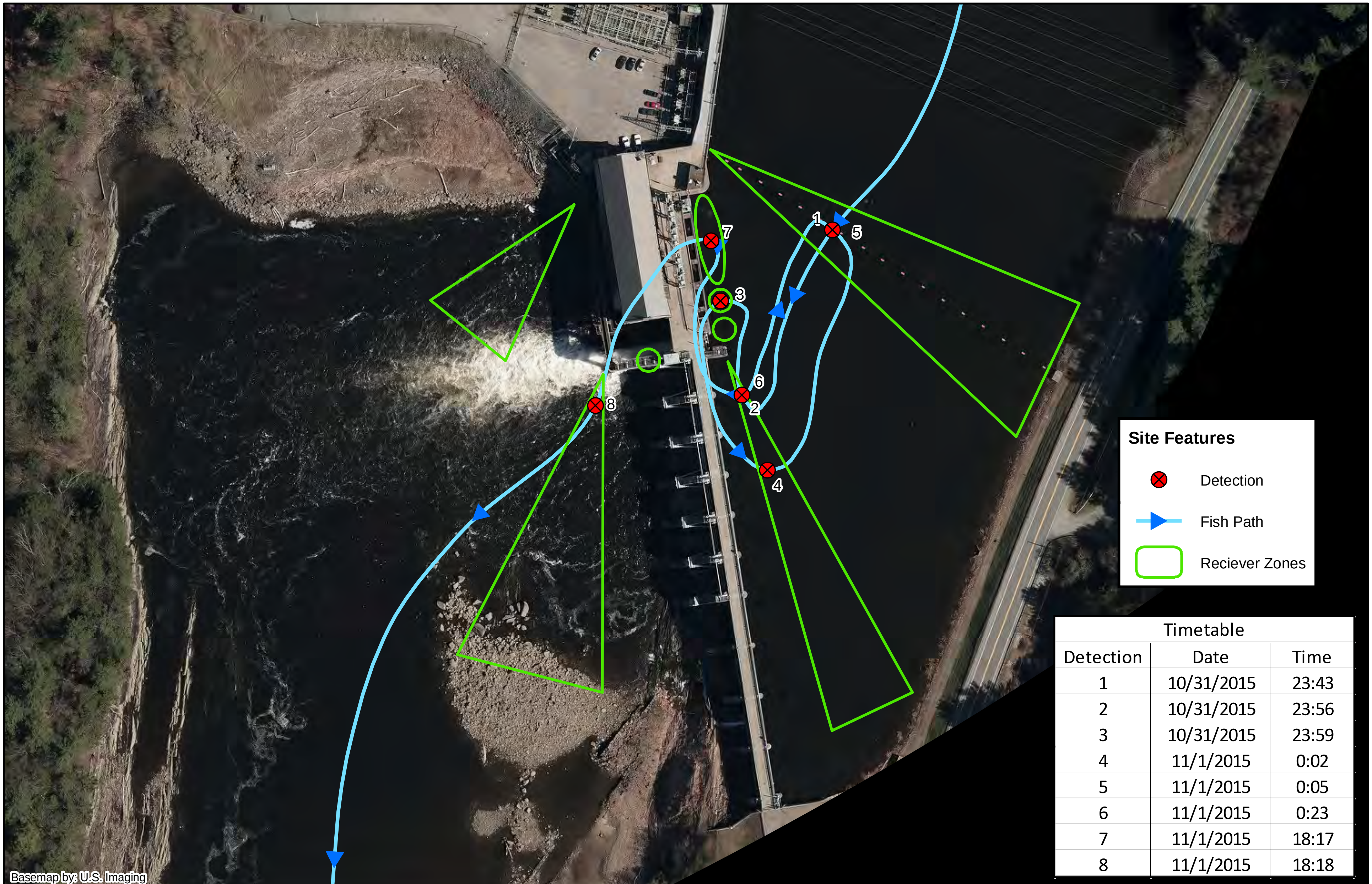
J:\Jen_TEST\TransCanada\S19\REV_2017\Wilder\MXD\TC_Wilder_34_156_021017.mxd



Timetable		
Detection	Date	Time
1	10/31/2015	23:43
2	10/31/2015	23:56
3	10/31/2015	23:59
4	11/1/2015	0:02
5	11/1/2015	0:05
6	11/1/2015	0:23
7	11/1/2015	18:17
8	11/1/2015	18:18

TransCanada Hydro Northeast Inc.
ILP Study 19
Wilder Dam

N

1 in = 150 feet

0 75 150 300 Feet

Study 19 Fish Number: 34-181

Release: Norwich, VT
Date Released: 10/31/2015
Time Released: 19:21

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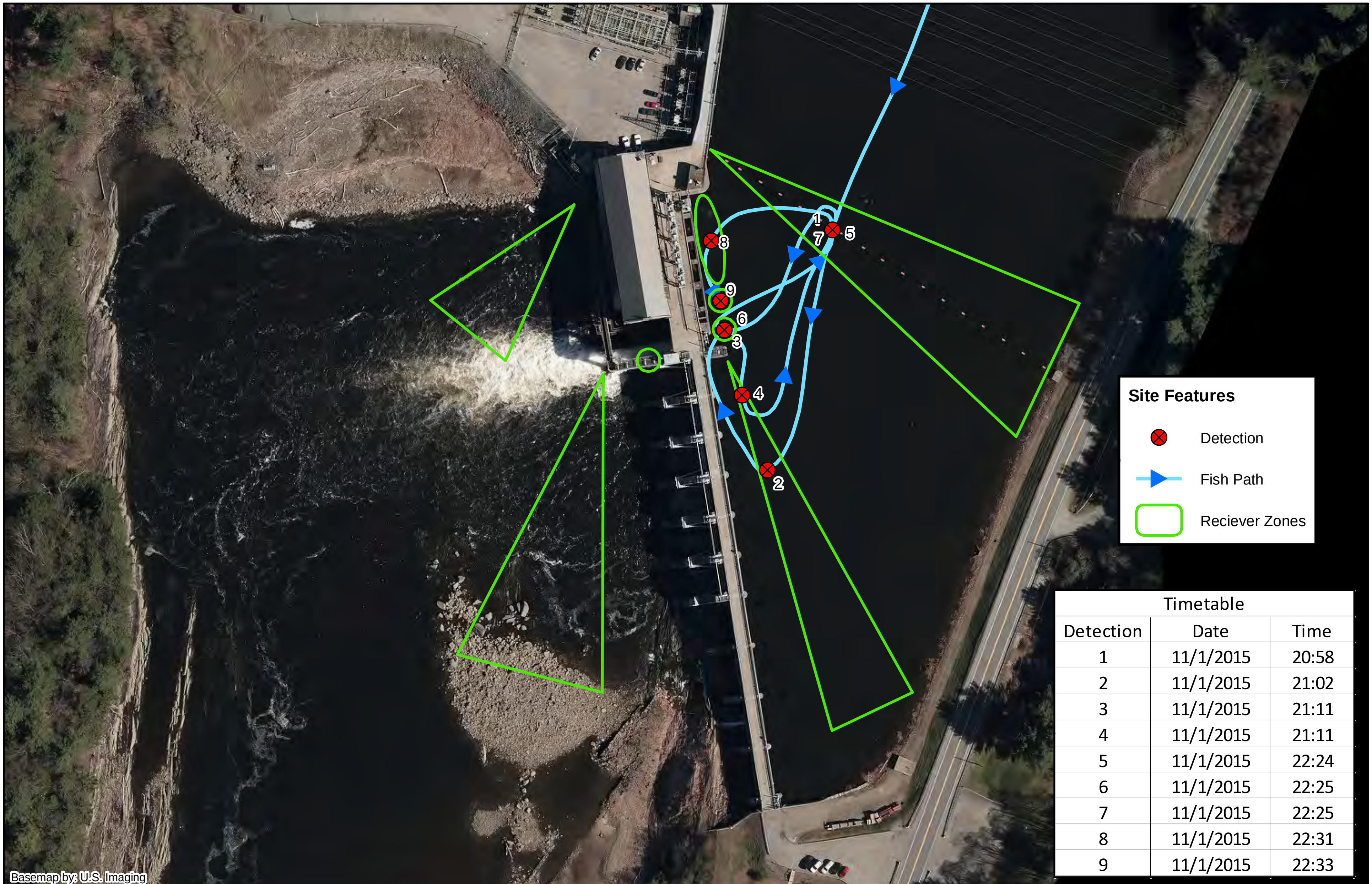

Timetable		
Detection	Date	Time
1	11/1/2015	20:58
2	11/1/2015	21:02
3	11/1/2015	21:11
4	11/1/2015	21:11
5	11/1/2015	22:24
6	11/1/2015	22:25
7	11/1/2015	22:25
8	11/1/2015	22:31
9	11/1/2015	22:33

TransCanada Hydro Northeast Inc.
ILP Study 19
Wilder Dam

N

1 in = 150 feet

0 75 150 300 Feet

Study 19 Fish Number: 34-182

Release: Norwich, VT
Date Released: 10/31/2015
Time Released: 19:21

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Environmental Consultants

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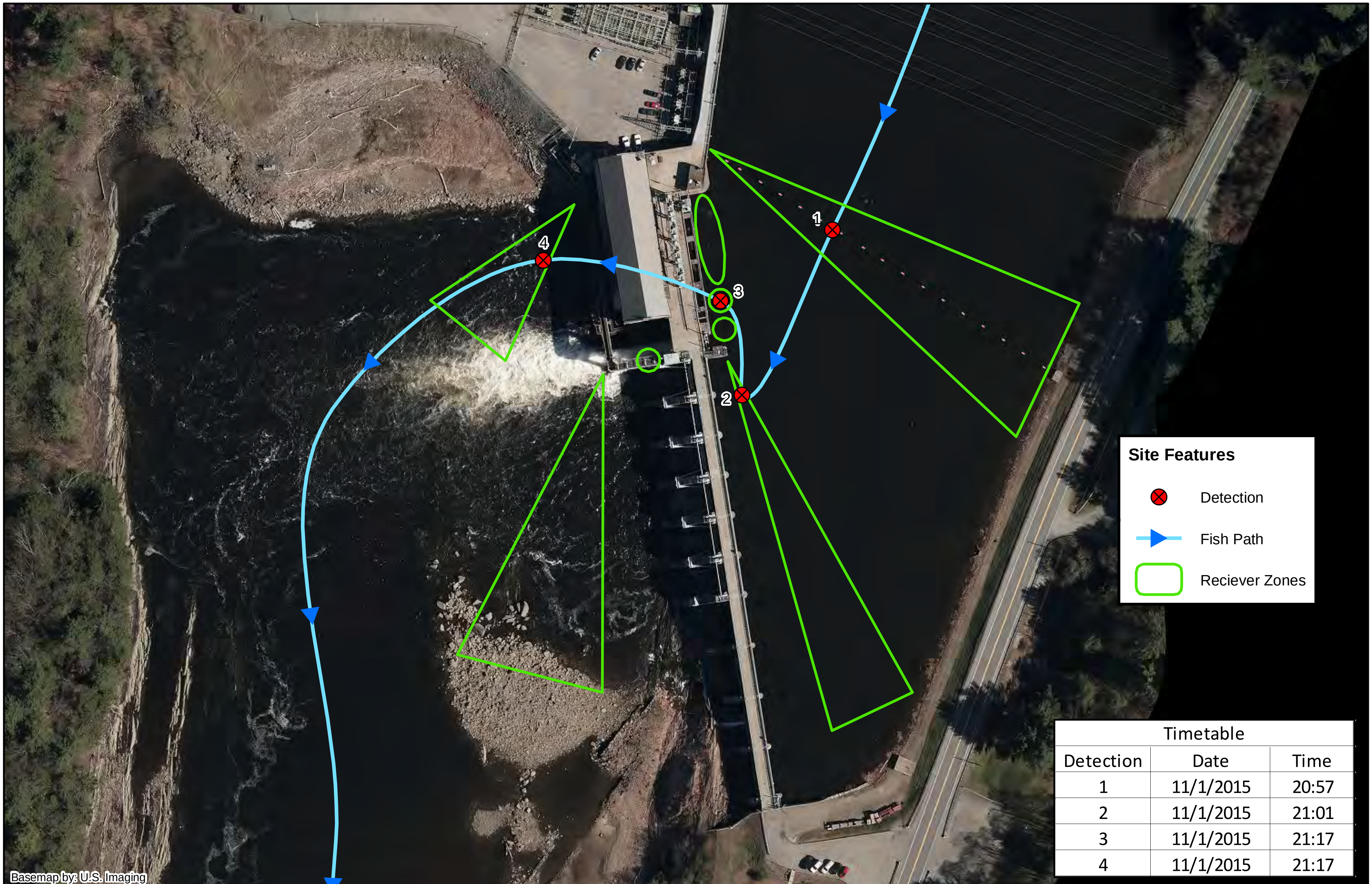

Timetable		
Detection	Date	Time
1	11/1/2015	20:57
2	11/1/2015	21:01
3	11/1/2015	21:17
4	11/1/2015	21:17

TransCanada Hydro Northeast Inc.
ILP Study 19
Wilder Dam

N

1 in = 150 feet

0 75 150 300 Feet

Study 19 Fish Number: 34-183

Release: Norwich, VT
Date Released: 10/31/2015
Time Released: 19:21

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Timetable		
Detection	Date	Time
1	11/4/2015	20:02
2	11/4/2015	20:09
3	11/4/2015	20:29
4	11/4/2015	20:33
5	11/4/2015	20:38
6	11/4/2015	20:38

TransCanada Hydro Northeast Inc.
ILP Study 19
Wilder Dam

Study 19 Fish Number: 36-121

Release: Norwich, VT
Date Released: 11/03/2015
Time Released: 17:32

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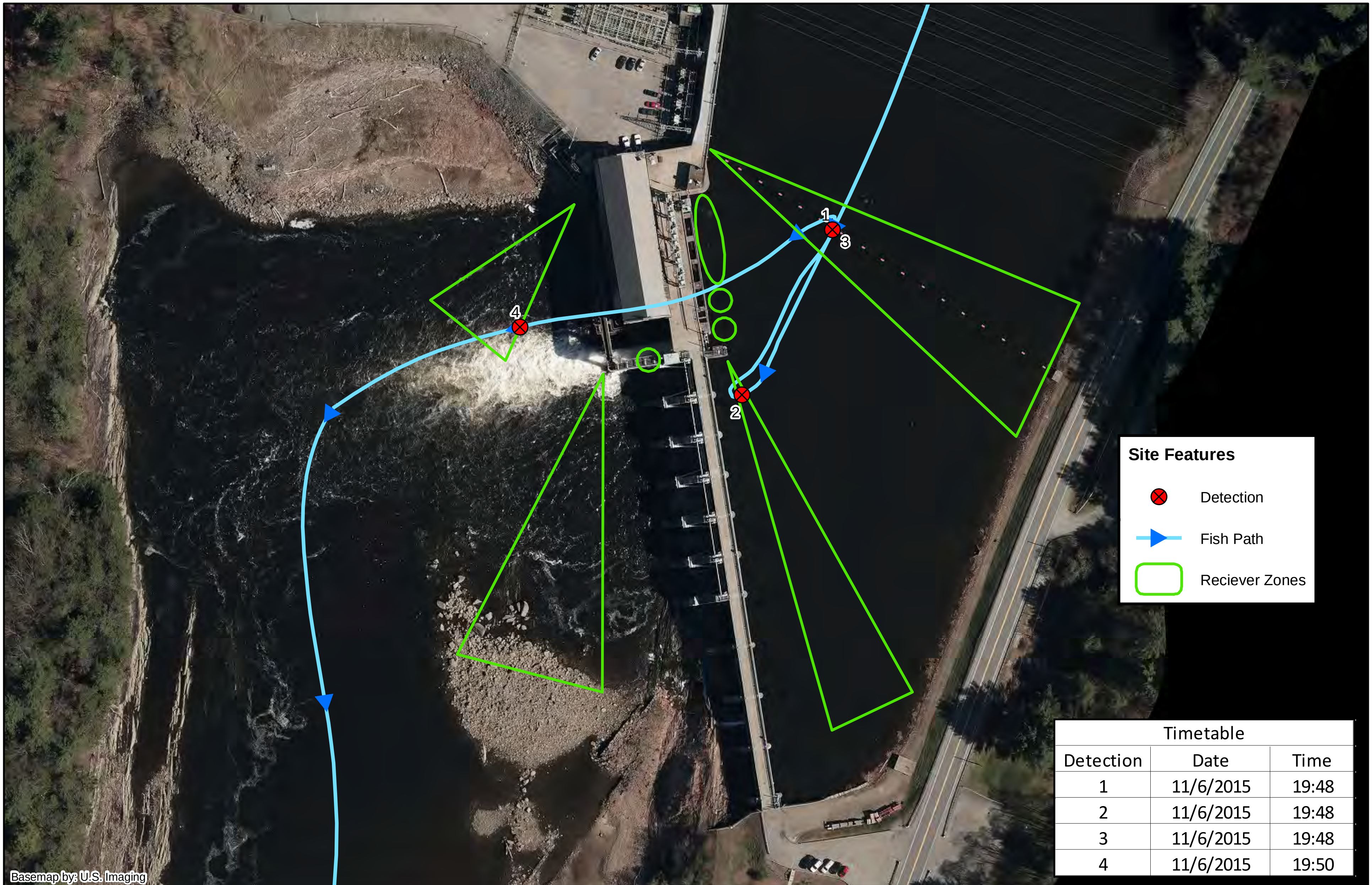
J:\Jen_TEST\TransCanada\S19\REV_2017\Wilder\MXD\TC_Wilder_36_121_021017.mxd



TransCanada Hydro Northeast Inc.
ILP Study 19
Wilder Dam

Study 19 Fish Number: 36-122

Release: Norwich, VT
Date Released: 11/03/2015
Time Released: 17:32

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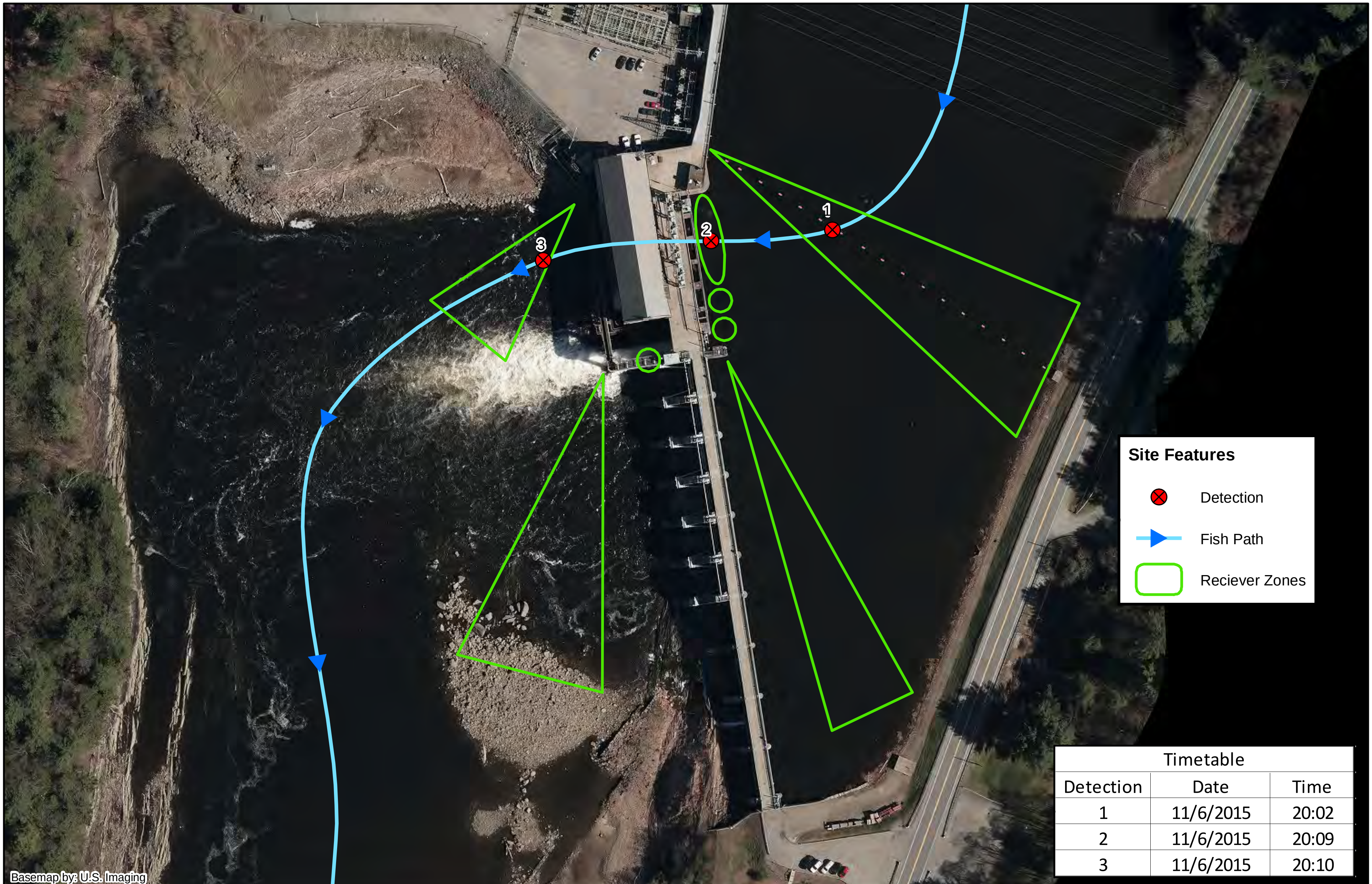
J:\Jen_TEST\TransCanada\S19\REV_2017\Wilder\MXD\TC_Wilder_36_122_021017.mxd



Timetable		
Detection	Date	Time
1	11/6/2015	20:02
2	11/6/2015	20:09
3	11/6/2015	20:10

TransCanada Hydro Northeast Inc.
ILP Study 19
Wilder Dam

1 in = 150 feet

0 75 150 300 Feet

Study 19 Fish Number: 36-123

Release: Norwich, VT
Date Released: 11/03/2015
Time Released: 17:32

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Environmental Consultants

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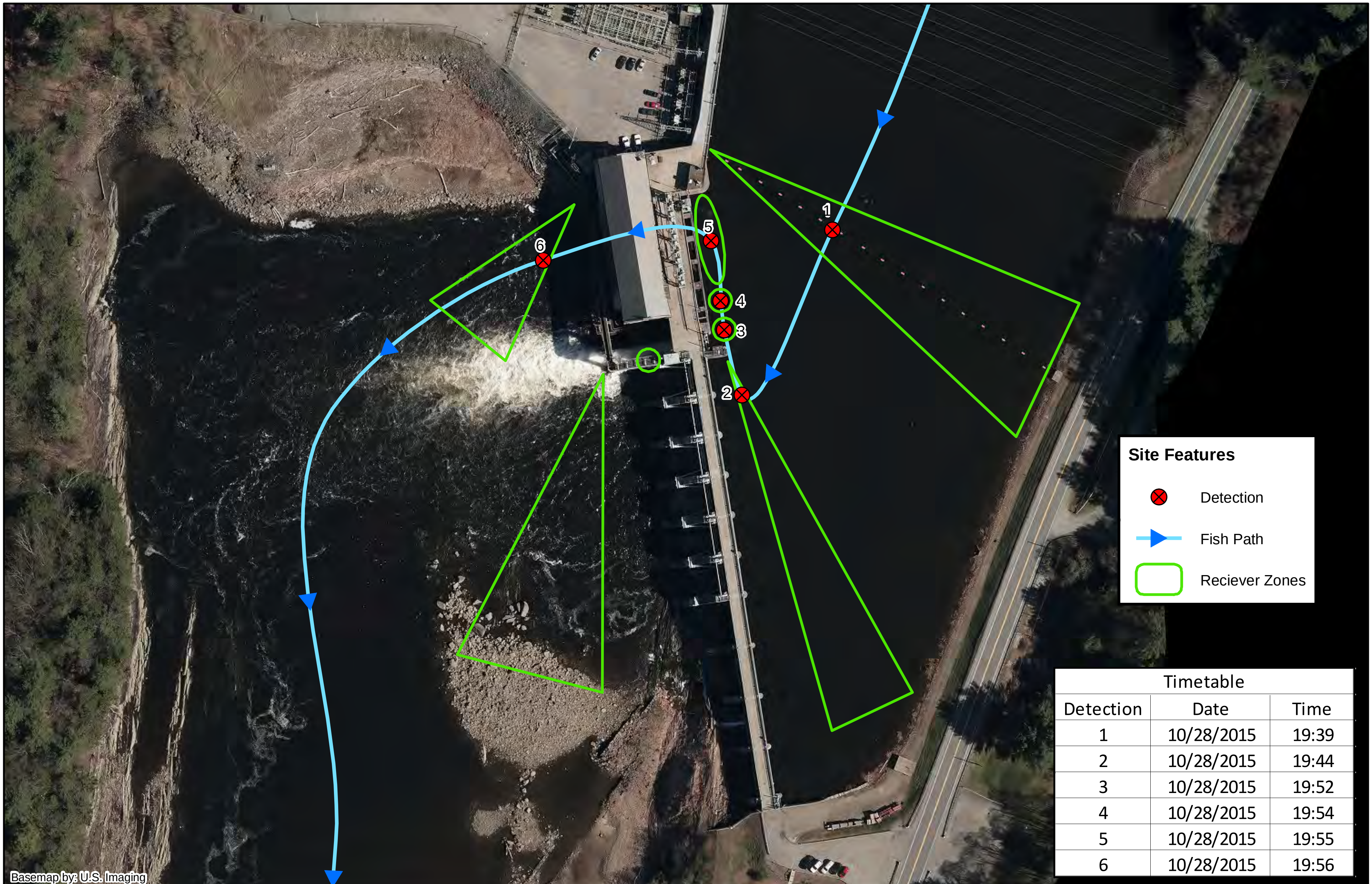
Bedford, NH USA
03110



Timetable		
Detection	Date	Time
1	10/28/2015	19:39
2	10/28/2015	19:44
3	10/28/2015	19:52
4	10/28/2015	19:54
5	10/28/2015	19:55
6	10/28/2015	19:56

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TransCanada Hydro Northeast Inc.
ILP Study 19
Wilder Dam

N

1 in = 150 feet

0 75 150 300 Feet

Study 19 Fish Number: 36-124

Release: Norwich, VT
Date Released: 10/27/2015
Time Released: 20:05

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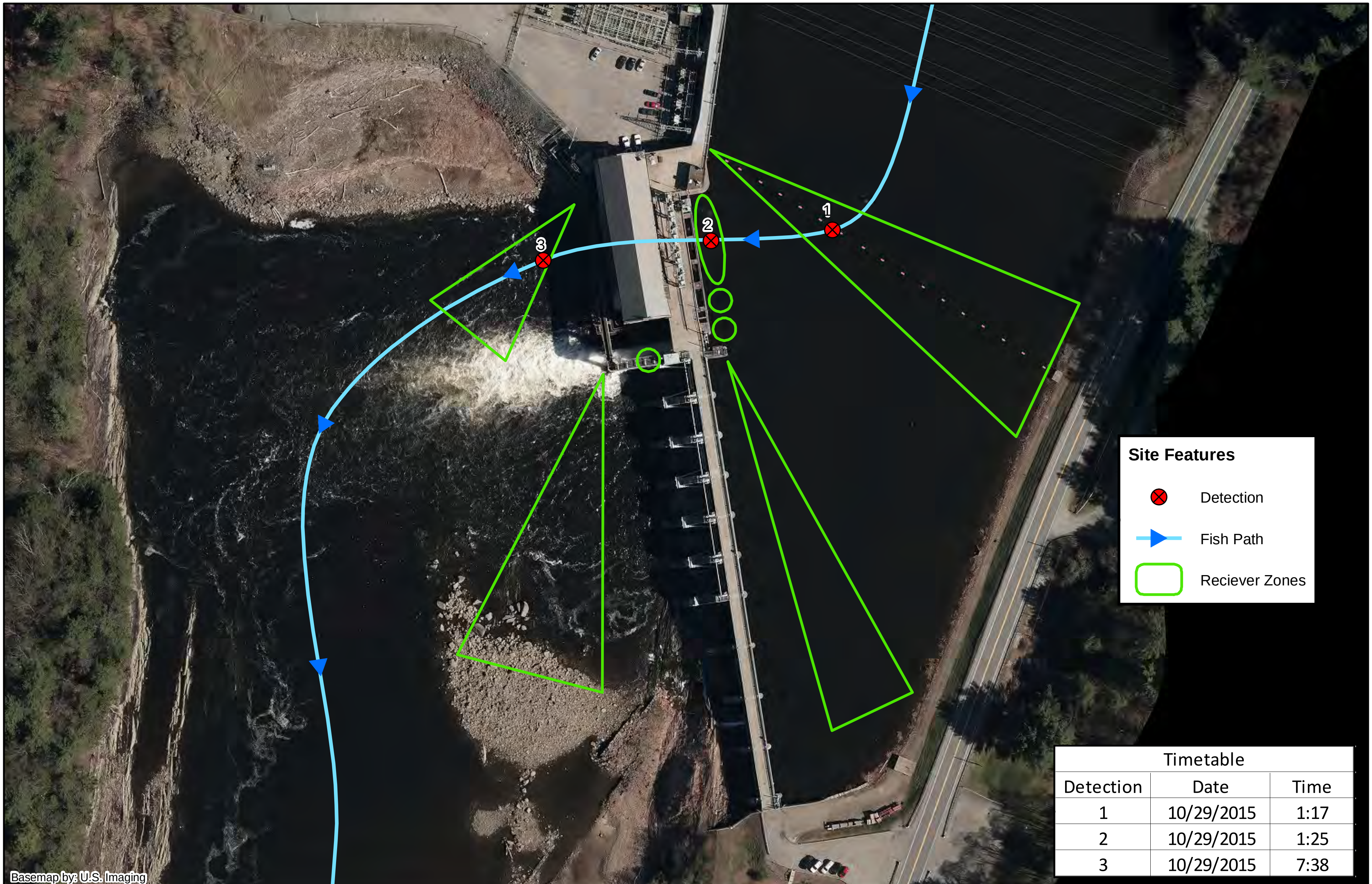
Bedford, NH USA
03110



Timetable		
Detection	Date	Time
1	10/29/2015	1:17
2	10/29/2015	1:25
3	10/29/2015	7:38

TransCanada Hydro Northeast Inc.
ILP Study 19
Wilder Dam

1 in = 150 feet

0 75 150 300 Feet

Study 19 Fish Number: 36-125

Release: Norwich, VT
Date Released: 10/27/2015
Time Released: 20:05

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Environmental Consultants

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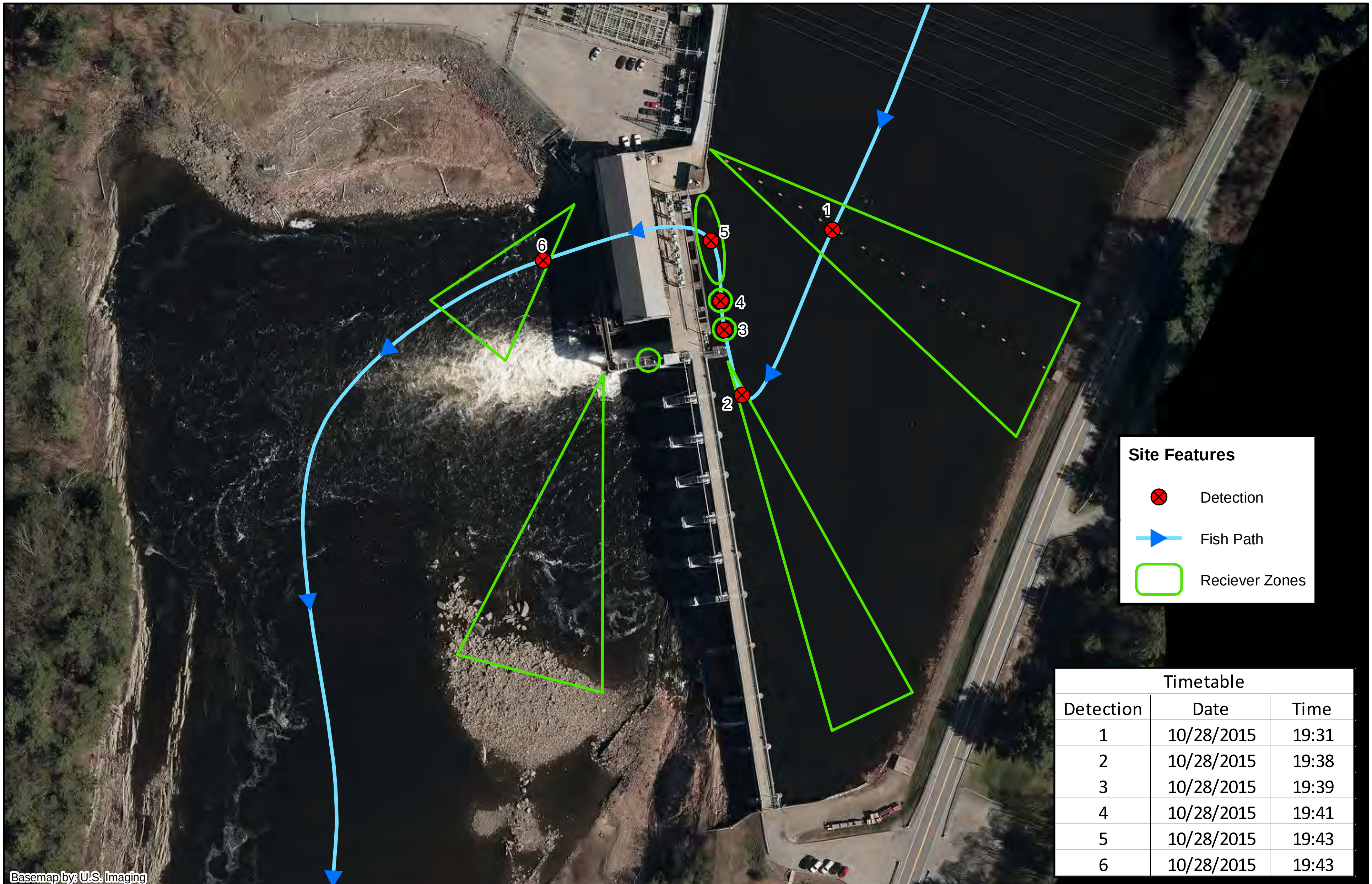
Bedford, NH USA
03110

J:\Jen_TEST\TransCanada\S19\REV_2017\Wilder\MXD\TC_Wilder_36_125_021017.mxd



Timetable		
Detection	Date	Time
1	10/28/2015	19:31
2	10/28/2015	19:38
3	10/28/2015	19:39
4	10/28/2015	19:41
5	10/28/2015	19:43
6	10/28/2015	19:43

TransCanada Hydro Northeast Inc.
ILP Study 19
Wilder Dam

N

1 in = 150 feet

0 75 150 300 Feet

Study 19 Fish Number: 36-126

Release: Norwich, VT
Date Released: 10/27/2015
Time Released: 20:05

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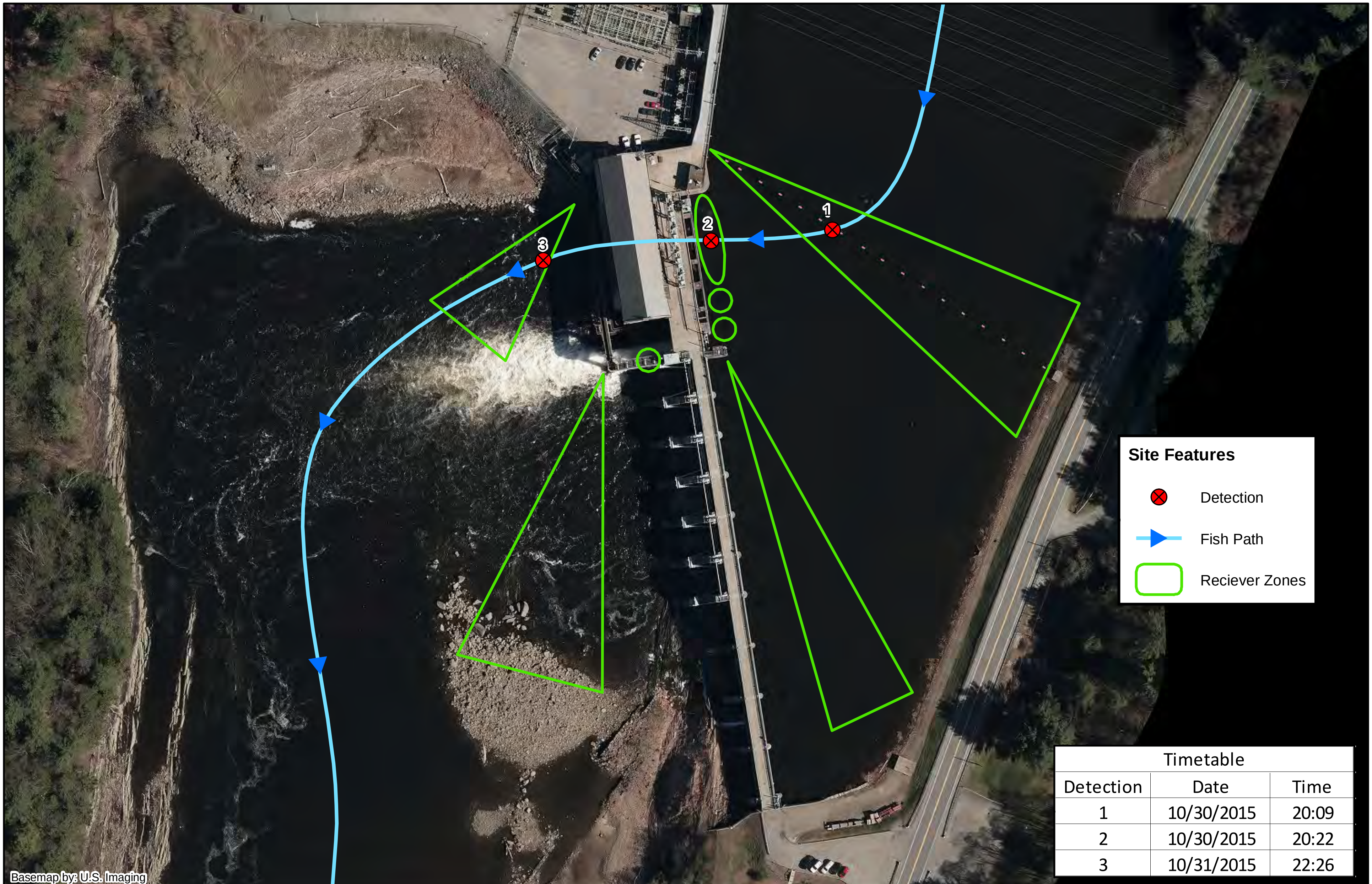
J:\Jen_TEST\TransCanada\S19\REV_2017\Wilder\MXD\TC_Wilder_36_126_021017.mxd



Timetable		
Detection	Date	Time
1	10/30/2015	20:09
2	10/30/2015	20:22
3	10/31/2015	22:26

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TransCanada Hydro Northeast Inc.
ILP Study 19
Wilder Dam

N

1 in = 150 feet

0 75 150 300 Feet

Study 19 Fish Number: 36-154

Release: Norwich, VT
Date Released: 10/29/2015
Time Released: 18:43

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Environmental Consultants

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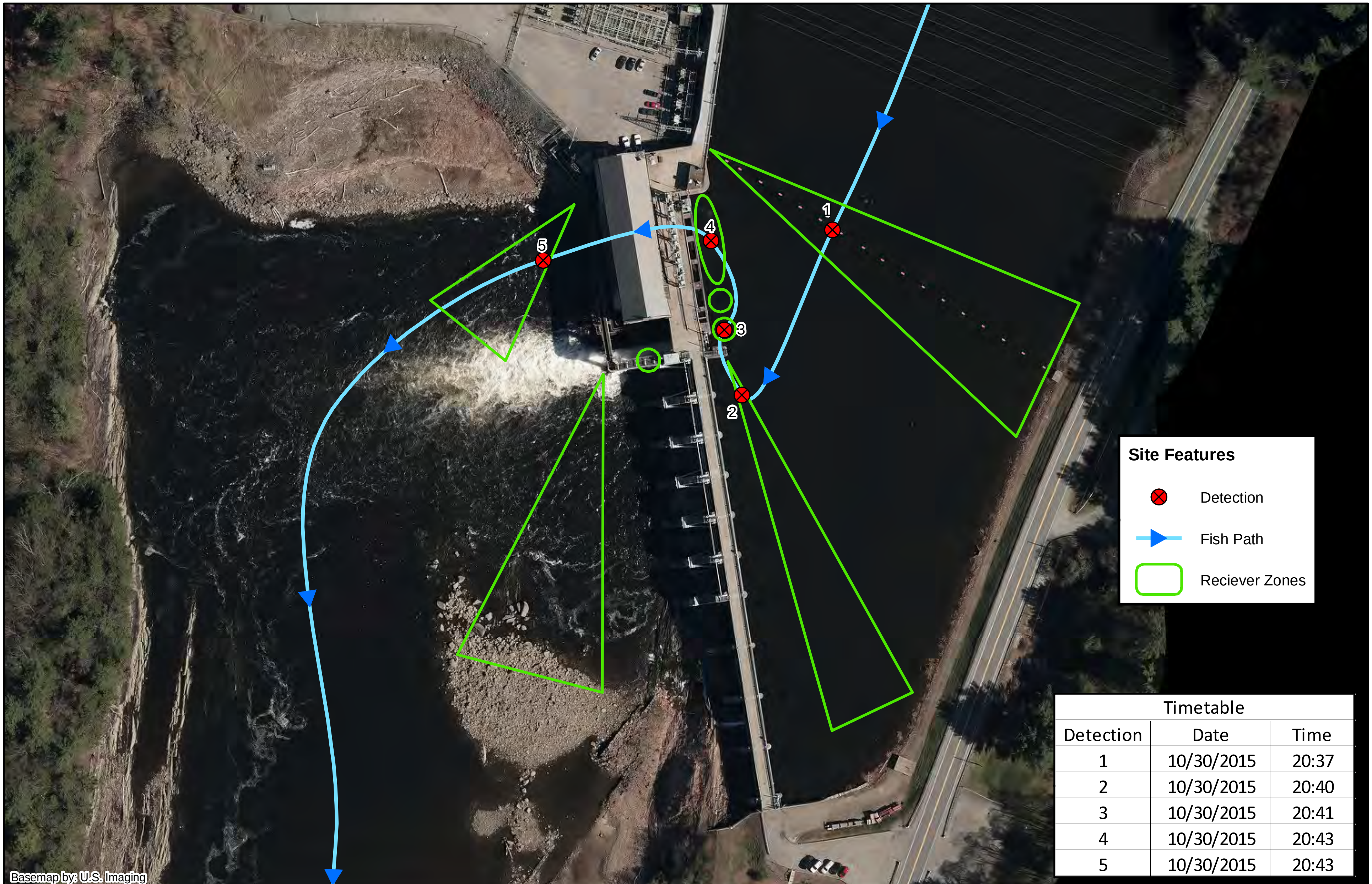
Bedford, NH USA
03110



Timetable

Detection	Date	Time
1	10/30/2015	20:37
2	10/30/2015	20:40
3	10/30/2015	20:41
4	10/30/2015	20:43
5	10/30/2015	20:43

TransCanada Hydro Northeast Inc.
ILP Study 19
Wilder Dam

Study 19 Fish Number: 36-156

Release: Norwich, VT
Date Released: 10/29/2015
Time Released: 18:43

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Environmental Consultants
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Bedford, NH USA
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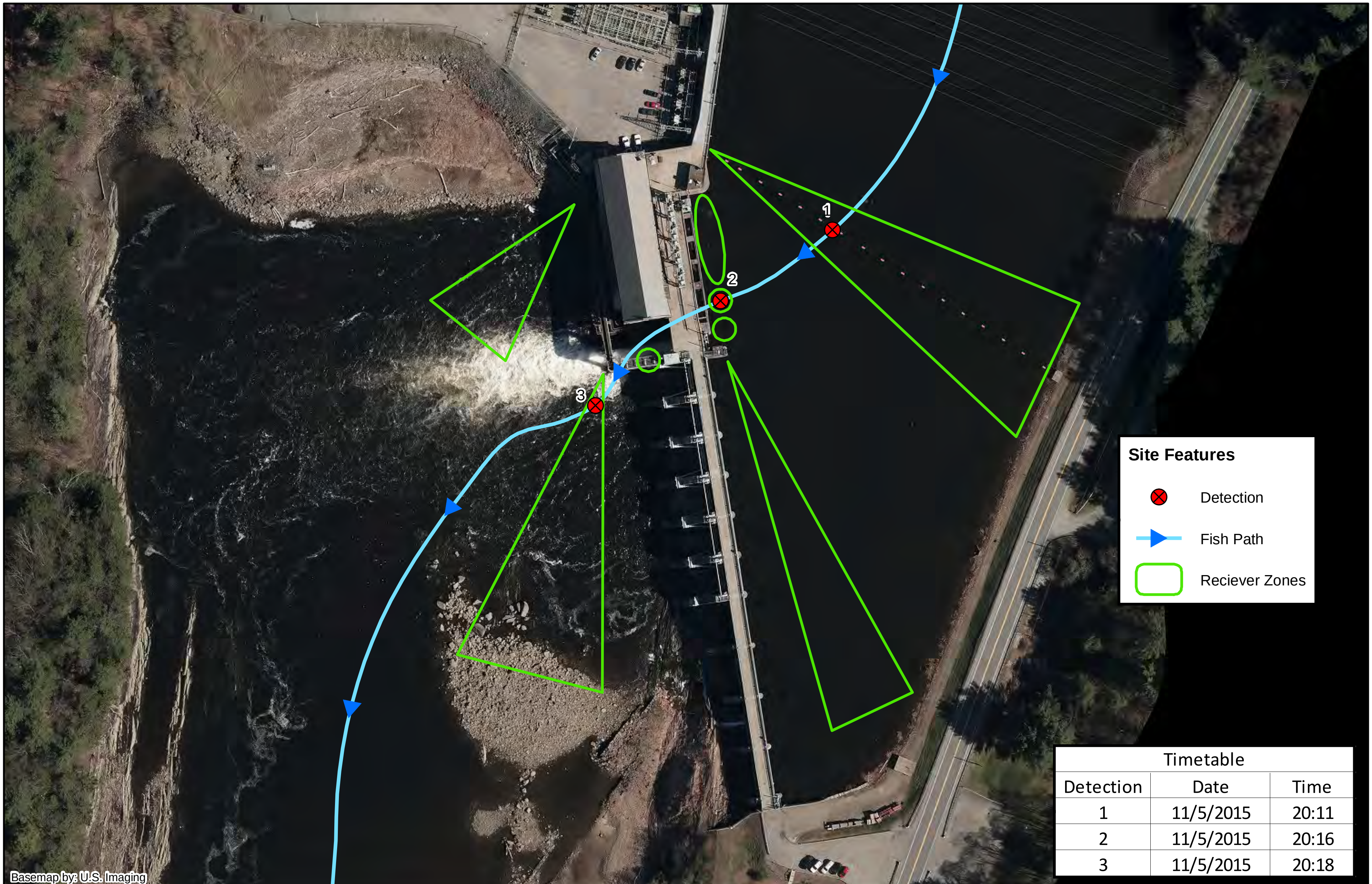
J:\Jen_TEST\TransCanada\S19\REV_2017\Wilder\MXD\TC_Wilder_36_156_021017.mxd



Timetable		
Detection	Date	Time
1	11/5/2015	20:11
2	11/5/2015	20:16
3	11/5/2015	20:18

J:\Jen_TEST\TransCanada\S19\REV_2017\Wilder\MXD\TC_Wilder_36_158_021017.mxd

TransCanada Hydro Northeast Inc.
ILP Study 19
Wilder Dam

1 in = 150 feet

0 75 150 300 Feet

Study 19 Fish Number: 36-158

Release: Norwich, VT
Date Released: 11/05/2015
Time Released: 17:05

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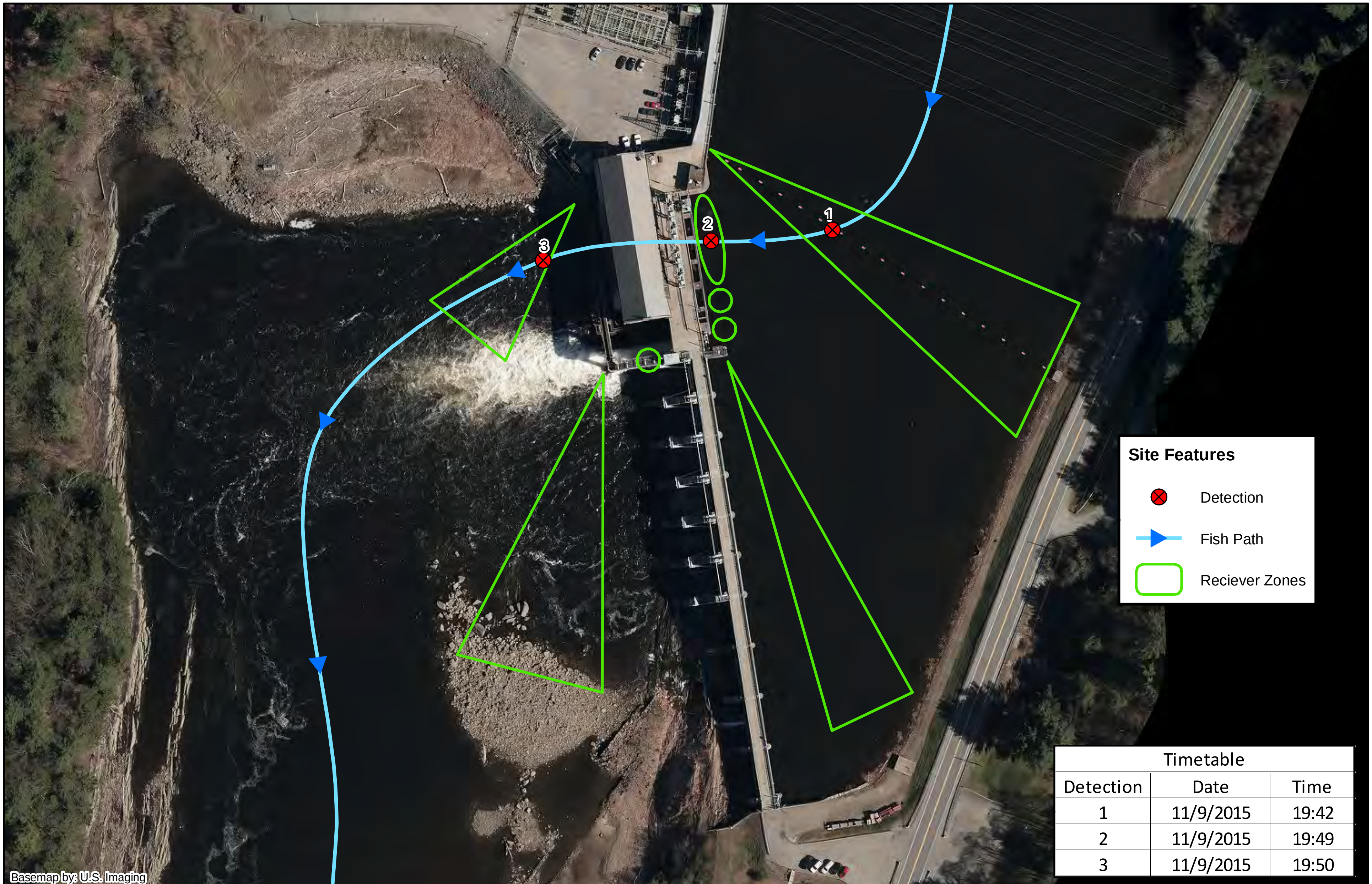
Bedford, NH USA
03110



Timetable		
Detection	Date	Time
1	11/9/2015	19:42
2	11/9/2015	19:49
3	11/9/2015	19:50

J:\Jen_TEST\TransCanada\S19\REV_2017\Wilder\MXD\TC_Wilder_36_160_021017.mxd

TransCanada Hydro Northeast Inc.
ILP Study 19
Wilder Dam

1 in = 150 feet

0 75 150 300 Feet

Study 19 Fish Number: 36-160

Release: Norwich, VT
Date Released: 11/05/2015
Time Released: 17:05

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Environmental Consultants

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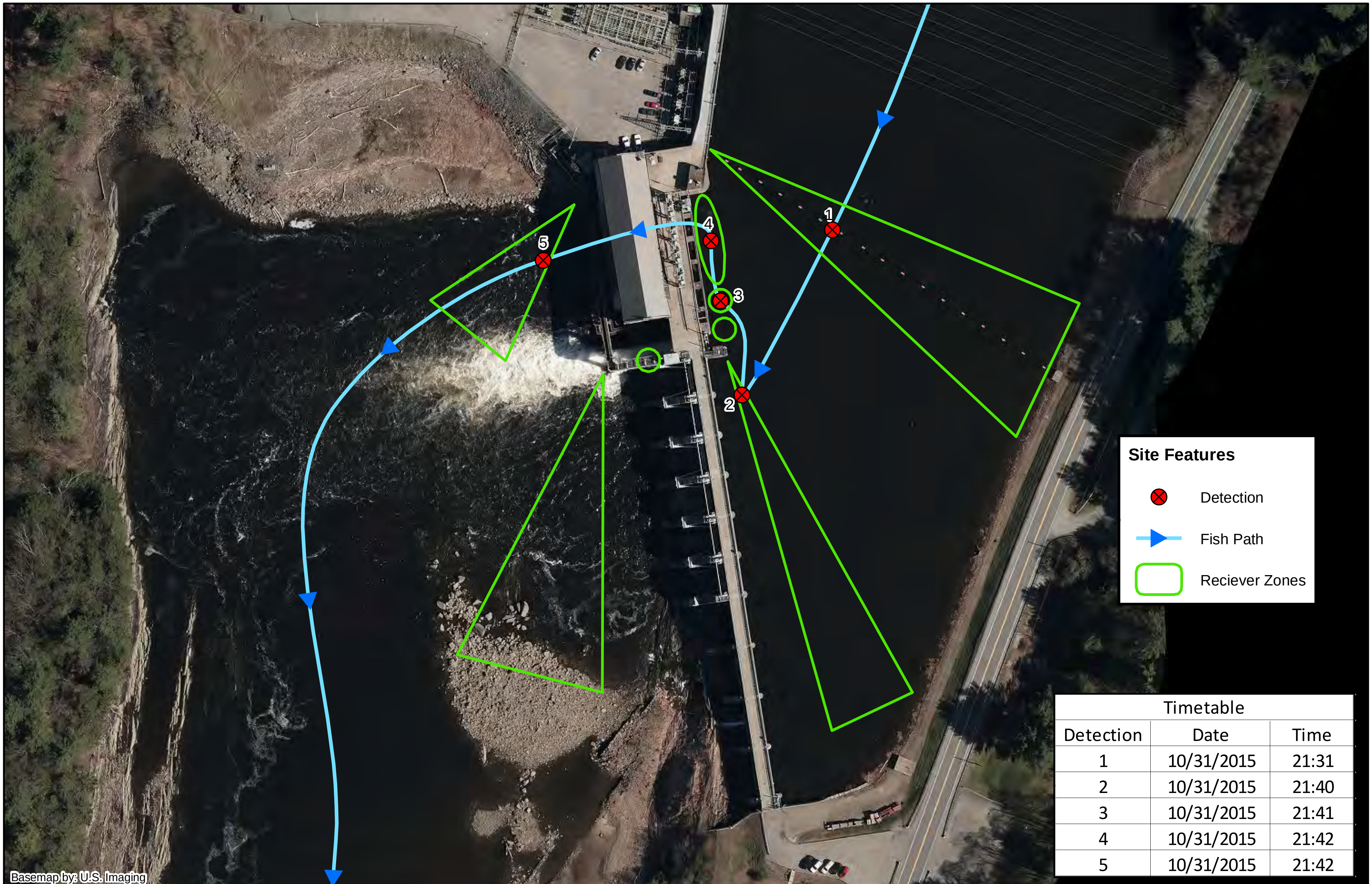
Bedford, NH USA
03110



Timetable		
Detection	Date	Time
1	10/31/2015	21:31
2	10/31/2015	21:40
3	10/31/2015	21:41
4	10/31/2015	21:42
5	10/31/2015	21:42

TransCanada Hydro Northeast Inc.
ILP Study 19
Wilder Dam

1 in = 150 feet

0 75 150 300 Feet

Study 19 Fish Number: 36-184

Release: Norwich, VT
Date Released: 10/31/2015
Time Released: 19:21

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Environmental Consultants

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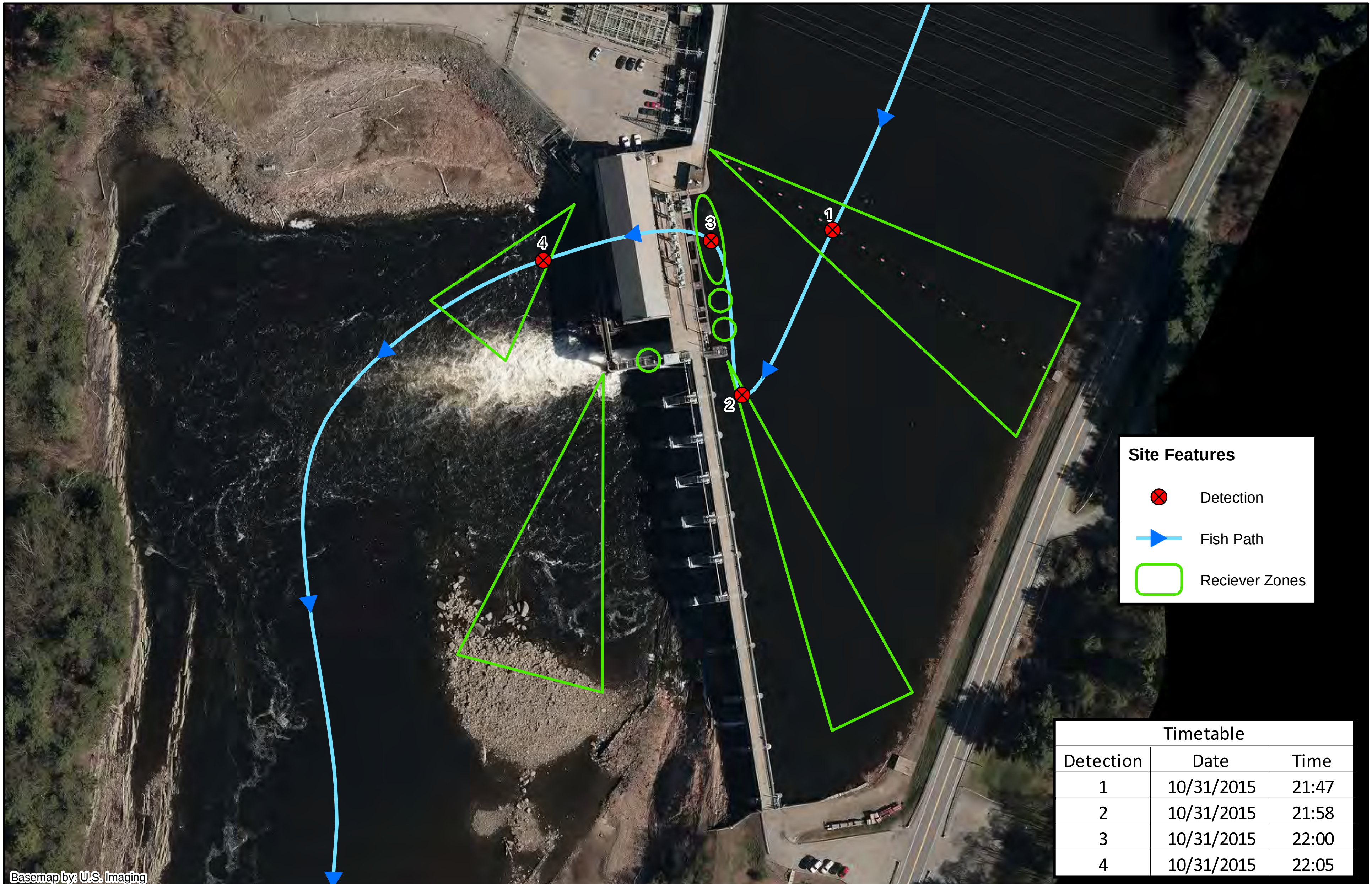
03110

J:\Jen_TEST\TransCanada\S19\REV_2017\Wilder\MXD\TC_Wilder_36_184_021017.mxd



Detection	Date	Time
1	10/31/2015	21:47
2	10/31/2015	21:58
3	10/31/2015	22:00
4	10/31/2015	22:05

Timetable

J:\Jen_TEST\TransCanada\S19\REV_2017\Wilder\MXD\TC_Wilder_36_187_021017.mxd

TransCanada Hydro Northeast Inc.
ILP Study 19
Wilder Dam

N

1 in = 150 feet

0 75 150 300 Feet

Study 19 Fish Number: 36-187

Release: Norwich, VT
Date Released: 10/31/2015
Time Released: 19:21

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Environmental Consultants

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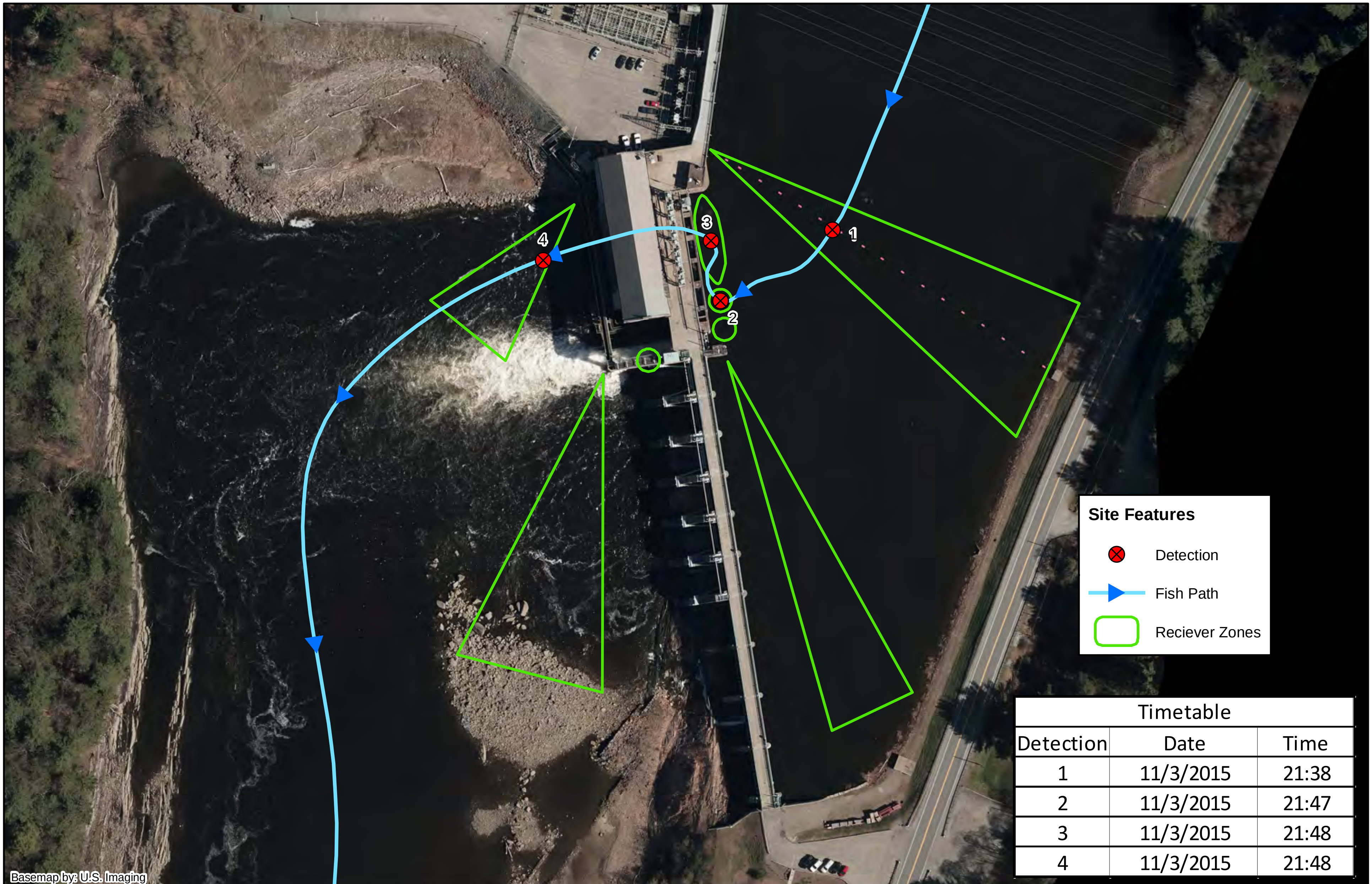

Timetable		
Detection	Date	Time
1	11/3/2015	21:38
2	11/3/2015	21:47
3	11/3/2015	21:48
4	11/3/2015	21:48

TransCanada Hydro Northeast Inc.
ILP Study 19
Wilder Dam

N

1 in = 150 feet

0 75 150 300 Feet

Study 19 Fish Number: 38-124

Release: Norwich, VT
Date Released: 11/3/2015
Time Released: 17:32

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Environmental Consultants

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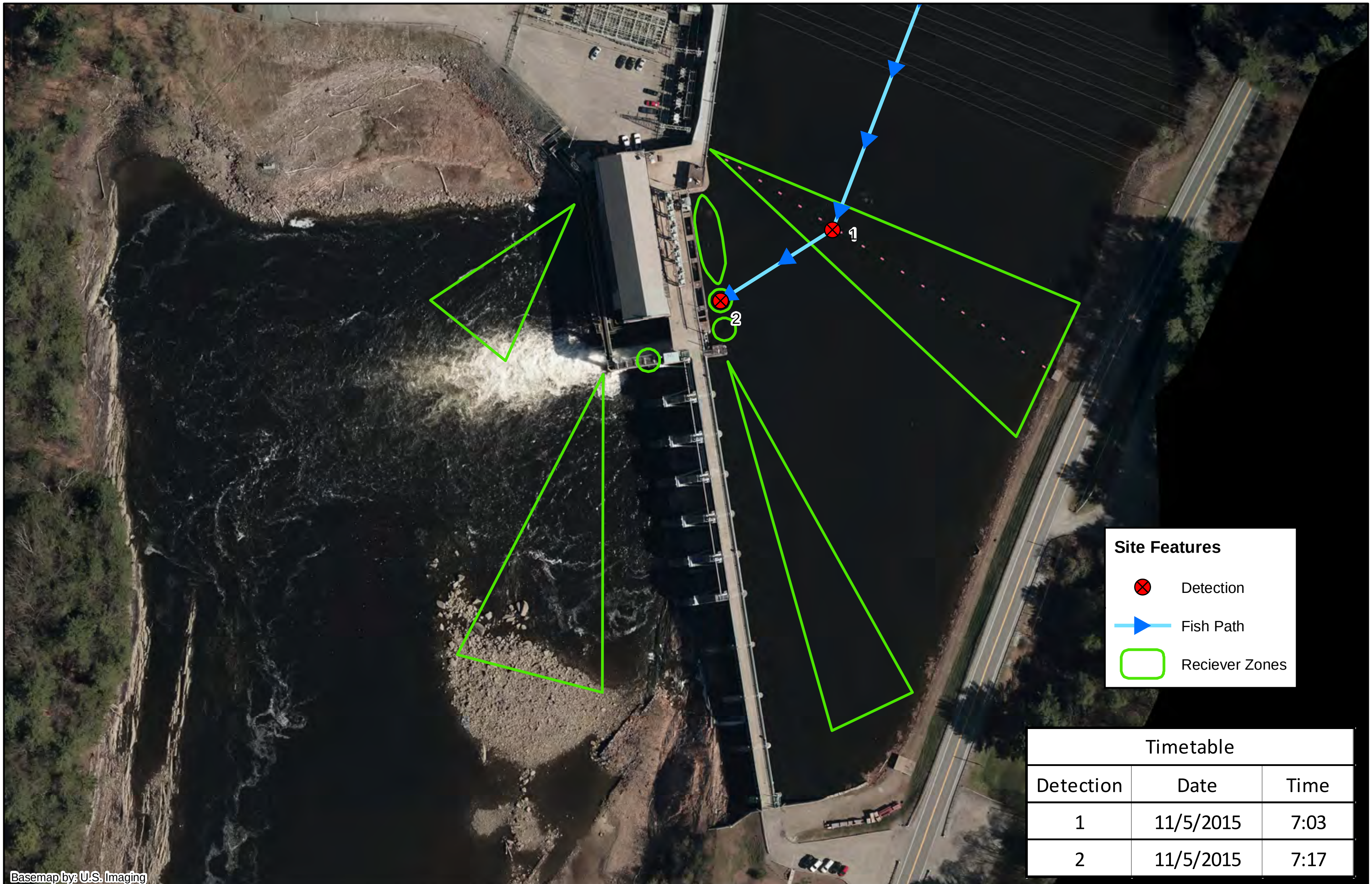

Timetable		
Detection	Date	Time
1	11/5/2015	7:03
2	11/5/2015	7:17

G:\Projects\GIS_Projects_2017\TransCanada\S19\MXD\TC_Wilder_38_125_020617.mxd

TransCanada Hydro Northeast Inc.
ILP Study 19
Wilder Dam

N

1 in = 150 feet

0 75 150 300 Feet

Study 19 Fish Number: 38-125

Release: Norwich, VT
Date Released: 11/3/2015
Time Released: 17:32

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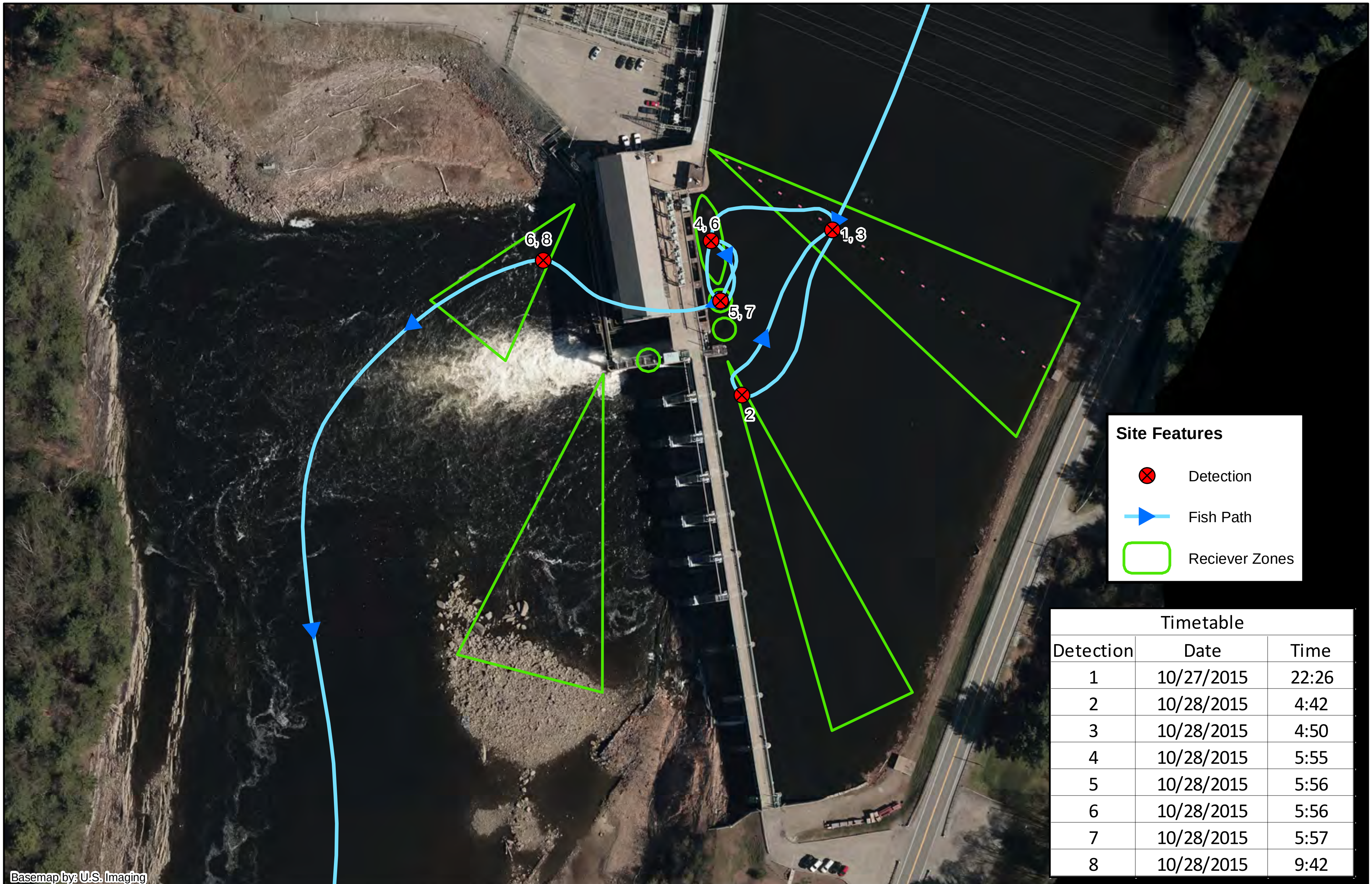
Bedford, NH USA
03110



Timetable		
Detection	Date	Time
1	10/27/2015	22:26
2	10/28/2015	4:42
3	10/28/2015	4:50
4	10/28/2015	5:55
5	10/28/2015	5:56
6	10/28/2015	5:56
7	10/28/2015	5:57
8	10/28/2015	9:42

TransCanada Hydro Northeast Inc.
ILP Study 19
Wilder Dam

N

1 in = 150 feet

0 75 150 300 Feet

Study 19 Fish Number: 38-127

Release: Norwich, VT
Date Released: 10/27/2015
Time Released: 20:05

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Bedford, NH USA
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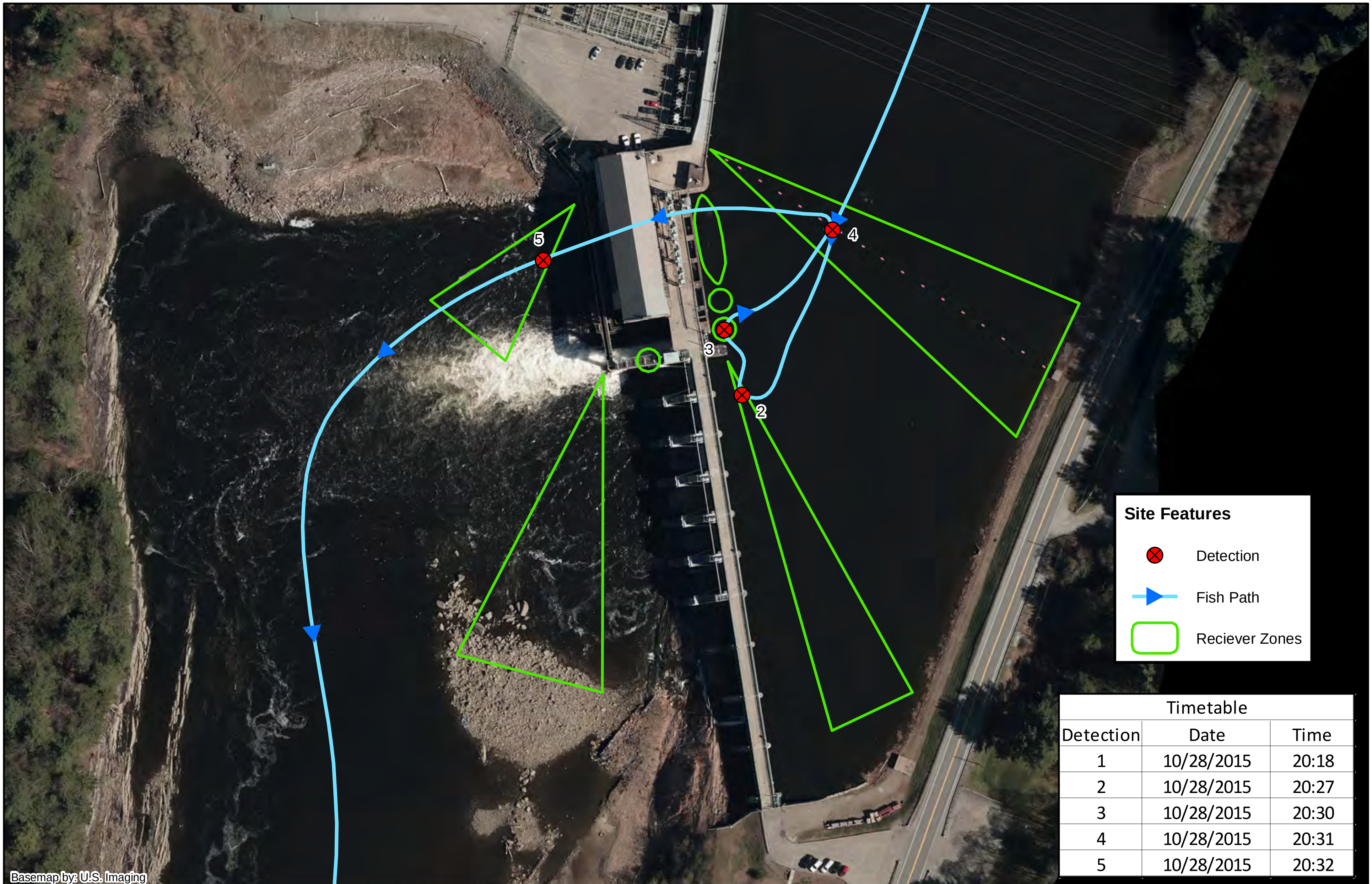
G:\Projects\GIS_Projects_2017\TransCanada\S19\MXD\TC_Wilder_38_127_020617.mxd



Timetable		
Detection	Date	Time
1	10/28/2015	20:18
2	10/28/2015	20:27
3	10/28/2015	20:30
4	10/28/2015	20:31
5	10/28/2015	20:32

TransCanada Hydro Northeast Inc.
ILP Study 19
Wilder Dam

N

1 in = 150 feet

0 75 150 300 Feet

Study 19 Fish Number: 38-128

Release: Norwich, VT
Date Released: 10/27/2015
Time Released: 20:05

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Site Features

- Detection
- Fish Path
- Reciever Zones

Timetable		
Detection	Date	Time
1	10/28/2015	20:11
2	10/28/2015	20:13
3	10/28/2015	20:16
4	10/28/2015	20:16
5	10/28/2015	20:21
6	10/28/2015	20:25
7	10/28/2015	20:27
8	10/28/2015	20:36
9	10/28/2015	20:39
10	10/28/2015	20:40
11	10/28/2015	20:50

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TransCanada Hydro Northeast Inc.
ILP Study 19
Wilder Dam

N

1 in = 150 feet

0 75 150 300 Feet

Study 19 Fish Number: 38-129

Release: Norwich, VT
Date Released: 10/27/2015
Time Released: 20:05

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Bedford, NH USA
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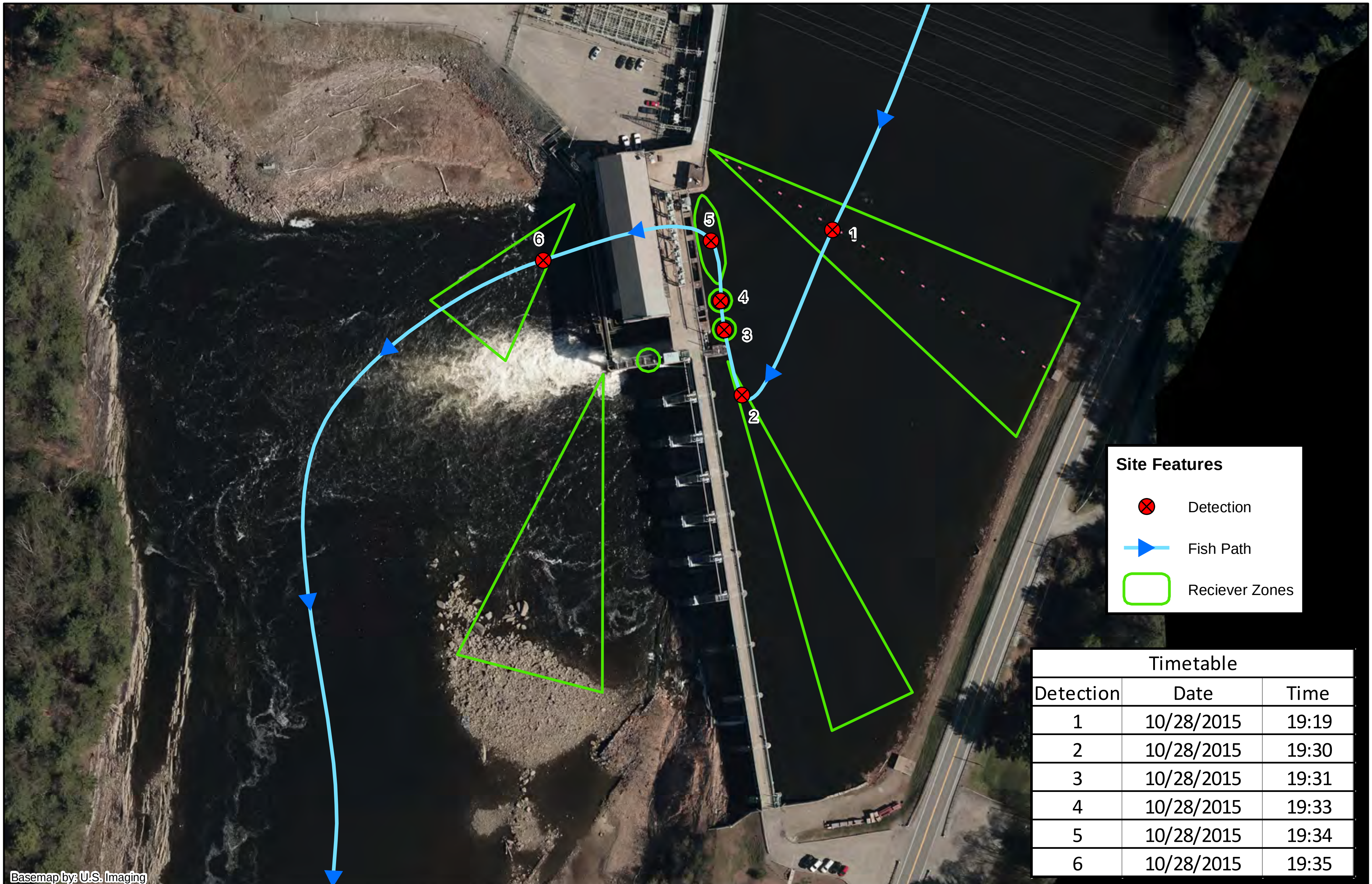

Timetable		
Detection	Date	Time
1	10/28/2015	19:19
2	10/28/2015	19:30
3	10/28/2015	19:31
4	10/28/2015	19:33
5	10/28/2015	19:34
6	10/28/2015	19:35

TransCanada Hydro Northeast Inc.
ILP Study 19
Wilder Dam

1 in = 150 feet

0 75 150 300 Feet

Study 19 Fish Number: 38-130

Release: Norwich, VT
Date Released: 10/27/2015
Time Released: 20:05

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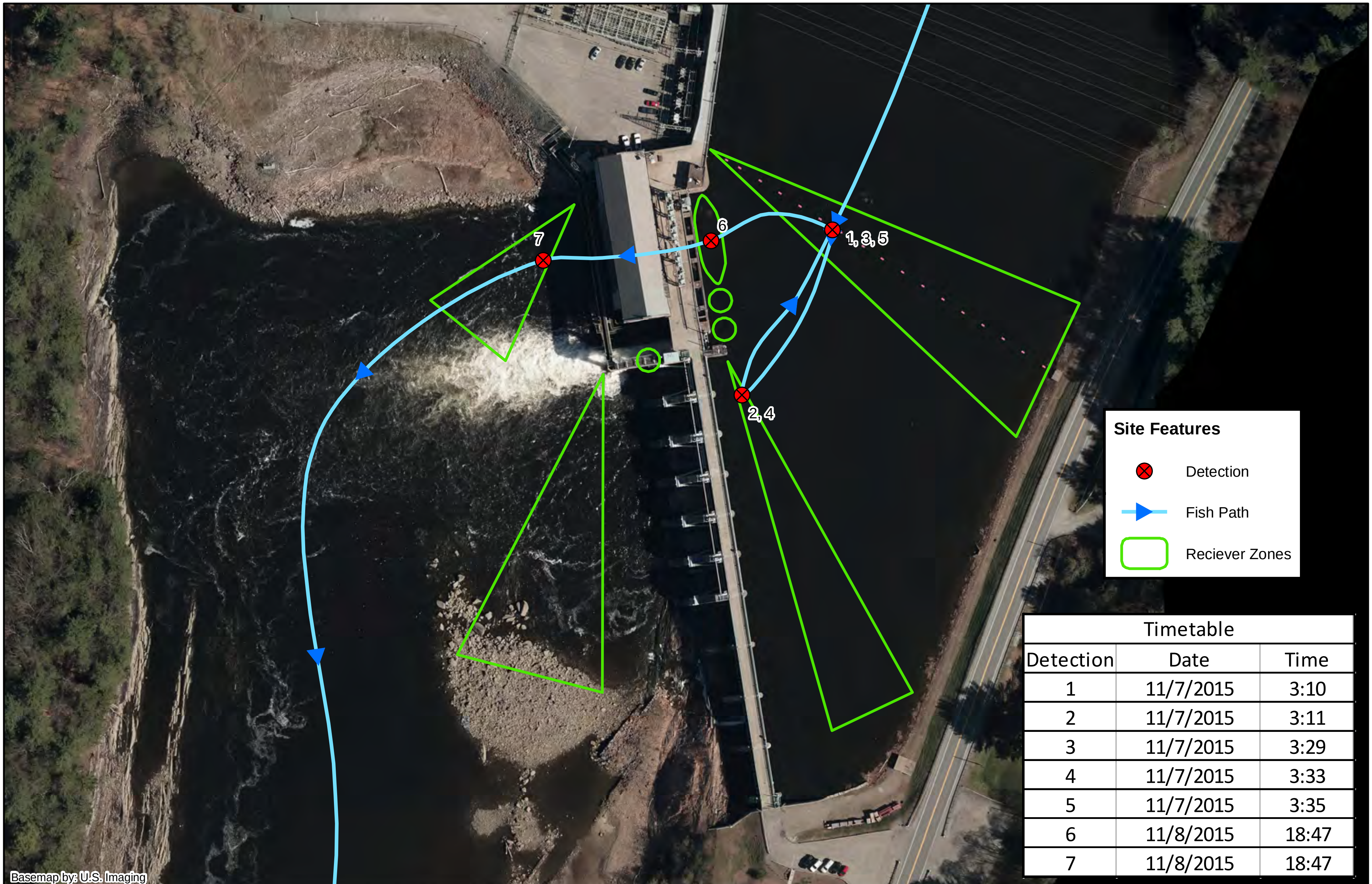
G:\Projects\GIS_Projects_2017\TransCanada\S19\MXD\TC_Wilder_38_130_020617.mxd



Timetable		
Detection	Date	Time
1	11/7/2015	3:10
2	11/7/2015	3:11
3	11/7/2015	3:29
4	11/7/2015	3:33
5	11/7/2015	3:35
6	11/8/2015	18:47
7	11/8/2015	18:47

TransCanada Hydro Northeast Inc.
ILP Study 19
Wilder Dam

N

1 in = 150 feet

0 75 150 300 Feet

Study 19 Fish Number: 38-151

Release: Norwich, VT
Date Released: 11/5/2015
Time Released: 17:05

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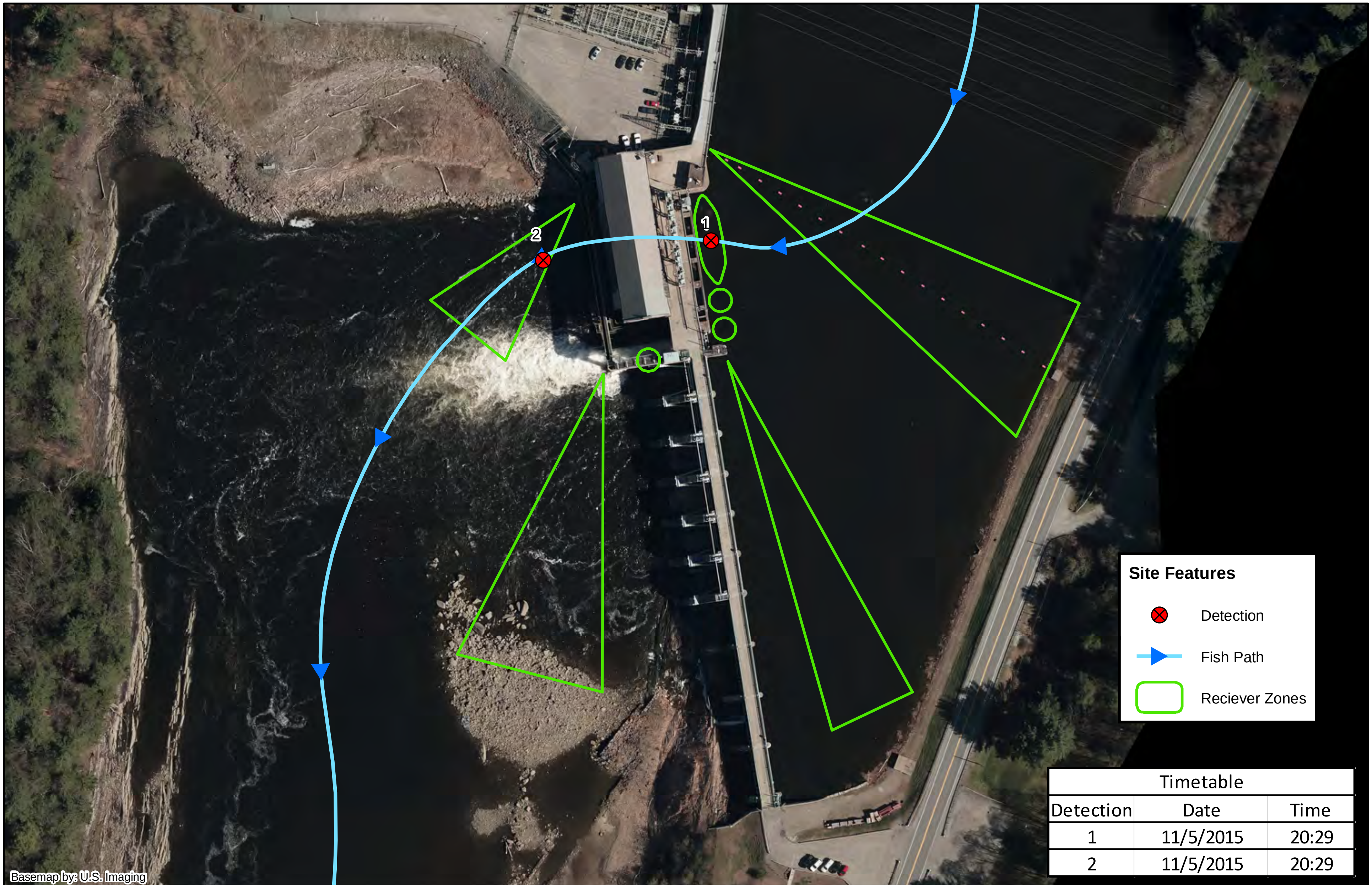
G:\Projects\GIS_Projects_2017\TransCanada\S19\MXD\TC_Wilder_38_151_020617.mxd



Timetable		
Detection	Date	Time
1	11/5/2015	20:29
2	11/5/2015	20:29

G:\Projects\GIS_Projects_2017\TransCanada\S19\MXD\TC_Wilder_38_152_020616.mxd

TransCanada Hydro Northeast Inc.
ILP Study 19
Wilder Dam

N

1 in = 150 feet

0 75 150 300 Feet

Study 19 Fish Number: 38-152

Release: Norwich, VT
Date Released: 11/5/2015
Time Released: 17:05

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Environmental Consultants
Normandeau Associates Inc.
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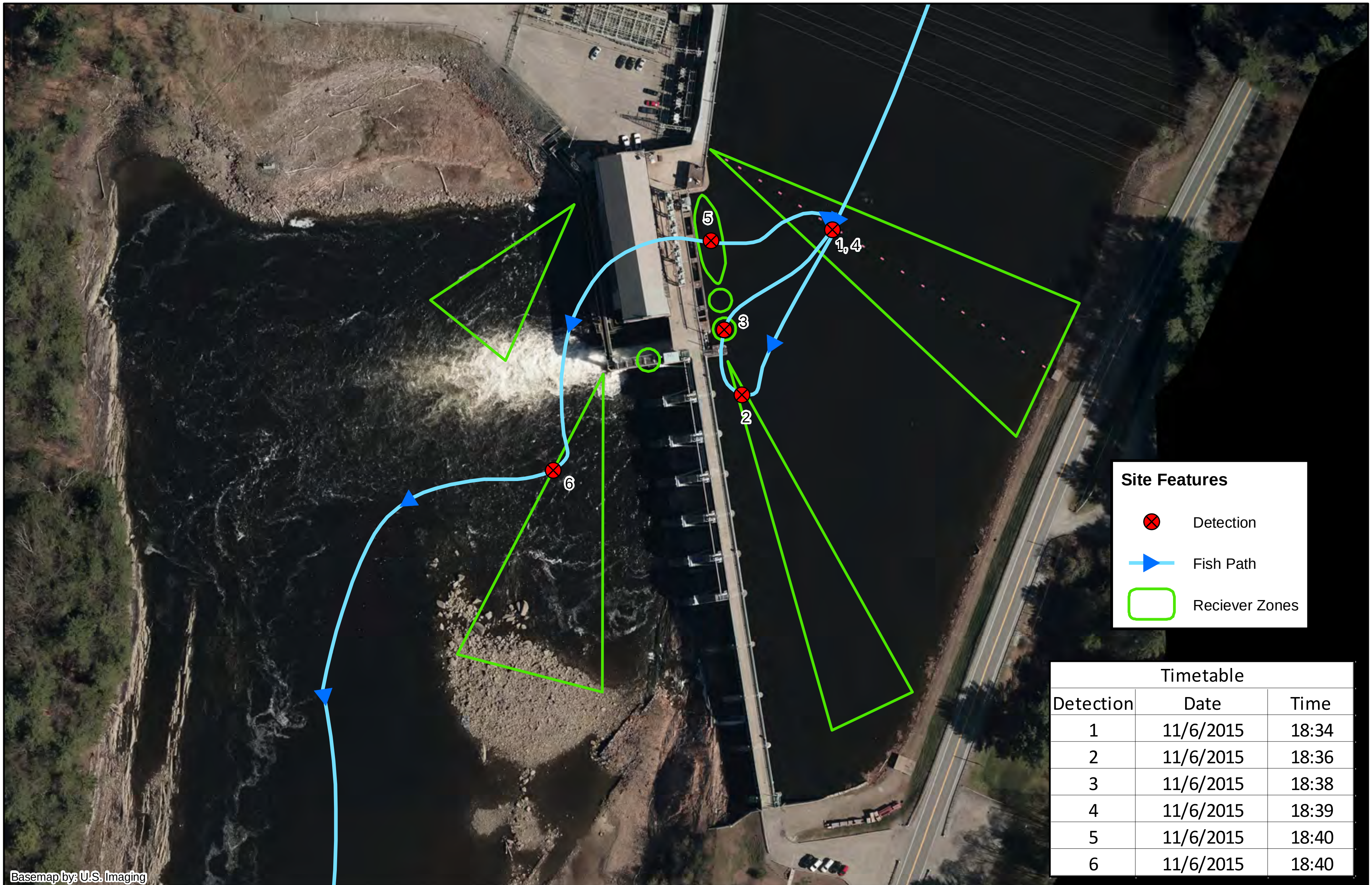
Bedford, NH USA
03110



Timetable		
Detection	Date	Time
1	11/6/2015	18:34
2	11/6/2015	18:36
3	11/6/2015	18:38
4	11/6/2015	18:39
5	11/6/2015	18:40
6	11/6/2015	18:40

TransCanada Hydro Northeast Inc.
ILP Study 19
Wilder Dam

N

1 in = 150 feet

0 75 150 300 Feet

Study 19 Fish Number: 38-153

Release: Norwich, VT
Date Released: 11/5/2015
Time Released: 17:05

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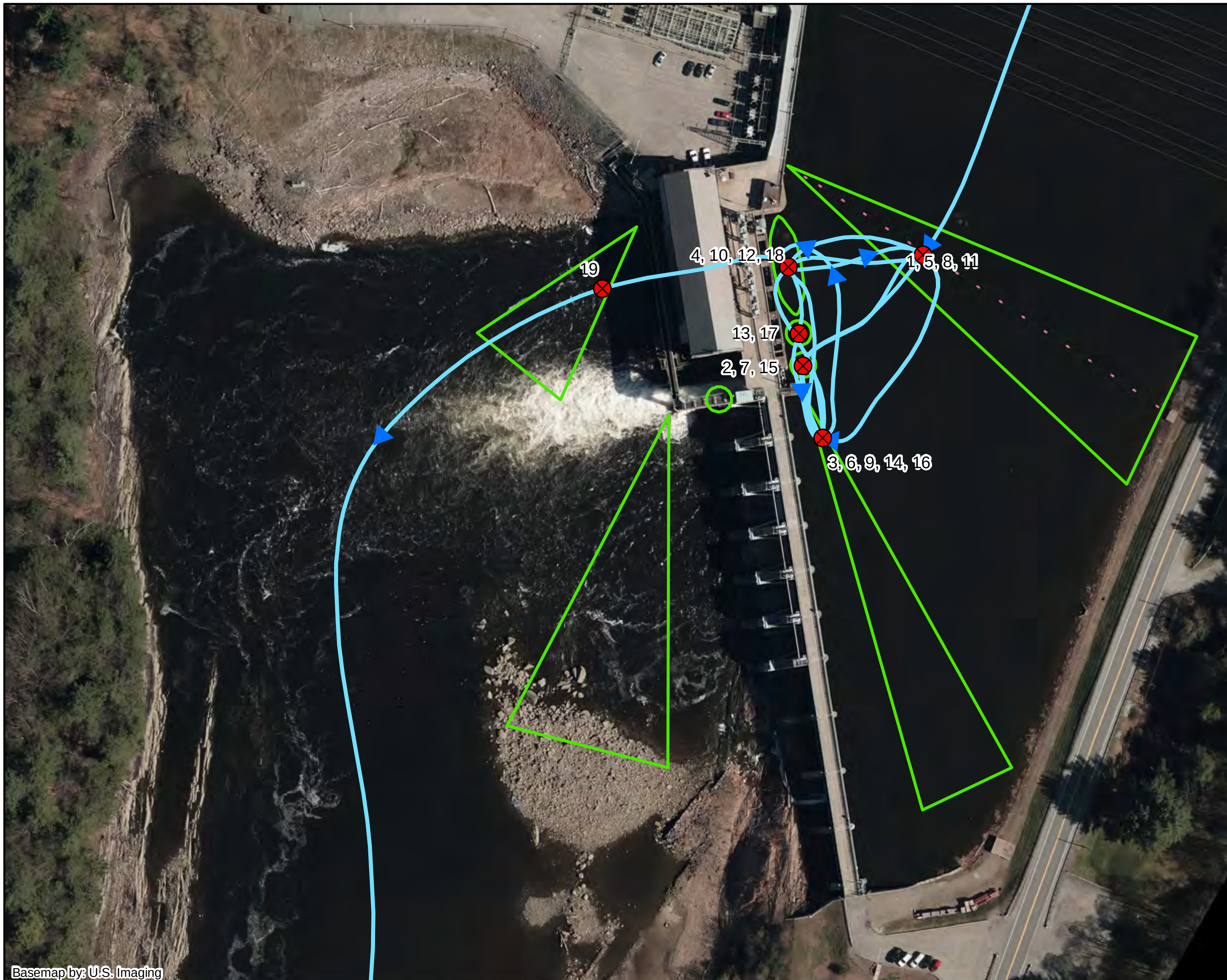
G:\Projects\GIS_Projects_2017\TransCanada\S19\MXD\TC_Wilder_38_153_020617.mxd



Timetable		
Detection	Date	Time
1	10/29/2015	21:50
2	10/29/2015	22:02
3	10/29/2015	22:04
4	10/29/2015	22:05
5	10/29/2015	22:06
6	10/29/2015	22:07
7	10/29/2015	22:10
8	10/29/2015	22:12
9	10/29/2015	23:25
10	10/29/2015	23:32
11	10/29/2015	23:34
12	10/30/2015	5:33
13	10/30/2015	5:34
14	10/30/2015	5:36
15	10/30/2015	5:43
16	10/30/2015	5:46
17	10/30/2015	5:46
18	10/30/2015	5:46
19	10/30/2015	5:49

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TransCanada Hydro Northeast Inc.
ILP Study 19
Wilder Dam

N

1 in = 150 feet

0 75 150 300 Feet

Study 19 Fish Number: 38-157

Release: Norwich, VT
Date Released: 10/29/15
Time Released: 18:43

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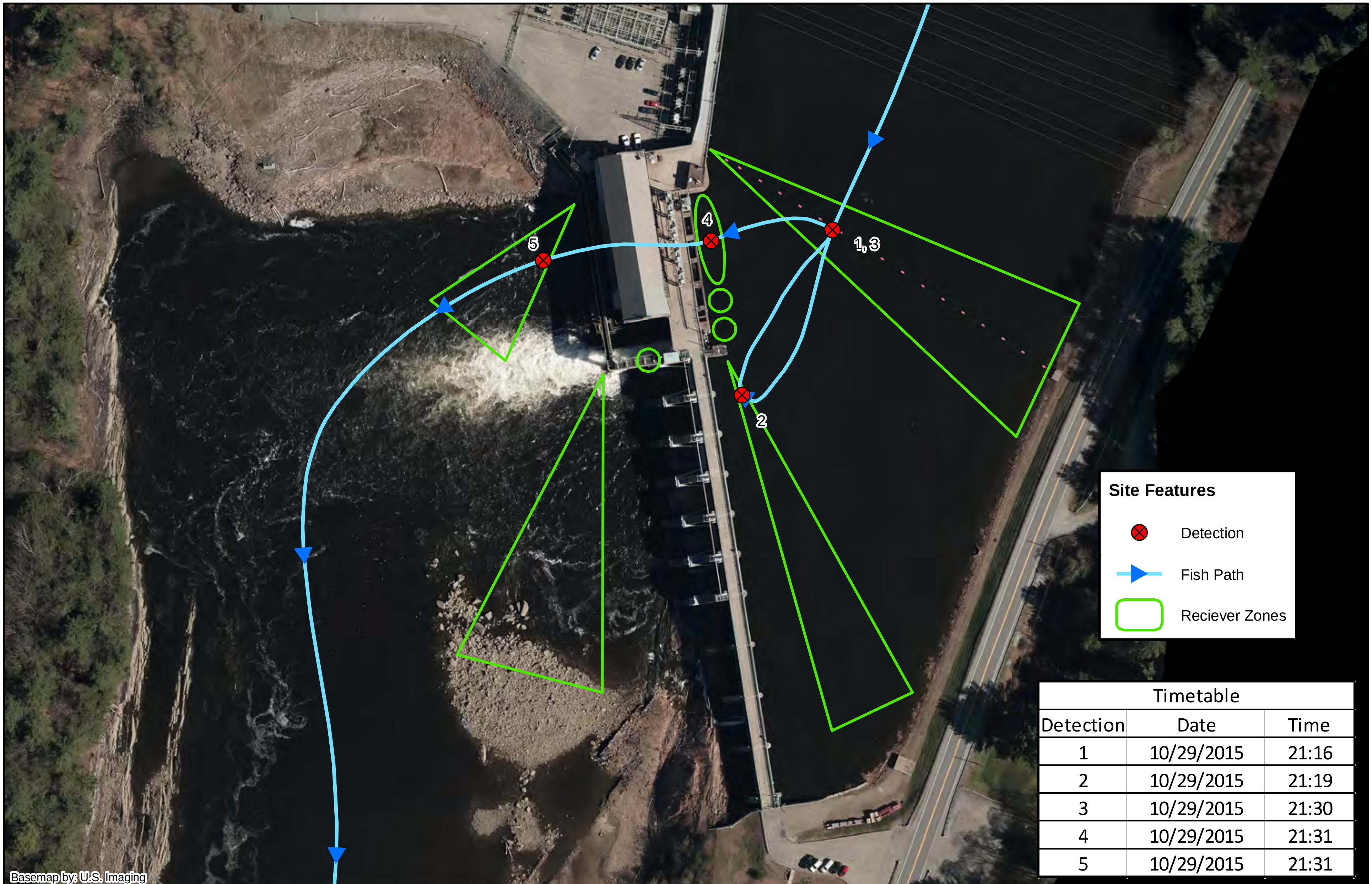
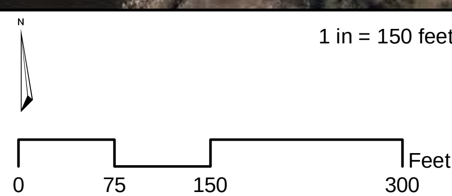


Timetable		
Detection	Date	Time
1	10/29/2015	21:16
2	10/29/2015	21:19
3	10/29/2015	21:30
4	10/29/2015	21:31
5	10/29/2015	21:31

TransCanada Hydro Northeast Inc.
ILP Study 19
Wilder Dam

1 in = 150 feet



Study 19 Fish Number: 38-158

Release: Norwich, VT
Date Released: 10/29/15
Time Released: 18:43

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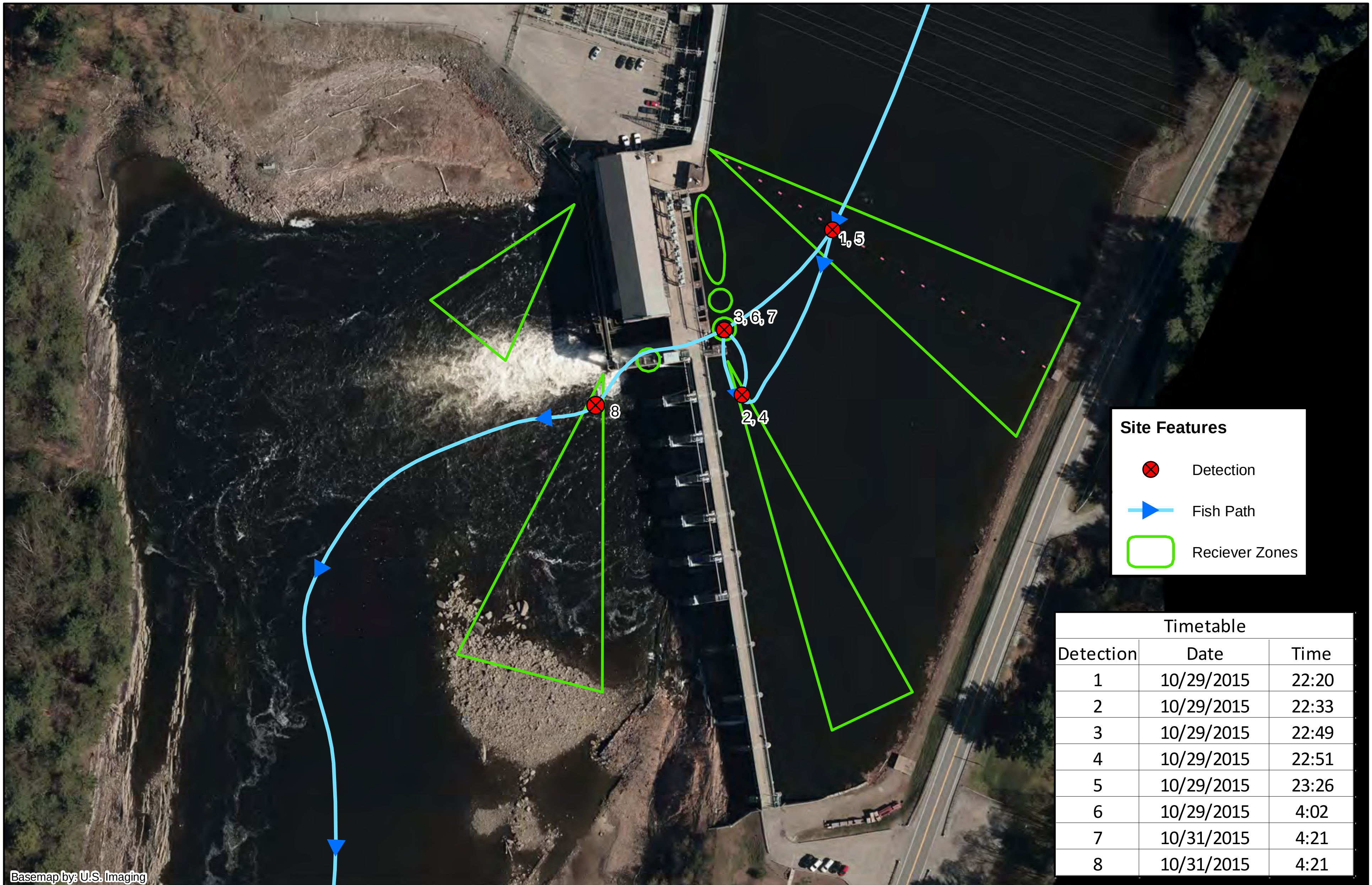

Timetable		
Detection	Date	Time
1	10/29/2015	22:20
2	10/29/2015	22:33
3	10/29/2015	22:49
4	10/29/2015	22:51
5	10/29/2015	23:26
6	10/29/2015	4:02
7	10/31/2015	4:21
8	10/31/2015	4:21

TransCanada Hydro Northeast Inc.
ILP Study 19
Wilder Dam

N

1 in = 150 feet

0 75 150 300 Feet

Study 19 Fish Number: 38-159

Release: Rockingham, VT
Date Released: 10/29/15
Time Released: 18:43

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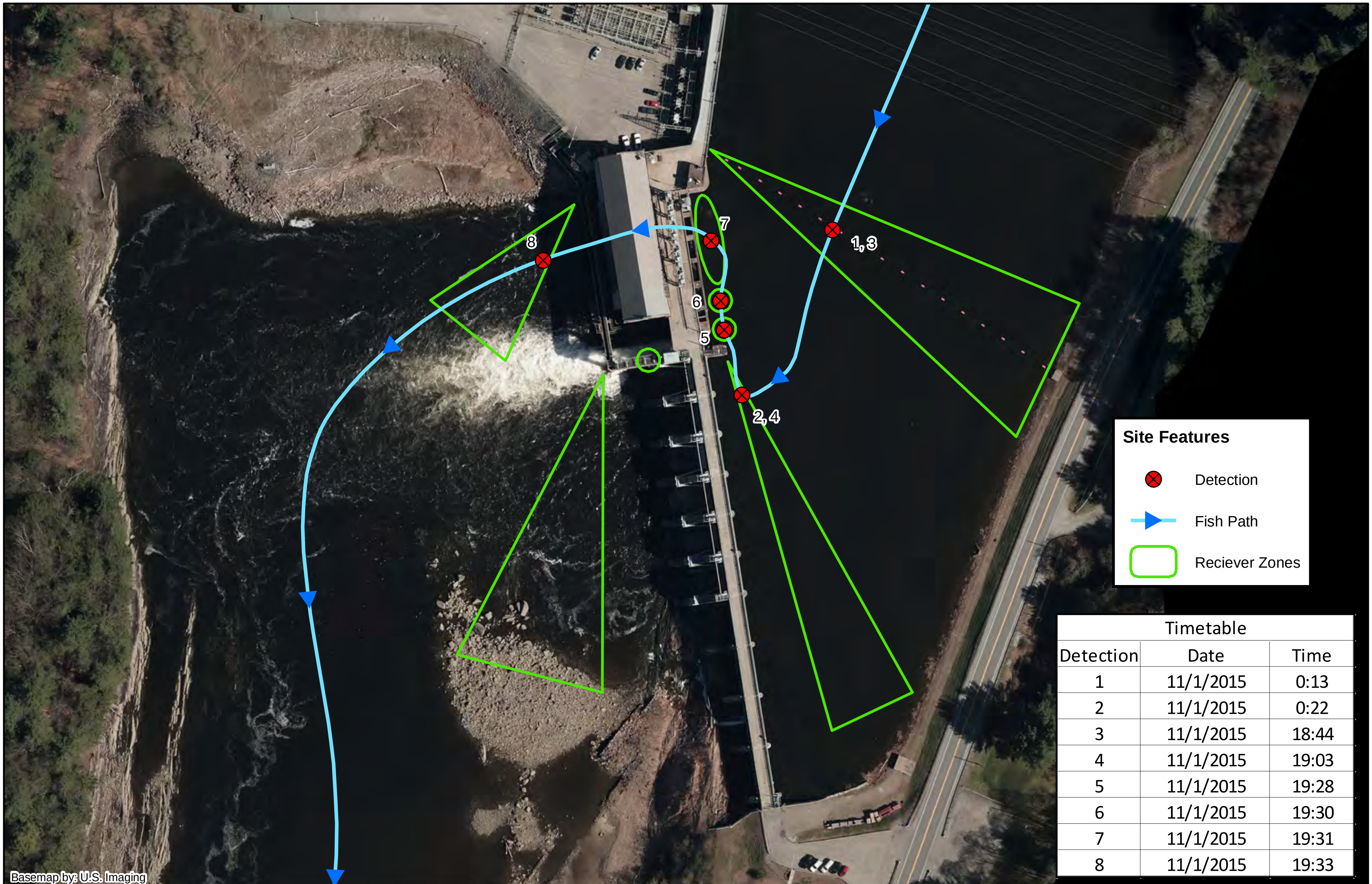

Timetable		
Detection	Date	Time
1	11/1/2015	0:13
2	11/1/2015	0:22
3	11/1/2015	18:44
4	11/1/2015	19:03
5	11/1/2015	19:28
6	11/1/2015	19:30
7	11/1/2015	19:31
8	11/1/2015	19:33

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TransCanada Hydro Northeast Inc.
ILP Study 19
Wilder Dam

N

1 in = 150 feet

0 75 150 300 Feet

Study 19 Fish Number: 38-160

Release: Norwich, VT
Date Released: 10/29/15
Time Released: 18:43

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Environmental Consultants
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Bedford, NH USA
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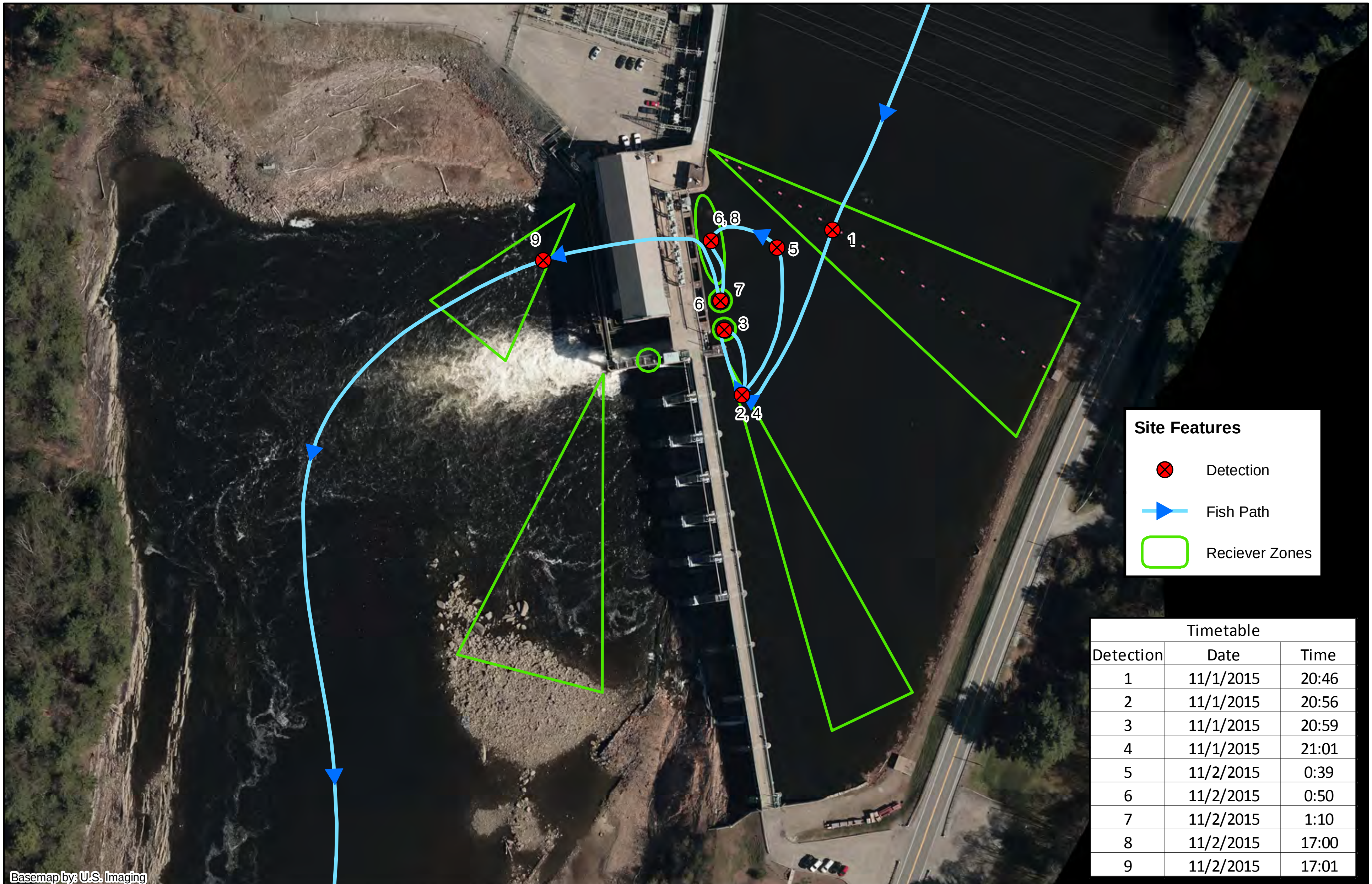

Timetable		
Detection	Date	Time
1	11/1/2015	20:46
2	11/1/2015	20:56
3	11/1/2015	20:59
4	11/1/2015	21:01
5	11/2/2015	0:39
6	11/2/2015	0:50
7	11/2/2015	1:10
8	11/2/2015	17:00
9	11/2/2015	17:01

TransCanada Hydro Northeast Inc.
ILP Study 19
Wilder Dam

Study 19 Fish Number: 38-188

Release: Norwich, VT
Date Released: 10/31/15
Time Released: 19:21

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Environmental Consultants

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Bedford, NH USA
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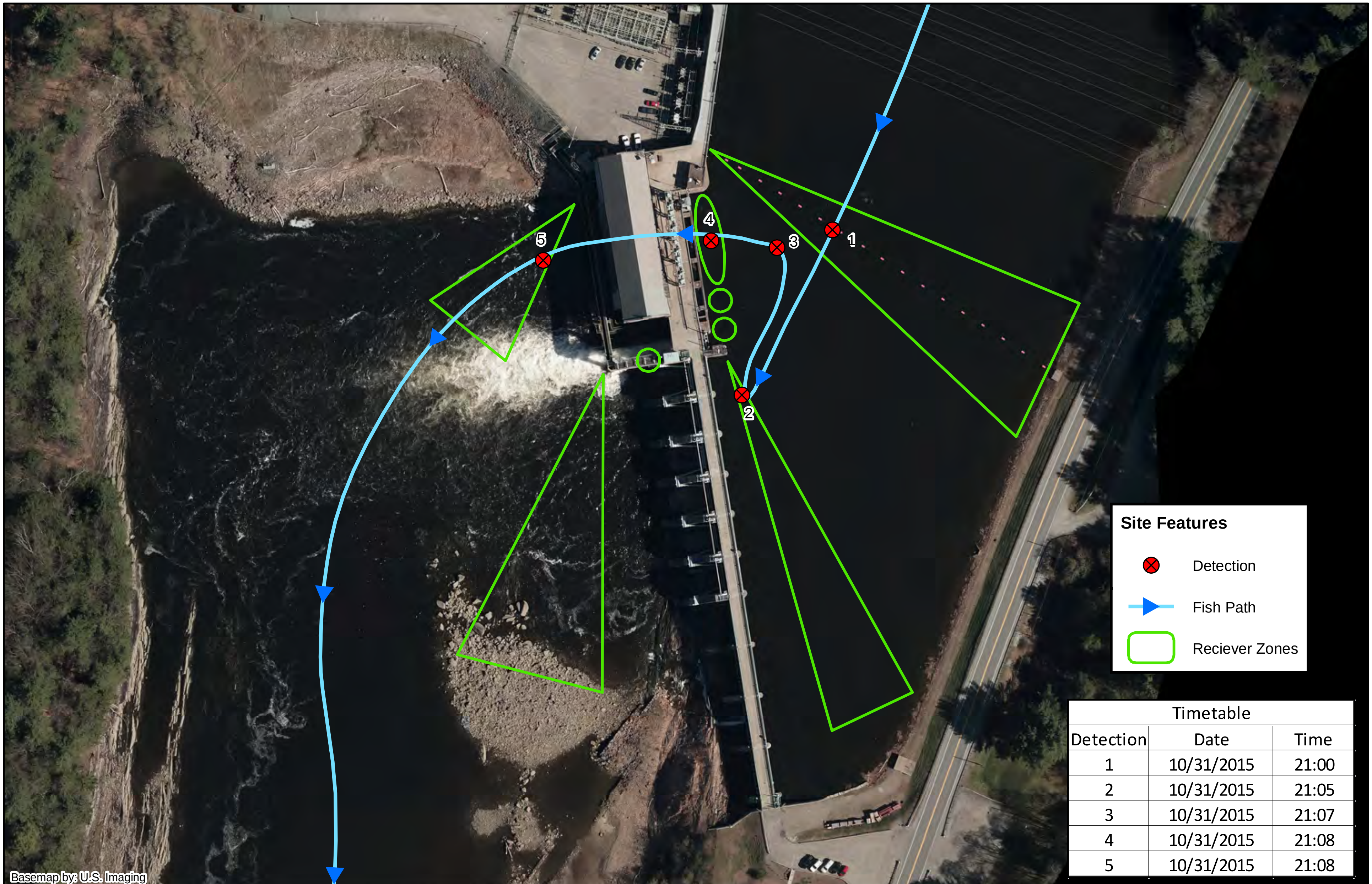

Timetable		
Detection	Date	Time
1	10/31/2015	21:00
2	10/31/2015	21:05
3	10/31/2015	21:07
4	10/31/2015	21:08
5	10/31/2015	21:08

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TransCanada Hydro Northeast Inc.
ILP Study 19
Wilder Dam

N

1 in = 150 feet

0 75 150 300 Feet

Study 19 Fish Number: 38-189

Release: Norwich, VT
Date Released: 10/31/15
Time Released: 19:21

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Environmental Consultants
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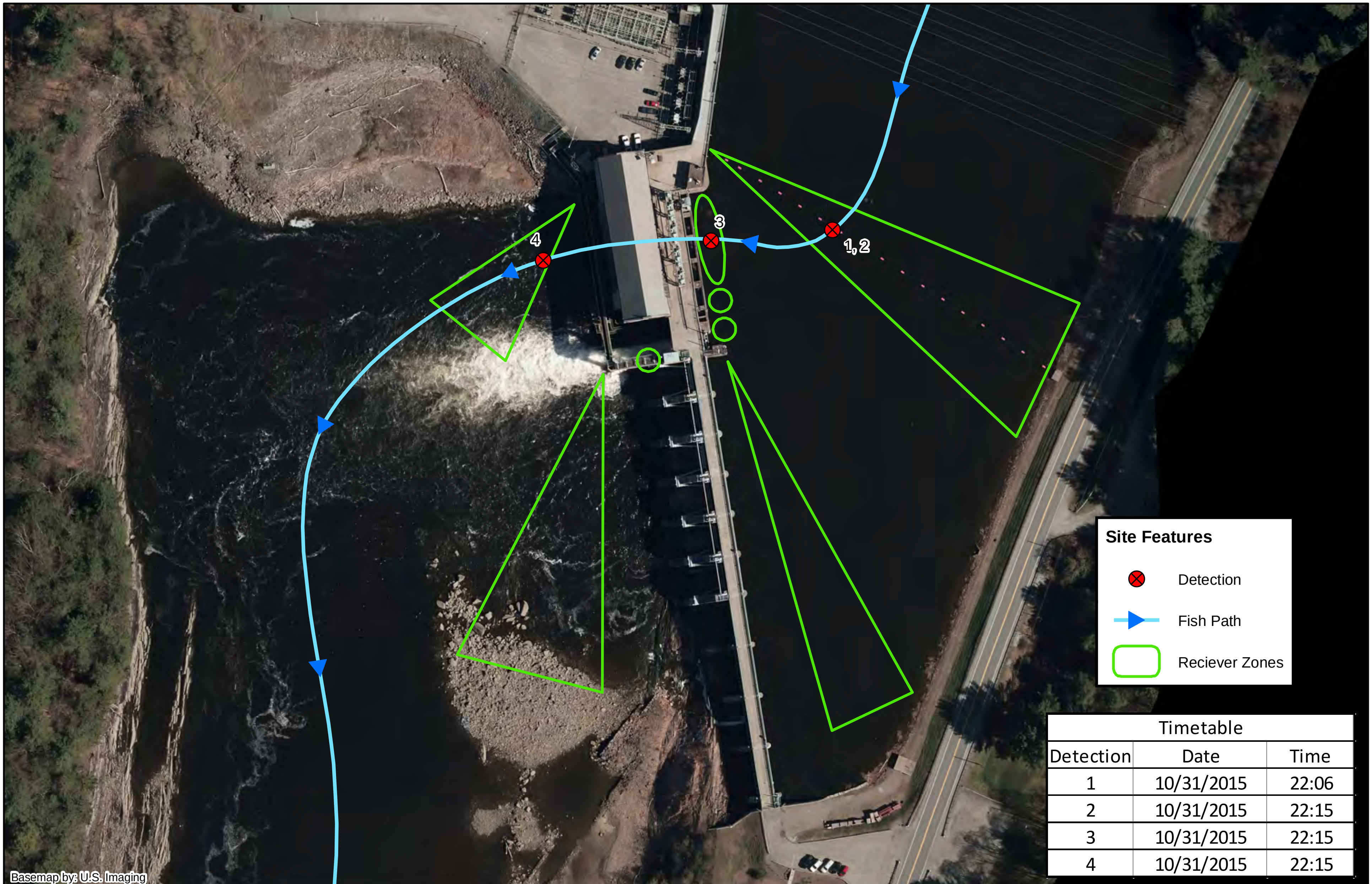
Bedford, NH USA
03110



Timetable		
Detection	Date	Time
1	10/31/2015	22:06
2	10/31/2015	22:15
3	10/31/2015	22:15
4	10/31/2015	22:15

TransCanada Hydro Northeast Inc.
ILP Study 19
Wilder Dam

1 in = 150 feet

0 75 150 300 Feet

Study 19 Fish Number: 38-190

Release: Norwich, VT
Date Released: 10/31/15
Time Released: 19:21

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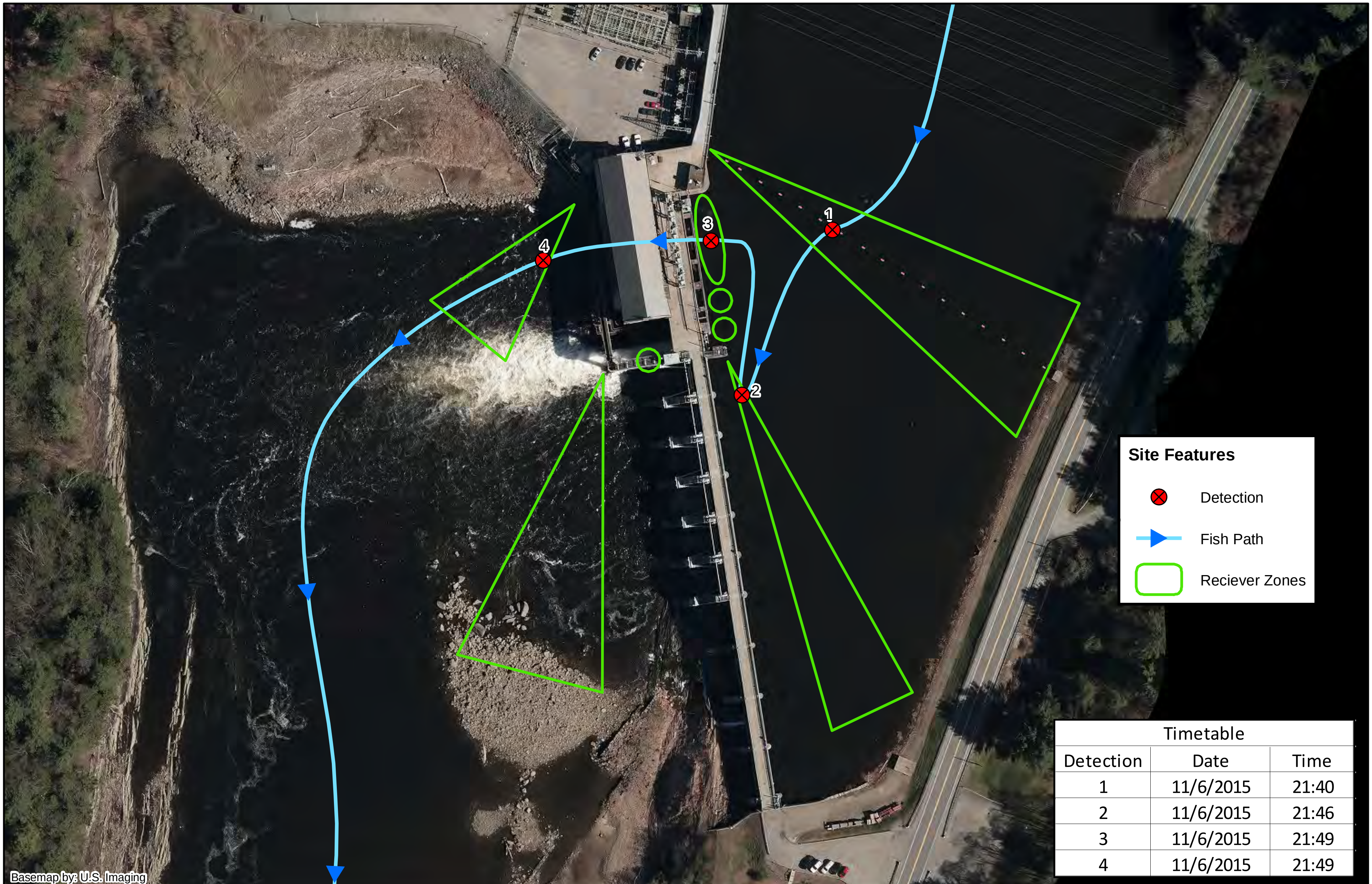
G:\Projects\GIS_Projects_2017\TransCanada\S19\MXD\TC_Wilder_38_190_013117.mxd



Timetable		
Detection	Date	Time
1	11/6/2015	21:40
2	11/6/2015	21:46
3	11/6/2015	21:49
4	11/6/2015	21:49

TransCanada Hydro Northeast Inc.
ILP Study 19
Wilder Dam

N

1 in = 150 feet

0 75 150 300 Feet

Study 19 Fish Number: 38-58

Release: Norwich, VT
Date Released: 11/03/2015
Time Released: 17:32

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Environmental Consultants

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Bedford, NH USA
03110

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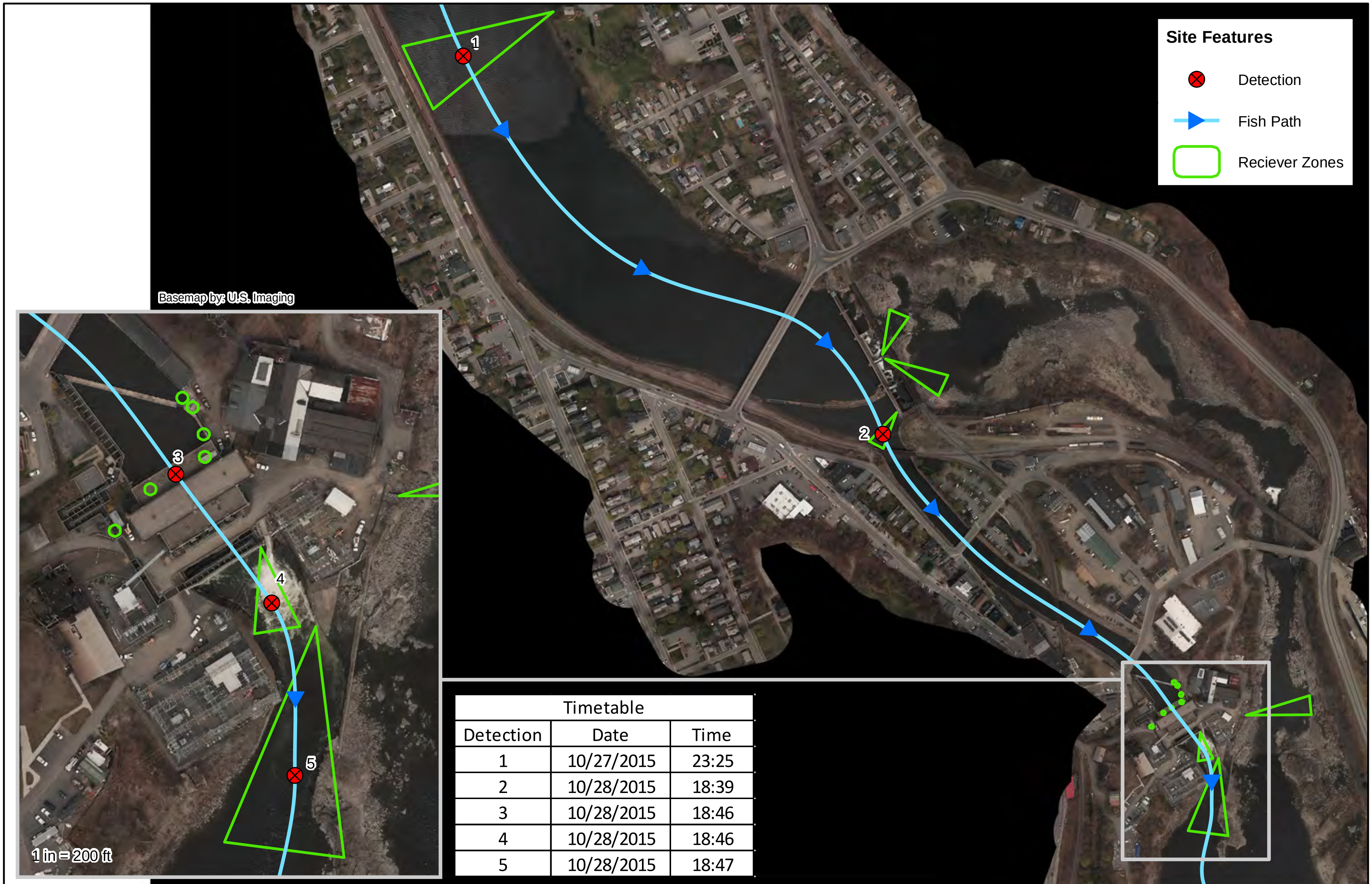

Timetable		
Detection	Date	Time
1	10/27/2015	23:25
2	10/28/2015	18:39
3	10/28/2015	18:46
4	10/28/2015	18:46
5	10/28/2015	18:47

TransCanada Hydro Northeast Inc.
ILP Study 19
Bellows Falls Dam

N

1 in = 600 feet

0 300 600 1,200 Feet

Study 19 Fish Number: 34-111

Release: Herricks Cove, VT
Date Released: 10/27/2015
Time Released: 18:20

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Environmental Consultants

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03110

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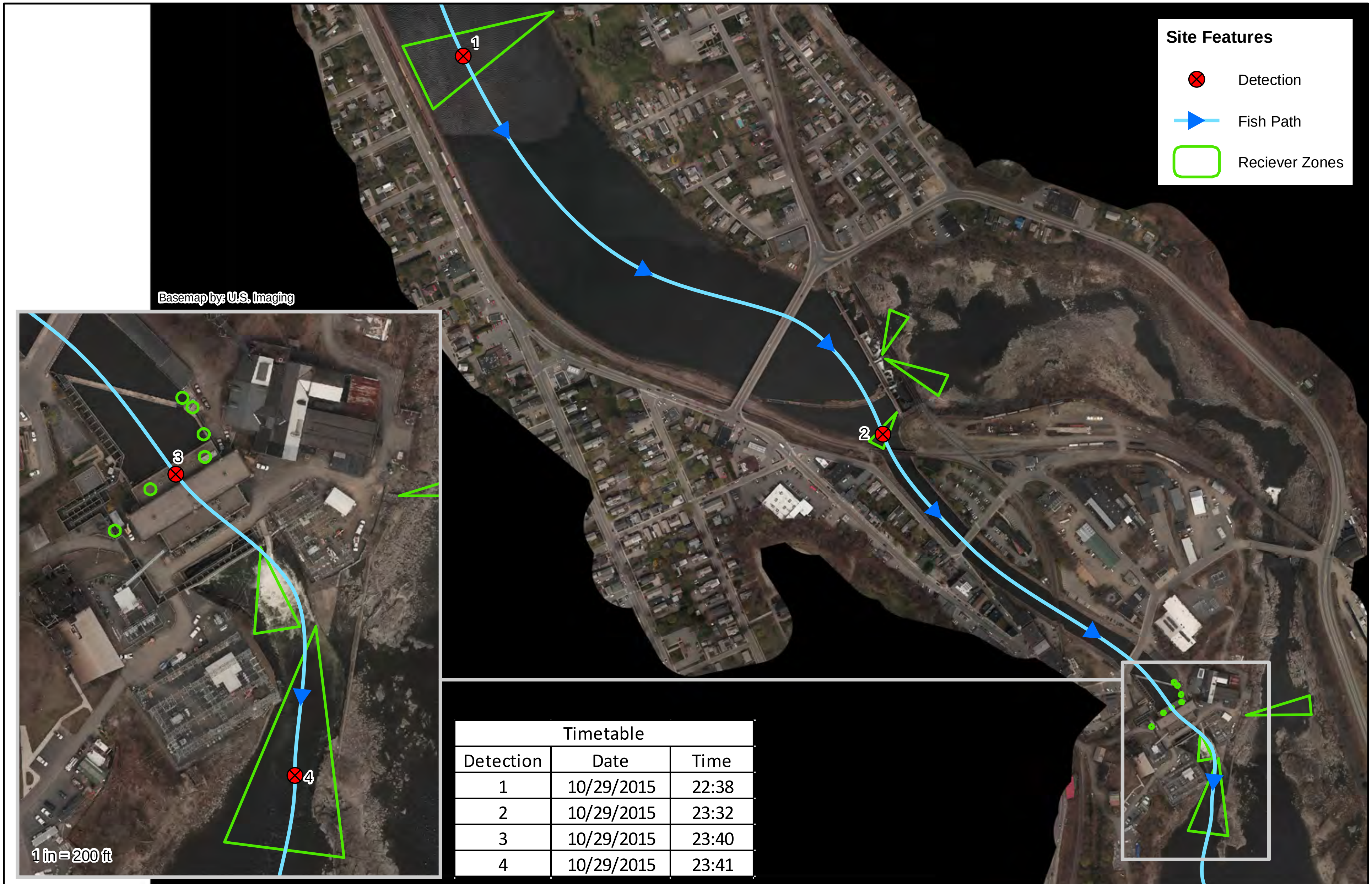
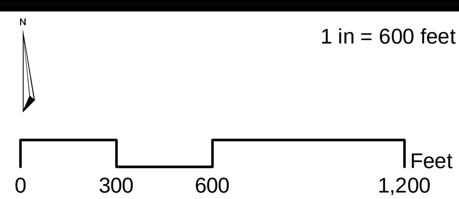


Timetable		
Detection	Date	Time
1	10/29/2015	22:38
2	10/29/2015	23:32
3	10/29/2015	23:40
4	10/29/2015	23:41

TransCanada Hydro Northeast Inc.
ILP Study 19
Bellows Falls Dam



Study 19 Fish Number: 34-112

Release: Herricks Cove, VT
Date Released: 10/27/2015
Time Released: 18:20

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Environmental Consultants
Normandeau Associates Inc.
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Bedford, NH USA
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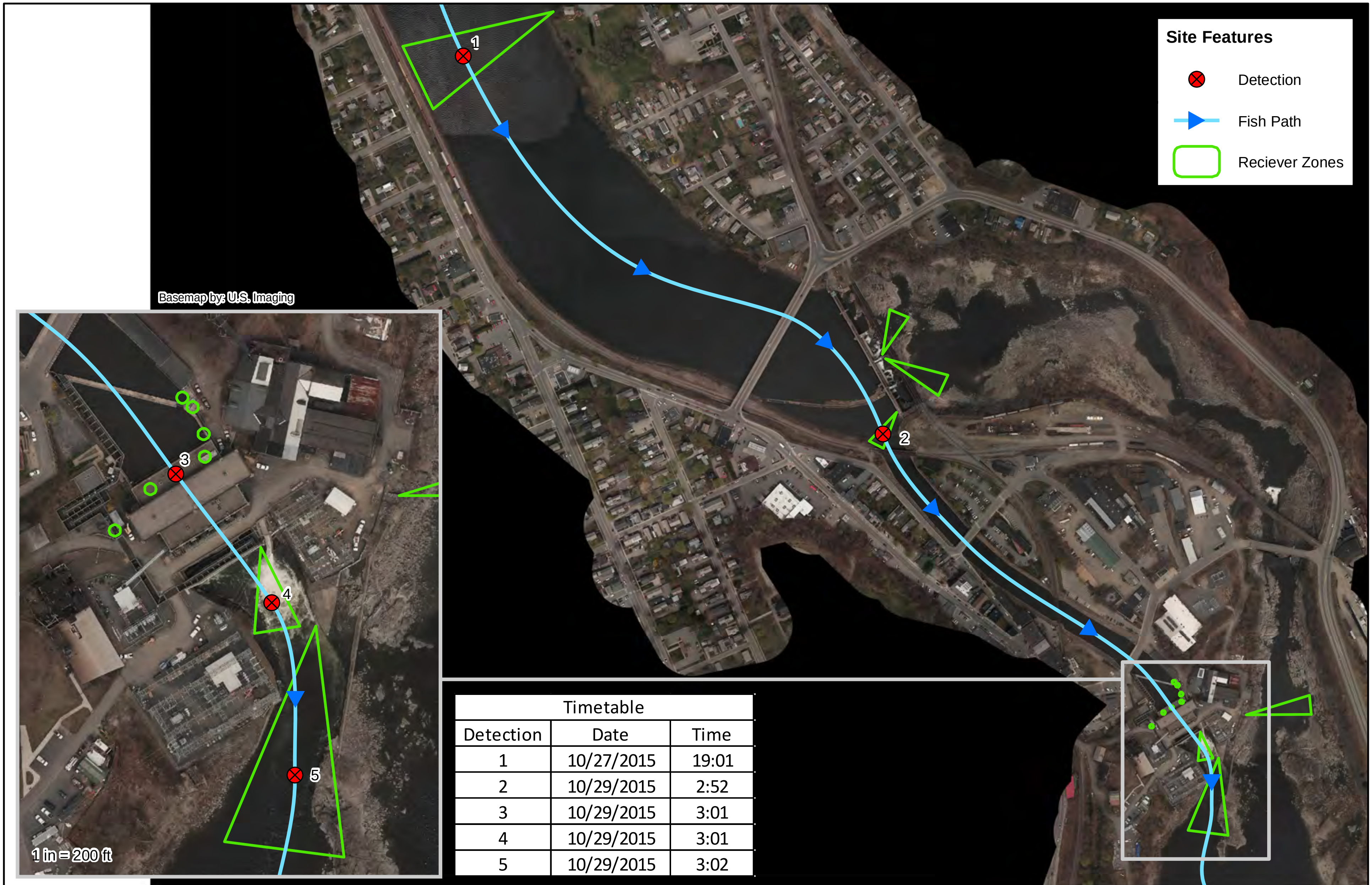

Timetable		
Detection	Date	Time
1	10/27/2015	19:01
2	10/29/2015	2:52
3	10/29/2015	3:01
4	10/29/2015	3:01
5	10/29/2015	3:02

TransCanada Hydro Northeast Inc.
ILP Study 19
Bellows Falls Dam

1 in = 600 feet

0 300 600 1,200 Feet

Study 19 Fish Number: 34-114

Release: Herricks Cove, VT
Date Released: 10/27/2015
Time Released: 18:20

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Environmental Consultants

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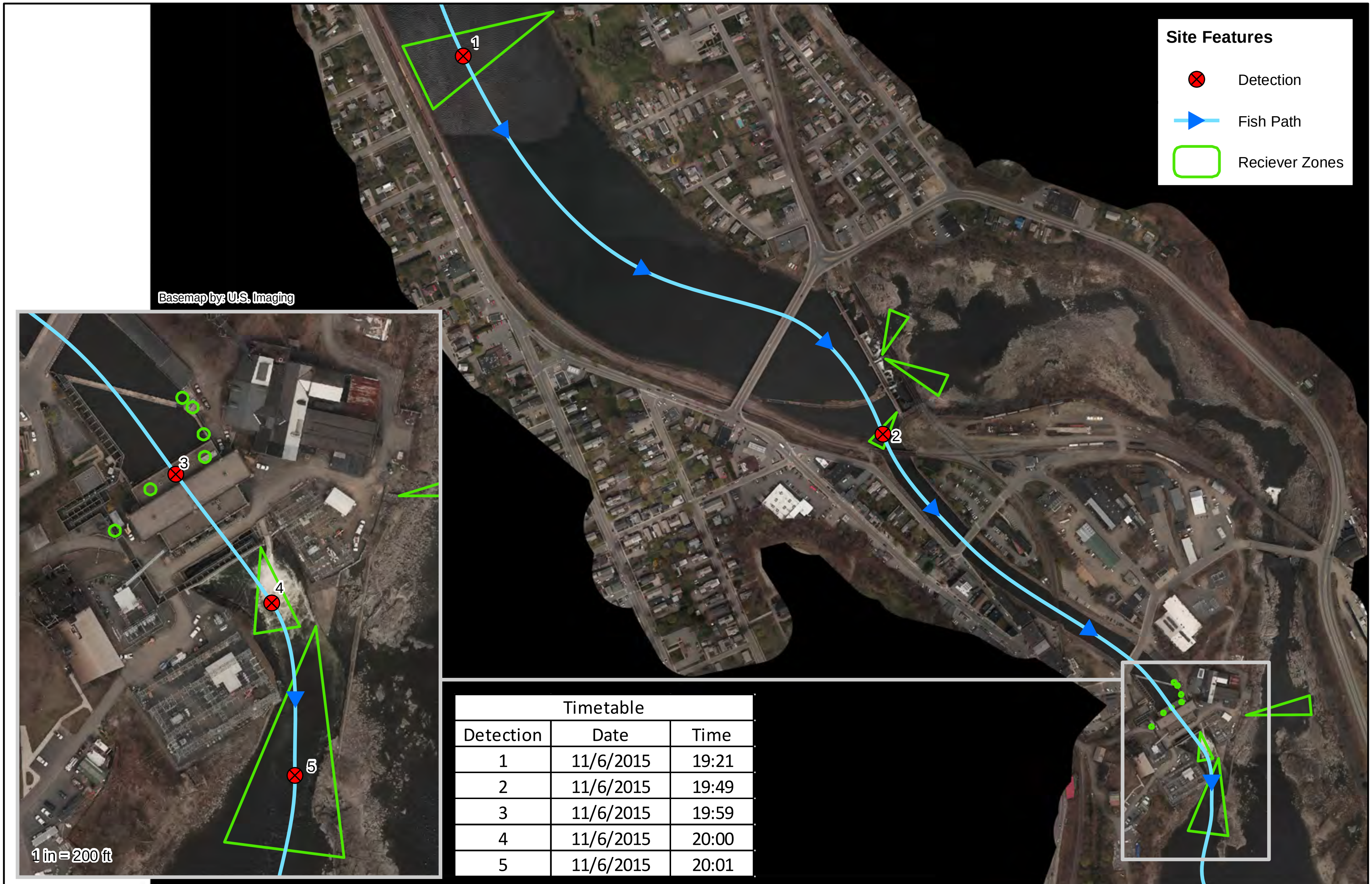
J:\Jen_TEST\TransCanada\S19\REV_2017\Bellows\MXD\TC_Bellows_34_114_A1_021017jo.mxd



Timetable		
Detection	Date	Time
1	11/6/2015	19:21
2	11/6/2015	19:49
3	11/6/2015	19:59
4	11/6/2015	20:00
5	11/6/2015	20:01

TransCanada Hydro Northeast Inc.
ILP Study 19
Bellows Falls Dam

1 in = 600 feet

0 300 600 1,200 Feet

Study 19 Fish Number: 34-115

Release: Herricks Cove, VT
Date Released: 11/03/2015
Time Released: 16:45

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Bedford, NH USA
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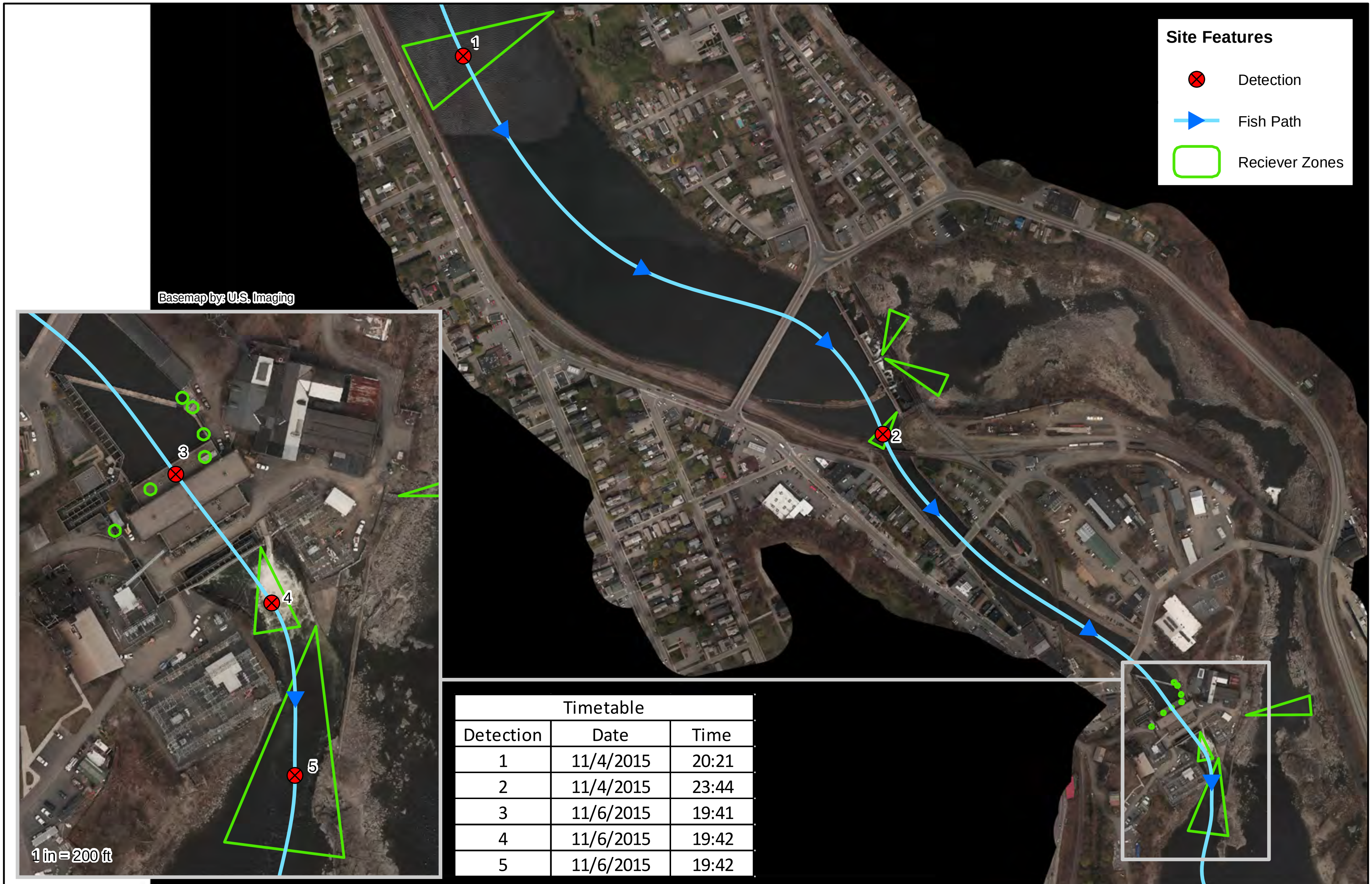
J:\Jen_TEST\TransCanada\S19\REV_2017\Bellows\MXD\TC_Bellows_34_115_T1_021017jo.mxd



Timetable		
Detection	Date	Time
1	11/4/2015	20:21
2	11/4/2015	23:44
3	11/6/2015	19:41
4	11/6/2015	19:42
5	11/6/2015	19:42

TransCanada Hydro Northeast Inc.
ILP Study 19
Bellows Falls Dam

N

1 in = 600 feet

0 300 600 1,200 Feet

Study 19 Fish Number: 34-116

Release: Herricks Cove, VT
Date Released: 11/03/2015
Time Released: 16:45

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Environmental Consultants

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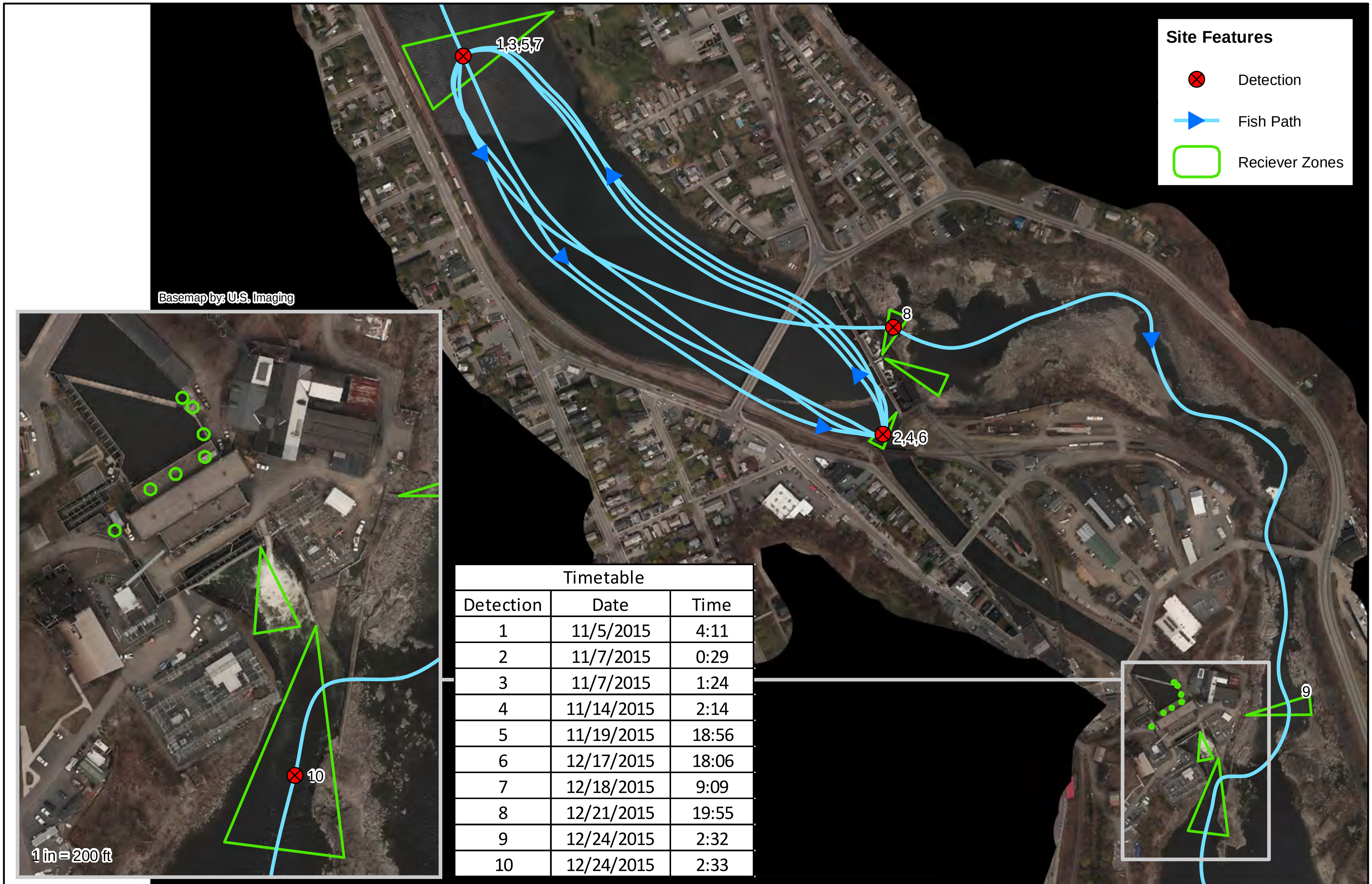
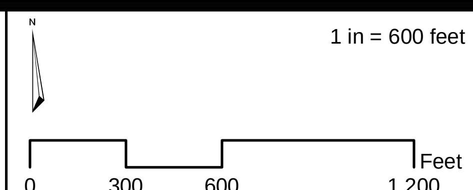
Bedford, NH USA
03110

J:\Jen_TEST\TransCanada\S19\REV_2017\Bellows\MXD\TC_Bellows_34_116_T1_021017jo.mxd



Timetable		
Detection	Date	Time
1	11/5/2015	4:11
2	11/7/2015	0:29
3	11/7/2015	1:24
4	11/14/2015	2:14
5	11/19/2015	18:56
6	12/17/2015	18:06
7	12/18/2015	9:09
8	12/21/2015	19:55
9	12/24/2015	2:32
10	12/24/2015	2:33

TransCanada Hydro Northeast Inc.
ILP Study 19
Bellows Falls Dam



Study 19 Fish Number: 34-117

Release: Herricks Cove, VT
Date Released: 11/03/2015
Time Released: 16:45

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Environmental Consultants

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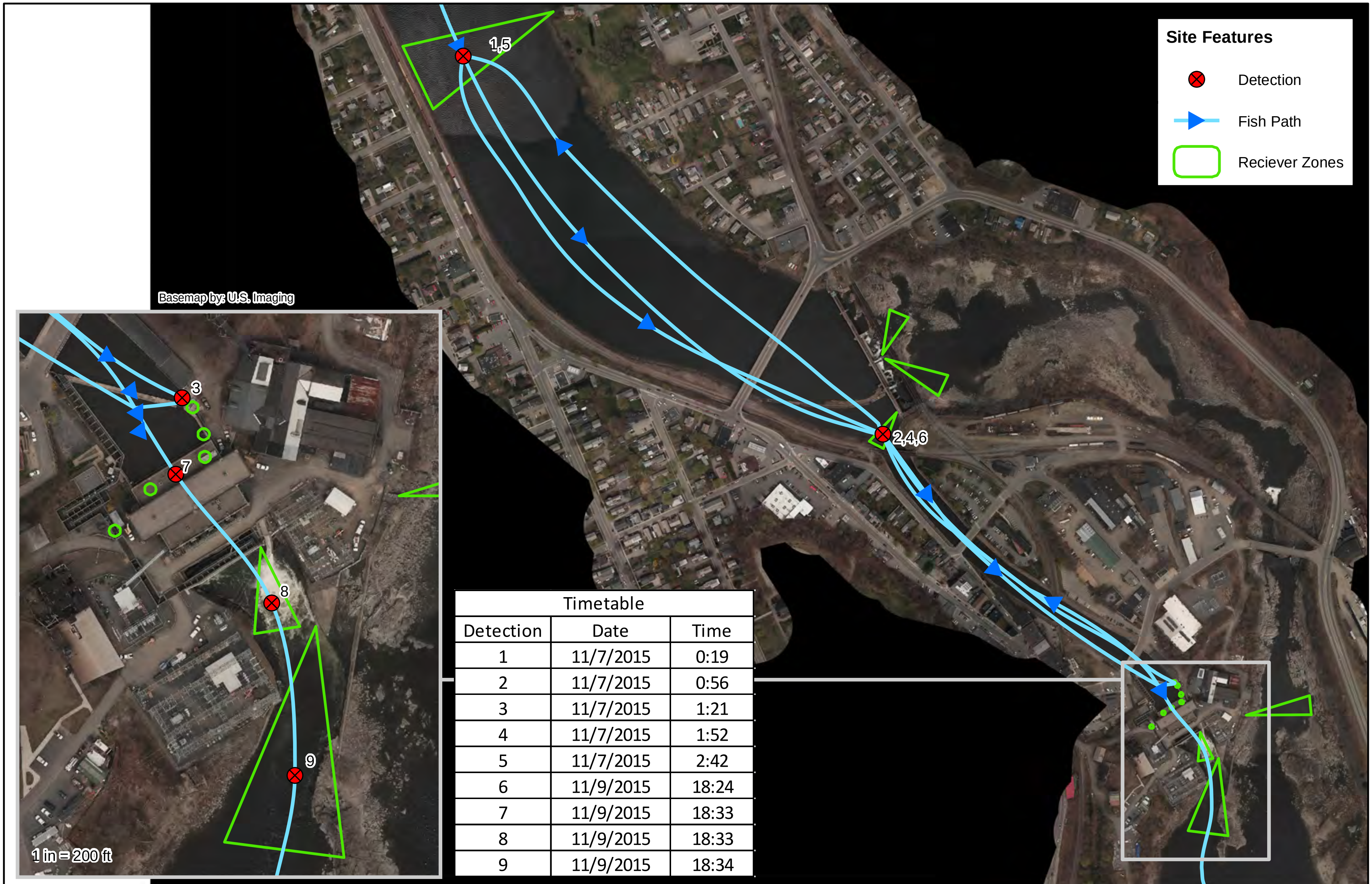
J:\Jen_TEST\TransCanada\S19\REV_2017\Bellows\MXD\TC_Bellows_34_117_T1_021017jo.mxd



Timetable		
Detection	Date	Time
1	11/7/2015	0:19
2	11/7/2015	0:56
3	11/7/2015	1:21
4	11/7/2015	1:52
5	11/7/2015	2:42
6	11/9/2015	18:24
7	11/9/2015	18:33
8	11/9/2015	18:33
9	11/9/2015	18:34

TransCanada Hydro Northeast Inc.
ILP Study 19
Bellows Falls Dam

Study 19 Fish Number: 34-118

Release: Bellows Falls, VT
Date Released: 11/03/2015
Time Released: 16:45

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Environmental Consultants

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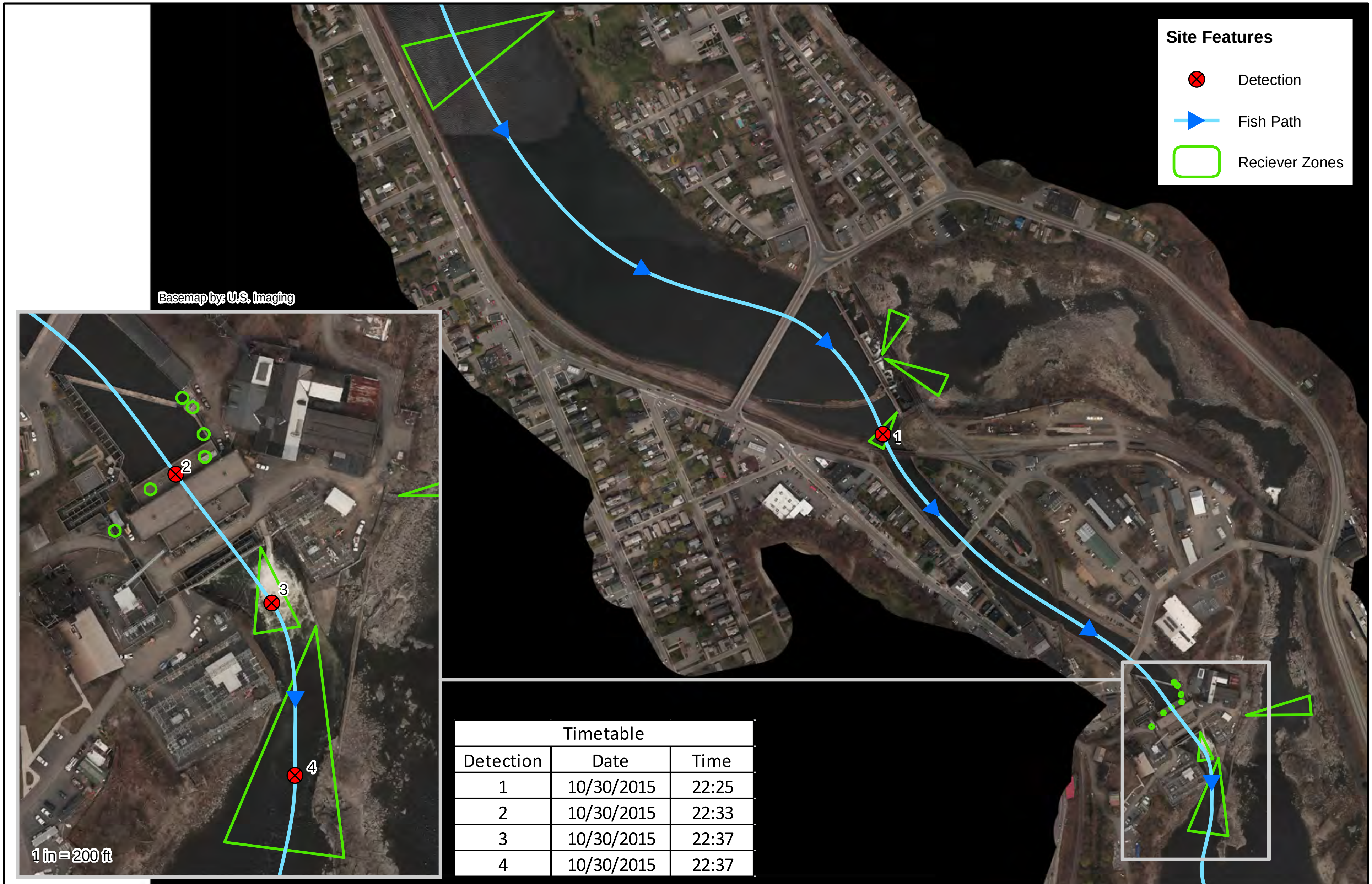
J:\Jen_TEST\TransCanada\S19\REV_2017\Bellows\MXD\TC_Bellows_34_118_T1_021017jo.mxd



Timetable		
Detection	Date	Time
1	10/30/2015	22:25
2	10/30/2015	22:33
3	10/30/2015	22:37
4	10/30/2015	22:37

TransCanada Hydro Northeast Inc.
ILP Study 19
Bellows Falls Dam

1 in = 600 feet

0 300 600 1,200 Feet

Study 19 Fish Number: 34-121

Release: Norwich, VT
Date Released: 10/27/2015
Time Released: 20:05

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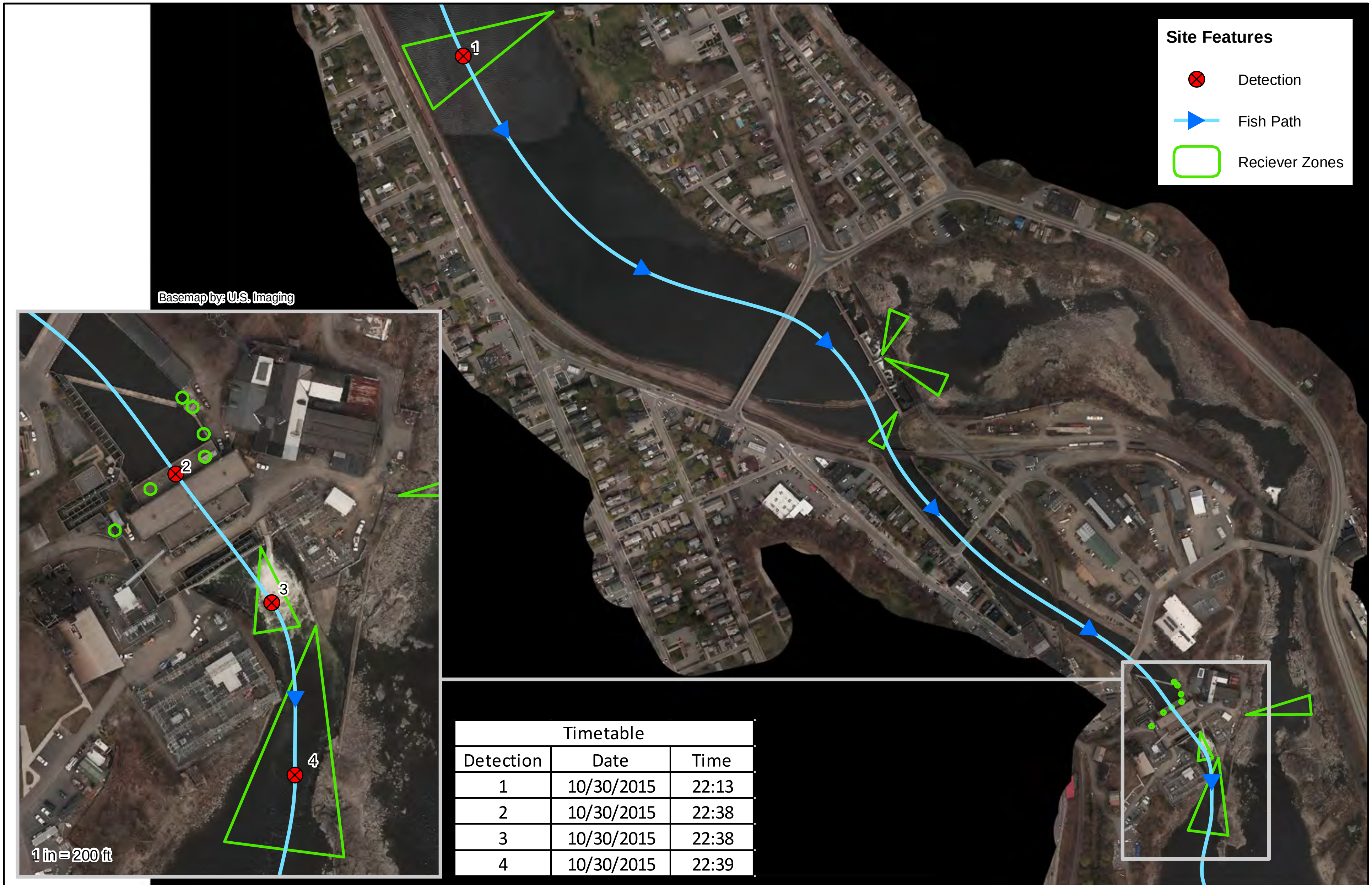

Timetable		
Detection	Date	Time
1	10/30/2015	22:13
2	10/30/2015	22:38
3	10/30/2015	22:38
4	10/30/2015	22:39

TransCanada Hydro Northeast Inc.
ILP Study 19
Bellows Falls Dam

N

1 in = 600 feet

0 300 600 1,200 Feet

Study 19 Fish Number: 34-122

Release: Norwich, VT
Date Released: 10/27/2015
Time Released: 20:05

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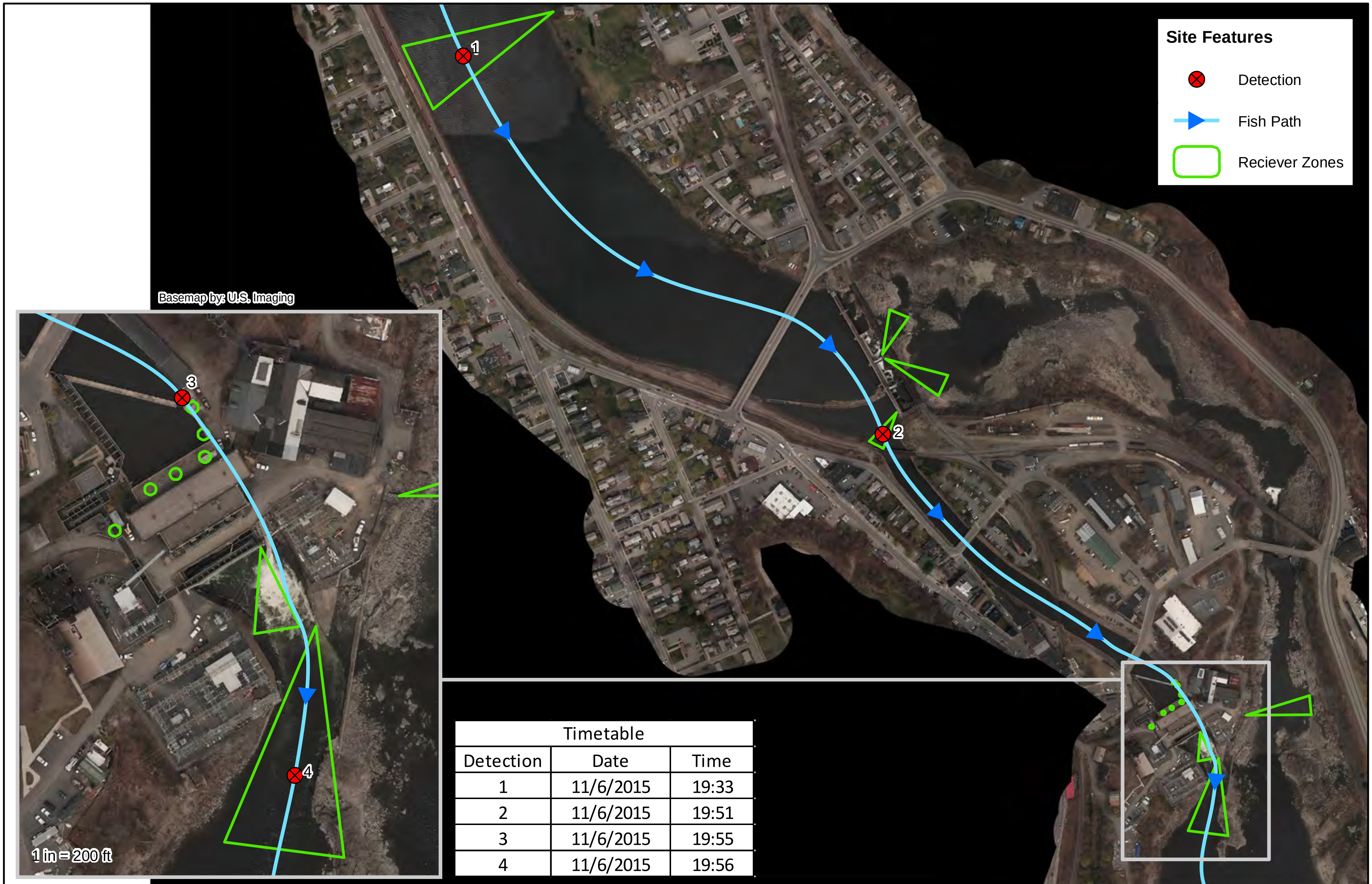

Timetable		
Detection	Date	Time
1	11/6/2015	19:33
2	11/6/2015	19:51
3	11/6/2015	19:55
4	11/6/2015	19:56

TransCanada Hydro Northeast Inc.
ILP Study 19
Bellows Falls Dam

N

1 in = 600 feet

0 300 600 1,200 Feet

Study 19 Fish Number: 34-128

Release: Norwich, VT
Date Released: 11/03/2015
Time Released: 17:32

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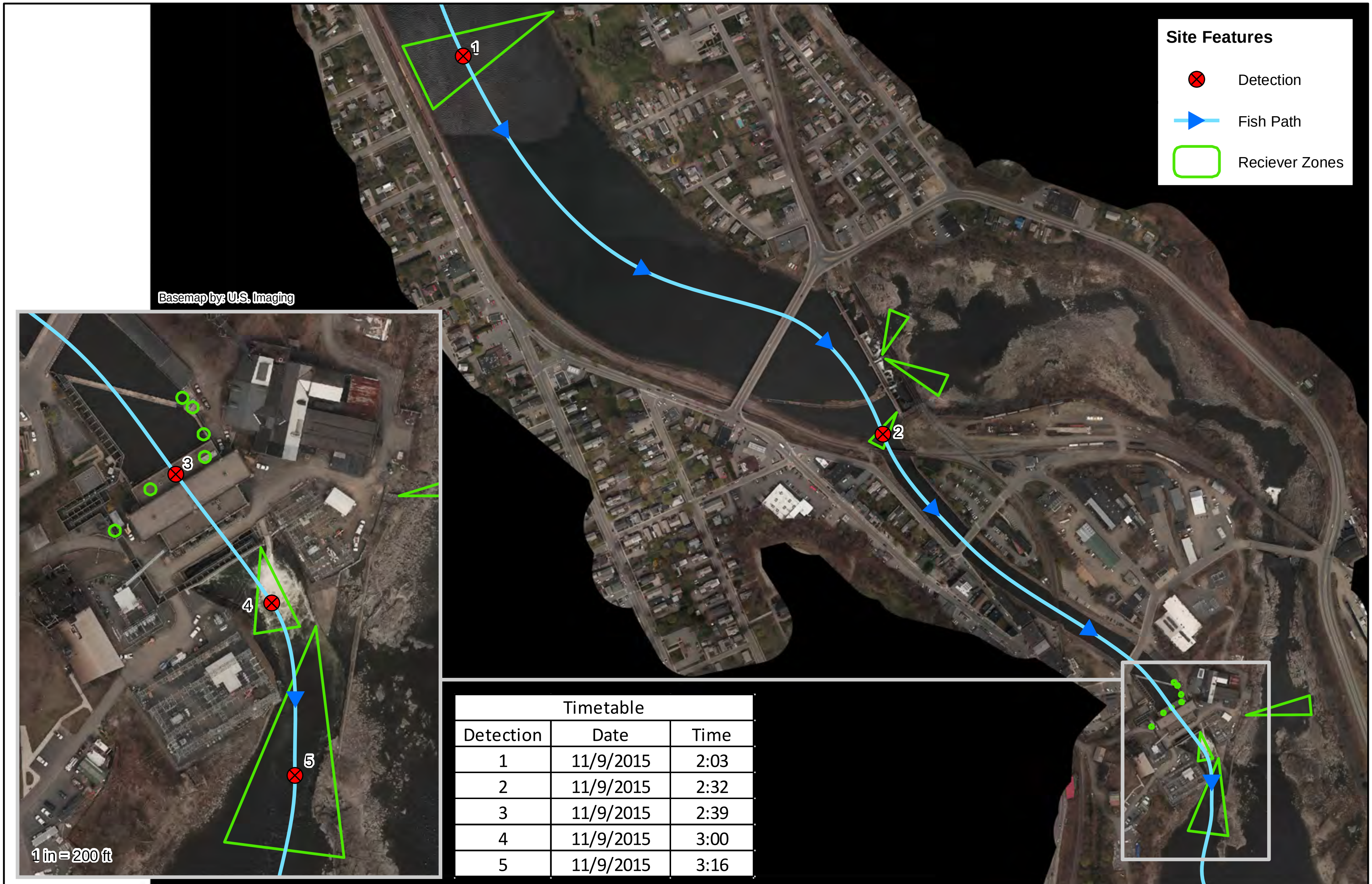

Timetable		
Detection	Date	Time
1	11/9/2015	2:03
2	11/9/2015	2:32
3	11/9/2015	2:39
4	11/9/2015	3:00
5	11/9/2015	3:16

TransCanada Hydro Northeast Inc.
ILP Study 19
Bellows Falls Dam

N

1 in = 600 feet

0 300 600 1,200 Feet

Study 19 Fish Number: 34-129

Release: Norwich, VT
Date Released: 11/03/2015
Time Released: 17:32

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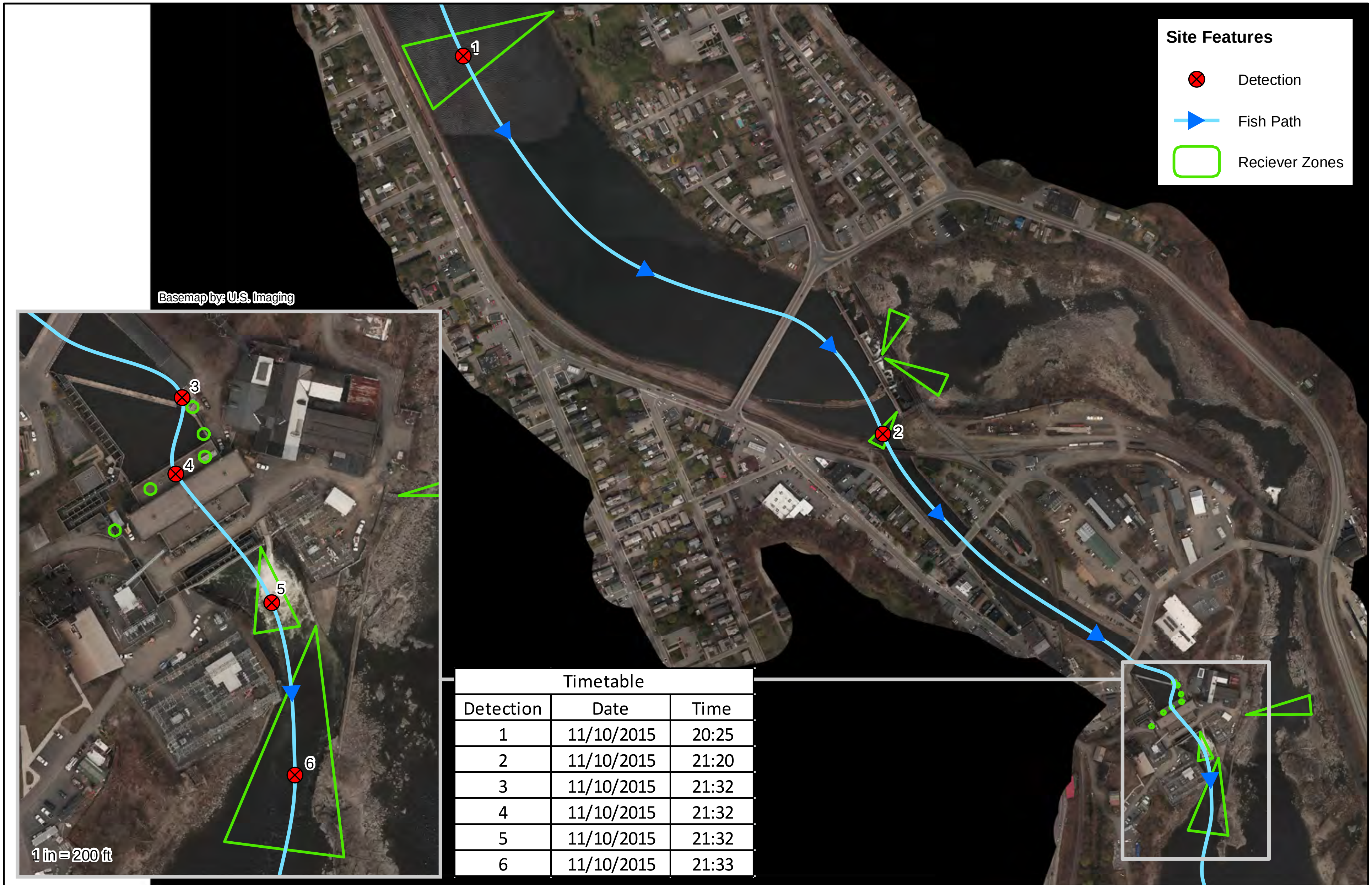

Timetable		
Detection	Date	Time
1	11/10/2015	20:25
2	11/10/2015	21:20
3	11/10/2015	21:32
4	11/10/2015	21:32
5	11/10/2015	21:32
6	11/10/2015	21:33

TransCanada Hydro Northeast Inc.
ILP Study 19
Bellows Falls Dam

N

1 in = 600 feet

0 300 600 1,200 Feet

Study 19 Fish Number: 34-130

Release: Norwich, VT
Date Released: 11/03/2015
Time Released: 17:32

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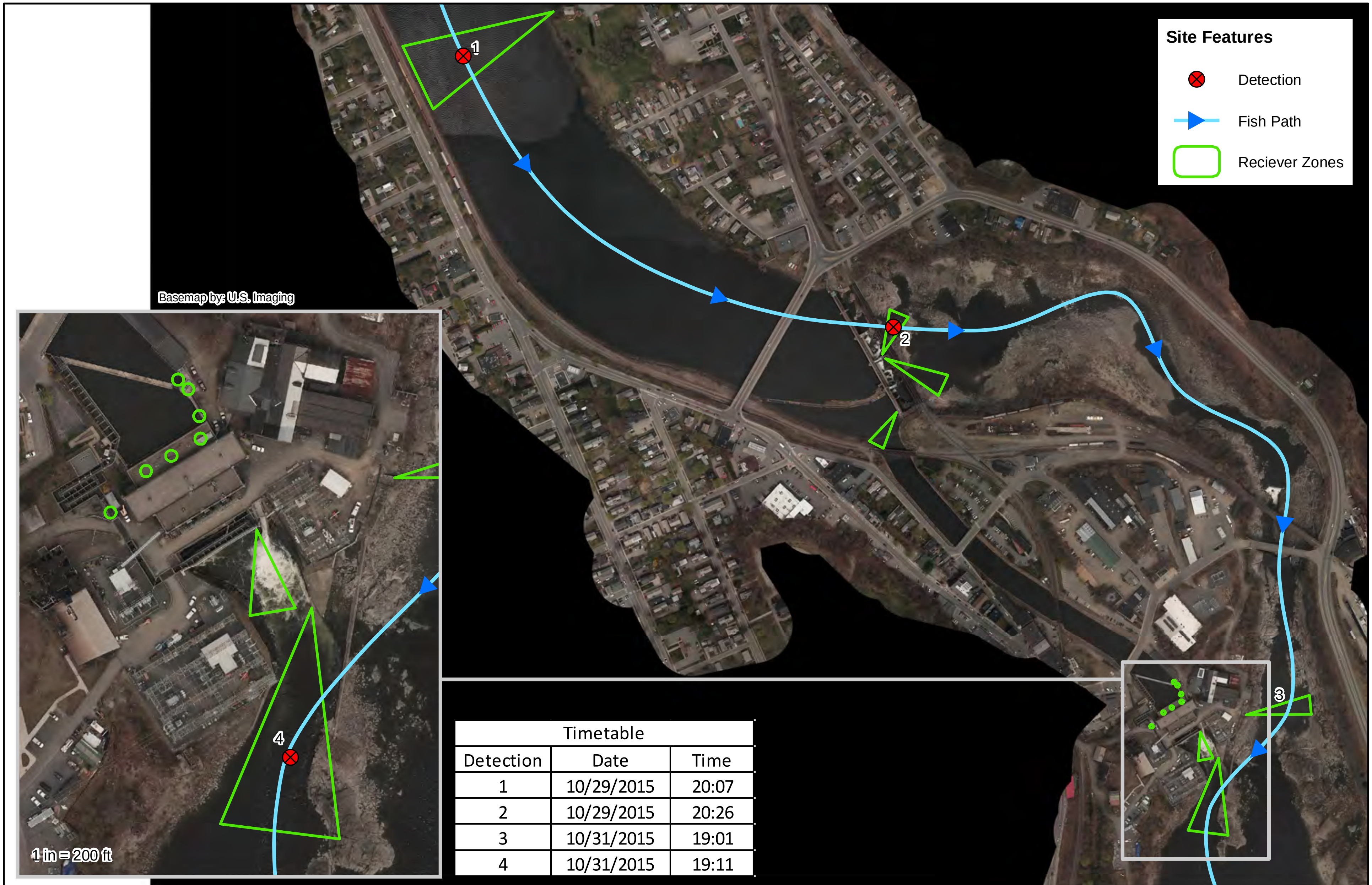

Timetable		
Detection	Date	Time
1	10/29/2015	20:07
2	10/29/2015	20:26
3	10/31/2015	19:01
4	10/31/2015	19:11

TransCanada Hydro Northeast Inc.
ILP Study 19
Bellows Falls Dam

1 in = 600 feet

0 300 600 1,200 Feet

Study 19 Fish Number: 34-141

Release: Herricks Cove, VT
Date Released: 10/29/2015
Time Released: 17:52

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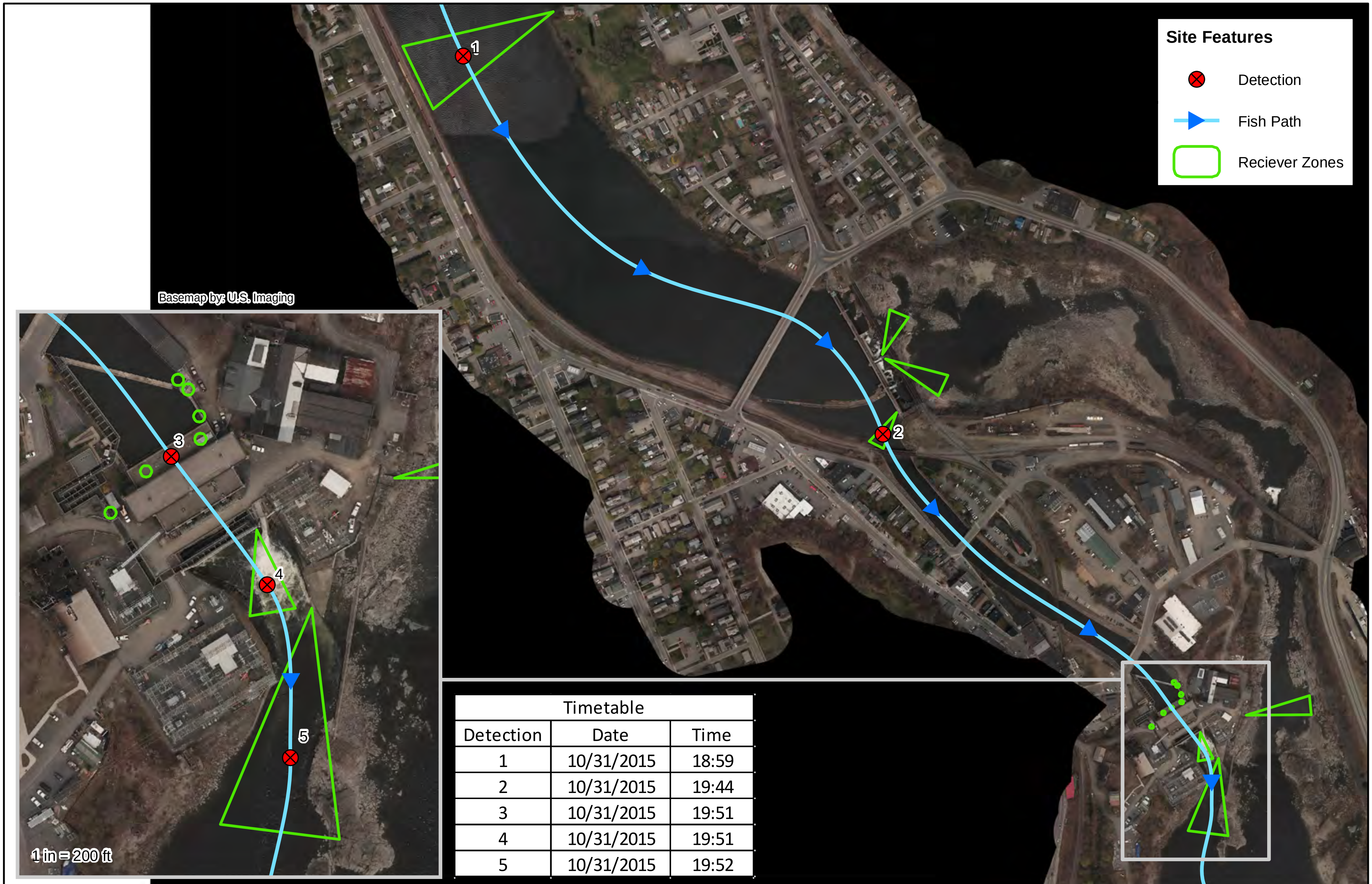

Timetable		
Detection	Date	Time
1	10/31/2015	18:59
2	10/31/2015	19:44
3	10/31/2015	19:51
4	10/31/2015	19:51
5	10/31/2015	19:52

TransCanada Hydro Northeast Inc.
ILP Study 19
Bellows Falls Dam

Study 19 Fish Number: 34-142

Release: Herricks Cove, VT
Date Released: 10/29/2015
Time Released: 17:52

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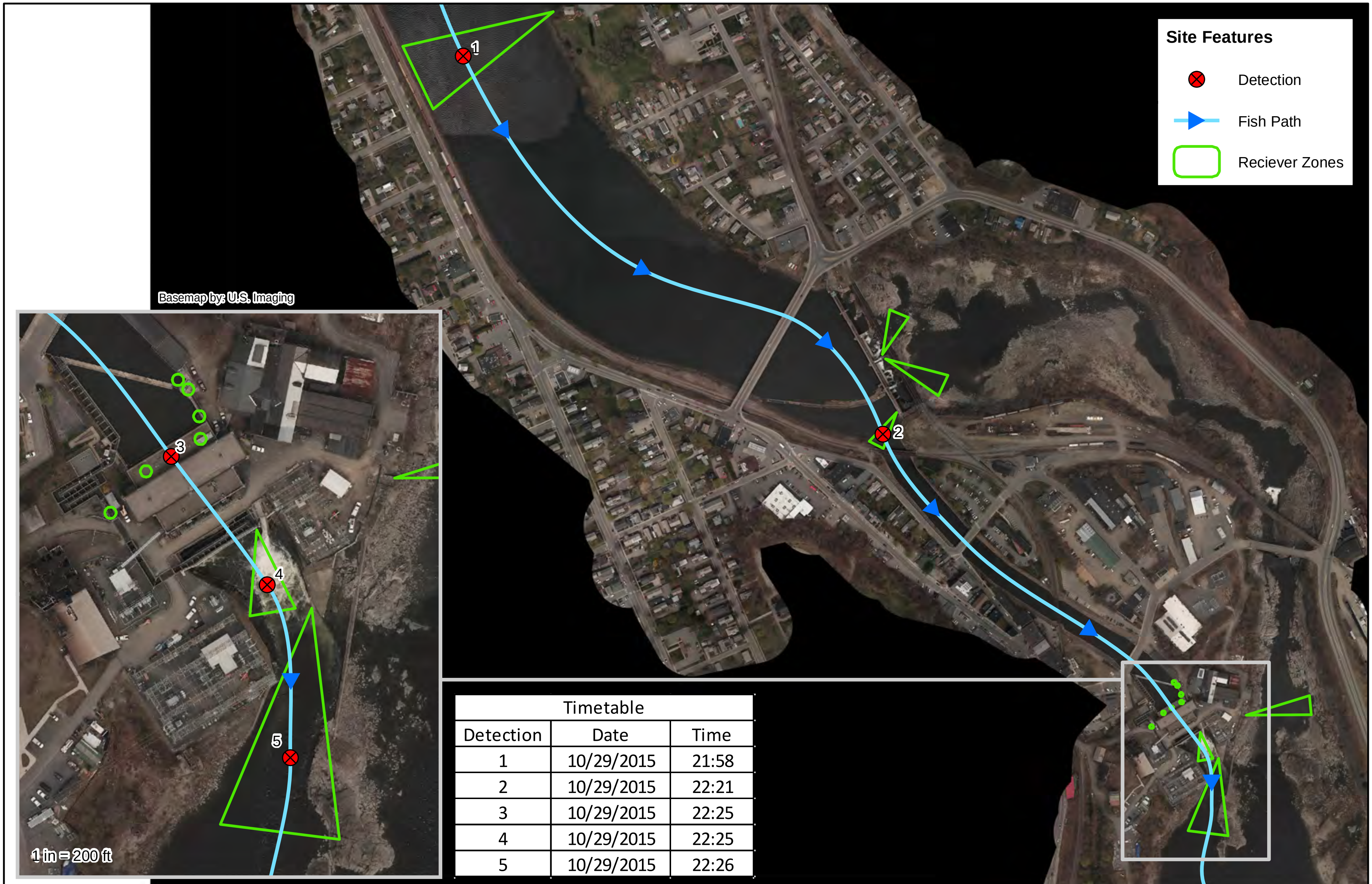

Timetable		
Detection	Date	Time
1	10/29/2015	21:58
2	10/29/2015	22:21
3	10/29/2015	22:25
4	10/29/2015	22:25
5	10/29/2015	22:26

TransCanada Hydro Northeast Inc.
ILP Study 19
Bellows Falls Dam

N

1 in = 600 feet

0 300 600 1,200 Feet

Study 19 Fish Number: 34-143

Release: Herricks Cove, VT
Date Released: 10/29/2015
Time Released: 17:52

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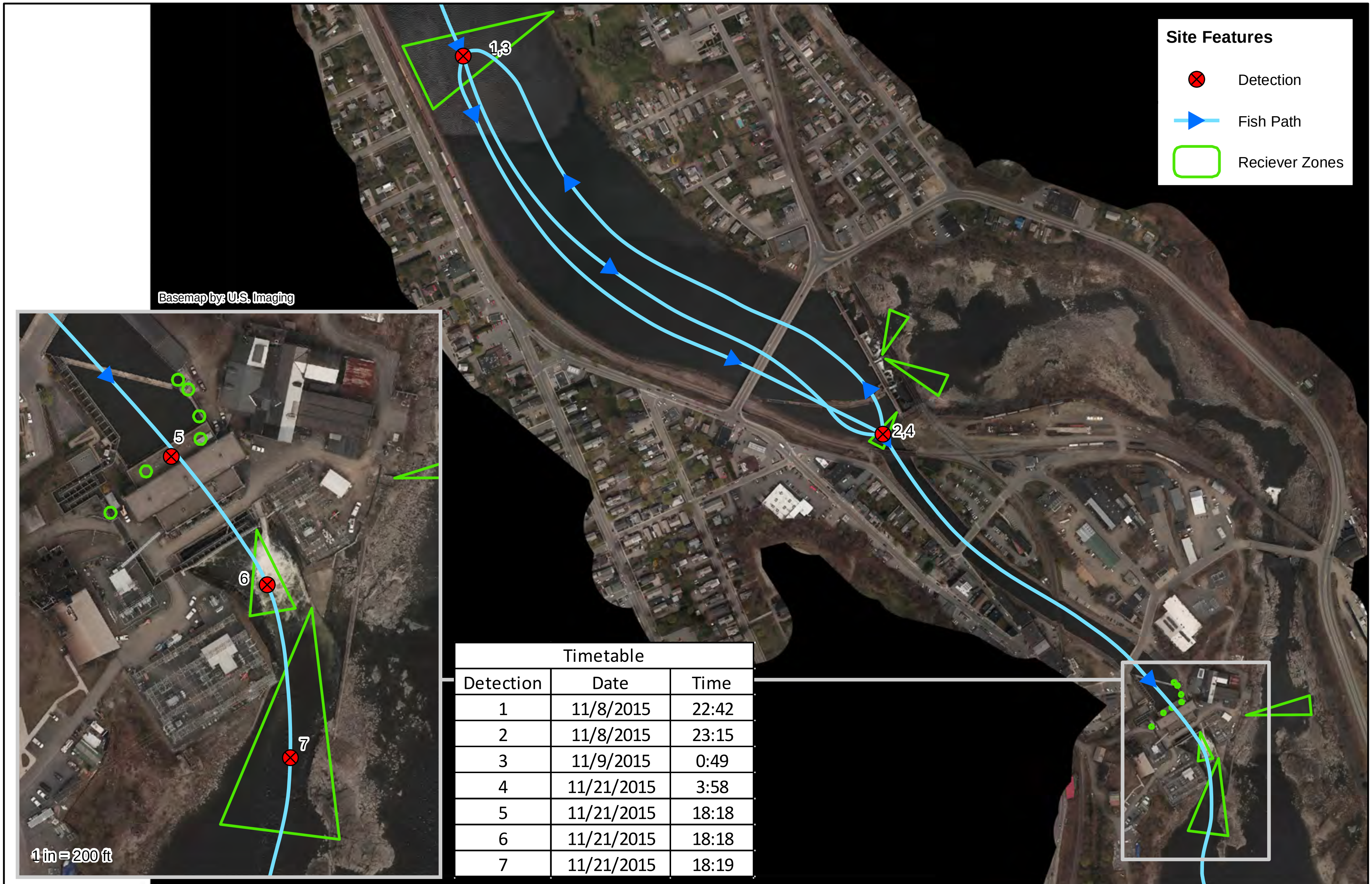

Timetable

Detection	Date	Time
1	11/8/2015	22:42
2	11/8/2015	23:15
3	11/9/2015	0:49
4	11/21/2015	3:58
5	11/21/2015	18:18
6	11/21/2015	18:18
7	11/21/2015	18:19

TransCanada Hydro Northeast Inc.
ILP Study 19
Bellows Falls Dam

N

1 in = 600 feet

0 300 600 1,200 Feet

Study 19 Fish Number: 34-148

Release: Herricks Cove, VT
Date Released: 11/05/2015
Time Released: 16:20

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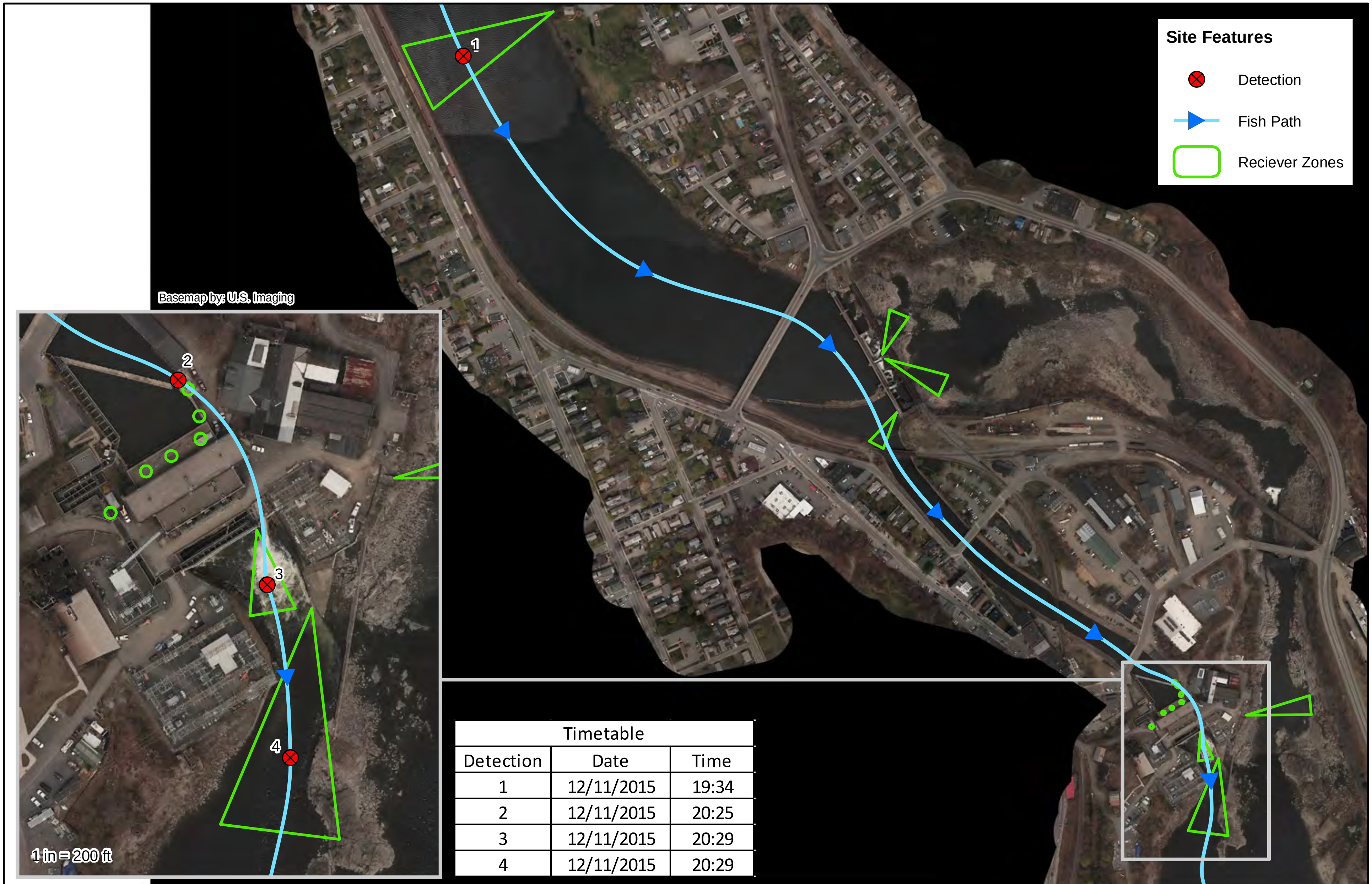

Timetable		
Detection	Date	Time
1	12/11/2015	19:34
2	12/11/2015	20:25
3	12/11/2015	20:29
4	12/11/2015	20:29

TransCanada Hydro Northeast Inc.
ILP Study 19
Bellows Falls Dam

N

1 in = 600 feet

0 300 600 1,200 Feet

Study 19 Fish Number: 34-149

Release: Herricks Cove, VT
Date Released: 11/05/2015
Time Released: 16:20

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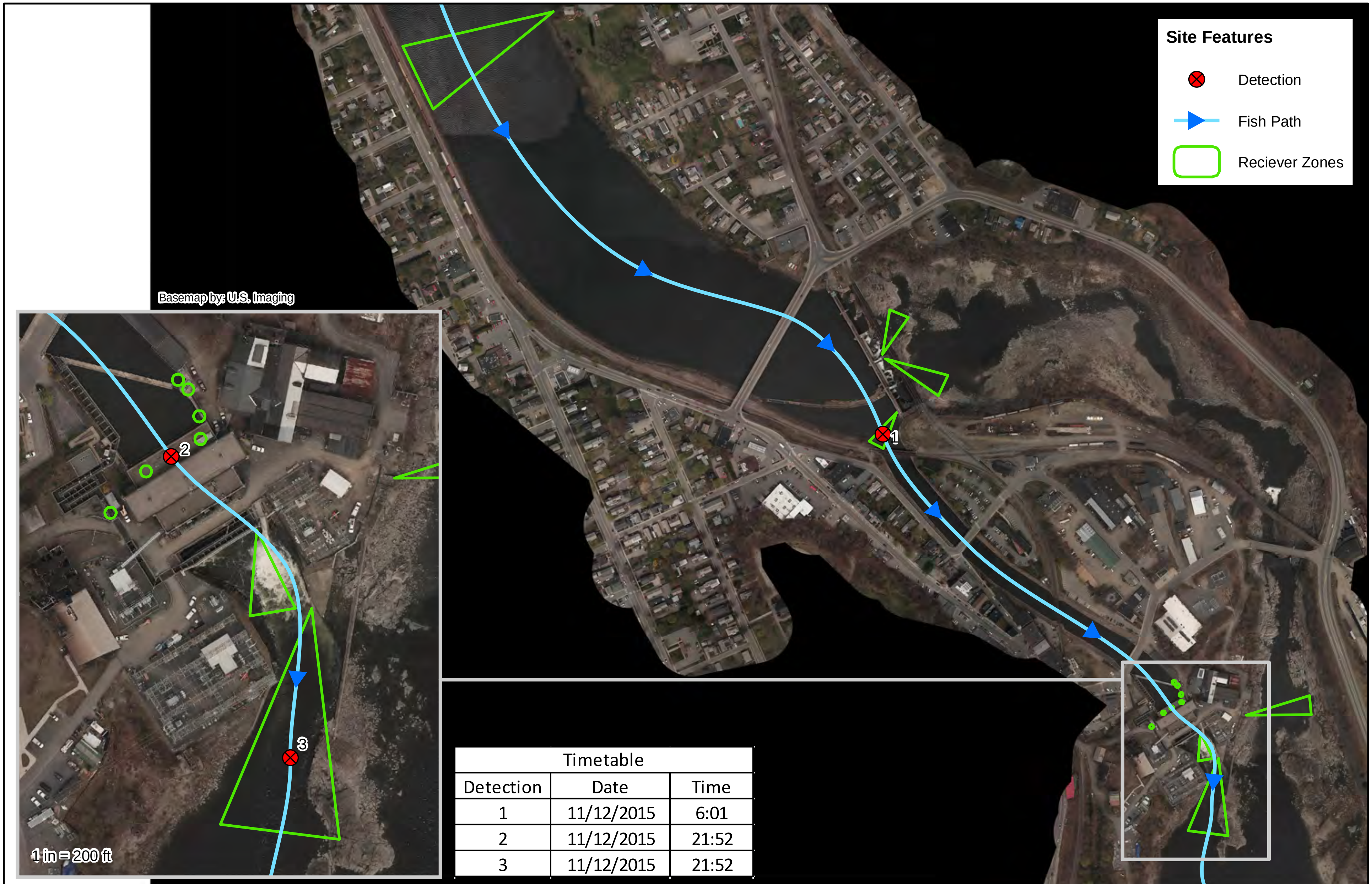

Timetable		
Detection	Date	Time
1	11/12/2015	6:01
2	11/12/2015	21:52
3	11/12/2015	21:52

TransCanada Hydro Northeast Inc.
ILP Study 19
Bellows Falls Dam

1 in = 600 feet

0 300 600 1,200 Feet

Study 19 Fish Number: 34-150

Release: Herricks Cove, VT
Date Released: 11/05/2015
Time Released: 16:20

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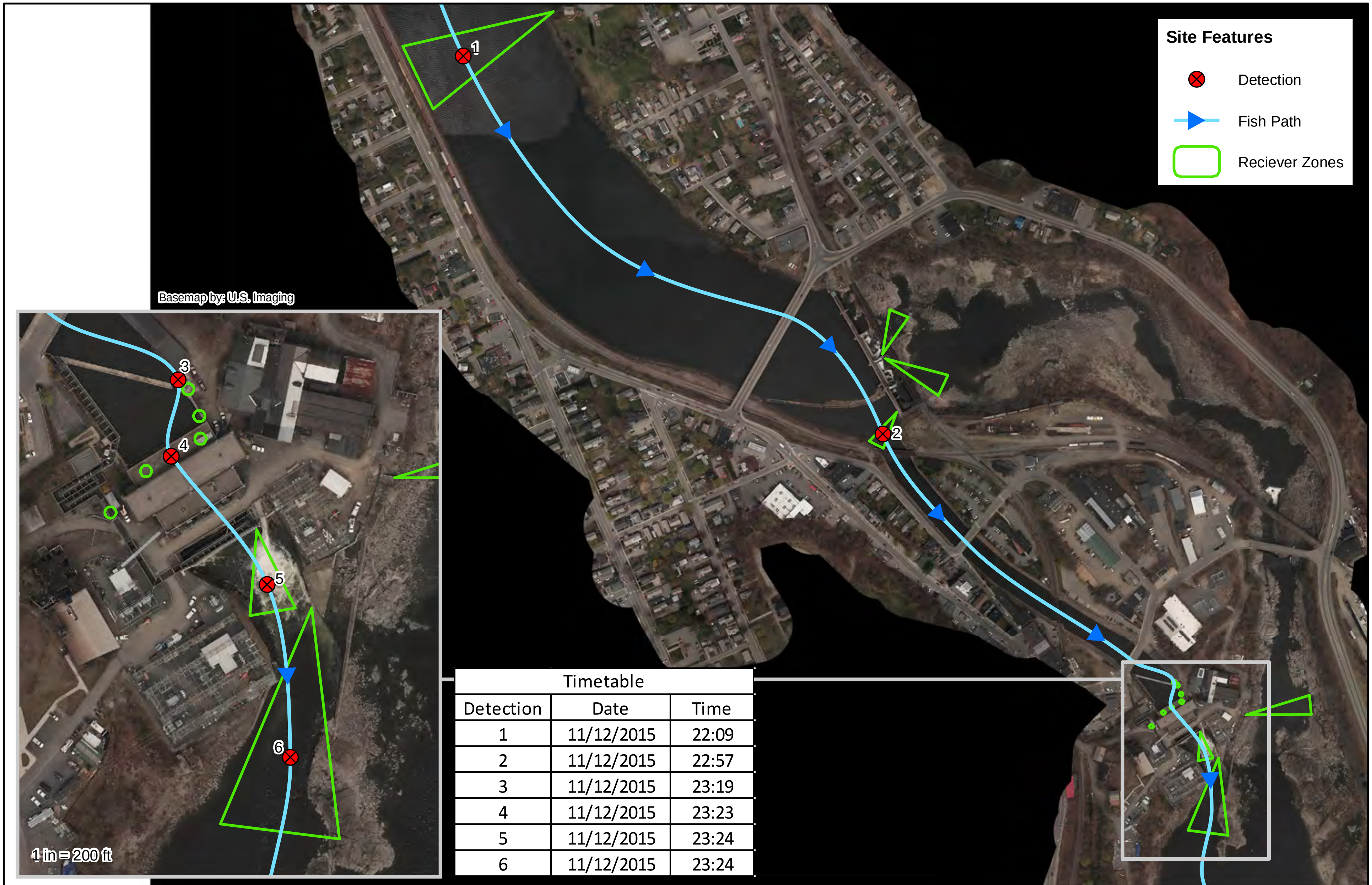

Timetable		
Detection	Date	Time
1	11/12/2015	22:09
2	11/12/2015	22:57
3	11/12/2015	23:19
4	11/12/2015	23:23
5	11/12/2015	23:24
6	11/12/2015	23:24

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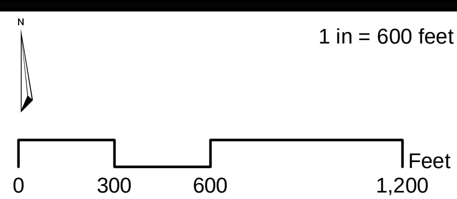
ILP Study 19
Bellows Falls Dam



Study 19 Fish Number: 34-151

Release: Norwich, VT
Date Released: 10/29/2015
Time Released: 18:43

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Environmental Consultants

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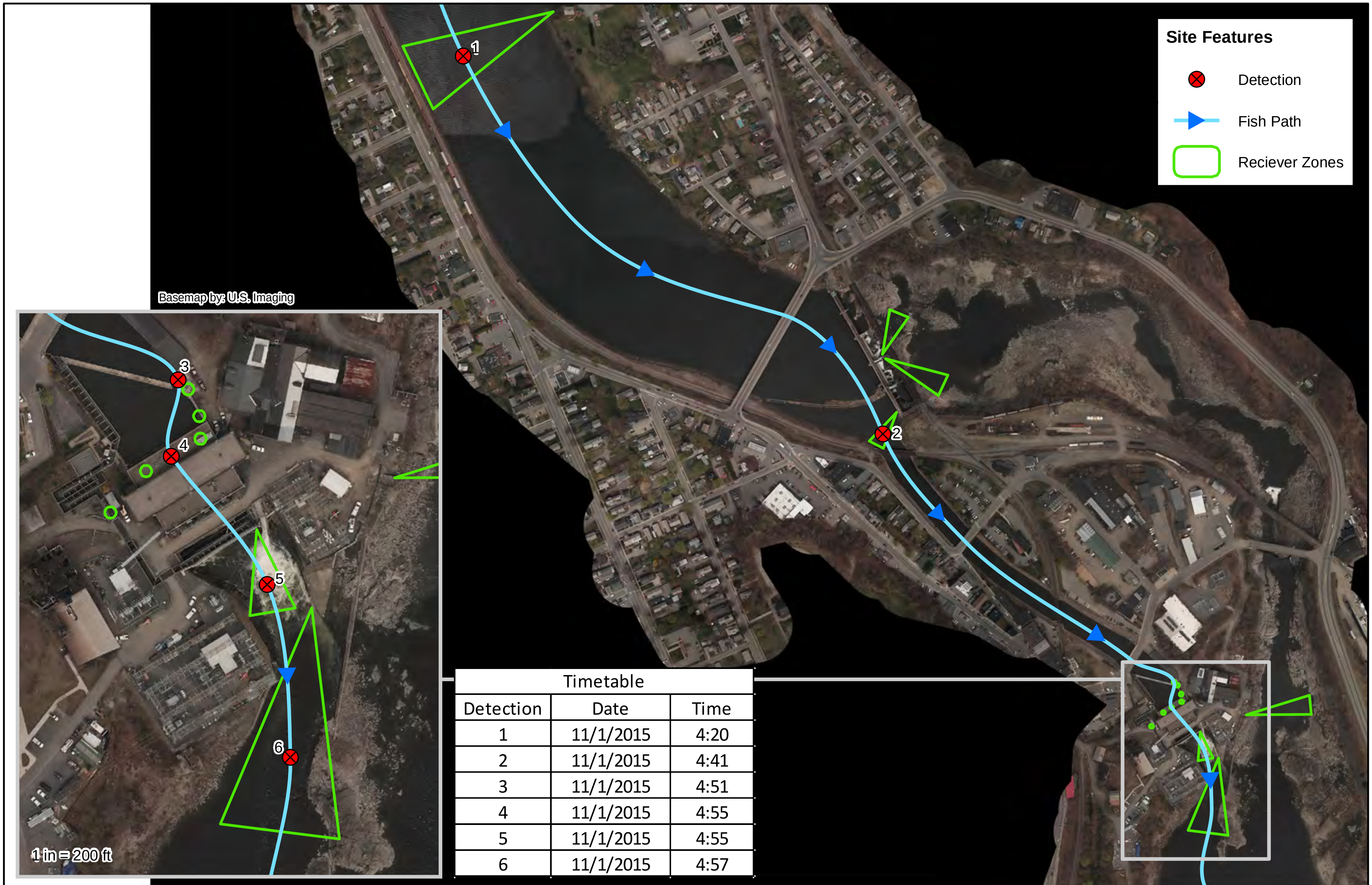

Timetable		
Detection	Date	Time
1	11/1/2015	4:20
2	11/1/2015	4:41
3	11/1/2015	4:51
4	11/1/2015	4:55
5	11/1/2015	4:55
6	11/1/2015	4:57

TransCanada Hydro Northeast Inc.
ILP Study 19
Bellows Falls Dam

N

1 in = 600 feet

0 300 600 1,200 Feet

Study 19 Fish Number: 34-152

Release: Norwich, VT
Date Released: 10/29/2015
Time Released: 18:43

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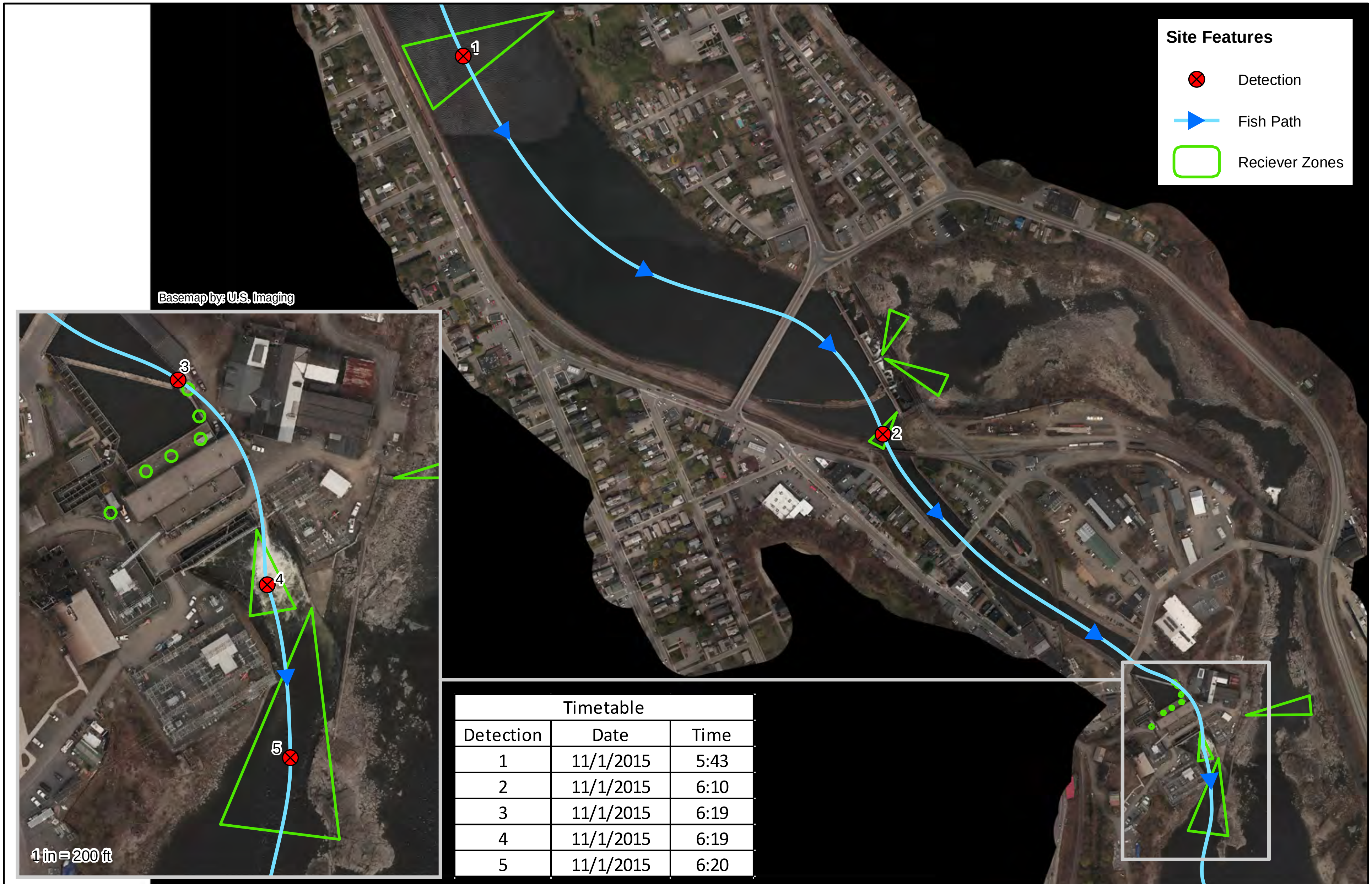

Timetable		
Detection	Date	Time
1	11/1/2015	5:43
2	11/1/2015	6:10
3	11/1/2015	6:19
4	11/1/2015	6:19
5	11/1/2015	6:20

TransCanada Hydro Northeast Inc.
ILP Study 19
Bellows Falls Dam

N

1 in = 600 feet

0 300 600 1,200 Feet

Study 19 Fish Number: 34-153

Release: Norwich, VT
Date Released: 10/29/2015
Time Released: 18:43

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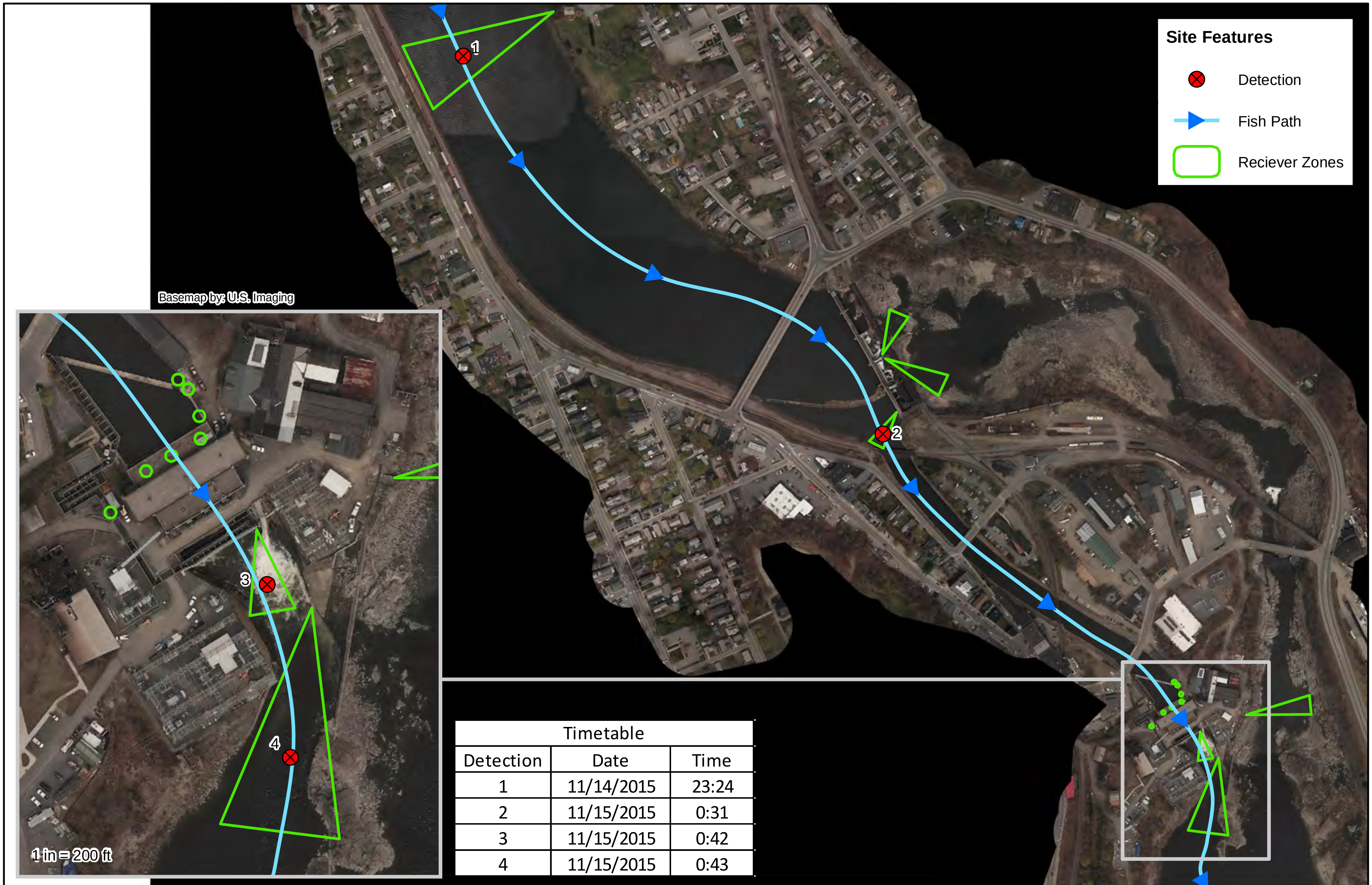

Timetable		
Detection	Date	Time
1	11/14/2015	23:24
2	11/15/2015	0:31
3	11/15/2015	0:42
4	11/15/2015	0:43

TransCanada Hydro Northeast Inc.
ILP Study 19
Bellows Falls Dam

N

1 in = 600 feet

0 300 600 1,200 Feet

Study 19 Fish Number: 34-156

Release: Norwich, VT
Date Released: 10/29/2015
Time Released:

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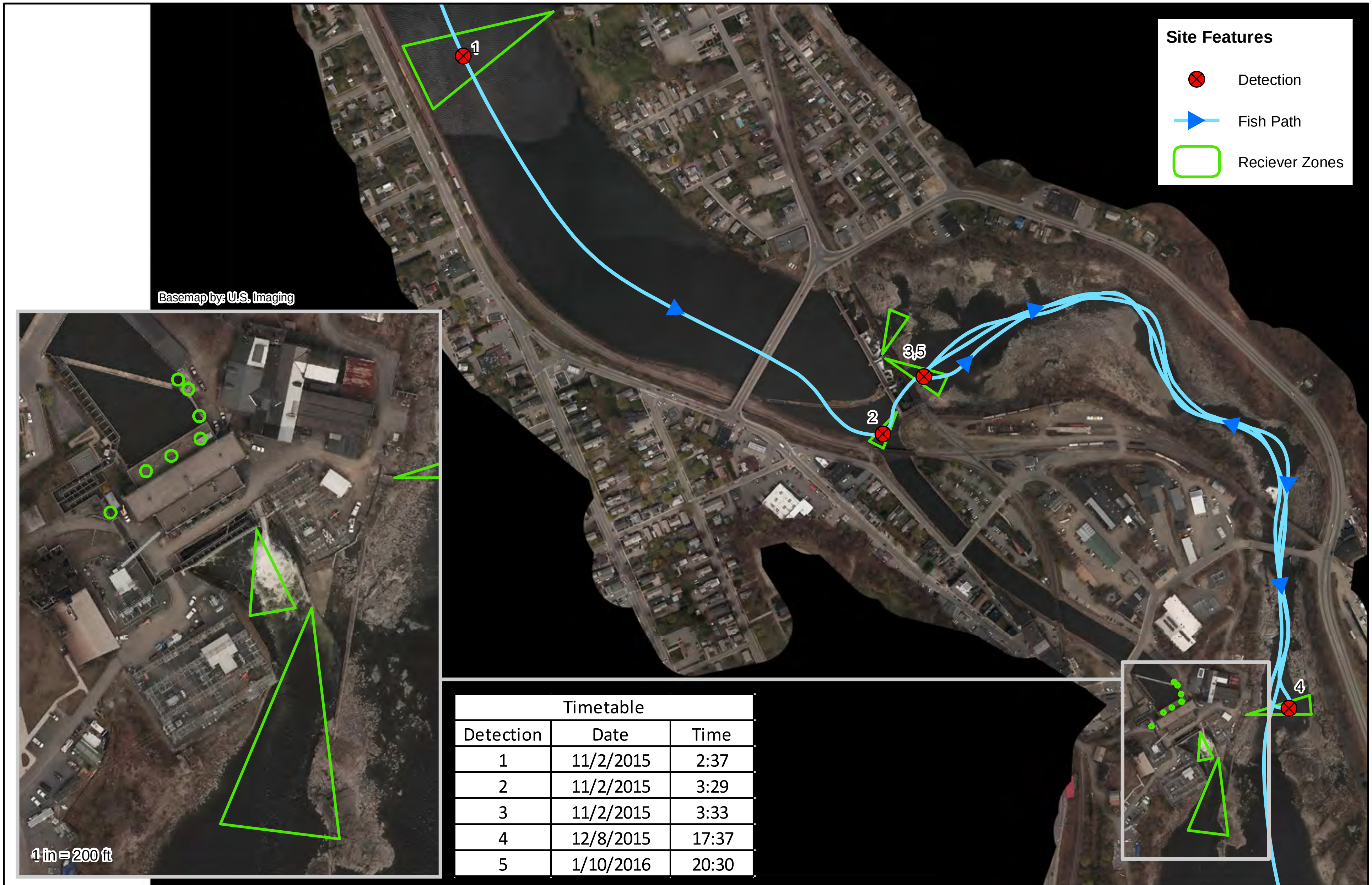
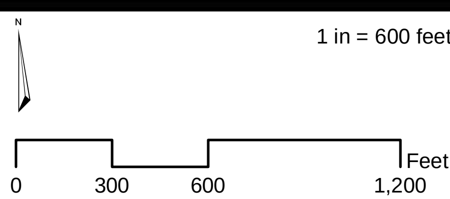


Timetable		
Detection	Date	Time
1	11/2/2015	2:37
2	11/2/2015	3:29
3	11/2/2015	3:33
4	12/8/2015	17:37
5	1/10/2016	20:30

TransCanada Hydro Northeast Inc.
ILP Study 19
Bellows Falls Dam



Study 19 Fish Number: 34-171

Release: Herricks Cove, VT
Date Released: 10/31/2015
Time Released: 18:22

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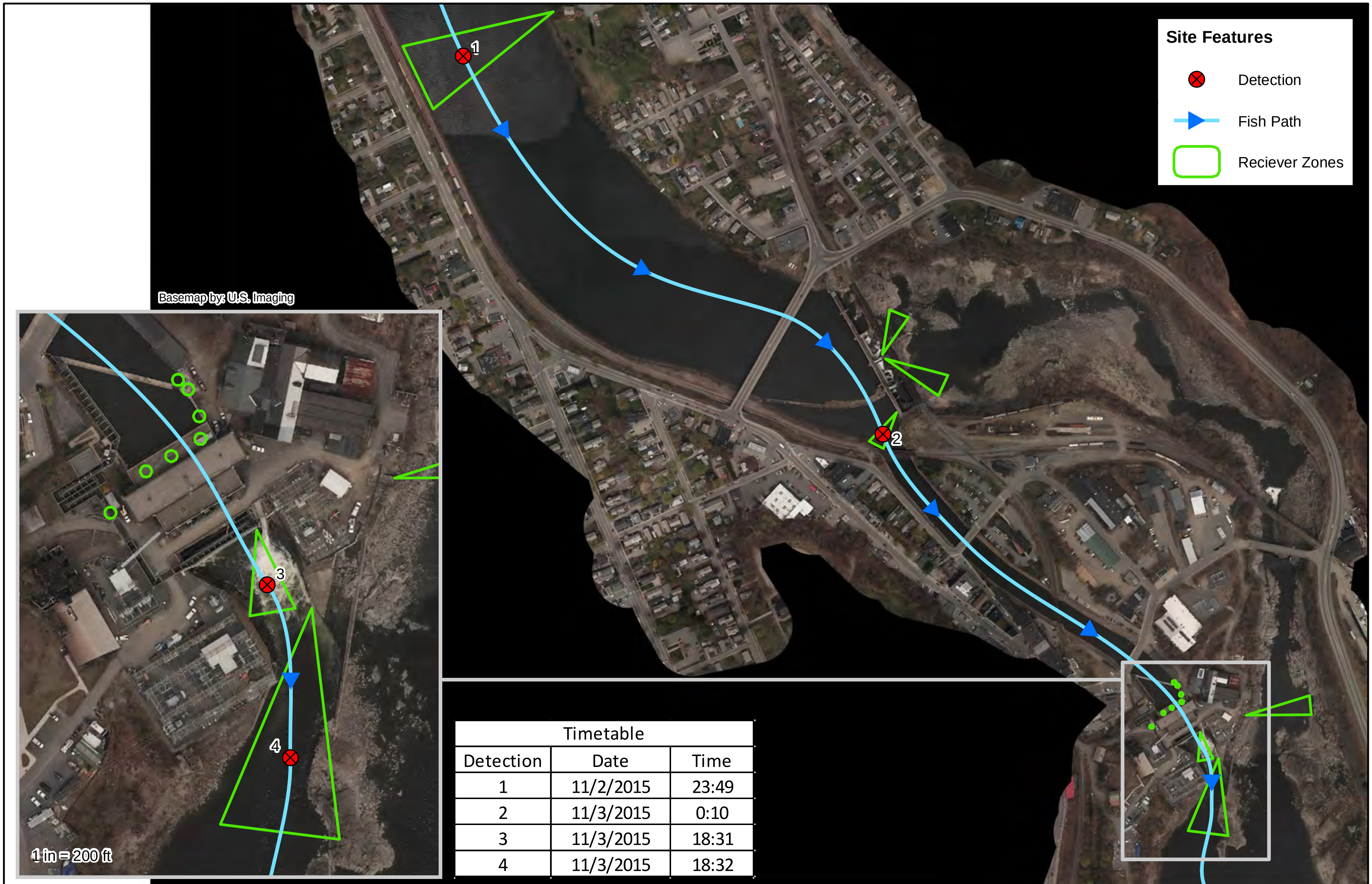

Timetable		
Detection	Date	Time
1	11/2/2015	23:49
2	11/3/2015	0:10
3	11/3/2015	18:31
4	11/3/2015	18:32

TransCanada Hydro Northeast Inc.
ILP Study 19
Bellows Falls Dam

N

1 in = 600 feet

0 300 600 1,200 Feet

Study 19 Fish Number: 34-173

Release: Herricks Cove, VT
Date Released: 10/31/2015
Time Released: 18:22

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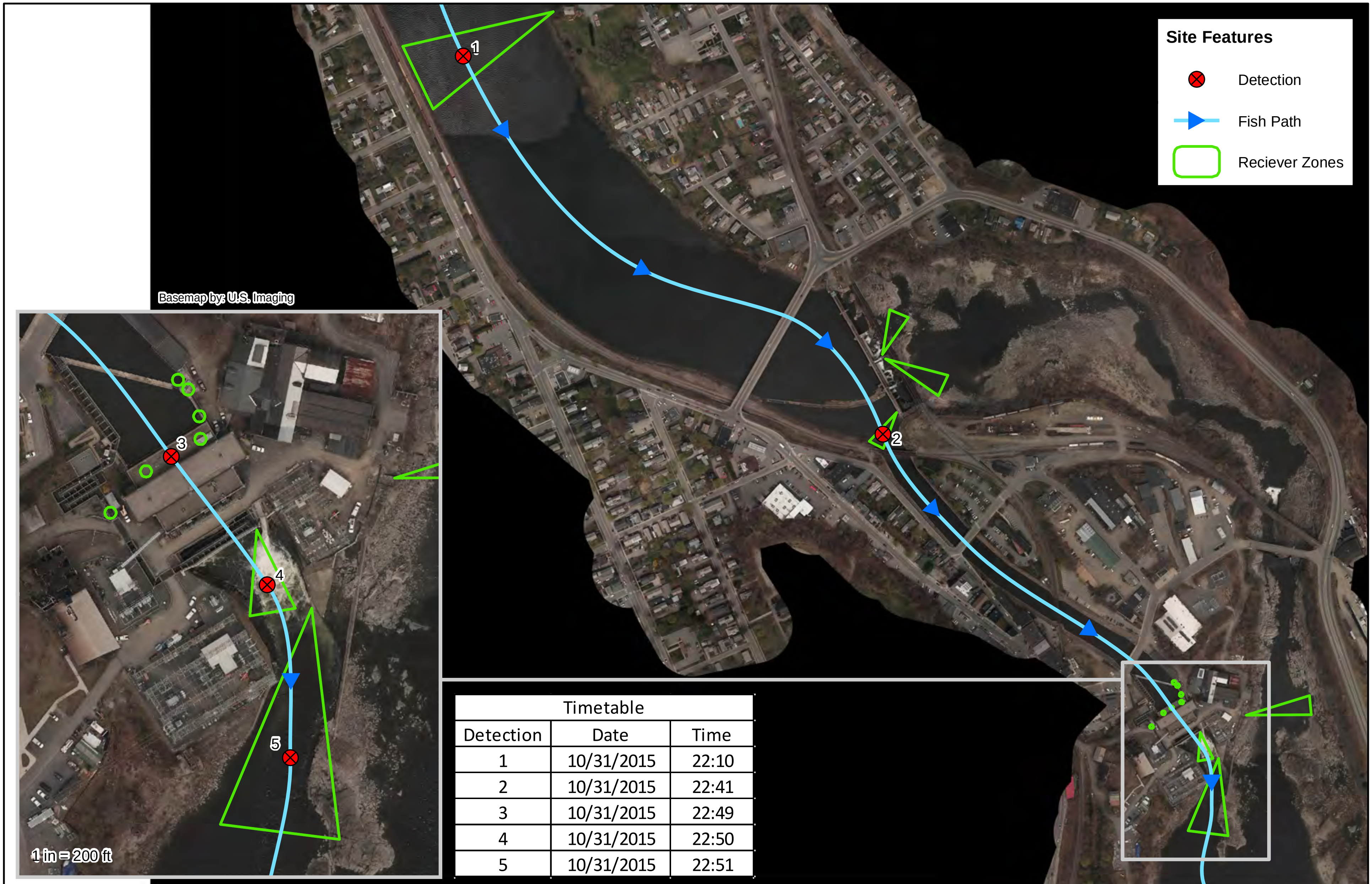

Timetable		
Detection	Date	Time
1	10/31/2015	22:10
2	10/31/2015	22:41
3	10/31/2015	22:49
4	10/31/2015	22:50
5	10/31/2015	22:51

TransCanada Hydro Northeast Inc.
ILP Study 19
Bellows Falls Dam

N

1 in = 600 feet

0 300 600 1,200 Feet

Study 19 Fish Number: 34-174

Release: Herricks Cove, VT
Date Released: 10/31/2015
Time Released: 18:22

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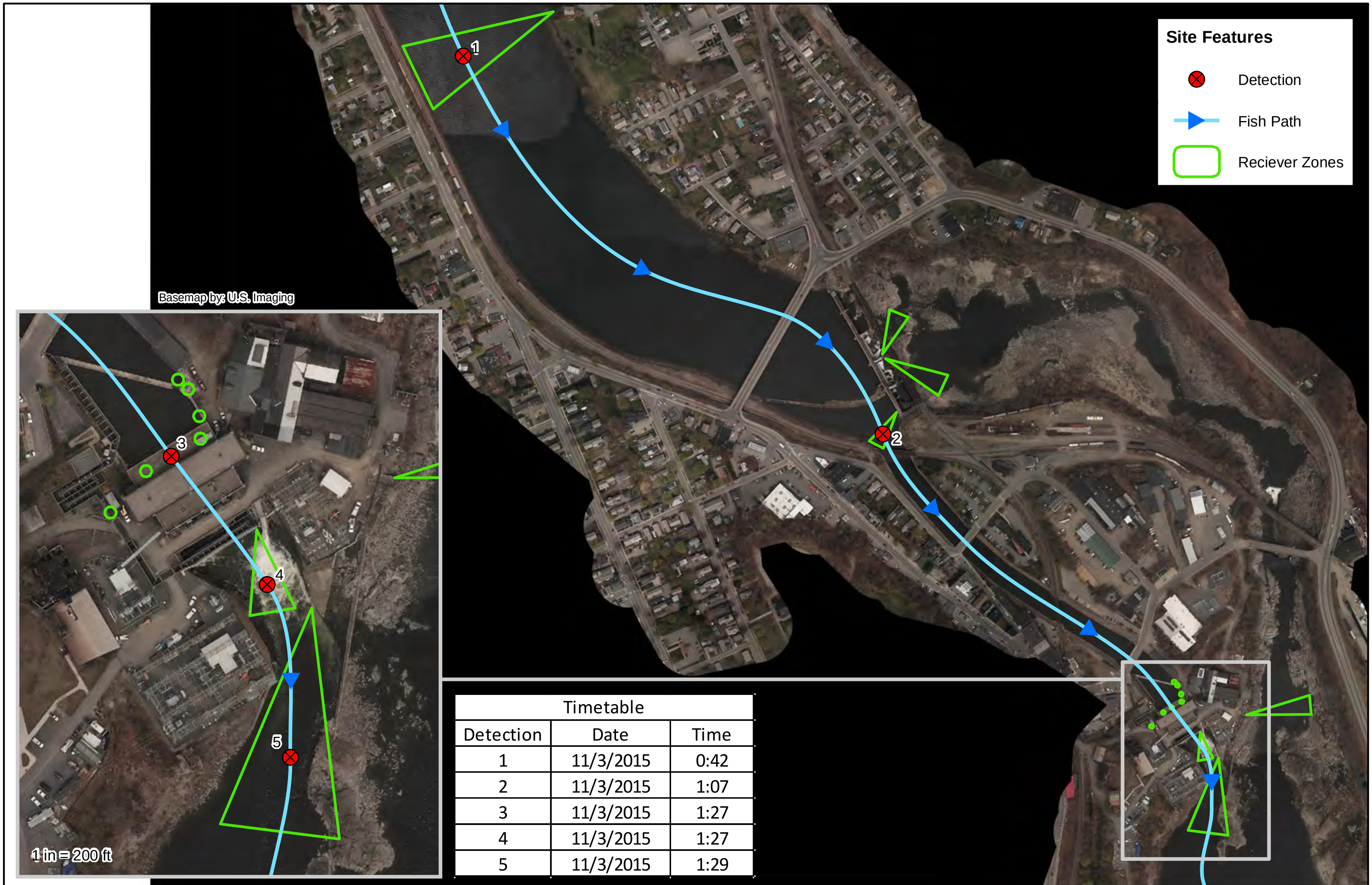

Timetable		
Detection	Date	Time
1	11/3/2015	0:42
2	11/3/2015	1:07
3	11/3/2015	1:27
4	11/3/2015	1:27
5	11/3/2015	1:29

TransCanada Hydro Northeast Inc.
ILP Study 19
Bellows Falls Dam

N

1 in = 600 feet

0 300 600 1,200 Feet

Study 19 Fish Number: 34-181

Release: Norwich, VT
Date Released: 10/31/2015
Time Released: 19:21

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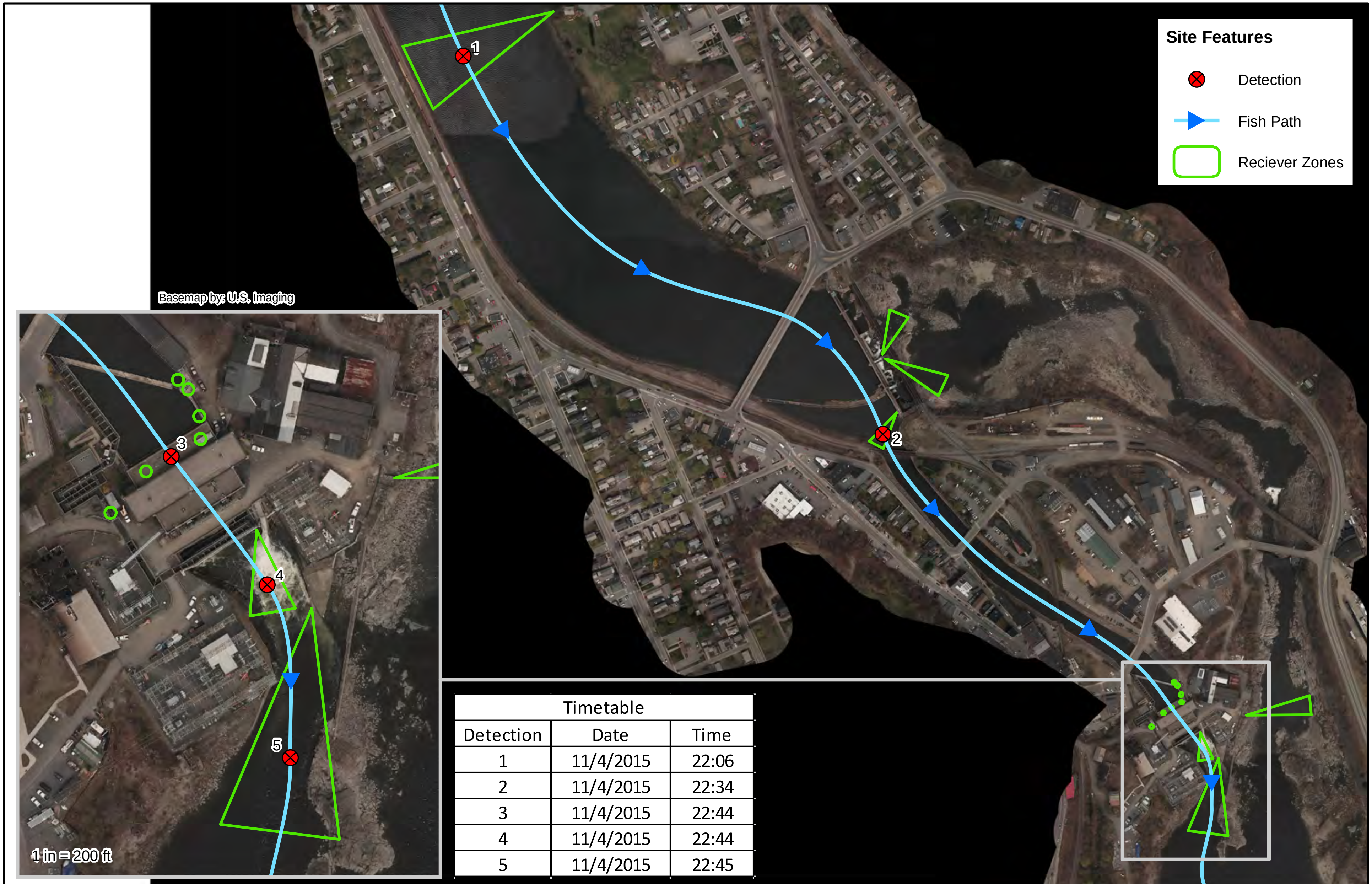

Timetable		
Detection	Date	Time
1	11/4/2015	22:06
2	11/4/2015	22:34
3	11/4/2015	22:44
4	11/4/2015	22:44
5	11/4/2015	22:45

TransCanada Hydro Northeast Inc.
ILP Study 19
Bellows Falls Dam

N

1 in = 600 feet

0 300 600 1,200 Feet

Study 19 Fish Number: 34-183

Release: Norwich, VT
Date Released: 10/31/2015
Time Released: 19:21

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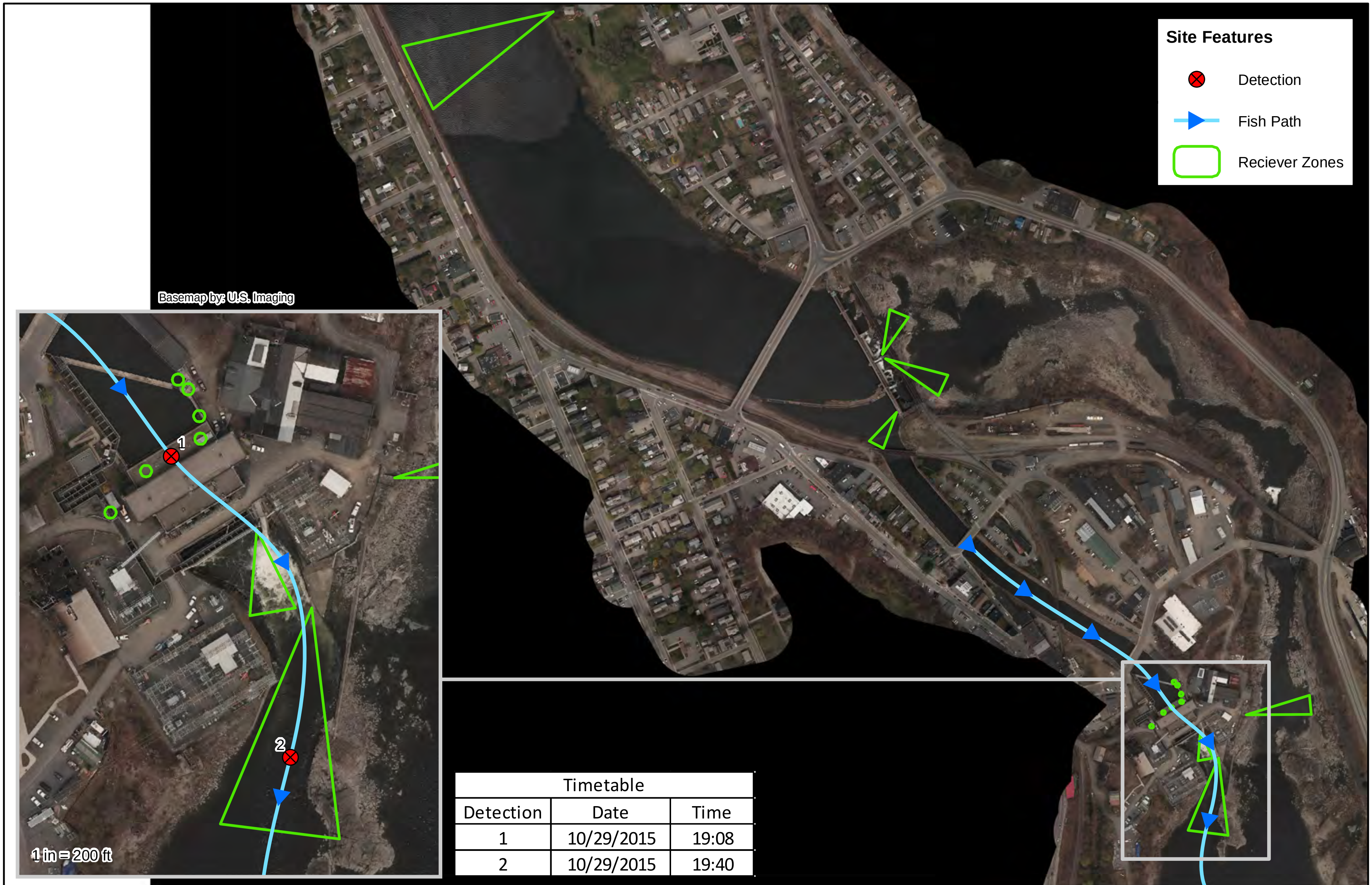

Timetable		
Detection	Date	Time
1	10/29/2015	19:08
2	10/29/2015	19:40

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TransCanada Hydro Northeast Inc.
ILP Study 19
Bellows Falls Dam

N

1 in = 600 feet

0 300 600 1,200 Feet

Study 19 Fish Number: 34-51

Release: Bellows Falls Canal, VT
Date Released: 10/29/2015
Time Released: 17:32

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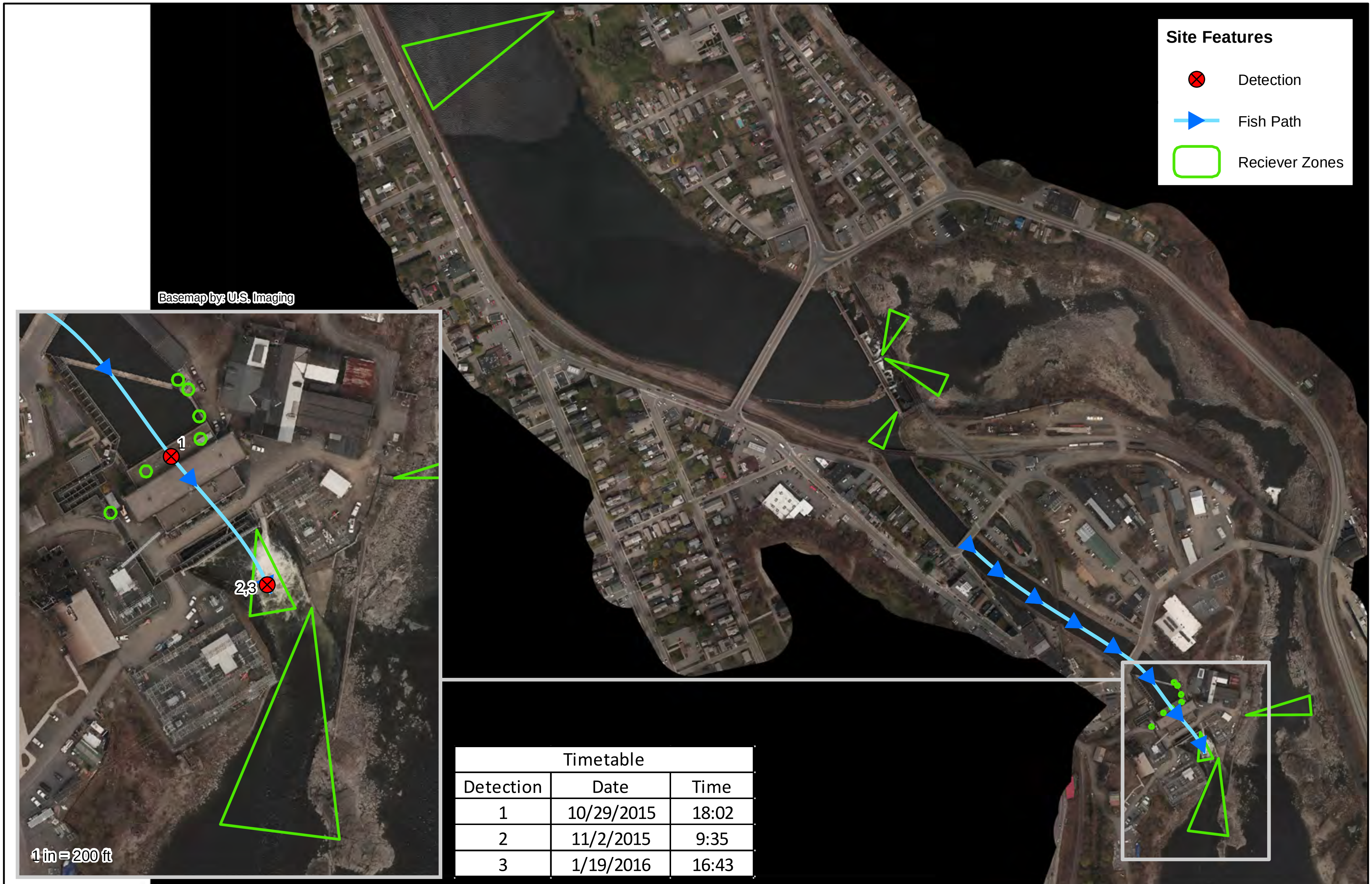

Timetable		
Detection	Date	Time
1	10/29/2015	18:02
2	11/2/2015	9:35
3	1/19/2016	16:43

TransCanada Hydro Northeast Inc.
ILP Study 19
Bellows Falls Dam

Study 19 Fish Number: 34-52

Release: Bellows Falls Canal, VT
Date Released: 10/29/2015
Time Released: 17:32

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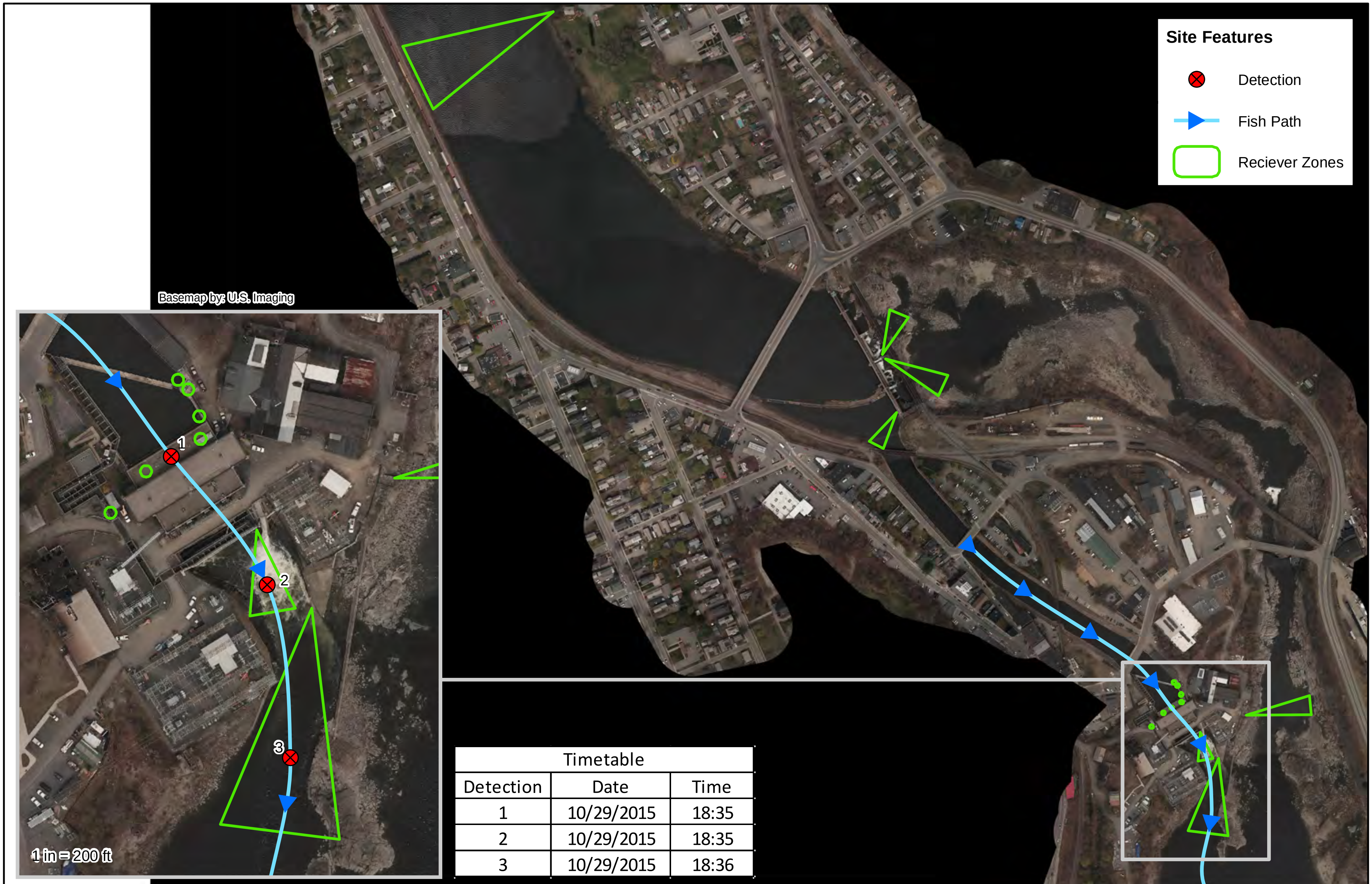

Timetable		
Detection	Date	Time
1	10/29/2015	18:35
2	10/29/2015	18:35
3	10/29/2015	18:36

TransCanada Hydro Northeast Inc.
ILP Study 19
Bellows Falls Dam

N

1 in = 600 feet

0 300 600 1,200 Feet

Study 19 Fish Number: 34-53

Release: Bellows Falls Canal, VT
Date Released: 10/29/2015
Time Released: 17:32

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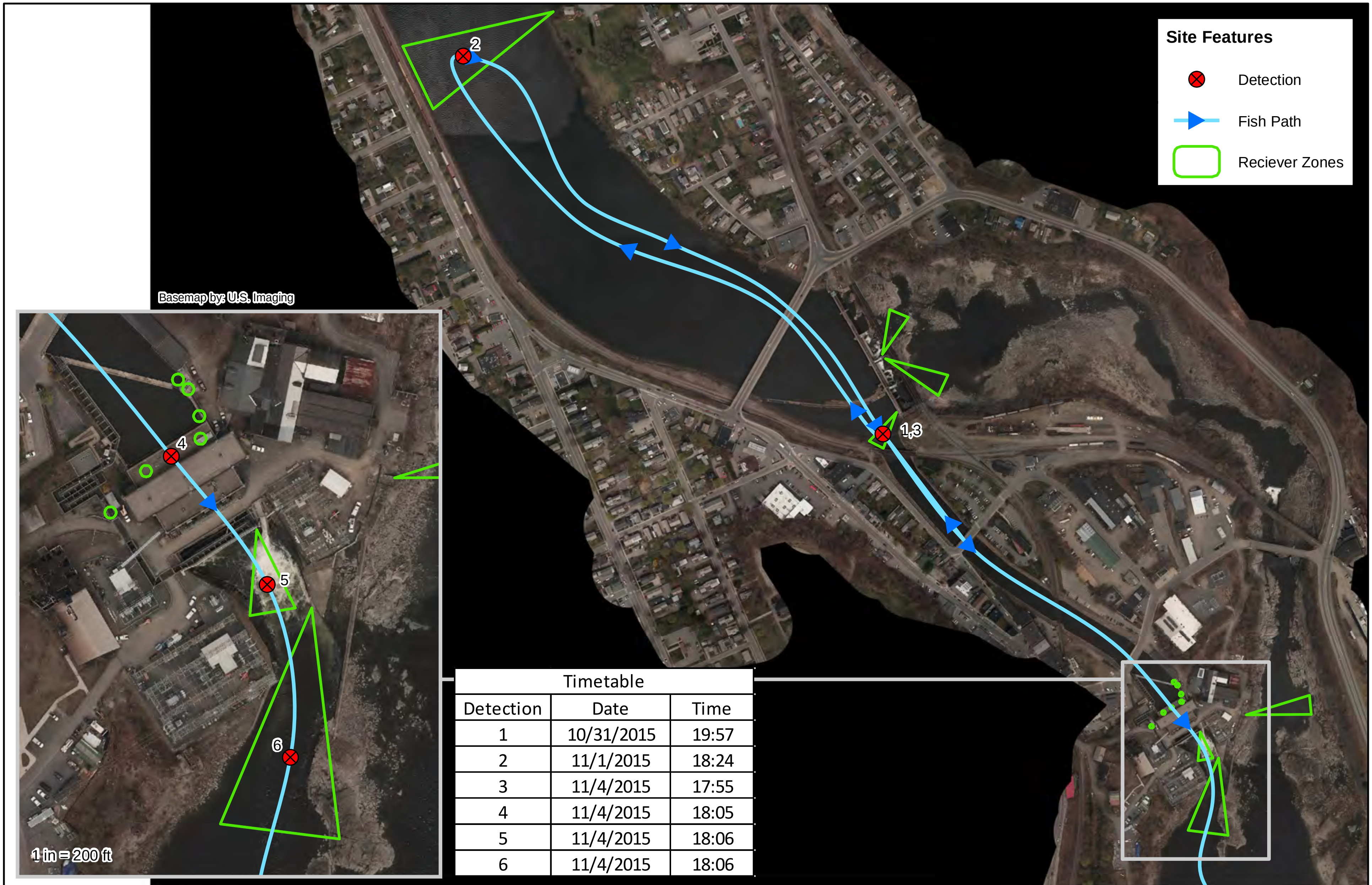

Timetable		
Detection	Date	Time
1	10/31/2015	19:57
2	11/1/2015	18:24
3	11/4/2015	17:55
4	11/4/2015	18:05
5	11/4/2015	18:06
6	11/4/2015	18:06

TransCanada Hydro Northeast Inc.
ILP Study 19
Bellows Falls Dam

Study 19 Fish Number: 34-54

Release: Bellows Falls Canal, VT
Date Released: 10/31/2015
Time Released: 18:05

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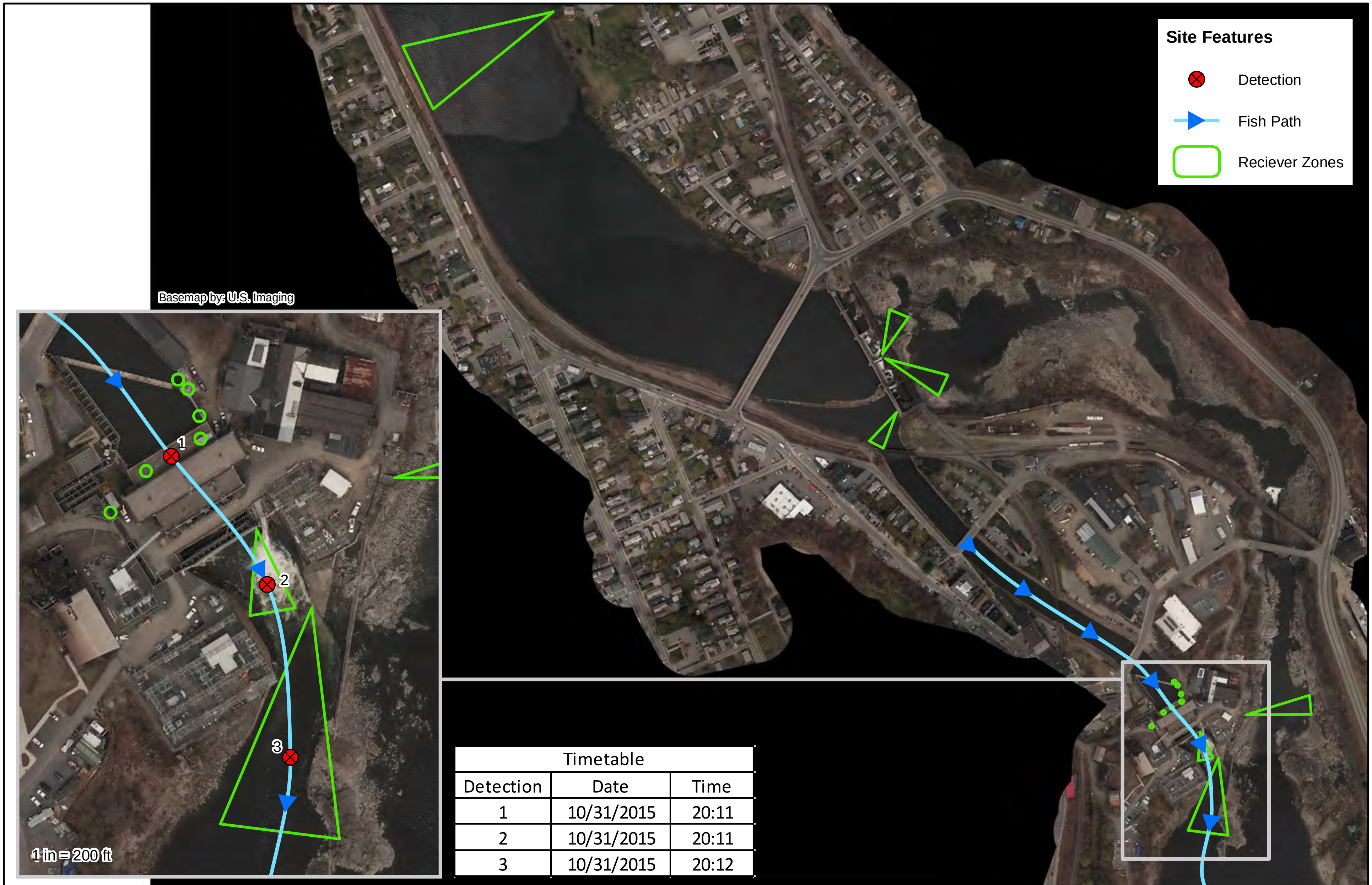

Timetable		
Detection	Date	Time
1	10/31/2015	20:11
2	10/31/2015	20:11
3	10/31/2015	20:12

TransCanada Hydro Northeast Inc.
ILP Study 19
Bellows Falls Dam

N

1 in = 600 feet

0 300 600 1,200 Feet

Study 19 Fish Number: 34-55

Release: Bellows Falls Canal, VT
Date Released: 10/31/2015
Time Released: 18:05

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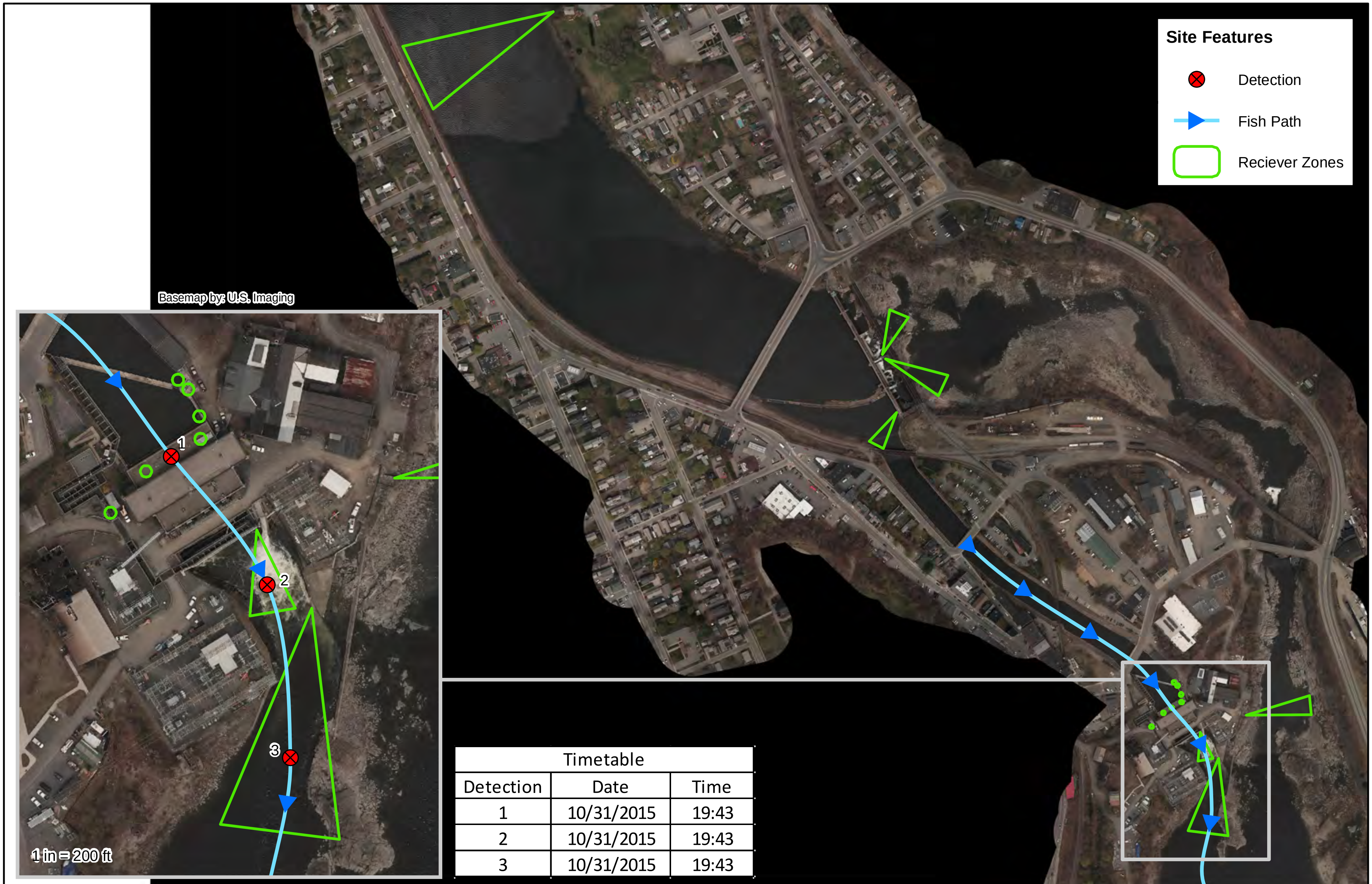

Timetable		
Detection	Date	Time
1	10/31/2015	19:43
2	10/31/2015	19:43
3	10/31/2015	19:43

TransCanada Hydro Northeast Inc.
ILP Study 19
Bellows Falls Dam

N

1 in = 600 feet

0 300 600 1,200 Feet

Study 19 Fish Number: 34-56

Release: Bellows Falls Canal, VT
Date Released: 10/31/2015
Time Released: 18:05

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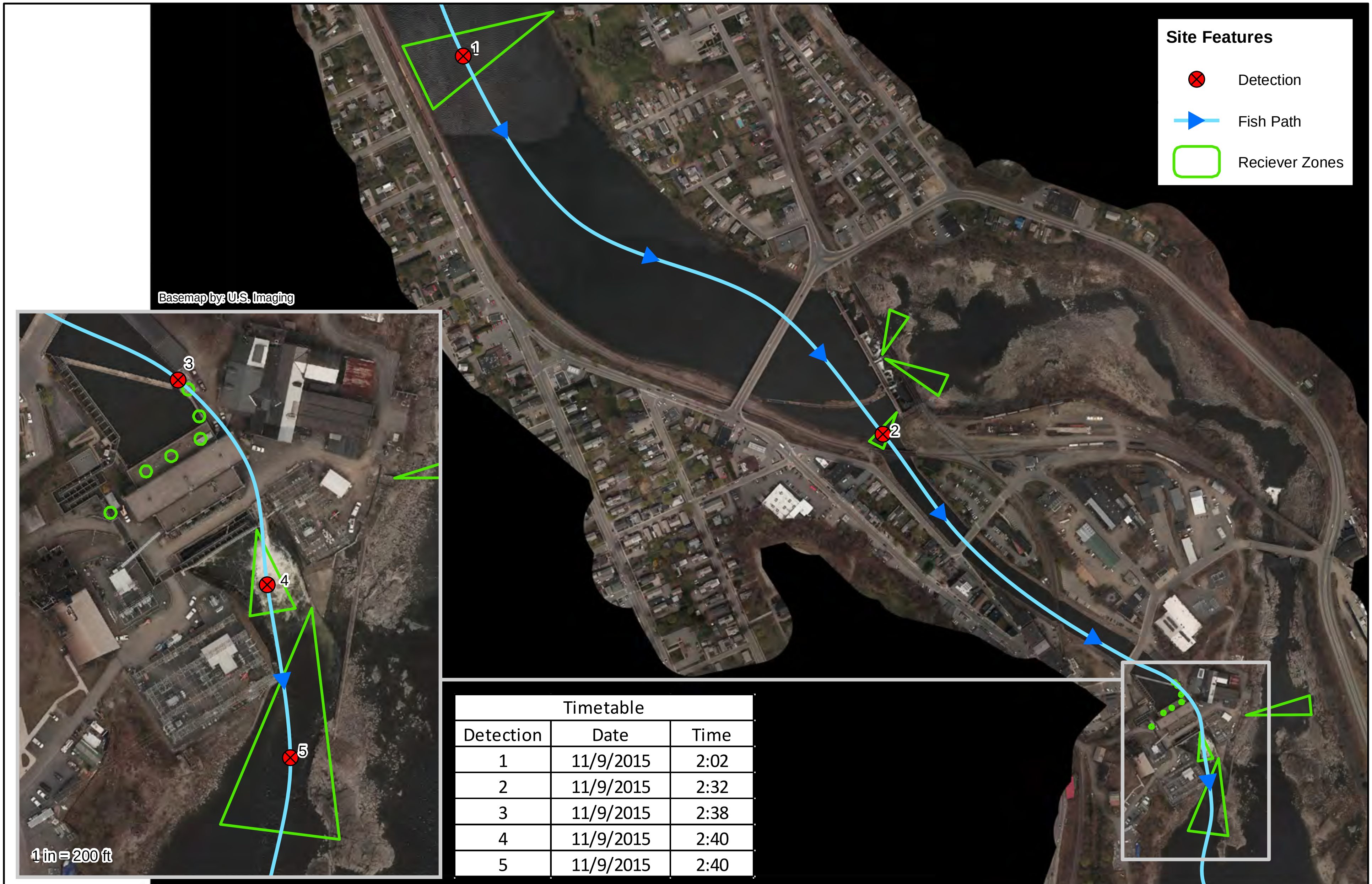

Timetable		
Detection	Date	Time
1	11/9/2015	2:02
2	11/9/2015	2:32
3	11/9/2015	2:38
4	11/9/2015	2:40
5	11/9/2015	2:40

TransCanada Hydro Northeast Inc.
ILP Study 19
Bellows Falls Dam

N

1 in = 600 feet

0 300 600 1,200 Feet

Study 19 Fish Number: 34-57

Release: Norwich, VT
Date Released: 11/05/2015
Time Released: 17:05

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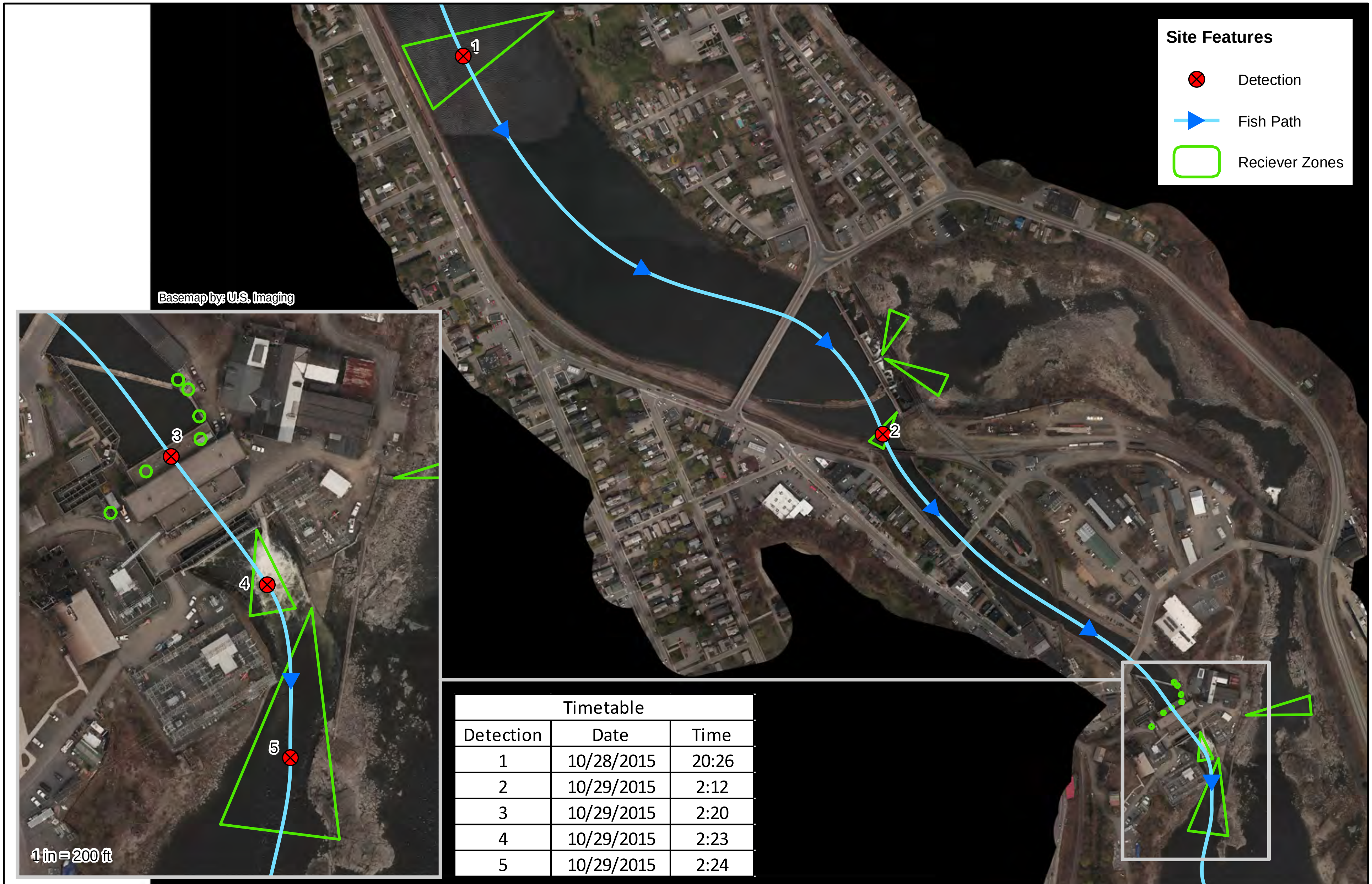

Timetable		
Detection	Date	Time
1	10/28/2015	20:26
2	10/29/2015	2:12
3	10/29/2015	2:20
4	10/29/2015	2:23
5	10/29/2015	2:24

TransCanada Hydro Northeast Inc.
ILP Study 19
Bellows Falls Dam

N

1 in = 600 feet

0 300 600 1,200 Feet

Study 19 Fish Number: 36-116

Release: Herricks Cove, VT
Date Released: 10/27/2015
Time Released: 18:20

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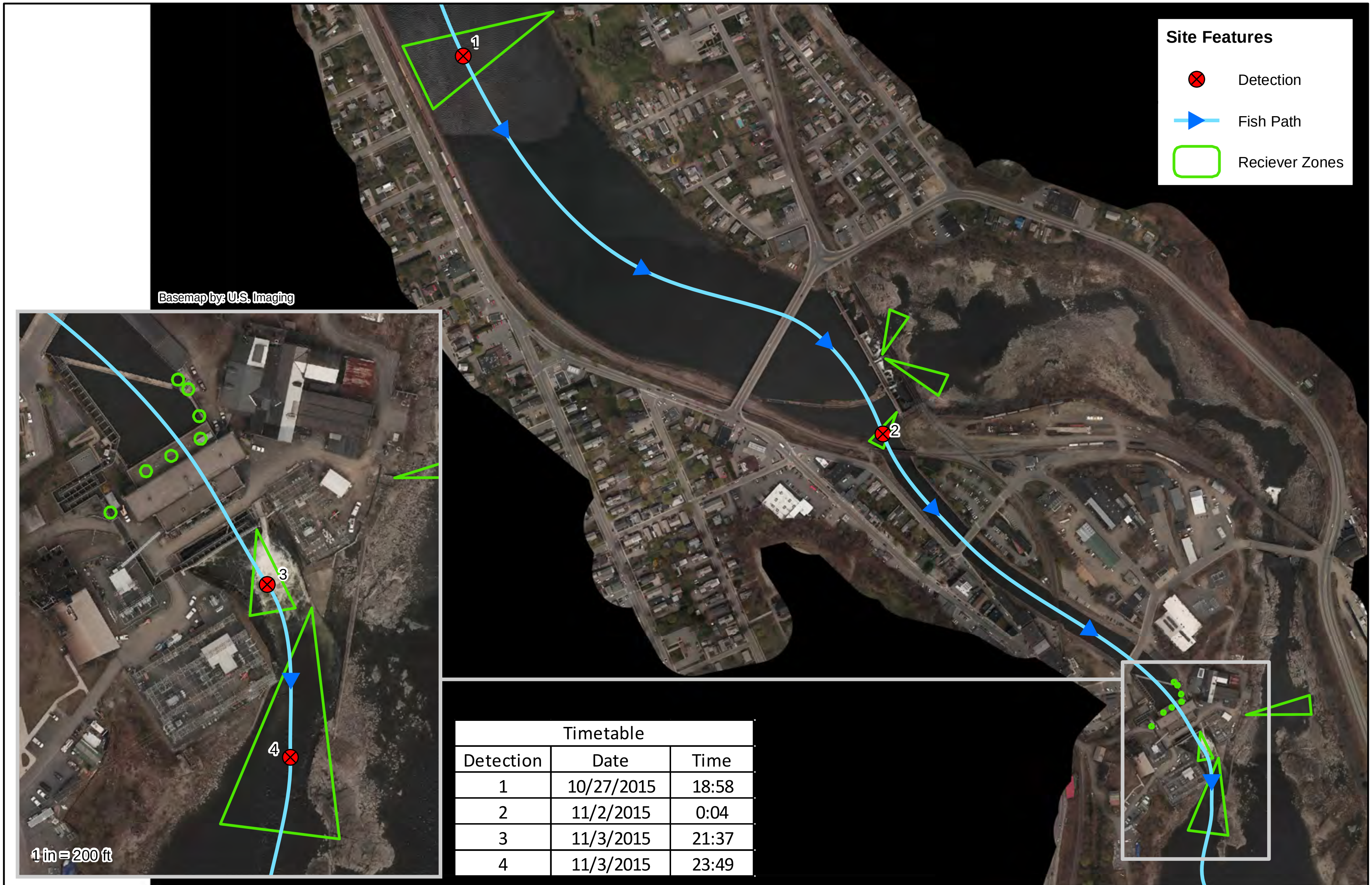

Timetable		
Detection	Date	Time
1	10/27/2015	18:58
2	11/2/2015	0:04
3	11/3/2015	21:37
4	11/3/2015	23:49

TransCanada Hydro Northeast Inc.
ILP Study 19
Bellows Falls Dam

N

1 in = 600 feet

0 300 600 1,200 Feet

Study 19 Fish Number: 36-117

Release: Herricks Cove, VT
Date Released: 10/27/2015
Time Released: 18:20

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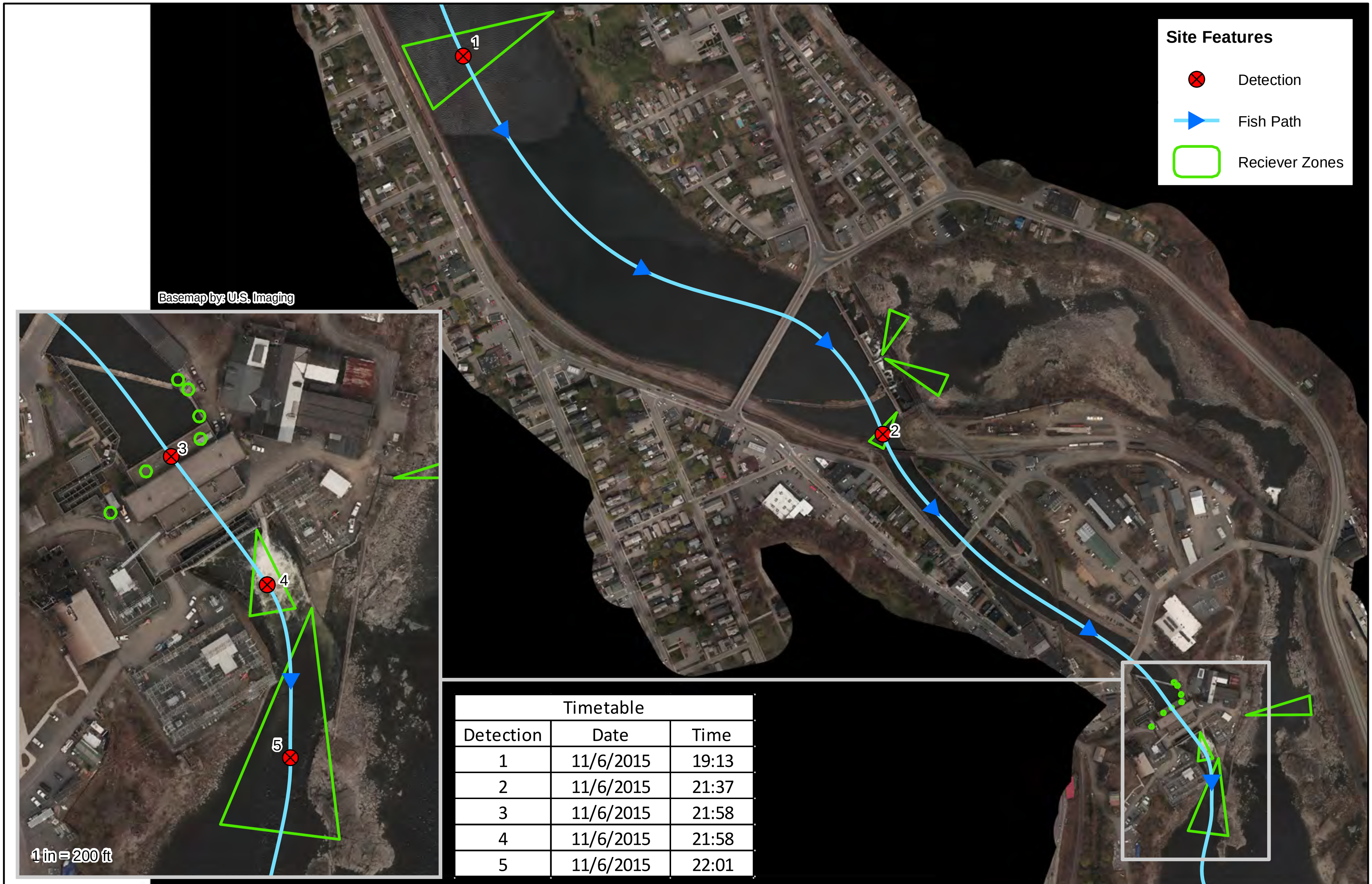

Timetable		
Detection	Date	Time
1	11/6/2015	19:13
2	11/6/2015	21:37
3	11/6/2015	21:58
4	11/6/2015	21:58
5	11/6/2015	22:01

TransCanada Hydro Northeast Inc.
ILP Study 19
Bellows Falls Dam

N

1 in = 600 feet

0 300 600 1,200 Feet

Study 19 Fish Number: 36-119

Release: Herricks Cove, VT
Date Released: 11/03/2015
Time Released: 16:45

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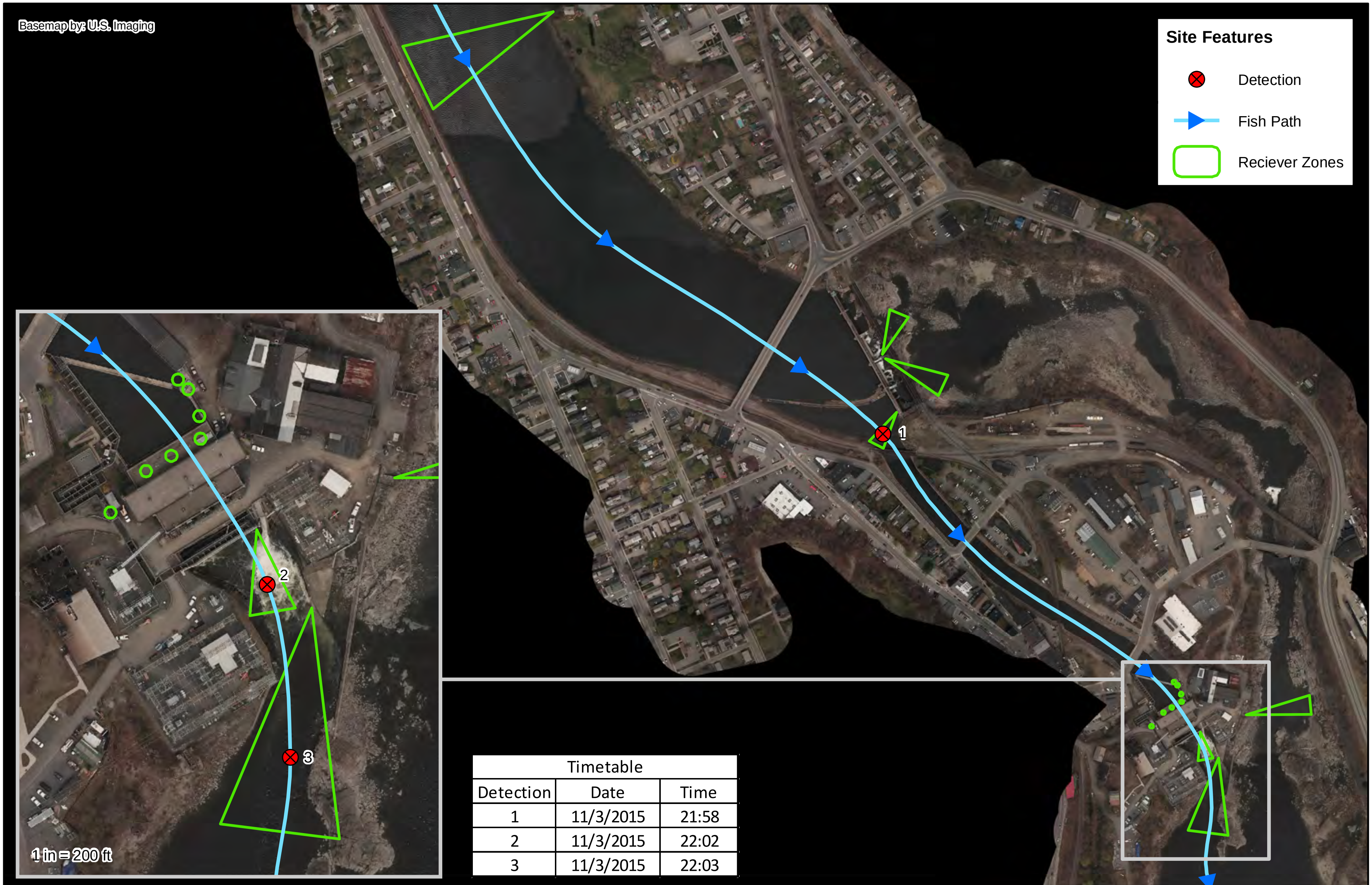

Timetable		
Detection	Date	Time
1	11/3/2015	21:58
2	11/3/2015	22:02
3	11/3/2015	22:03

TransCanada Hydro Northeast Inc.
ILP Study 19
Bellows Falls Dam

1 in = 600 feet

0 300 600 1,200 Feet

Study 19 Fish Number: 36-120

Release: Herricks Cove, VT
Date Released: 11/03/2015
Time Released: 16:45

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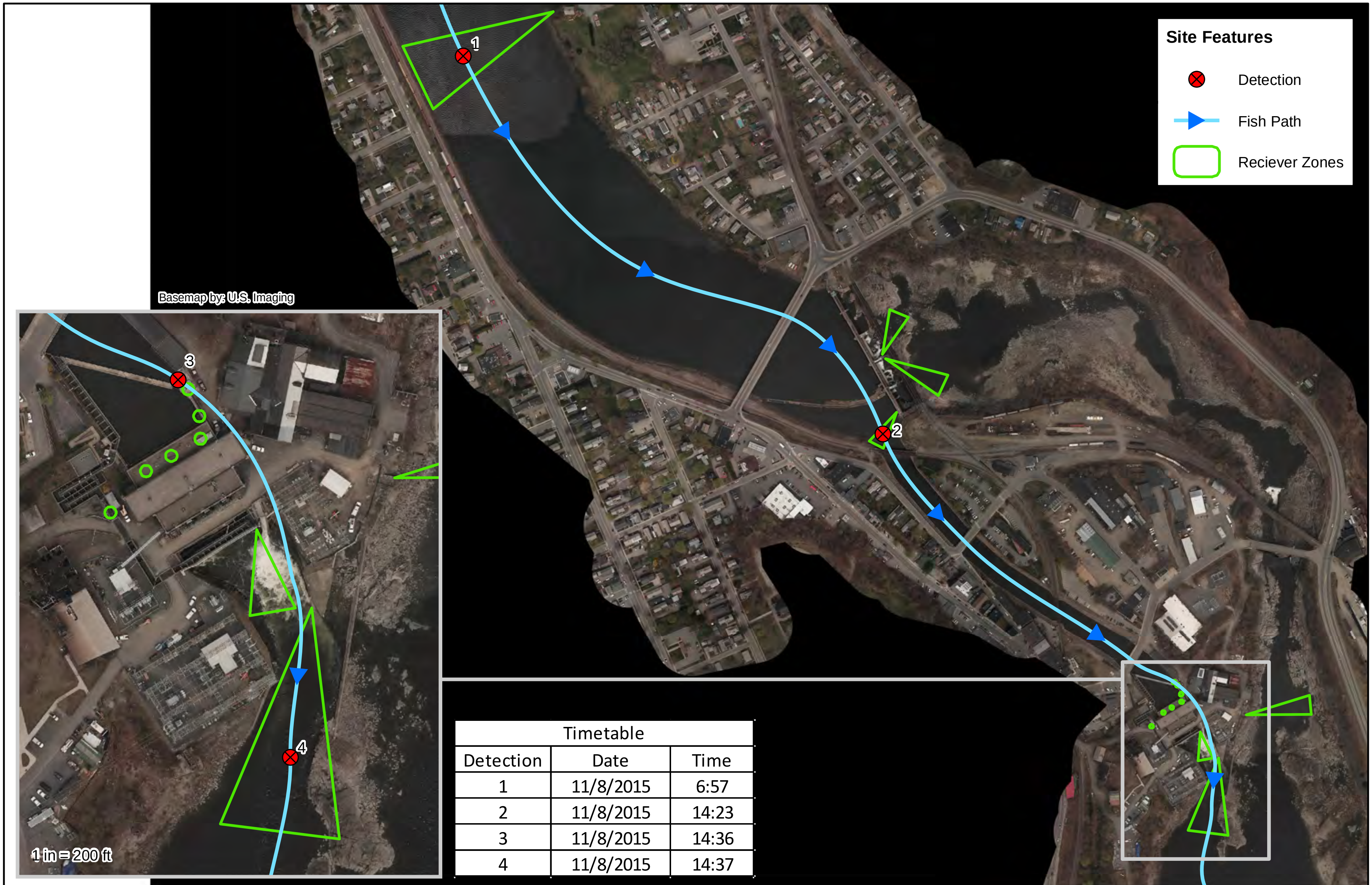

Timetable		
Detection	Date	Time
1	11/8/2015	6:57
2	11/8/2015	14:23
3	11/8/2015	14:36
4	11/8/2015	14:37

TransCanada Hydro Northeast Inc.
ILP Study 19
Bellows Falls Dam

Study 19 Fish Number: 36-122

Release: Norwich, VT
Date Released: 11/03/2015
Time Released: 17:32

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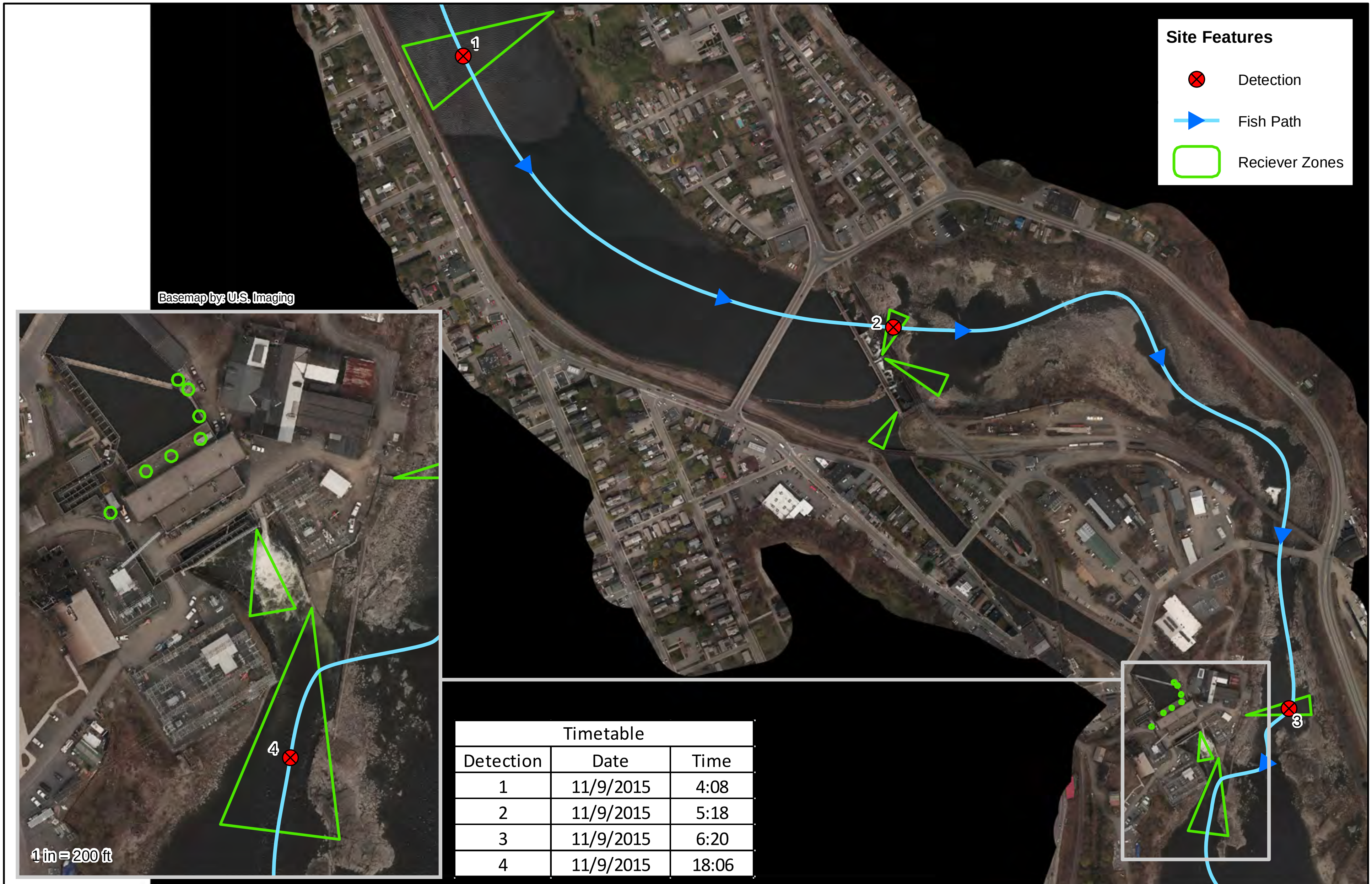

Timetable		
Detection	Date	Time
1	11/9/2015	4:08
2	11/9/2015	5:18
3	11/9/2015	6:20
4	11/9/2015	18:06

TransCanada Hydro Northeast Inc.
ILP Study 19
Bellows Falls Dam

N

1 in = 600 feet

0 300 600 1,200 Feet

Study 19 Fish Number: 36-123

Release: Norwich, VT
Date Released: 11/03/2015
Time Released: 17:32

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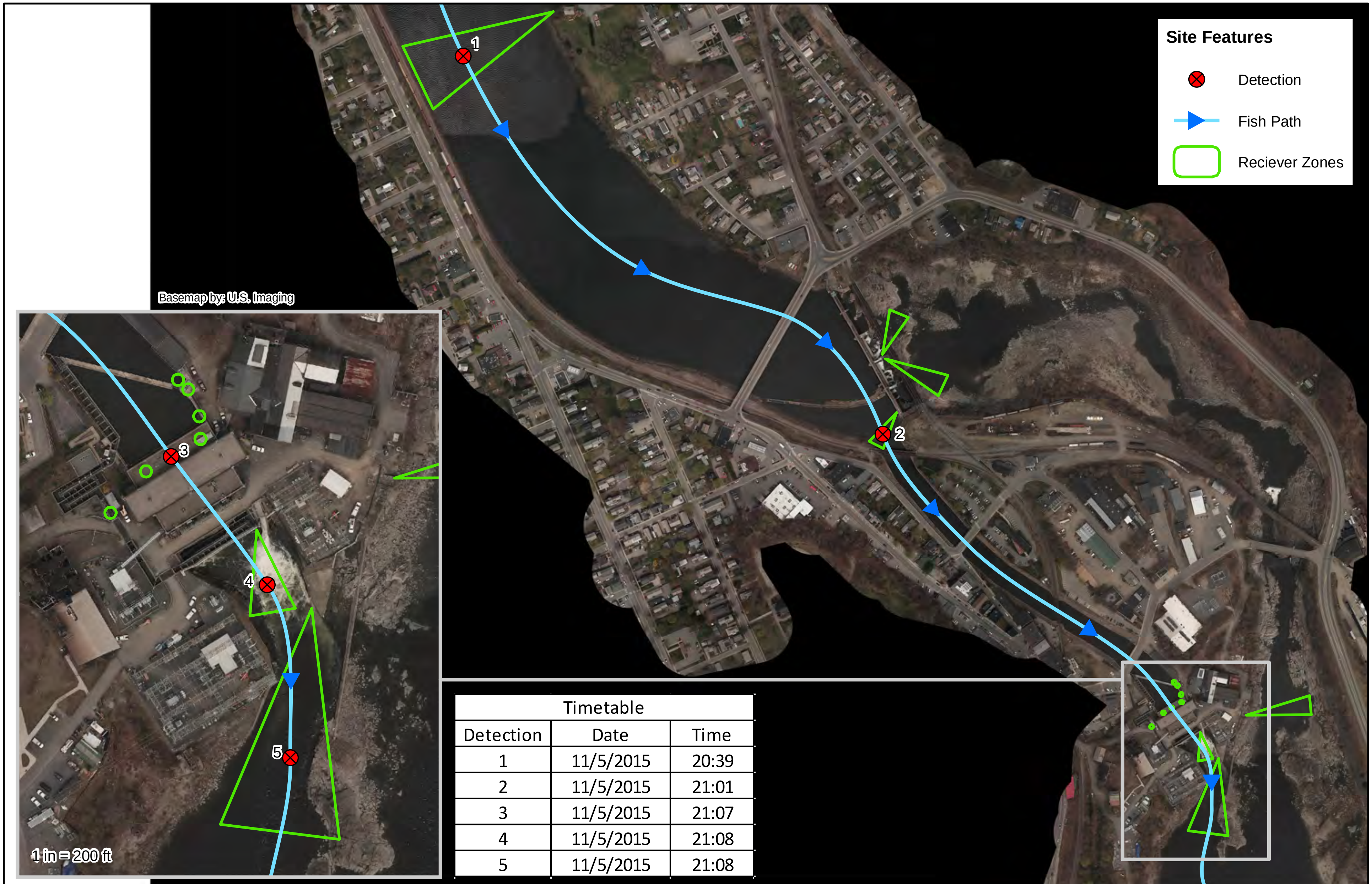

Timetable		
Detection	Date	Time
1	11/5/2015	20:39
2	11/5/2015	21:01
3	11/5/2015	21:07
4	11/5/2015	21:08
5	11/5/2015	21:08

TransCanada Hydro Northeast Inc.
ILP Study 19
Bellows Falls Dam

N

1 in = 600 feet

0 300 600 1,200 Feet

Study 19 Fish Number: 36-141

Release: Herricks Cove, VT
Date Released: 11/05/2015
Time Released: 16:20

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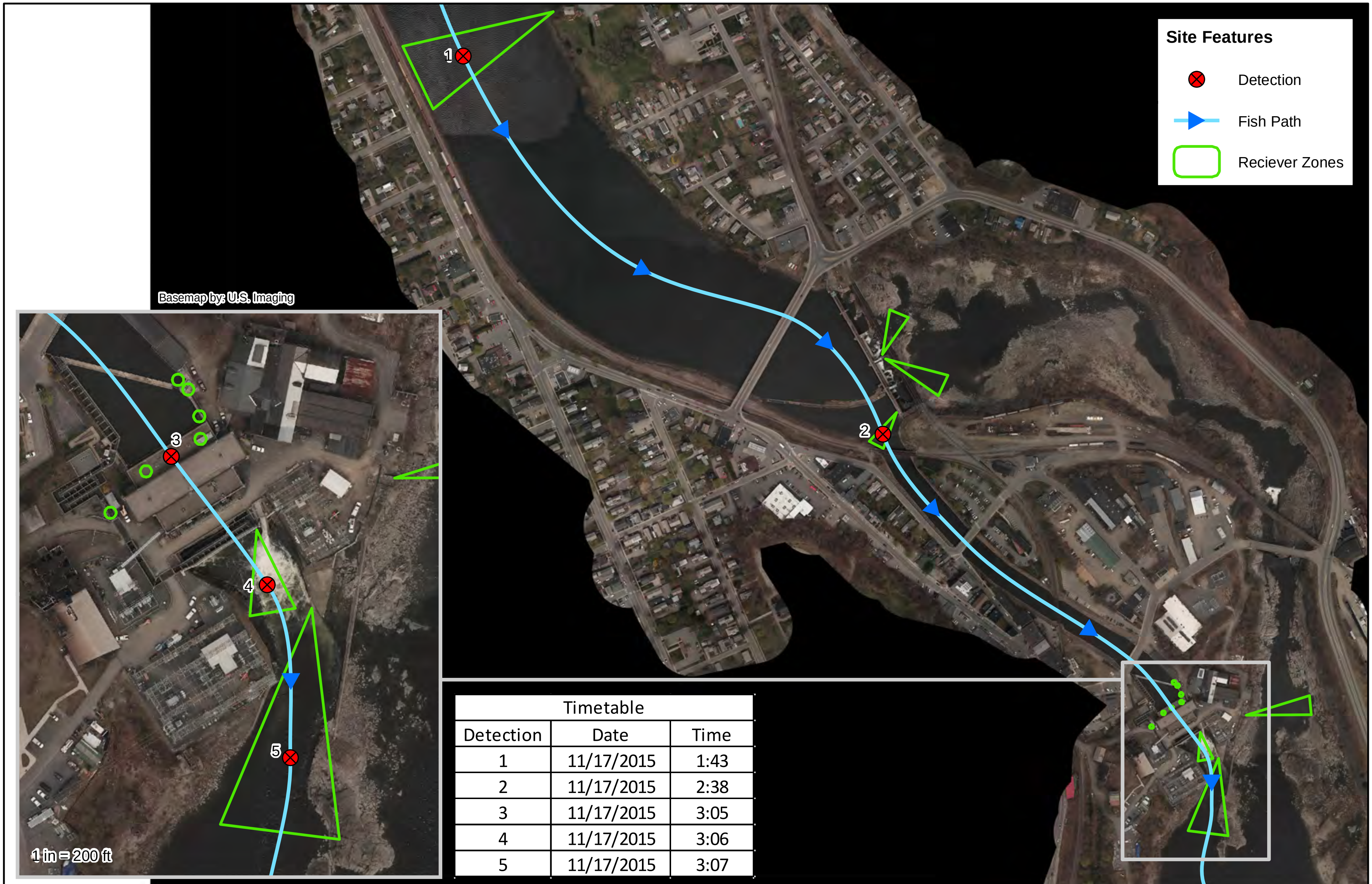

Timetable		
Detection	Date	Time
1	11/17/2015	1:43
2	11/17/2015	2:38
3	11/17/2015	3:05
4	11/17/2015	3:06
5	11/17/2015	3:07

TransCanada Hydro Northeast Inc.
ILP Study 19
Bellows Falls Dam

Study 19 Fish Number: 36-142

Release: Herricks Cove, VT
Date Released: 11/05/2015
Time Released: 16:20

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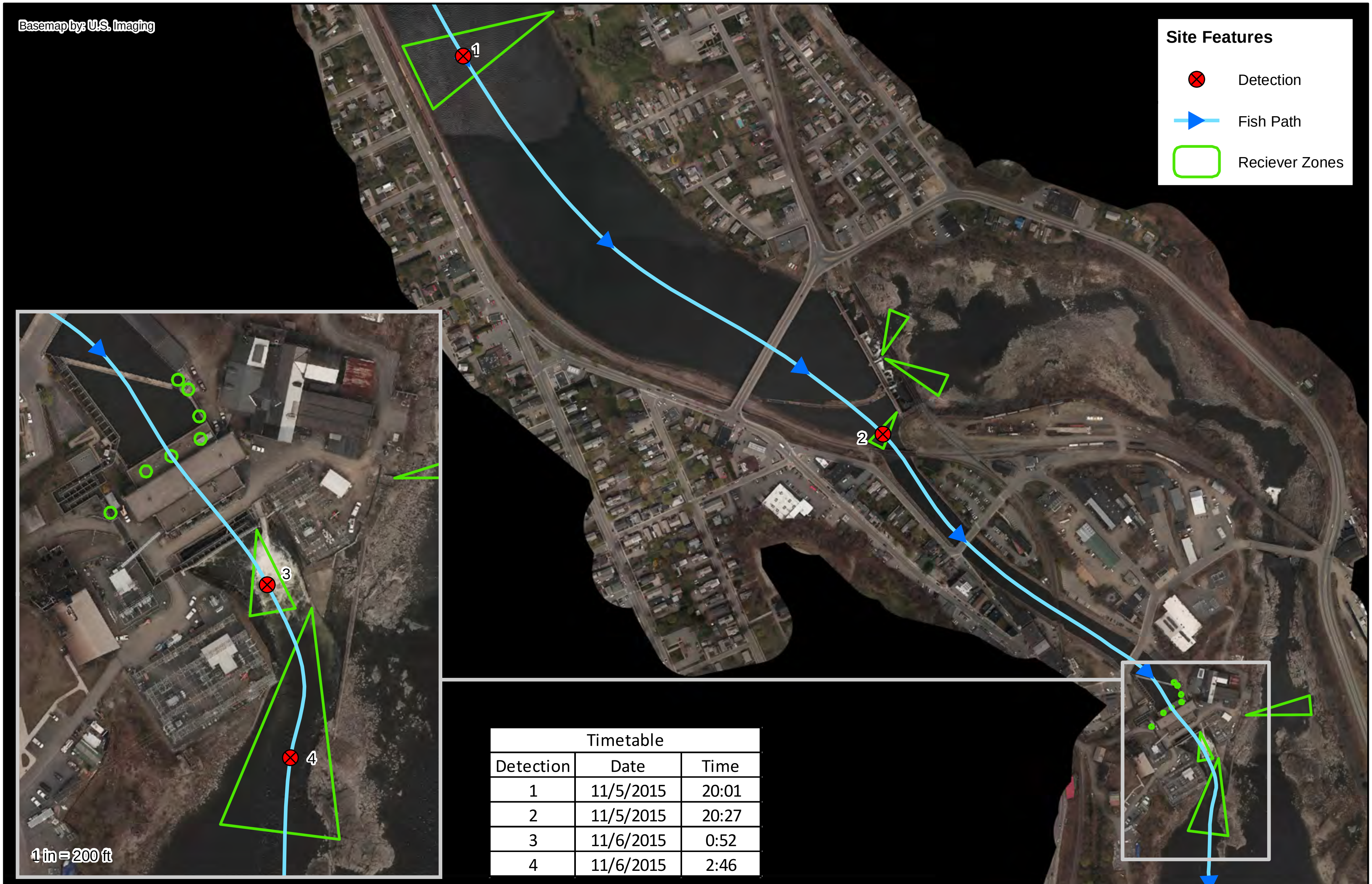

Timetable		
Detection	Date	Time
1	11/5/2015	20:01
2	11/5/2015	20:27
3	11/6/2015	0:52
4	11/6/2015	2:46

TransCanada Hydro Northeast Inc.
ILP Study 19
Bellows Falls Dam

N

1 in = 600 feet

0 300 600 1,200 Feet

Study 19 Fish Number: 36-143

Release: Herricks Cove, VT
Date Released: 11/05/2015
Time Released: 16:20

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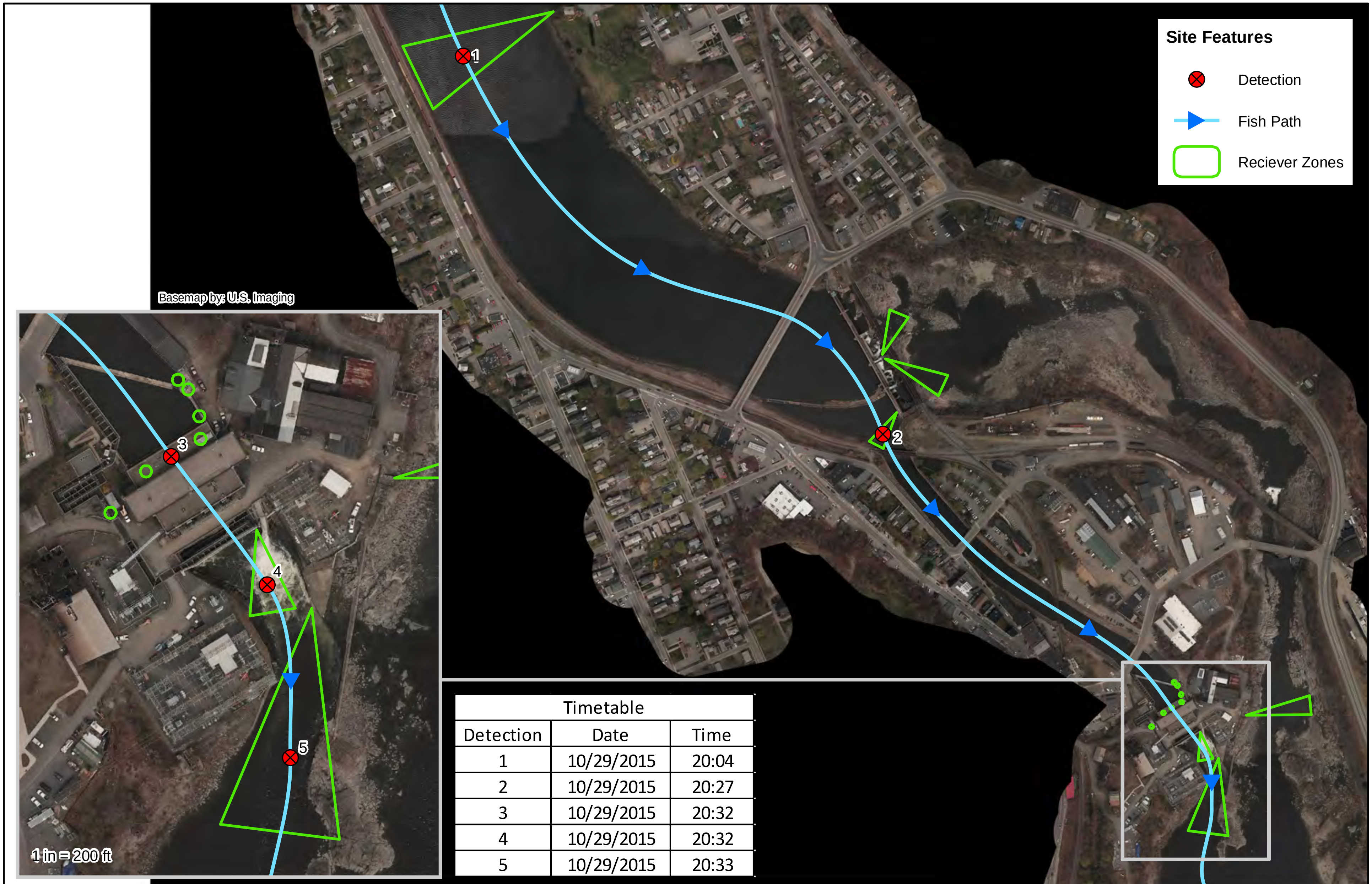

Timetable		
Detection	Date	Time
1	10/29/2015	20:04
2	10/29/2015	20:27
3	10/29/2015	20:32
4	10/29/2015	20:32
5	10/29/2015	20:33

TransCanada Hydro Northeast Inc.
ILP Study 19
Bellows Falls Dam

N

1 in = 600 feet

0 300 600 1,200 Feet

Study 19 Fish Number: 36-144

Release: Herricks Cove, VT
Date Released: 10/29/2015
Time Released: 17:52

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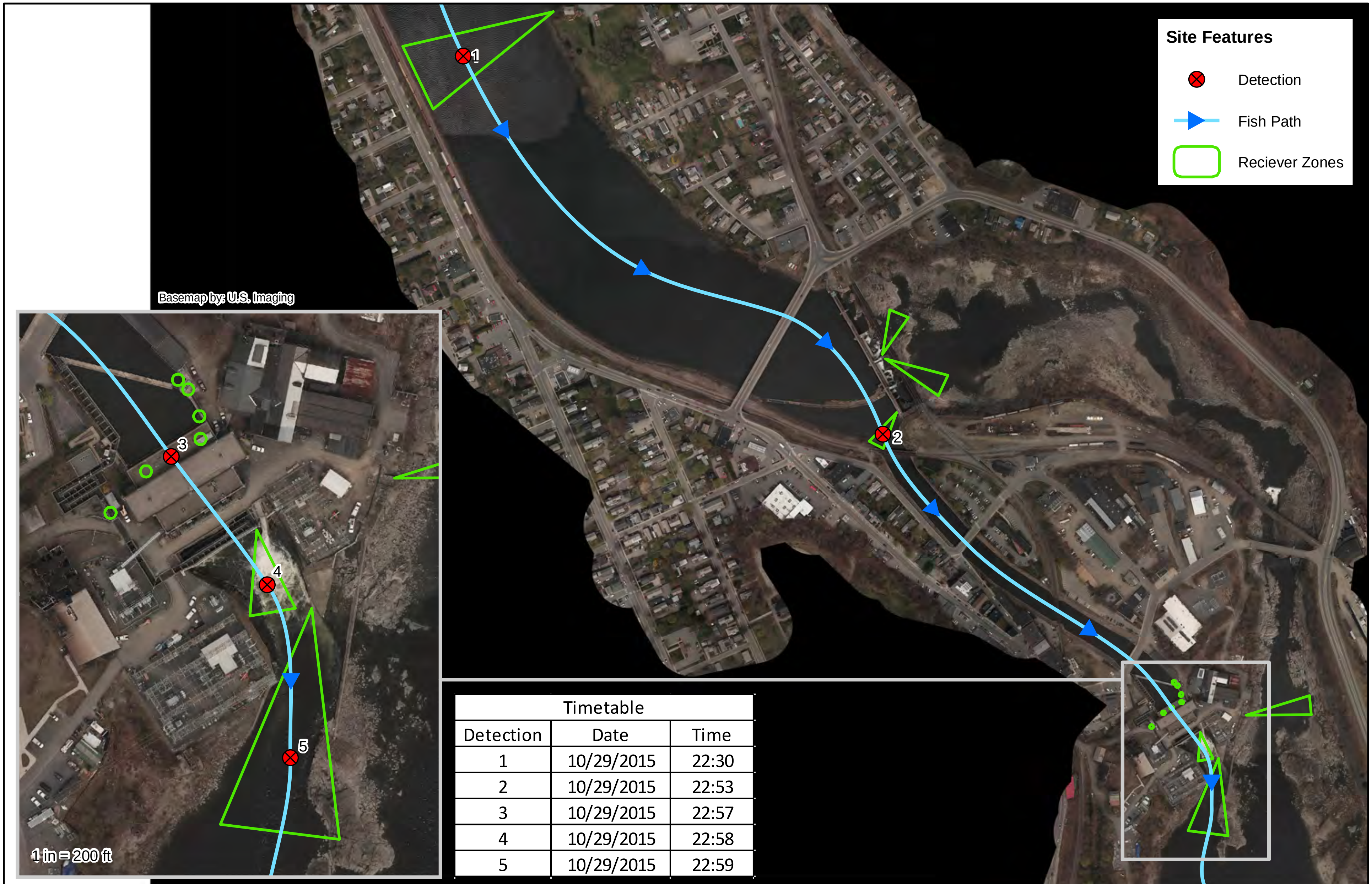

Timetable		
Detection	Date	Time
1	10/29/2015	22:30
2	10/29/2015	22:53
3	10/29/2015	22:57
4	10/29/2015	22:58
5	10/29/2015	22:59

TransCanada Hydro Northeast Inc.
ILP Study 19
Bellows Falls Dam

N
1 in = 600 feet
0 300 600 1,200 Feet

Study 19 Fish Number: 36-145

Release: Herricks Cove, VT
Date Released: 10/29/2015
Time Released: 17:52

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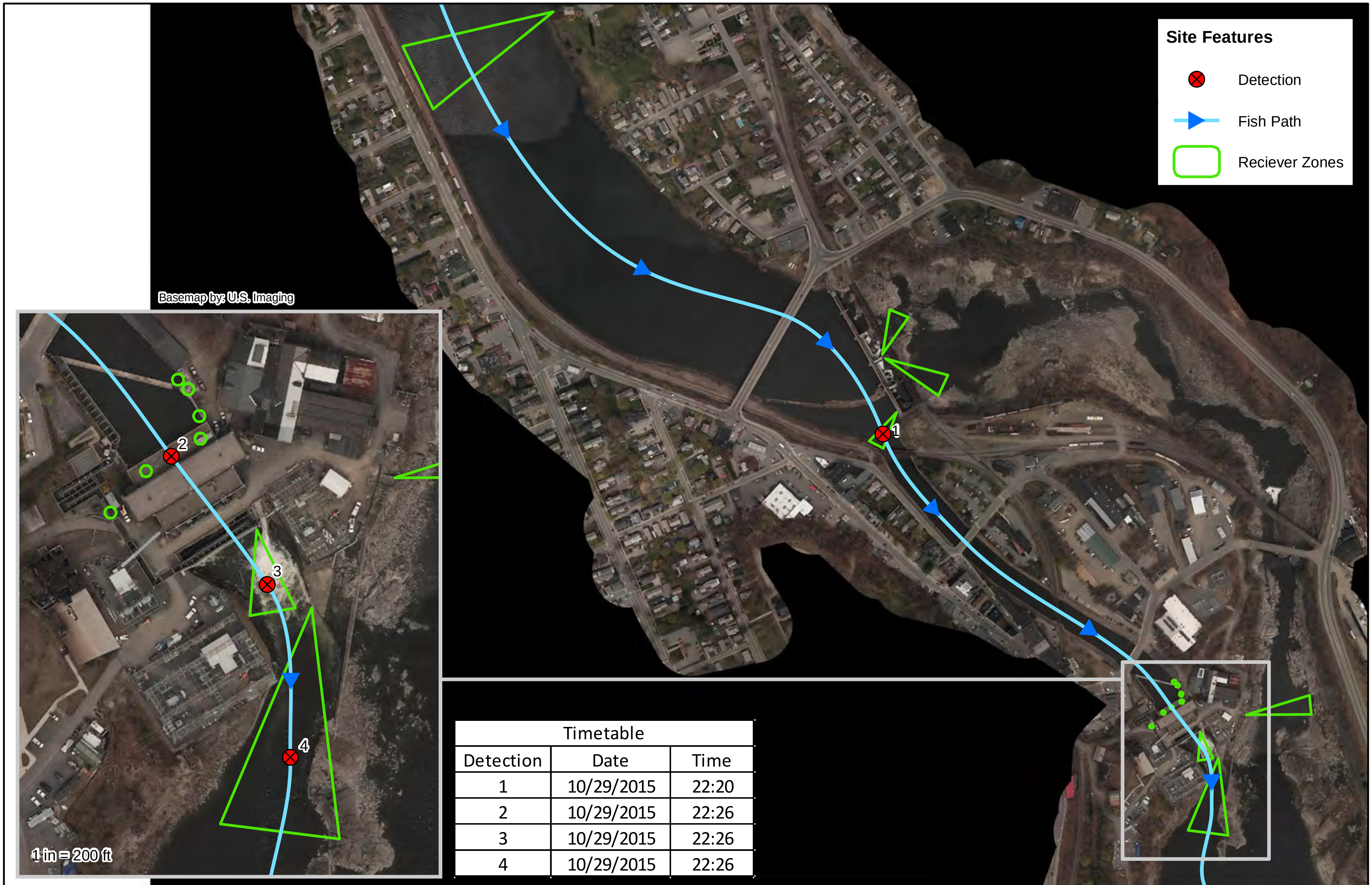

Timetable		
Detection	Date	Time
1	10/29/2015	22:20
2	10/29/2015	22:26
3	10/29/2015	22:26
4	10/29/2015	22:26

TransCanada Hydro Northeast Inc.
ILP Study 19
Bellows Falls Dam

1 in = 600 feet

0 300 600 1,200 Feet

Study 19 Fish Number: 36-146

Release: Herricks Cove, VT
Date Released: 10/29/2015
Time Released: 17:52

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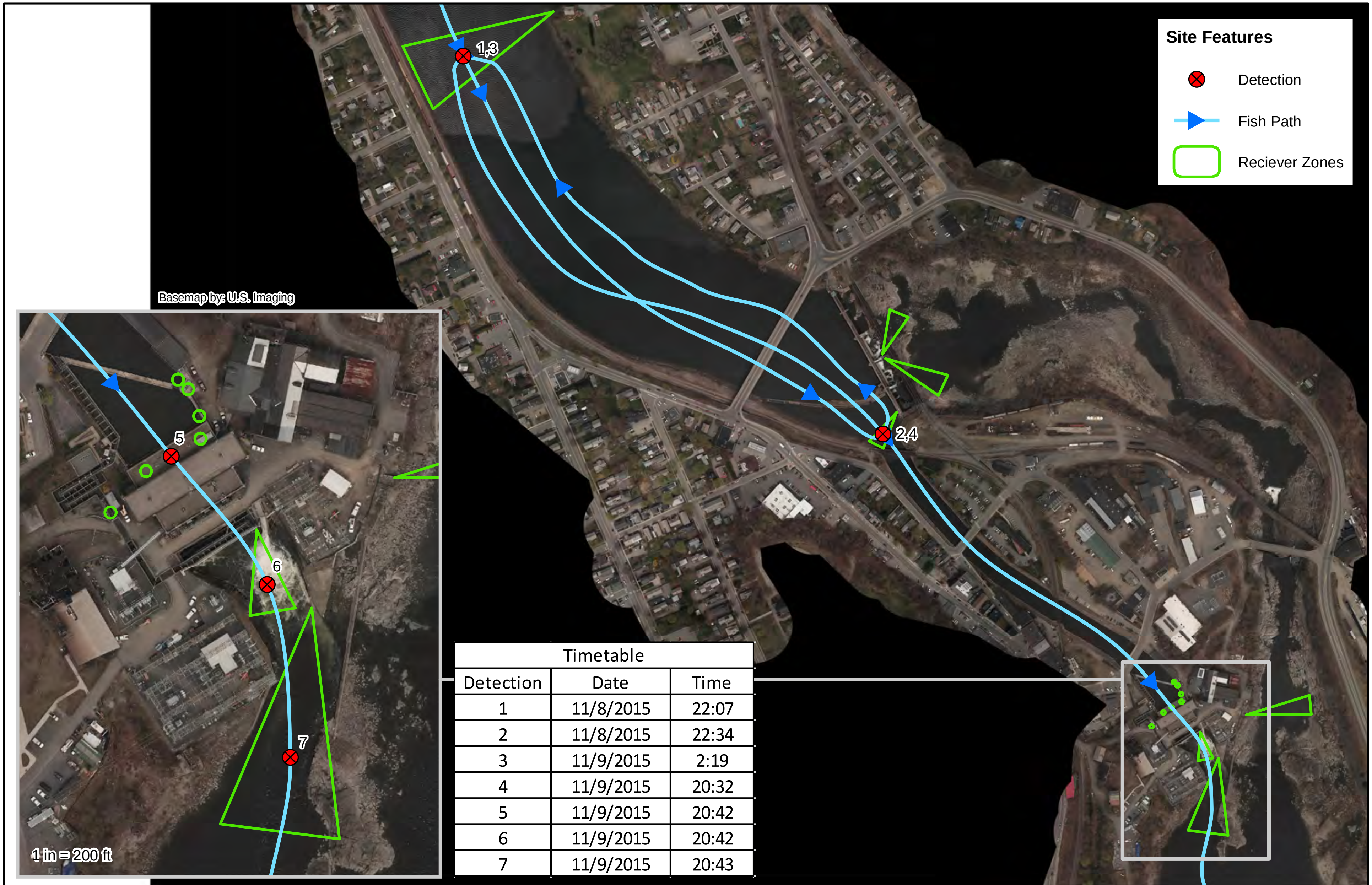

Timetable		
Detection	Date	Time
1	11/8/2015	22:07
2	11/8/2015	22:34
3	11/9/2015	2:19
4	11/9/2015	20:32
5	11/9/2015	20:42
6	11/9/2015	20:42
7	11/9/2015	20:43

TransCanada Hydro Northeast Inc.
ILP Study 19
Bellows Falls Dam

N

1 in = 600 feet

0 300 600 1,200 Feet

Study 19 Fish Number: 36-147

Release: Herricks Cove, VT
Date Released: 10/29/2015
Time Released: 17:52

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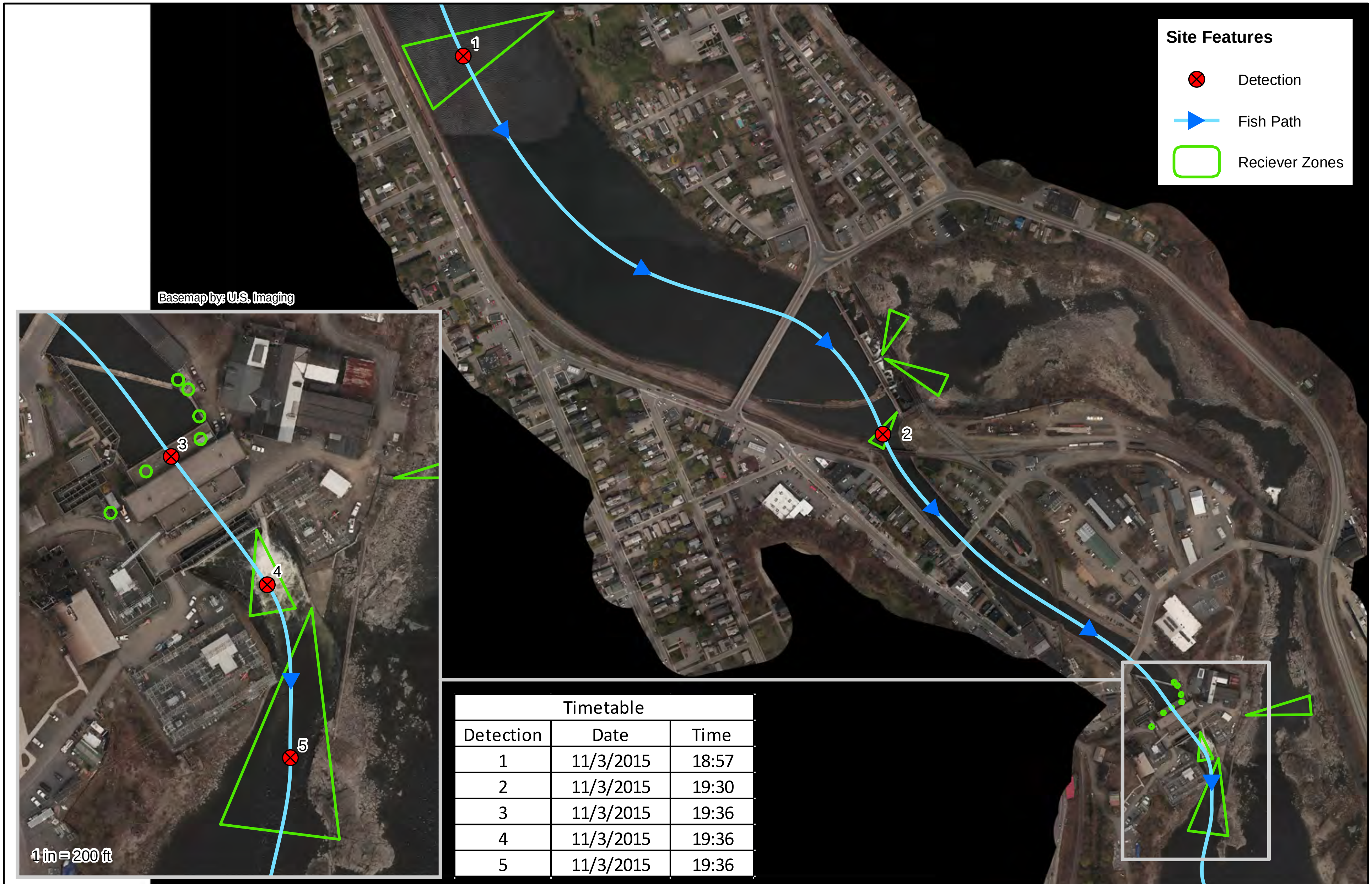

Timetable		
Detection	Date	Time
1	11/3/2015	18:57
2	11/3/2015	19:30
3	11/3/2015	19:36
4	11/3/2015	19:36
5	11/3/2015	19:36

TransCanada Hydro Northeast Inc.
ILP Study 19
Bellows Falls Dam

N

1 in = 600 feet

0 300 600 1,200 Feet

Study 19 Fish Number: 36-155

Release: Norwich, VT
Date Released: 10/29/2015
Time Released: 18:43

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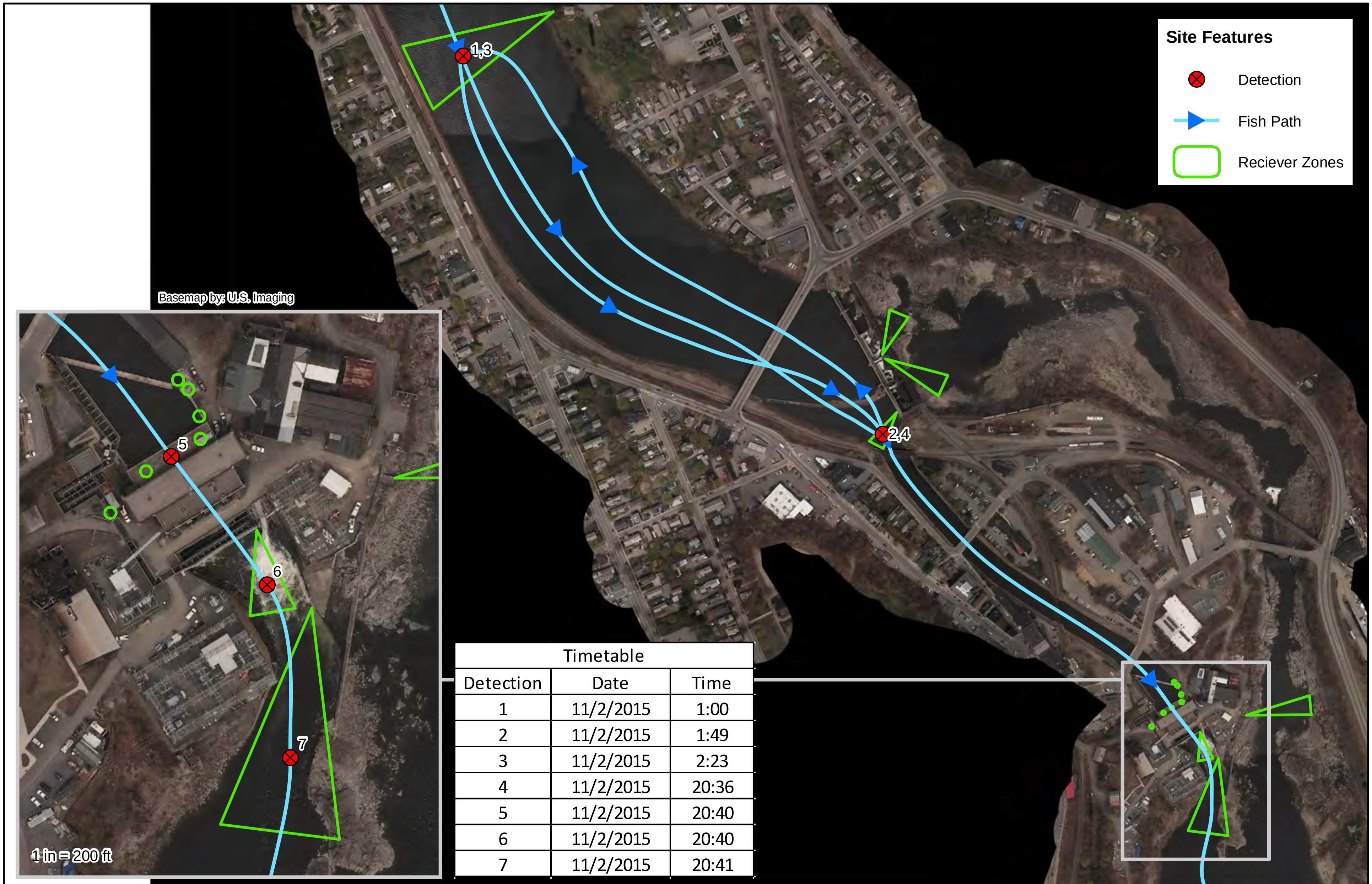

Timetable		
Detection	Date	Time
1	11/2/2015	1:00
2	11/2/2015	1:49
3	11/2/2015	2:23
4	11/2/2015	20:36
5	11/2/2015	20:40
6	11/2/2015	20:40
7	11/2/2015	20:41

TransCanada Hydro Northeast Inc.
ILP Study 19
Bellows Falls Dam

N

1 in = 600 feet

0 300 600 1,200 Feet

Study 19 Fish Number: 36-156

Release: Norwich, VT
Date Released: 10/29/2015
Time Released: 18:43

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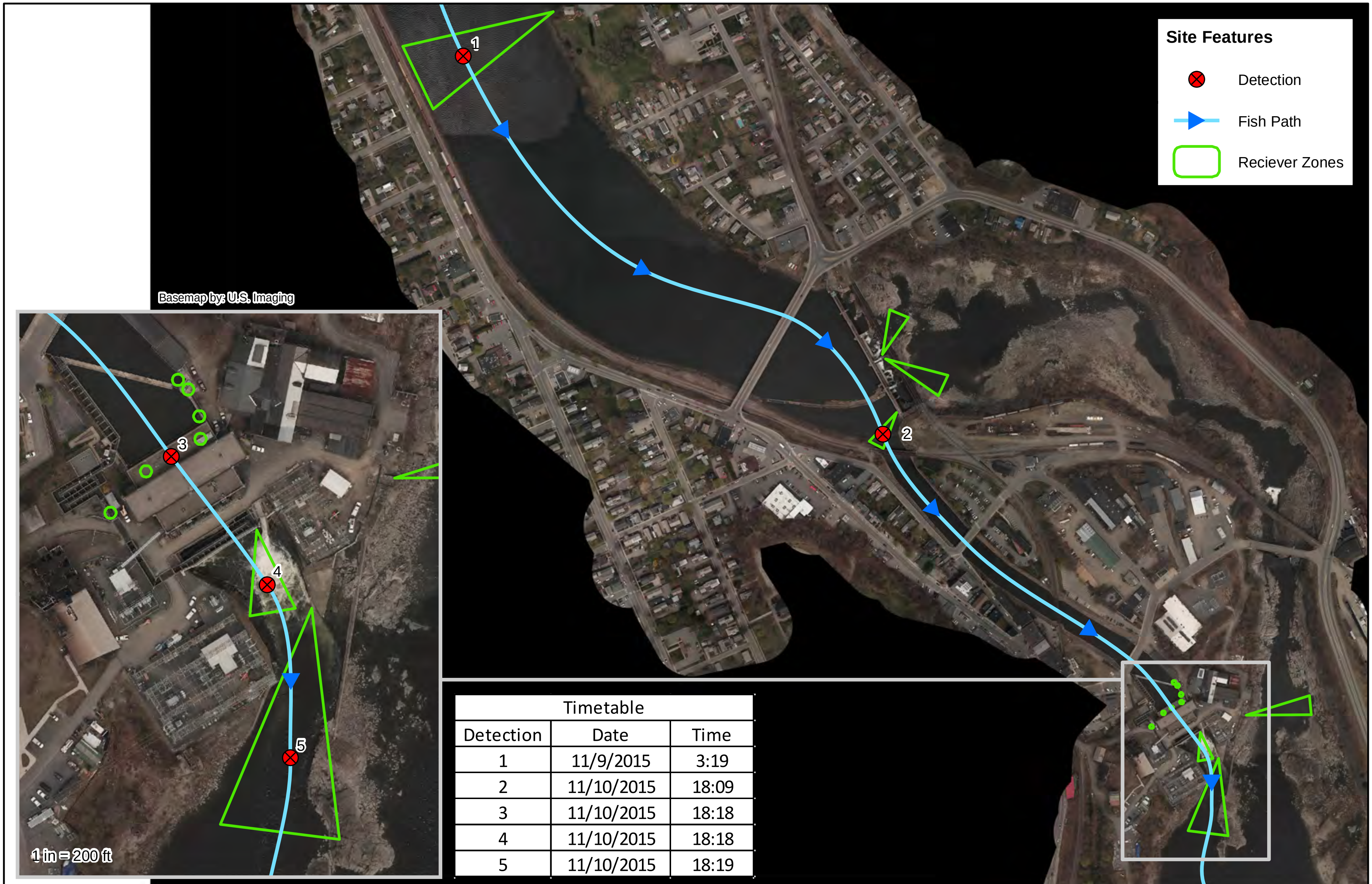

Timetable		
Detection	Date	Time
1	11/9/2015	3:19
2	11/10/2015	18:09
3	11/10/2015	18:18
4	11/10/2015	18:18
5	11/10/2015	18:19

TransCanada Hydro Northeast Inc.
ILP Study 19
Bellows Falls Dam

N

1 in = 600 feet

0 300 600 1,200 Feet

Study 19 Fish Number: 36-158

Release: Norwich, VT
Date Released: 11/05/2015
Time Released: 17:05

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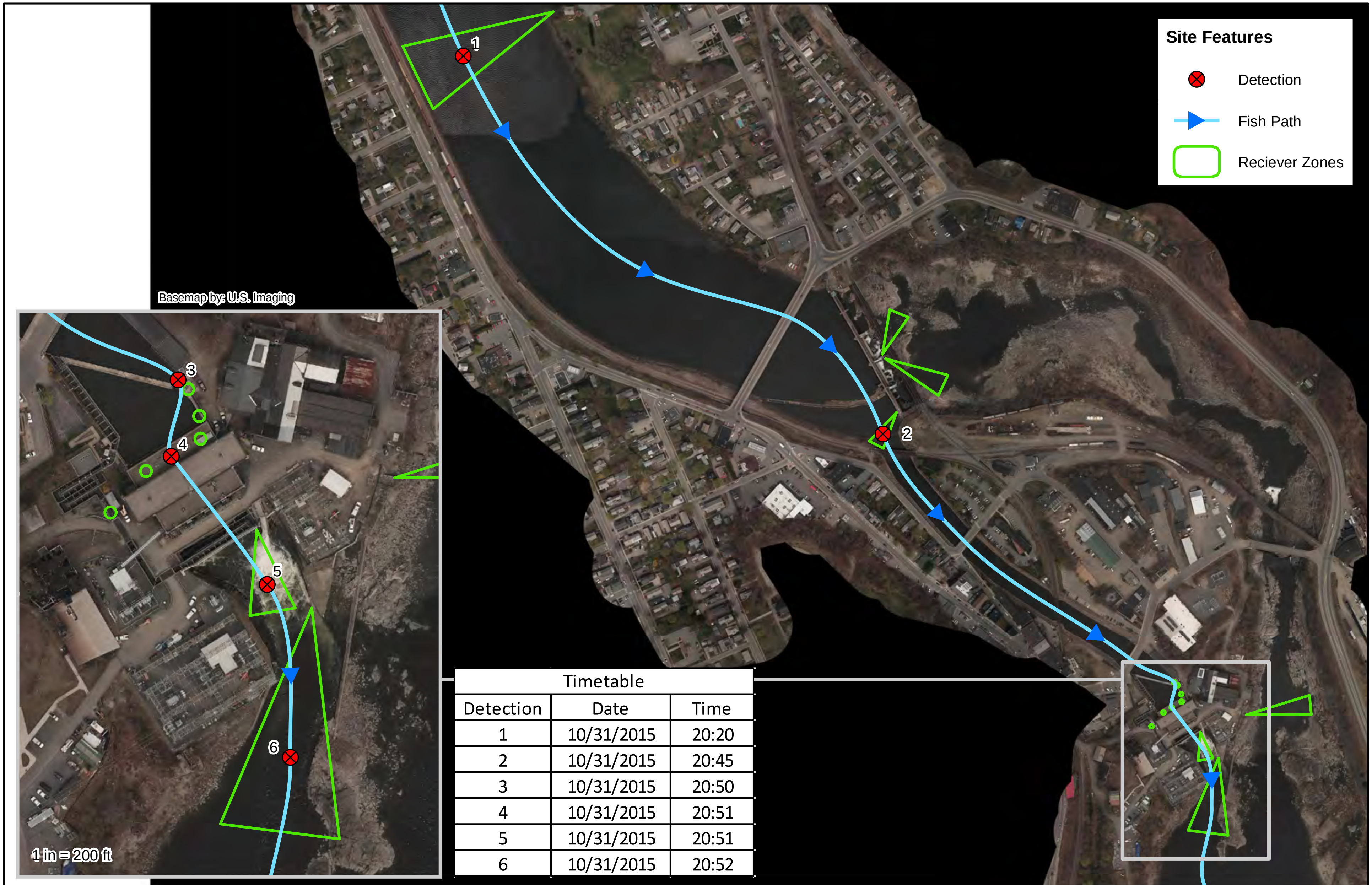

Timetable		
Detection	Date	Time
1	10/31/2015	20:20
2	10/31/2015	20:45
3	10/31/2015	20:50
4	10/31/2015	20:51
5	10/31/2015	20:51
6	10/31/2015	20:52

TransCanada Hydro Northeast Inc.
ILP Study 19
Bellows Falls Dam

N

1 in = 600 feet

0 300 600 1,200 Feet

Study 19 Fish Number: 36-175

Release: Herricks Cove, VT
Date Released: 10/31/2015
Time Released: 18:22

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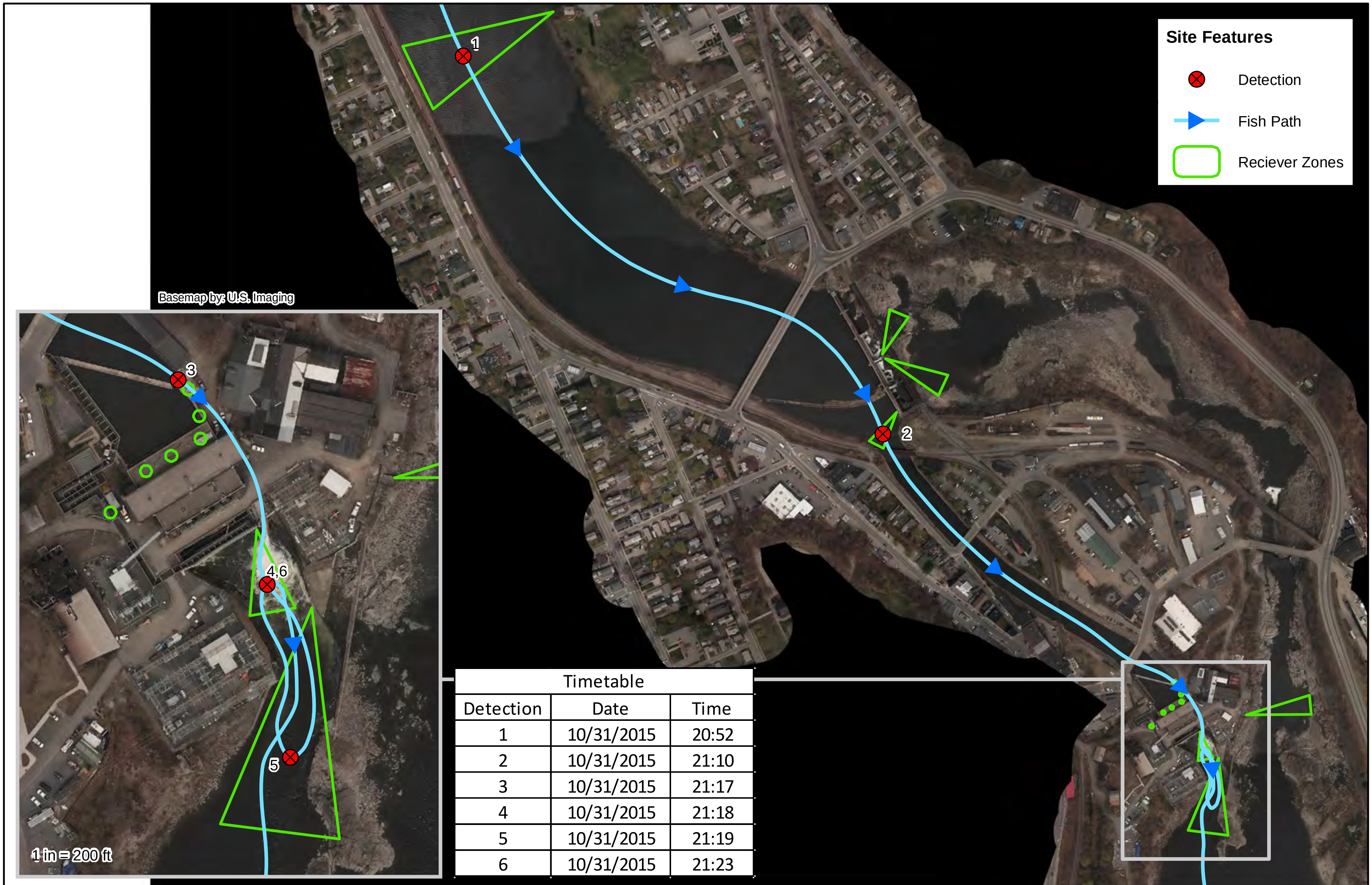

Timetable		
Detection	Date	Time
1	10/31/2015	20:52
2	10/31/2015	21:10
3	10/31/2015	21:17
4	10/31/2015	21:18
5	10/31/2015	21:19
6	10/31/2015	21:23

TransCanada Hydro Northeast Inc.
ILP Study 19
Bellows Falls Dam

Study 19 Fish Number: 36-176

Release: Herricks Cove, VT
Date Released: 10/31/2015
Time Released: 18:22

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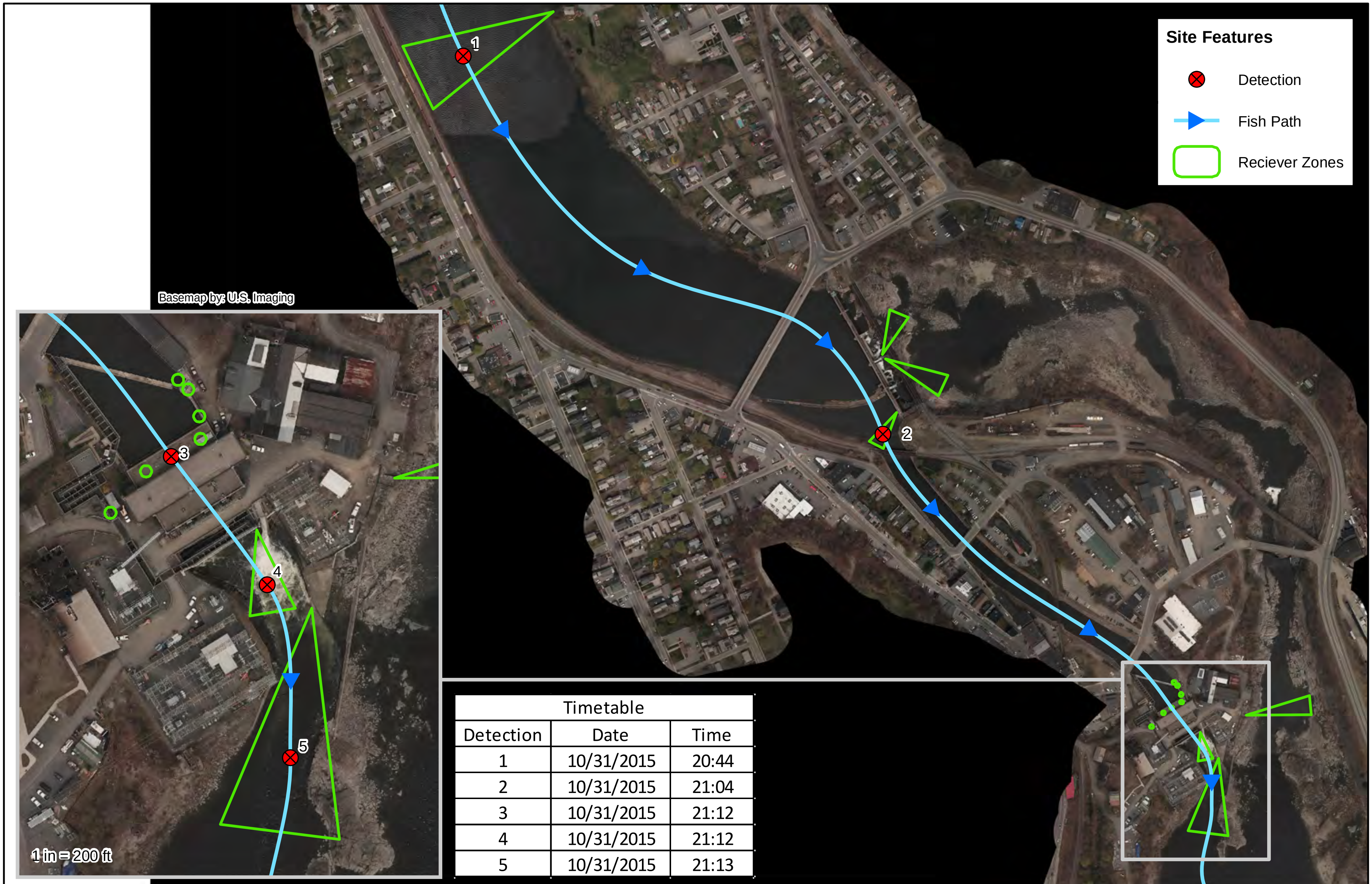

Timetable		
Detection	Date	Time
1	10/31/2015	20:44
2	10/31/2015	21:04
3	10/31/2015	21:12
4	10/31/2015	21:12
5	10/31/2015	21:13

TransCanada Hydro Northeast Inc.
ILP Study 19
Bellows Falls Dam

N

1 in = 600 feet

0 300 600 1,200 Feet

Study 19 Fish Number: 36-177

Release: Herricks Cove, VT
Date Released: 10/31/2015
Time Released: 18:22

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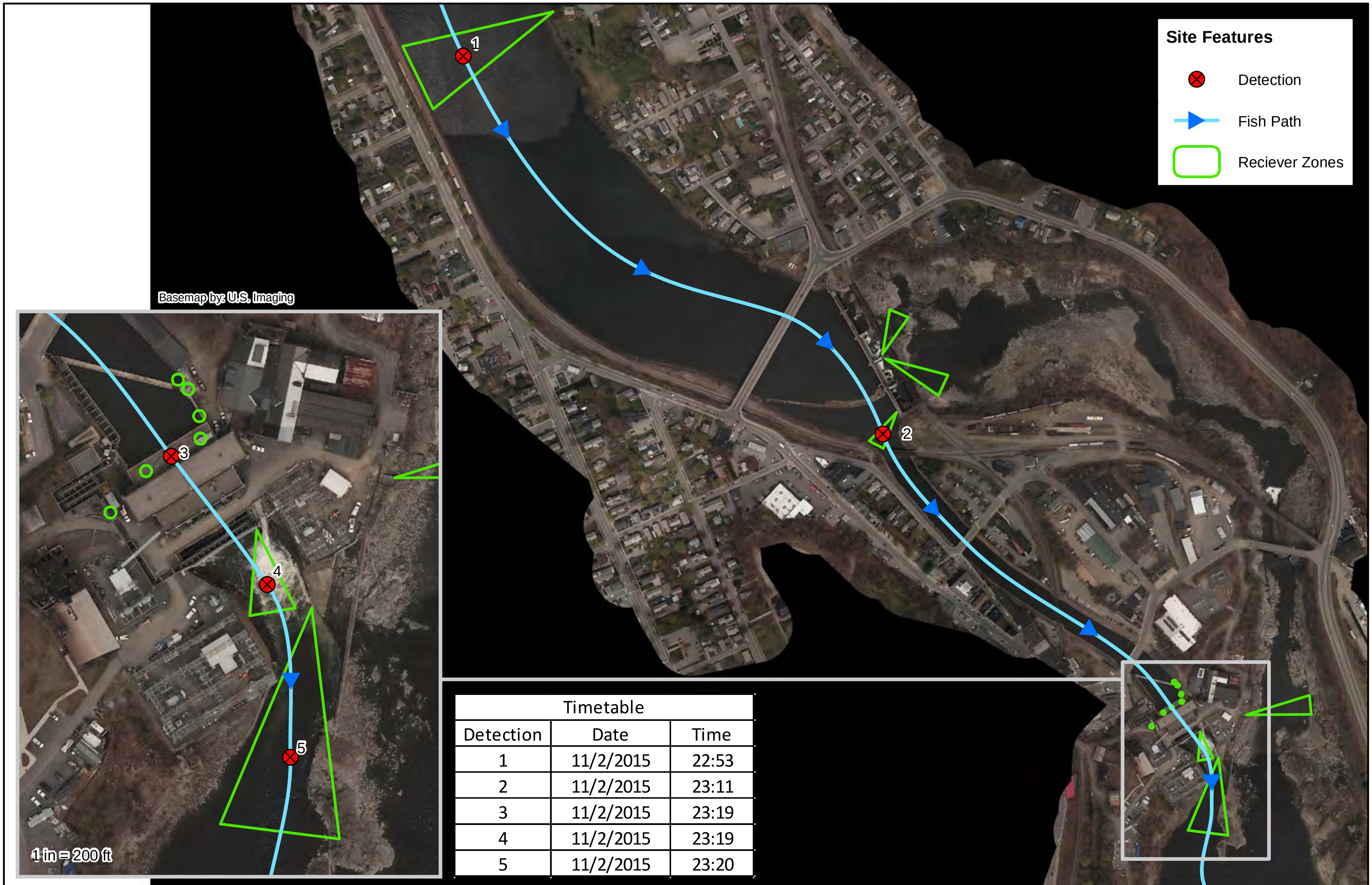

Timetable		
Detection	Date	Time
1	11/2/2015	22:53
2	11/2/2015	23:11
3	11/2/2015	23:19
4	11/2/2015	23:19
5	11/2/2015	23:20

TransCanada Hydro Northeast Inc.
ILP Study 19
Bellows Falls Dam

1 in = 600 feet

0 300 600 1,200 Feet

Study 19 Fish Number: 36-184

Release: Norwich, VT
Date Released: 10/31/2015
Time Released: 19:21

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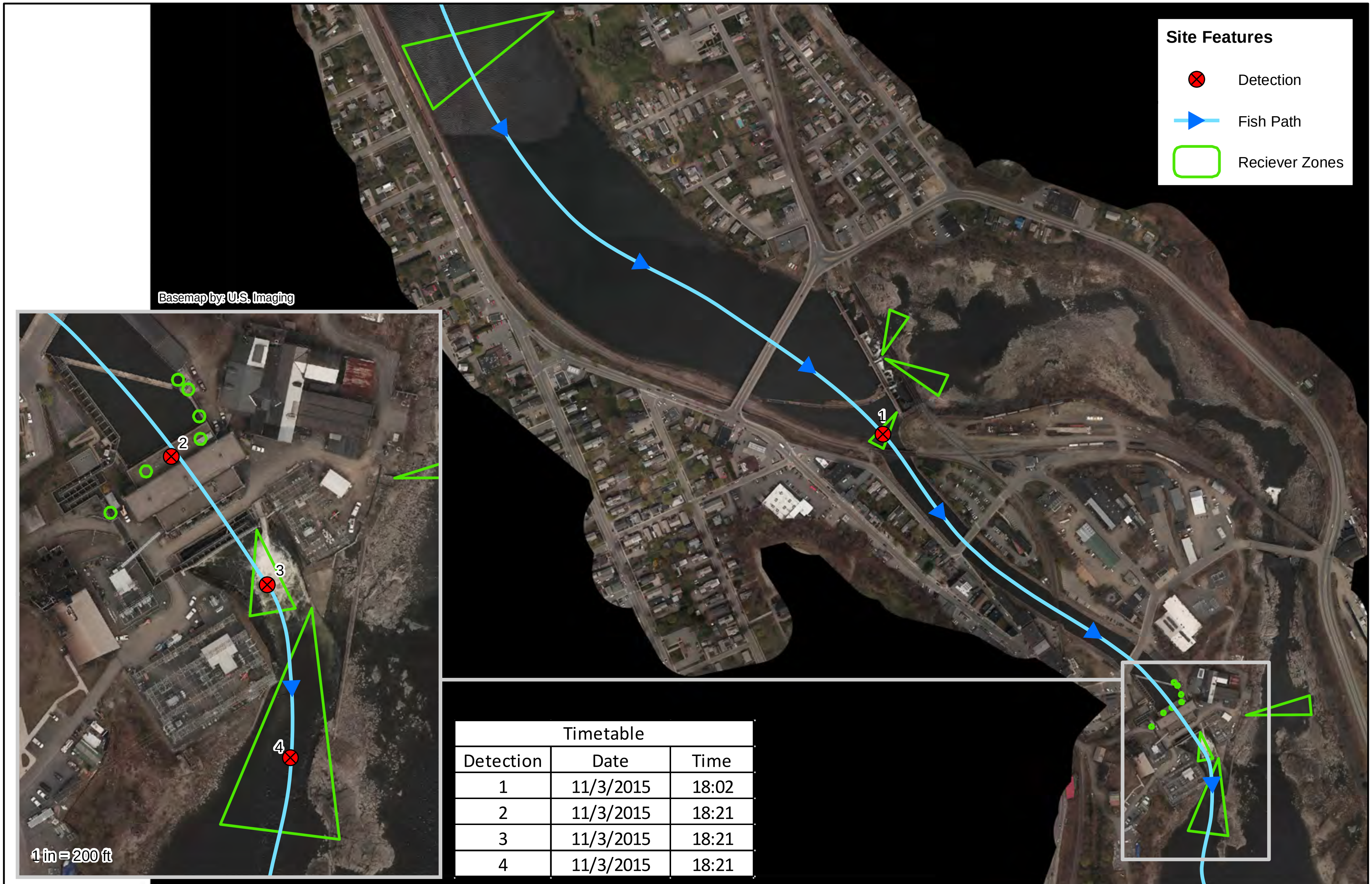

Timetable		
Detection	Date	Time
1	11/3/2015	18:02
2	11/3/2015	18:21
3	11/3/2015	18:21
4	11/3/2015	18:21

TransCanada Hydro Northeast Inc.
ILP Study 19
Bellows Falls Dam

N

1 in = 600 feet

0 300 600 1,200 Feet

Study 19 Fish Number: 36-187

Release: Norwich, VT
Date Released: 10/31/2015
Time Released: 19:21

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Bedford, NH USA
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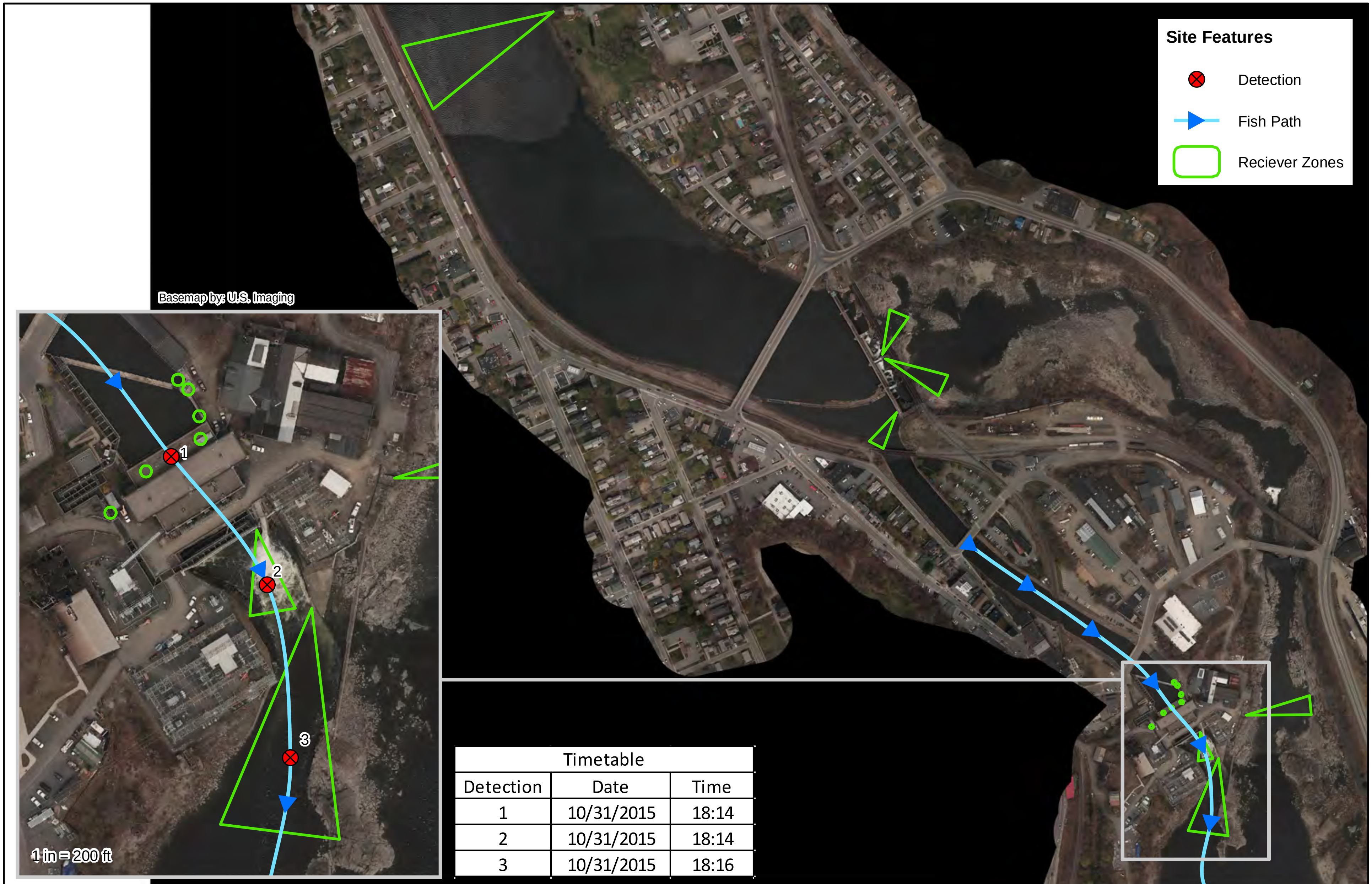

Timetable		
Detection	Date	Time
1	10/31/2015	18:14
2	10/31/2015	18:14
3	10/31/2015	18:16

TransCanada Hydro Northeast Inc.
ILP Study 19
Bellows Falls Dam

N

1 in = 600 feet

0 300 600 1,200 Feet

Study 19 Fish Number: 36-51

Release: Bellows Falls Canal, VT
Date Released: 10/31/2015
Time Released: 18:05

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Environmental Consultants

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Bedford, NH USA
03110

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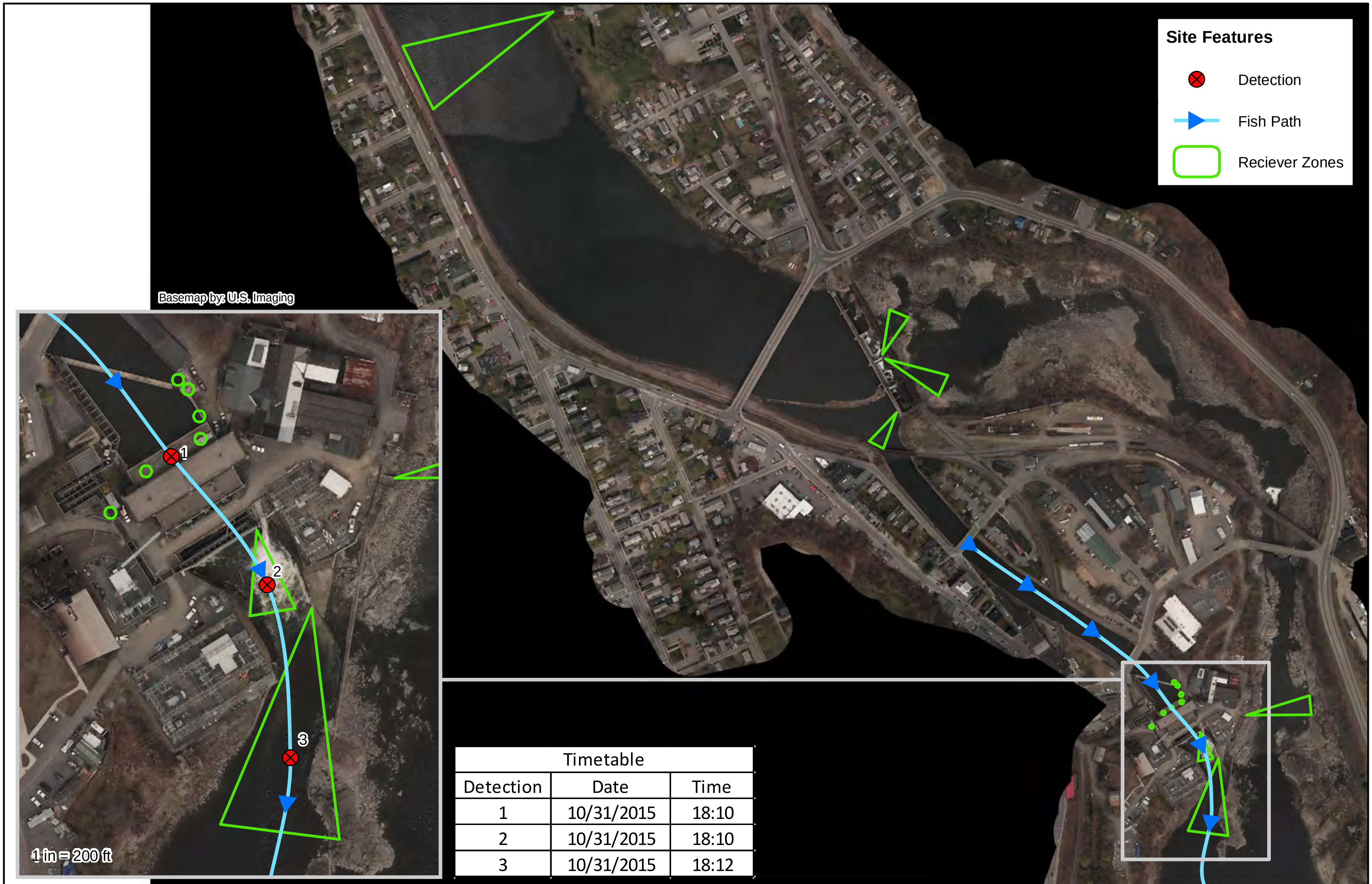

Timetable		
Detection	Date	Time
1	10/31/2015	18:10
2	10/31/2015	18:10
3	10/31/2015	18:12

TransCanada Hydro Northeast Inc.
ILP Study 19
Bellows Falls Dam

1 in = 600 feet

0 300 600 1,200 Feet

Study 19 Fish Number: 36-52

Release: Bellows Falls Canal, VT
Date Released: 10/31/2015
Time Released: 18:05

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Environmental Consultants

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Bedford, NH USA
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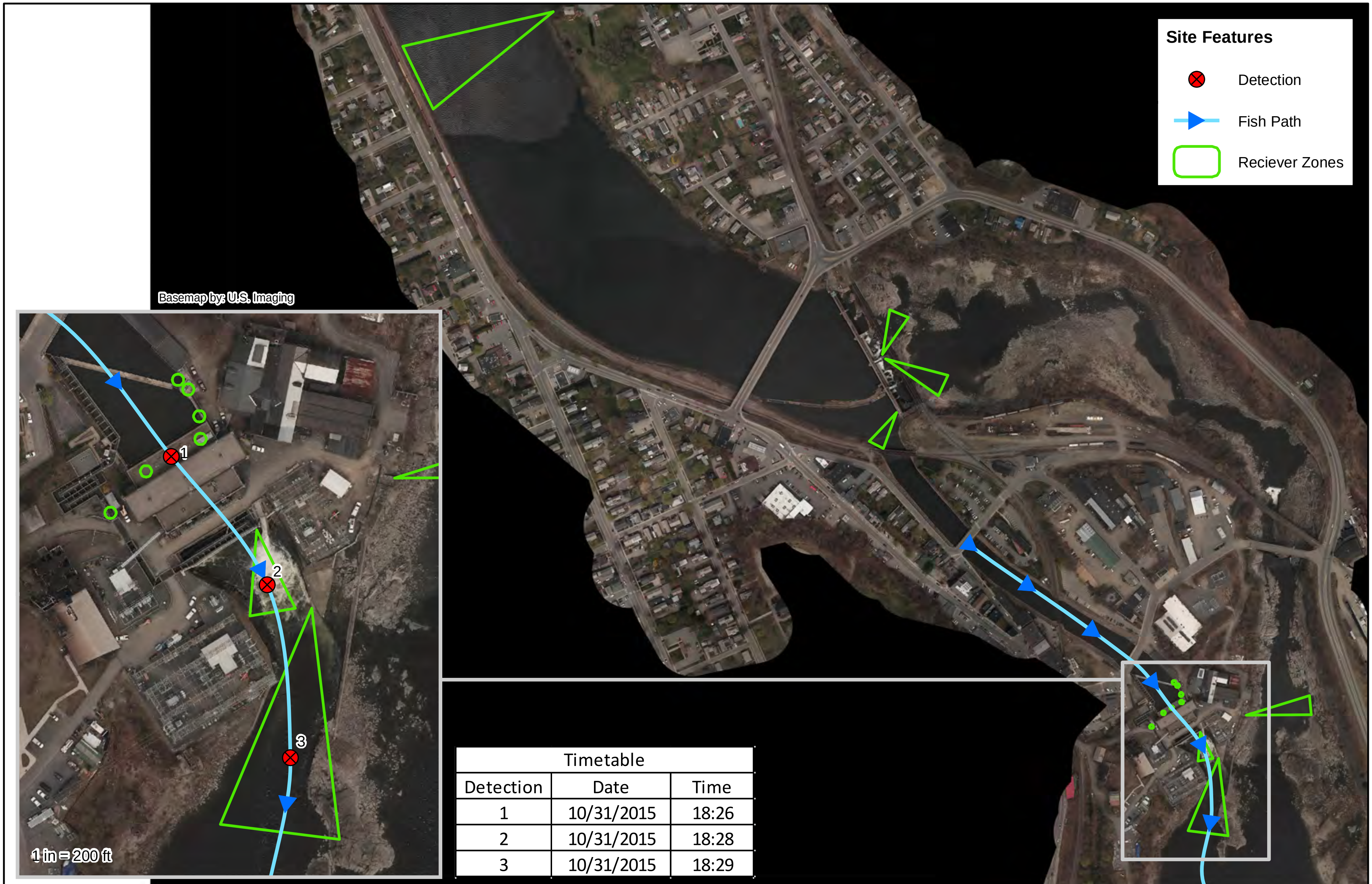

Timetable		
Detection	Date	Time
1	10/31/2015	18:26
2	10/31/2015	18:28
3	10/31/2015	18:29

TransCanada Hydro Northeast Inc.
ILP Study 19
Bellows Falls Dam

N

1 in = 600 feet

0 300 600 1,200 Feet

Study 19 Fish Number: 36-53

Release: Bellows Falls Canal, VT
Date Released: 10/31/2015
Time Released: 18:05

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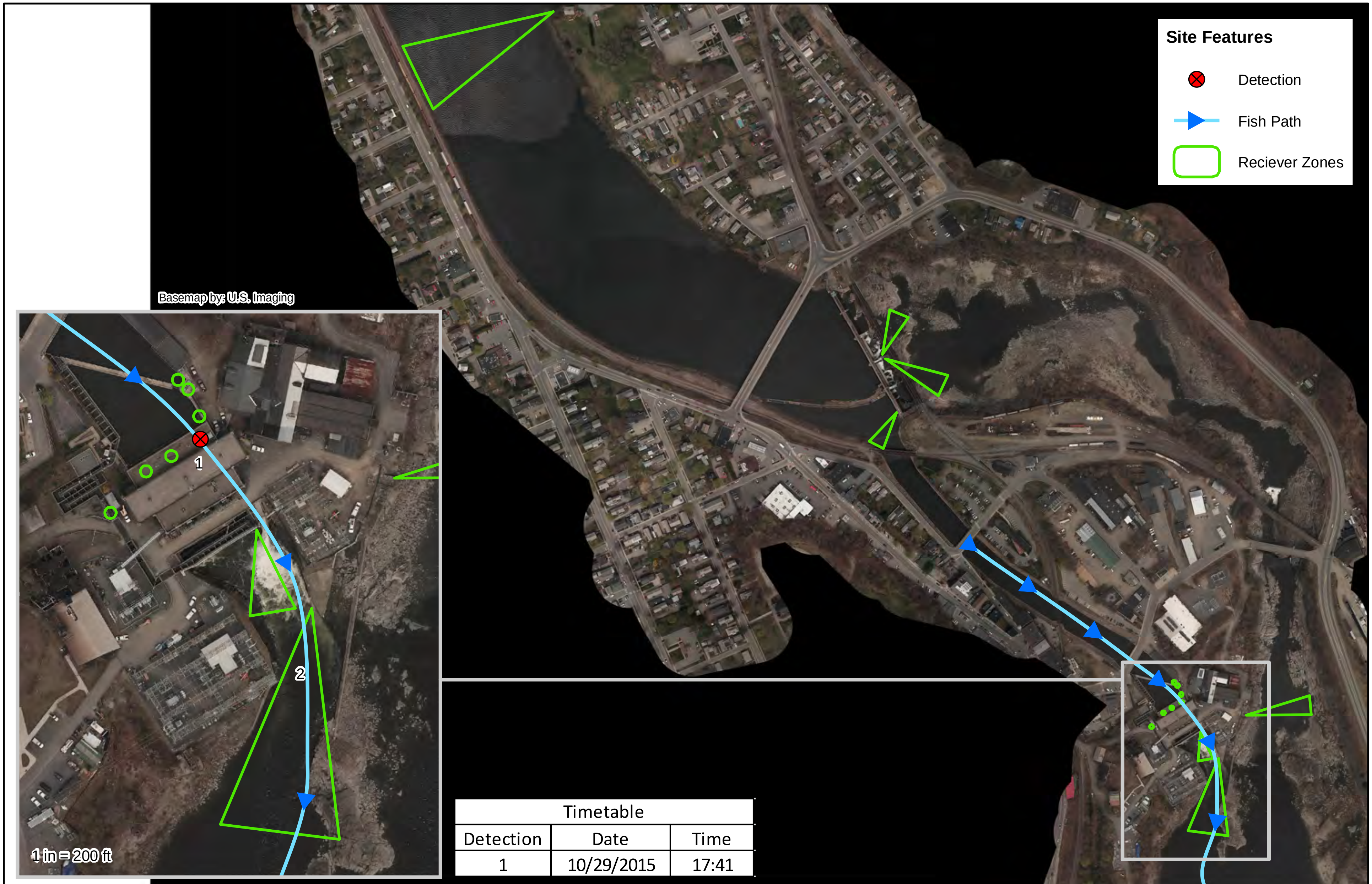

Timetable		
Detection	Date	Time
1	10/29/2015	17:41

TransCanada Hydro Northeast Inc.
ILP Study 19
Bellows Falls Dam

N

1 in = 600 feet

0 300 600 1,200 Feet

Study 19 Fish Number: 36-68

Release: Bellows Falls Canal, VT
Date Released: 10/29/2015
Time Released: 17:32

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Bedford, NH USA
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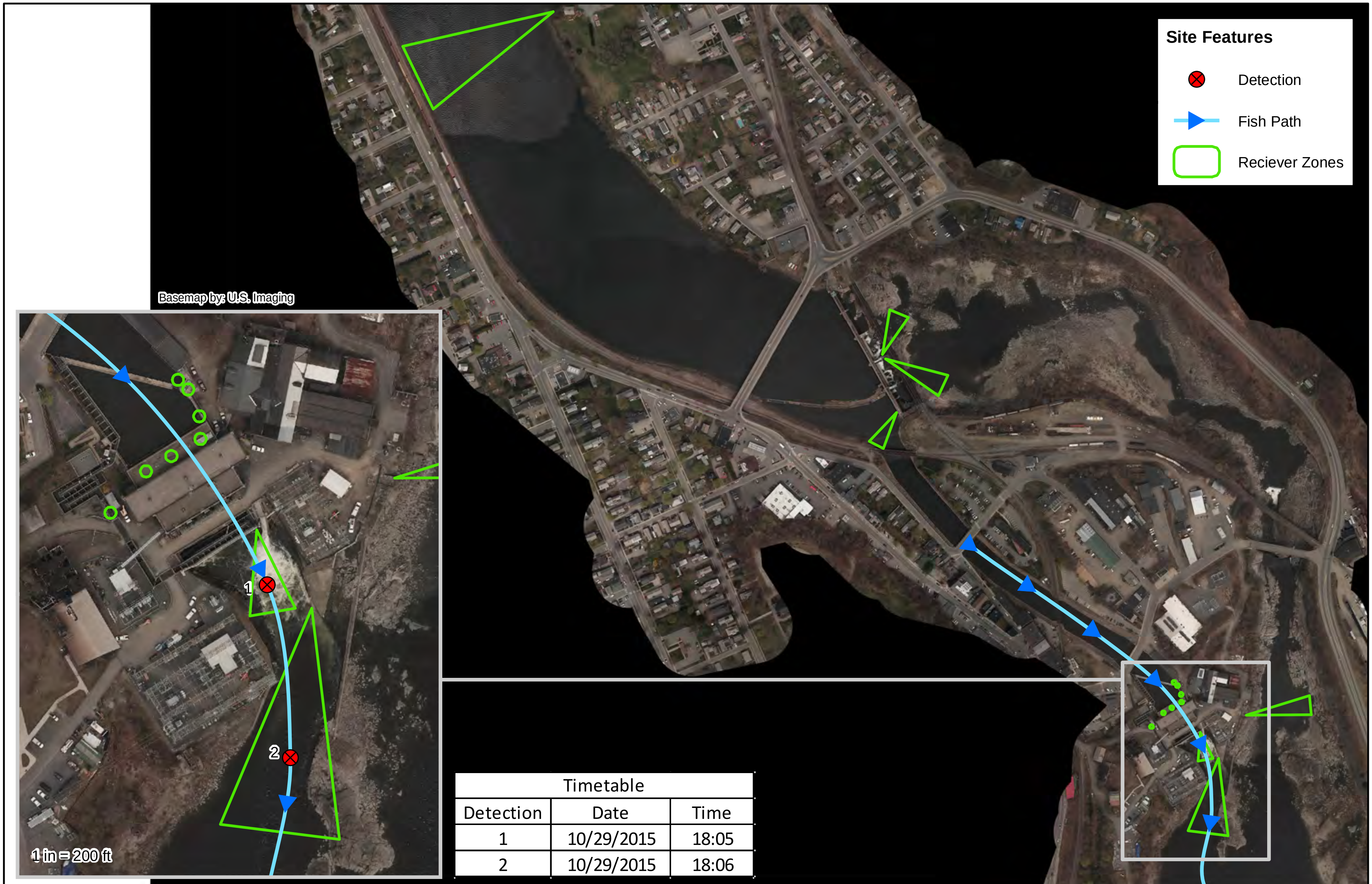

Timetable		
Detection	Date	Time
1	10/29/2015	18:05
2	10/29/2015	18:06

TransCanada Hydro Northeast Inc.
ILP Study 19
Bellows Falls Dam

N

1 in = 600 feet

0 300 600 1,200 Feet

Study 19 Fish Number: 36-69

Release: Bellows Falls Canal, VT
Date Released: 10/29/2015
Time Released: 17:32

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Environmental Consultants
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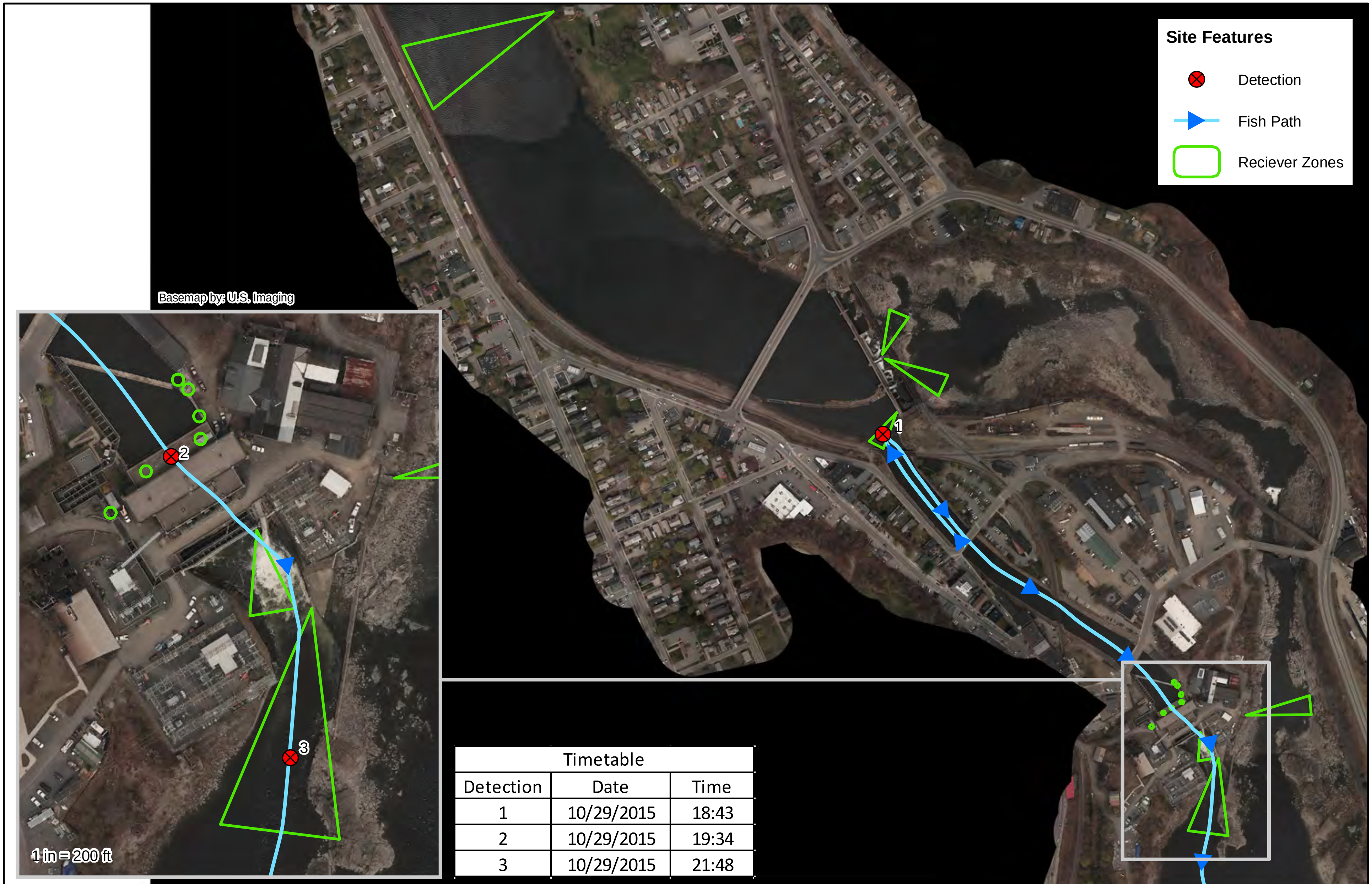
Bedford, NH USA
03110



Timetable		
Detection	Date	Time
1	10/29/2015	18:43
2	10/29/2015	19:34
3	10/29/2015	21:48

TransCanada Hydro Northeast Inc.
ILP Study 19
Bellows Falls Dam

N

1 in = 600 feet

0 300 600 1,200 Feet

Study 19 Fish Number: 36-70

Release: Bellows Falls Canal, VT
Date Released: 10/29/2015
Time Released: 17:32

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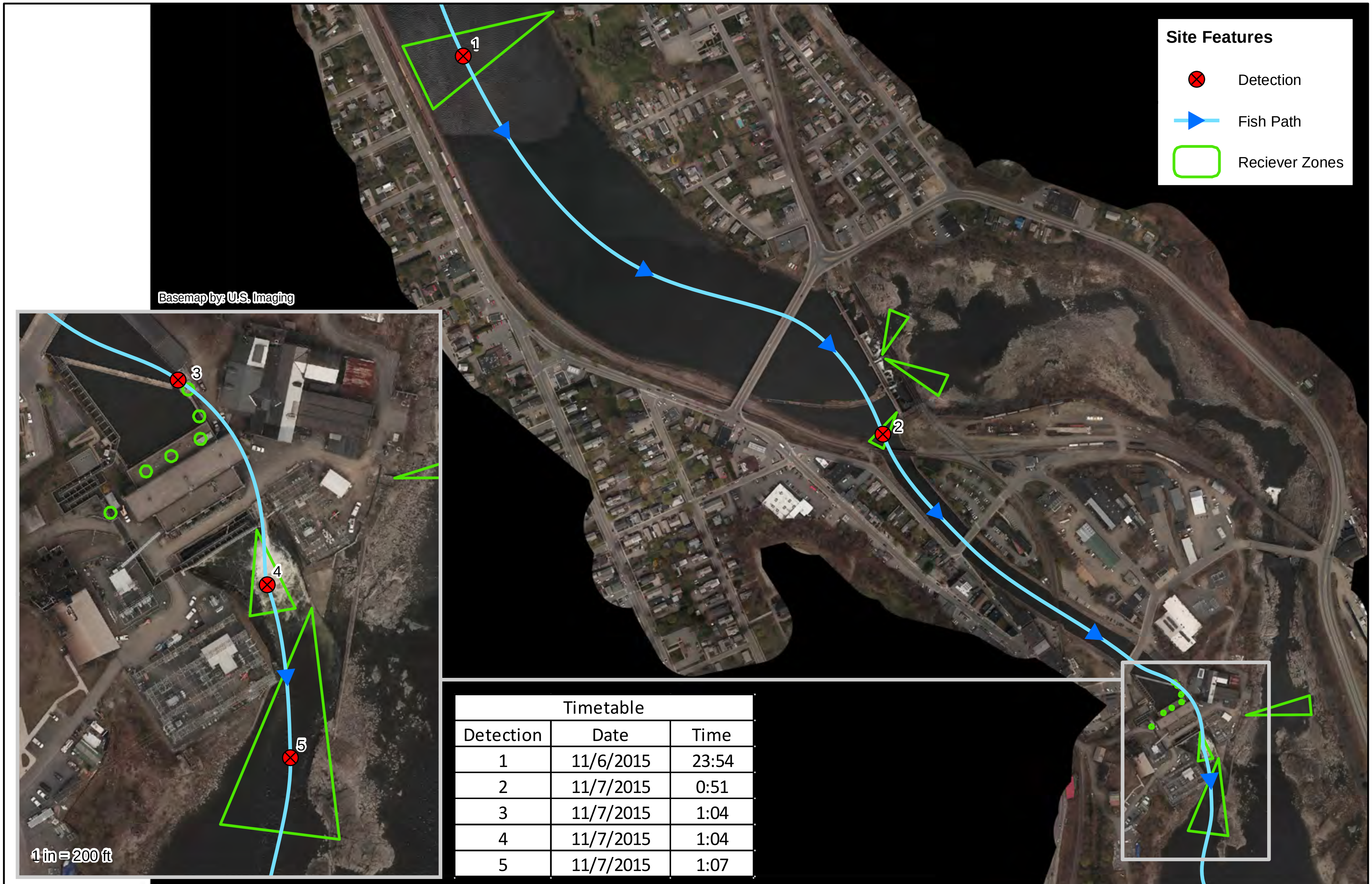

Timetable		
Detection	Date	Time
1	11/6/2015	23:54
2	11/7/2015	0:51
3	11/7/2015	1:04
4	11/7/2015	1:04
5	11/7/2015	1:07

TransCanada Hydro Northeast Inc.
ILP Study 19
Bellows Falls Dam

N

1 in = 600 feet

0 300 600 1,200 Feet

Study 19 Fish Number: 38-111

Release: Herricks Cove, VT
Date Released: 11/03/2015
Time Released: 16:45

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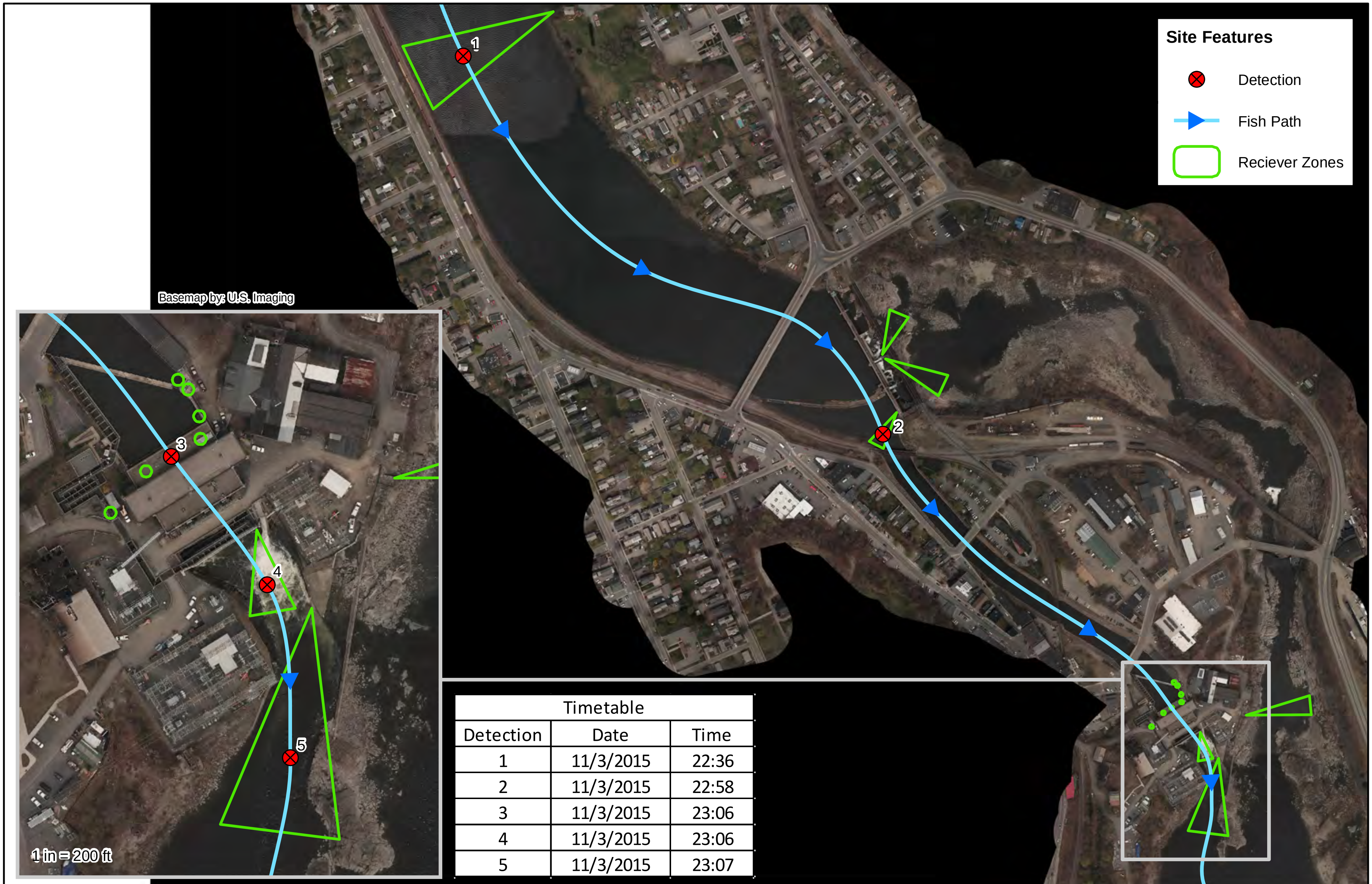

Timetable		
Detection	Date	Time
1	11/3/2015	22:36
2	11/3/2015	22:58
3	11/3/2015	23:06
4	11/3/2015	23:06
5	11/3/2015	23:07

TransCanada Hydro Northeast Inc.
ILP Study 19
Bellows Falls Dam

N

1 in = 600 feet

0 300 600 1,200 Feet

Study 19 Fish Number: 38-112

Release: Herricks Cove, VT
Date Released: 11/03/2015
Time Released: 16:45

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Environmental Consultants
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Bedford, NH USA
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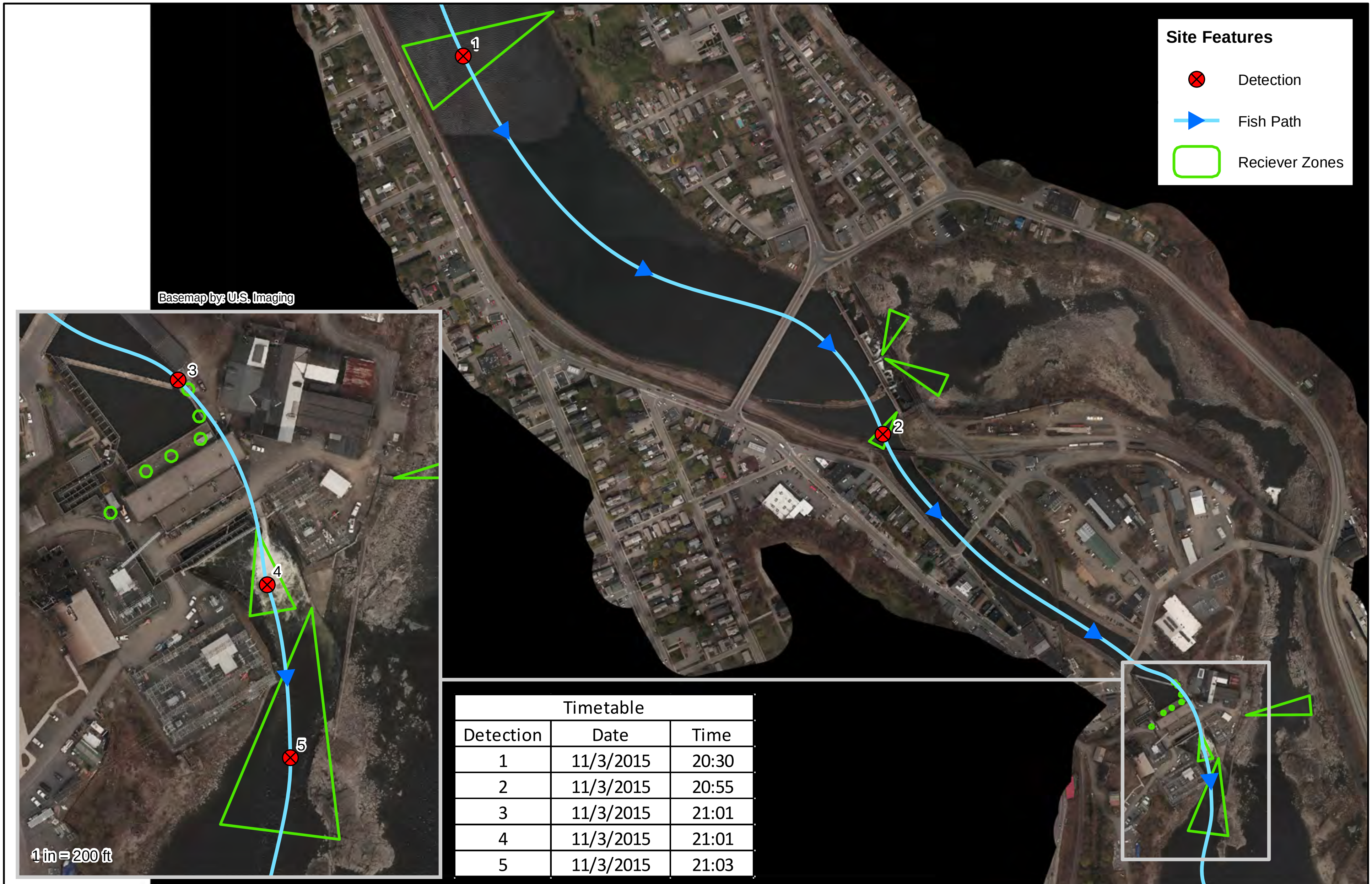

Timetable		
Detection	Date	Time
1	11/3/2015	20:30
2	11/3/2015	20:55
3	11/3/2015	21:01
4	11/3/2015	21:01
5	11/3/2015	21:03

TransCanada Hydro Northeast Inc.
ILP Study 19
Bellows Falls Dam

N

1 in = 600 feet

0 300 600 1,200 Feet

Study 19 Fish Number: 38-113

Release: Herricks Cove, VT
Date Released: 11/03/2015
Time Released: 16:45

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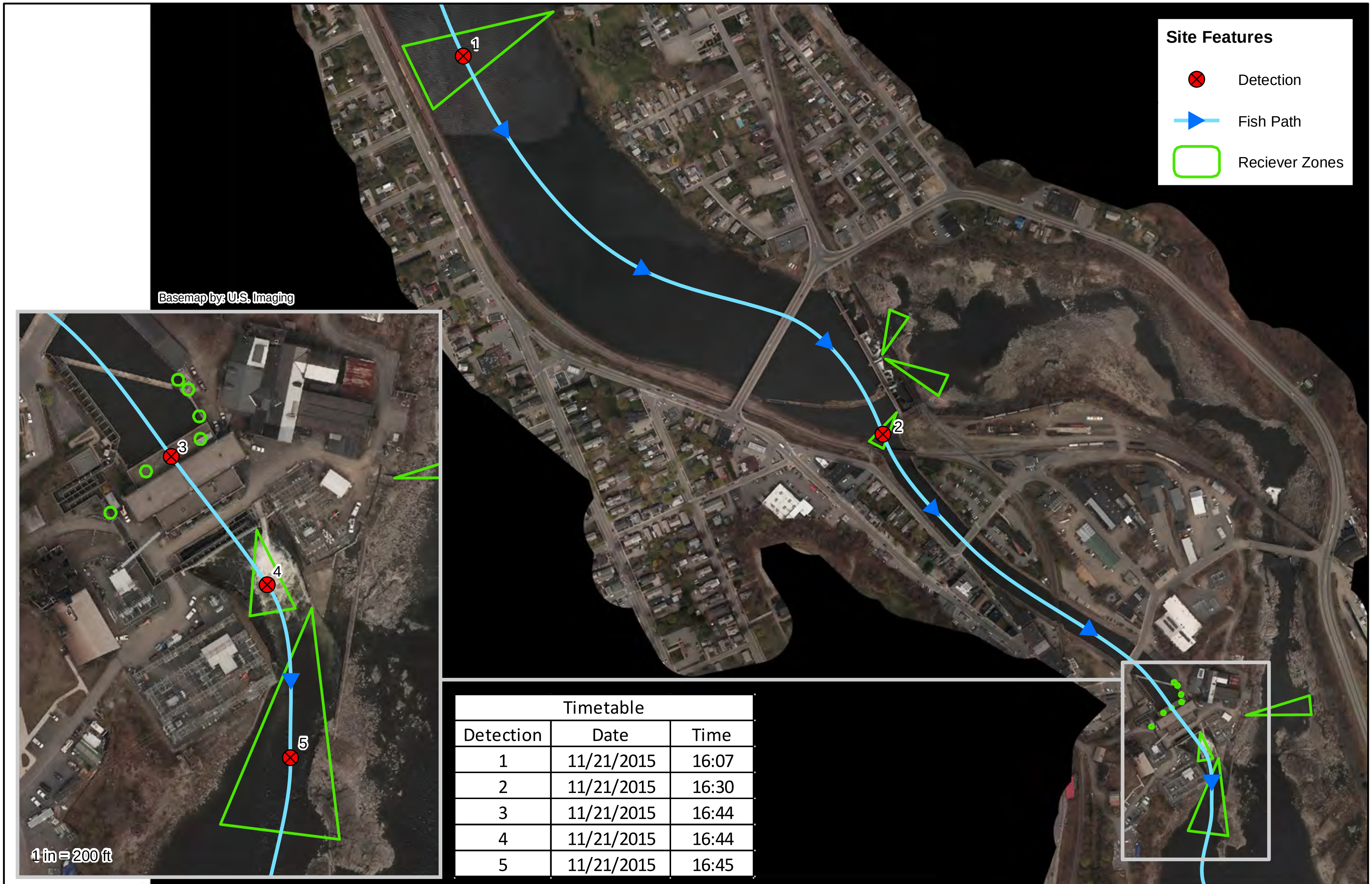

Timetable		
Detection	Date	Time
1	11/21/2015	16:07
2	11/21/2015	16:30
3	11/21/2015	16:44
4	11/21/2015	16:44
5	11/21/2015	16:45

TransCanada Hydro Northeast Inc.
ILP Study 19
Bellows Falls Dam

N

1 in = 600 feet

0 300 600 1,200 Feet

Study 19 Fish Number: 38-114

Release: Herricks Cove, VT
Date Released: 11/03/2015
Time Released: 16:45

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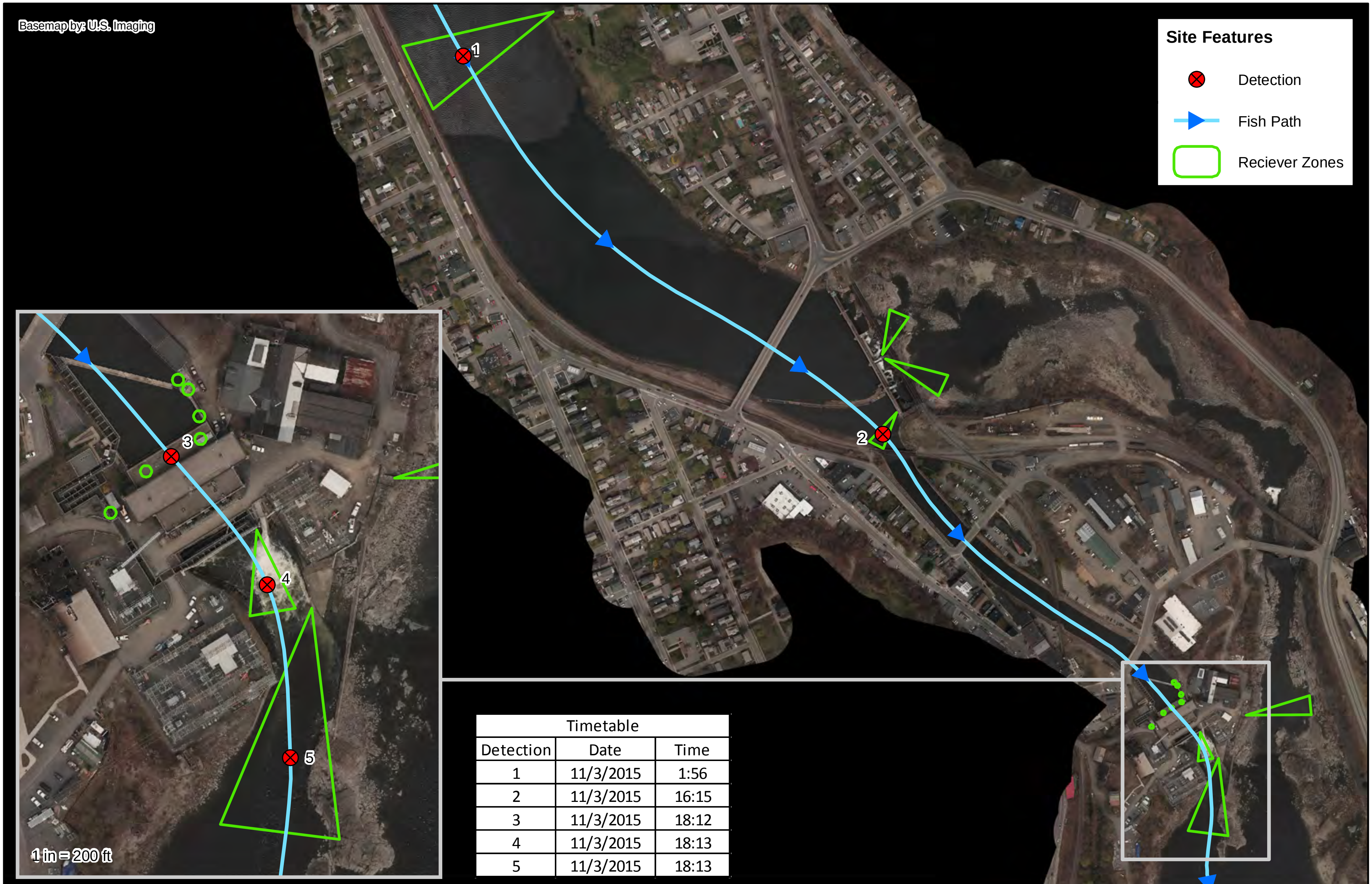

Timetable		
Detection	Date	Time
1	11/3/2015	1:56
2	11/3/2015	16:15
3	11/3/2015	18:12
4	11/3/2015	18:13
5	11/3/2015	18:13

TransCanada Hydro Northeast Inc.
ILP Study 19
Bellows Falls Dam

N

1 in = 600 feet

0 300 600 1,200 Feet

Study 19 Fish Number: 38-118

Release: Herricks Cove, VT
Date Released: 10/27/2015
Time Released: 18:20

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Bedford, NH USA
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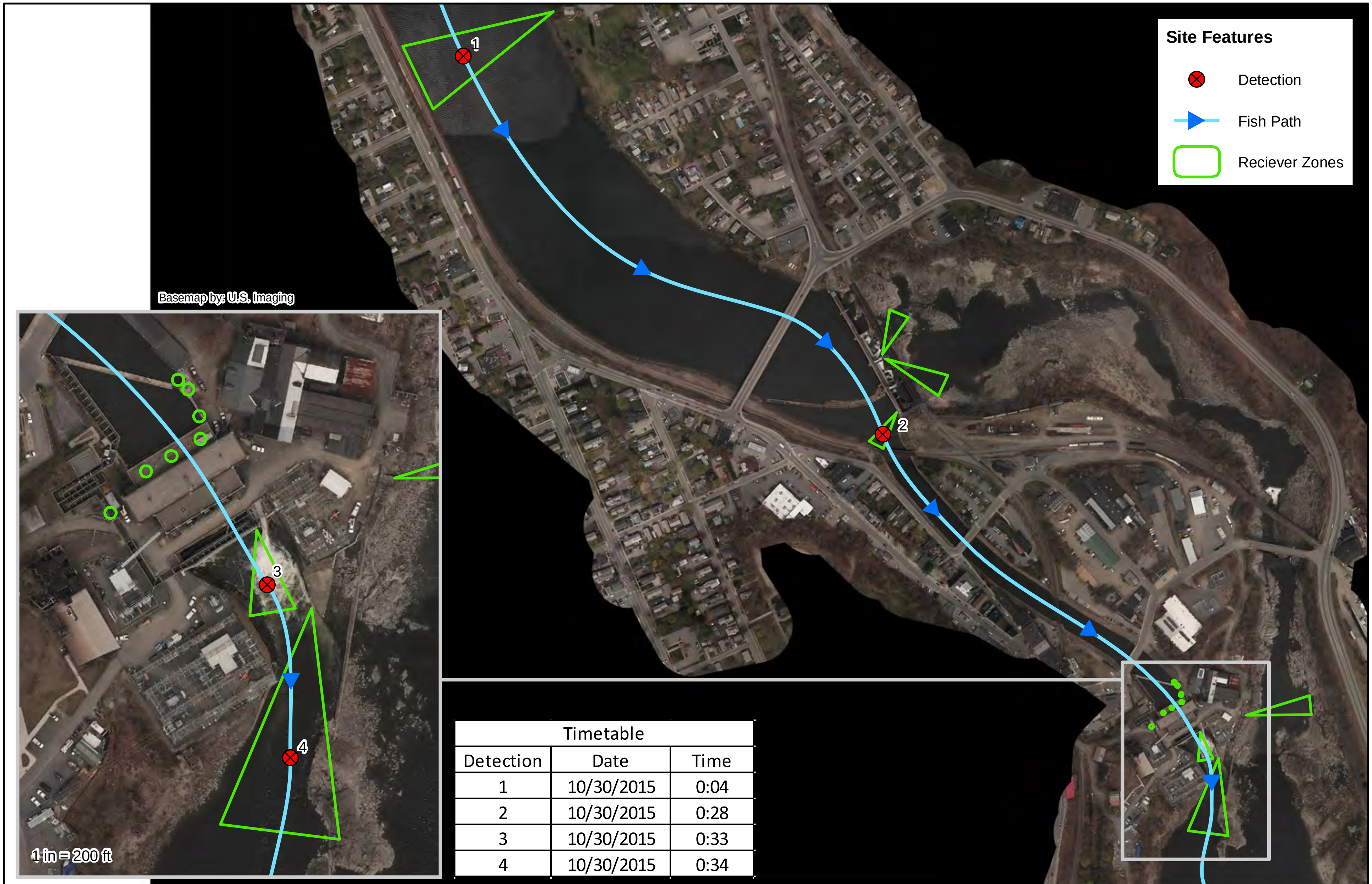

Timetable		
Detection	Date	Time
1	10/30/2015	0:04
2	10/30/2015	0:28
3	10/30/2015	0:33
4	10/30/2015	0:34

TransCanada Hydro Northeast Inc.
ILP Study 19
Bellows Falls Dam

N

1 in = 600 feet

0 300 600 1,200 Feet

Study 19 Fish Number: 38-119

Release: Herricks Cove, VT
Date Released: 10/27/2015
Time Released: 18:20

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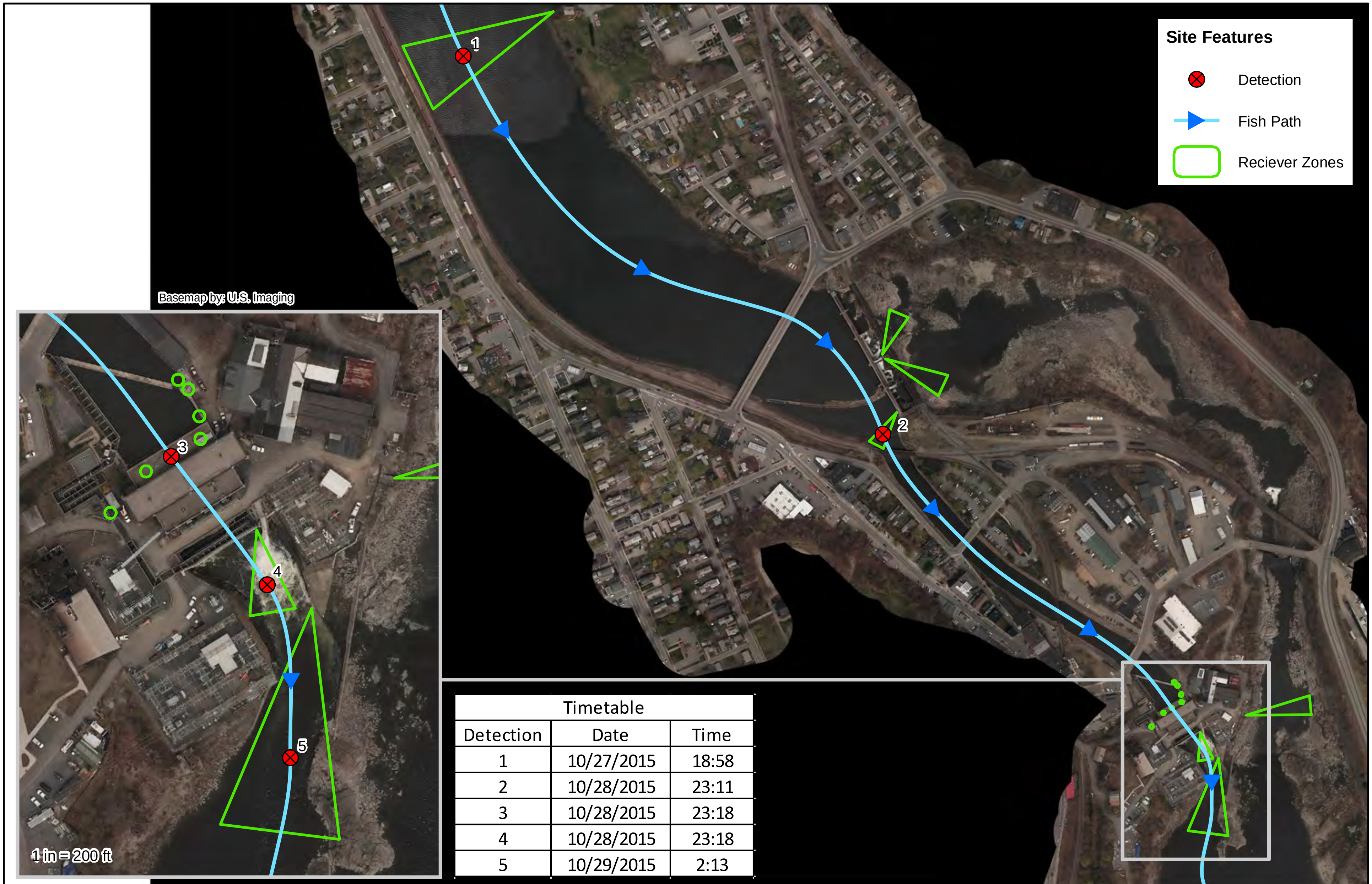

Timetable		
Detection	Date	Time
1	10/27/2015	18:58
2	10/28/2015	23:11
3	10/28/2015	23:18
4	10/28/2015	23:18
5	10/29/2015	2:13

TransCanada Hydro Northeast Inc.
ILP Study 19
Bellows Falls Dam

N

1 in = 600 feet

0 300 600 1,200 Feet

Study 19 Fish Number: 38-120

Release: Herricks Cove, VT
Date Released: 10/27/2015
Time Released: 18:20

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Bedford, NH USA
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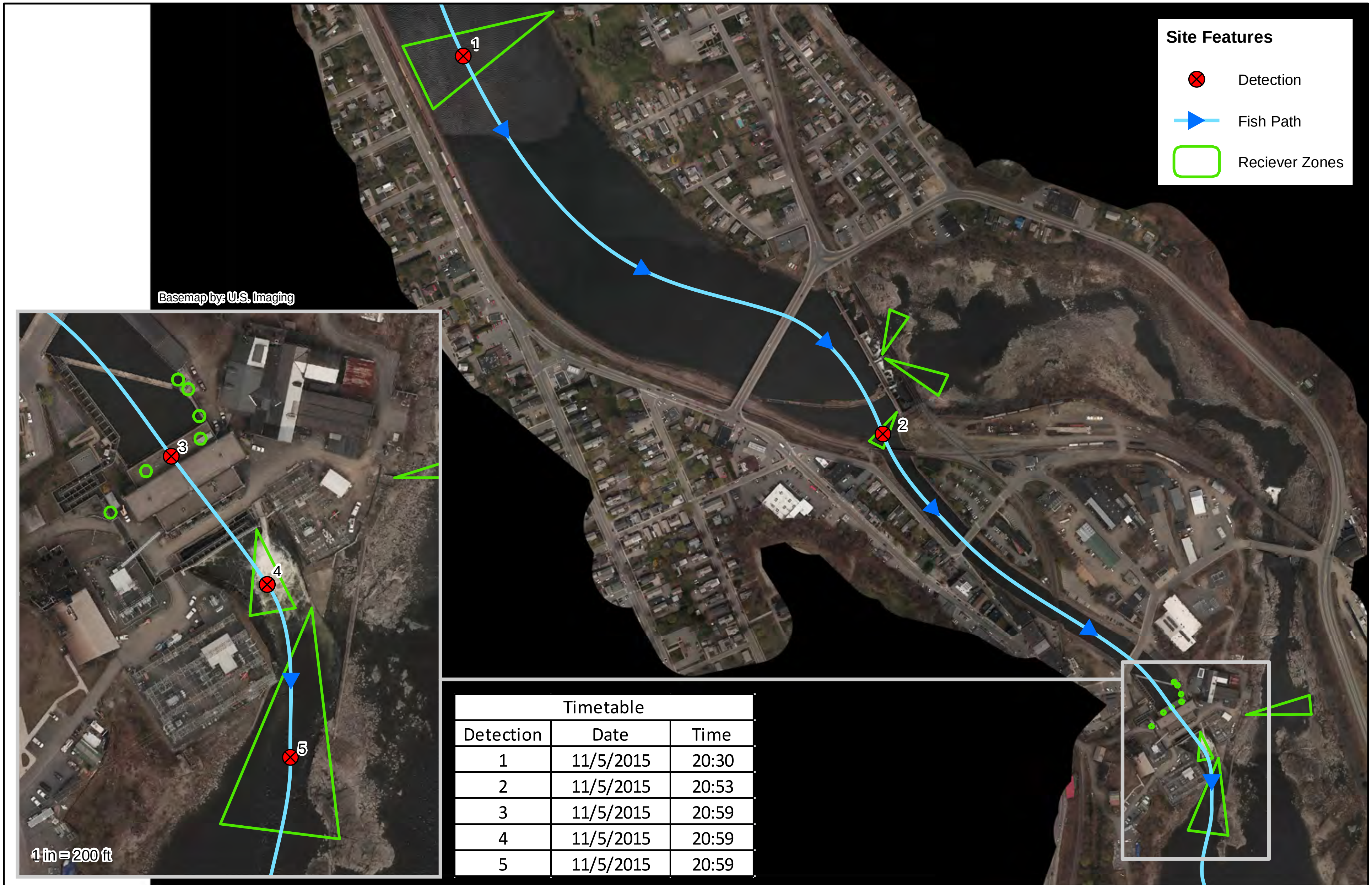

Timetable		
Detection	Date	Time
1	11/5/2015	20:30
2	11/5/2015	20:53
3	11/5/2015	20:59
4	11/5/2015	20:59
5	11/5/2015	20:59

TransCanada Hydro Northeast Inc.
ILP Study 19
Bellows Falls Dam

Study 19 Fish Number: 38-124

Release: Herricks Cove, VT
Date Released: 11/03/2015
Time Released: 17:32

NORMANDEAU ASSOCIATES
Environmental Consultants
Normandeau Associates Inc.
25 Nashua Road
Bedford, NH USA
03110

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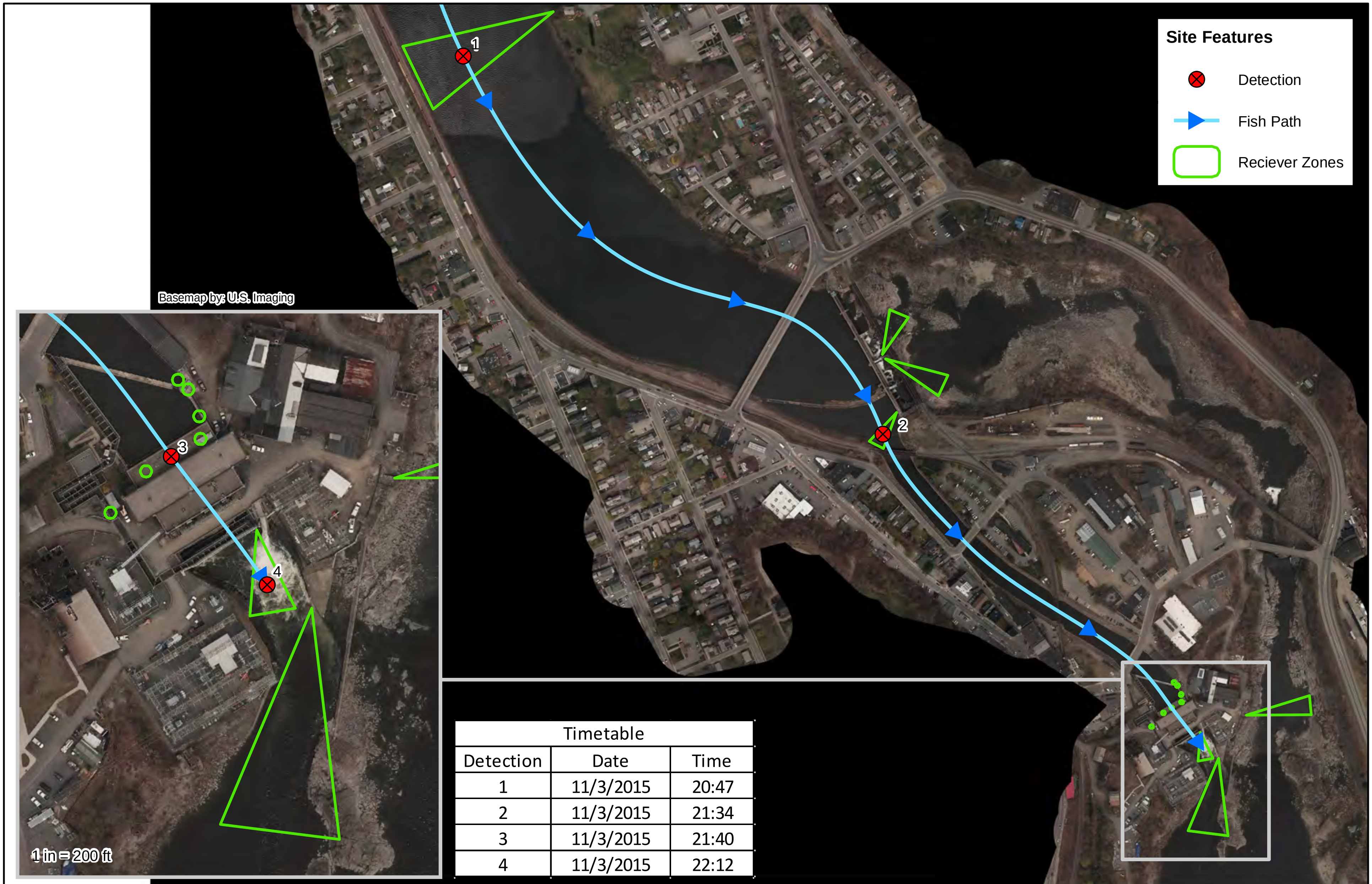
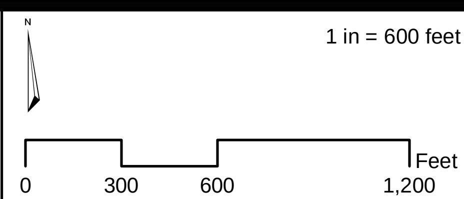


Timetable		
Detection	Date	Time
1	11/3/2015	20:47
2	11/3/2015	21:34
3	11/3/2015	21:40
4	11/3/2015	22:12

TransCanada Hydro Northeast Inc.
ILP Study 19
Bellows Falls Dam



Study 19 Fish Number: 38-130

Release: Norwich, VT
Date Released: 10/27/2015
Time Released: 20:05

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Environmental Consultants
Normandeau Associates Inc.
25 Nashua Road
Bedford, NH USA
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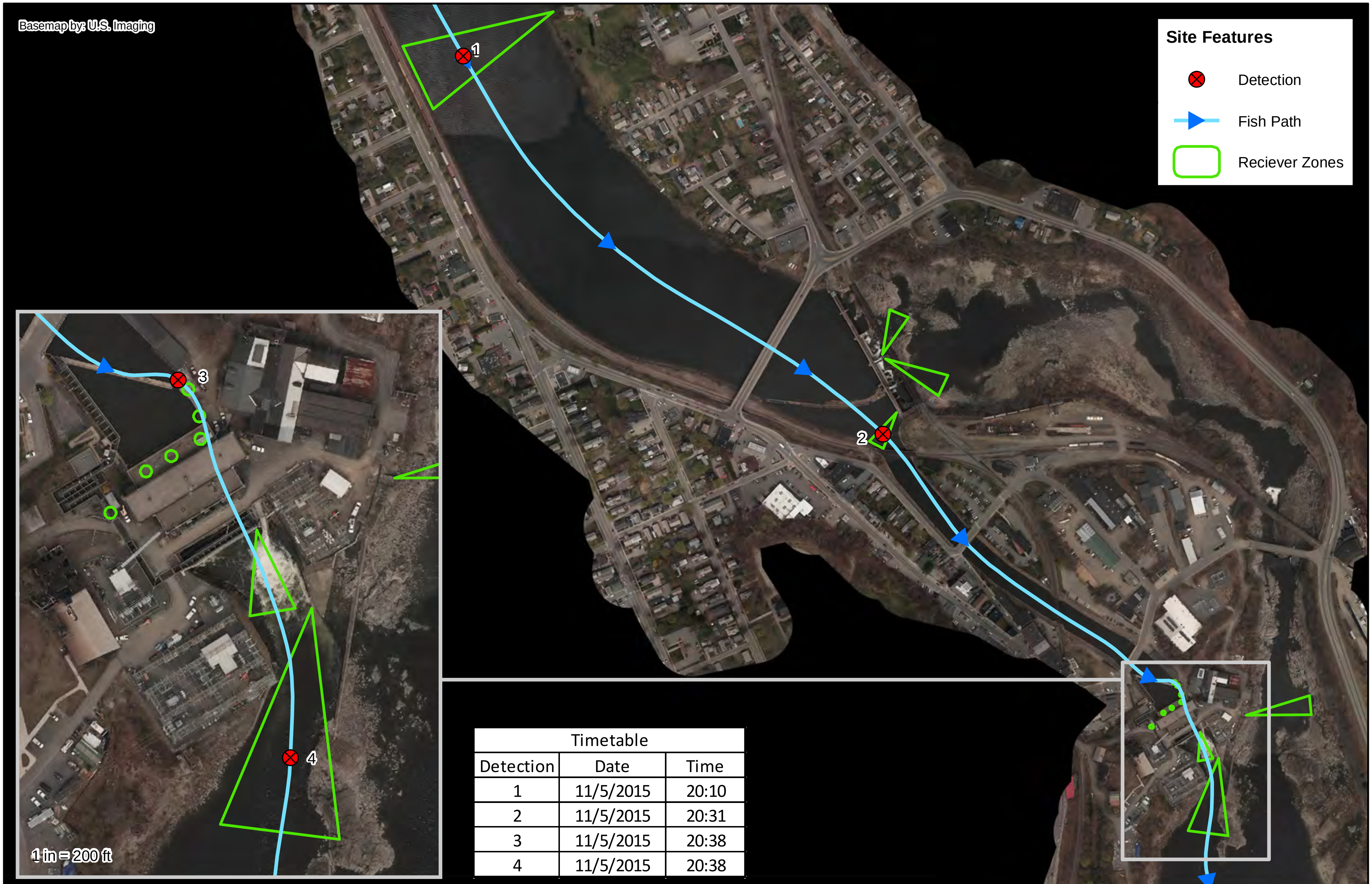

Timetable		
Detection	Date	Time
1	11/5/2015	20:10
2	11/5/2015	20:31
3	11/5/2015	20:38
4	11/5/2015	20:38

TransCanada Hydro Northeast Inc.
ILP Study 19
Bellows Falls Dam

N

1 in = 600 feet

0 300 600 1,200 Feet

Study 19 Fish Number: 38-144

Release: Herricks Cove, VT
Date Released: 11/05/2015
Time Released: 16:20

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Environmental Consultants

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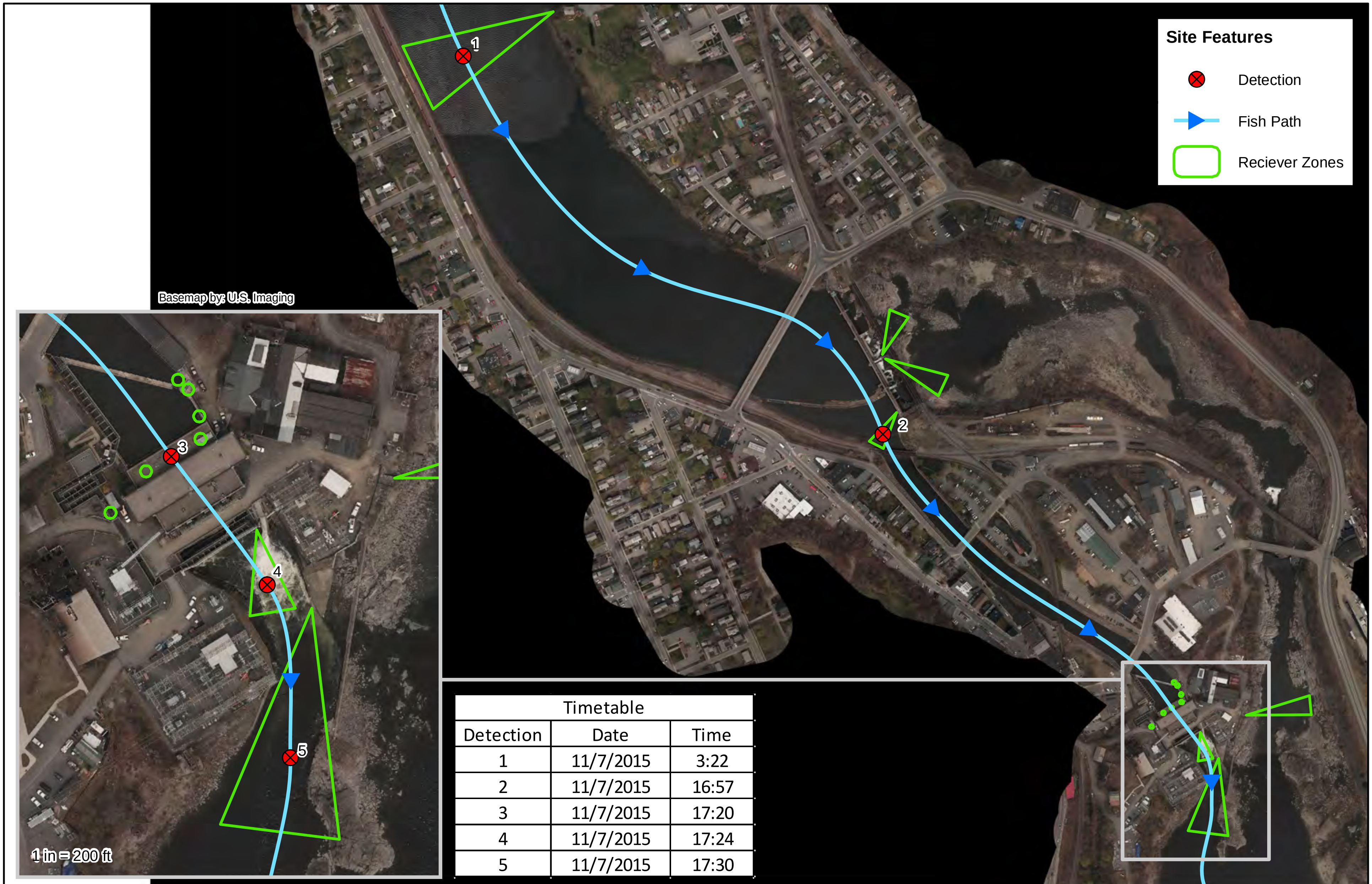

Timetable		
Detection	Date	Time
1	11/7/2015	3:22
2	11/7/2015	16:57
3	11/7/2015	17:20
4	11/7/2015	17:24
5	11/7/2015	17:30

TransCanada Hydro Northeast Inc.
ILP Study 19
Bellows Falls Dam

N

1 in = 600 feet

0 300 600 1,200 Feet

Study 19 Fish Number: 38-145

Release: Herricks Cove, VT
Date Released: 11/05/2015
Time Released: 16:20

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Environmental Consultants

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Bedford, NH USA
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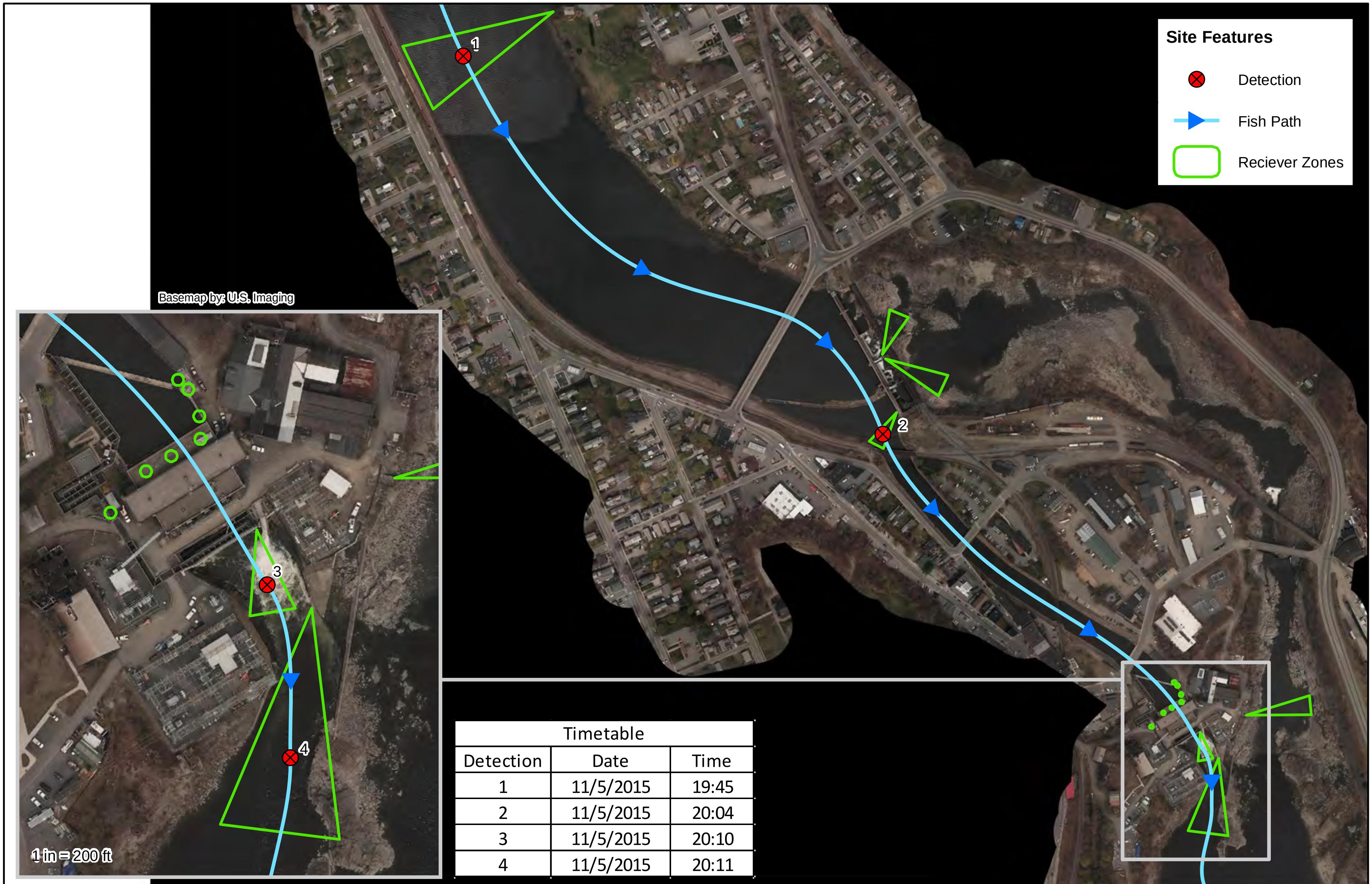

Timetable		
Detection	Date	Time
1	11/5/2015	19:45
2	11/5/2015	20:04
3	11/5/2015	20:10
4	11/5/2015	20:11

TransCanada Hydro Northeast Inc.
ILP Study 19
Bellows Falls Dam

N

1 in = 600 feet

0 300 600 1,200 Feet

Study 19 Fish Number: 38-146

Release: Herricks Cove, VT
Date Released: 11/05/2015
Time Released: 16:20

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Environmental Consultants

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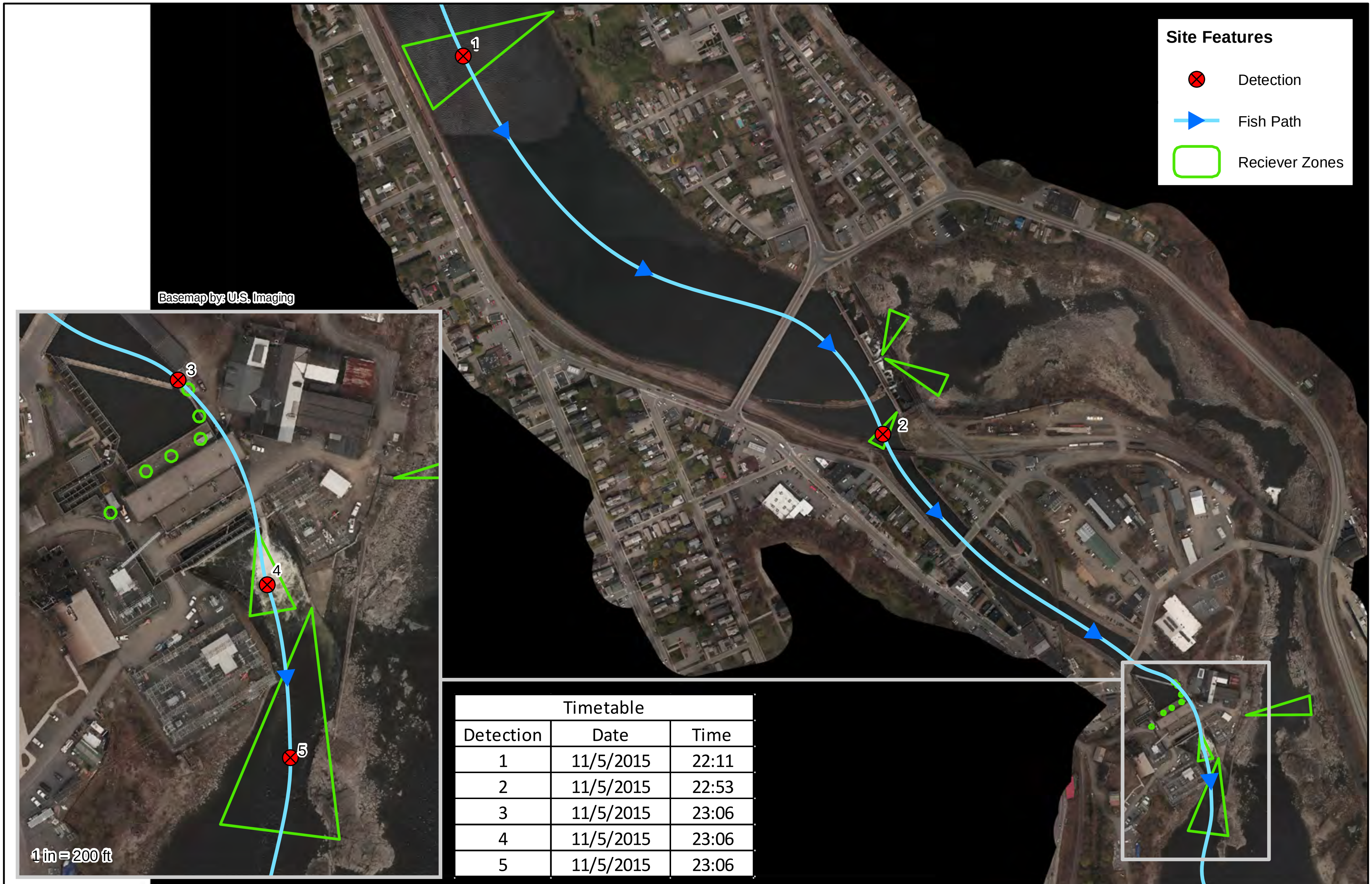

Timetable		
Detection	Date	Time
1	11/5/2015	22:11
2	11/5/2015	22:53
3	11/5/2015	23:06
4	11/5/2015	23:06
5	11/5/2015	23:06

TransCanada Hydro Northeast Inc.
ILP Study 19
Bellows Falls Dam

N
1 in = 600 feet
0 300 600 1,200 Feet

Study 19 Fish Number: 38-147

Release: Herricks Cove, VT
Date Released: 11/05/2015
Time Released: 16:20

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Environmental Consultants
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Bedford, NH USA
03110

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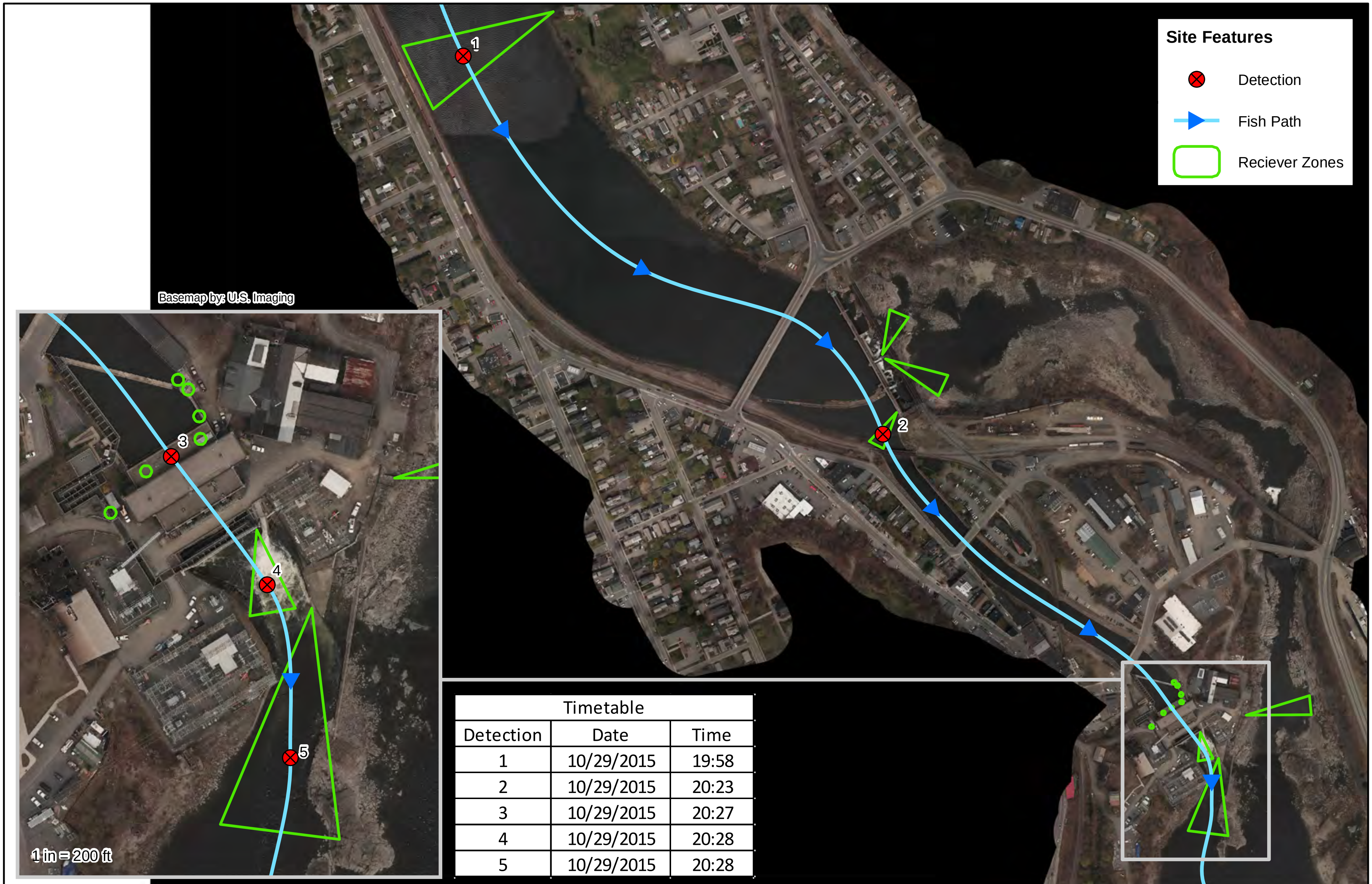
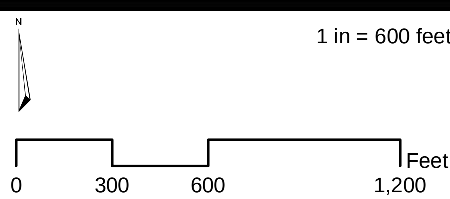


Timetable		
Detection	Date	Time
1	10/29/2015	19:58
2	10/29/2015	20:23
3	10/29/2015	20:27
4	10/29/2015	20:28
5	10/29/2015	20:28

TransCanada Hydro Northeast Inc.
ILP Study 19
Bellows Falls Dam



Study 19 Fish Number: 38-148

Release: Herricks Cove, VT
Date Released: 10/29/2015
Time Released: 17:52

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Environmental Consultants

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Bedford, NH USA
03110

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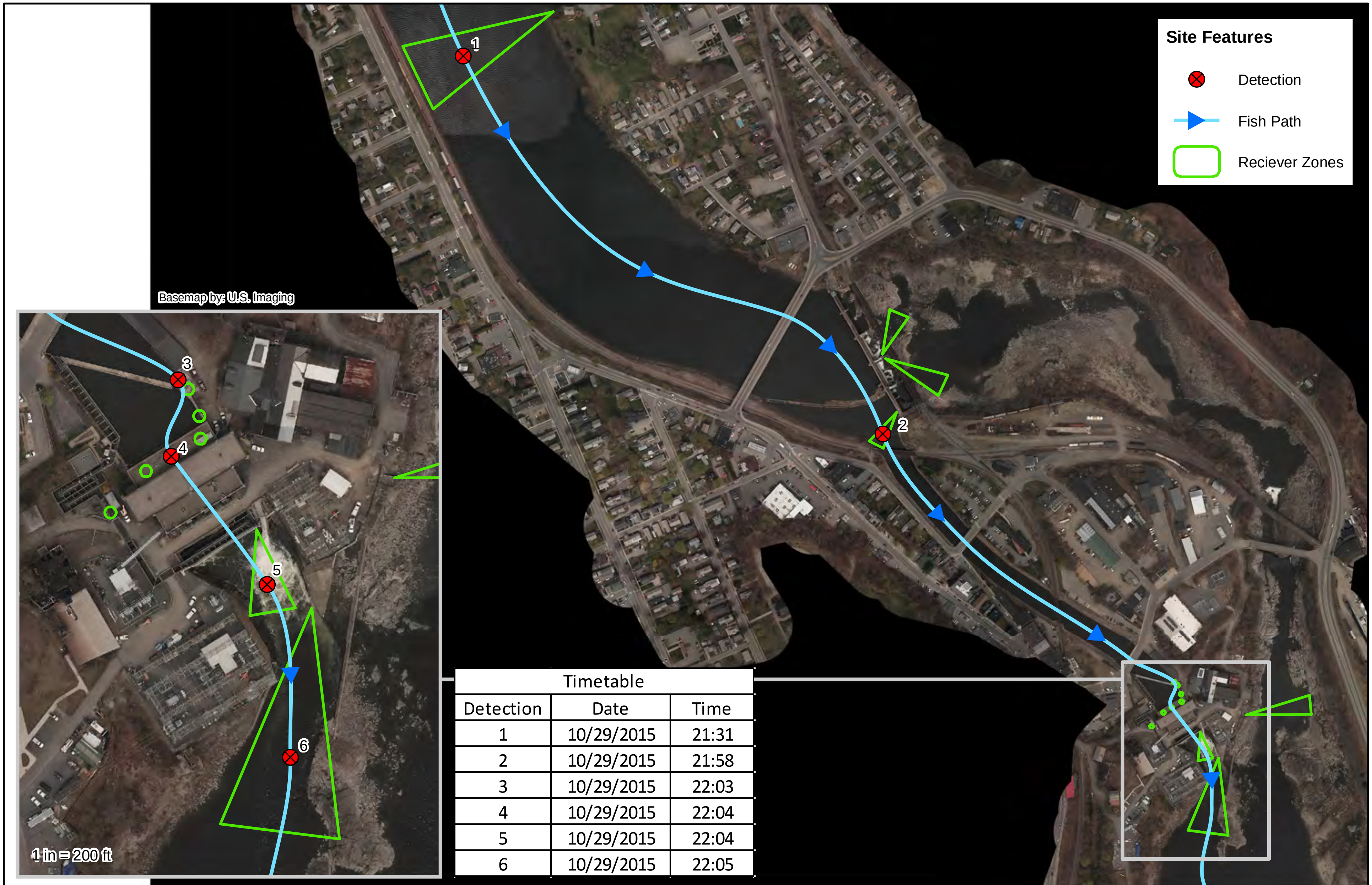

Timetable		
Detection	Date	Time
1	10/29/2015	21:31
2	10/29/2015	21:58
3	10/29/2015	22:03
4	10/29/2015	22:04
5	10/29/2015	22:04
6	10/29/2015	22:05

TransCanada Hydro Northeast Inc.
ILP Study 19
Bellows Falls Dam

Study 19 Fish Number: 38-149

Release: Herricks Cove, VT
Date Released: 10/29/2015
Time Released: 17:52

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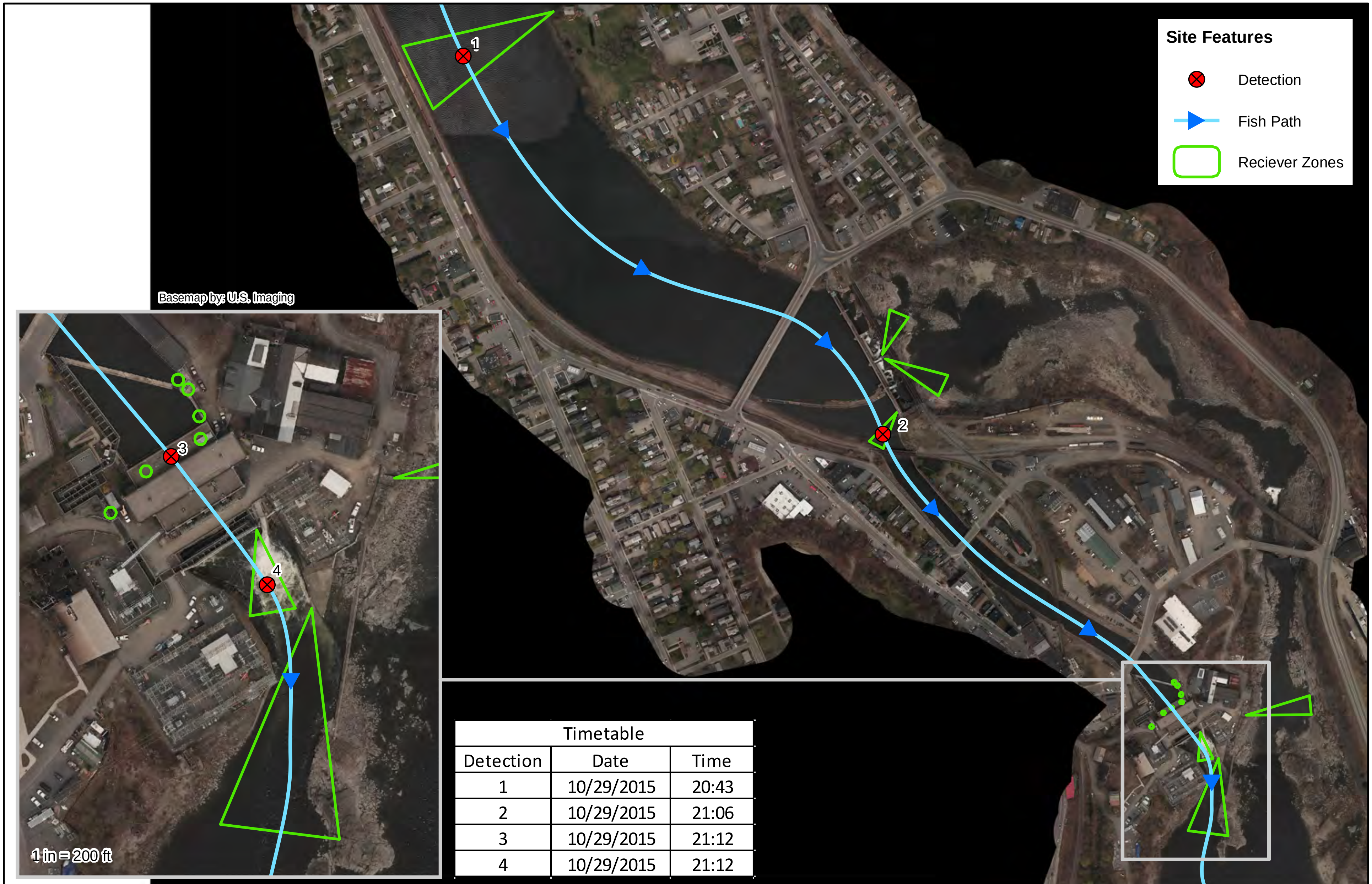

Timetable		
Detection	Date	Time
1	10/29/2015	20:43
2	10/29/2015	21:06
3	10/29/2015	21:12
4	10/29/2015	21:12

TransCanada Hydro Northeast Inc.
ILP Study 19
Bellows Falls Dam

N
1 in = 600 feet
0 300 600 1,200 Feet

Study 19 Fish Number: 38-150

Release: Herricks Cove, VT
Date Released: 10/29/2015
Time Released: 17:52

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Bedford, NH USA
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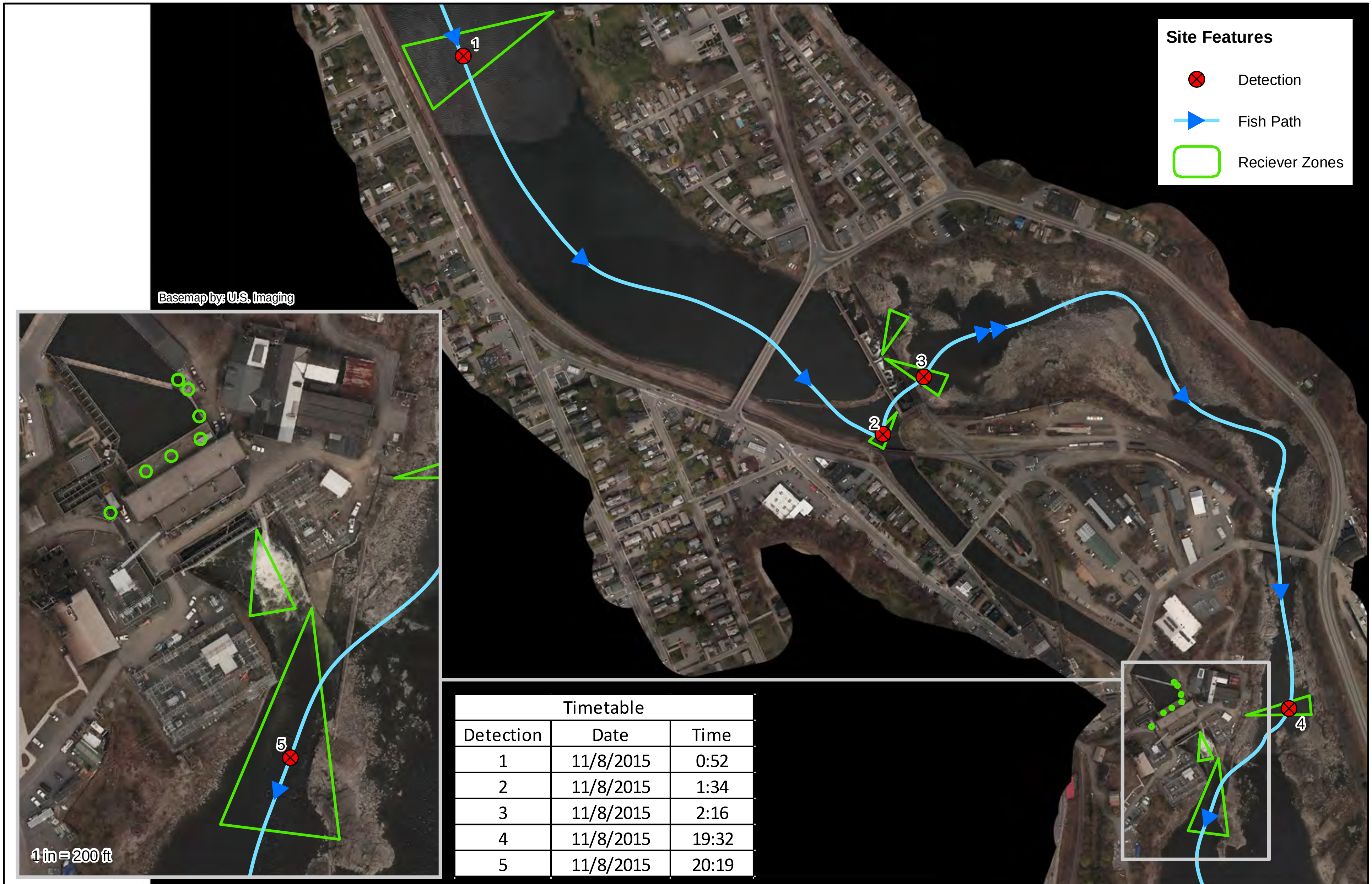

Timetable		
Detection	Date	Time
1	11/8/2015	0:52
2	11/8/2015	1:34
3	11/8/2015	2:16
4	11/8/2015	19:32
5	11/8/2015	20:19

TransCanada Hydro Northeast Inc.
ILP Study 19
Bellows Falls Dam

N

1 in = 600 feet

0 300 600 1,200 Feet

Study 19 Fish Number: 38-152

Release: Norwich, VT
Date Released: 11/05/2015
Time Released: 17:05

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Environmental Consultants
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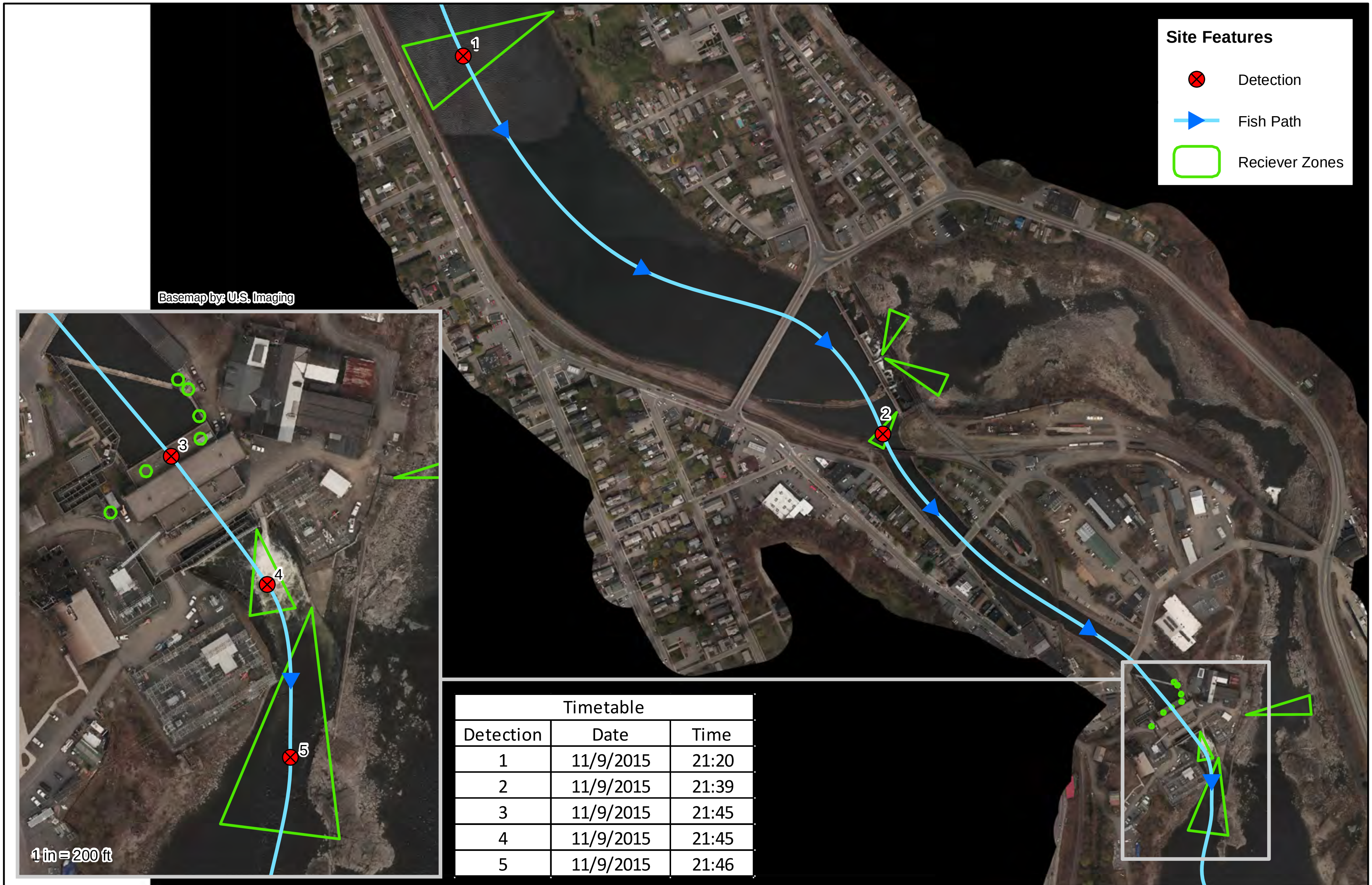

Timetable		
Detection	Date	Time
1	11/9/2015	21:20
2	11/9/2015	21:39
3	11/9/2015	21:45
4	11/9/2015	21:45
5	11/9/2015	21:46

TransCanada Hydro Northeast Inc.
ILP Study 19
Bellows Falls Dam

N

1 in = 600 feet

0 300 600 1,200 Feet

Study 19 Fish Number: 38-153

Release: Herricks Cove, VT
Date Released: 11/05/2015
Time Released: 17:05

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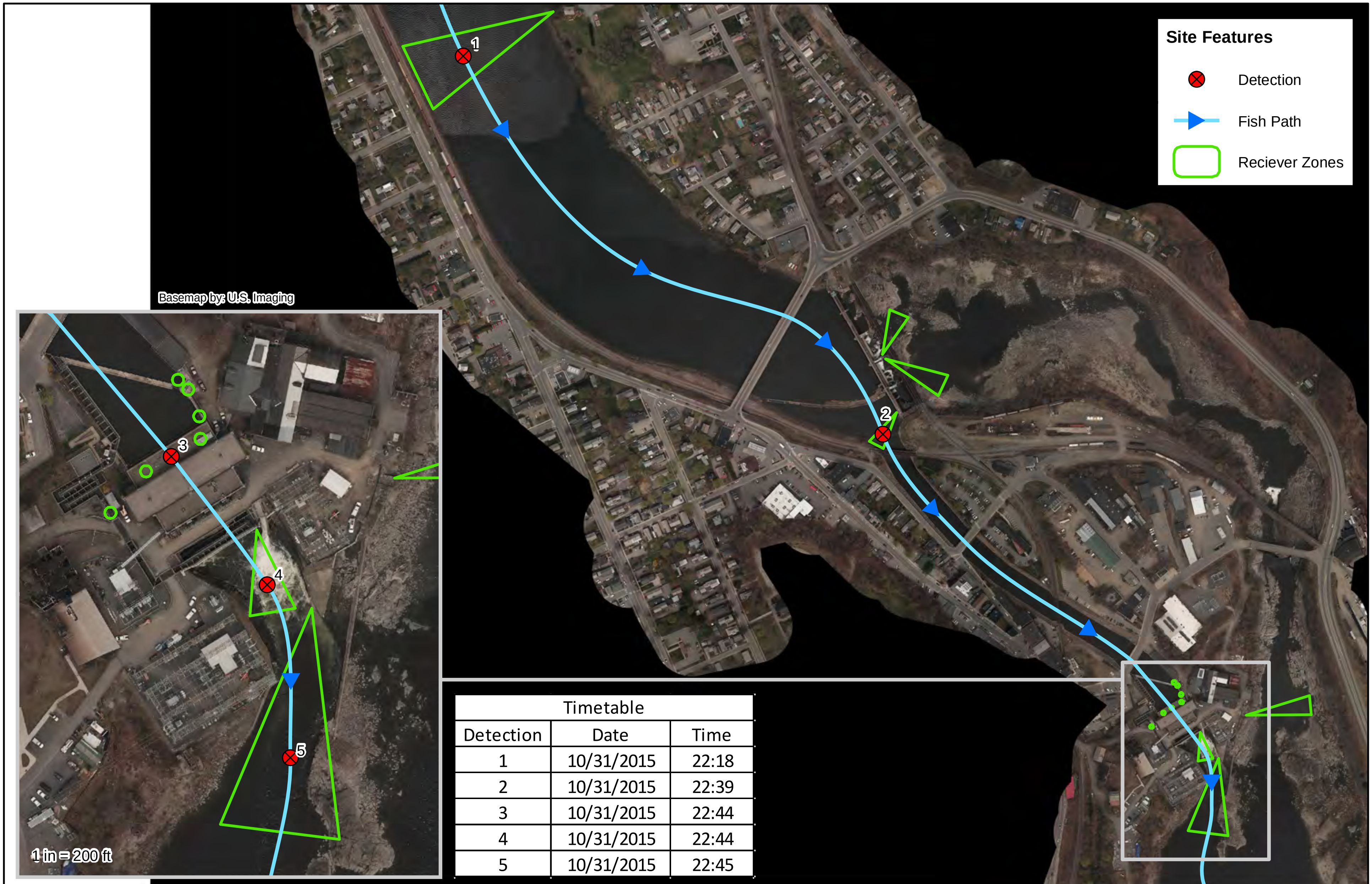
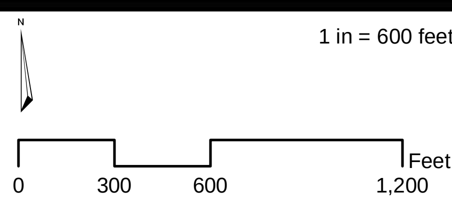


Timetable		
Detection	Date	Time
1	10/31/2015	22:18
2	10/31/2015	22:39
3	10/31/2015	22:44
4	10/31/2015	22:44
5	10/31/2015	22:45

TransCanada Hydro Northeast Inc.
ILP Study 19
Bellows Falls Dam



Study 19 Fish Number: 38-158

Release: Norwich, VT
Date Released: 10/29/2015
Time Released: 18:43

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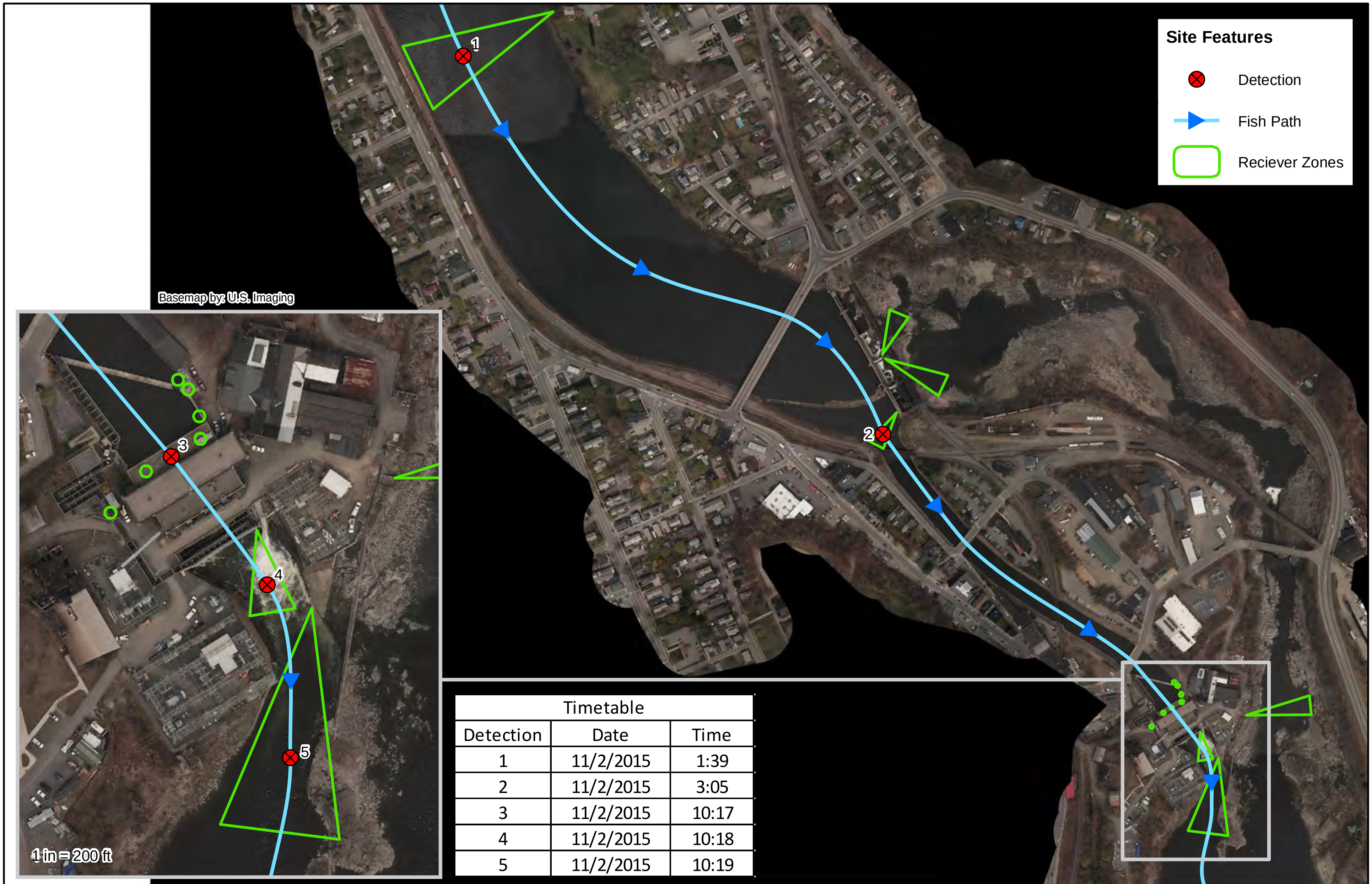

Timetable		
Detection	Date	Time
1	11/2/2015	1:39
2	11/2/2015	3:05
3	11/2/2015	10:17
4	11/2/2015	10:18
5	11/2/2015	10:19

TransCanada Hydro Northeast Inc.
ILP Study 19
Bellows Falls Dam

N

1 in = 600 feet

0 300 600 1,200 Feet

Study 19 Fish Number: 38-159

Release: Norwich, VT
Date Released: 10/29/2015
Time Released: 18:43

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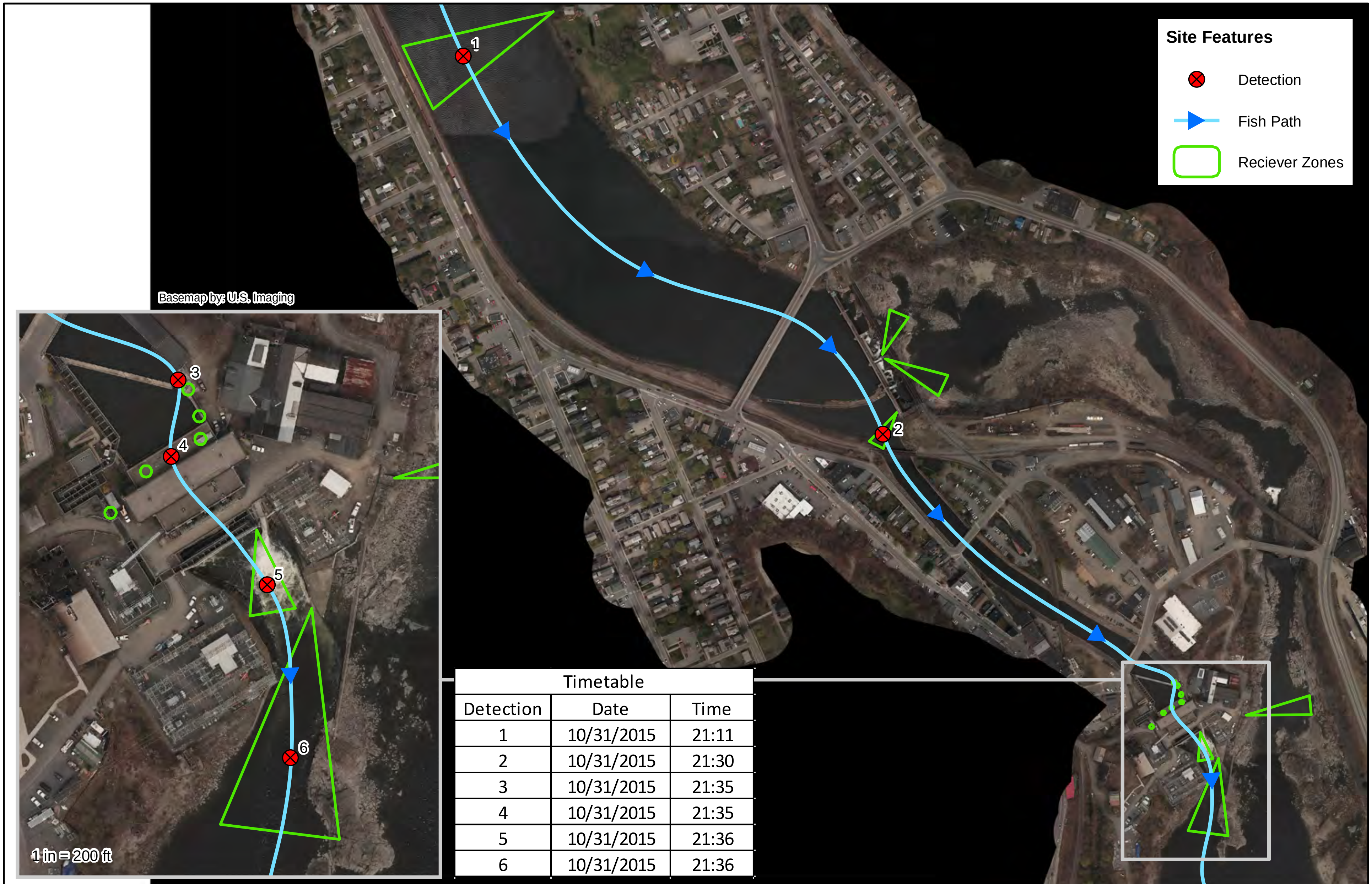

Timetable		
Detection	Date	Time
1	10/31/2015	21:11
2	10/31/2015	21:30
3	10/31/2015	21:35
4	10/31/2015	21:35
5	10/31/2015	21:36
6	10/31/2015	21:36

TransCanada Hydro Northeast Inc.
ILP Study 19
Bellows Falls Dam

N

1 in = 600 feet

0 300 600 1,200 Feet

Study 19 Fish Number: 38-178

Release: Herricks Cove, VT
Date Released: 10/31/2015
Time Released: 18:22

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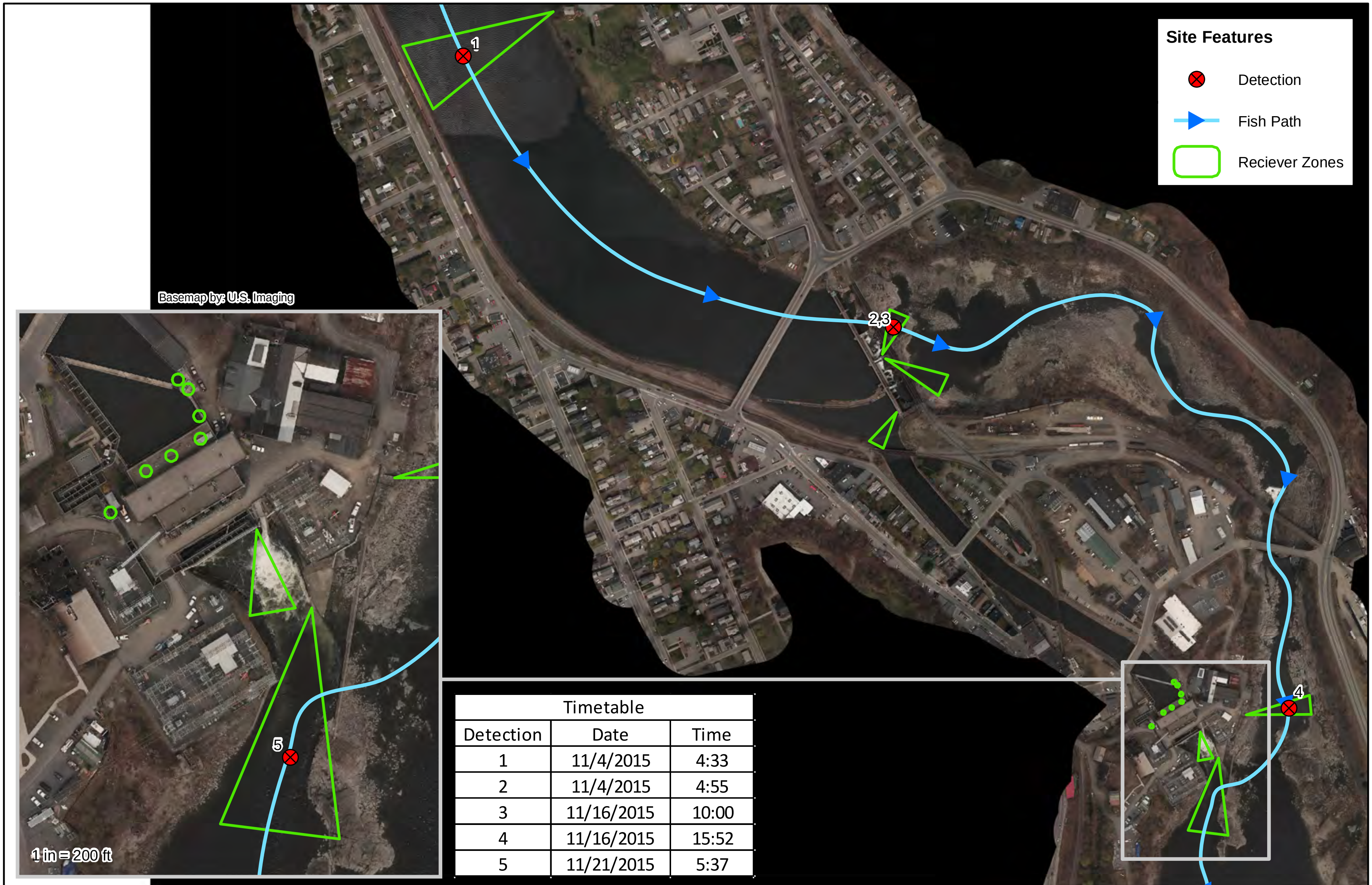

Timetable		
Detection	Date	Time
1	11/4/2015	4:33
2	11/4/2015	4:55
3	11/16/2015	10:00
4	11/16/2015	15:52
5	11/21/2015	5:37

TransCanada Hydro Northeast Inc.
ILP Study 19
Bellows Falls Dam

N

1 in = 600 feet

0 300 600 1,200 Feet

Study 19 Fish Number: 38-179

Release: Herricks Cove, VT
Date Released: 10/31/2015
Time Released: 18:22

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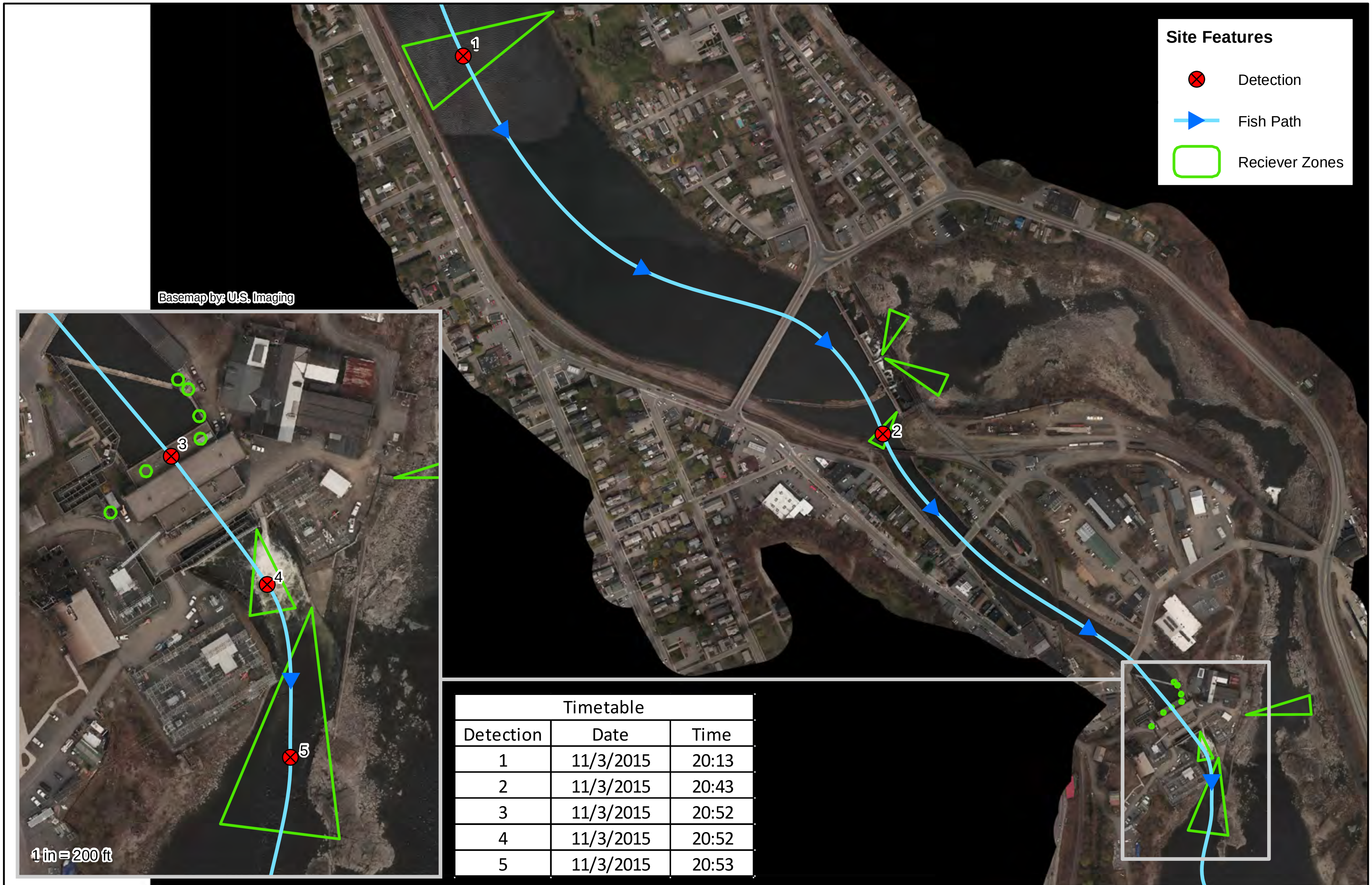

Timetable		
Detection	Date	Time
1	11/3/2015	20:13
2	11/3/2015	20:43
3	11/3/2015	20:52
4	11/3/2015	20:52
5	11/3/2015	20:53

TransCanada Hydro Northeast Inc.
ILP Study 19
Bellows Falls Dam

N

1 in = 600 feet

0 300 600 1,200 Feet

Study 19 Fish Number: 38-180

Release: Herricks Cove, VT
Date Released: 10/31/2015
Time Released: 18:22

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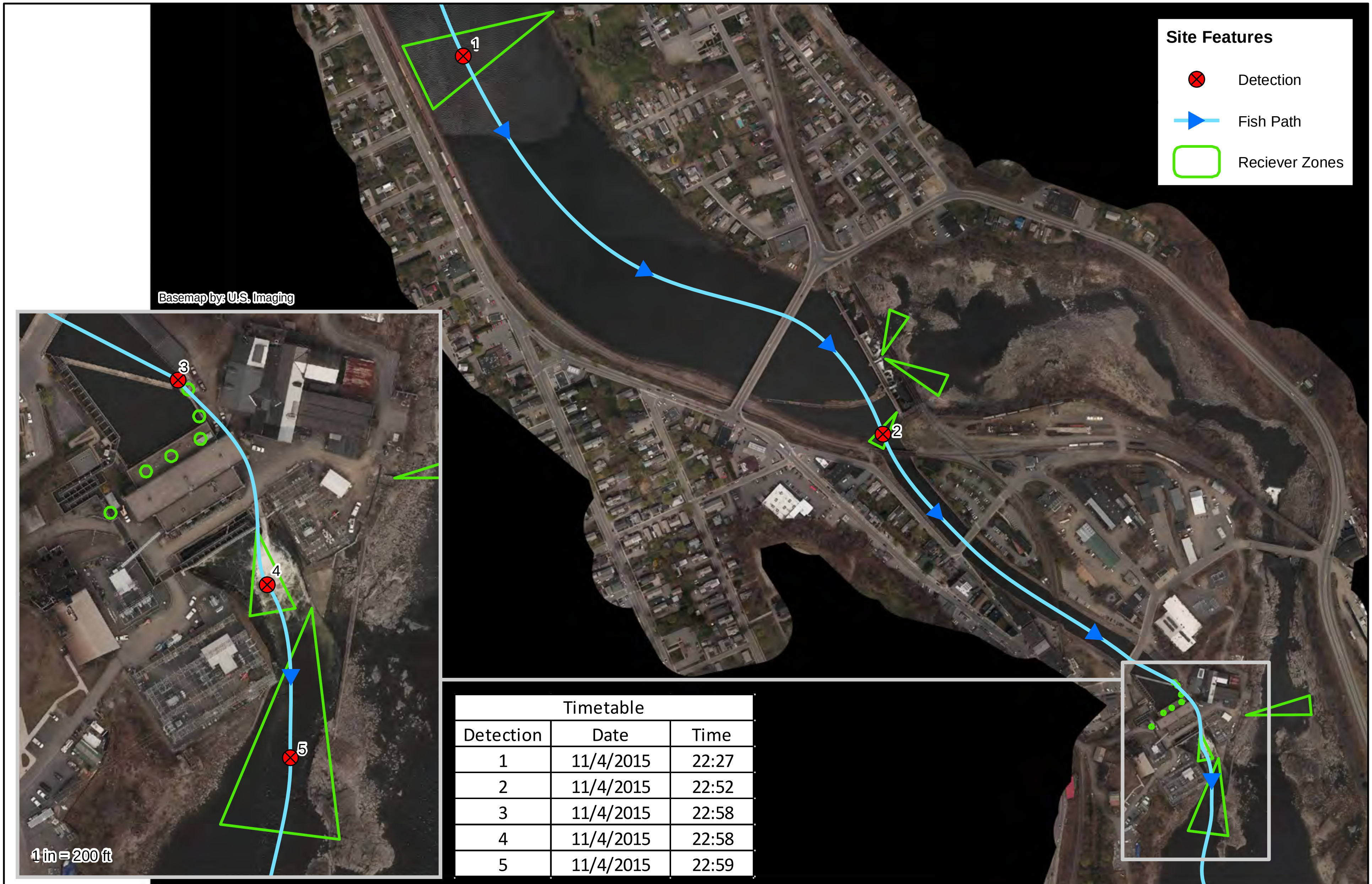

Timetable		
Detection	Date	Time
1	11/4/2015	22:27
2	11/4/2015	22:52
3	11/4/2015	22:58
4	11/4/2015	22:58
5	11/4/2015	22:59

TransCanada Hydro Northeast Inc.
ILP Study 19
Bellows Falls Dam

N

1 in = 600 feet

0 300 600 1,200 Feet

Study 19 Fish Number: 38-188

Release: Norwich, VT
Date Released: 10/31/2015
Time Released: 19:21

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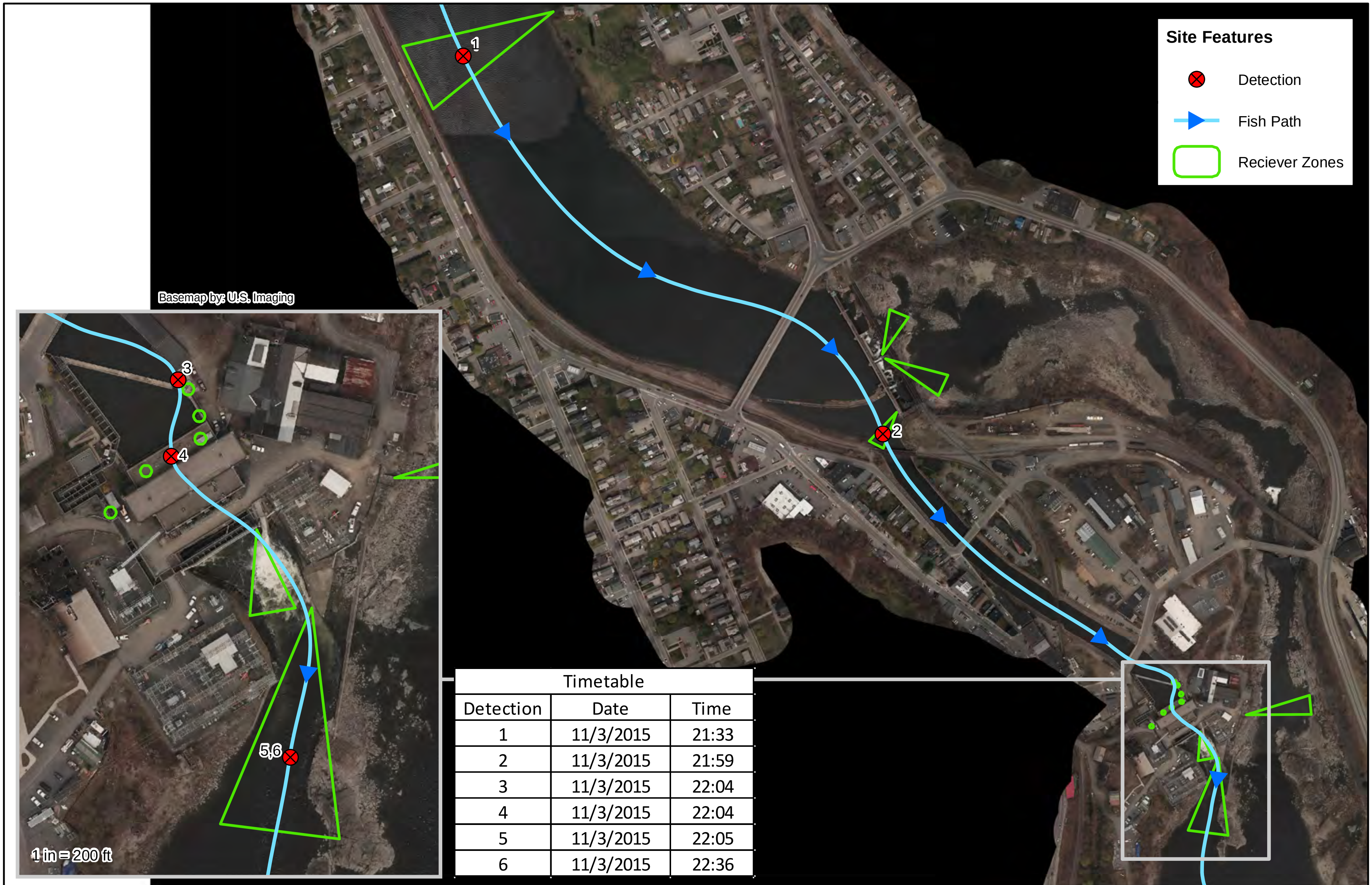

Timetable		
Detection	Date	Time
1	11/3/2015	21:33
2	11/3/2015	21:59
3	11/3/2015	22:04
4	11/3/2015	22:04
5	11/3/2015	22:05
6	11/3/2015	22:36

TransCanada Hydro Northeast Inc.
ILP Study 19
Bellows Falls Dam

Study 19 Fish Number: 38-189

Release: Norwich, VT
Date Released: 10/31/2015
Time Released: 19:21

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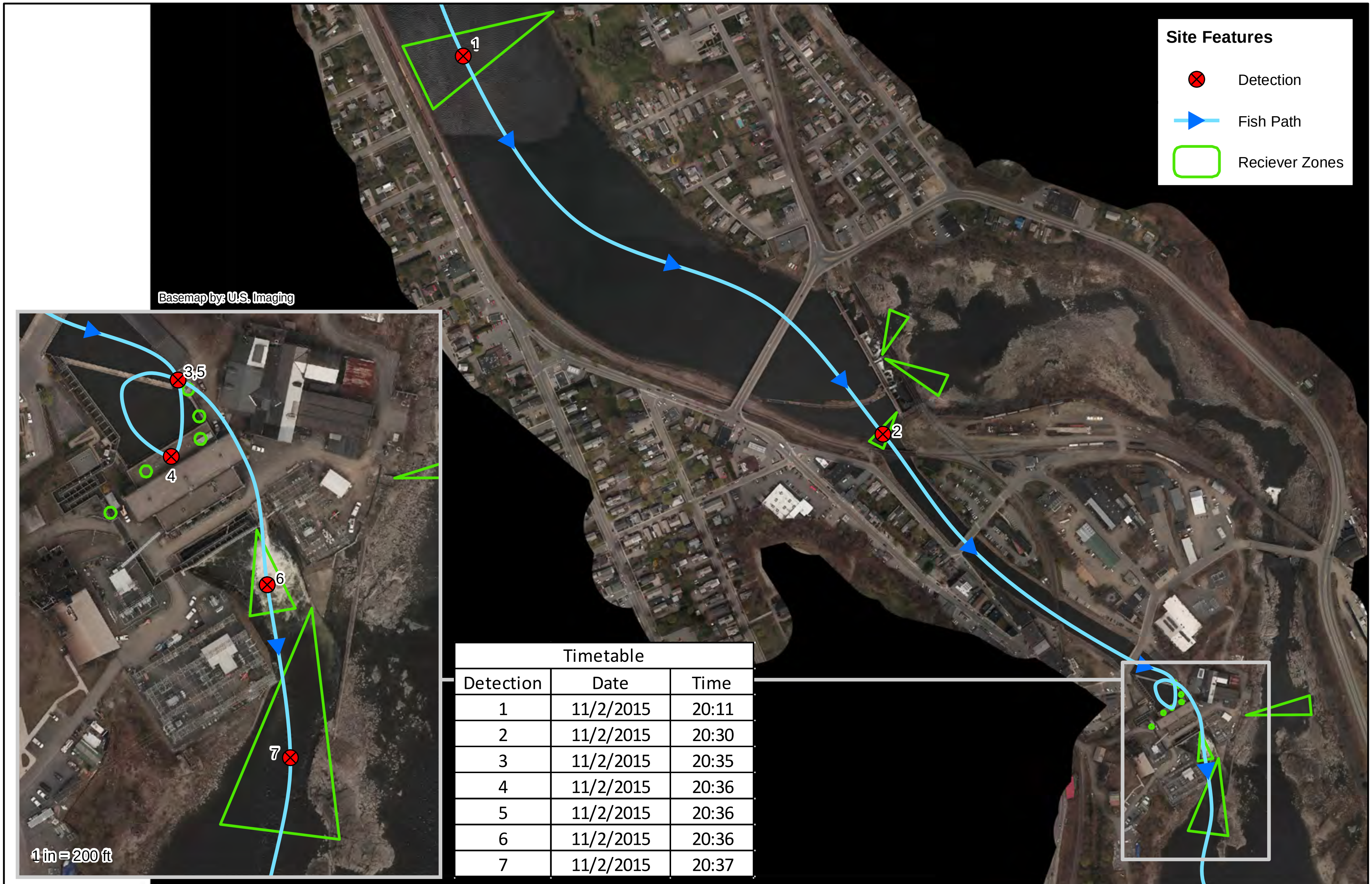
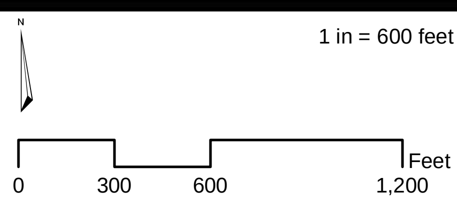


Timetable		
Detection	Date	Time
1	11/2/2015	20:11
2	11/2/2015	20:30
3	11/2/2015	20:35
4	11/2/2015	20:36
5	11/2/2015	20:36
6	11/2/2015	20:36
7	11/2/2015	20:37

TransCanada Hydro Northeast Inc.
ILP Study 19
Bellows Falls Dam



Study 19 Fish Number: 38-190

Release: Herricks Cove, VT
Date Released: 10/31/2015
Time Released: 19:21

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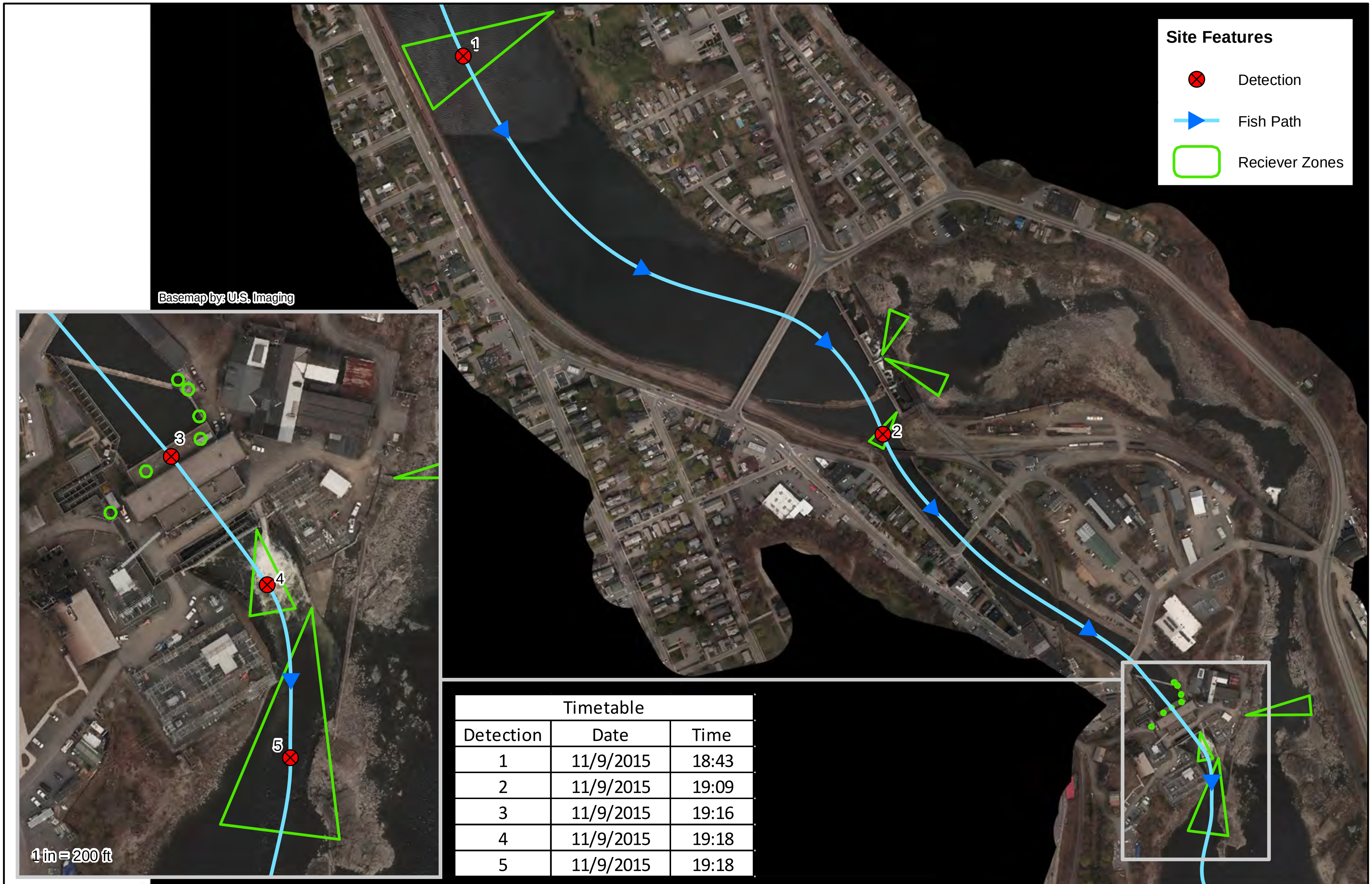

Timetable		
Detection	Date	Time
1	11/9/2015	18:43
2	11/9/2015	19:09
3	11/9/2015	19:16
4	11/9/2015	19:18
5	11/9/2015	19:18

TransCanada Hydro Northeast Inc.
ILP Study 19
Bellows Falls Dam

N

1 in = 600 feet

0 300 600 1,200 Feet

Study 19 Fish Number: 38-58

Release: Herricks Cove, VT
Date Released: 11/03/2015
Time Released: 17:32

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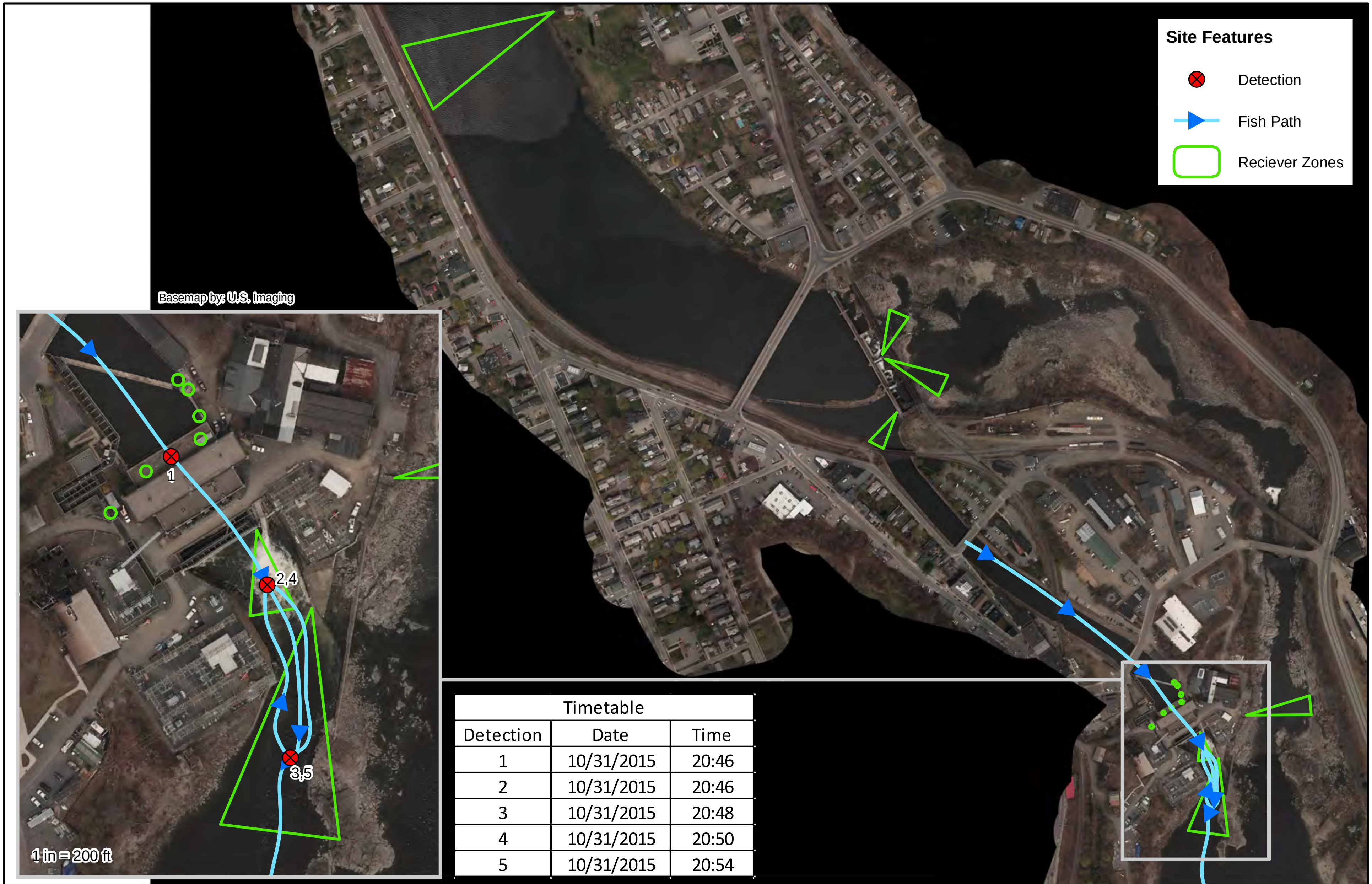

Timetable		
Detection	Date	Time
1	10/31/2015	20:46
2	10/31/2015	20:46
3	10/31/2015	20:48
4	10/31/2015	20:50
5	10/31/2015	20:54

TransCanada Hydro Northeast Inc.
ILP Study 19
Bellows Falls Dam

N

1 in = 600 feet

0 300 600 1,200 Feet

Study 19 Fish Number: 38-59

Release: Bellows Falls Canal, VT
Date Released: 10/31/2015
Time Released: 18:05

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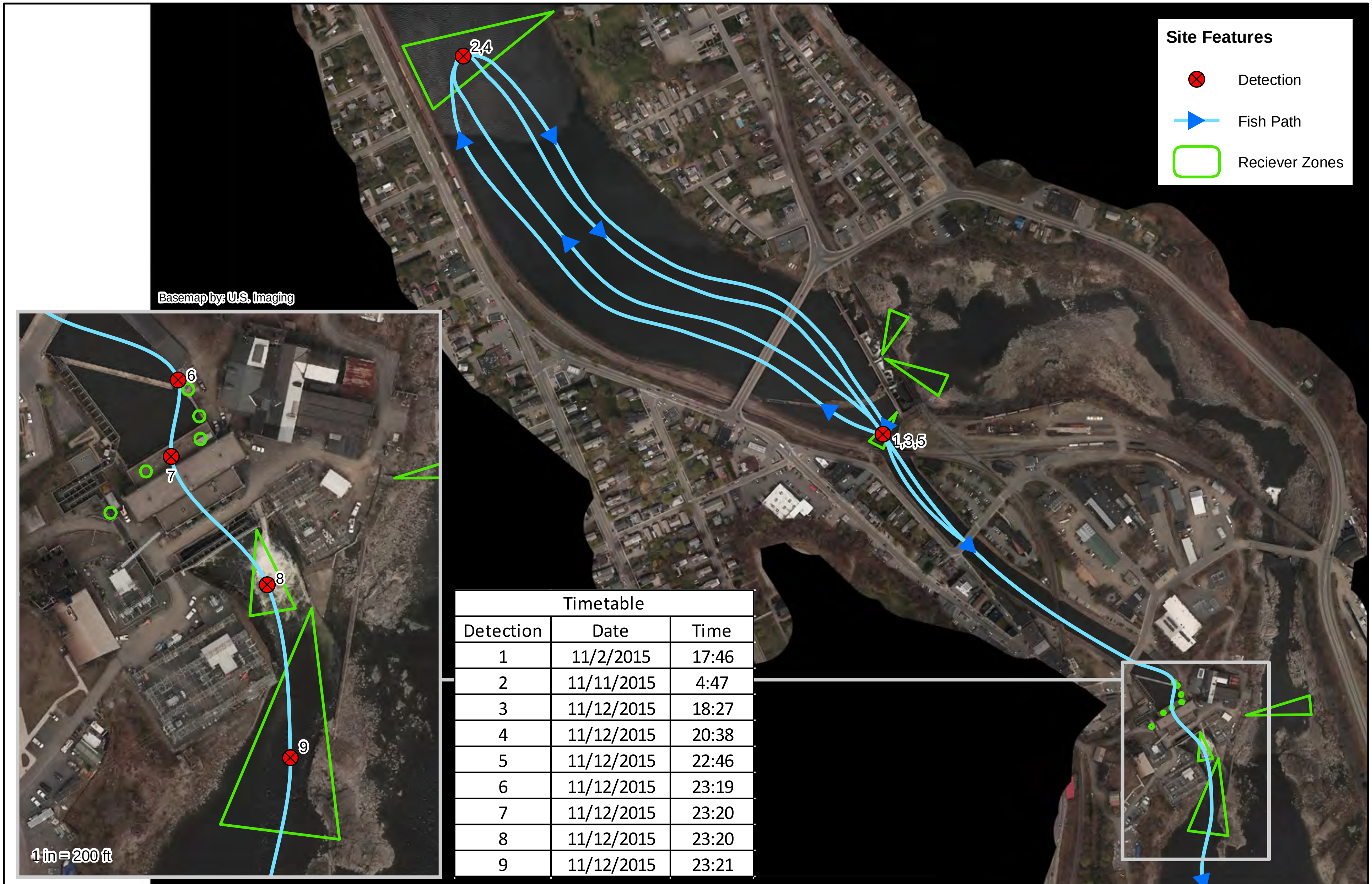

Timetable		
Detection	Date	Time
1	11/2/2015	17:46
2	11/11/2015	4:47
3	11/12/2015	18:27
4	11/12/2015	20:38
5	11/12/2015	22:46
6	11/12/2015	23:19
7	11/12/2015	23:20
8	11/12/2015	23:20
9	11/12/2015	23:21

TransCanada Hydro Northeast Inc.
ILP Study 19
Bellows Falls Dam

N

1 in = 600 feet

0 300 600 1,200 Feet

Study 19 Fish Number: 38-60

Release: Bellows Falls Canal, VT
Date Released: 10/31/2015
Time Released: 18:05

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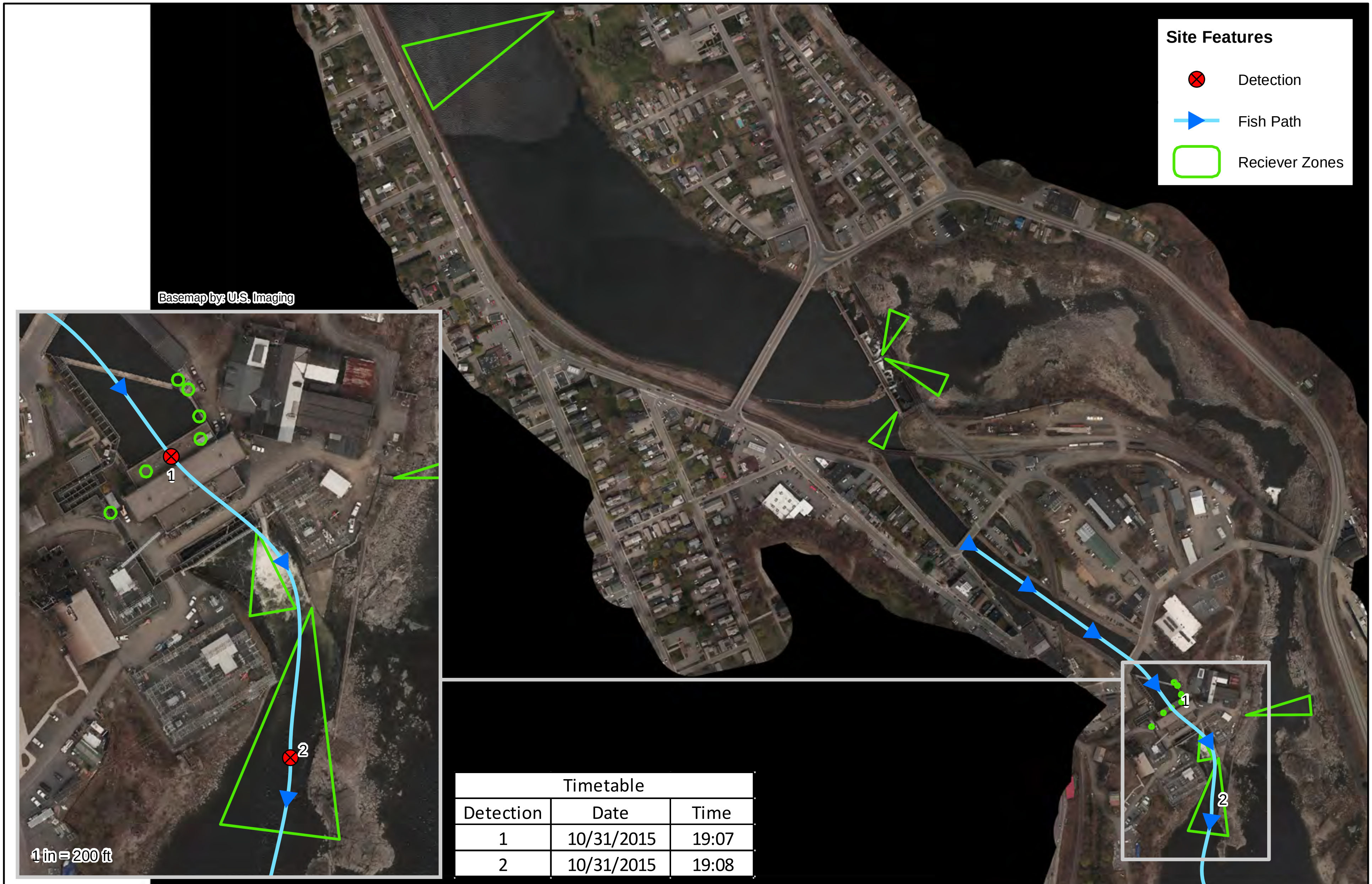

Timetable		
Detection	Date	Time
1	10/31/2015	19:07
2	10/31/2015	19:08

TransCanada Hydro Northeast Inc.
ILP Study 19
Bellows Falls Dam

N

1 in = 600 feet

0 300 600 1,200 Feet

Study 19 Fish Number: 38-61

Release: Bellows Falls Canal, VT
Date Released: 10/31/2015
Time Released: 18:05

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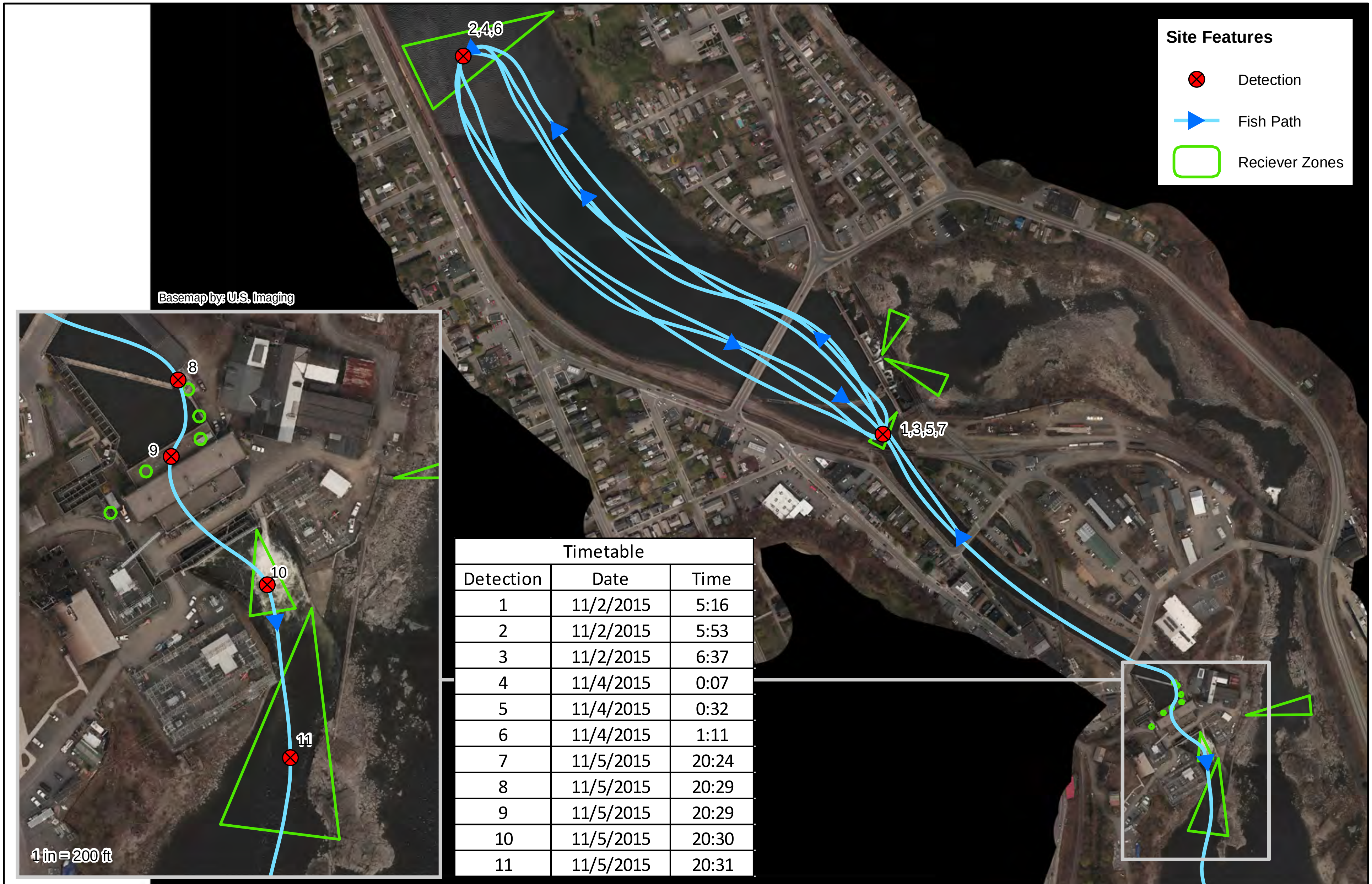

Timetable		
Detection	Date	Time
1	11/2/2015	5:16
2	11/2/2015	5:53
3	11/2/2015	6:37
4	11/4/2015	0:07
5	11/4/2015	0:32
6	11/4/2015	1:11
7	11/5/2015	20:24
8	11/5/2015	20:29
9	11/5/2015	20:29
10	11/5/2015	20:30
11	11/5/2015	20:31

TransCanada Hydro Northeast Inc.
ILP Study 19
Bellows Falls Dam

N

1 in = 600 feet

0 300 600 1,200 Feet

Study 19 Fish Number: 38-62

Release: Bellows Falls Canal, VT
Date Released: 10/31/2015
Time Released: 18:05

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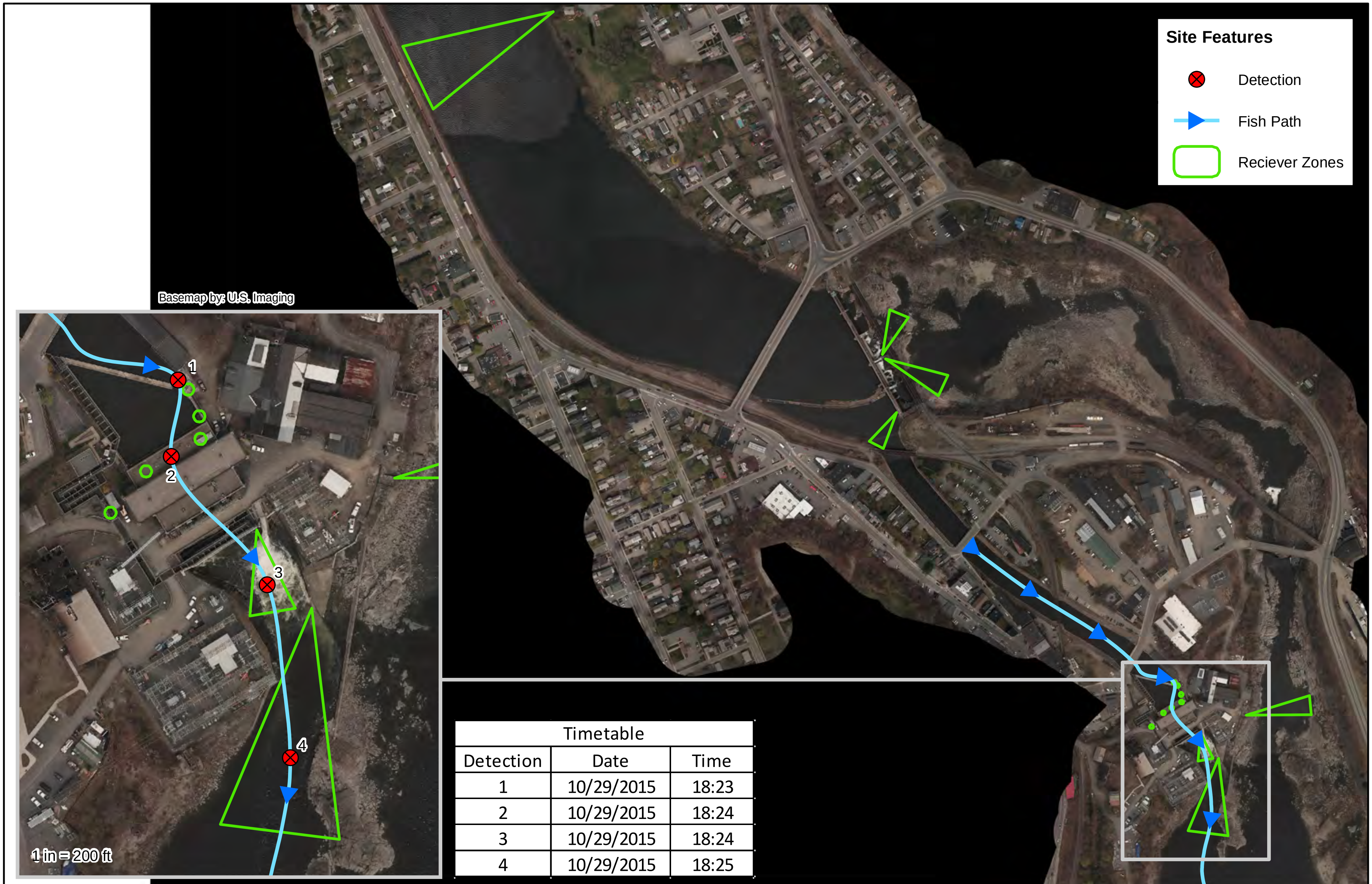

Timetable		
Detection	Date	Time
1	10/29/2015	18:23
2	10/29/2015	18:24
3	10/29/2015	18:24
4	10/29/2015	18:25

TransCanada Hydro Northeast Inc.
ILP Study 19
Bellows Falls Dam

N

1 in = 600 feet

0 300 600 1,200 Feet

Study 19 Fish Number: 38-63

Release: Bellows Falls Canal, VT
Date Released: 10/29/2015
Time Released: 17:32

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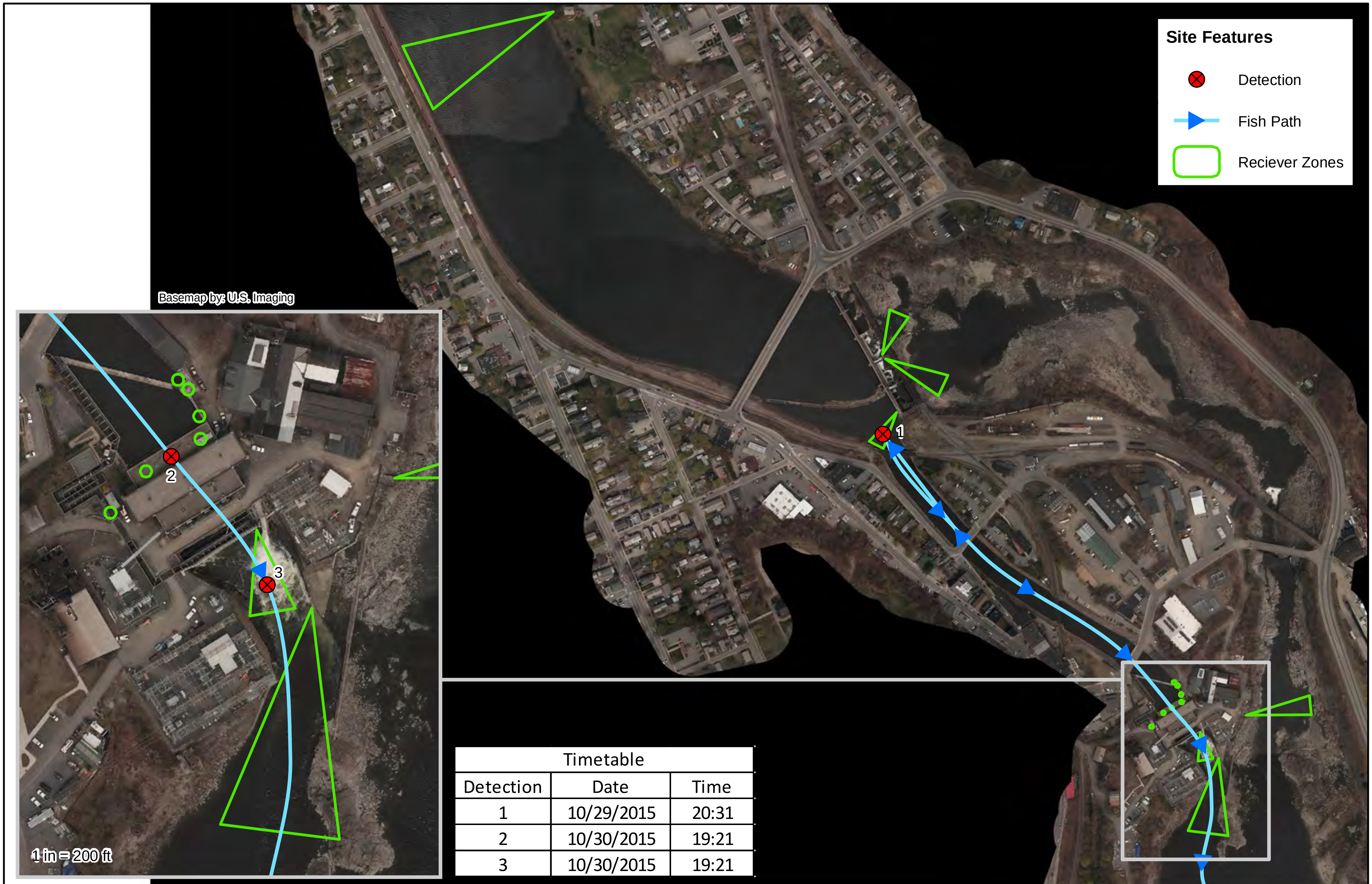

Timetable		
Detection	Date	Time
1	10/29/2015	20:31
2	10/30/2015	19:21
3	10/30/2015	19:21

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TransCanada Hydro Northeast Inc.
ILP Study 19
Bellows Falls Dam

N
1 in = 600 feet
0 300 600 1,200 Feet

Study 19 Fish Number: 38-64
Release: Bellows Falls Canal, VT
Date Released: 10/29/2015
Time Released: 17:32

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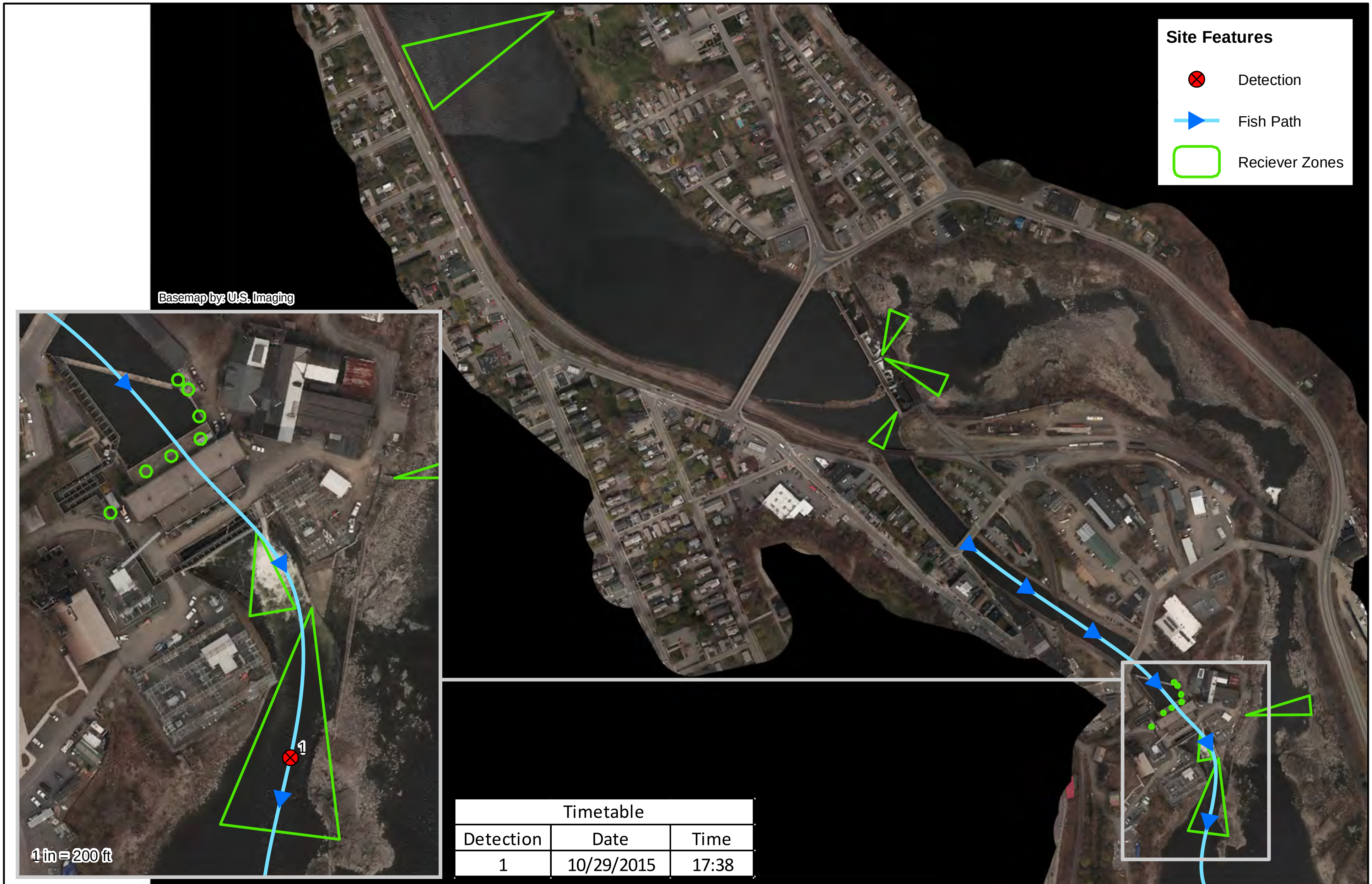

Timetable		
Detection	Date	Time
1	10/29/2015	17:38

TransCanada Hydro Northeast Inc.
ILP Study 19
Bellows Falls Dam

N

1 in = 600 feet

0 300 600 1,200 Feet

Study 19 Fish Number: 38-65

Release: Bellows Falls Canal, VT
Date Released: 10/29/2015
Time Released: 17:32

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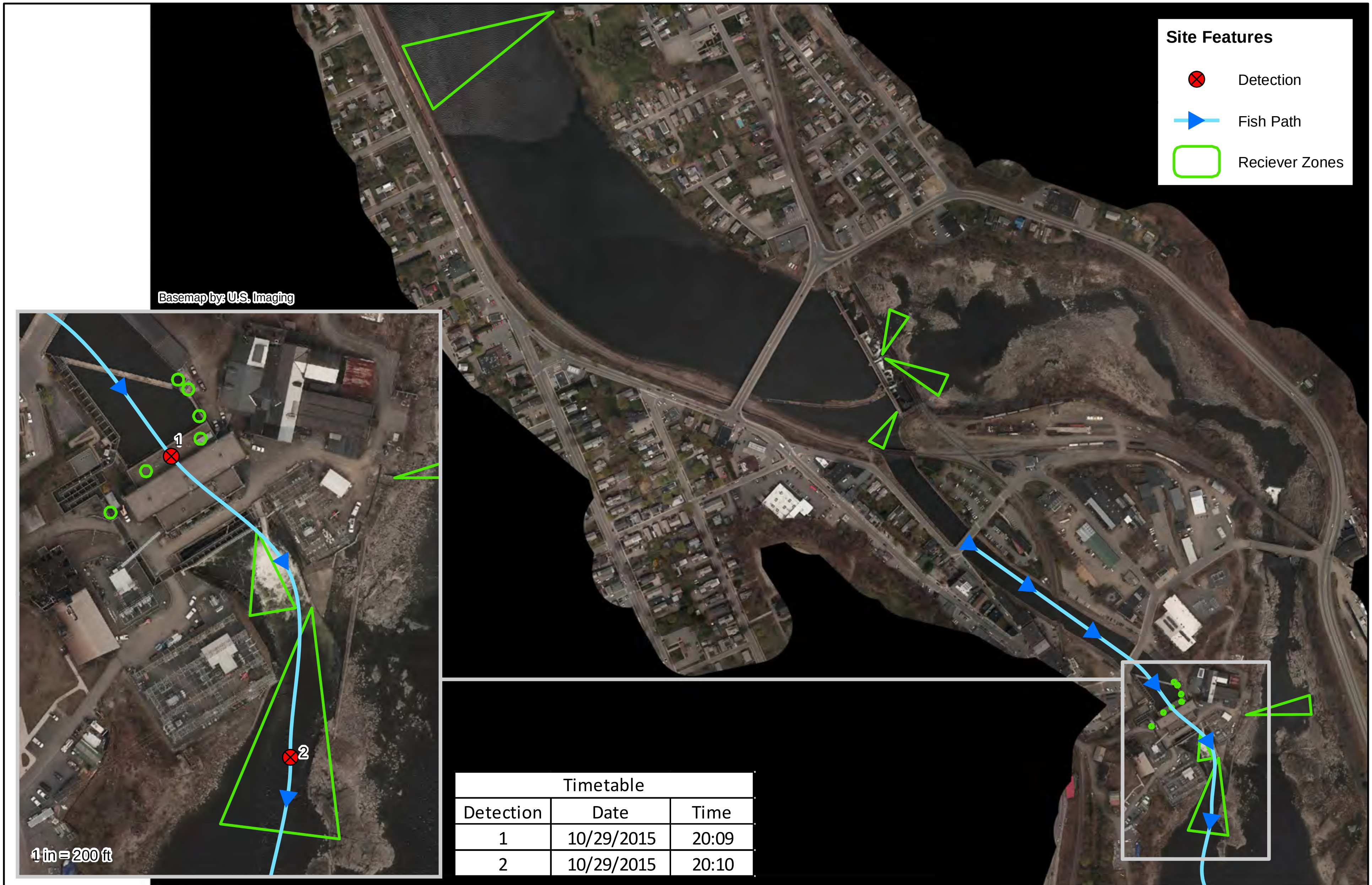
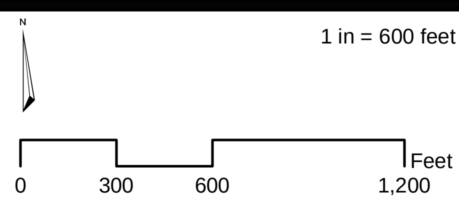


Timetable		
Detection	Date	Time
1	10/29/2015	20:09
2	10/29/2015	20:10

TransCanada Hydro Northeast Inc.
ILP Study 19
Bellows Falls Dam



Study 19 Fish Number: 38-66

Release: Bellows Falls Canal, VT
Date Released: 10/29/2015
Time Released: 17:32

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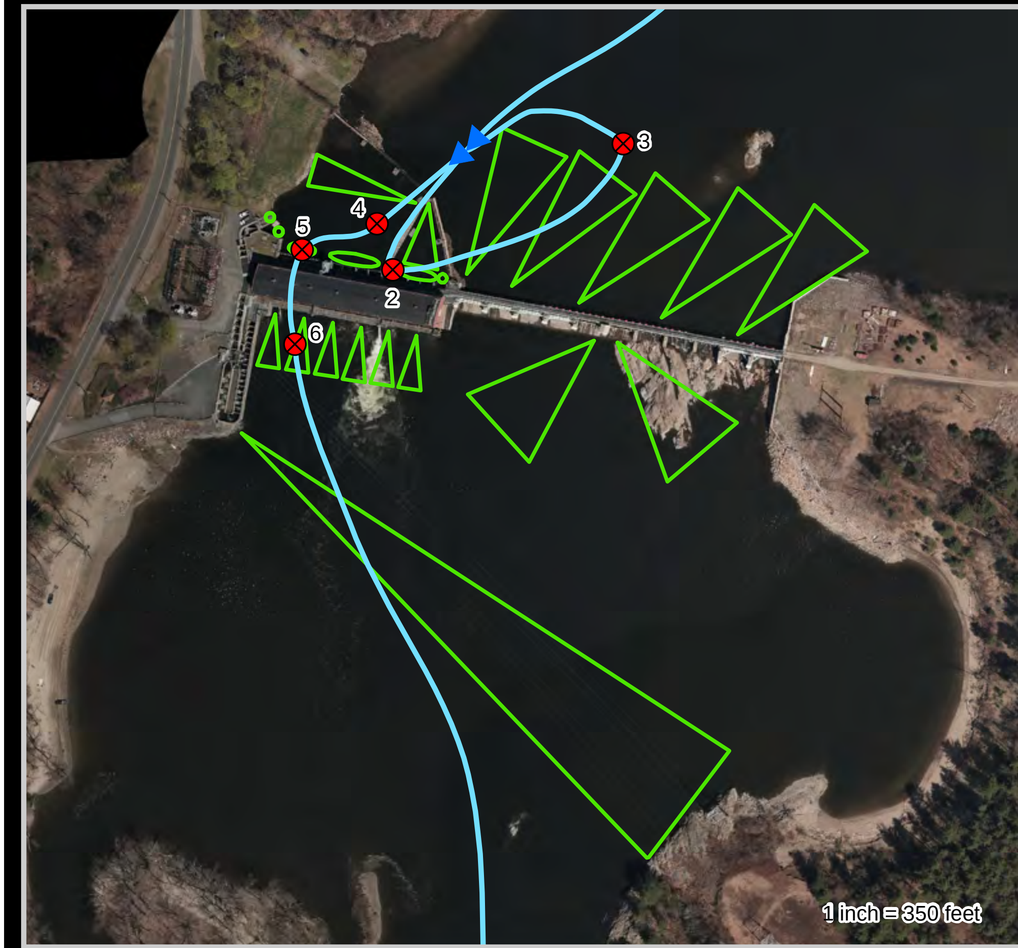

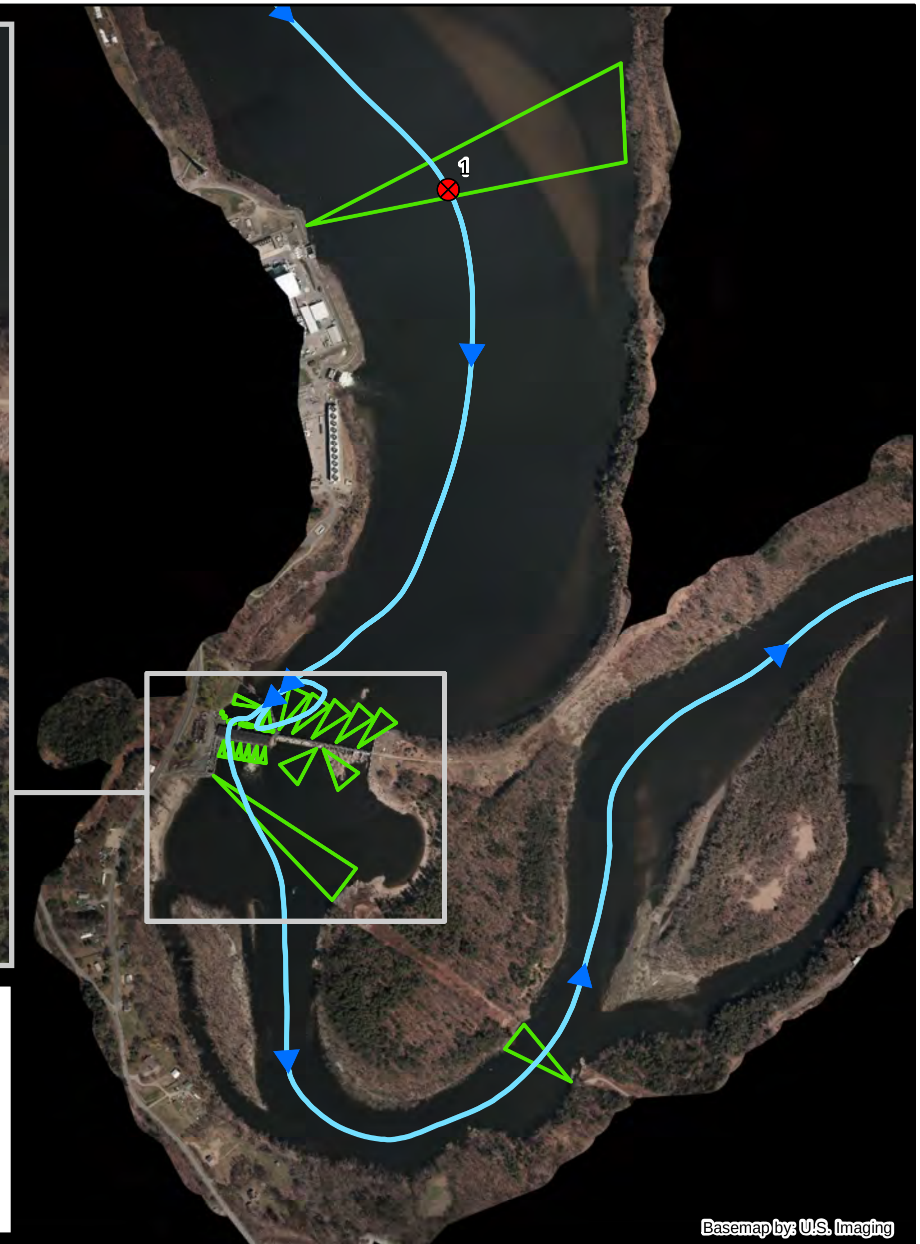

Timetable		
Detection	Date	Time
1	10/27/2015	21:37
2	10/27/2015	21:48
3	10/27/2015	22:04
4	10/27/2015	22:19
5	10/27/2015	22:22
6	10/27/2015	22:25

Site Features

- Detection
- Fish Path
- Reciever Zones

TransCanada Hydro Northeast Inc.
ILP Study 19
Vernon Dam

N

1 in = 1,200 feet

0 600 1,200 2,400 Feet

Study 19 Fish Number: 34-101
Release: Riverside Industrial Complex
Brattleboro, VT
Date Released: 10/27/2015
Time Released: 17:45

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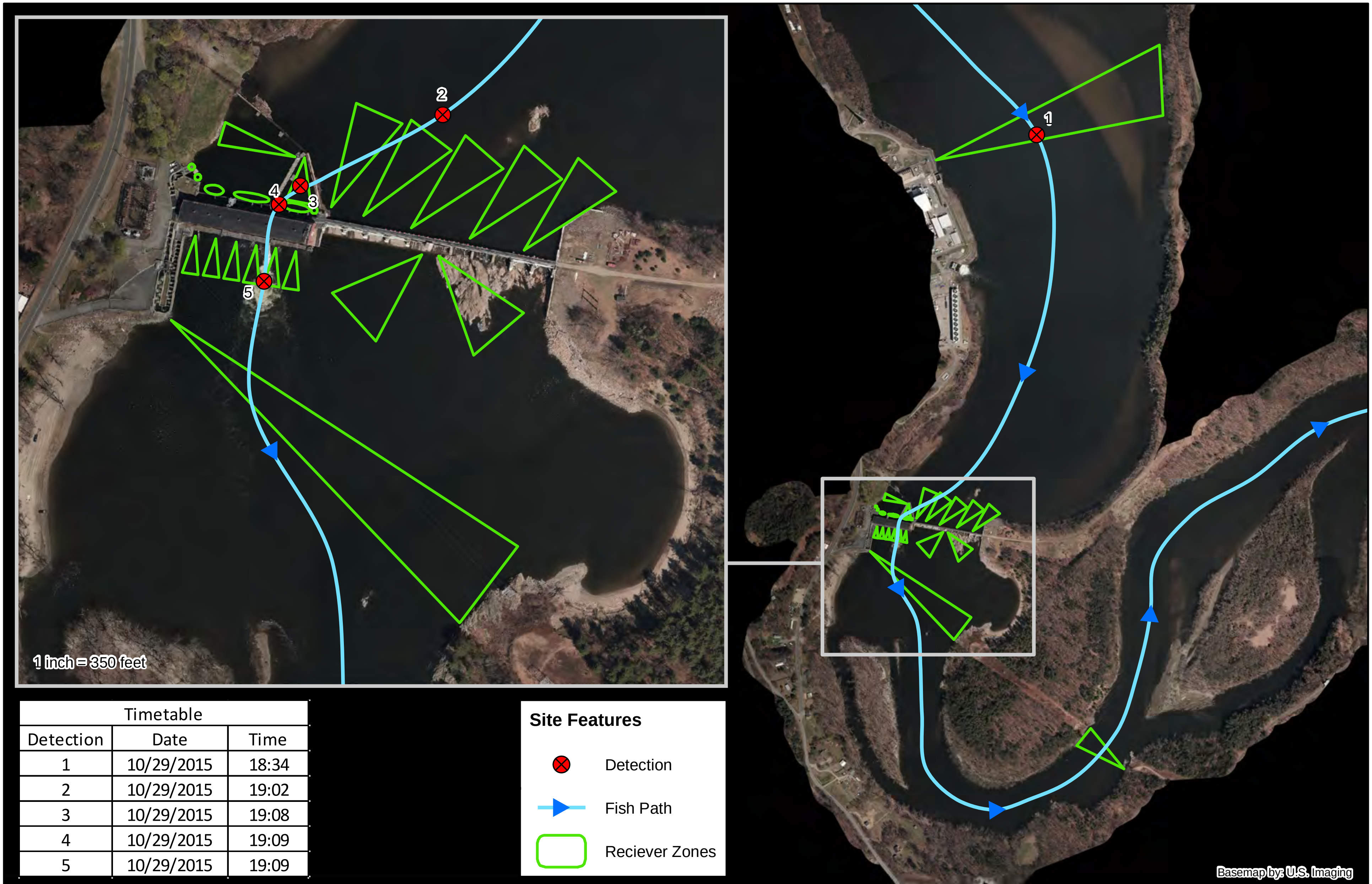
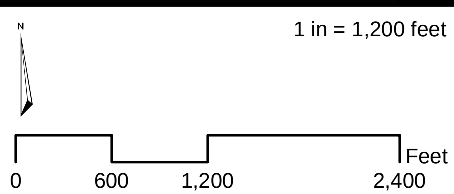


Timetable		
Detection	Date	Time
1	10/29/2015	18:34
2	10/29/2015	19:02
3	10/29/2015	19:08
4	10/29/2015	19:09
5	10/29/2015	19:09

TransCanada Hydro Northeast Inc.
ILP Study 19
Vernon Dam



Study 19 Fish Number: 34-102
Release: Riverside Industrial Complex
Brattleboro, VT
Date Released: 10/27/2015
Time Released: 17:45

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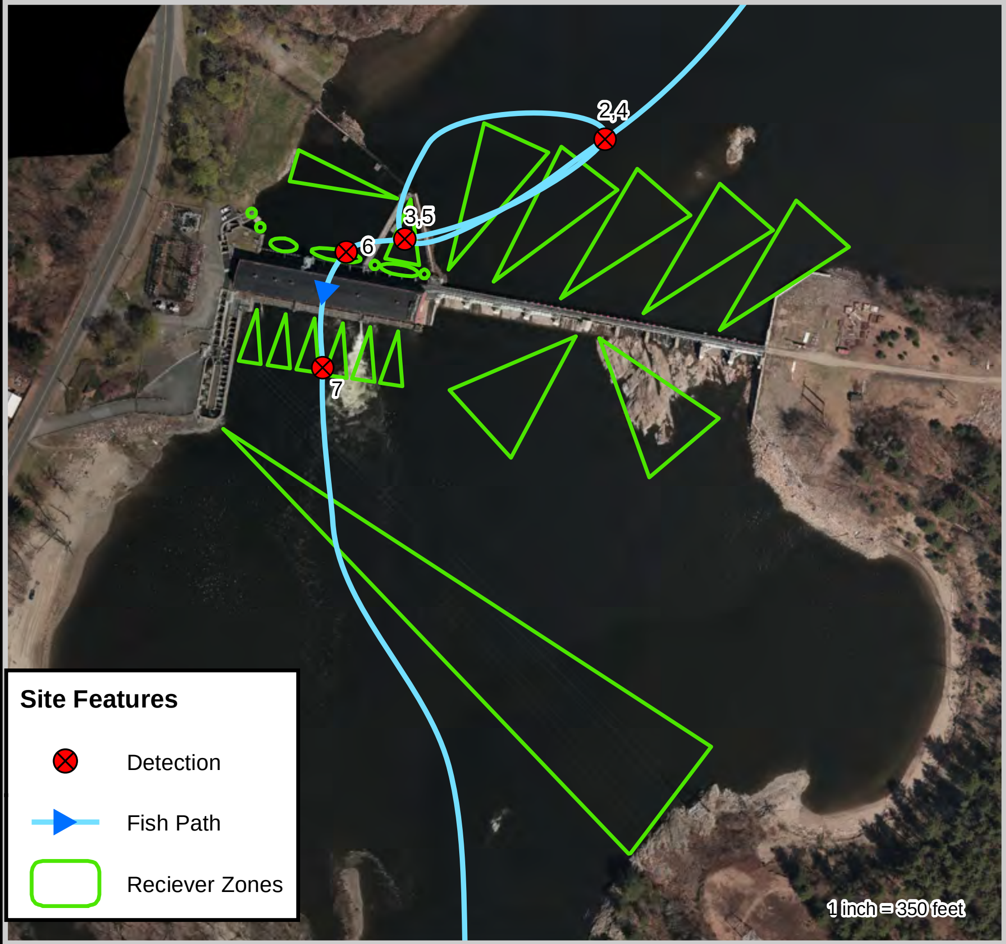

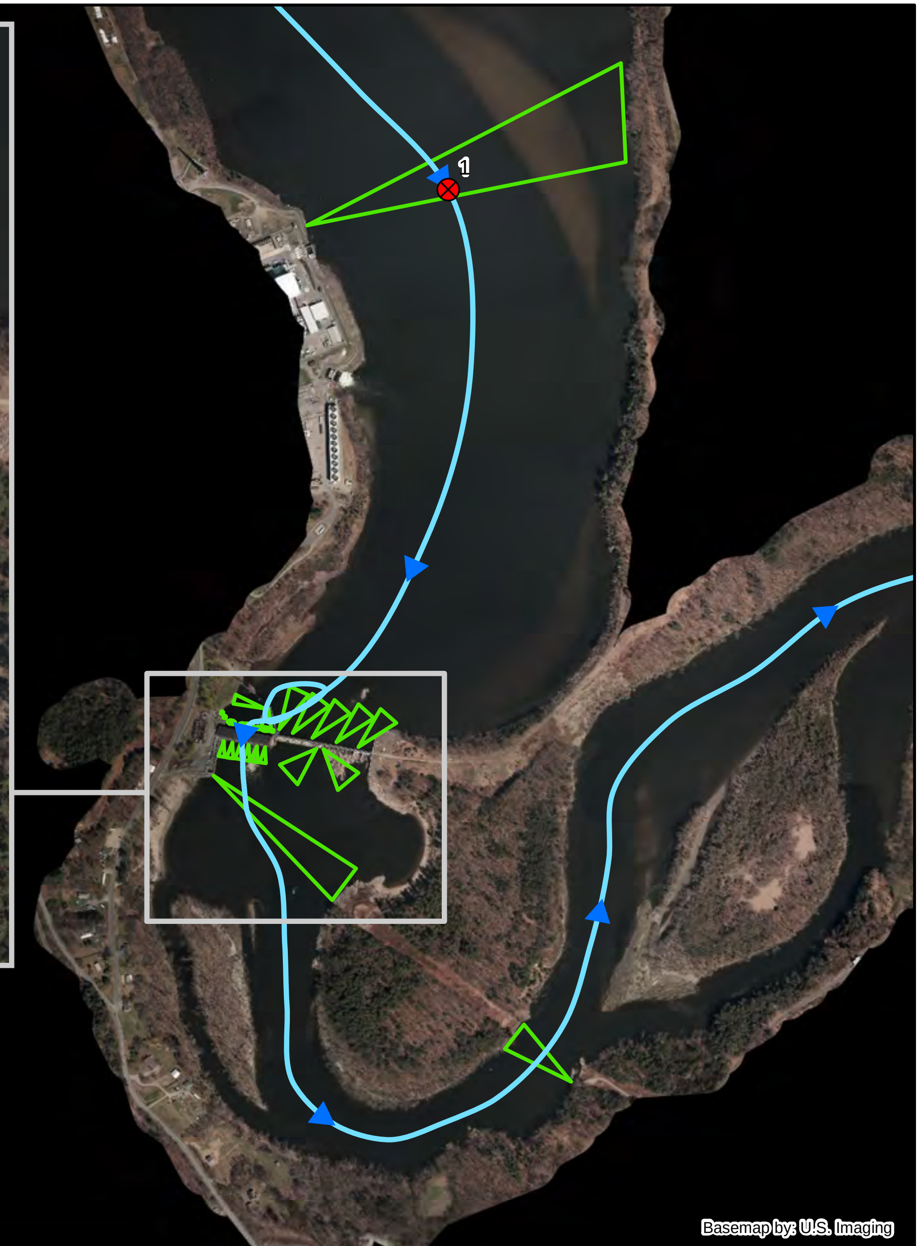

Timetable					
Detection	Date	Time	Detection	Date	Time
1	10/28/2015	19:52	6	10/28/2015	20:38
2	10/28/2015	20:26	7	10/28/2015	20:38
3	10/28/2015	20:27			
4	10/28/2015	20:33			
5	10/28/2015	20:34			

TransCanada Hydro Northeast Inc.
ILP Study 19
Vernon Dam

N

1 in = 1,200 feet

0 600 1,200 2,400 Feet

Study 19 Fish Number: 34-103
Release: Riverside Industrial Complex
Brattleboro, VT
Date Released: 10/27/2015
Time Released: 17:45

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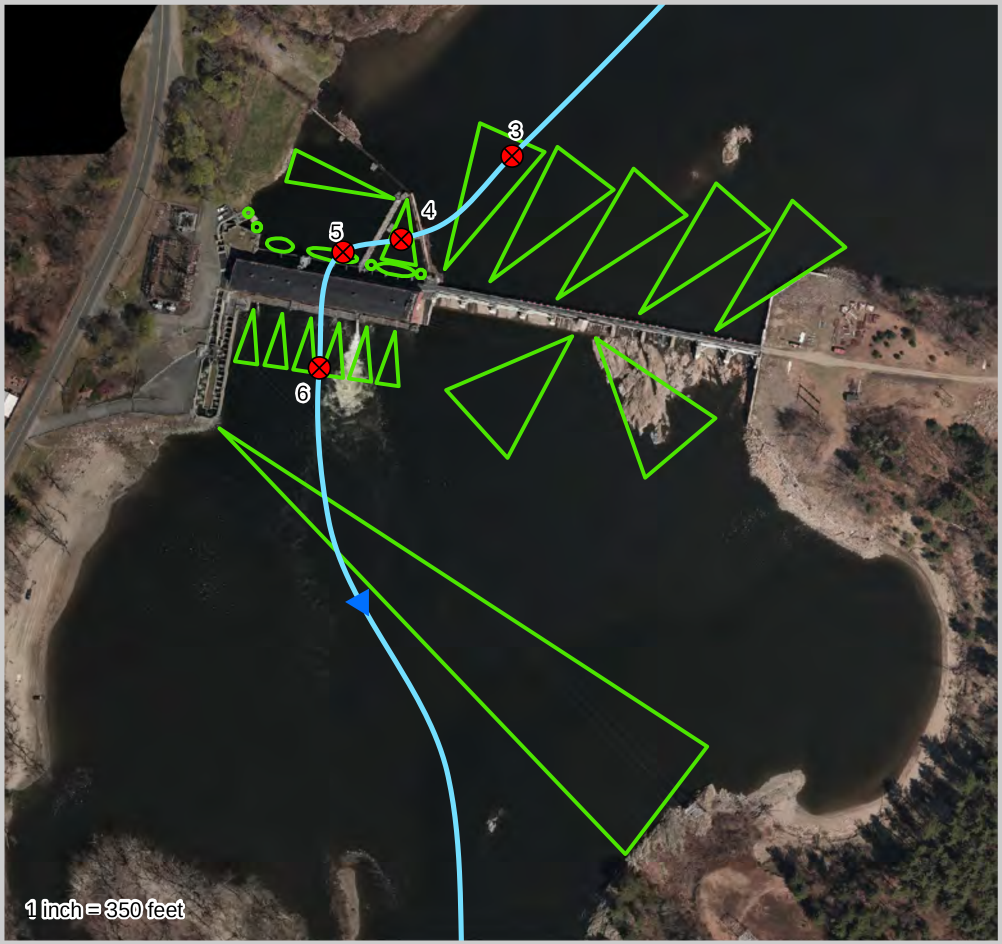

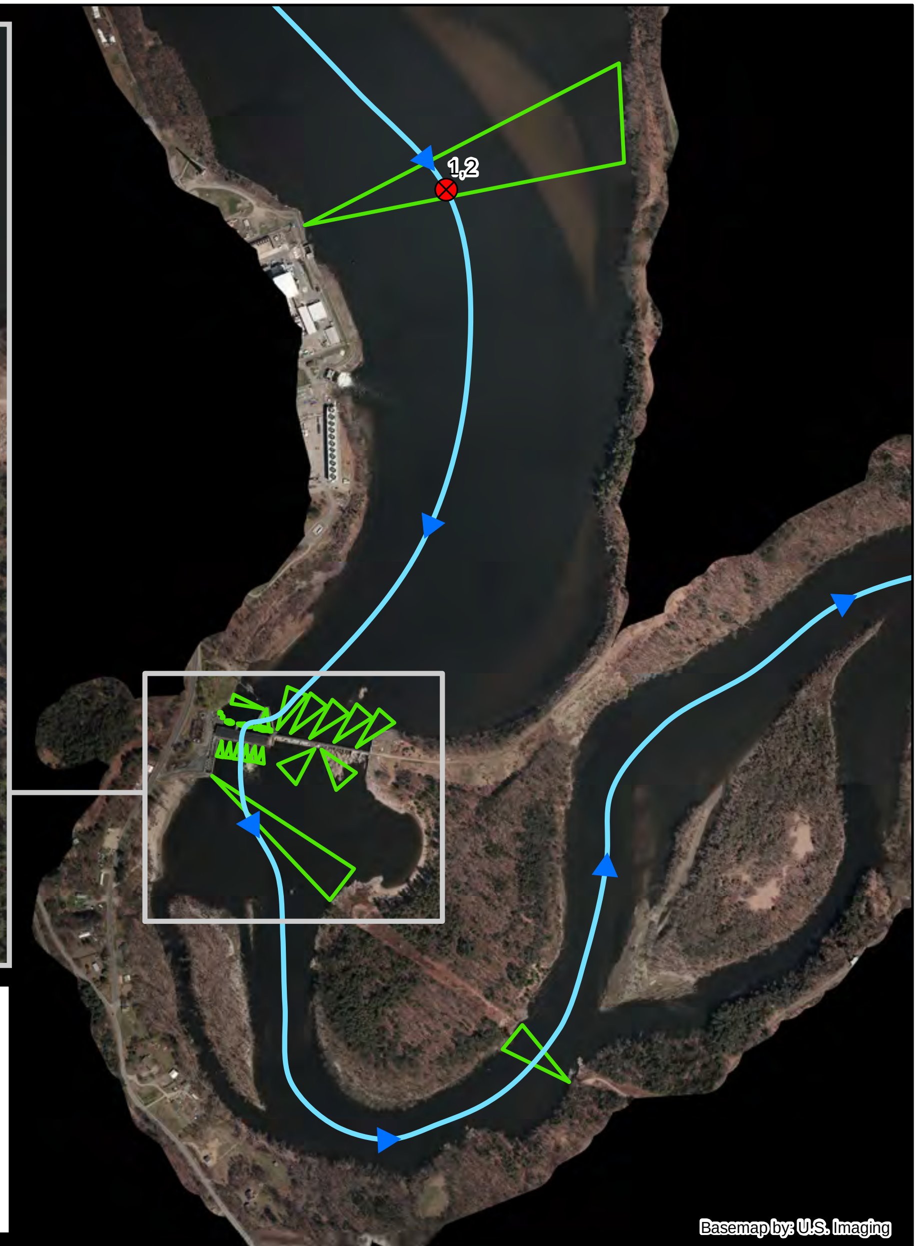

Timetable		
Detection	Date	Time
1	11/4/2015	3:27
2	11/6/2015	18:07
3	11/6/2015	19:15
4	11/6/2015	19:17
5	11/6/2015	19:23
6	11/6/2015	19:24

Site Features

- Detection
- Fish Path
- Reciever Zones

TransCanada Hydro Northeast Inc.
ILP Study 19
Vernon Dam

N

1 in = 1,200 feet

0 600 1,200 2,400 Feet

Study 19 Fish Number: 34-104
Release: Riverside Industrial Complex
Brattleboro, VT
Date Released: 11/03/2015
Time Released: 15:55

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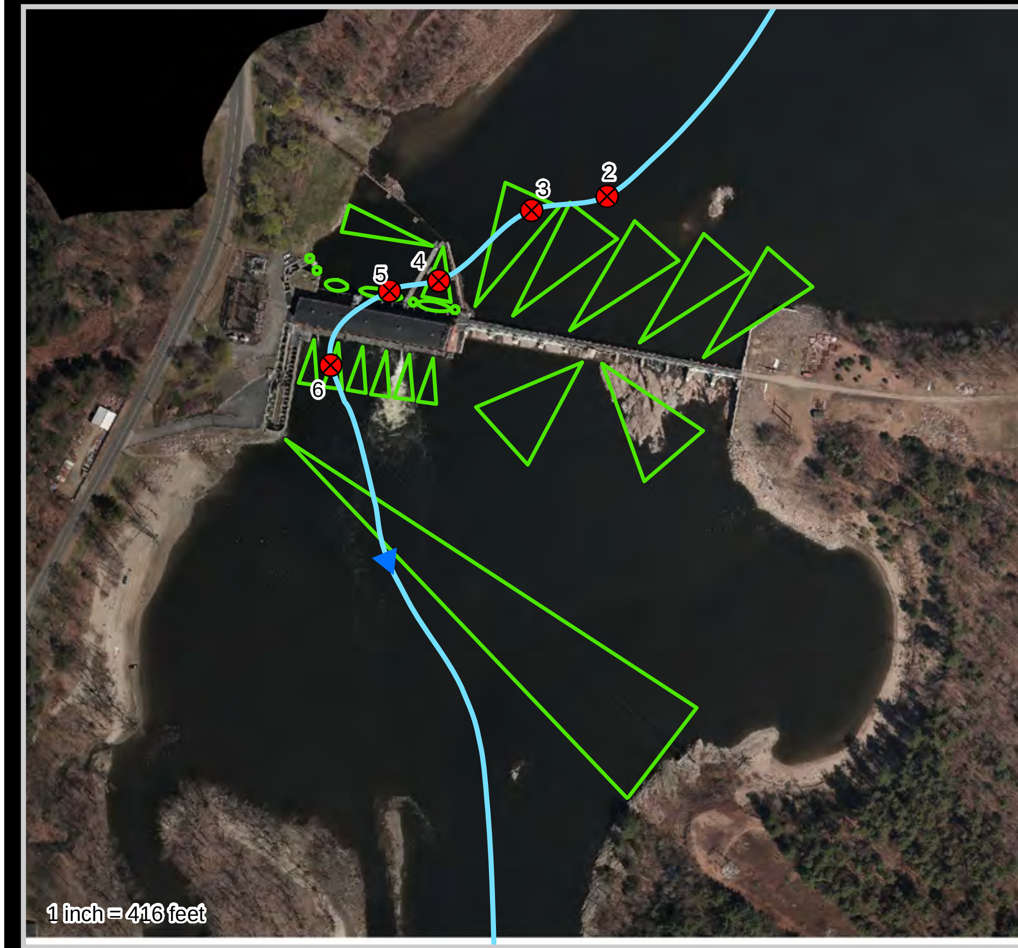

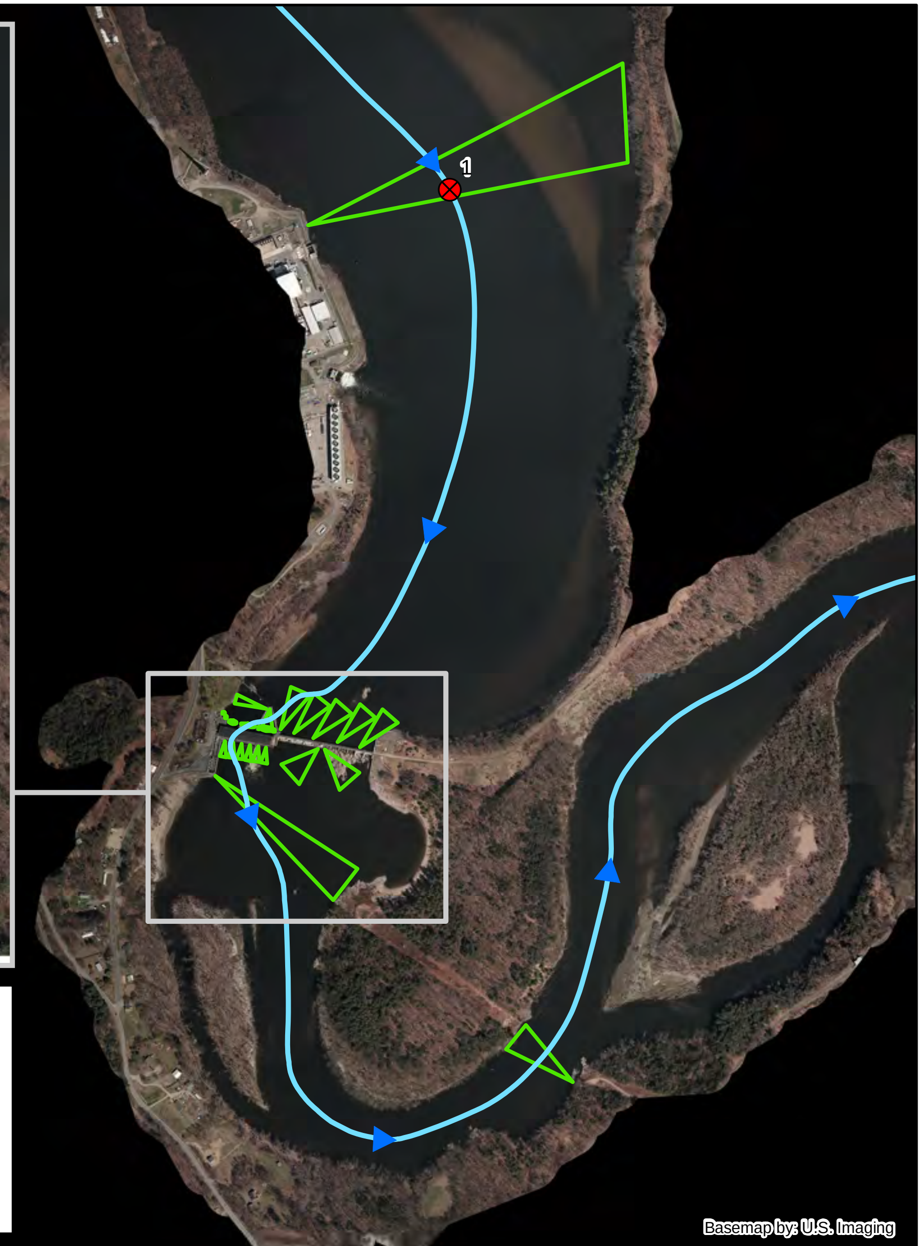

Timetable		
Detection	Date	Time
1	11/13/2015	1:53
2	11/14/2015	20:31
3	11/14/2015	20:32
4	11/14/2015	20:35
5	11/14/2015	20:52
6	11/14/2015	20:53

Site Features

- Detection
- Fish Path
- Reciever Zones

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TransCanada Hydro Northeast Inc.
ILP Study 19
Vernon Dam

N

1 in = 1,200 feet

0 600 1,200 2,400 Feet

Study 19 Fish Number: 34-105
Release: Riverside Industrial Complex
Brattleboro, VT
Date Released: 11/03/2015
Time Released: 15:55

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Timetable

Detection	Date	Time	Detection	Date	Time	Detection	Date	Time	Detection	Date	Time
1	11/6/2015	20:20	7	11/6/2015	21:58	13	11/9/2015	4:33	19	11/10/2015	21:37
2	11/6/2015	21:31	8	11/6/2015	22:00	14	11/10/2015	21:20	20	11/10/2015	21:37
3	11/6/2015	21:33	9	11/7/2015	0:28	15	11/10/2015	21:20	21	11/10/2015	21:38
4	11/6/2015	21:44	10	11/9/2015	2:58	16	11/10/2015	21:32	22	11/10/2015	21:39
5	11/6/2015	21:48	11	11/9/2015	3:05	17	11/10/2015	21:36			
6	11/6/2015	21:50	12	11/9/2015	3:05	18	11/10/2015	21:37			

TransCanada Hydro Northeast Inc.
ILP Study 19
Vernon Dam

N

1 in = 1,200 feet

0 600 1,200 2,400 Feet

Study 19 Fish Number: 34-107
Release: Riverside Industrial Complex
Brattleboro, VT
Date Released: 11/03/2015
Time Released: 15:55

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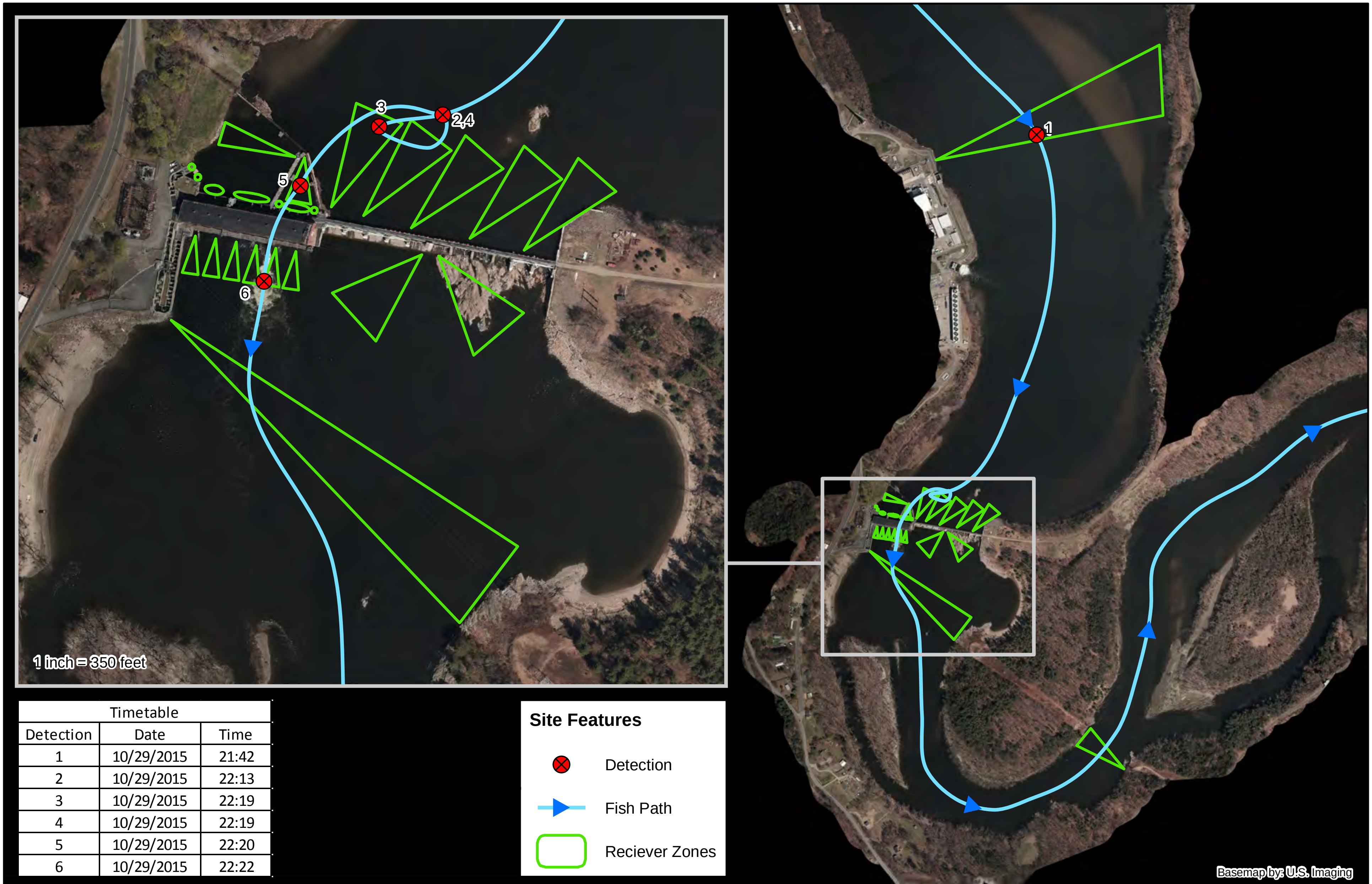

Timetable		
Detection	Date	Time
1	10/29/2015	21:42
2	10/29/2015	22:13
3	10/29/2015	22:19
4	10/29/2015	22:19
5	10/29/2015	22:20
6	10/29/2015	22:22

Site Features

- Detection
- Fish Path
- Reciever Zones

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TransCanada Hydro Northeast Inc.
ILP Study 19
Vernon Dam

N

1 in = 1,200 feet

0 600 1,200 2,400 Feet

Study 19 Fish Number: 34-111

Release: Herricks Cove, VT
Date Released: 10/27/2015
Time Released: 18:20

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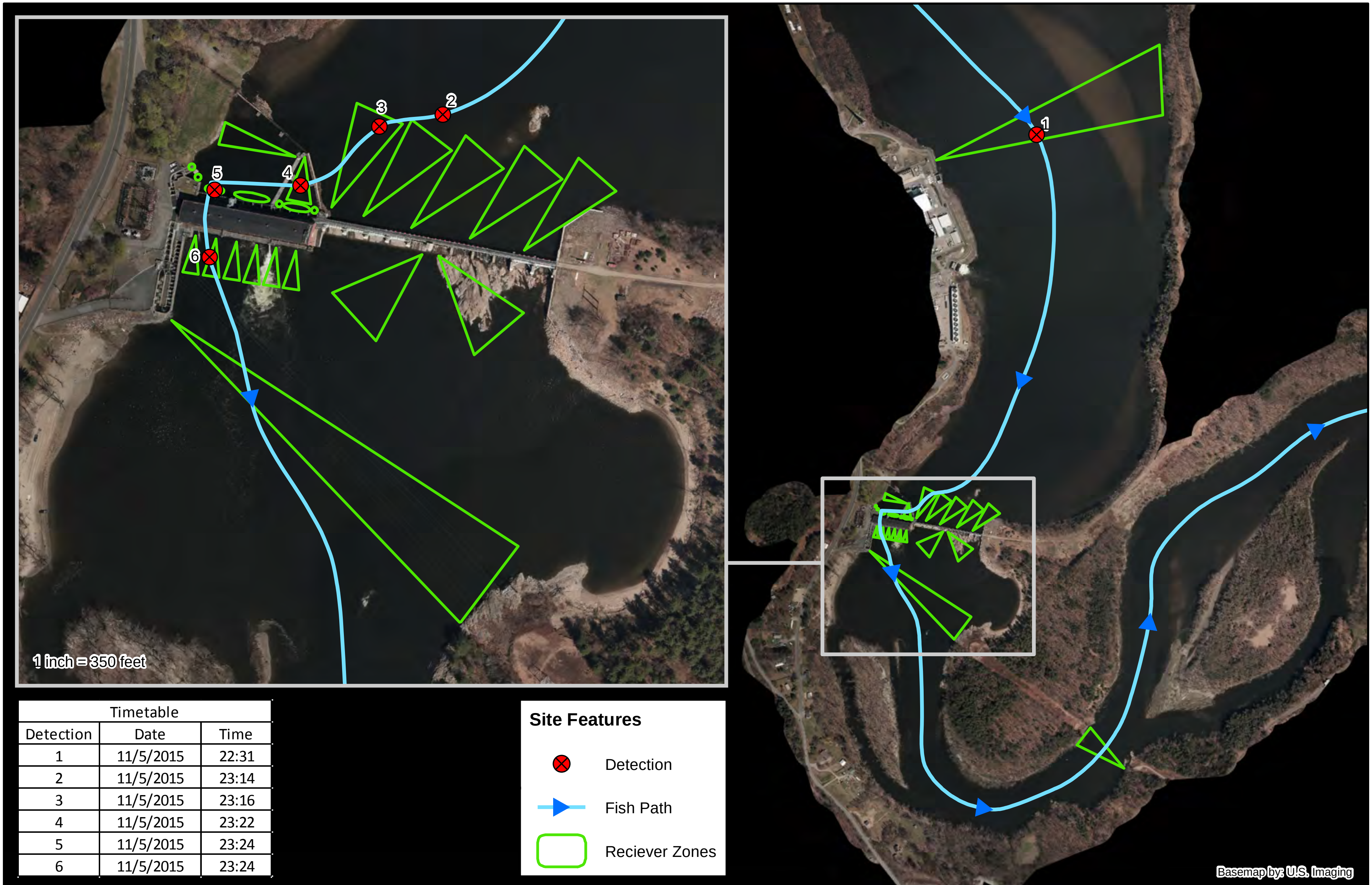

Timetable		
Detection	Date	Time
1	11/5/2015	22:31
2	11/5/2015	23:14
3	11/5/2015	23:16
4	11/5/2015	23:22
5	11/5/2015	23:24
6	11/5/2015	23:24

Site Features

- Detection
- Fish Path
- Reciever Zones

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TransCanada Hydro Northeast Inc.
ILP Study 19
Vernon Dam

N

1 in = 1,200 feet

0 600 1,200 2,400 Feet

Study 19 Fish Number: 34-112

Release: Herricks Cove, VT
Date Released: 10/27/2015
Time Released: 18:20

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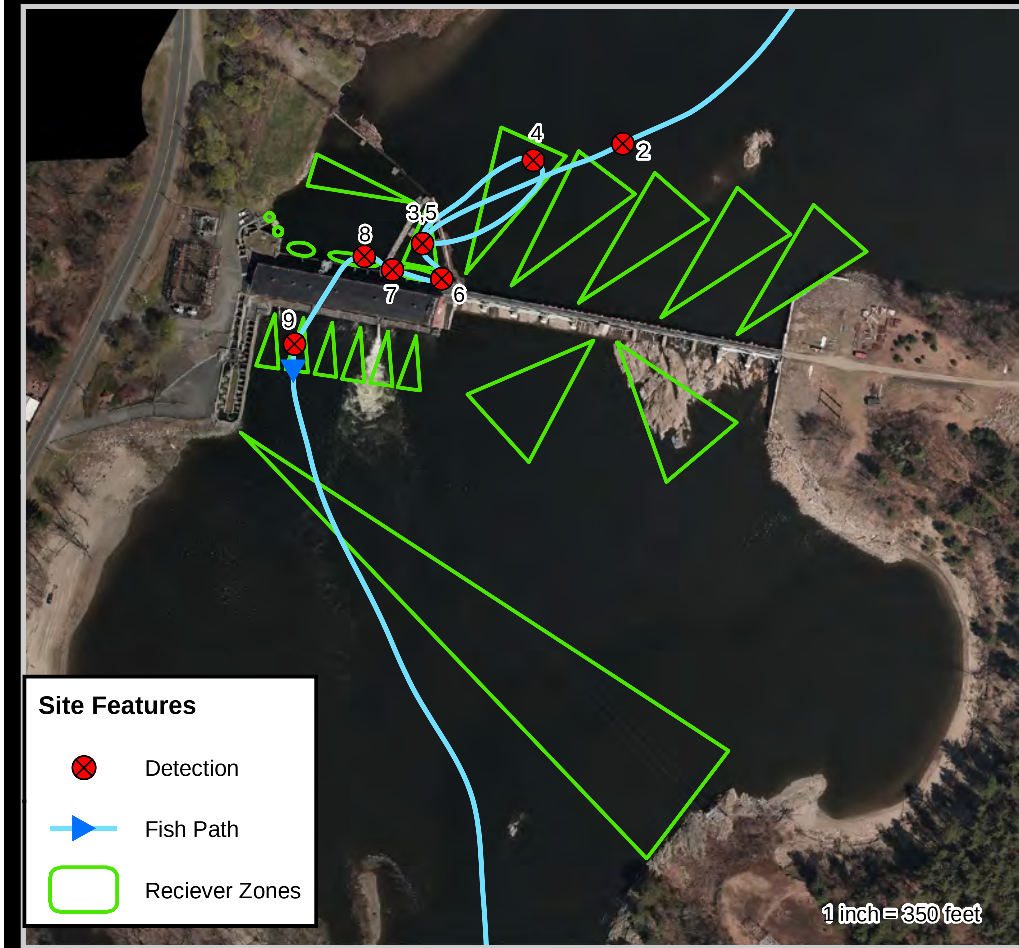

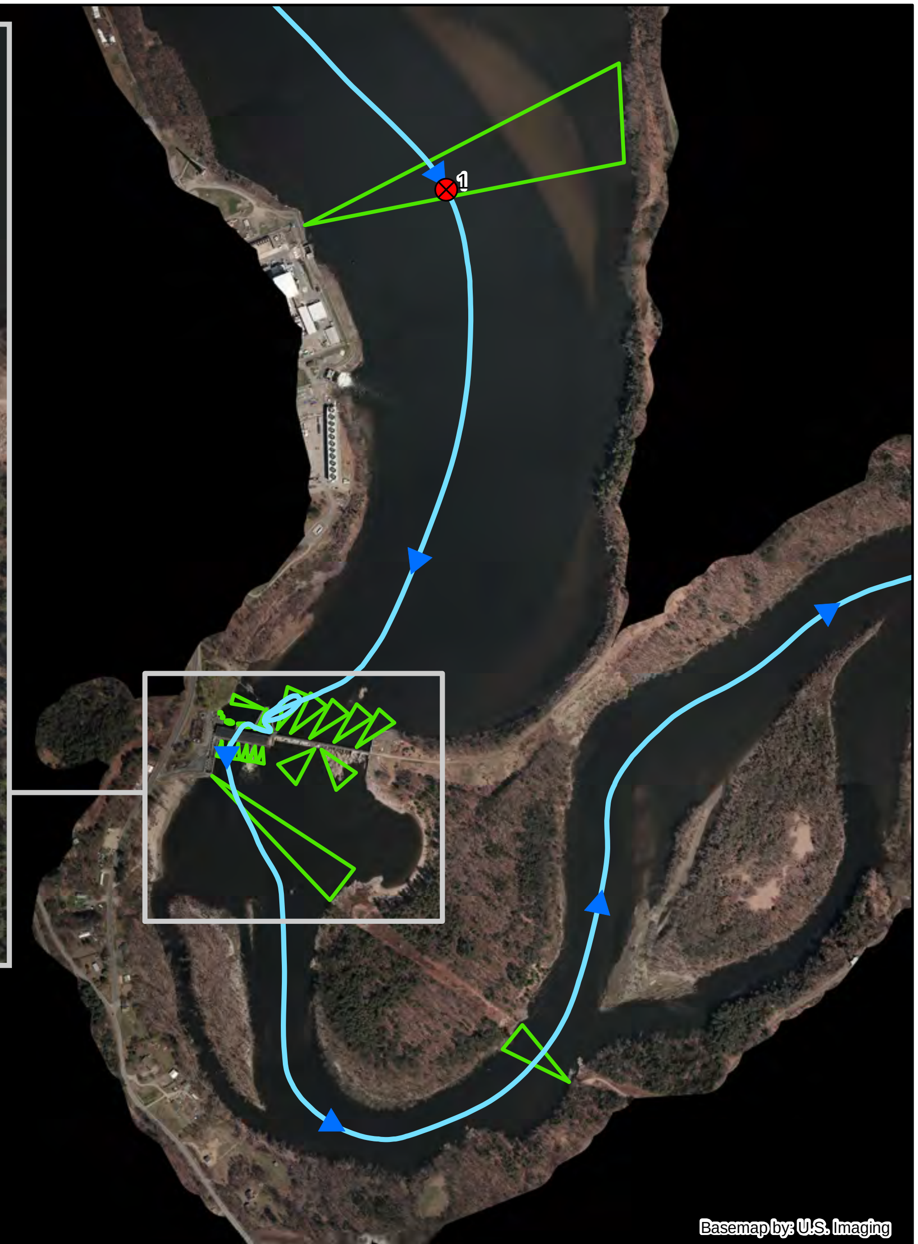

Timetable					
Detection	Date	Time	Detection	Date	Time
1	11/20/2015	4:26	6	11/20/2015	22:31
2	11/20/2015	22:09	7	11/20/2015	22:31
3	11/20/2015	22:25	8	11/20/2015	22:32
4	11/20/2015	22:27	9	11/20/2015	22:32
5	11/20/2015	22:28			

TransCanada Hydro Northeast Inc.
ILP Study 19
Vernon Dam

N

1 in = 1,200 feet

0 600 1,200 2,400 Feet

Study 19 Fish Number: 34-116

Release: Herricks Cove, VT
Date Released: 11/03/2015
Time Released: 16:45

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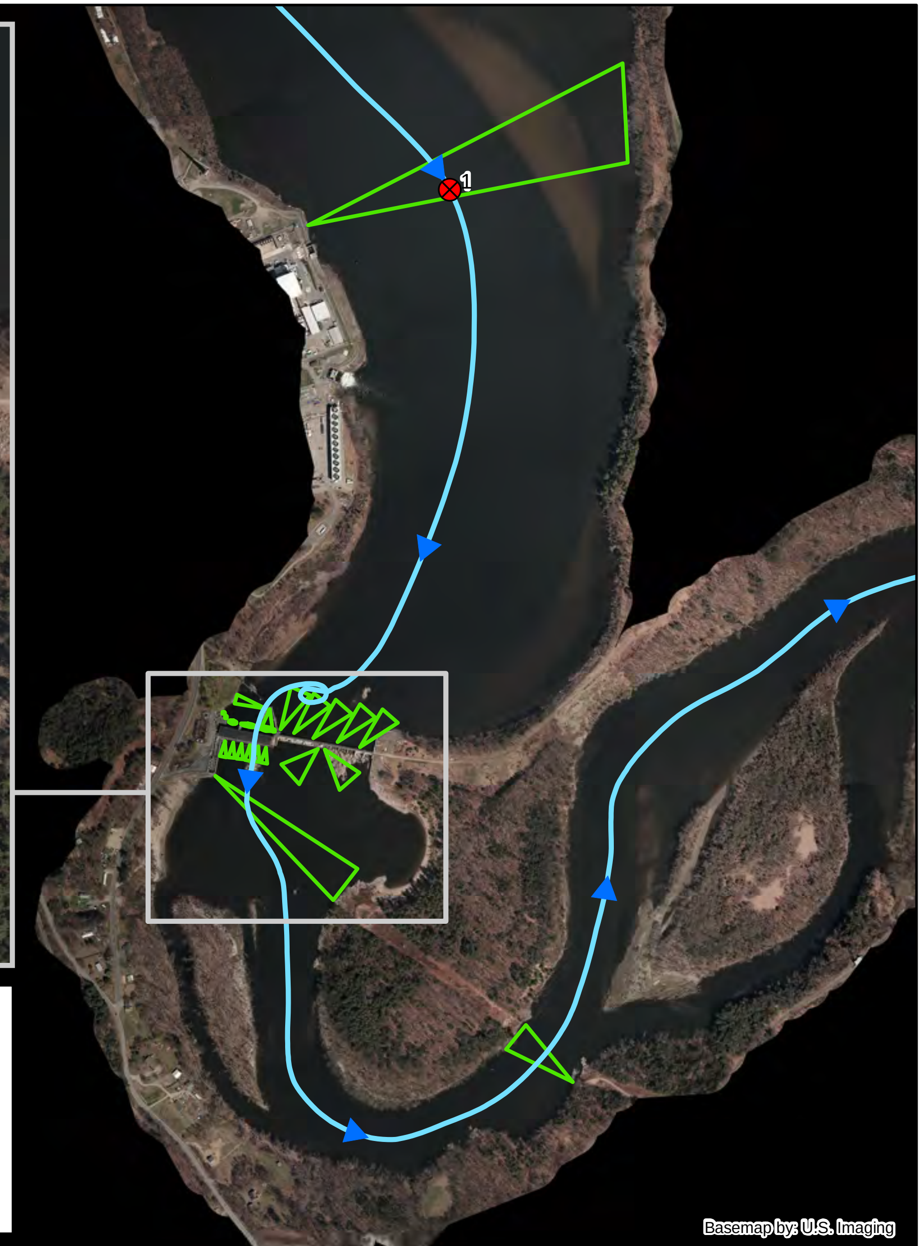

Timetable		
Detection	Date	Time
1	12/24/2015	16:35
2	12/24/2015	17:02
3	12/24/2015	17:04
4	12/24/2015	17:07
5	12/24/2015	17:13

Site Features

- Detection
- Fish Path
- Reciever Zones

TransCanada Hydro Northeast Inc.
ILP Study 19
Vernon Dam

N

1 in = 1,200 feet

0 600 1,200 2,400 Feet

Study 19 Fish Number: 34-117

Release: Herricks Cove, VT
Date Released: 11/03/2015
Time Released: 16:45

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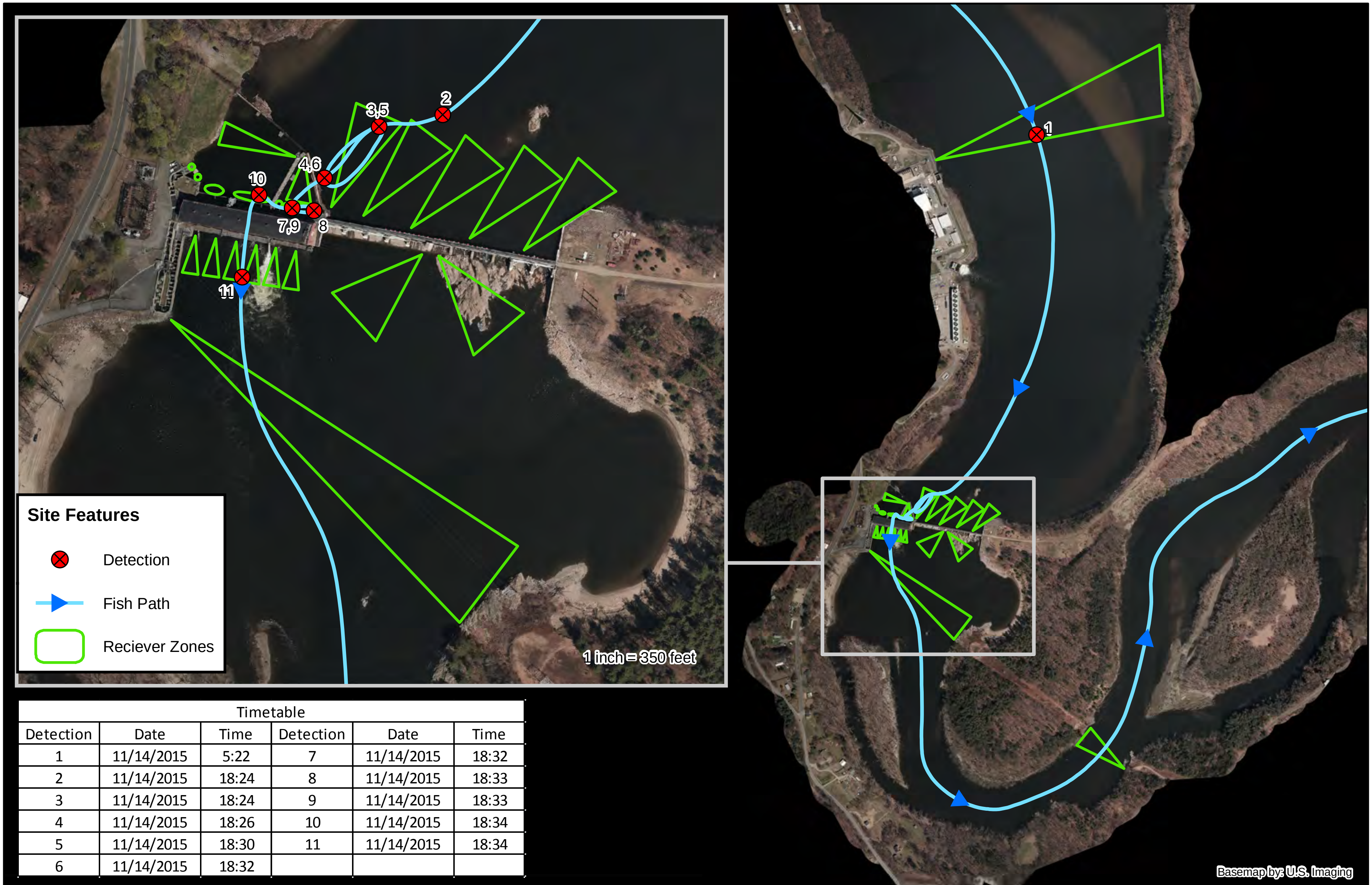

Timetable					
Detection	Date	Time	Detection	Date	Time
1	11/14/2015	5:22	7	11/14/2015	18:32
2	11/14/2015	18:24	8	11/14/2015	18:33
3	11/14/2015	18:24	9	11/14/2015	18:33
4	11/14/2015	18:26	10	11/14/2015	18:34
5	11/14/2015	18:30	11	11/14/2015	18:34
6	11/14/2015	18:32			

TransCanada Hydro Northeast Inc.
ILP Study 19
Vernon Dam

N

1 in = 1,200 feet

0 600 1,200 2,400 Feet

Study 19 Fish Number: 34-118

Release: Herricks Cove, VT
Date Released: 11/03/2015
Time Released: 16:45

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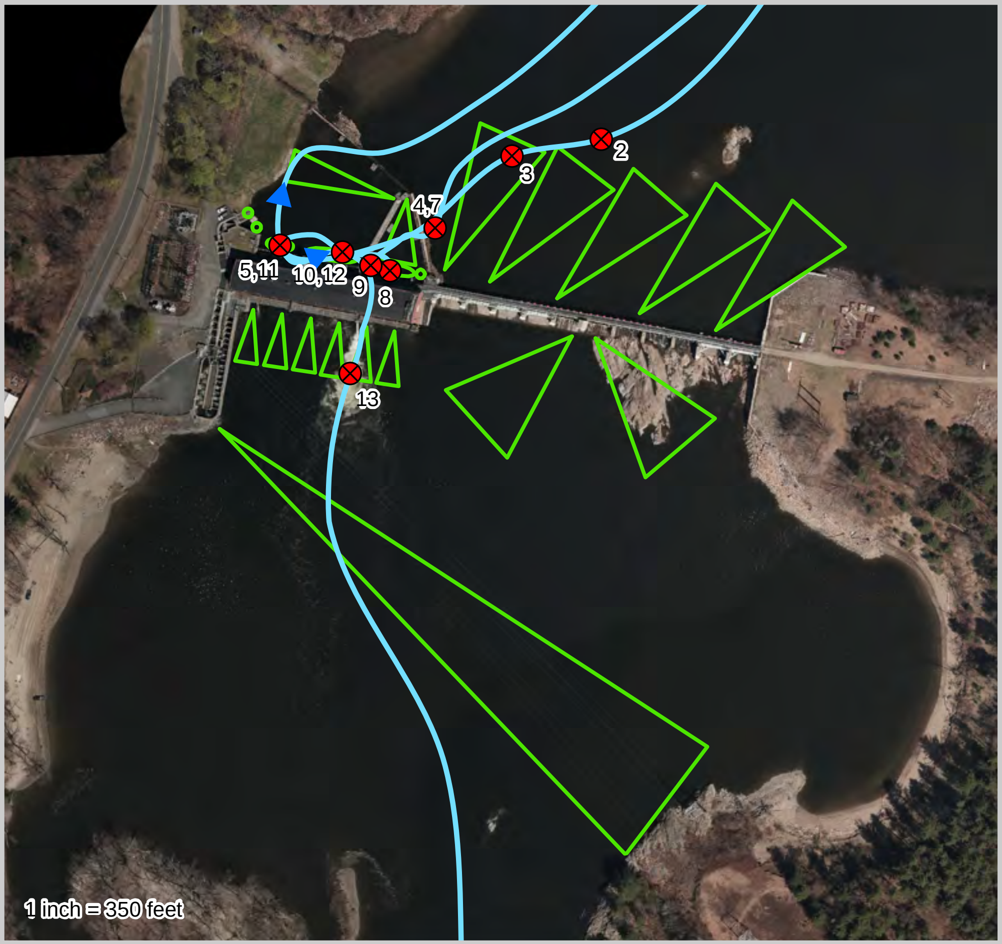

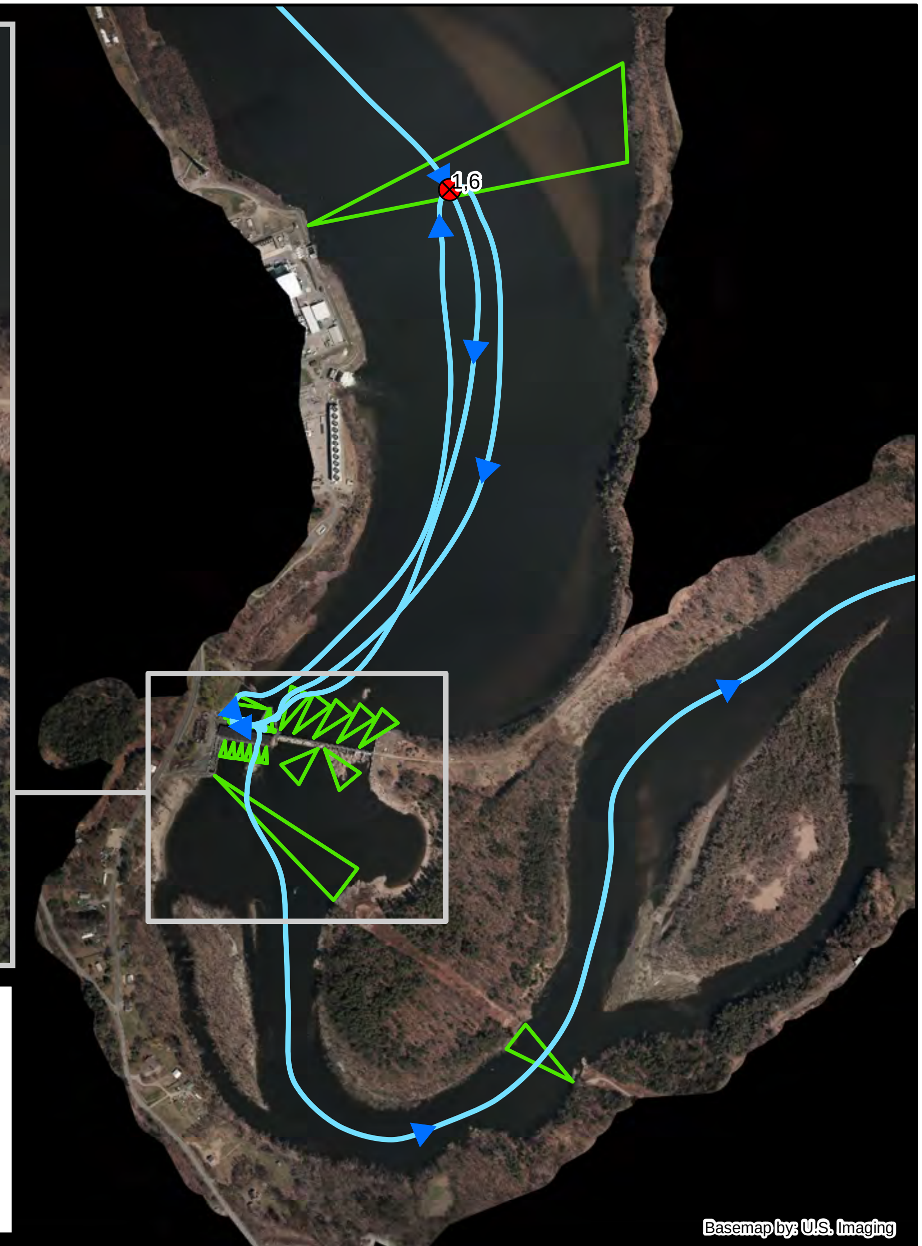

Timetable					
Detection	Date	Time	Detection	Date	Time
1	11/1/2015	23:56	8	11/2/2015	19:09
2	11/2/2015	0:50	9	11/2/2015	19:10
3	11/2/2015	2:38	10	11/2/2015	19:10
4	11/2/2015	3:03	11	11/2/2015	19:11
5	11/2/2015	3:11	12	11/2/2015	19:50
6	11/2/2015	4:38	13	11/2/2015	19:50
7	11/2/2015	19:07			

Site Features

- Detection
- Fish Path
- Reciever Zones

TransCanada Hydro Northeast Inc.
ILP Study 19
Vernon Dam

N

1 in = 1,200 feet

0 600 1,200 2,400 Feet

Study 19 Fish Number: 34-121

Release: Norwich, VT
Date Released: 10/27/2015
Time Released: 20:05

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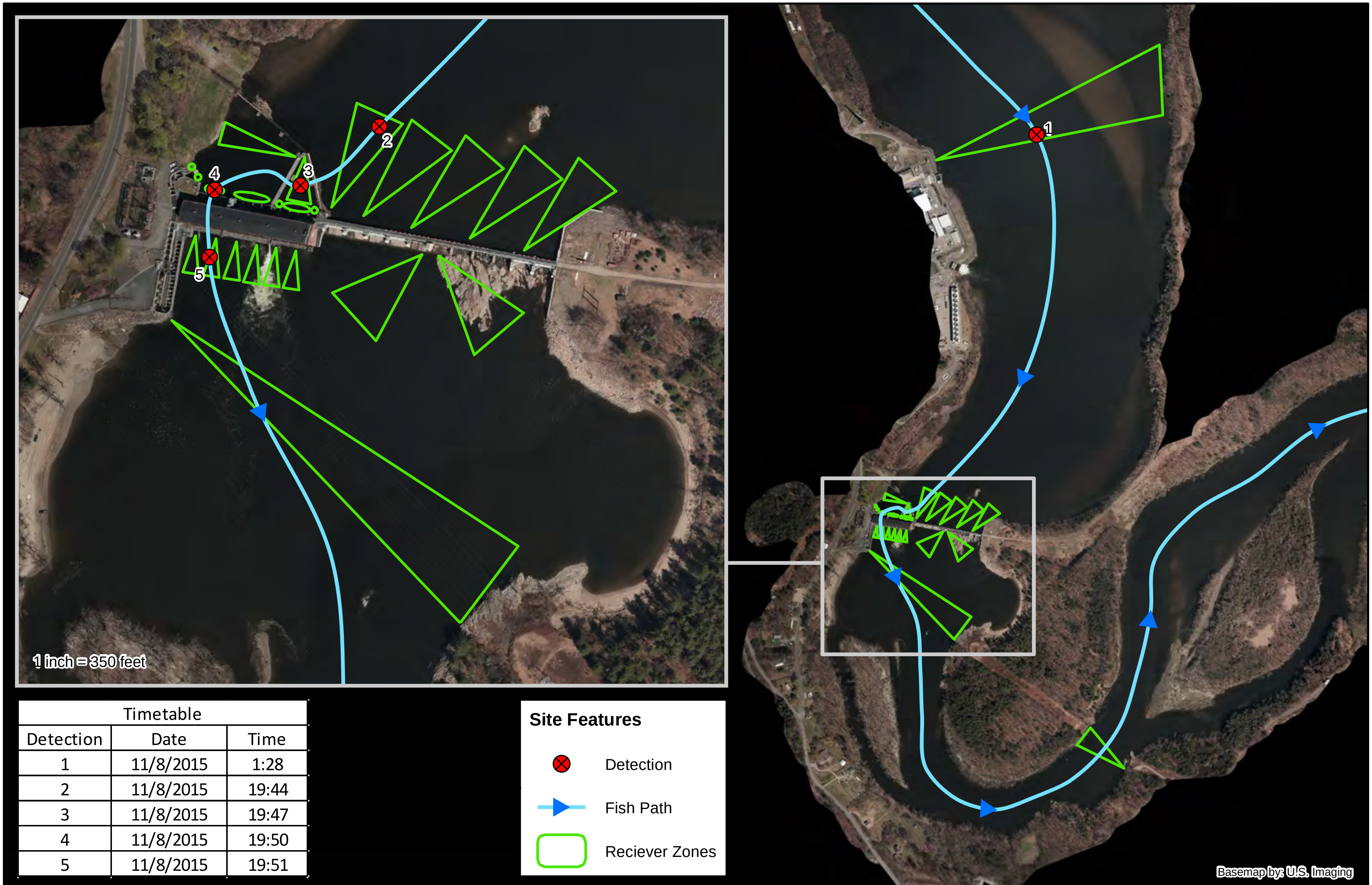

Timetable		
Detection	Date	Time
1	11/8/2015	1:28
2	11/8/2015	19:44
3	11/8/2015	19:47
4	11/8/2015	19:50
5	11/8/2015	19:51

Site Features

- Detection
- Fish Path
- Reciever Zones

TransCanada Hydro Northeast Inc.
ILP Study 19
Vernon Dam

1 in = 1,200 feet

0 600 1,200 2,400 Feet

Study 19 Fish Number: 34-128

Release: Norwich, VT
Date Released: 11/03/2015
Time Released: 17:32

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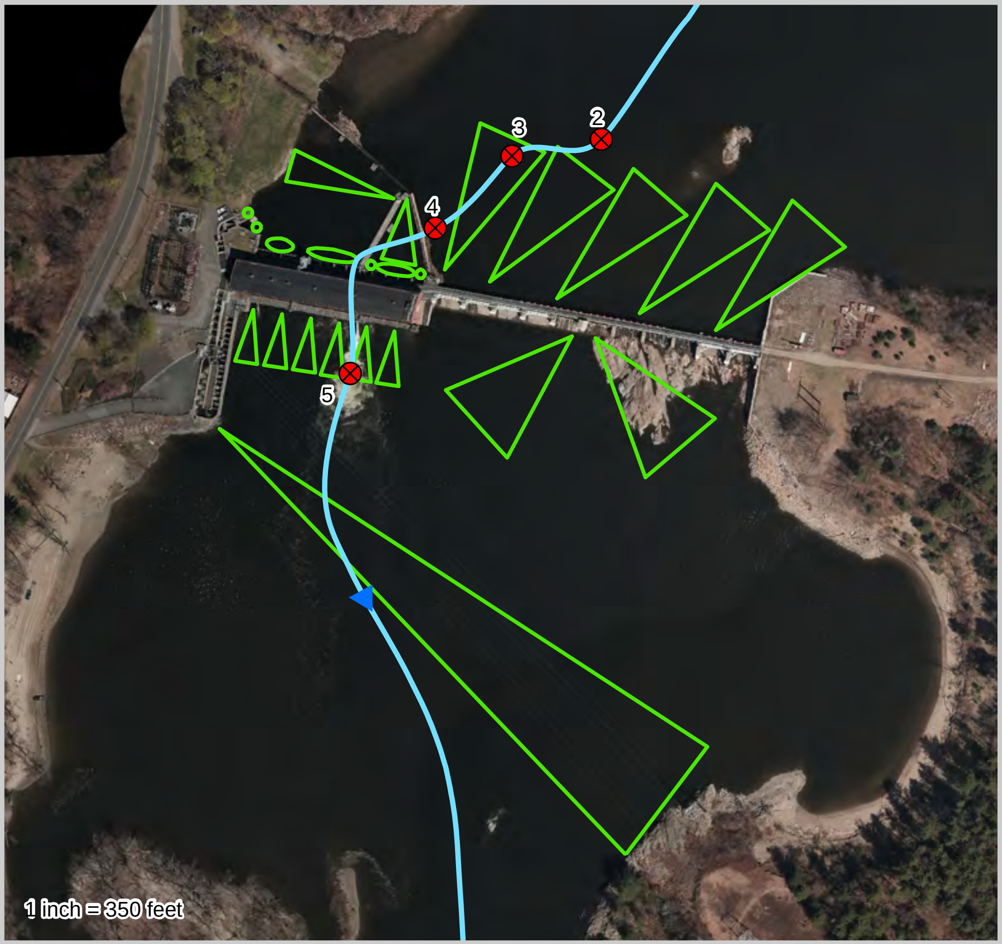

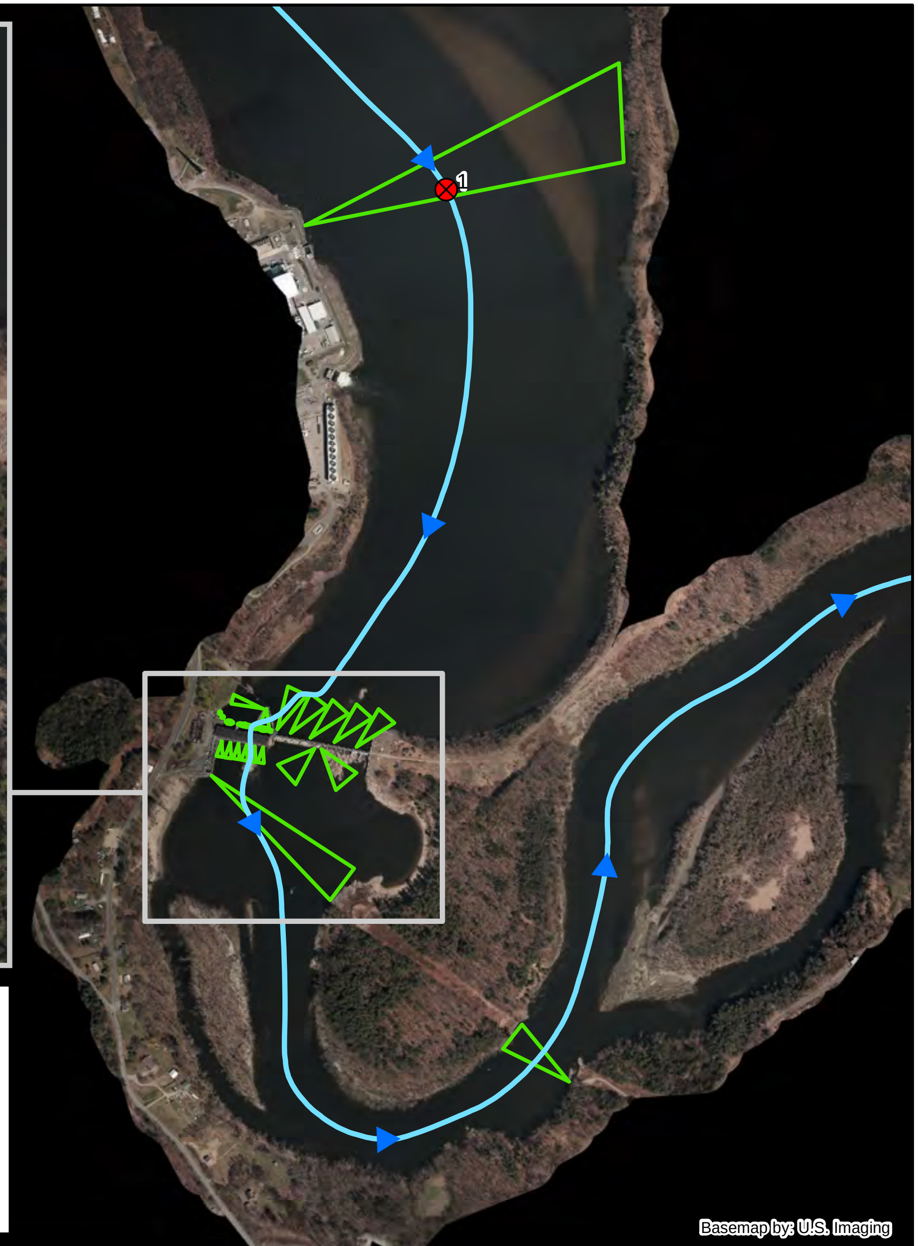

Timetable		
Detection	Date	Time
1	11/10/2015	23:40
2	11/11/2015	0:09
3	11/11/2015	0:10
4	11/11/2015	0:14
5	11/11/2015	0:20

Site Features

- Detection
- Fish Path
- Reciever Zones

TransCanada Hydro Northeast Inc.
ILP Study 19
Vernon Dam

N

1 in = 1,200 feet

0 600 1,200 2,400 Feet

Study 19 Fish Number: 34-129

Release: Norwich, VT
Date Released: 11/03/2015
Time Released: 17:32

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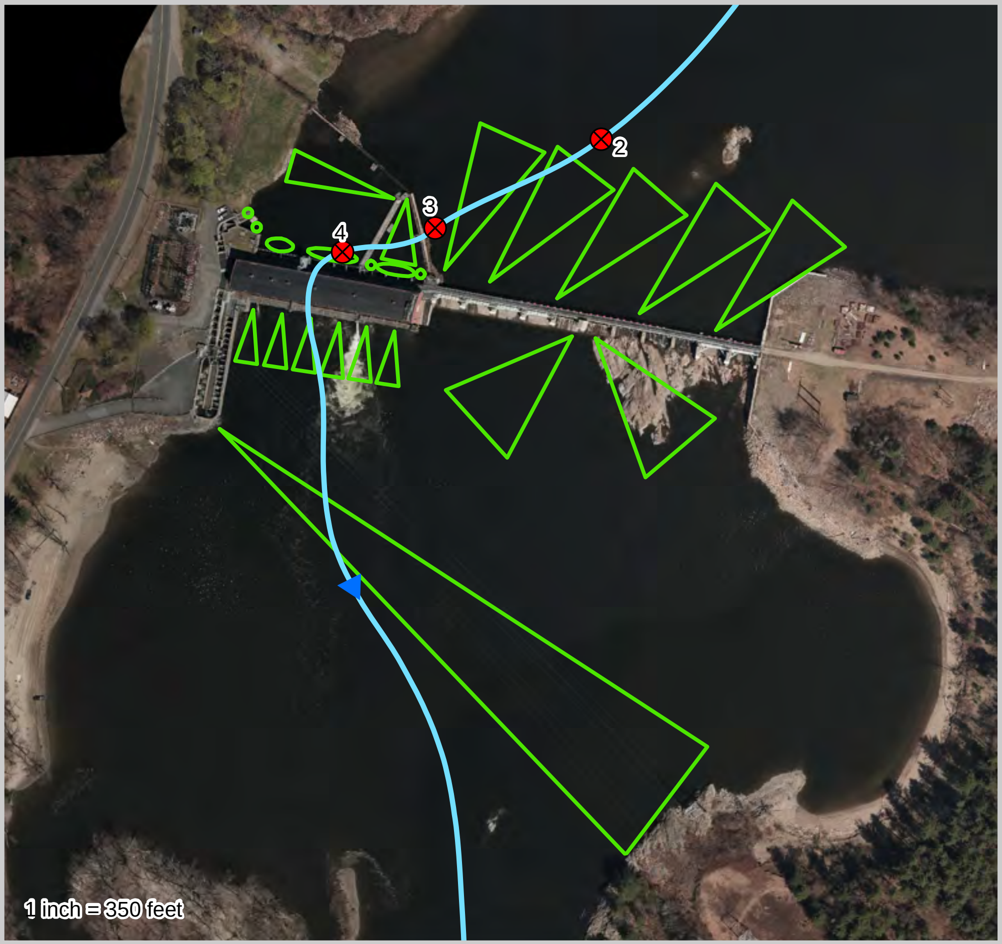

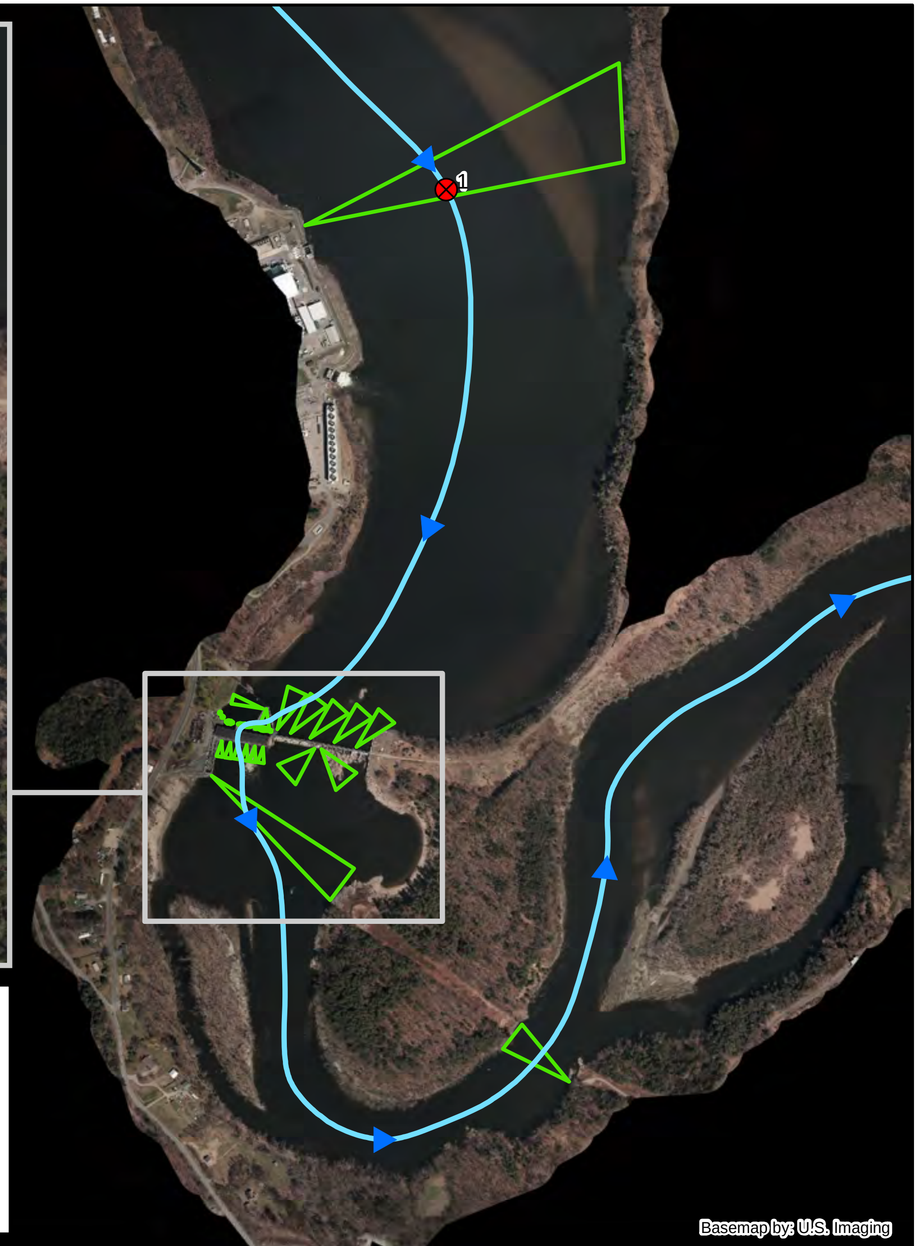

Timetable		
Detection	Date	Time
1	10/29/2015	22:23
2	10/29/2015	22:58
3	10/29/2015	23:03
4	10/29/2015	23:05

Site Features

- Detection
- Fish Path
- Reciever Zones

TransCanada Hydro Northeast Inc.
ILP Study 19
Vernon Dam

N

1 in = 1,200 feet

0 600 1,200 2,400 Feet

Study 19 Fish Number: 34-131
Release: Riverside Industrial Complex
Brattleboro, VT
Date Released: 10/29/2015
Time Released: 13:05

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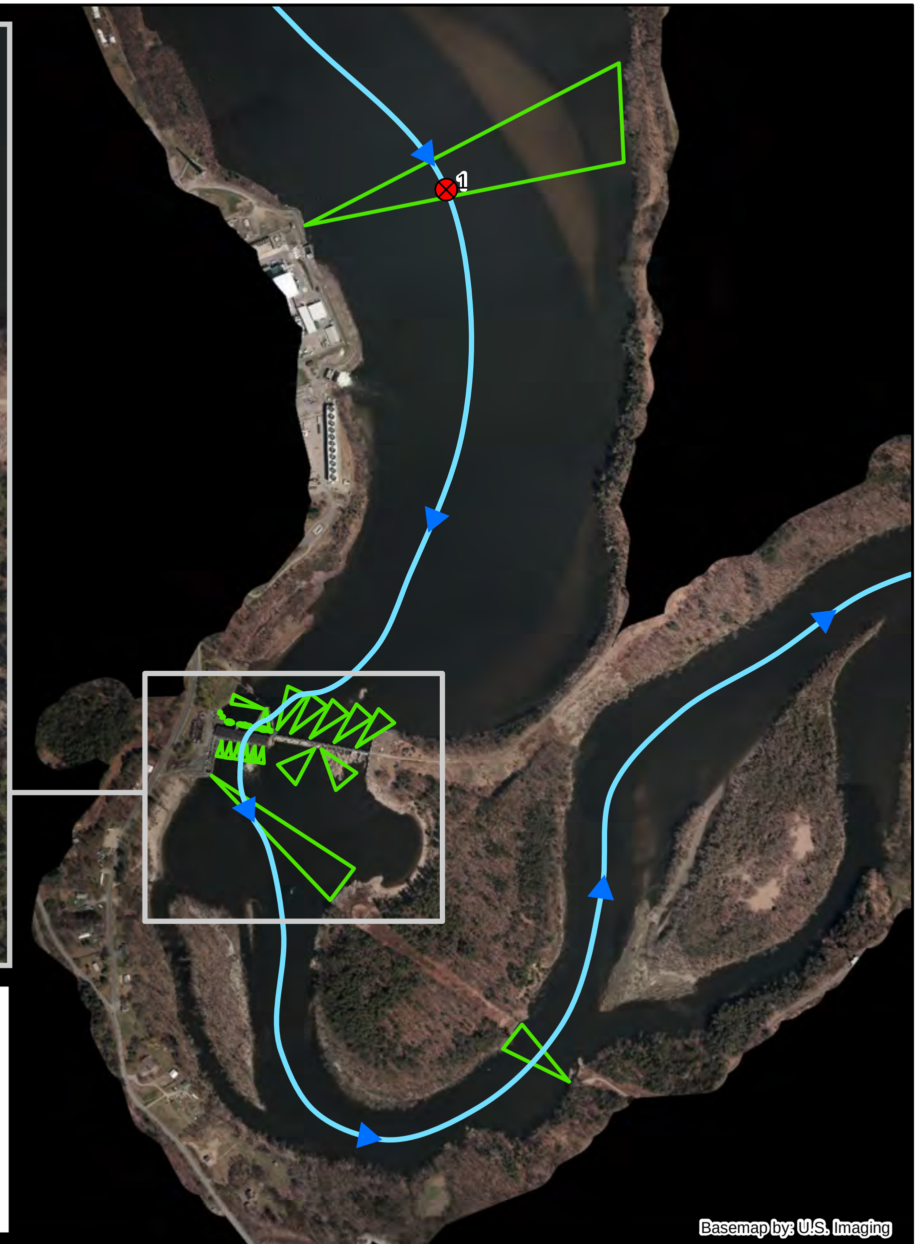

Timetable		
Detection	Date	Time
1	10/29/2015	18:32
2	10/29/2015	18:58
3	10/29/2015	19:02
4	10/29/2015	19:02
5	10/29/2015	19:05

Site Features

- Detection
- Fish Path
- Reciever Zones

TransCanada Hydro Northeast Inc.
ILP Study 19
Vernon Dam

N

1 in = 1,200 feet

0 600 1,200 2,400 Feet

Study 19 Fish Number: 34-132
Release: Riverside Industrial Complex
Brattleboro, VT
Date Released: 10/29/2015
Time Released: 13:05

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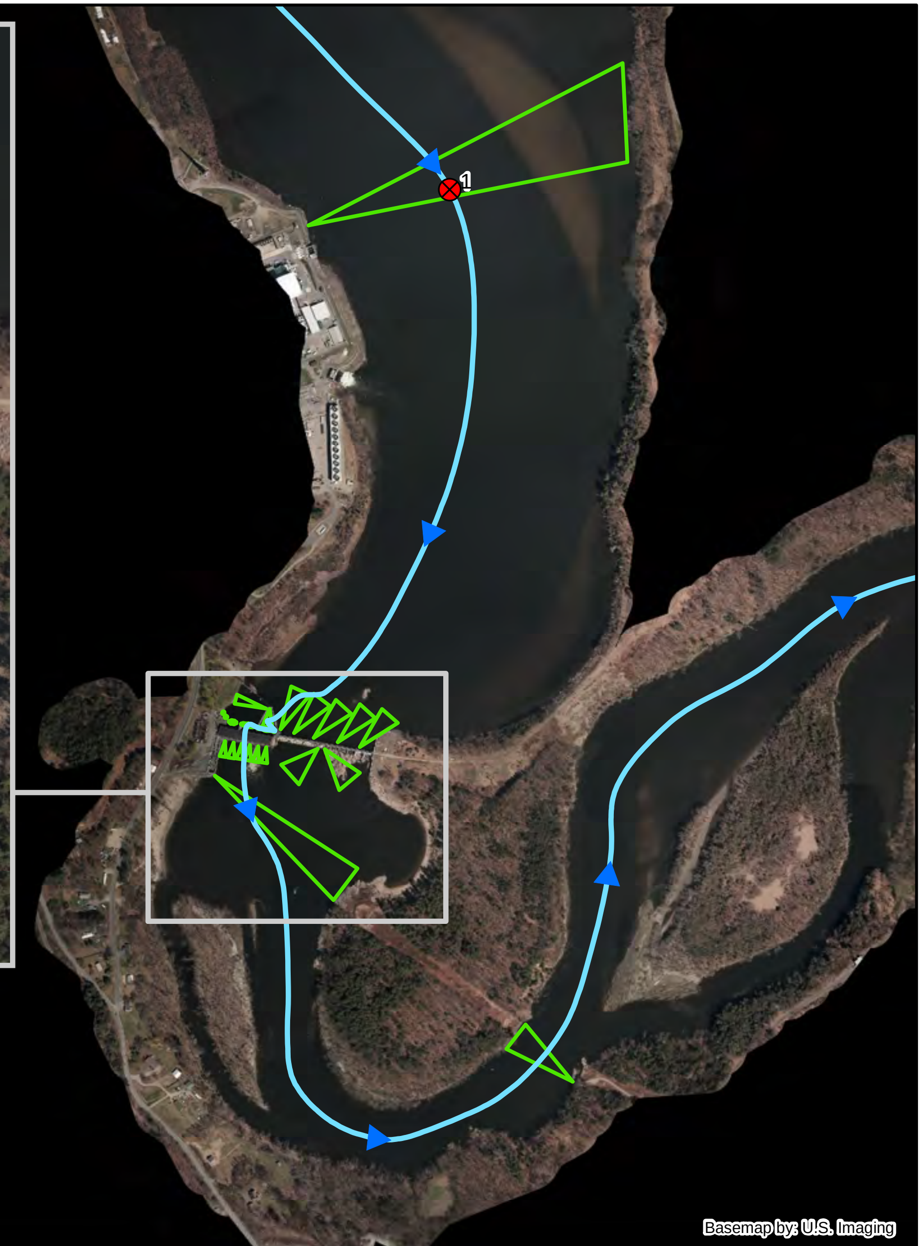

Timetable					
Detection	Date	Time	Detection	Date	Time
1	10/29/2015	19:49	6	10/29/2015	20:23
2	10/29/2015	20:15	7	10/29/2015	20:24
3	10/29/2015	20:21	8	10/29/2015	20:24
4	10/29/2015	20:21	9	10/29/2015	20:24
5	10/29/2015	20:22			

TransCanada Hydro Northeast Inc.
ILP Study 19
Vernon Dam

N

1 in = 1,200 feet

0 600 1,200 2,400 Feet

Study 19 Fish Number: 34-133
Release: Riverside Industrial Complex
Brattleboro, VT
Date Released: 10/29/2015
Time Released: 13:05

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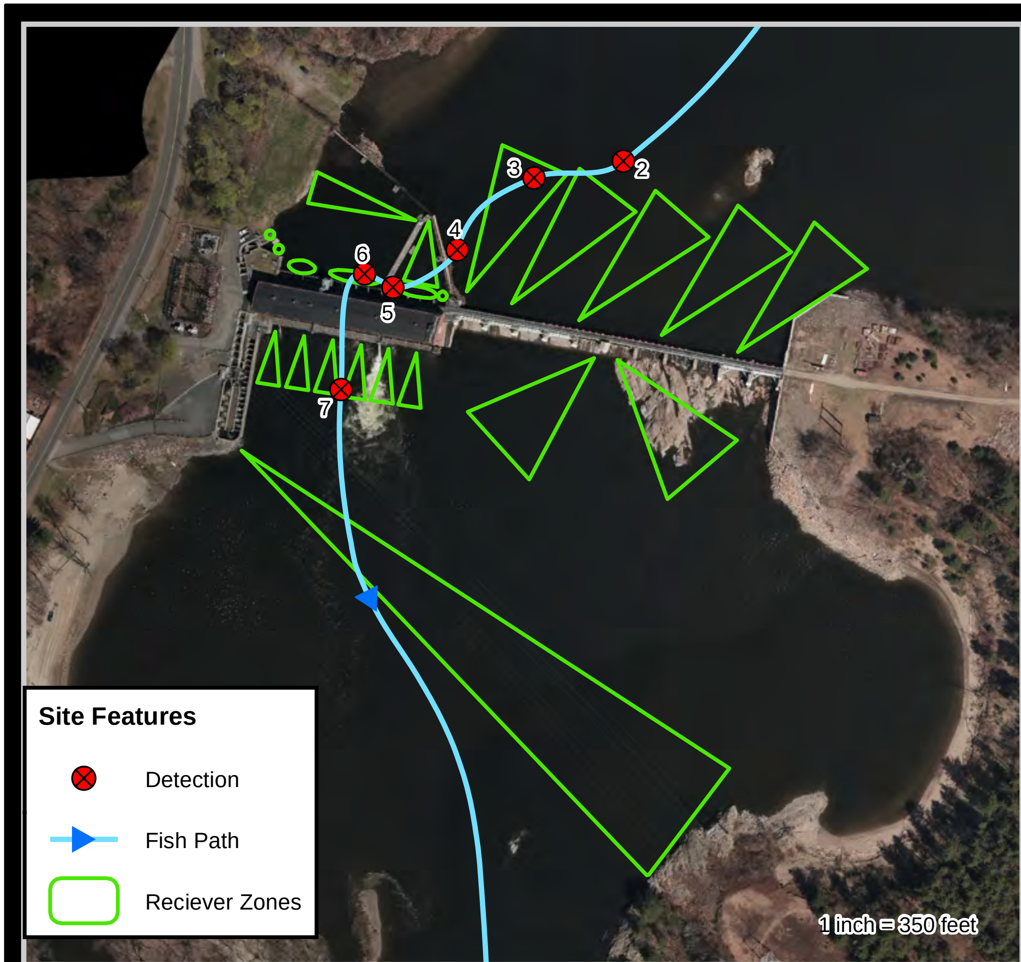

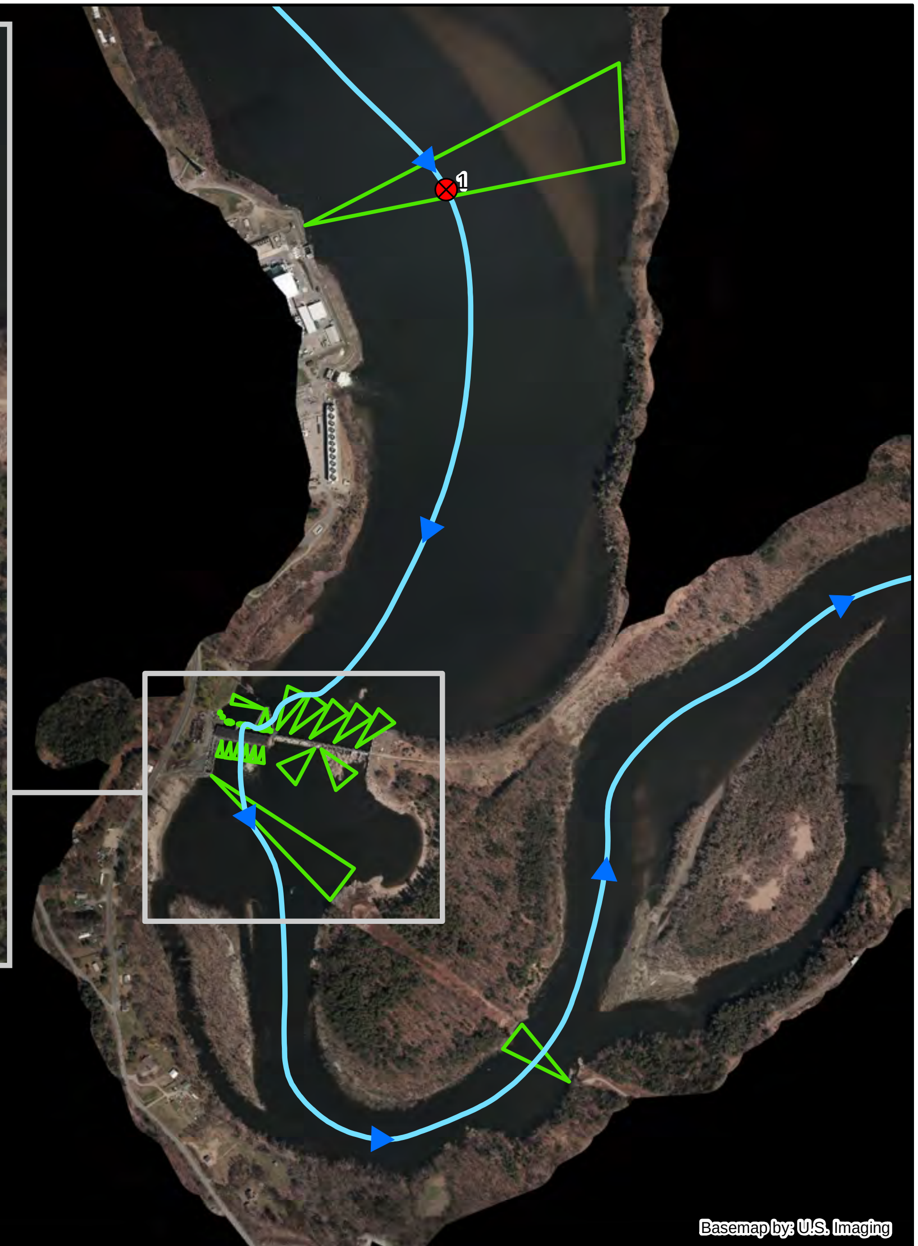

Timetable					
Detection	Date	Time	Detection	Date	Time
1	10/29/2015	18:02	6	10/29/2015	18:47
2	10/29/2015	18:37	7	10/29/2015	18:46
3	10/29/2015	18:43			
4	10/29/2015	18:43			
5	10/29/2015	18:45			

TransCanada Hydro Northeast Inc.
ILP Study 19
Vernon Dam

N

1 in = 1,200 feet

0 600 1,200 2,400 Feet

Study 19 Fish Number: 34-134
Release: Riverside Industrial Complex
Brattleboro, VT
Date Released: 10/29/2015
Time Released: 13:05

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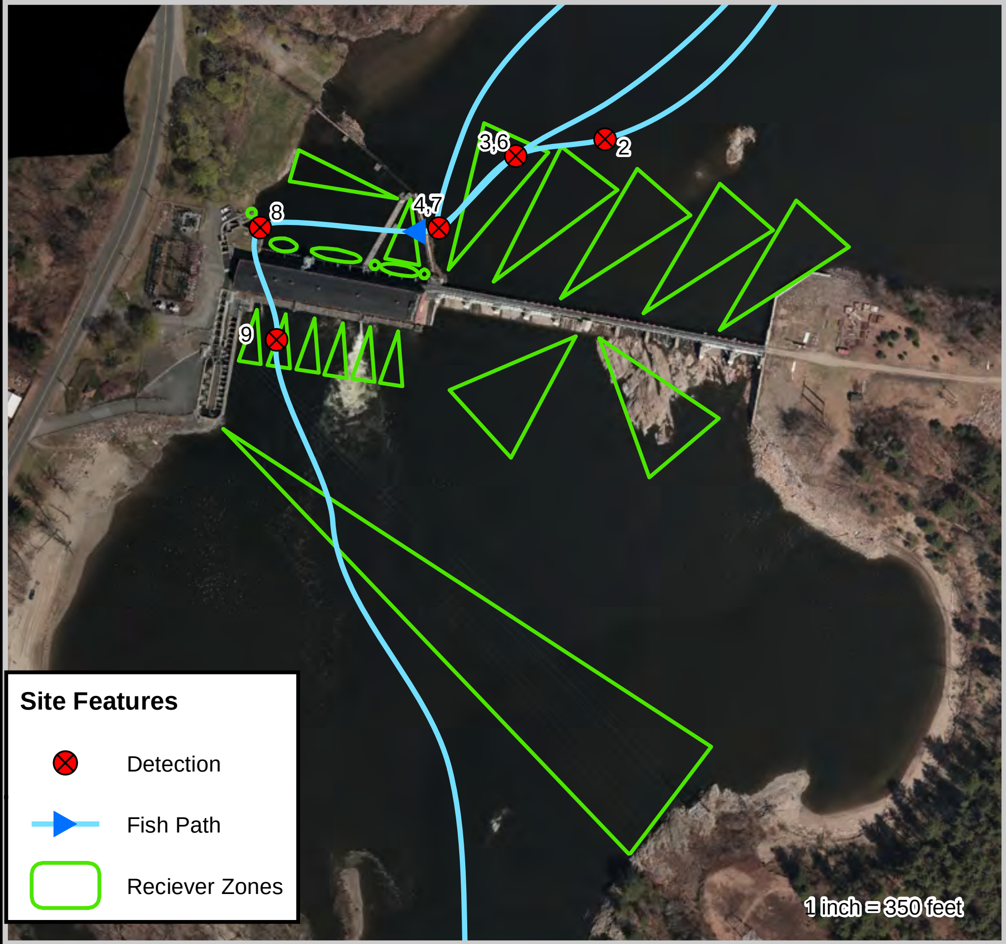

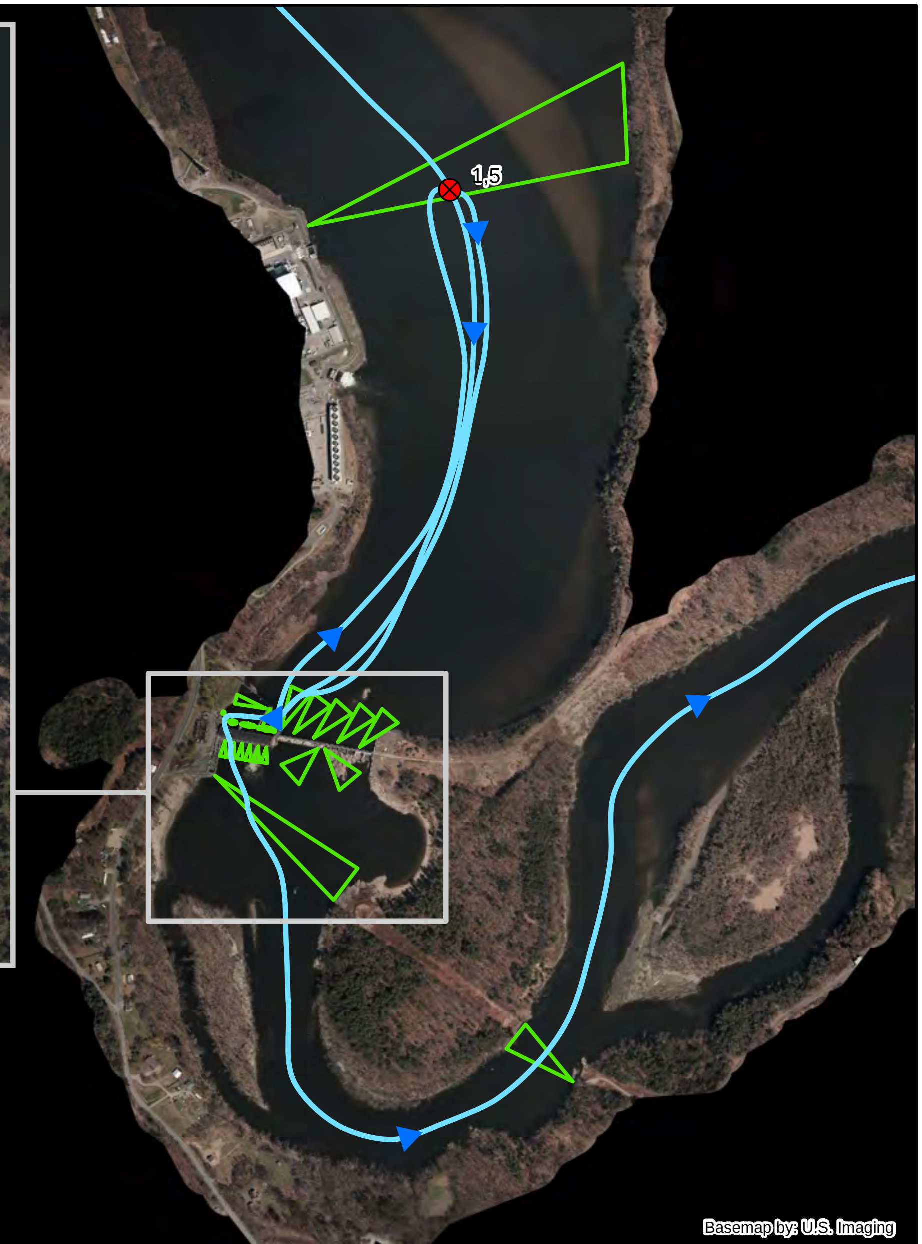

Timetable					
Detection	Date	Time	Detection	Date	Time
1	11/8/2015	19:24	6	11/13/2015	2:49
2	11/8/2015	21:05	7	11/13/2015	2:55
3	11/8/2015	21:07	8	11/13/2015	3:04
4	11/8/2015	21:14	9	11/13/2015	3:05
5	11/8/2015	22:40			

TransCanada Hydro Northeast Inc.
ILP Study 19
Vernon Dam

N

1 in = 1,200 feet

0 600 1,200 2,400 Feet

Study 19 Fish Number: 34-135
Release: Riverside Industrial Complex
Brattleboro, VT
Date Released: 11/05/2015
Time Released: 15:35

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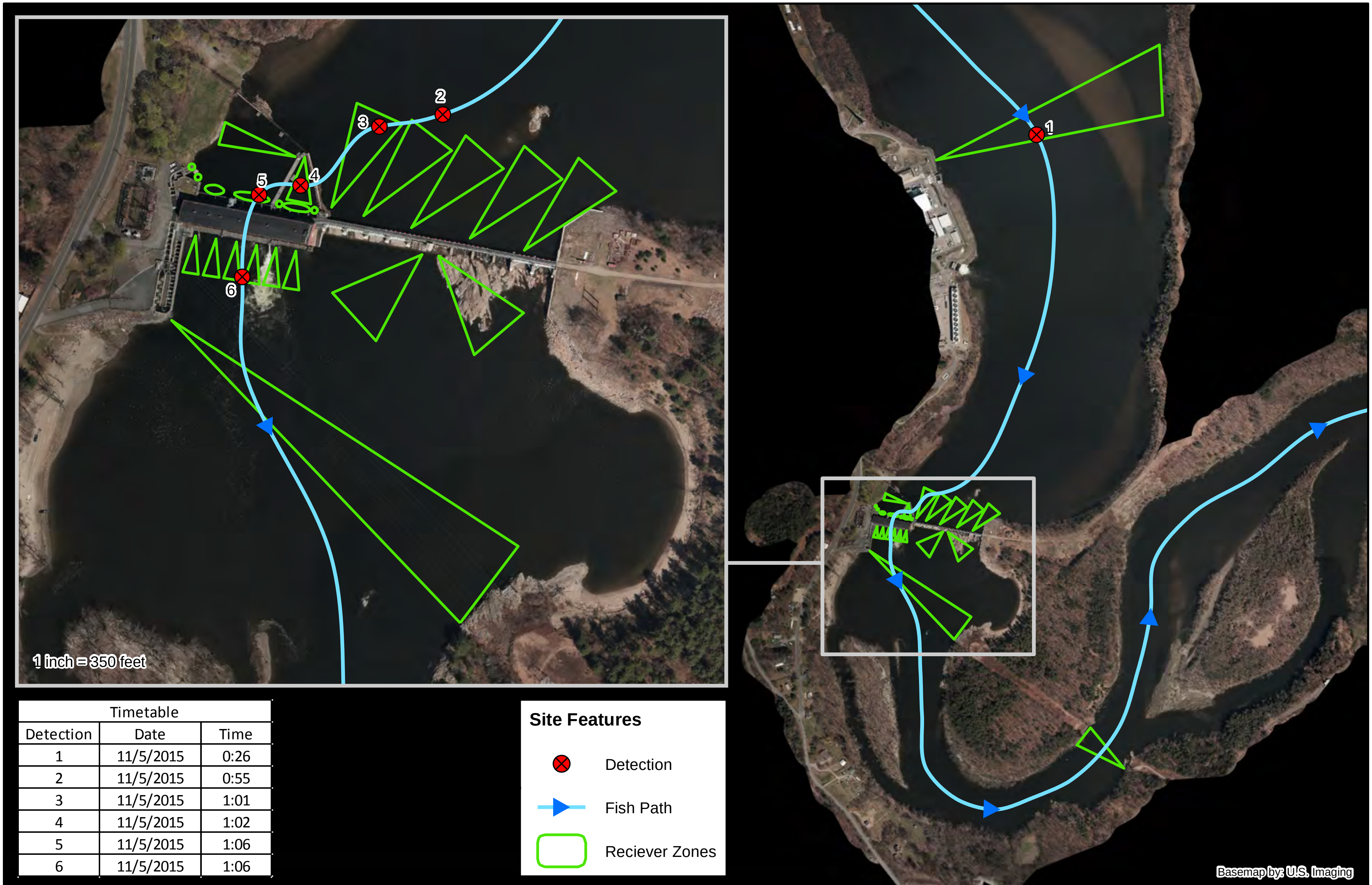

Timetable		
Detection	Date	Time
1	11/5/2015	0:26
2	11/5/2015	0:55
3	11/5/2015	1:01
4	11/5/2015	1:02
5	11/5/2015	1:06
6	11/5/2015	1:06

TransCanada Hydro Northeast Inc.
ILP Study 19
Vernon Dam

N

1 in = 1,200 feet

0 600 1,200 2,400 Feet

Study 19 Fish Number: 34-141

Release: Herricks Cove, VT
Date Released: 10/29/2015
Time Released: 17:52

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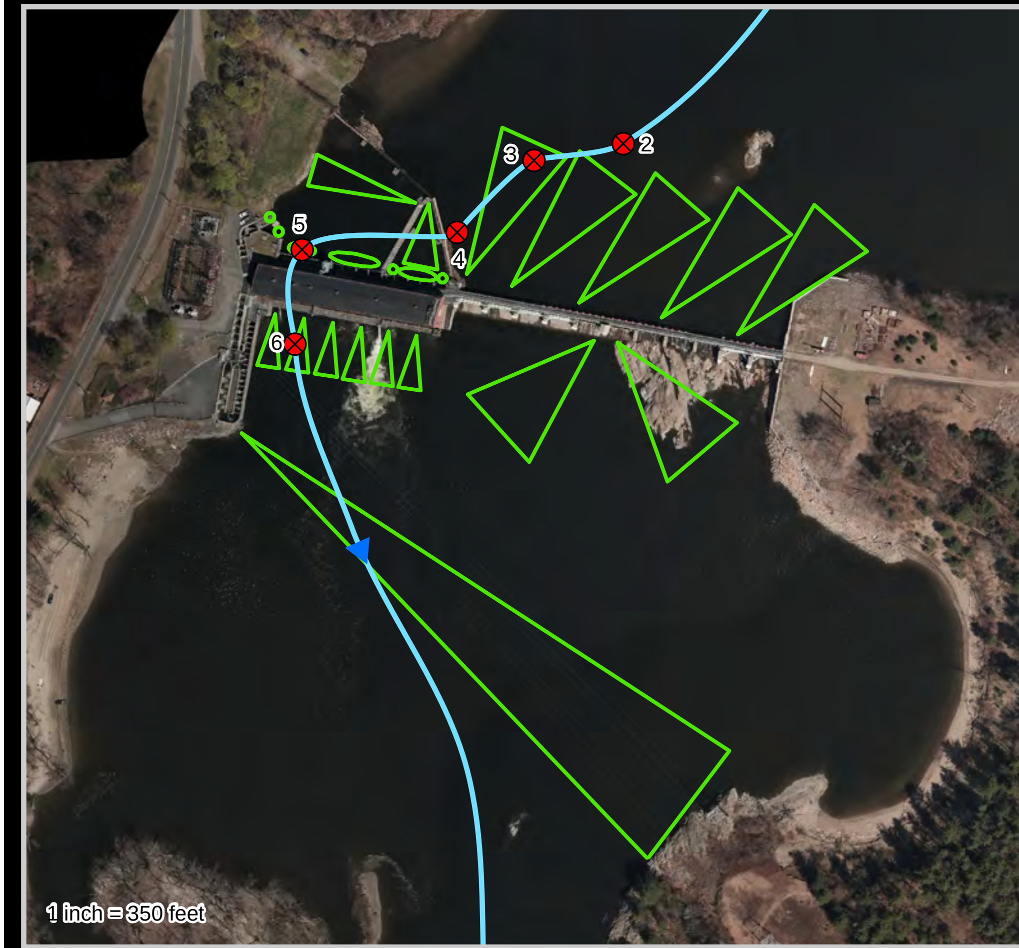

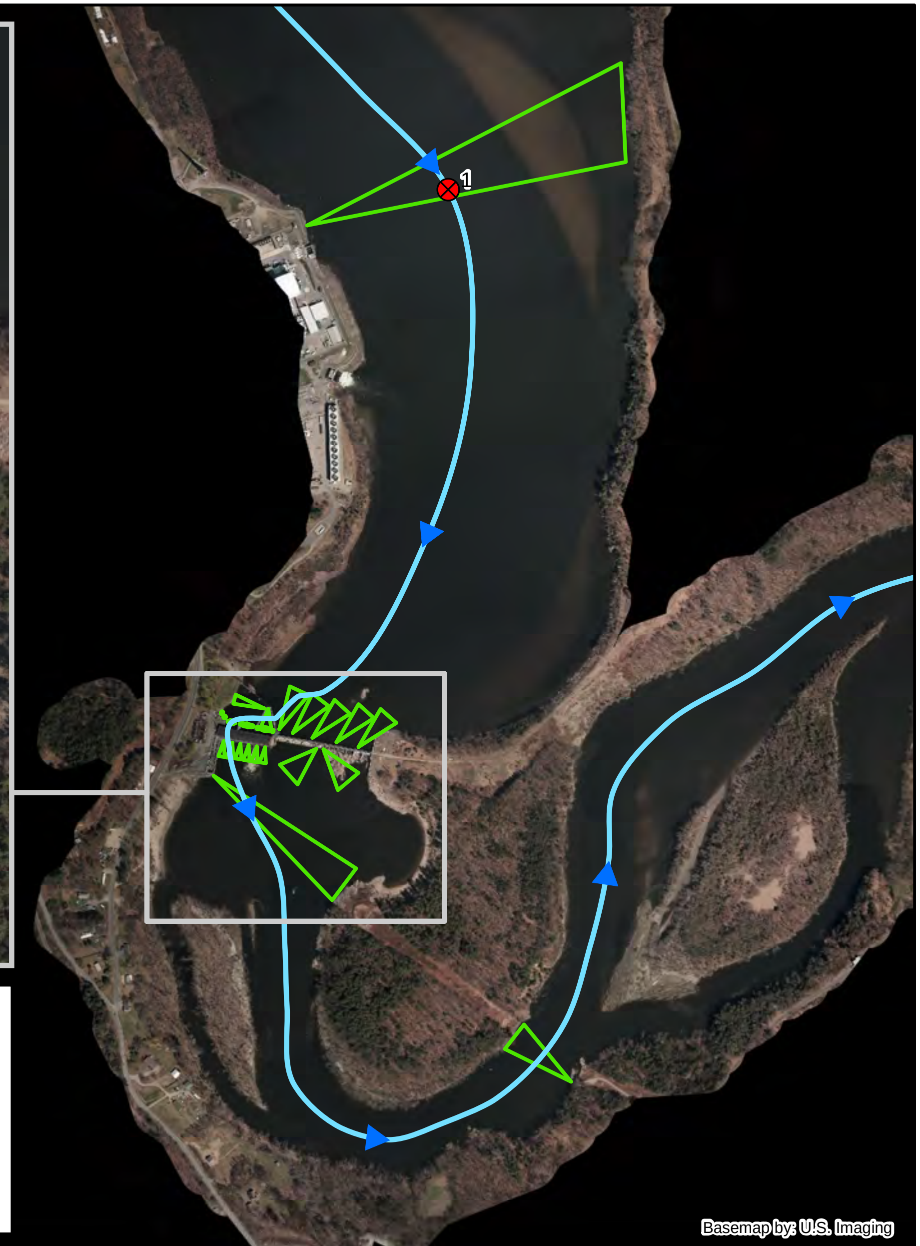

Timetable		
Detection	Date	Time
1	11/5/2015	19:45
2	11/5/2015	20:20
3	11/5/2015	20:27
4	11/5/2015	20:30
5	11/5/2015	20:31
6	11/5/2015	20:33

Site Features

- Detection
- Fish Path
- Reciever Zones

TransCanada Hydro Northeast Inc.
ILP Study 19
Vernon Dam

N

1 in = 1,200 feet

0 600 1,200 2,400 Feet

Study 19 Fish Number: 34-142

Release: Herricks Cove, VT
Date Released: 10/29/2015
Time Released: 17:52

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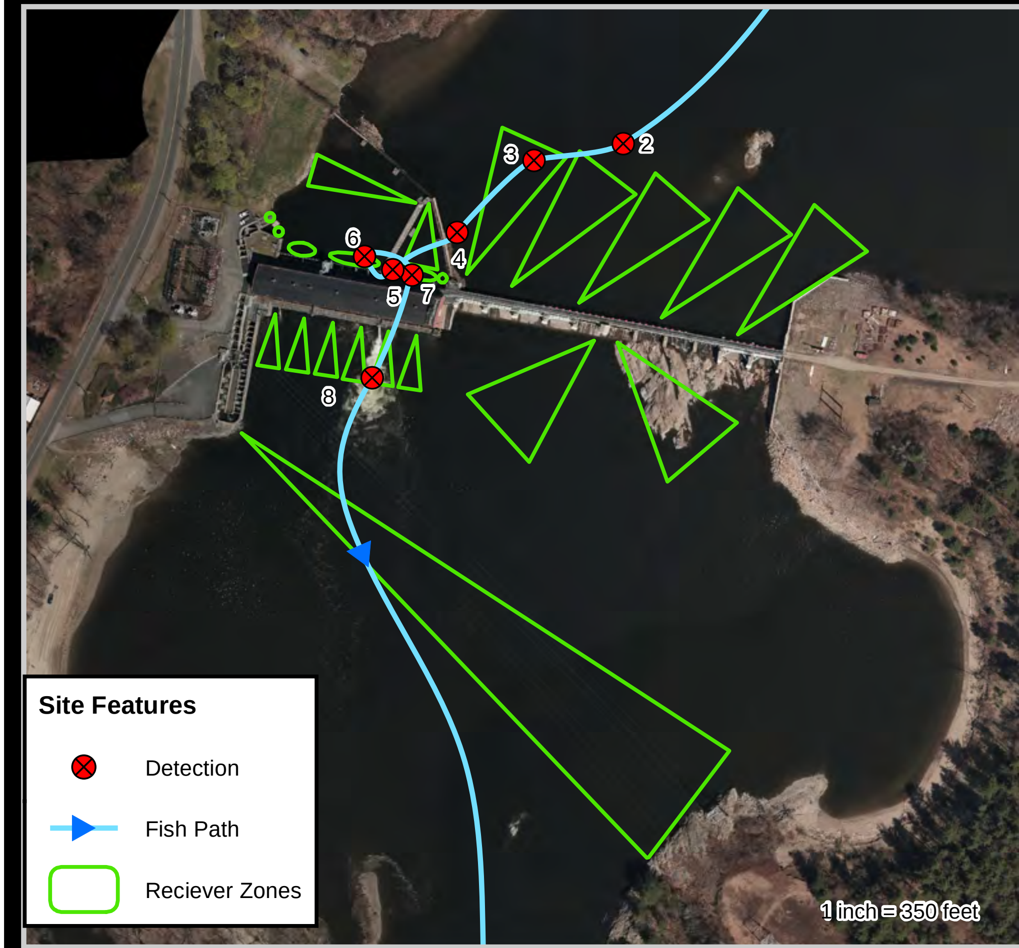

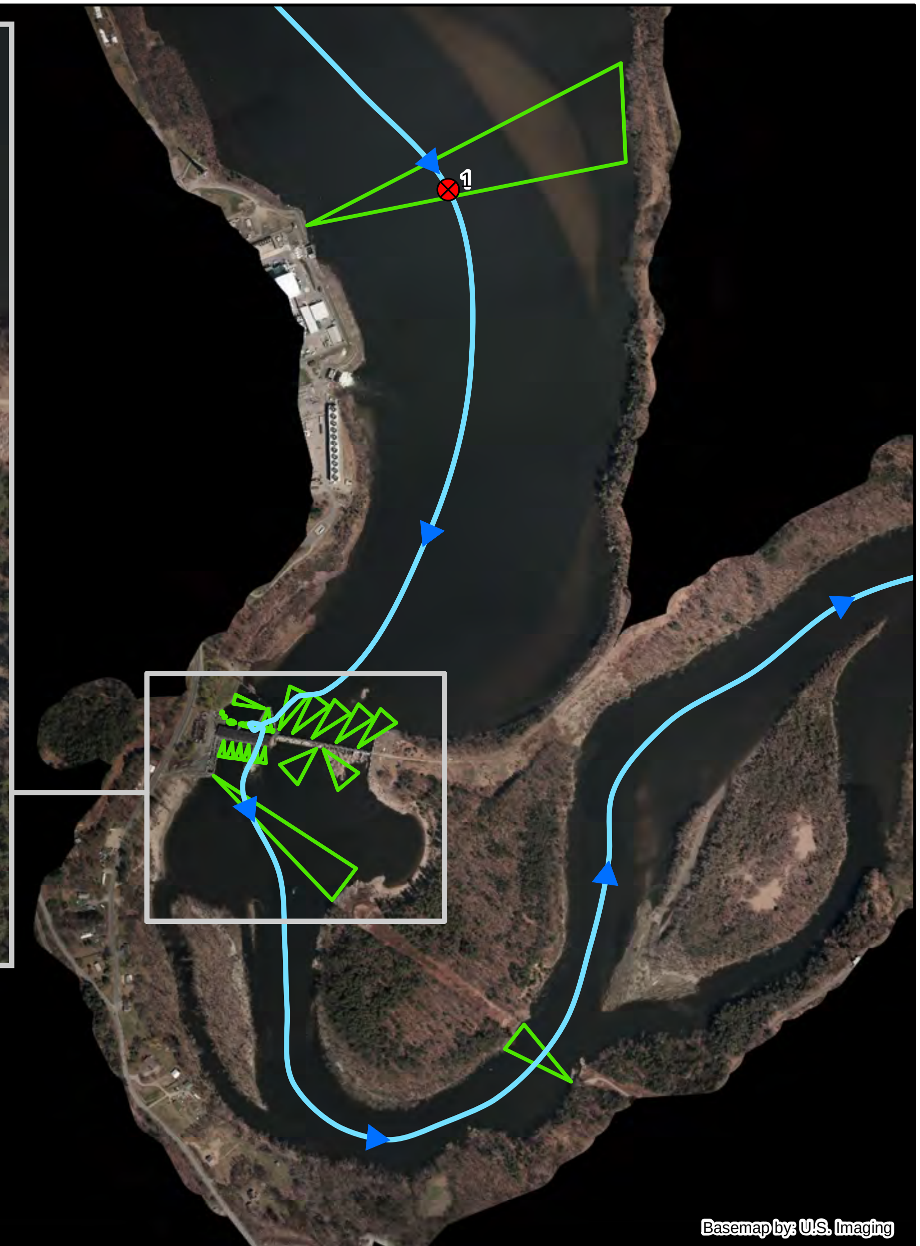

Timetable					
Detection	Date	Time	Detection	Date	Time
1	11/4/2015	20:12	6	11/4/2015	21:28
2	11/4/2015	21:07	7	11/4/2015	21:28
3	11/4/2015	21:19	8	11/4/2015	21:28
4	11/4/2015	21:27			
5	11/4/2015	21:27			

TransCanada Hydro Northeast Inc.
ILP Study 19
Vernon Dam

N

1 in = 1,200 feet

0 600 1,200 2,400 Feet

Study 19 Fish Number: 34-143

Release: Herricks Cove, VT
Date Released: 10/29/2015
Time Released: 17:52

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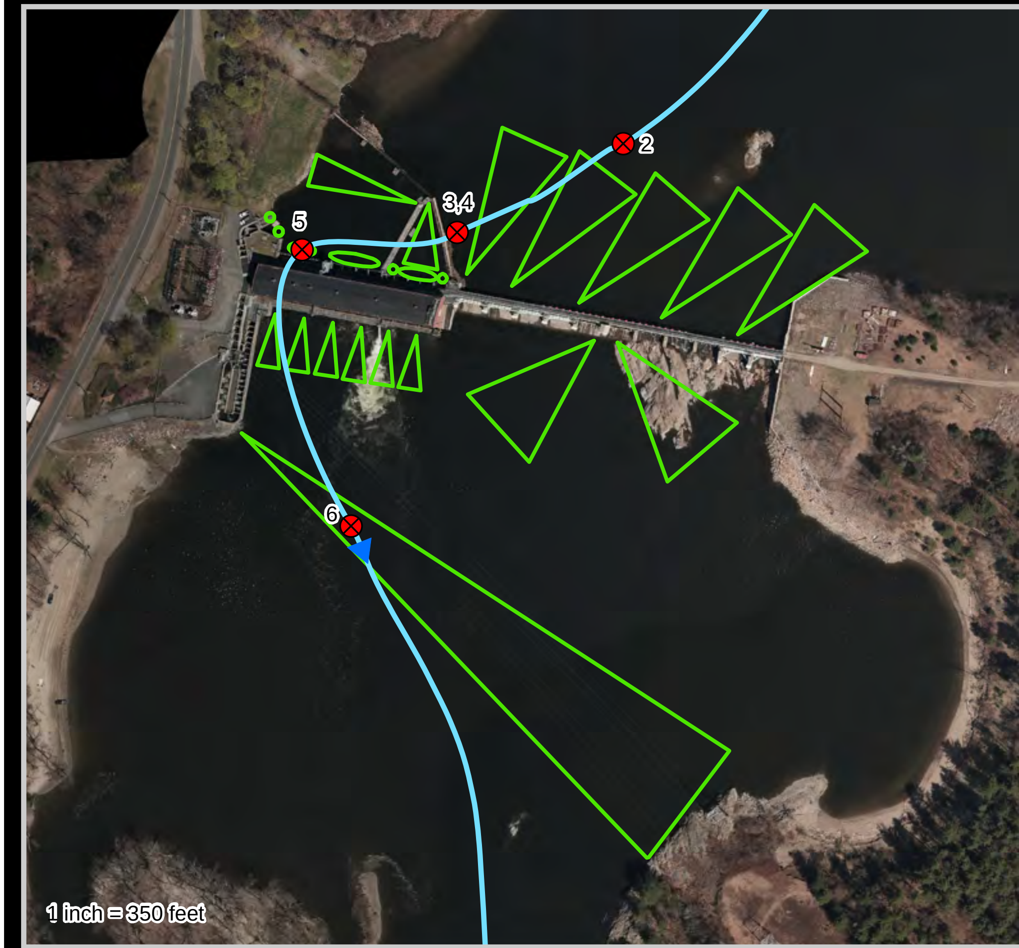
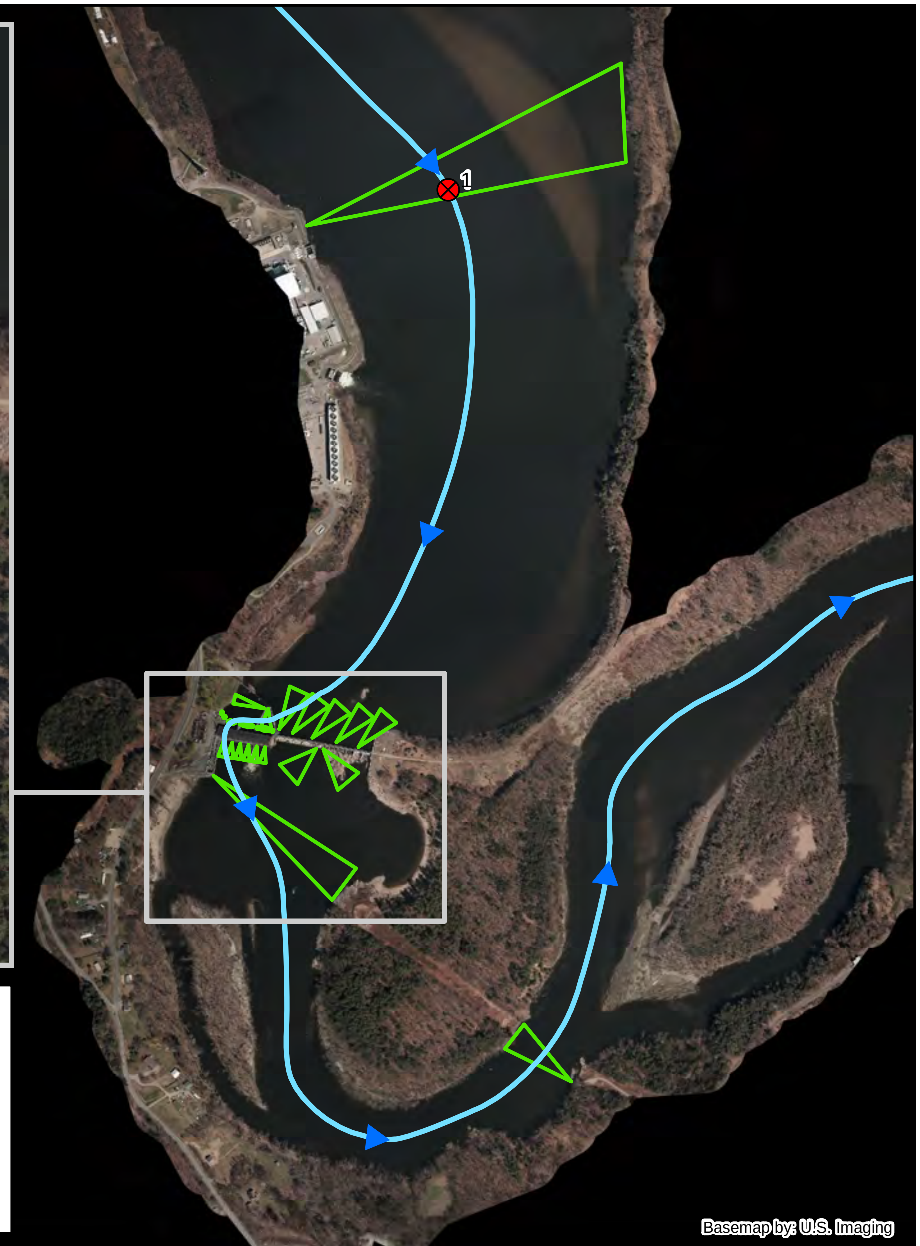
Environmental Consultants
Normandeau Associates Inc.
25 Nashua Road
Bedford, NH USA
03110

J:\Jen_TEST\TransCanada\S19\REV_2017\Vernon\MXD\TC_Vernon_34_143_T1_022017.mxd





Timetable		
Detection	Date	Time
1	12/18/2015	9:23
2	12/18/2015	11:00
3	12/18/2015	11:39
4	12/18/2015	11:42
5	12/18/2015	11:59
6	12/18/2015	12:02

Site Features

- Detection
- Fish Path
- Reciever Zones

TransCanada Hydro Northeast Inc.
ILP Study 19
Vernon Dam

N

1 in = 1,200 feet

0 600 1,200 2,400 Feet

Study 19 Fish Number: 34-149

Release: Herricks Cove, VT
Date Released: 11/05/2015
Time Released: 16:20

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Bedford, NH USA
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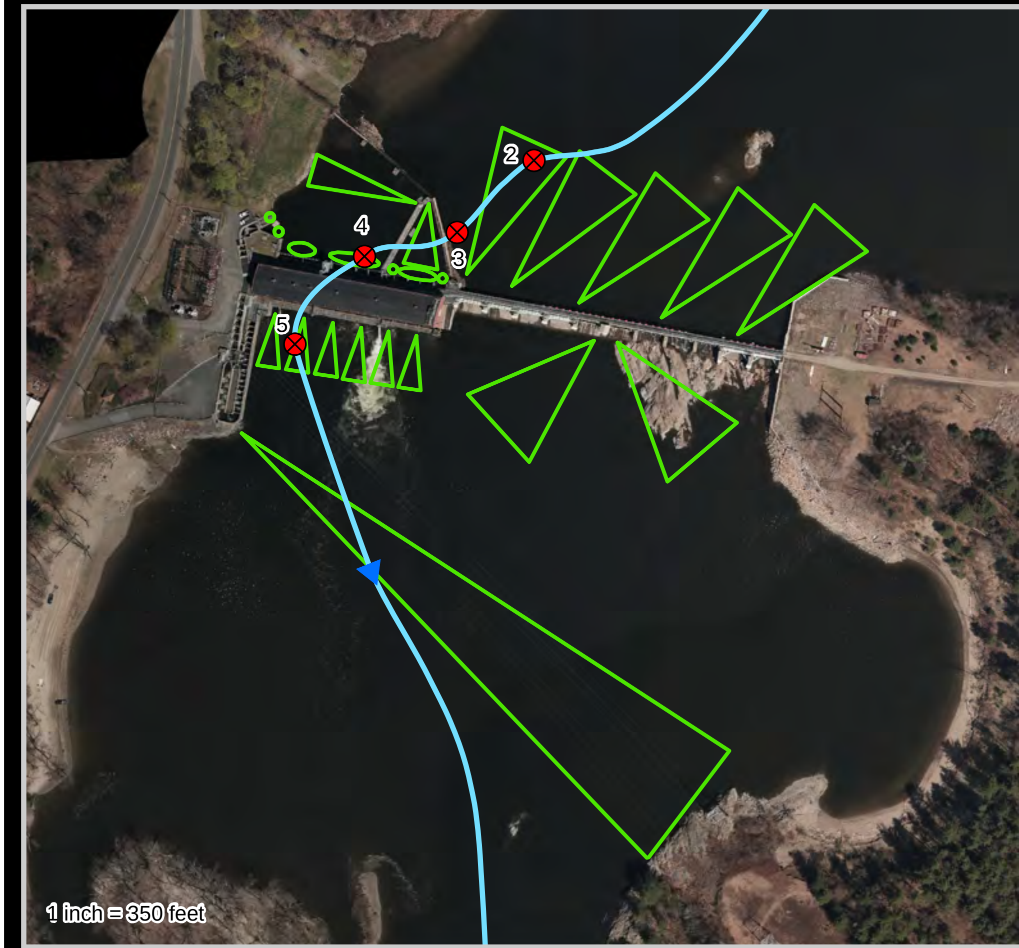

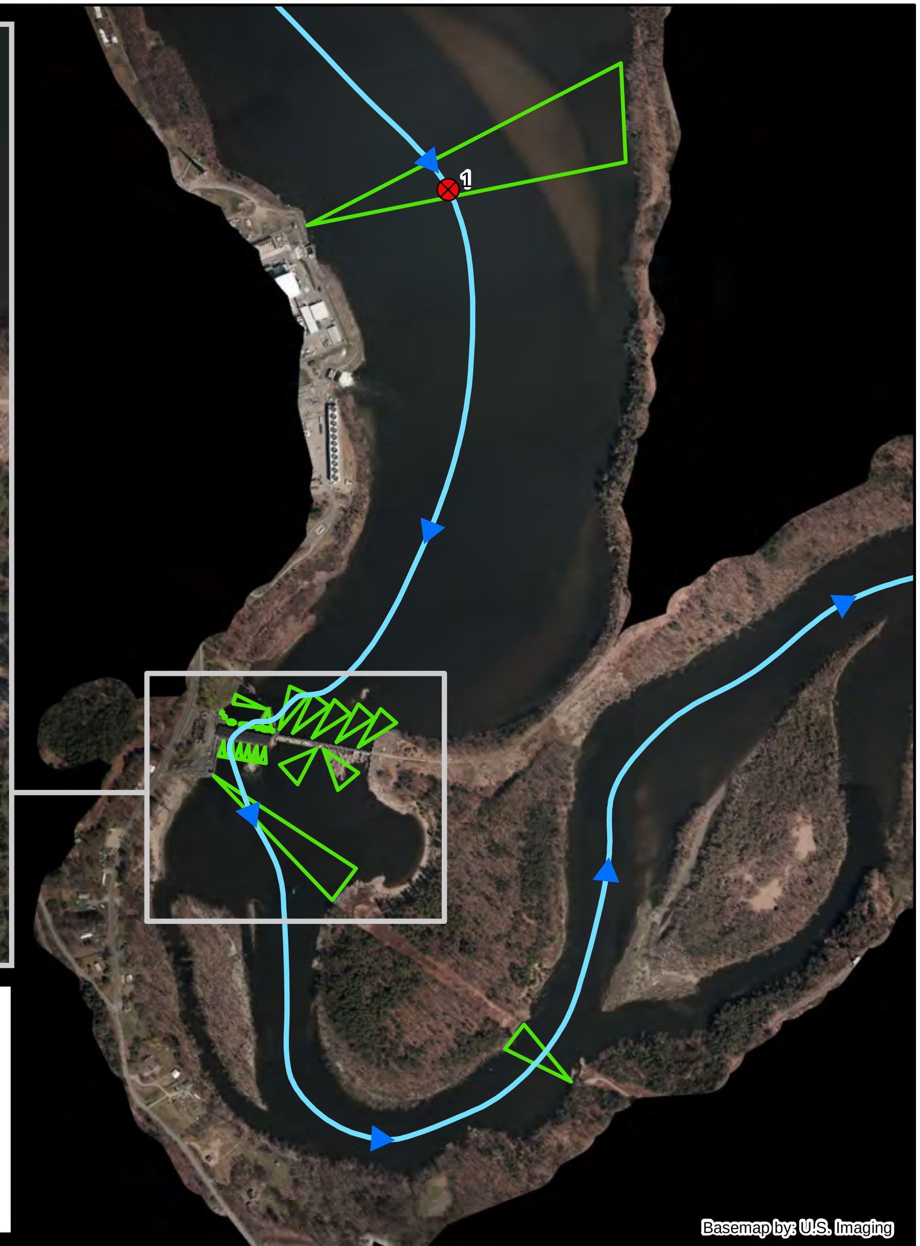

Timetable		
Detection	Date	Time
1	11/15/2015	18:52
2	11/15/2015	20:29
3	11/15/2015	20:38
4	11/15/2015	20:40
5	11/15/2015	20:41

Site Features

- Detection
- Fish Path
- Reciever Zones

TransCanada Hydro Northeast Inc.
ILP Study 19
Vernon Dam

N

1 in = 1,200 feet

0 600 1,200 2,400 Feet

Study 19 Fish Number: 34-150

Release: Herricks Cove, VT
Date Released: 11/05/2015
Time Released: 16:20

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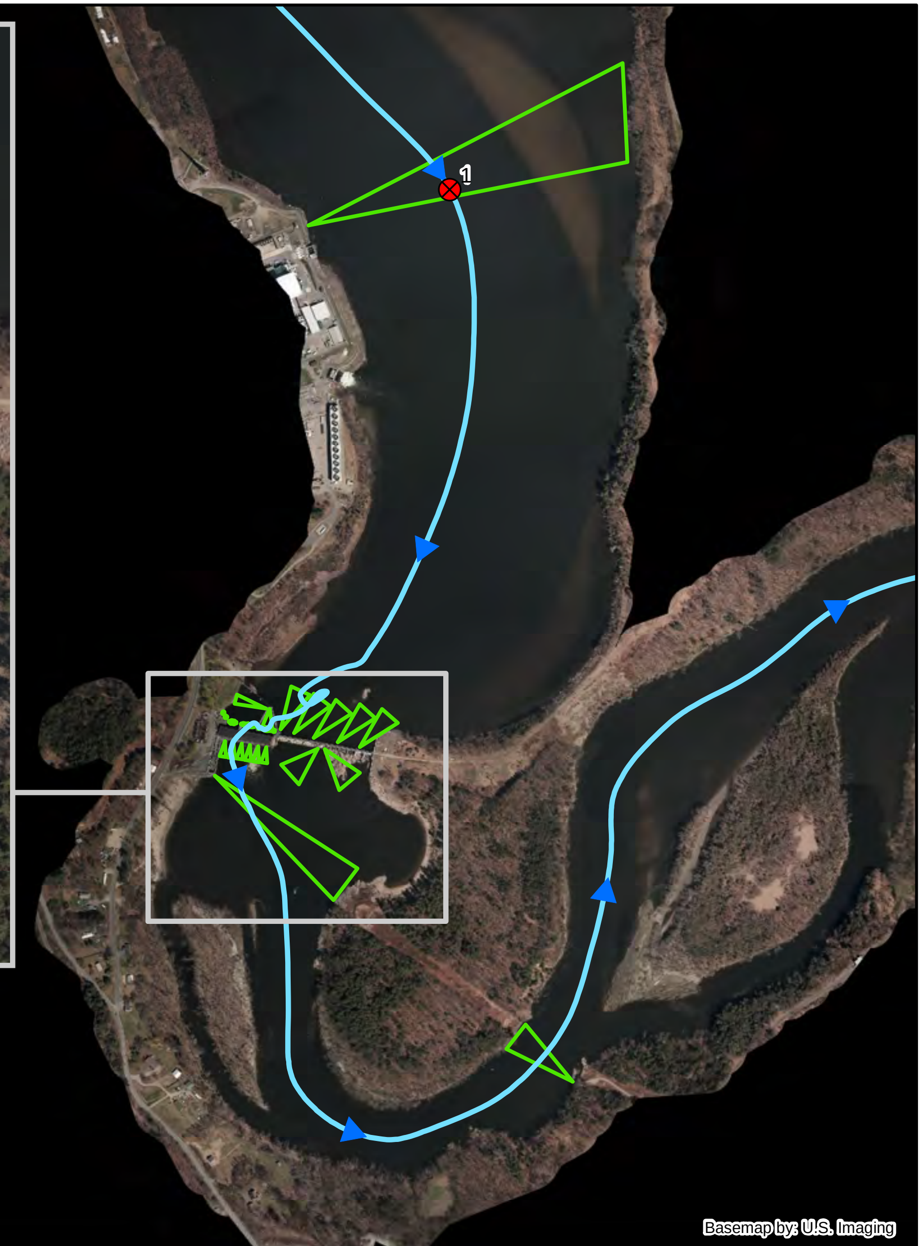

Timetable					
Detection	Date	Time	Detection	Date	Time
1	11/15/2015	4:57	6	11/15/2015	20:12
2	11/15/2015	19:59	7	11/15/2015	20:12
3	11/15/2015	20:00	8	11/15/2015	20:13
4	11/15/2015	20:10			
5	11/15/2015	20:12			

TransCanada Hydro Northeast Inc.
ILP Study 19
Vernon Dam

N

1 in = 1,200 feet

0 600 1,200 2,400 Feet

Study 19 Fish Number: 34-151

Release: Norwich, VT
Date Released: 10/29/2015
Time Released: 18:43

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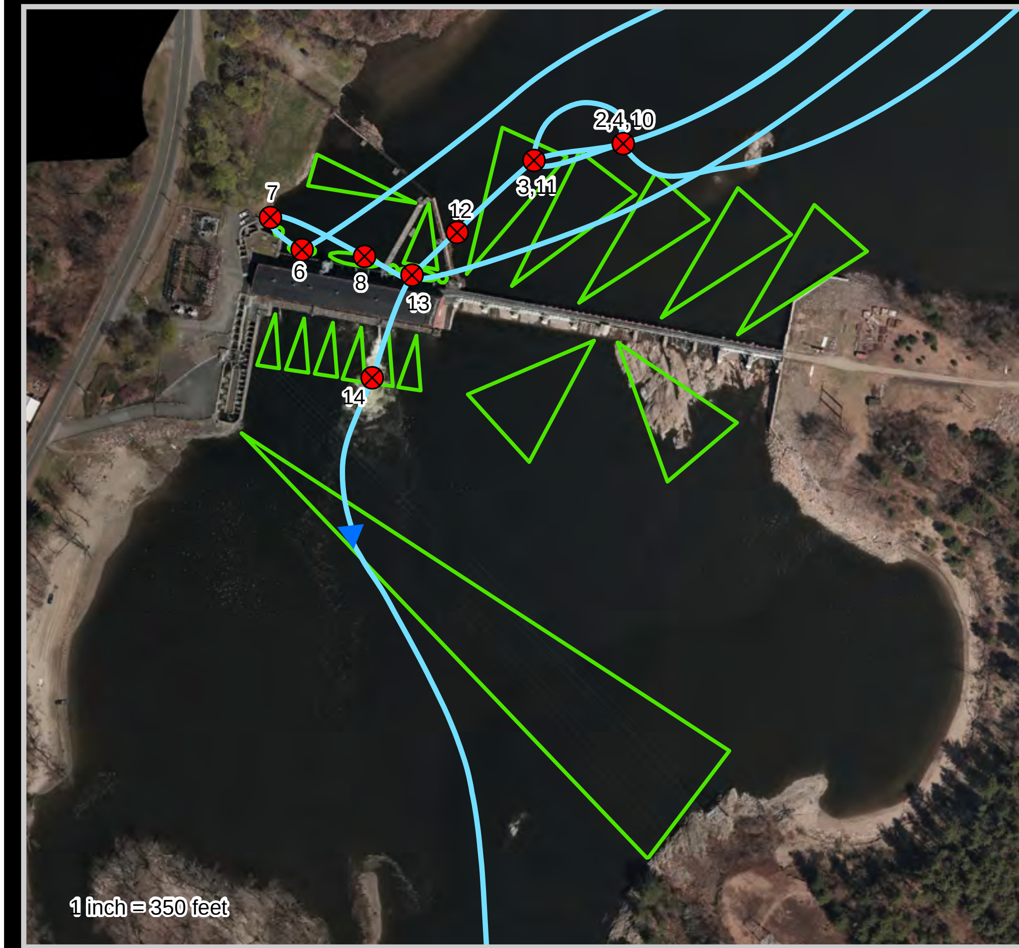

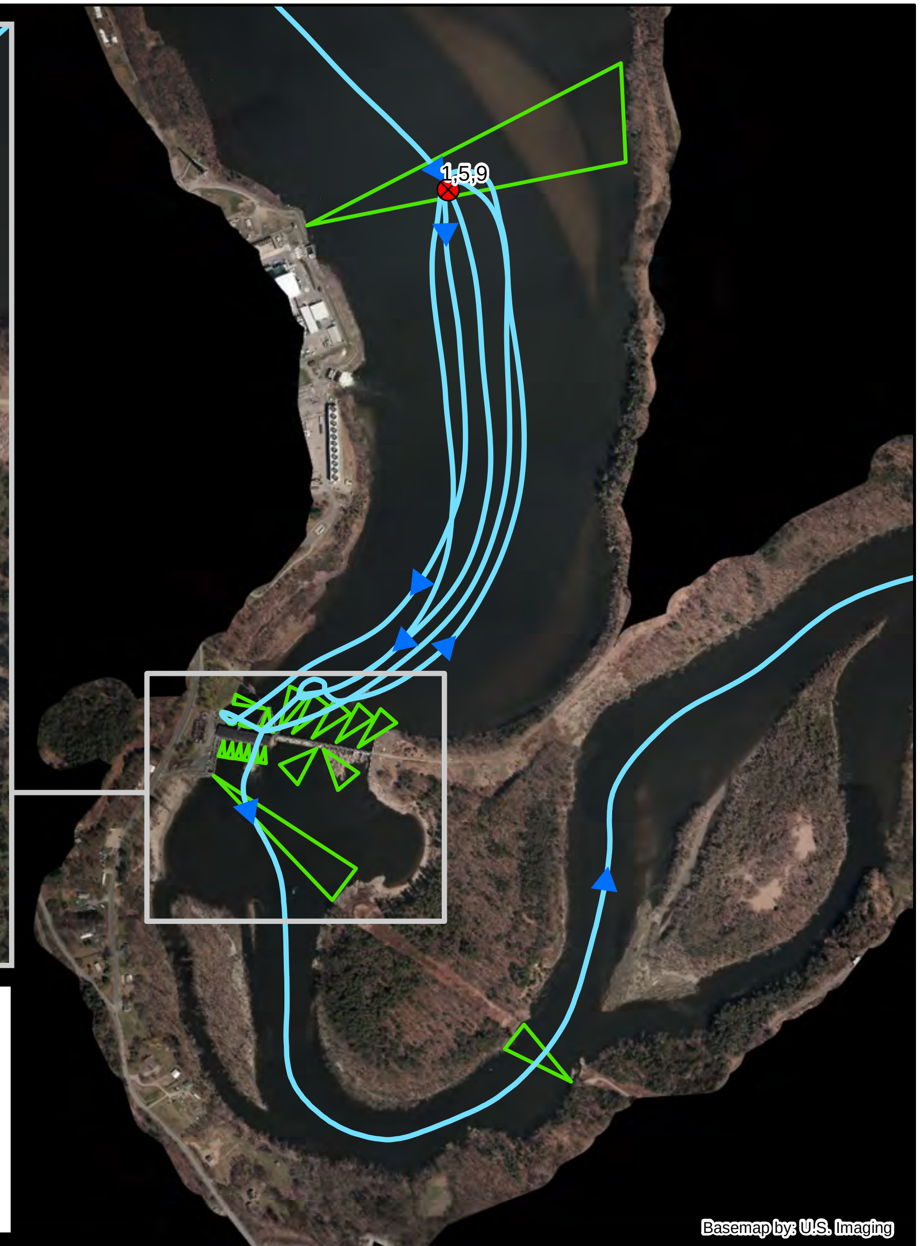

Timetable					
Detection	Date	Time	Detection	Date	Time
1	11/3/2015	0:54	8	11/3/2015	16:35
2	11/3/2015	1:52	9	11/3/2015	19:39
3	11/3/2015	1:57	10	11/3/2015	20:08
4	11/3/2015	2:19	11	11/3/2015	20:15
5	11/3/2015	3:04	12	11/3/2015	20:17
6	11/3/2015	16:13	13	11/3/2015	20:18
7	11/3/2015	16:31	14	11/3/2015	20:20

Site Features

- Detection
- Fish Path
- Reciever Zones

TransCanada Hydro Northeast Inc.
ILP Study 19
Vernon Dam

N

1 in = 1,200 feet

0 600 1,200 2,400 Feet

Study 19 Fish Number: 34-152

Release: Norwich, VT
Date Released: 10/29/2015
Time Released: 18:43

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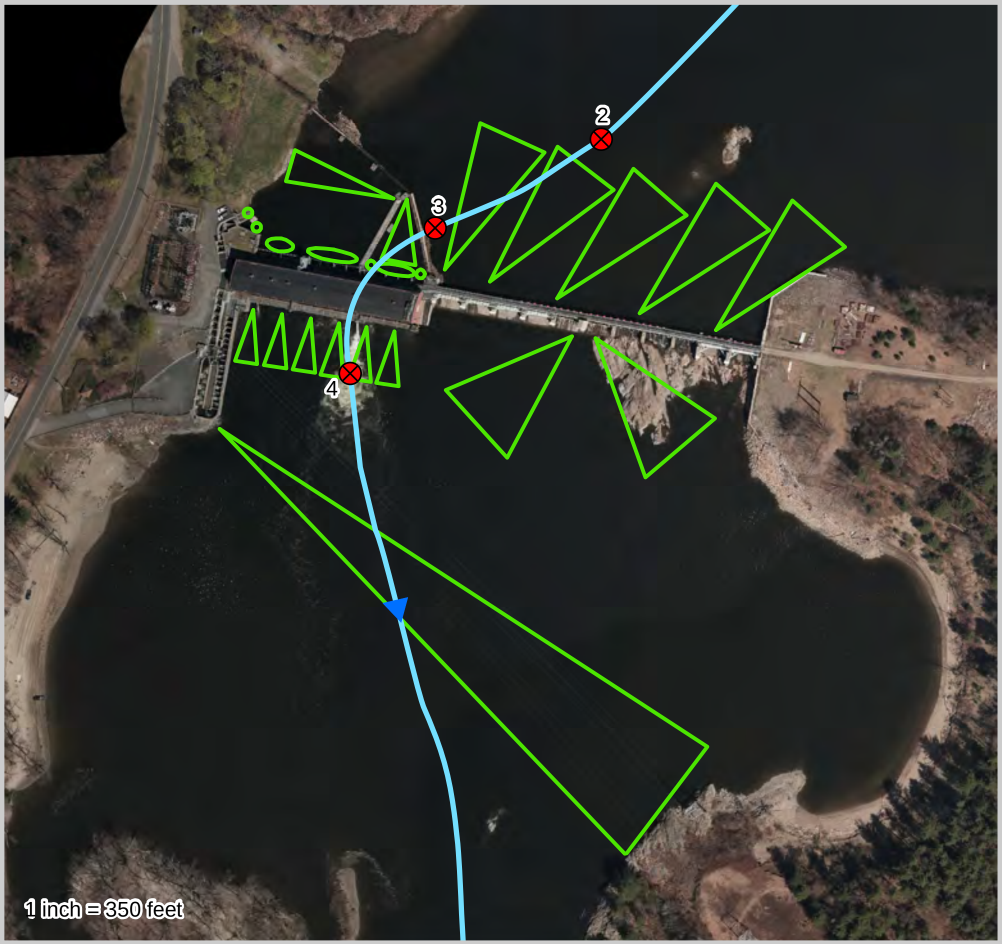

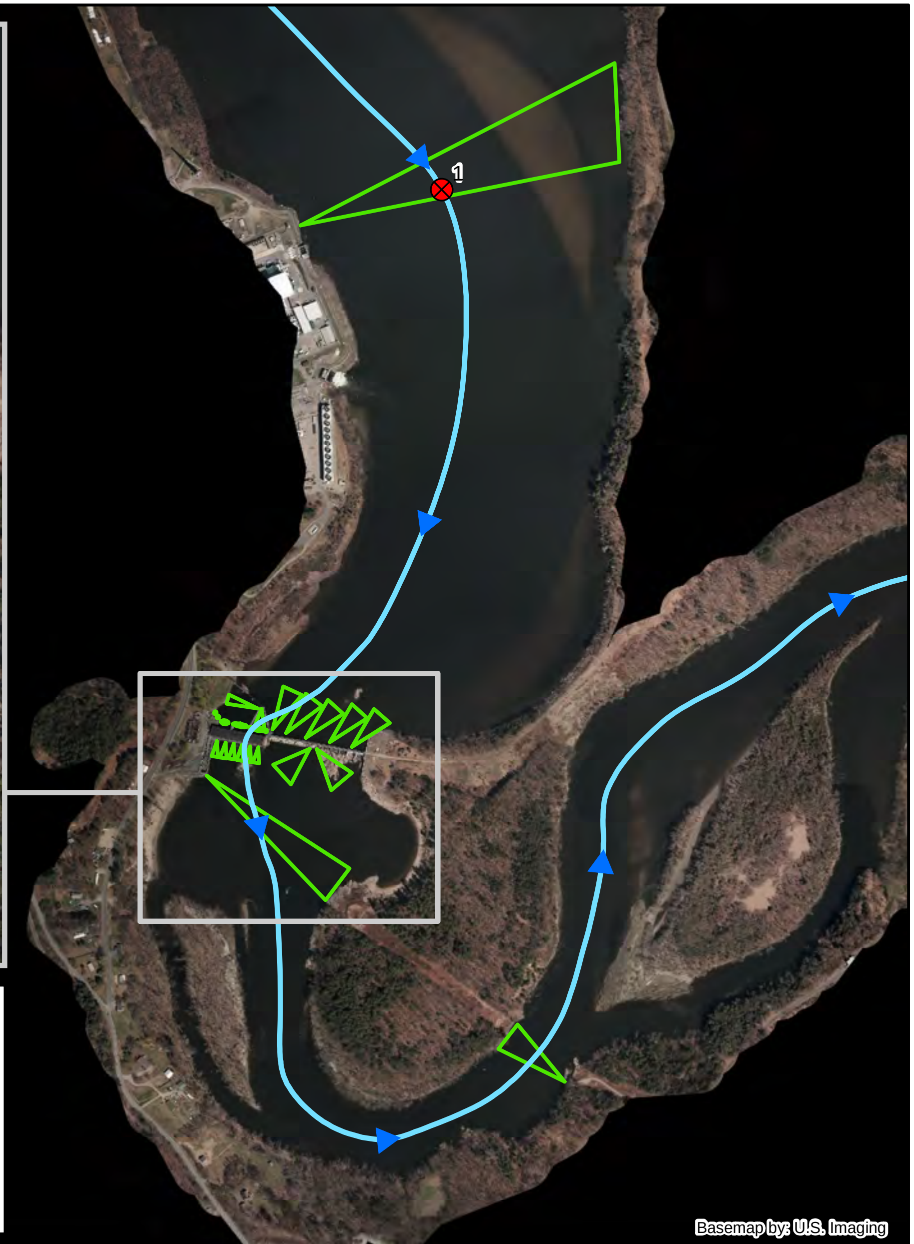

Timetable		
Detection	Date	Time
1	11/1/2015	22:34
2	11/1/2015	23:01
3	11/1/2015	23:08
4	11/1/2015	23:12

Site Features

- Detection
- Fish Path
- Reciever Zones

TransCanada Hydro Northeast Inc.
ILP Study 19
Vernon Dam

N

1 in = 1,200 feet

0 600 1,200 2,400 Feet

Study 19 Fish Number: 34-153

Release: Norwich, VT
Date Released: 10/29/2015
Time Released: 18:43

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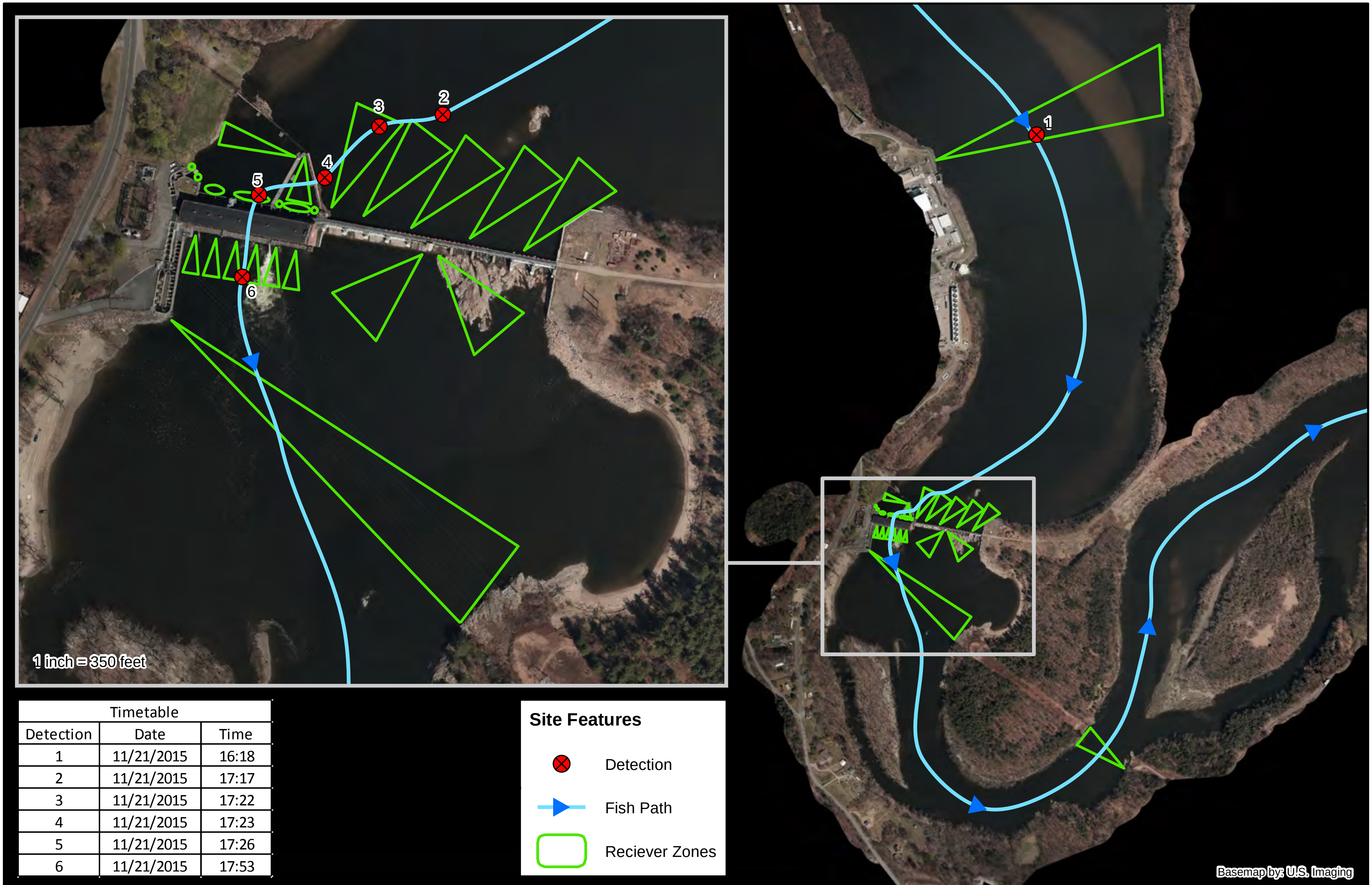

Timetable		
Detection	Date	Time
1	11/21/2015	16:18
2	11/21/2015	17:17
3	11/21/2015	17:22
4	11/21/2015	17:23
5	11/21/2015	17:26
6	11/21/2015	17:53

Site Features

- Detection
- Fish Path
- Reciever Zones

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TransCanada Hydro Northeast Inc.
ILP Study 19
Vernon Dam

N

1 in = 1,200 feet

0 600 1,200 2,400 Feet

Study 19 Fish Number: 34-156

Release: Norwich, VT
Date Released: 11/05/2015
Time Released: 17:05

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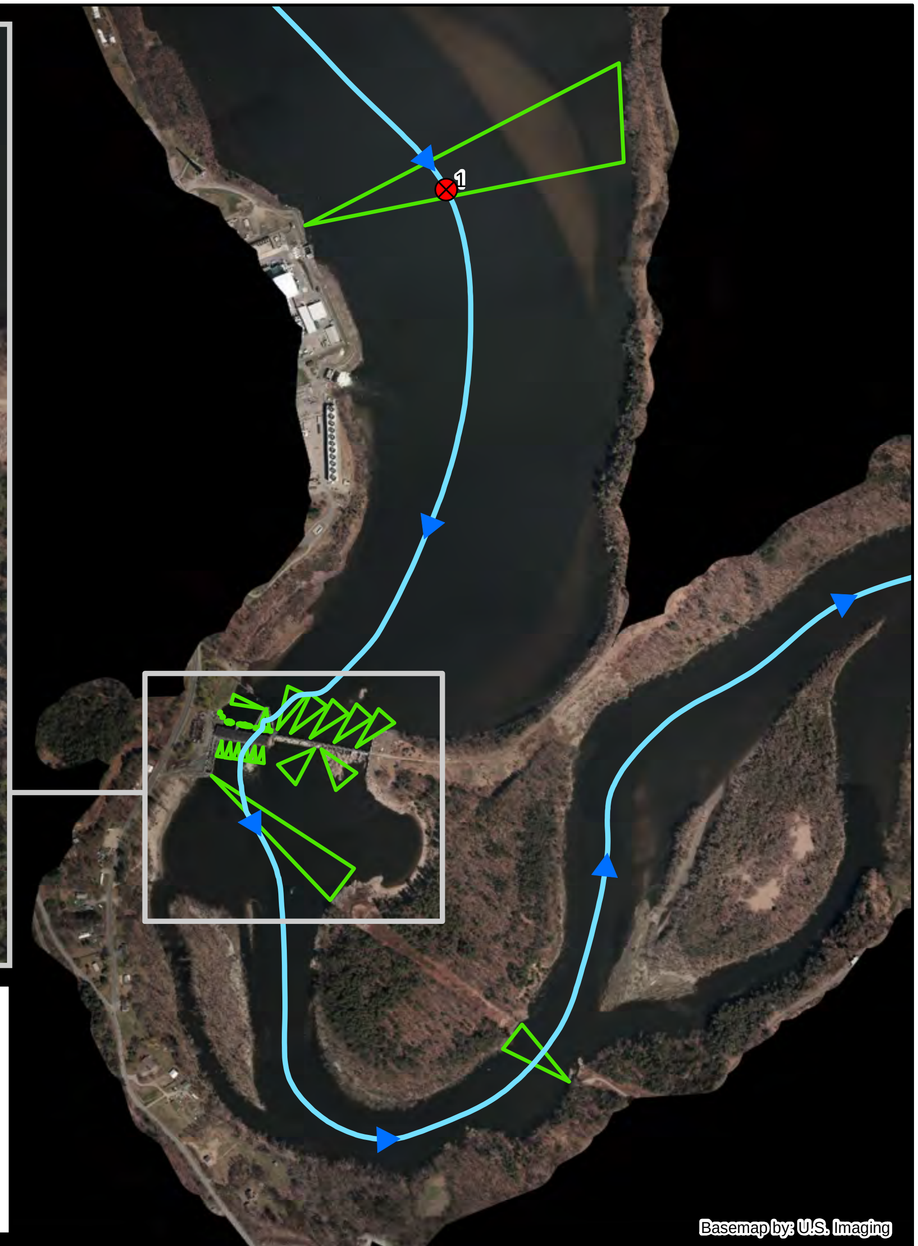

Timetable		
Detection	Date	Time
1	11/3/2015	19:09
2	11/3/2015	19:43
3	11/3/2015	19:50
4	11/3/2015	19:53
5	11/3/2015	19:53
6	11/3/2015	19:54

Site Features

- Detection
- Fish Path
- Reciever Zones

TransCanada Hydro Northeast Inc.
ILP Study 19
Vernon Dam

N

1 in = 1,200 feet

0 600 1,200 2,400 Feet

Study 19 Fish Number: 34-161
Release: Riverside Industrial Complex
Brattleboro, VT
Date Released: 10/31/2015
Time Released: 13:40

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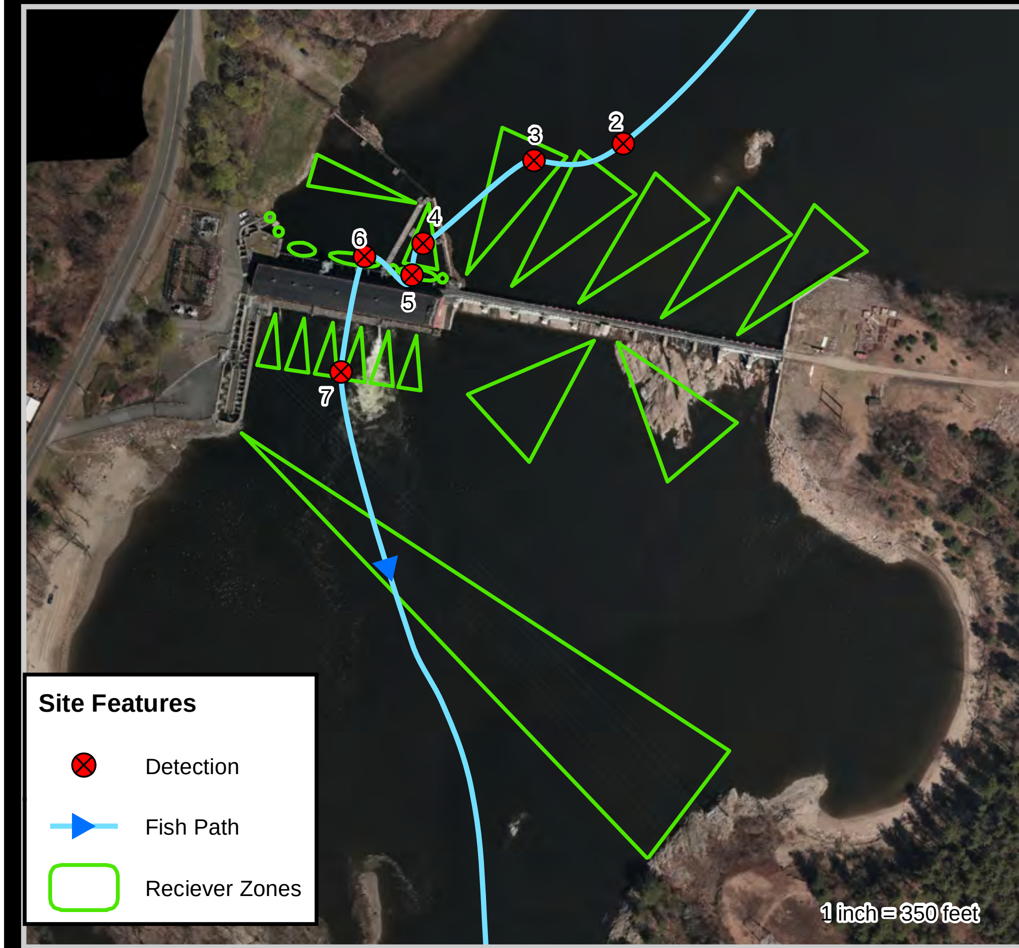

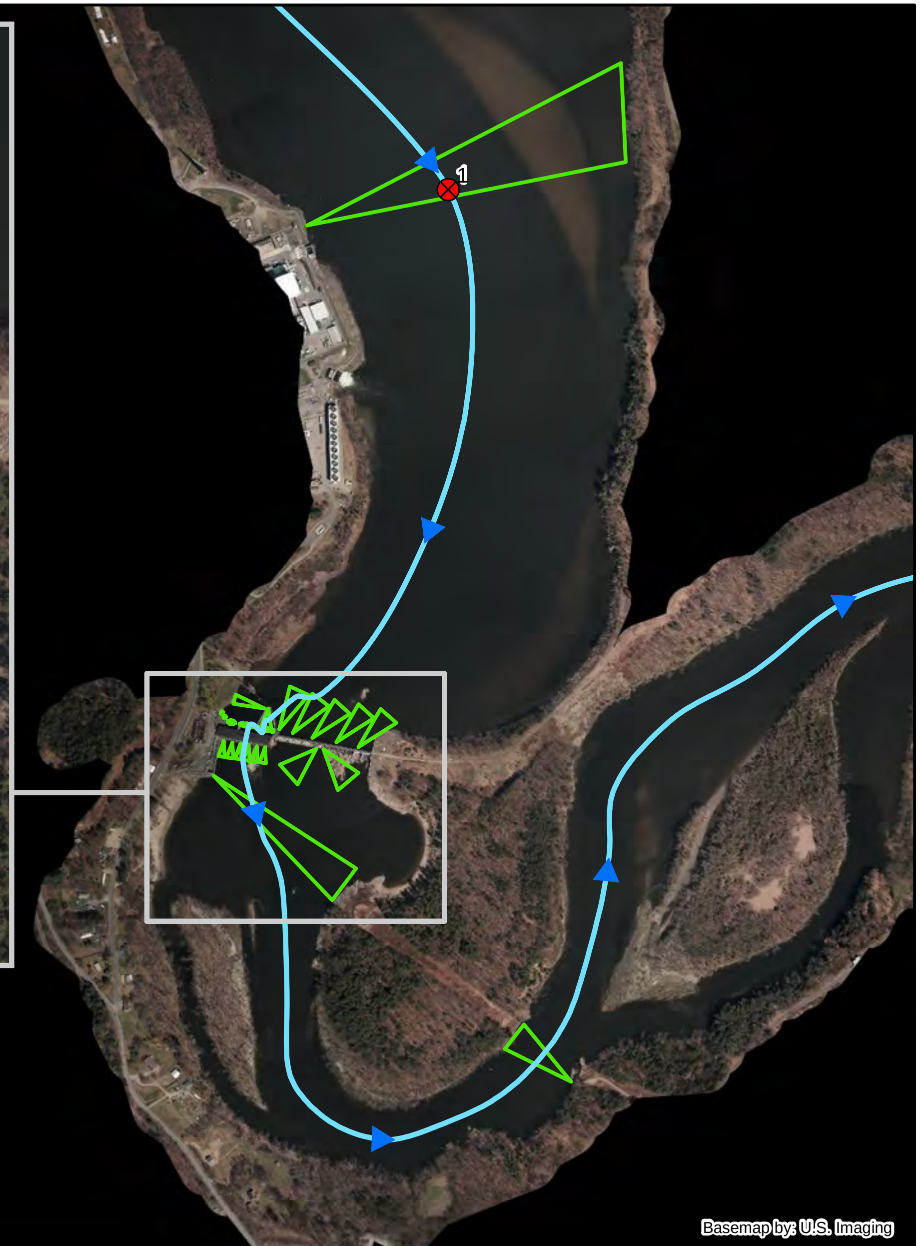

Timetable					
Detection	Date	Time	Detection	Date	Time
1	10/31/2015	20:44	6	10/31/2015	21:10
2	10/31/2015	21:07	7	10/31/2015	21:10
3	10/31/2015	21:07			
4	10/31/2015	21:08			
5	10/31/2015	21:10			

TransCanada Hydro Northeast Inc.
ILP Study 19
Vernon Dam

N

1 in = 1,200 feet

0 600 1,200 2,400 Feet

Study 19 Fish Number: 34-163
Release: Riverside Industrial Complex
Brattleboro, VT
Date Released: 10/31/2015
Time Released: 13:40

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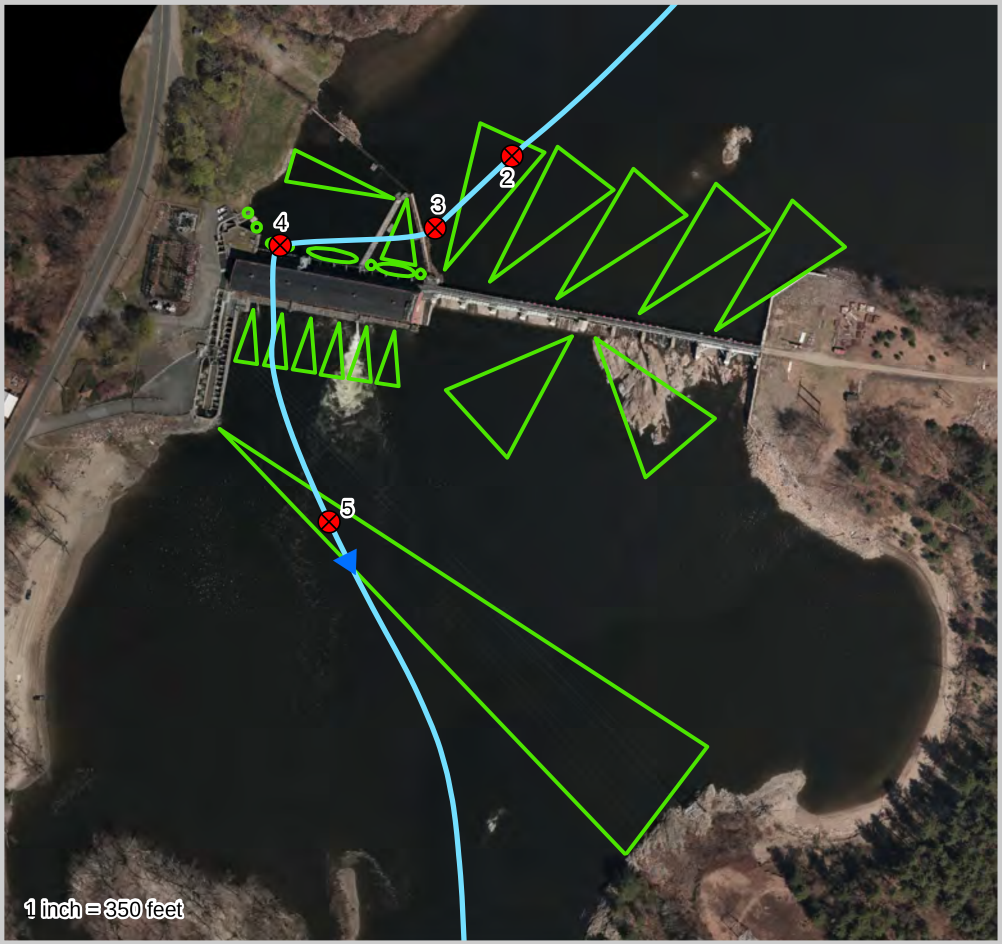

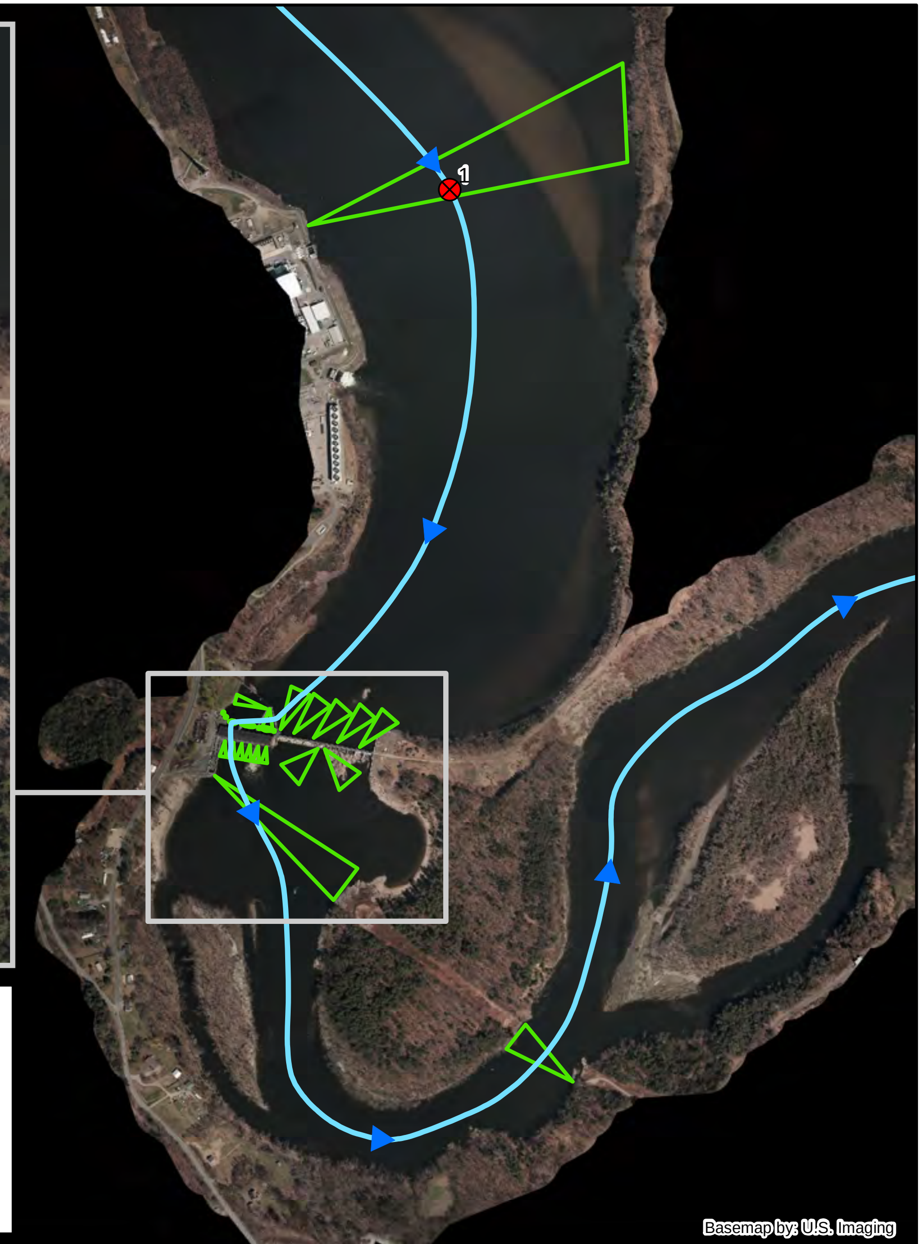

Timetable		
Detection	Date	Time
1	11/8/2015	23:30
2	11/9/2015	0:28
3	11/9/2015	0:29
4	11/9/2015	0:35
5	11/9/2015	0:38

Site Features

- Detection
- Fish Path
- Reciever Zones

TransCanada Hydro Northeast Inc.
ILP Study 19
Vernon Dam

1 in = 1,200 feet

0 600 1,200 2,400 Feet

Study 19 Fish Number: 34-173

Release: Herricks Cove, VT
Date Released: 10/31/2015
Time Released: 18:22

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Bedford, NH USA
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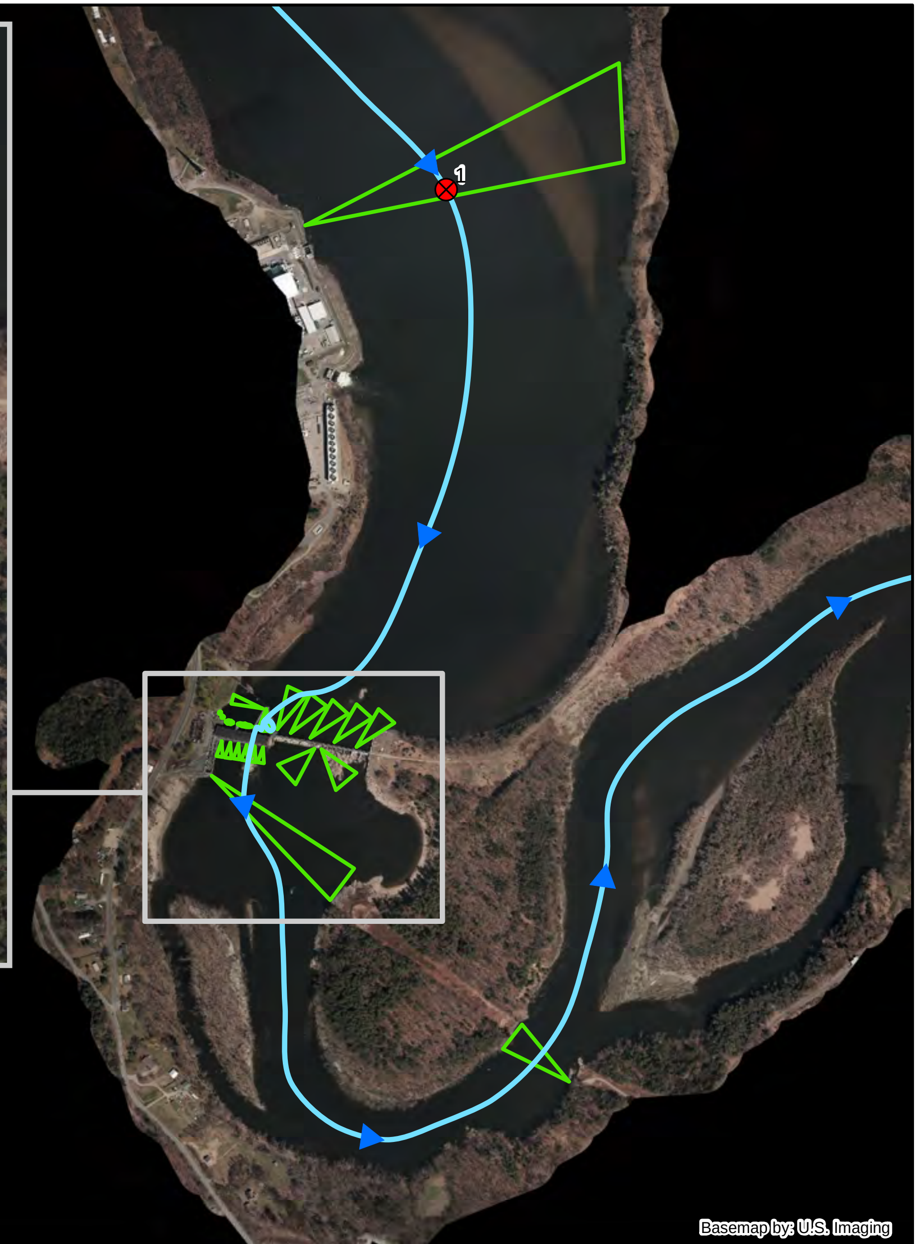

Timetable					
Detection	Date	Time	Detection	Date	Time
1	11/4/2015	4:32	6	11/4/2015	5:31
2	11/4/2015	5:07	7	11/4/2015	5:31
3	11/4/2015	5:23	8	11/4/2015	5:31
4	11/4/2015	5:29	9	11/4/2015	5:31
5	11/4/2015	5:30	10	11/4/2015	5:32

TransCanada Hydro Northeast Inc.
ILP Study 19
Vernon Dam

N

1 in = 1,200 feet

0 600 1,200 2,400 Feet

Study 19 Fish Number: 34-181

Release: Norwich, VT
Date Released: 10/31/2015
Time Released: 19:21

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Environmental Consultants

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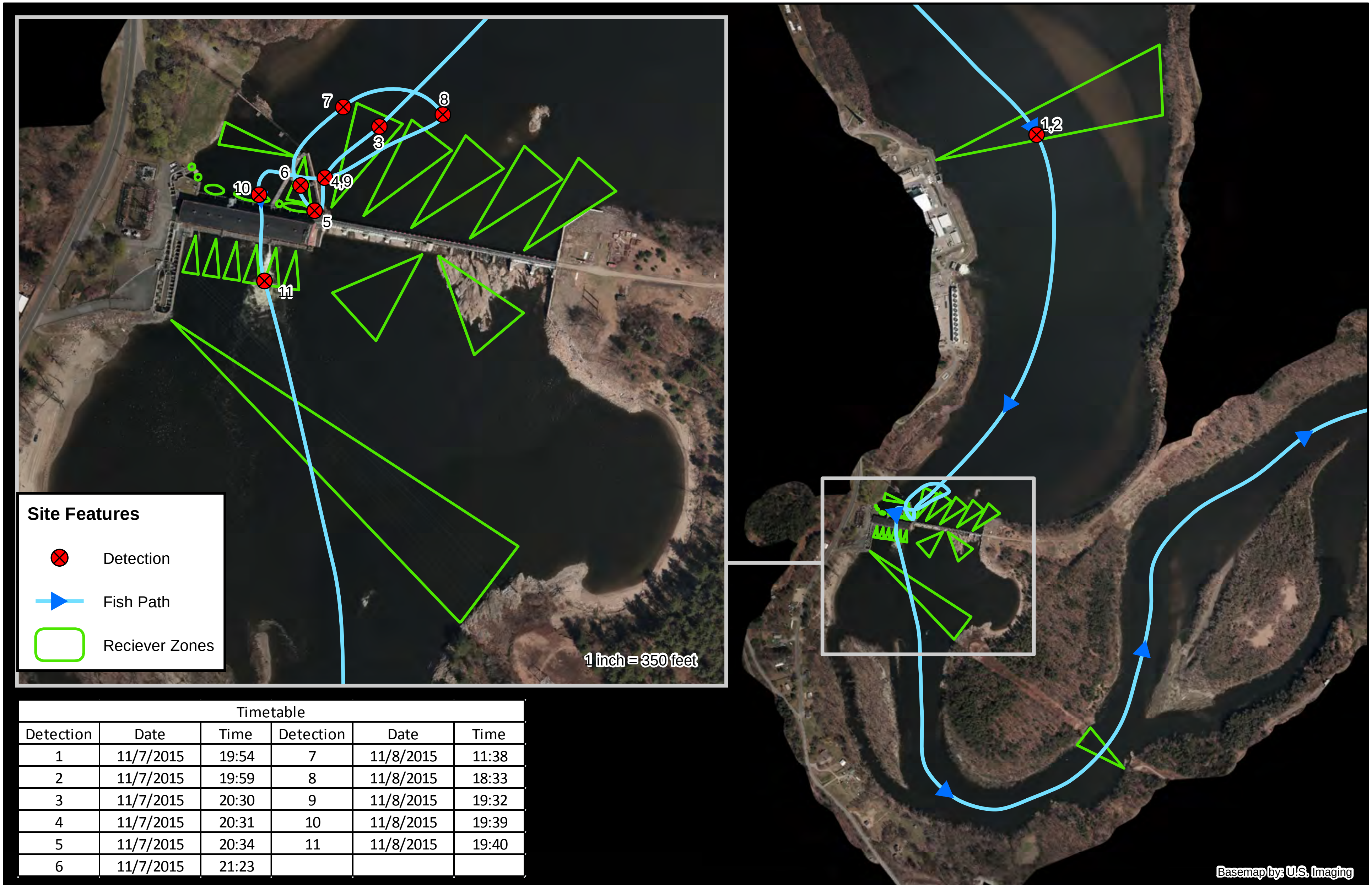
Bedford, NH USA
03110



Timetable					
Detection	Date	Time	Detection	Date	Time
1	11/7/2015	19:54	7	11/8/2015	11:38
2	11/7/2015	19:59	8	11/8/2015	18:33
3	11/7/2015	20:30	9	11/8/2015	19:32
4	11/7/2015	20:31	10	11/8/2015	19:39
5	11/7/2015	20:34	11	11/8/2015	19:40
6	11/7/2015	21:23			

TransCanada Hydro Northeast Inc.
ILP Study 19
Vernon Dam

N

1 in = 1,200 feet

0 600 1,200 2,400 Feet

Study 19 Fish Number: 34-183

Release: Norwich, VT
Date Released: 10/31/2015
Time Released: 19:21

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03110

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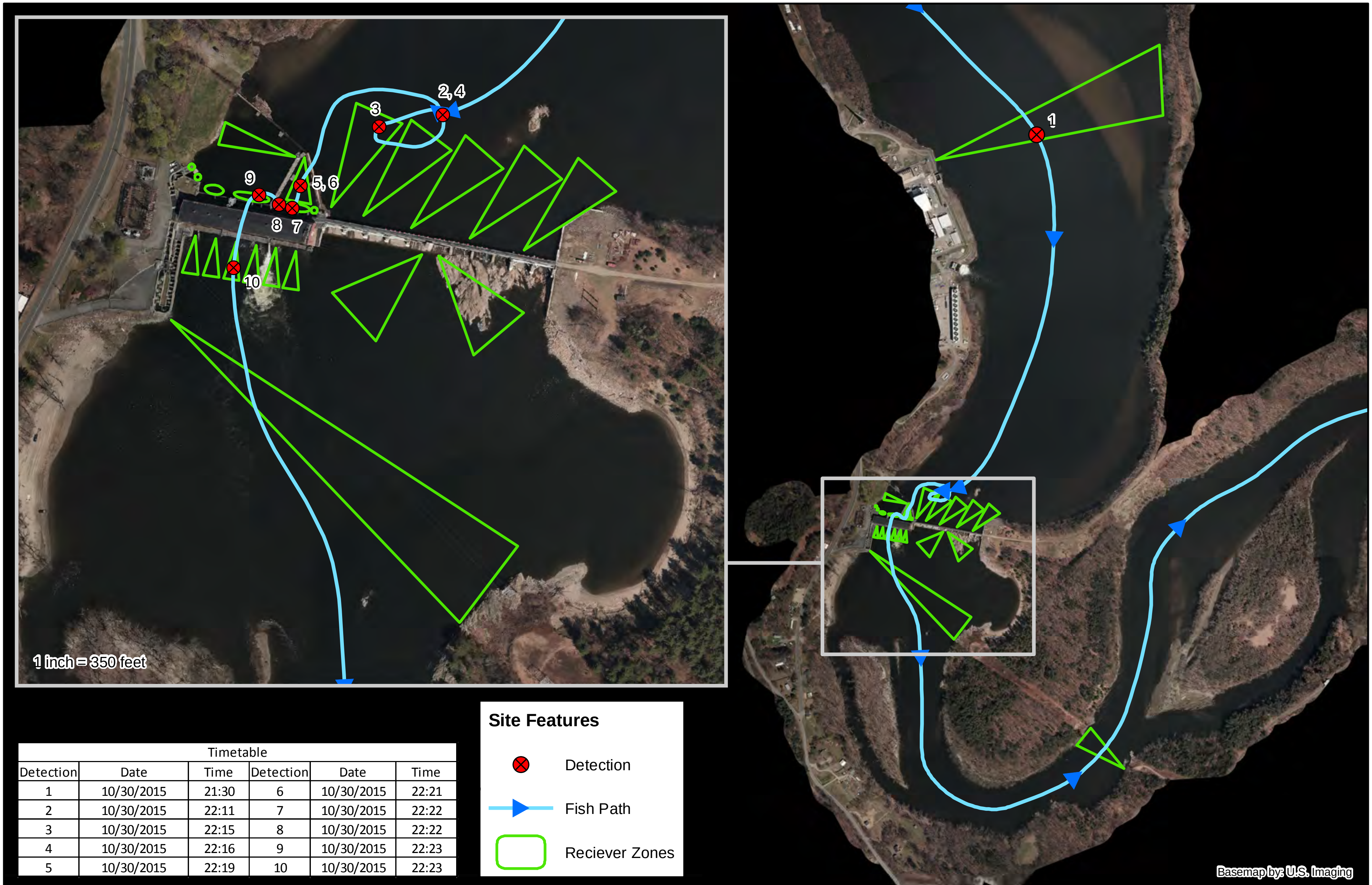

Timetable					
Detection	Date	Time	Detection	Date	Time
1	10/30/2015	21:30	6	10/30/2015	22:21
2	10/30/2015	22:11	7	10/30/2015	22:22
3	10/30/2015	22:15	8	10/30/2015	22:22
4	10/30/2015	22:16	9	10/30/2015	22:23
5	10/30/2015	22:19	10	10/30/2015	22:23

Site Features

Detection

Fish Path

Reciever Zones

TransCanada Hydro Northeast Inc.
ILP Study 19
Vernon Dam

N

1 in = 1,200 feet

0 600 1,200 2,400 Feet

Study 19 Fish Number: 34-53

Release: Bellows Falls Canal
Date Released: 10/29/2015
Time Released: 17:32

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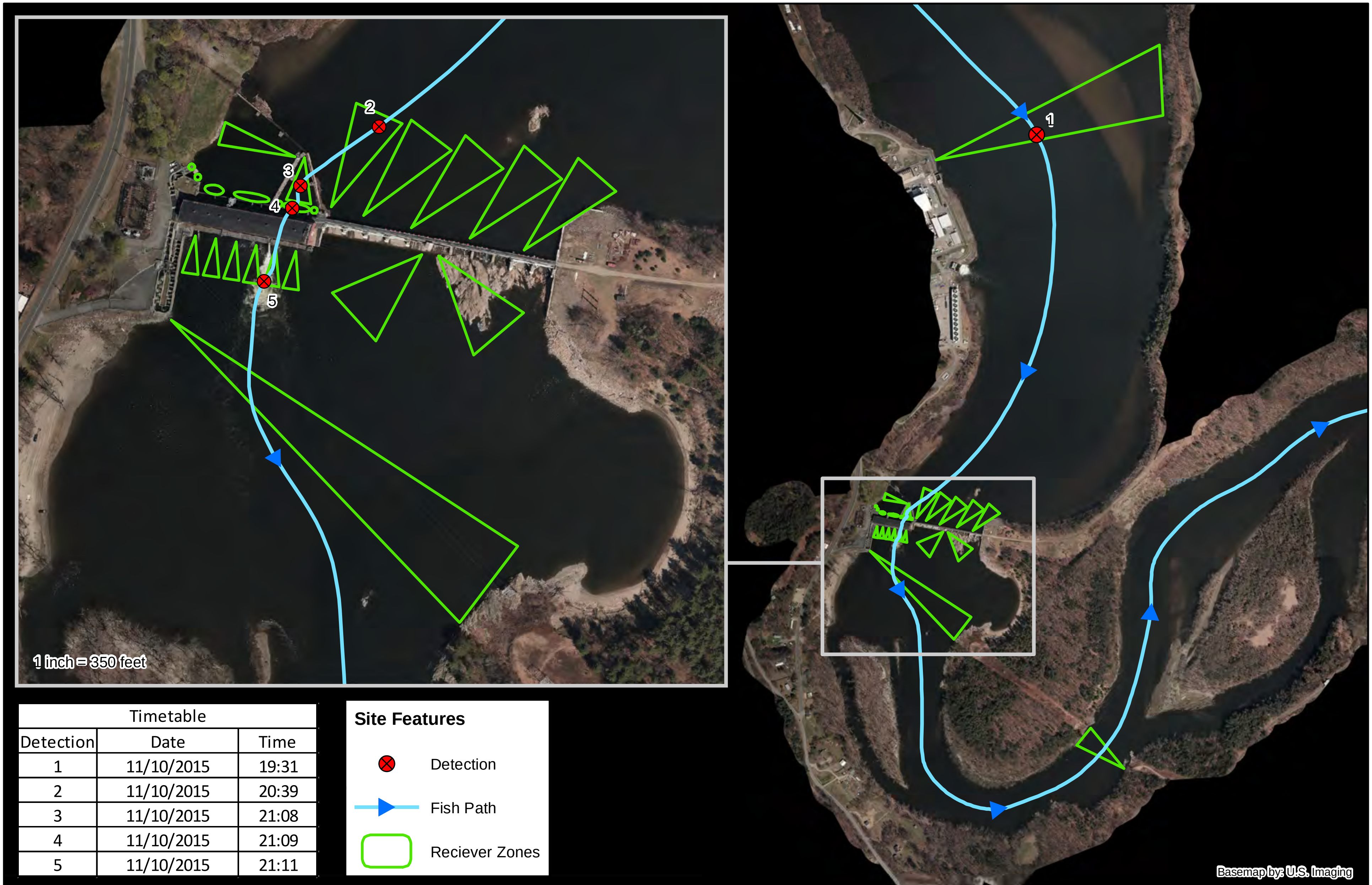

Timetable		
Detection	Date	Time
1	11/10/2015	19:31
2	11/10/2015	20:39
3	11/10/2015	21:08
4	11/10/2015	21:09
5	11/10/2015	21:11

Site Features

Detection

Fish Path

Reciever Zones

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TransCanada Hydro Northeast Inc.
ILP Study 19
Vernon Dam

N

1 in = 1,200 feet

0 600 1,200 2,400 Feet

Study 19 Fish Number: 34-54

Release: Bellows Falls Canal
Date Released: 10/31/2015
Time Released: 18:05

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Bedford, NH USA
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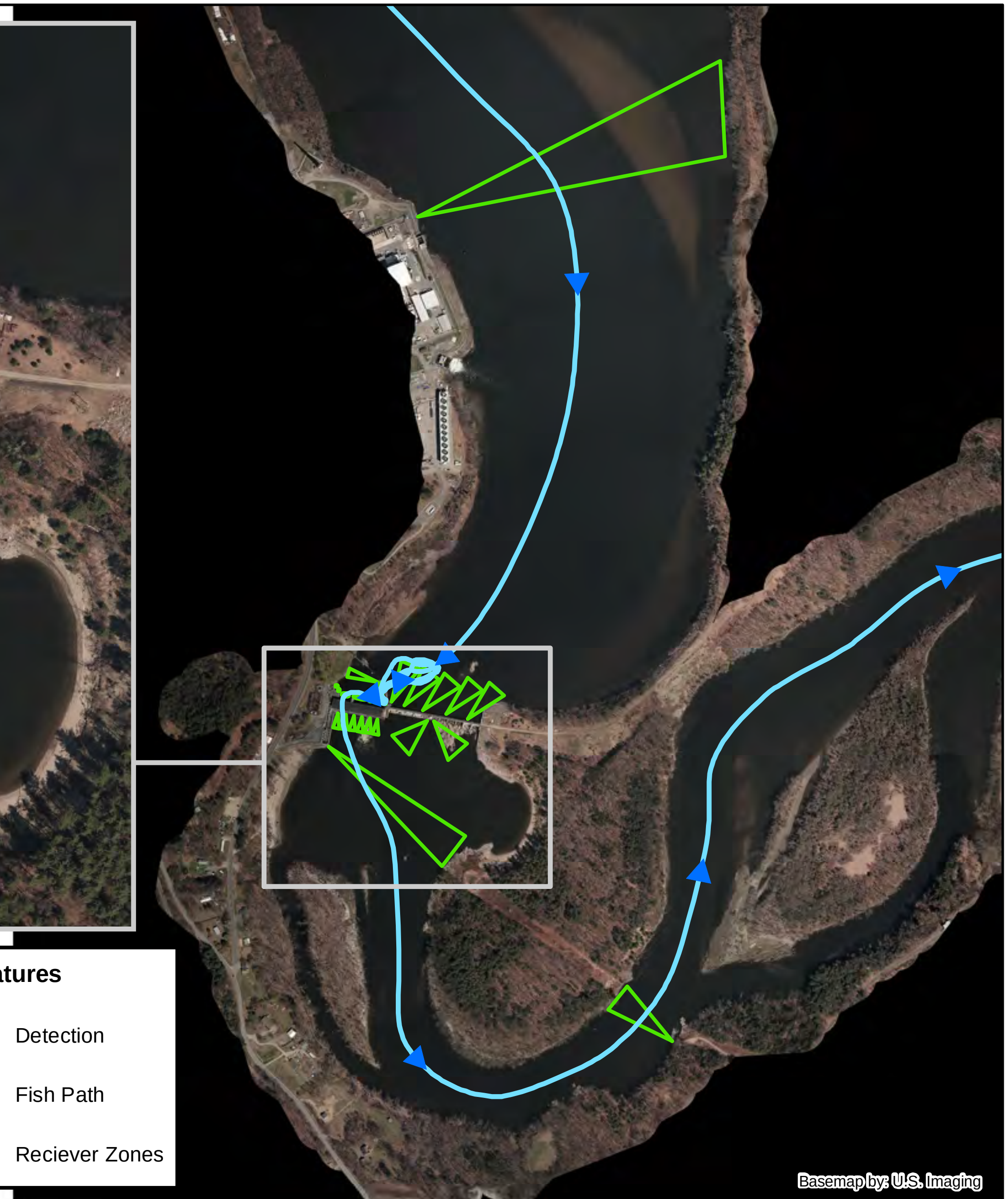

Timetable					
Detection	Date	Time	Detection	Date	Time
1	11/5/2015	12:53	7	11/5/2015	13:08
2	11/5/2015	12:55	8	11/5/2015	13:09
3	11/5/2015	12:59	9	11/5/2015	13:37
4	11/5/2015	13:00	10	11/5/2015	13:50
5	11/5/2015	13:04	11	11/5/2015	13:53
6	11/5/2015	13:07			

Site Features

- Detection
- Fish Path
- Reciever Zones

TransCanada Hydro Northeast Inc.
ILP Study 19
Vernon Falls Dam

N

1 in = 1,200 feet

0 600 1,200 2,400 Feet

Study 19 Fish Number: 34-55

Release: Bellows Falls Canal
Date Released: 10/31/2015
Time Released: 18:05

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Environmental Consultants

Normandeau Associates Inc.
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Portland, ME USA
04101

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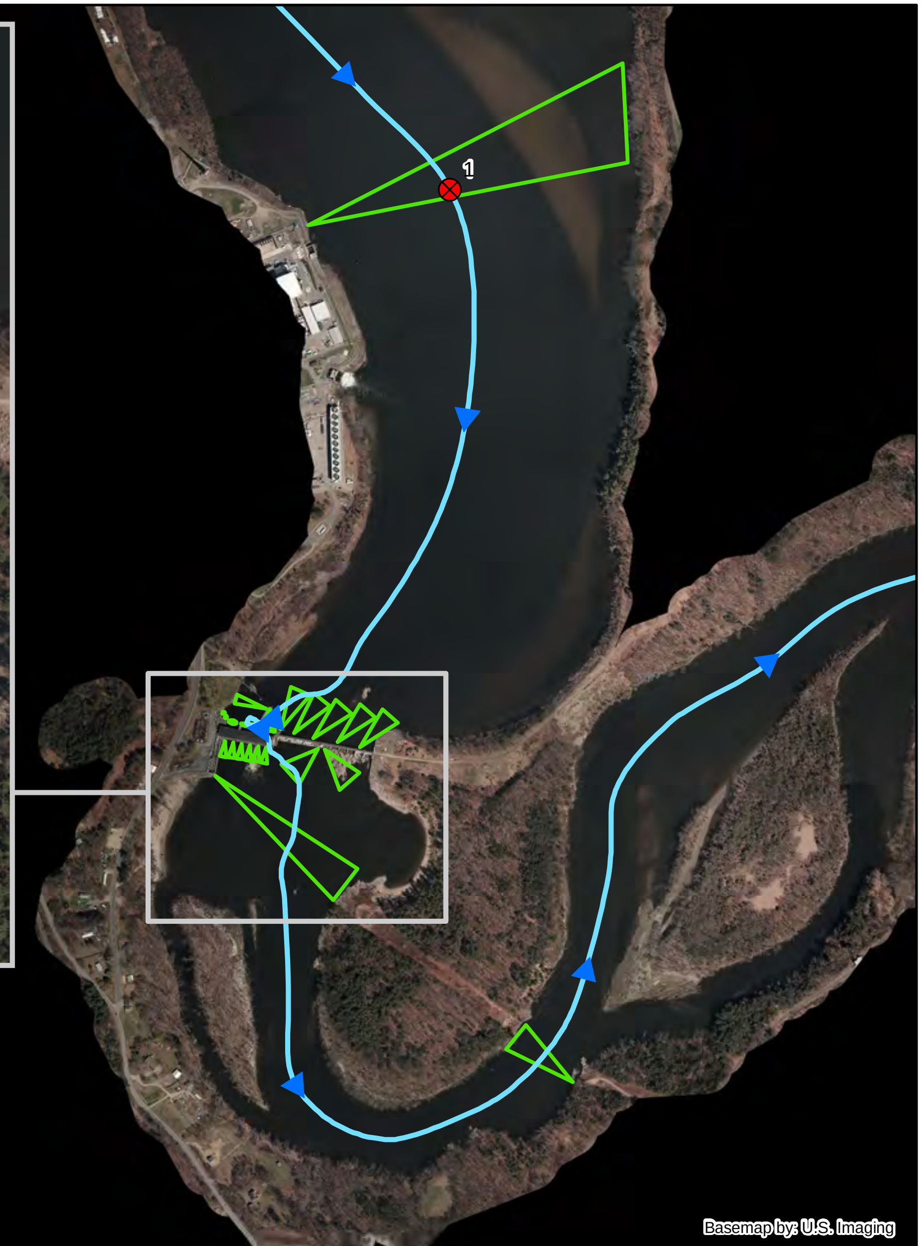

Timetable		
Detection	Date	Time
1	11/10/2015	21:15
2	11/10/2015	21:46
3	11/10/2015	21:46
4	11/10/2015	21:48
5	11/10/2015	21:52
6	11/10/2015	21:52

Site Features

- Detection
- Fish Path
- Reciever Zones

TransCanada Hydro Northeast Inc.
ILP Study 19
Vernon Dam

N

1 in = 1,200 feet

0 600 1,200 2,400 Feet

Study 19 Fish Number: 34-57

Release: Norwich, VT
Date Released: 11/5/2015
Time Released: 17:05

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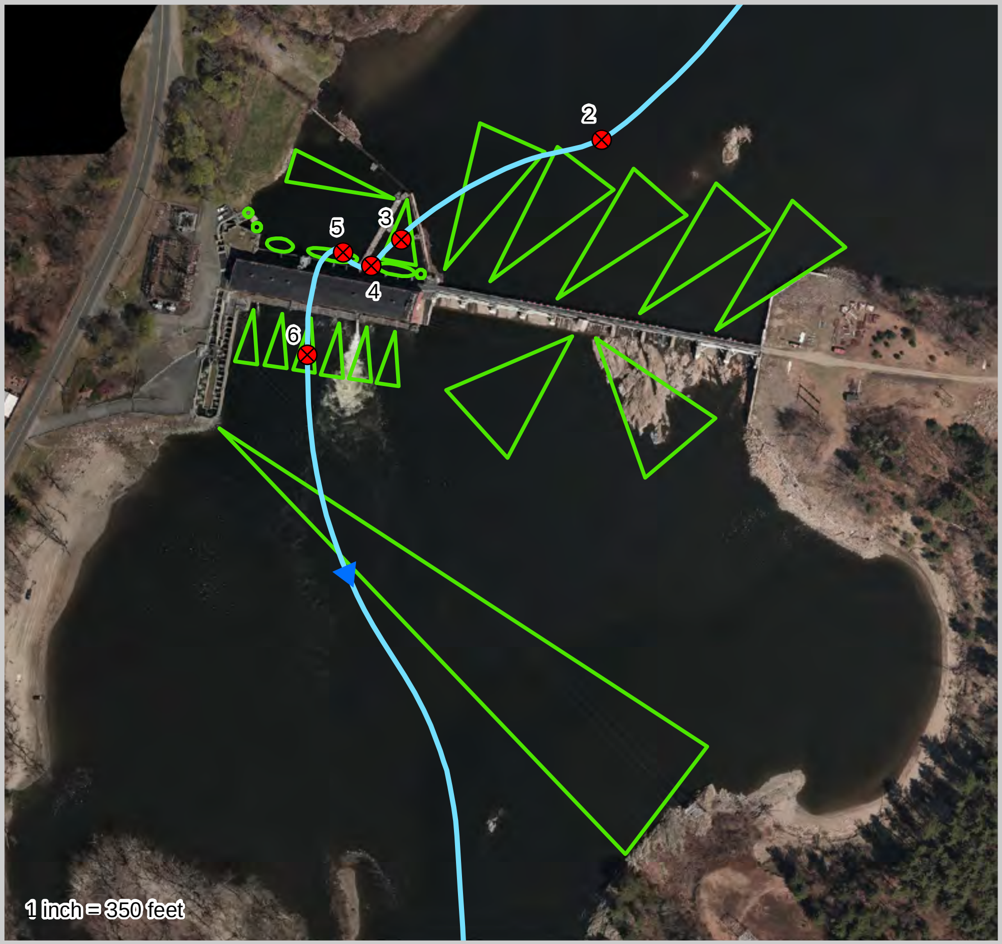

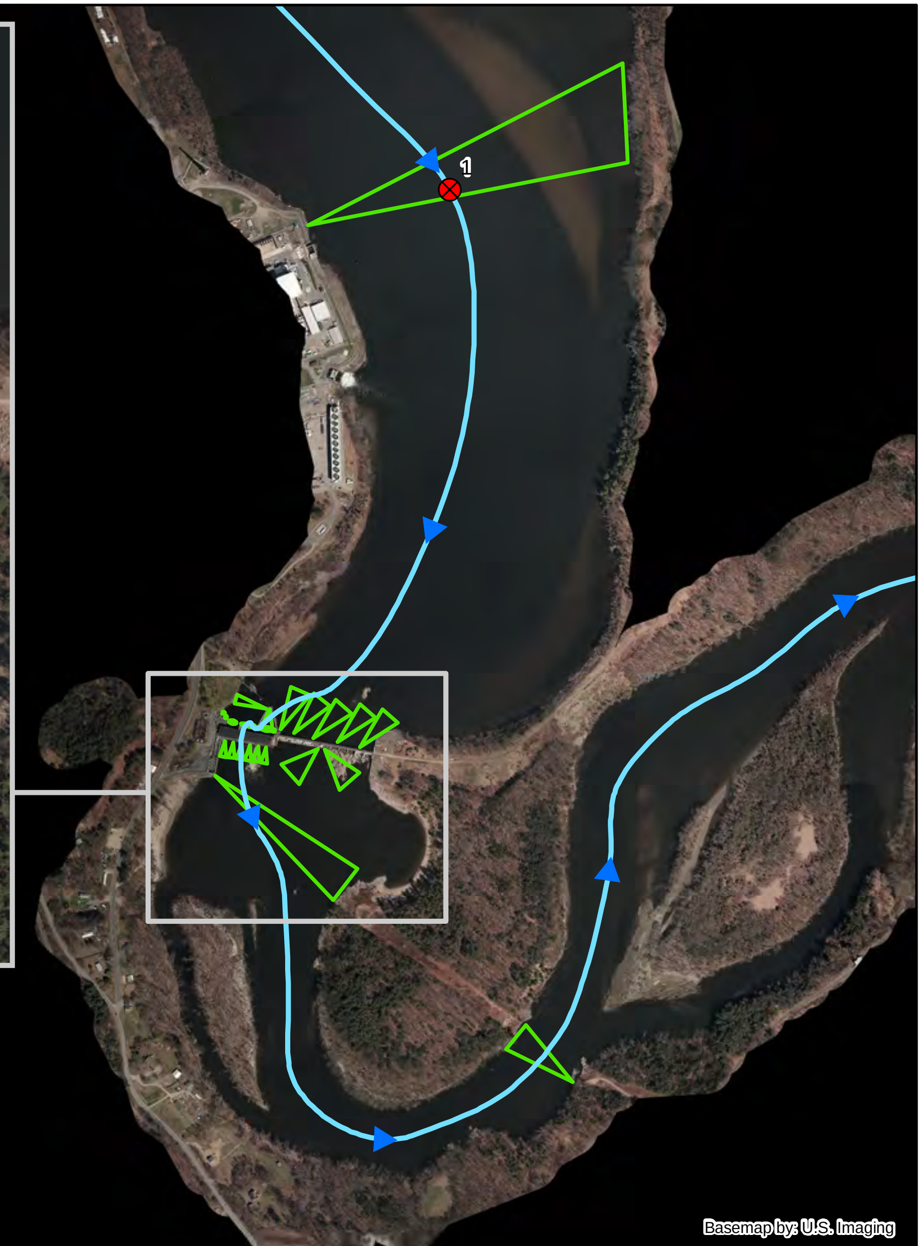

Timetable		
Detection	Date	Time
1	10/28/2015	21:43
2	10/28/2015	22:26
3	10/28/2015	23:42
4	10/29/2015	0:09
5	10/29/2015	17:55
5	10/29/2015	17:55

Site Features

- Detection
- Fish Path
- Reciever Zones

TransCanada Hydro Northeast Inc.
ILP Study 19
Vernon Dam

N

1 in = 1,200 feet

0 600 1,200 2,400 Feet

Study 19 Fish Number: 36-104

Release: Riverside Industrial Center
Brattleboro, VT
Date Released: 10/27/2015
Time Released: 17:45

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Environmental Consultants

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Bedford, NH USA
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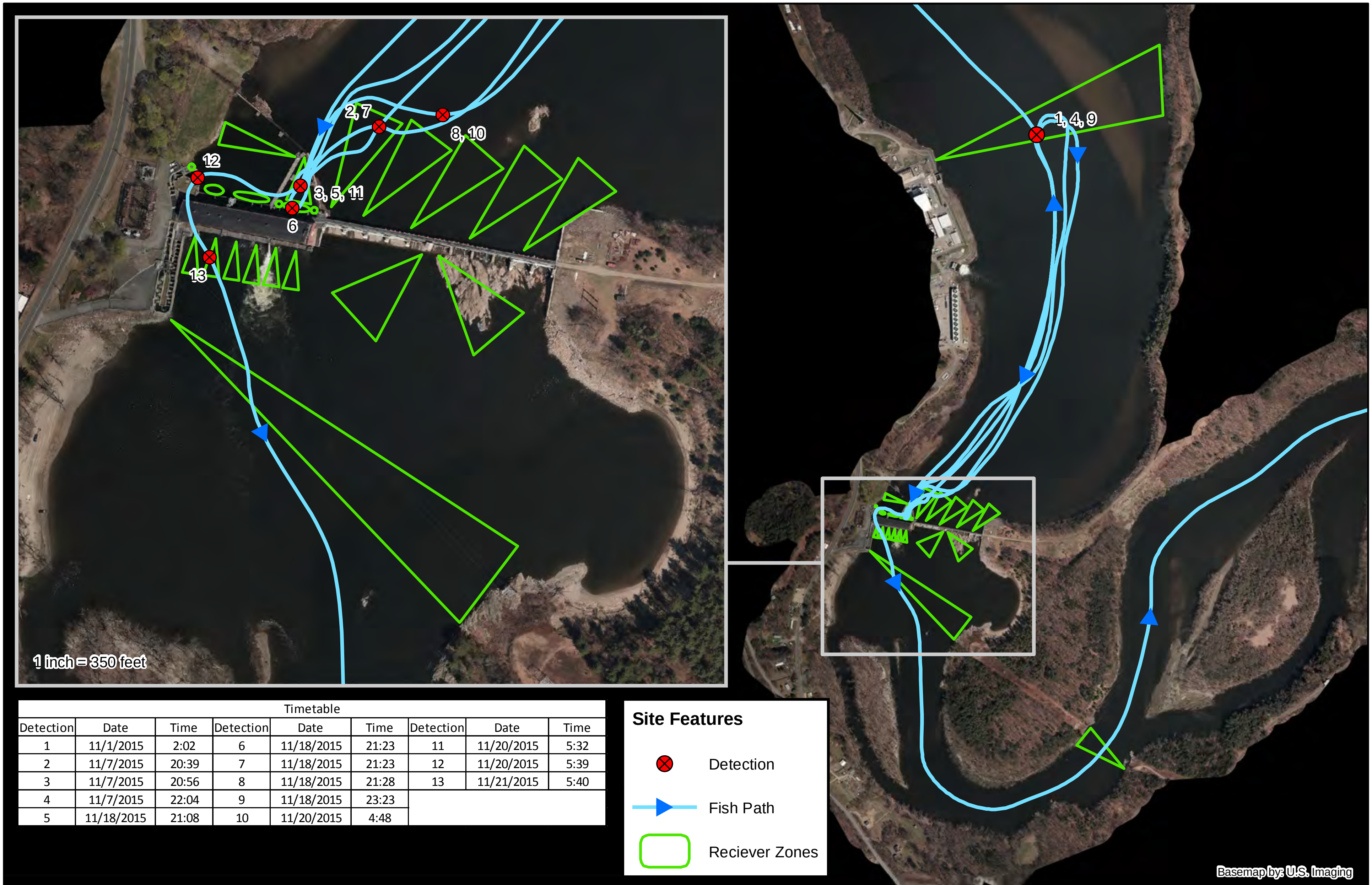

Timetable

Detection	Date	Time	Detection	Date	Time	Detection	Date	Time
1	11/1/2015	2:02	6	11/18/2015	21:23	11	11/20/2015	5:32
2	11/7/2015	20:39	7	11/18/2015	21:23	12	11/20/2015	5:39
3	11/7/2015	20:56	8	11/18/2015	21:28	13	11/21/2015	5:40
4	11/7/2015	22:04	9	11/18/2015	23:23			
5	11/18/2015	21:08	10	11/20/2015	4:48			

Site Features

- Detection
- Fish Path
- Reciever Zones

TransCanada Hydro Northeast Inc.
ILP Study 19
Vernon Dam

N

1 in = 1,200 feet

0 600 1,200 2,400 Feet

Study 19 Fish Number: 36-105
Release: Riverside Industrial Center
Brattleboro, VT
Date Released: 10/27/2015
Time Released: 17:45

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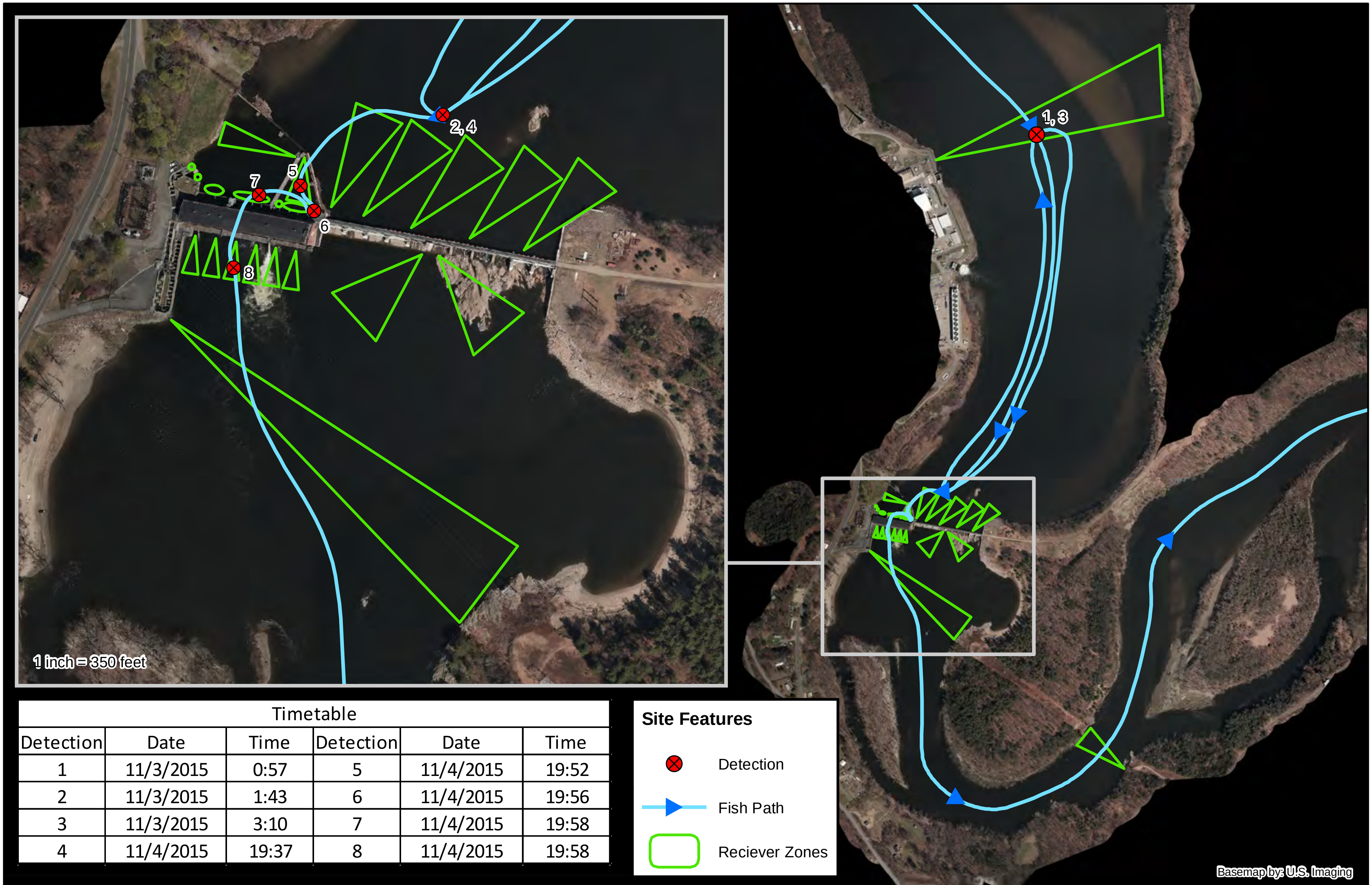

Timetable					
Detection	Date	Time	Detection	Date	Time
1	11/3/2015	0:57	5	11/4/2015	19:52
2	11/3/2015	1:43	6	11/4/2015	19:56
3	11/3/2015	3:10	7	11/4/2015	19:58
4	11/4/2015	19:37	8	11/4/2015	19:58

Site Features

- Detection
- Fish Path
- Reciever Zones

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TransCanada Hydro Northeast Inc.
ILP Study 19
Vernon Dam

N

1 in = 1,200 feet

0 600 1,200 2,400 Feet

Study 19 Fish Number: 36-106
Release: Riverside Industrial Complex
Brattleboro, VT
Date Released: 10/27/2015
Time Released: 17:45

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Bedford, NH USA
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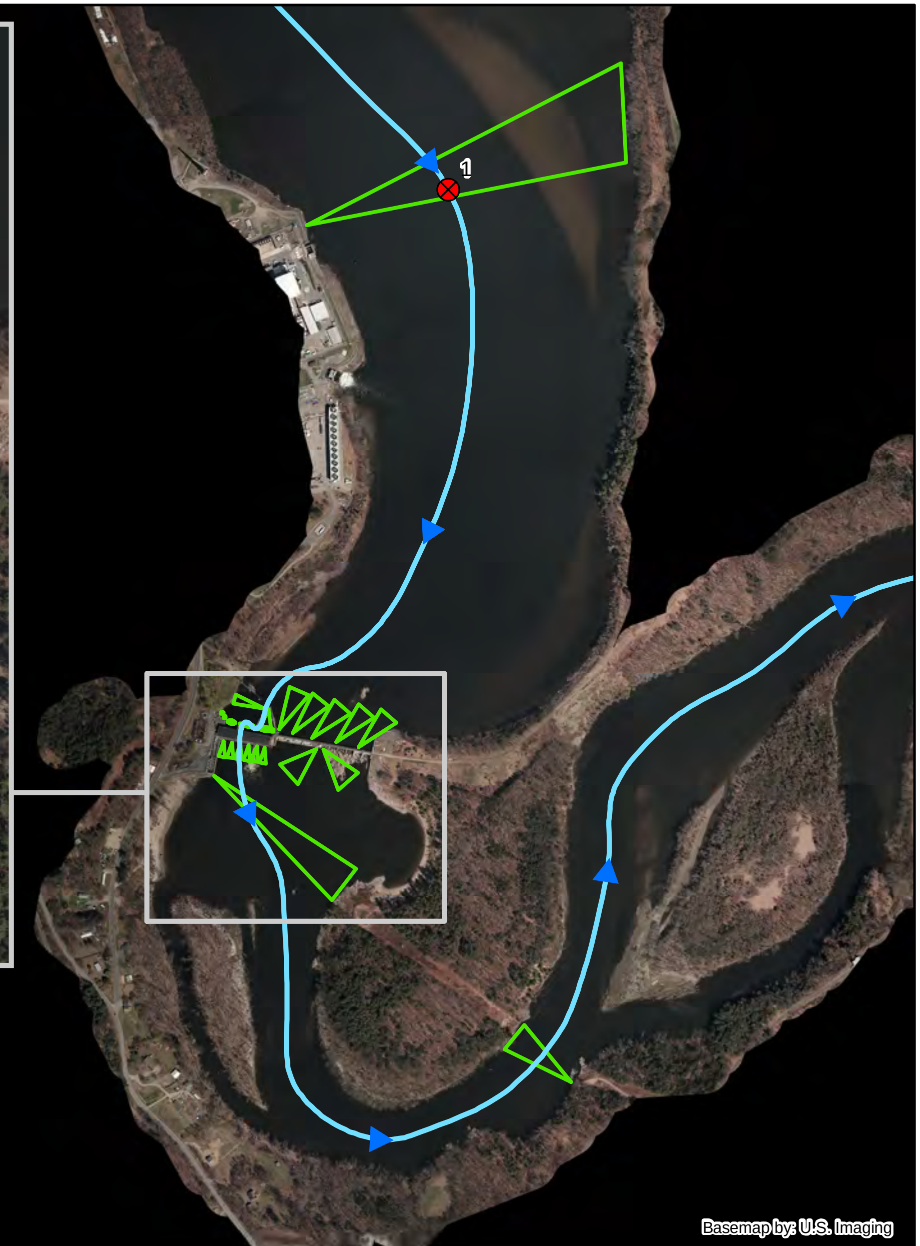

Timetable		
Detection	Date	Time
1	10/29/2015	14:55
2	10/29/2015	15:35
3	10/29/2015	15:35
4	10/29/2015	15:40

Site Features

- Detection
- Fish Path
- Reciever Zones

TransCanada Hydro Northeast Inc.
ILP Study 19
Vernon Dam

N

1 in = 1,200 feet

0 600 1,200 2,400 Feet

Study 19 Fish Number: 36-107
Release: Riverside Industrial Complex
Brattleboro, VT
Date Released: 10/27/2015
Time Released: 17:45

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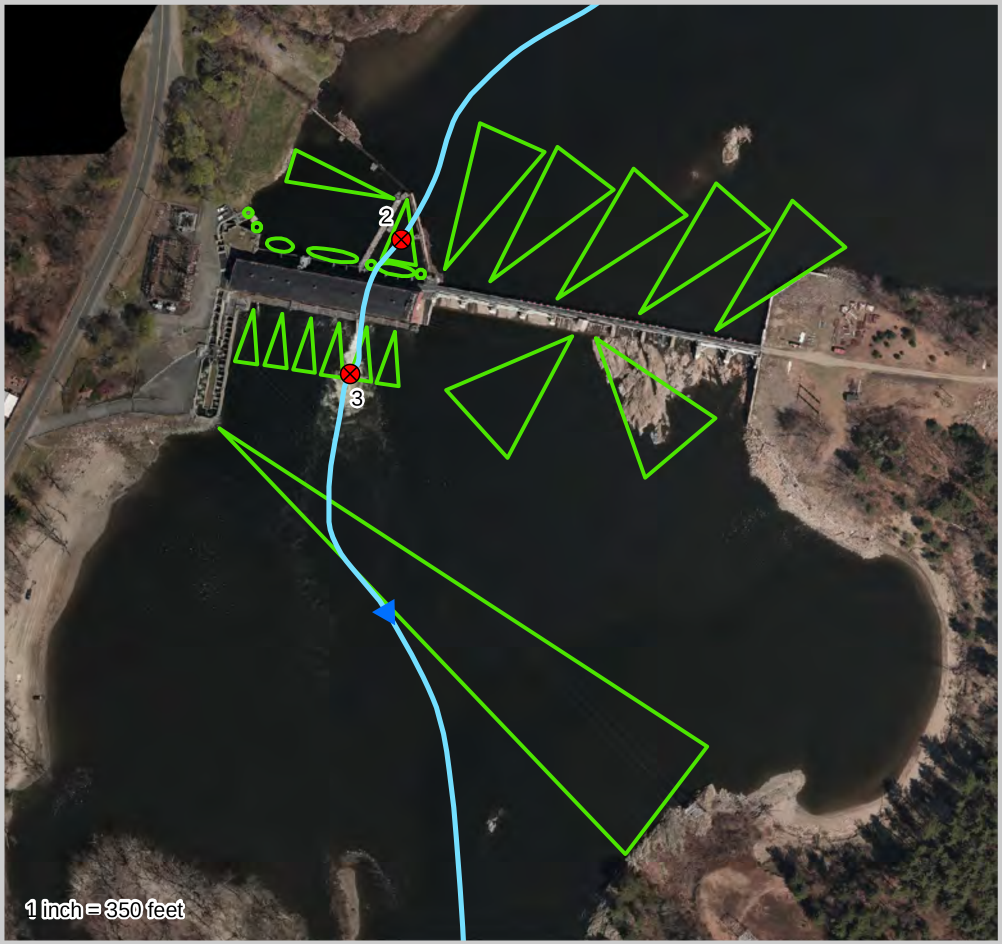

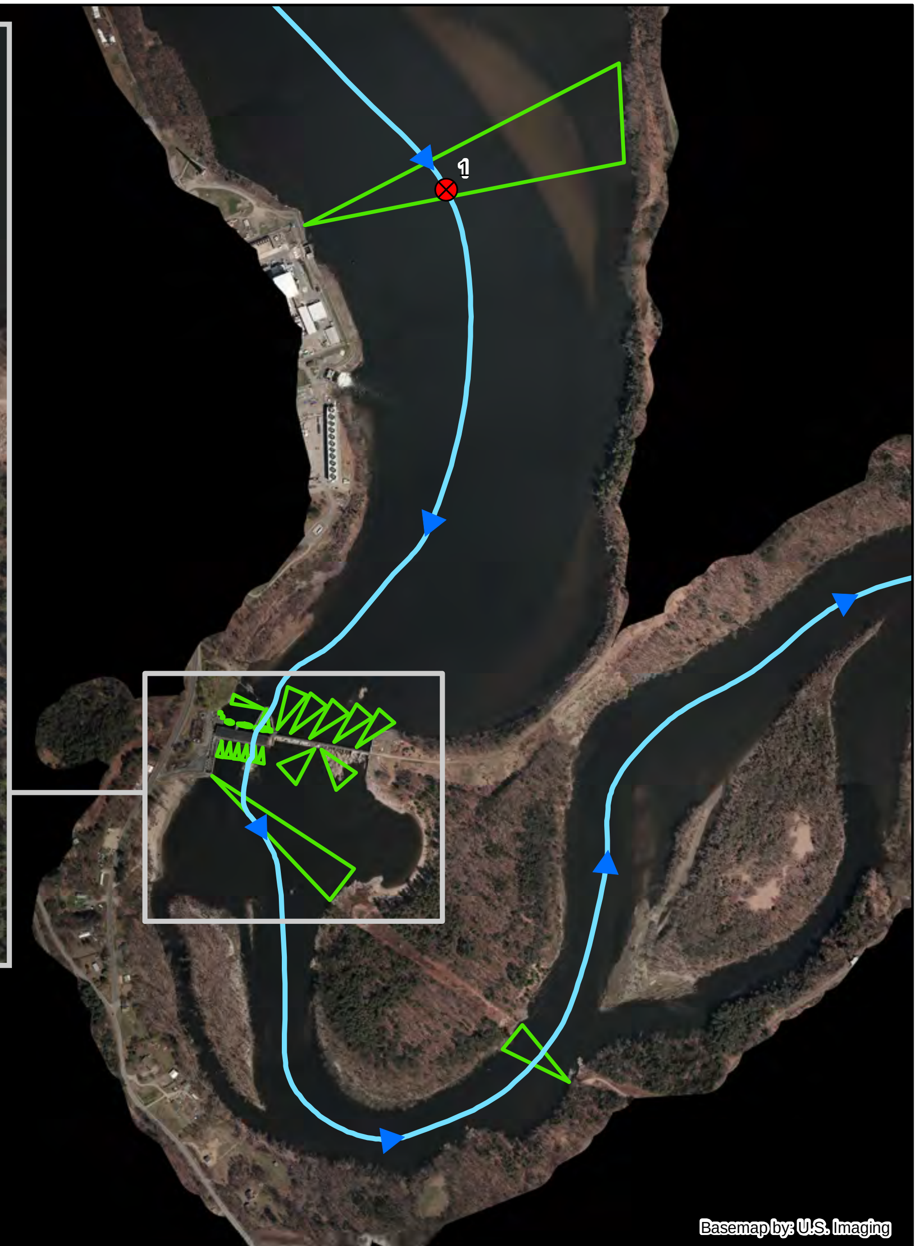

Timetable		
Detection	Date	Time
1	11/8/2015	23:41
2	11/9/2015	4:23
3	11/9/2015	4:26

Site Features

- Detection
- Fish Path
- Reciever Zones

TransCanada Hydro Northeast Inc.
ILP Study 19
Vernon Dam

N

1 in = 1,200 feet

0 600 1,200 2,400 Feet

Study 19 Fish Number: 36-108
Release: Riverside Industrial Complex
Brattleboro, VT
Date Released: 11/3/2015
Time Released: 15:55

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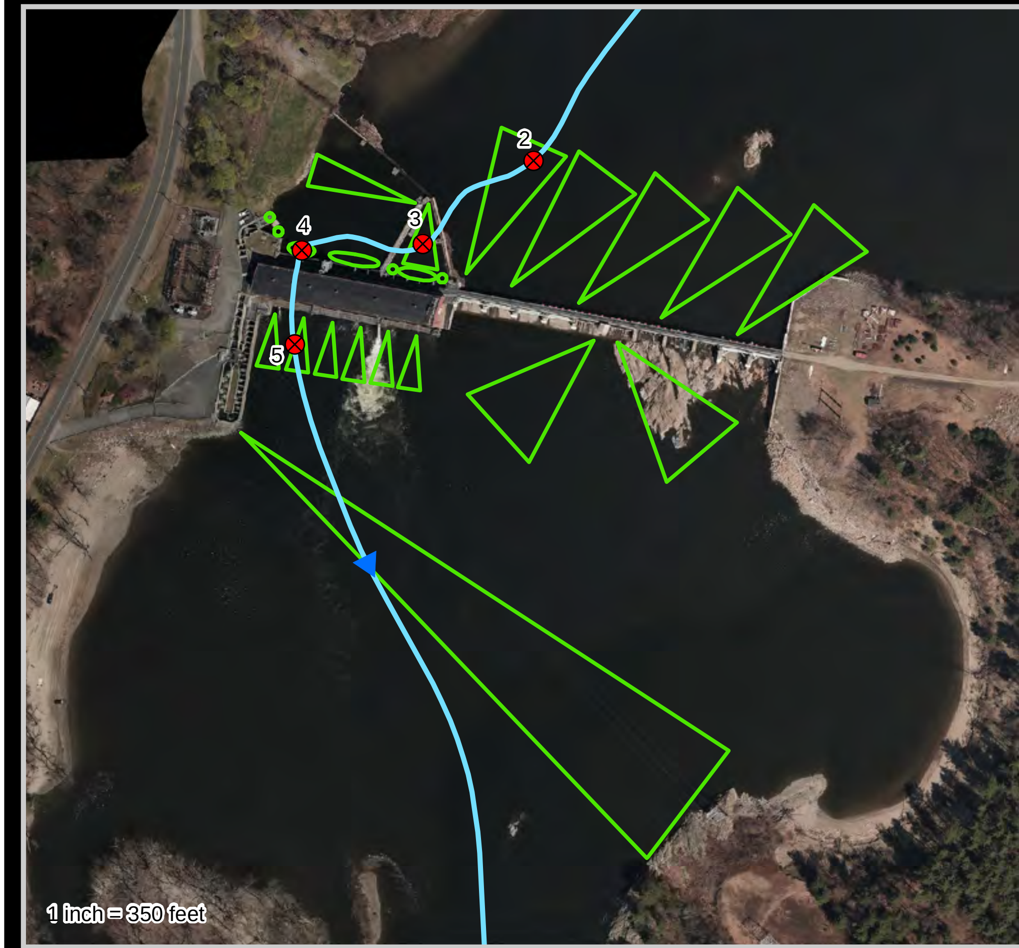

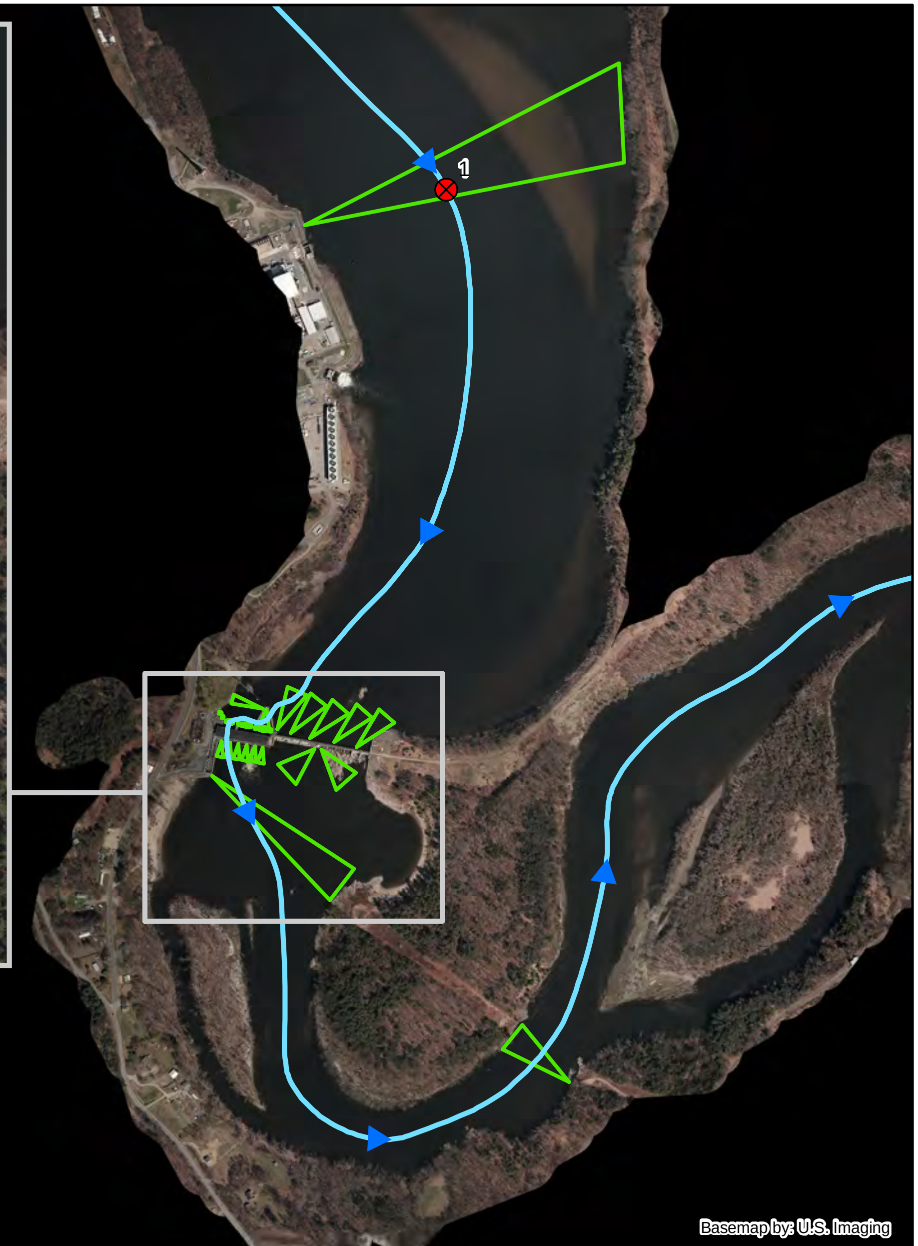

Timetable		
Detection	Date	Time
1	11/13/2015	0:47
2	11/13/2015	1:49
3	11/13/2015	1:49
4	11/13/2015	1:54
5	11/13/2015	1:55

Site Features

- Detection
- Fish Path
- Reciever Zones

TransCanada Hydro Northeast Inc.
ILP Study 19
Vernon Dam

N

1 in = 1,200 feet

0 600 1,200 2,400 Feet

Study 19 Fish Number: 36-109
Release: Riverside Industrial Complex
Brattleboro, VT
Date Released: 11/3/2015
Time Released: 15:55

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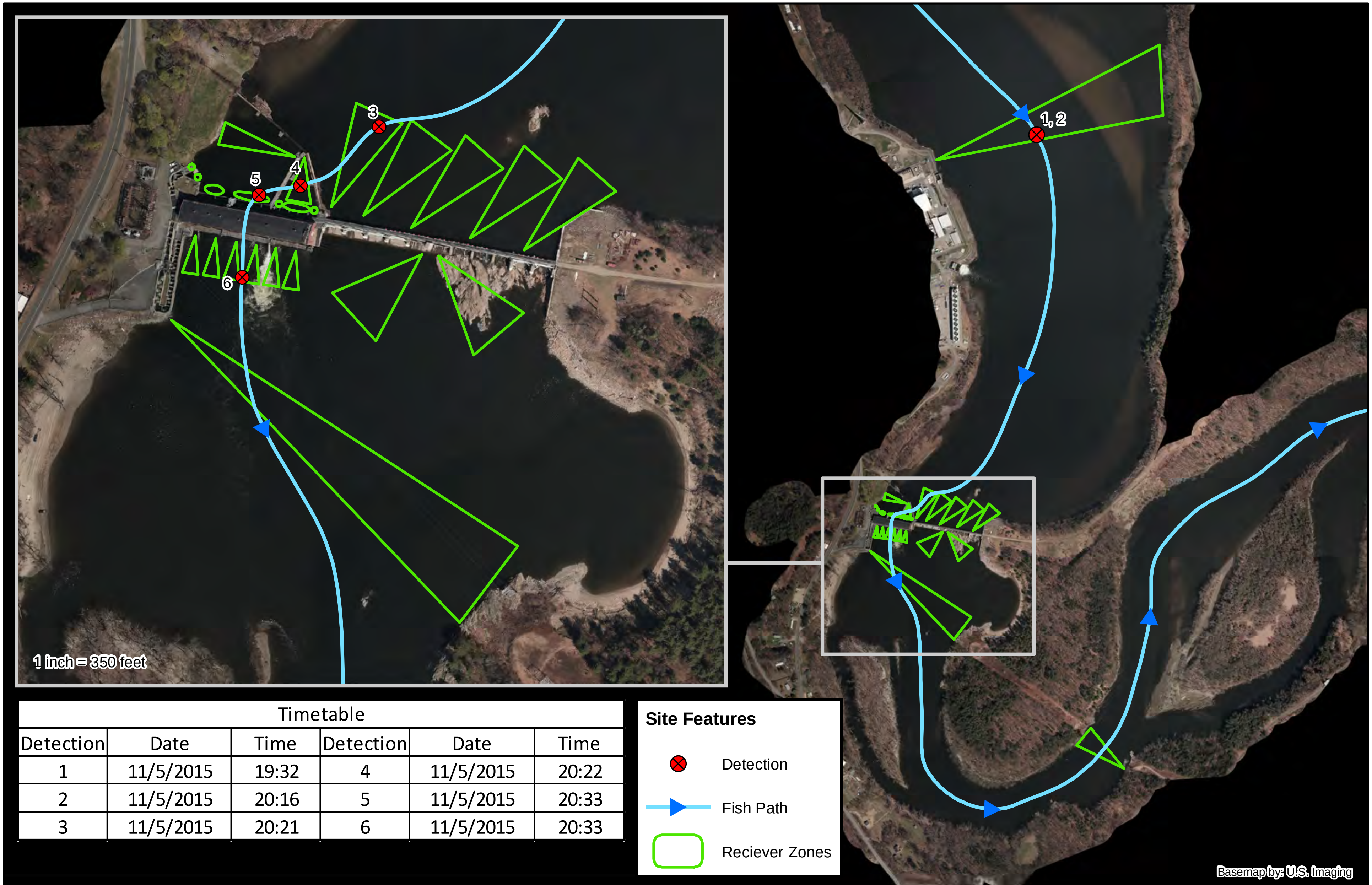

Timetable					
Detection	Date	Time	Detection	Date	Time
1	11/5/2015	19:32	4	11/5/2015	20:22
2	11/5/2015	20:16	5	11/5/2015	20:33
3	11/5/2015	20:21	6	11/5/2015	20:33

Site Features

- Detection
- Fish Path
- Reciever Zones

TransCanada Hydro Northeast Inc.
ILP Study 19
Vernon Dam

1 in = 1,200 feet

0 600 1,200 2,400 Feet

Study 19 Fish Number: 36-110
Release: Riverside Industrial Complex
Brattleboro, VT
Date Released: 11/3/2015
Time Released: 15:55

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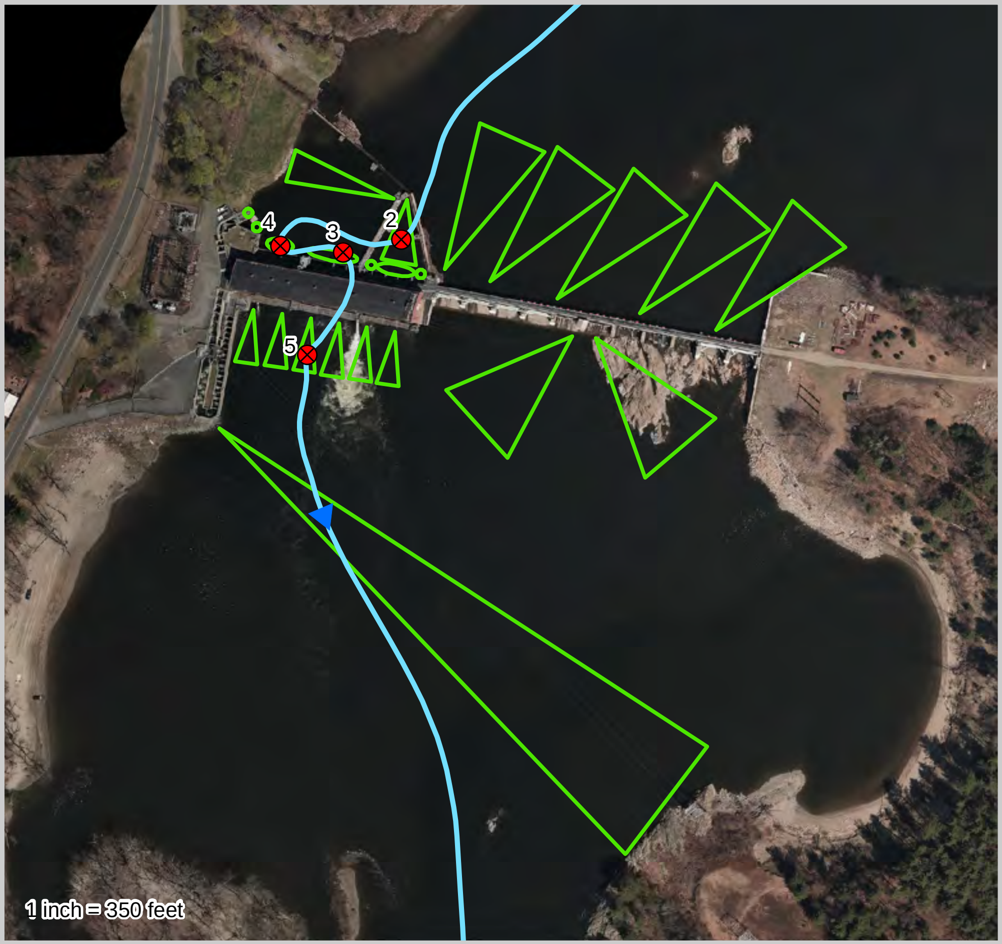

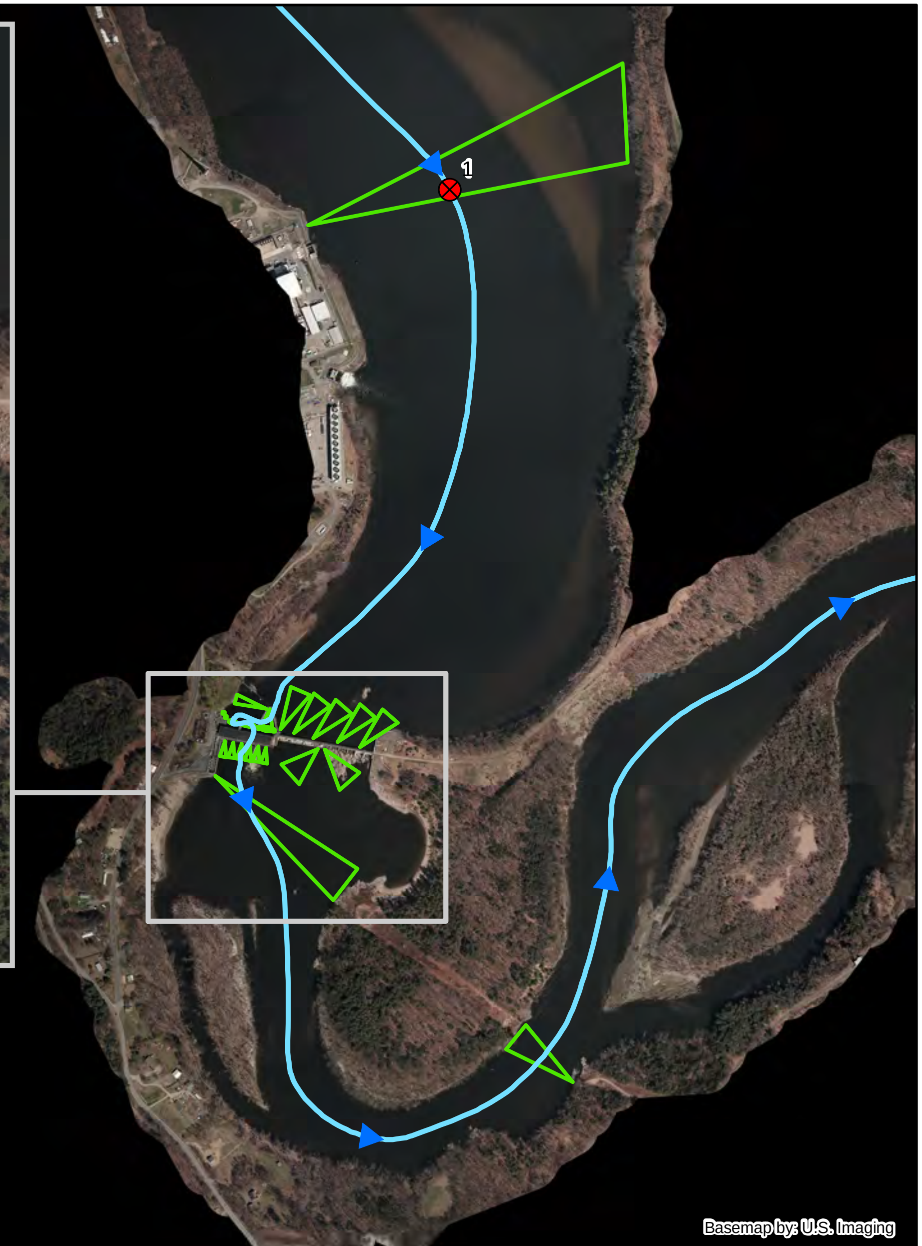

Timetable		
Detection	Date	Time
1	10/30/2015	19:59
2	10/30/2015	20:36
3	10/30/2015	20:36
4	10/30/2015	20:37
5	10/30/2015	20:37

Site Features

- Detection
- Fish Path
- Reciever Zones

TransCanada Hydro Northeast Inc.
ILP Study 19
Vernon Dam

N

1 in = 1,200 feet

0 600 1,200 2,400 Feet

Study 19 Fish Number: 36-116

Release: Herricks Cove, VT
Date Released: 10/27/15
Time Released: 18:20

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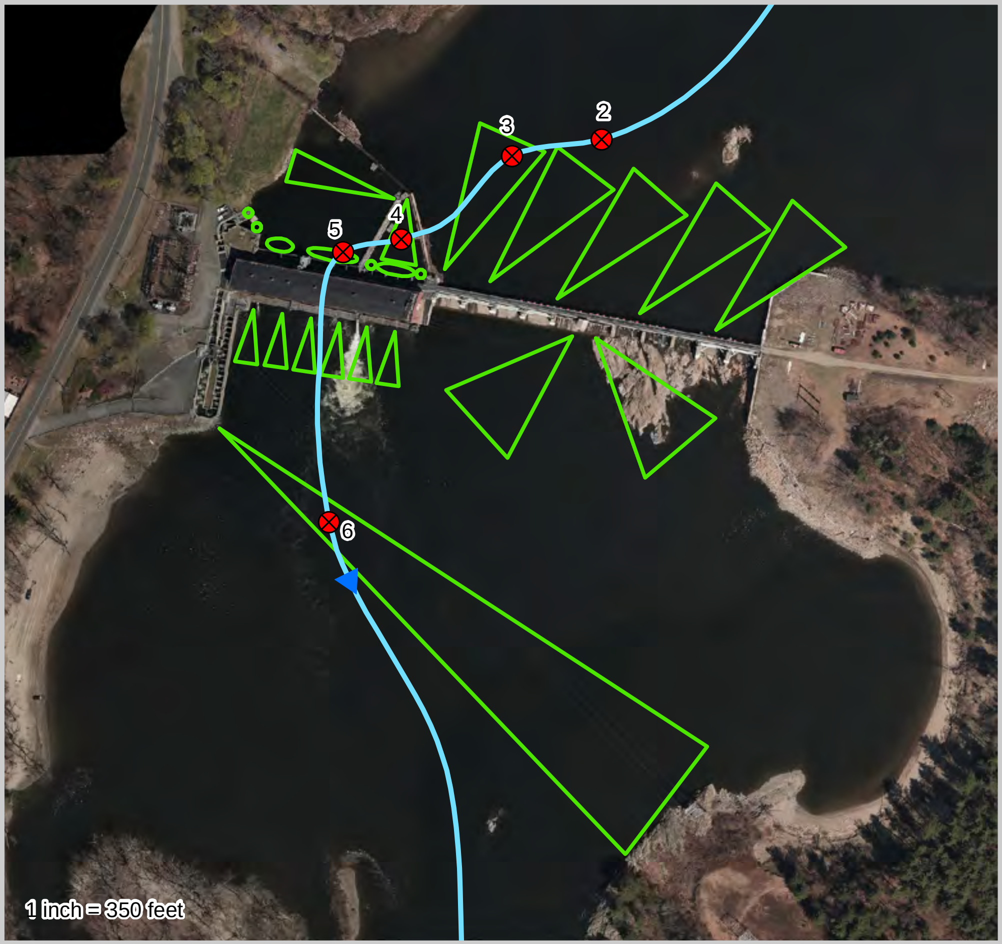

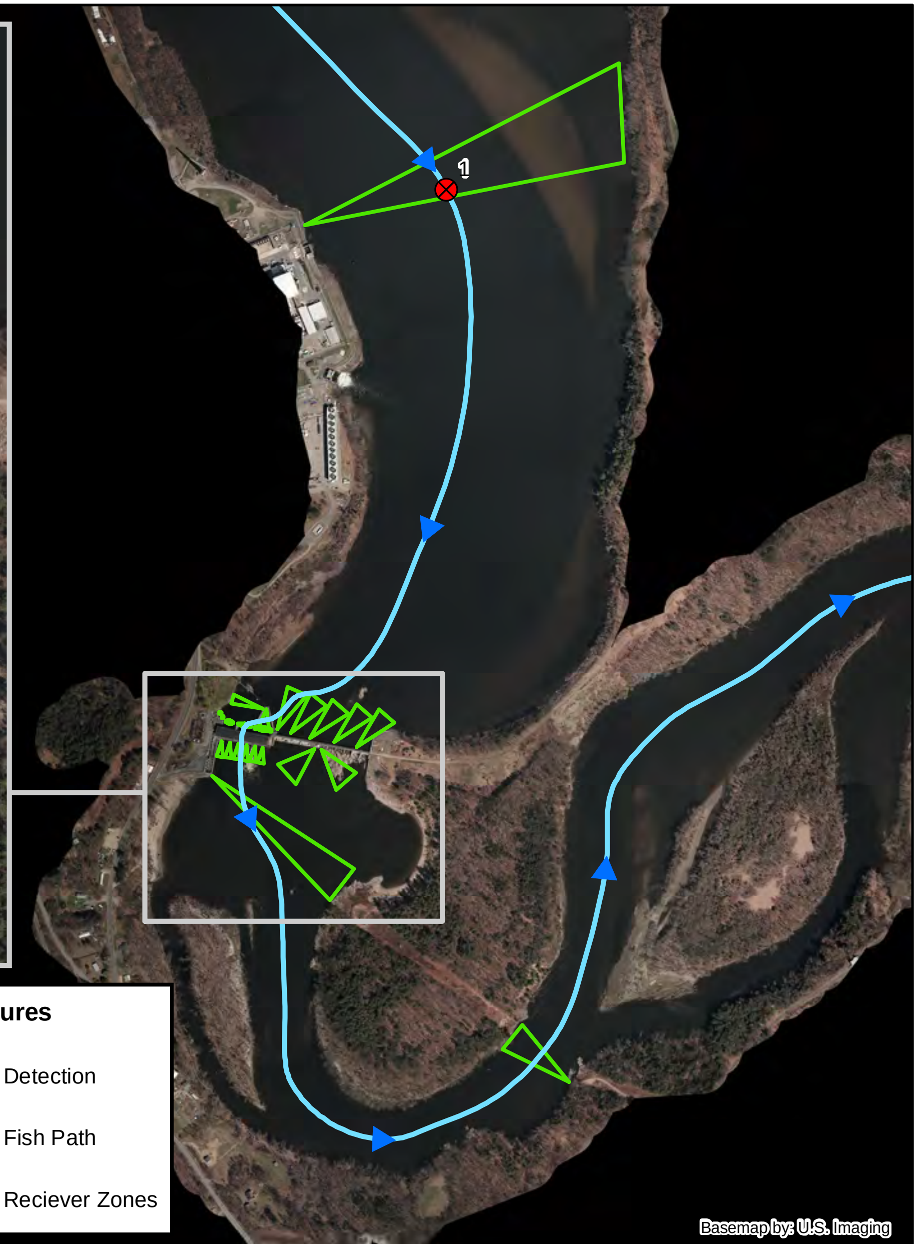

Timetable					
Detection	Date	Time	Detection	Date	Time
1	11/22/2015	6:14	4	11/22/2015	7:10
2	11/22/2015	6:55	5	11/22/2015	7:19
3	11/22/2015	7:06	6	11/22/2015	7:20

Site Features

- Detection
- Fish Path
- Reciever Zones

TransCanada Hydro Northeast Inc.
ILP Study 19
Vernon Dam

N

1 in = 1,200 feet

0 600 1,200 2,400 Feet

Study 19 Fish Number: 36-117

Release: Herricks Cove, VT
Date Released: 10/27/15
Time Released: 18:20

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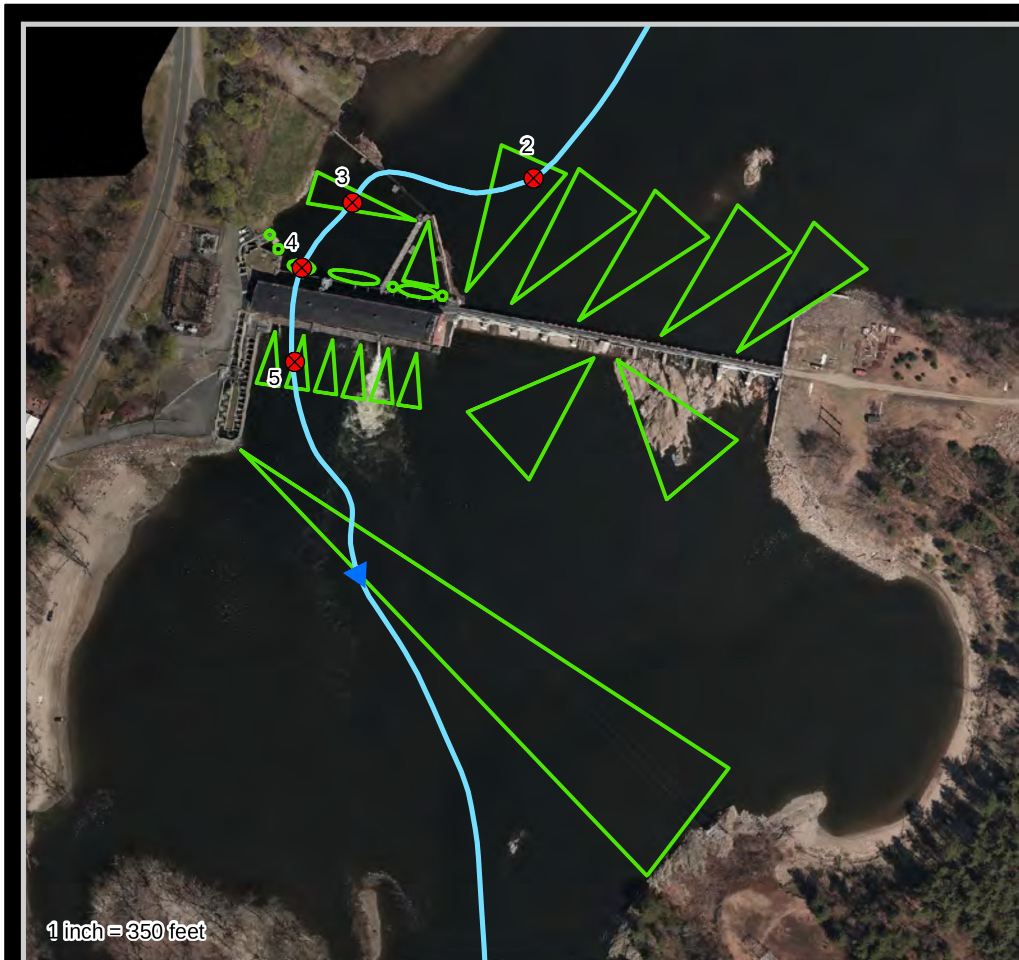

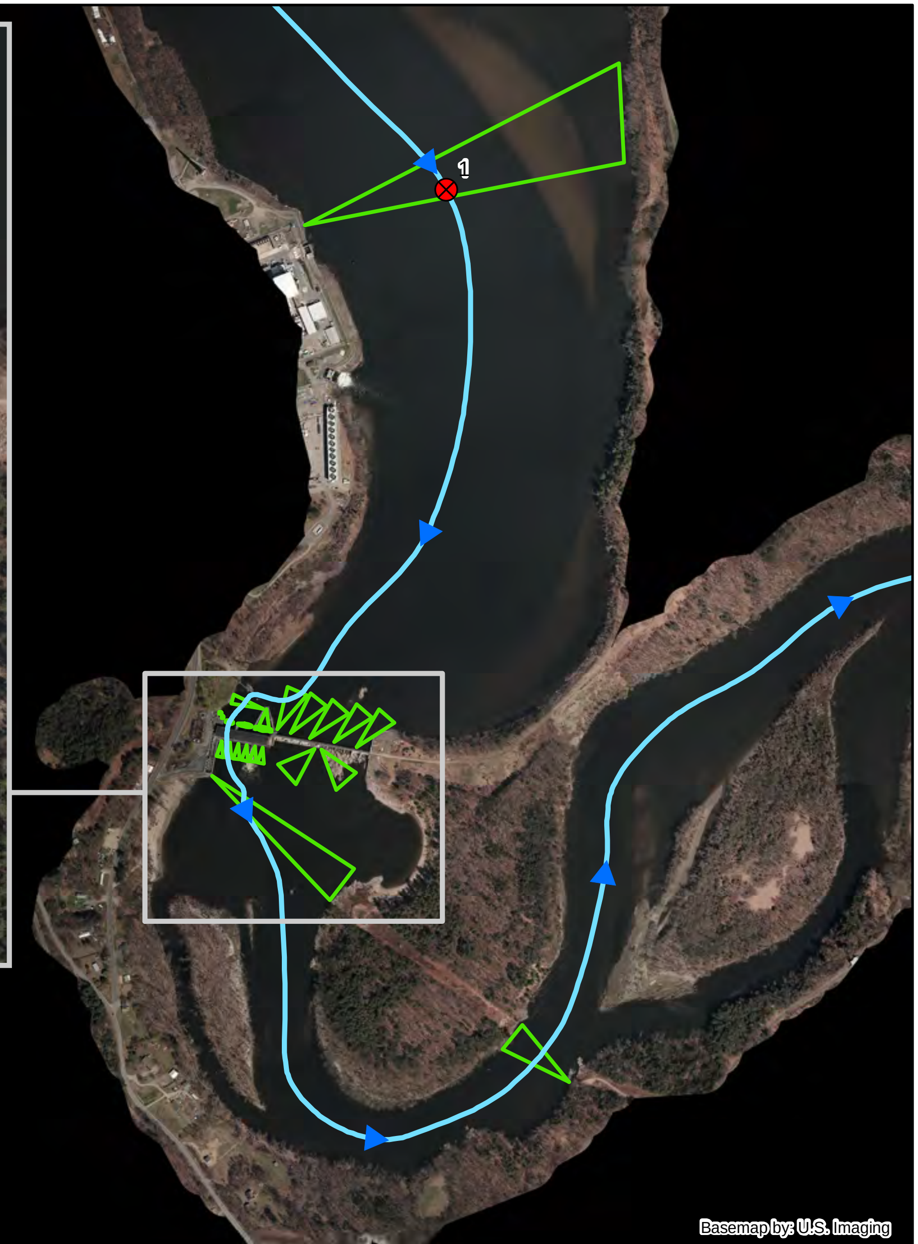

Timetable		
Detection	Date	Time
1	11/10/2015	3:49
2	11/10/2015	17:58
3	11/10/2015	17:58
4	11/10/2015	18:02
5	11/10/2015	18:03

Site Features

- Detection
- Fish Path
- Reciever Zones

TransCanada Hydro Northeast Inc.
ILP Study 19
Vernon Dam

N

1 in = 1,200 feet

0 600 1,200 2,400 Feet

Study 19 Fish Number: 36-119

Release: Herricks Cove, VT
Date Released: 11/3/15
Time Released: 16:45

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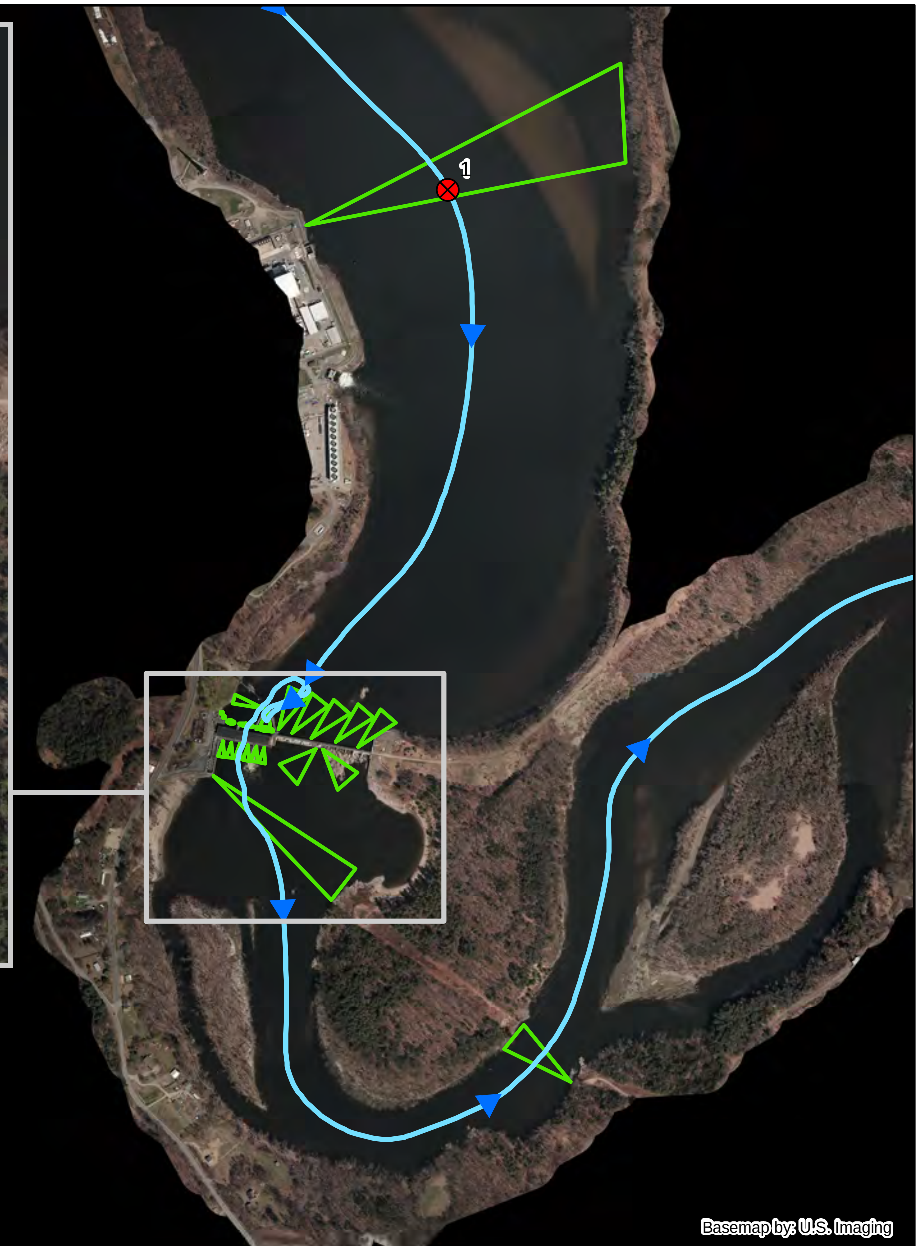

Timetable		
Detection	Date	Time
1	11/7/2015	20:33
2	11/7/2015	21:14
3	11/7/2015	21:16
4	11/7/2015	21:21
5	11/7/2015	21:23
6	11/7/2015	21:23

Site Features

- Detection
- Fish Path
- Reciever Zones

TransCanada Hydro Northeast Inc.
ILP Study 19
Vernon Dam

N

1 in = 1,200 feet

0 600 1,200 2,400 Feet

Study 19 Fish Number: 36-120

Release: Herricks Cove, VT
Date Released: 11/3/15
Time Released: 16:45

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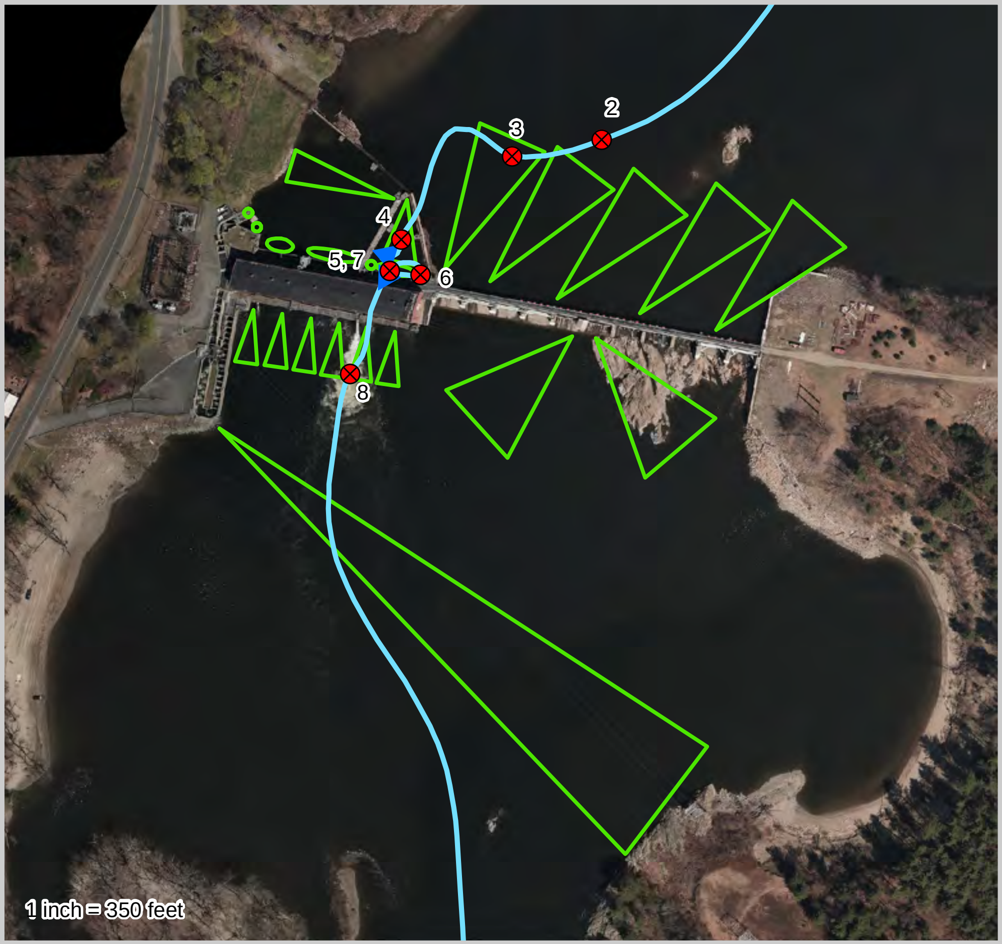

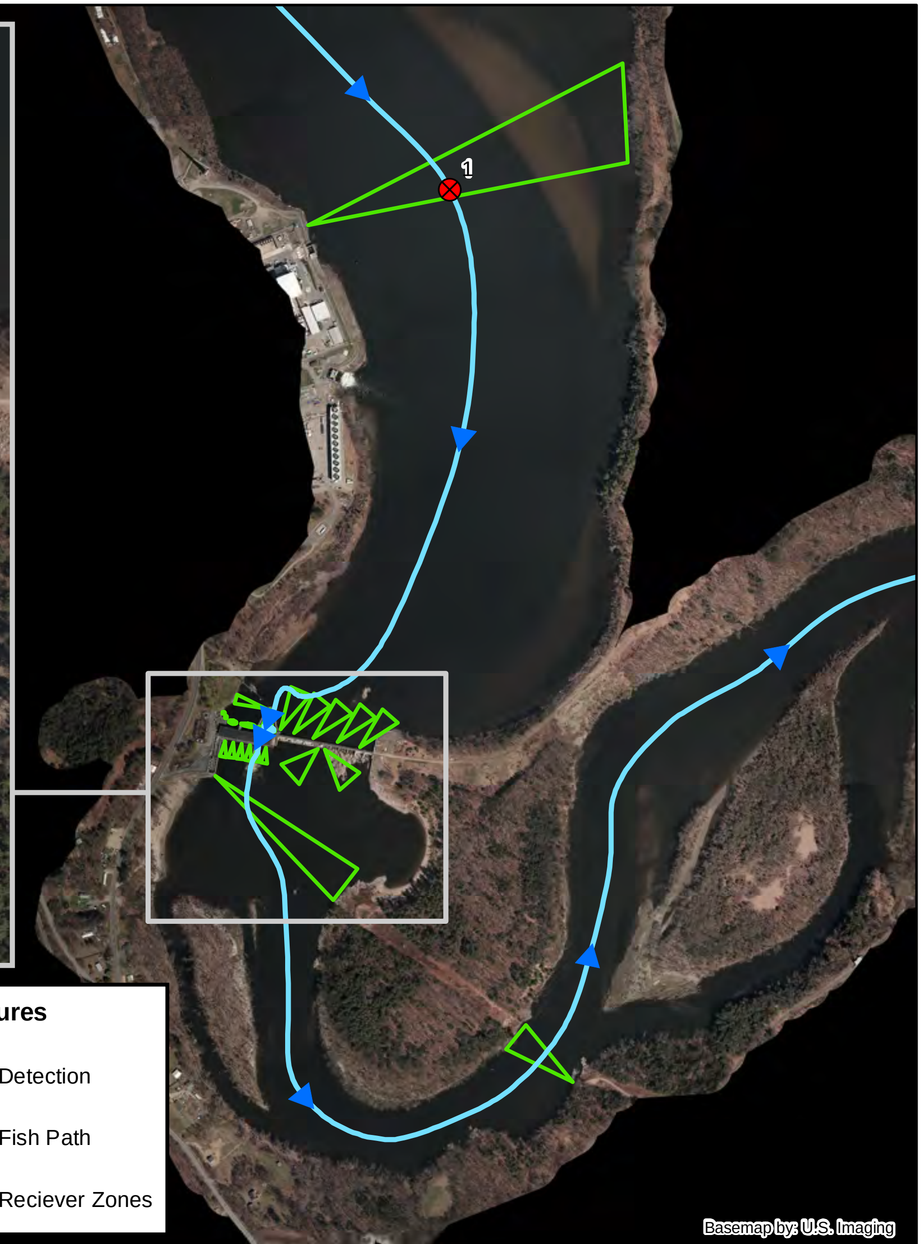

Timetable					
Detection	Date	Time	Detection	Date	Time
1	11/9/2015	22:10	5	11/9/2015	22:46
2	11/9/2015	22:41	6	11/9/2015	22:47
3	11/9/2015	22:42	6	11/9/2015	22:47
4	11/9/2015	22:45	6	11/9/2015	22:50

Site Features

- Detection
- Fish Path
- Reciever Zones

TransCanada Hydro Northeast Inc.
ILP Study 19
Vernon Dam

N

1 in = 1,200 feet

0 600 1,200 2,400 Feet

Study 19 Fish Number: 36-122

Release: Norwich, VT
Date Released: 11/3/15
Time Released: 17:32

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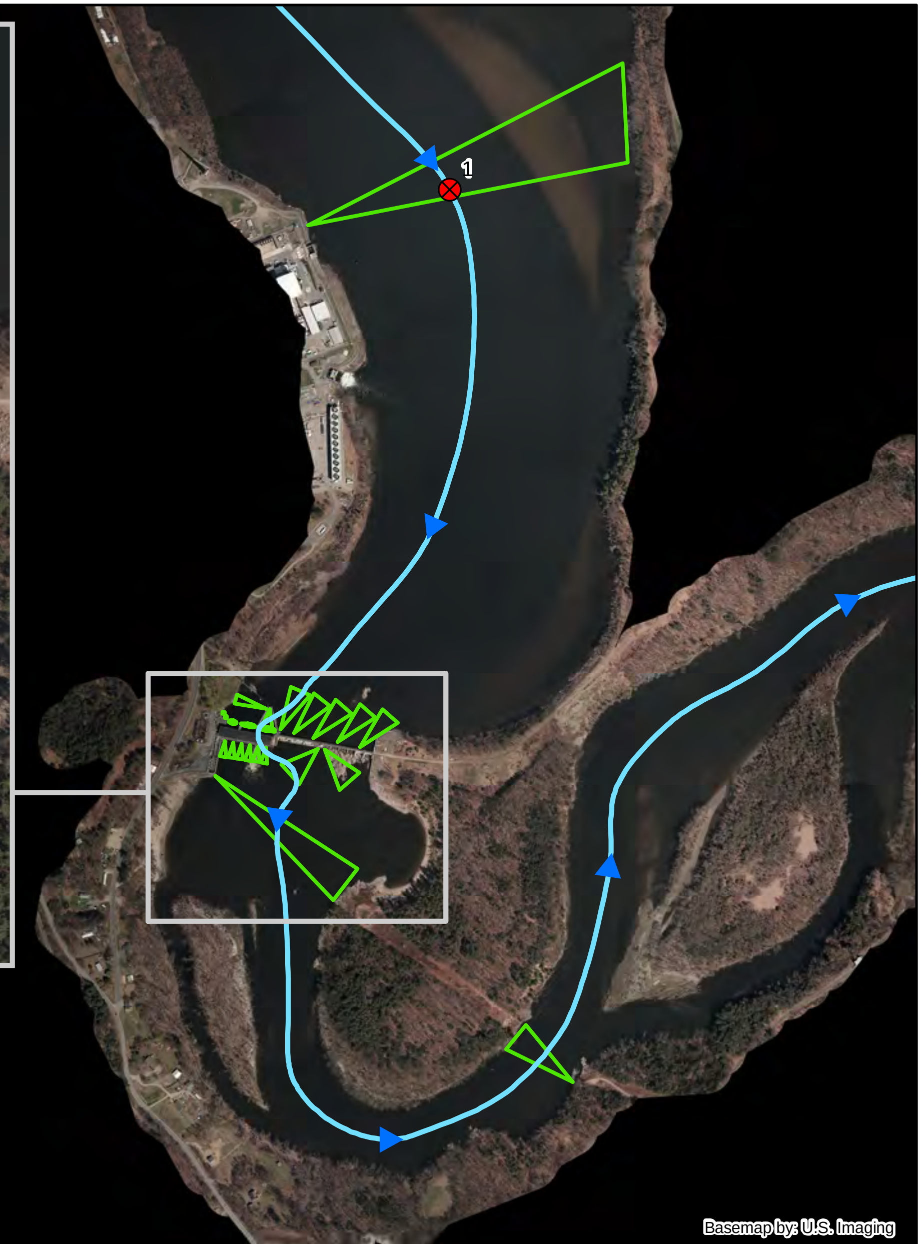

Timetable		
Detection	Date	Time
1	11/11/2015	9:28
2	11/11/2015	10:35
3	11/11/2015	10:36
4	11/11/2015	10:40
5	11/11/2015	10:41

Site Features

- Detection
- Fish Path
- Reciever Zones

TransCanada Hydro Northeast Inc.
ILP Study 19
Vernon Dam

N

1 in = 1,200 feet

0 600 1,200 2,400 Feet

Study 19 Fish Number: 36-123

Release: Norwich, VT
Date Released: 11/3/15
Time Released: 17:32

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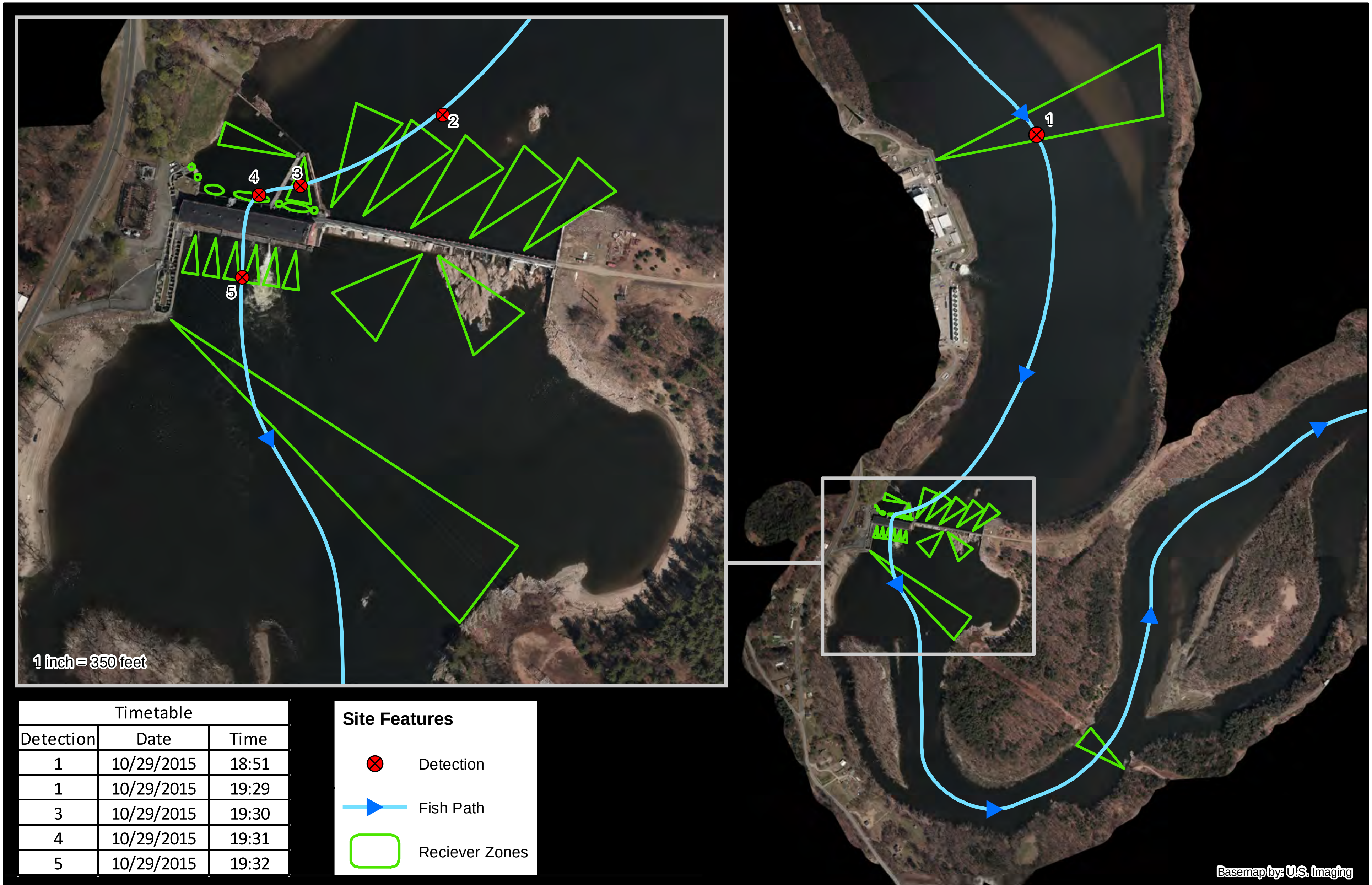

Timetable		
Detection	Date	Time
1	10/29/2015	18:51
1	10/29/2015	19:29
3	10/29/2015	19:30
4	10/29/2015	19:31
5	10/29/2015	19:32

TransCanada Hydro Northeast Inc.
ILP Study 19
Vernon Dam

N

1 in = 1,200 feet

0 600 1,200 2,400 Feet

Study 19 Fish Number: 36-135
Release: Riverside Industrial Complex
Brattleboro, VT
Date Released: 10/29/15
Time Released: 13:05

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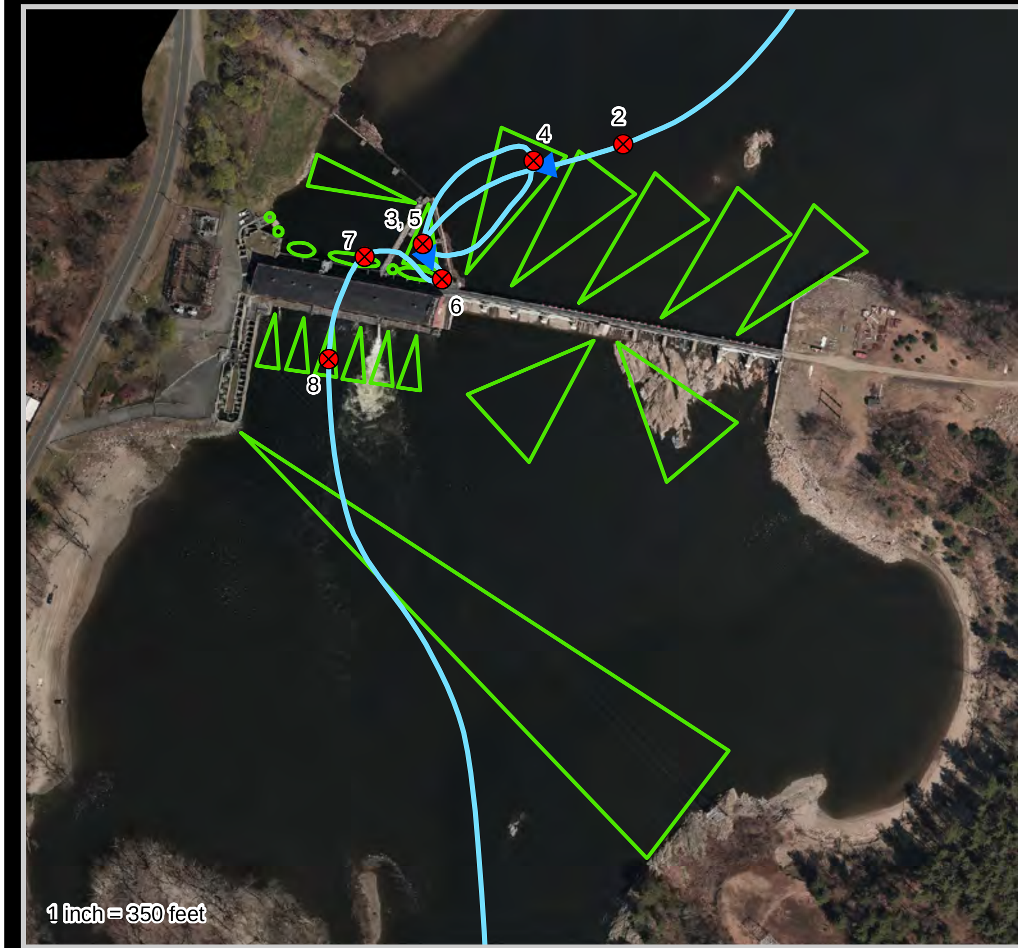

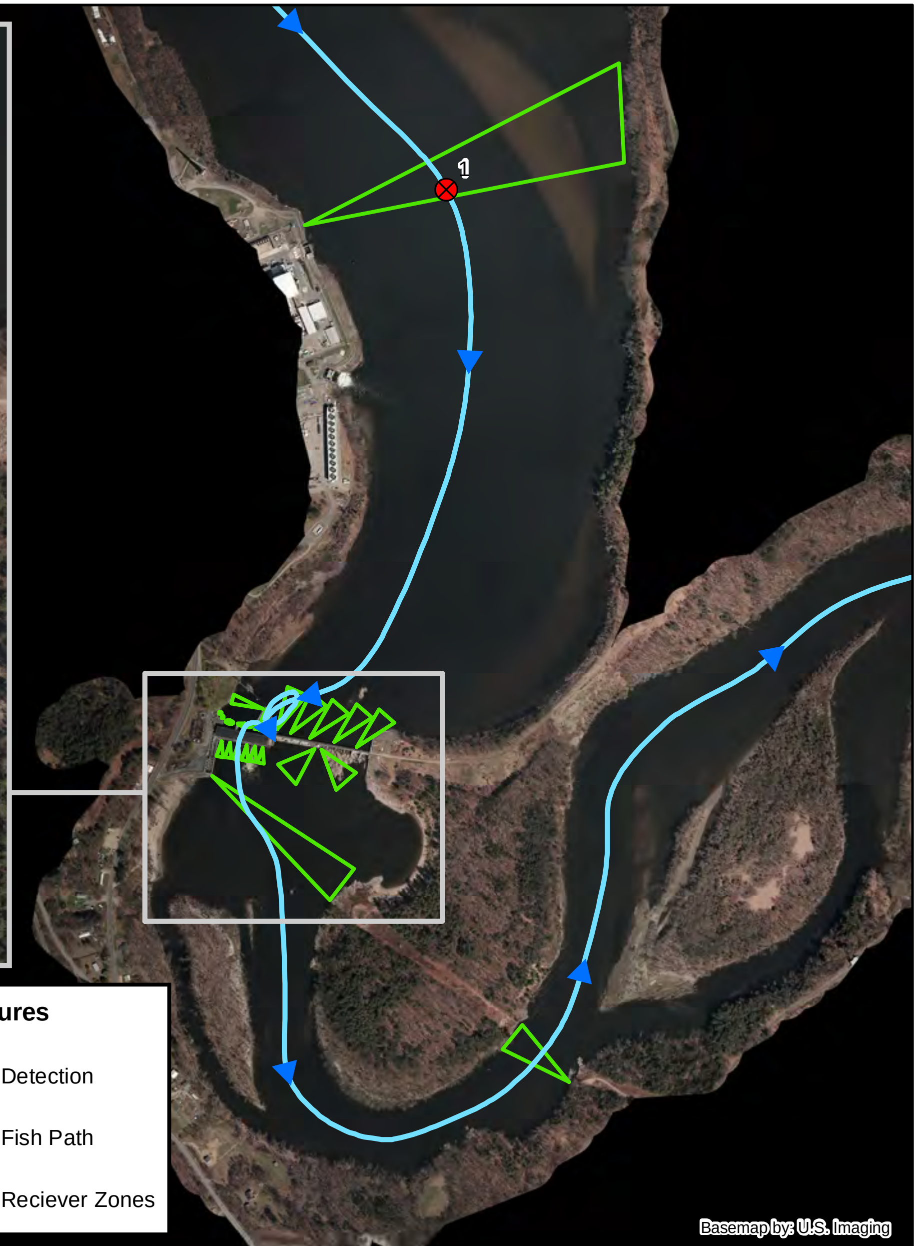

Timetable					
Detection	Date	Time	Detection	Date	Time
1	10/29/2015	18:26	5	10/29/2015	18:59
2	10/29/2015	18:54	6	10/29/2015	18:59
3	10/29/2015	18:57	7	10/29/2015	19:00
4	10/29/2015	18:58	8	10/29/2015	19:00

Site Features

Detection

Fish Path

Reciever Zones

TransCanada Hydro Northeast Inc.
ILP Study 19
Vernon Dam

N

1 in = 1,200 feet

0 600 1,200 2,400 Feet

Study 19 Fish Number: 36-136
Release: Riverside Industrial Complex
Brattleboro, VT
Date Released: 10/29/15
Time Released: 13:05

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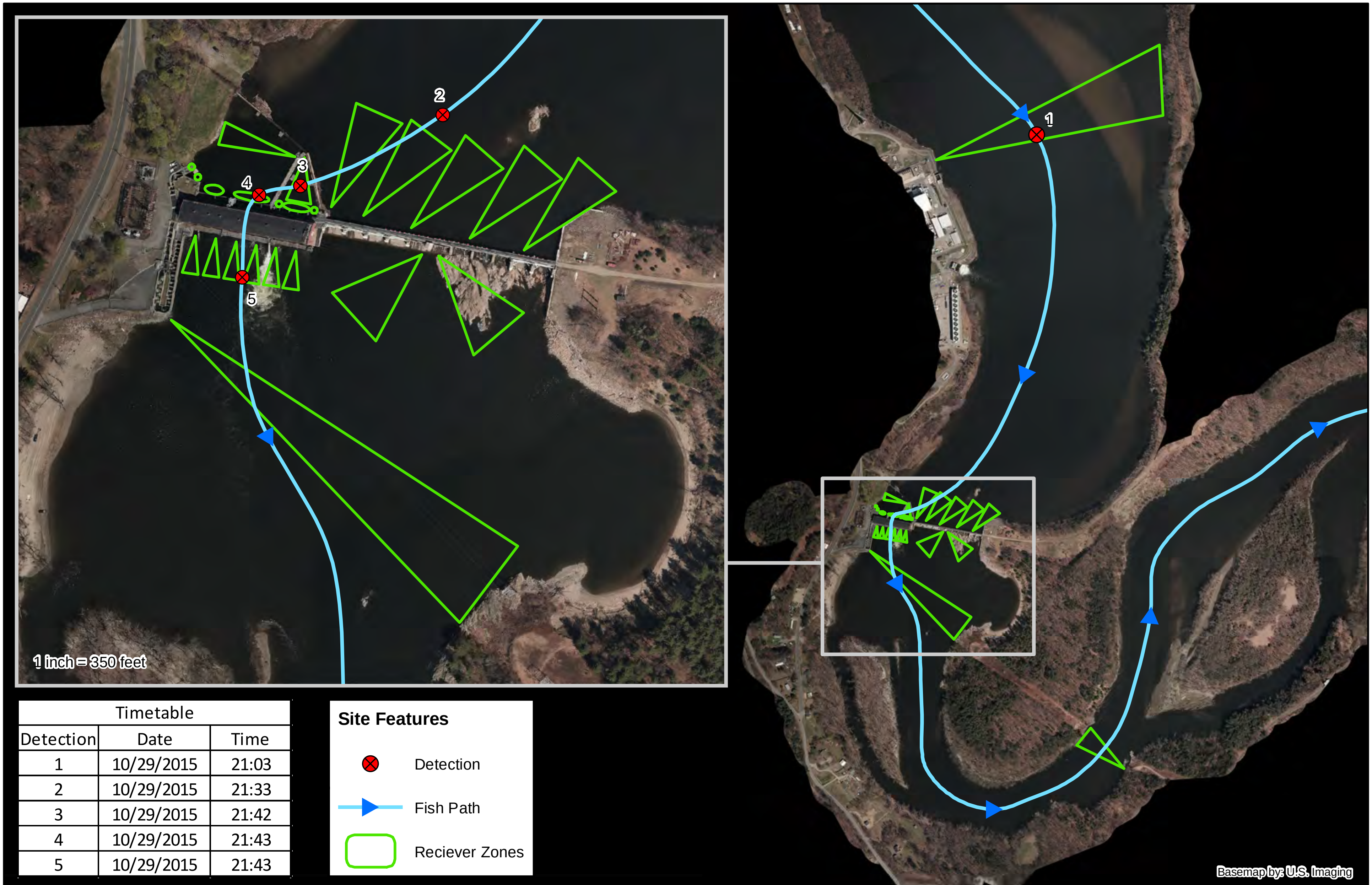

Timetable		
Detection	Date	Time
1	10/29/2015	21:03
2	10/29/2015	21:33
3	10/29/2015	21:42
4	10/29/2015	21:43
5	10/29/2015	21:43

Site Features

- Detection
- Fish Path
- Reciever Zones

TransCanada Hydro Northeast Inc.
ILP Study 19
Vernon Dam

1 in = 1,200 feet

0 600 1,200 2,400 Feet

Study 19 Fish Number: 36-137
Release: Riverside Industrial Complex
Brattleboro, VT
Date Released: 10/29/15
Time Released: 13:05

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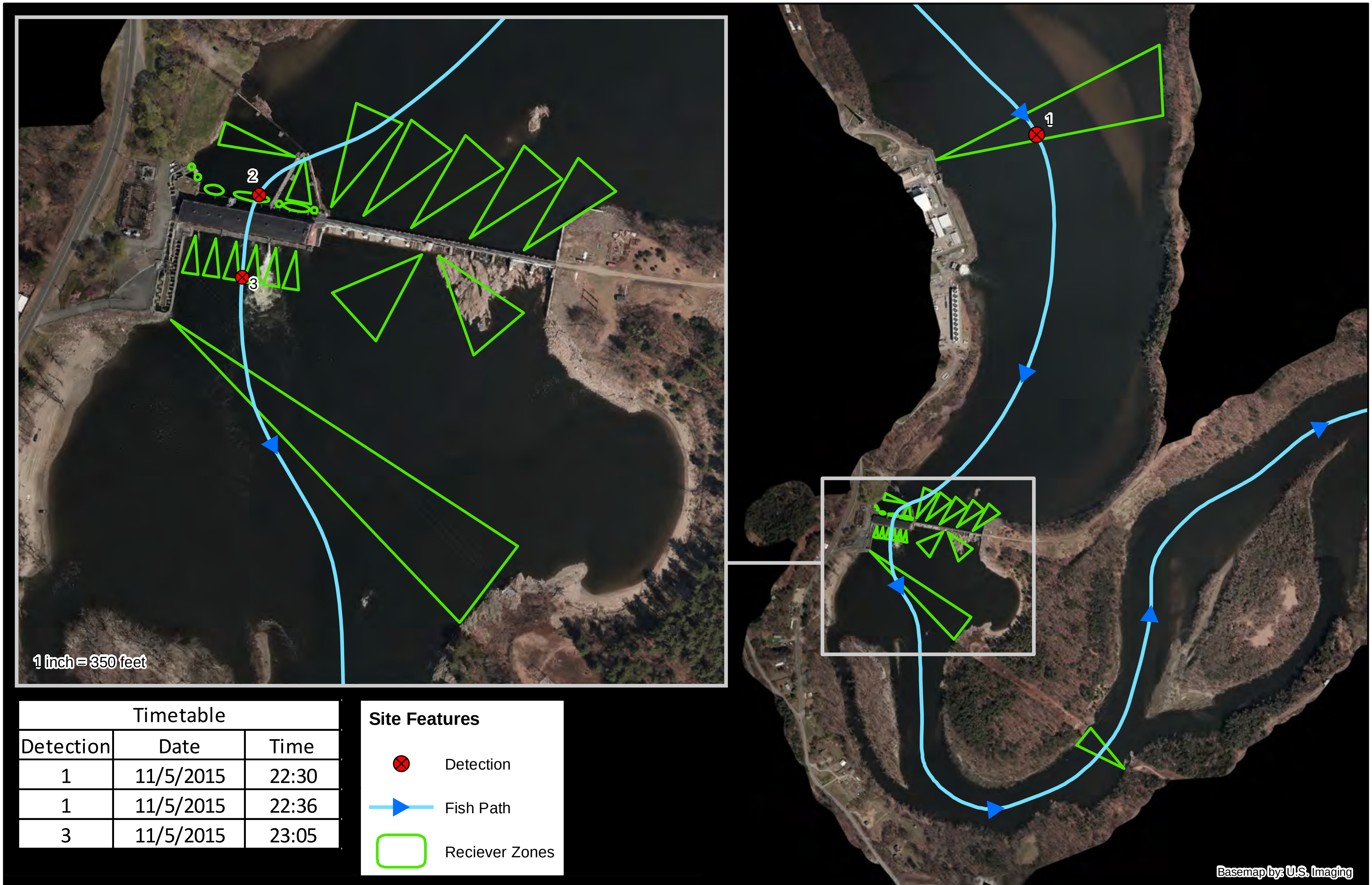

Timetable		
Detection	Date	Time
1	11/5/2015	22:30
1	11/5/2015	22:36
3	11/5/2015	23:05

Site Features

- Detection
- Fish Path
- Reciever Zones

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TransCanada Hydro Northeast Inc.
ILP Study 19
Vernon Dam

1 in = 1,200 feet

0 600 1,200 2,400 Feet

Study 19 Fish Number: 36-138
Release: Riverside Industrial Complex
Brattleboro, VT
Date Released: 11/5/15
Time Released: 15:35

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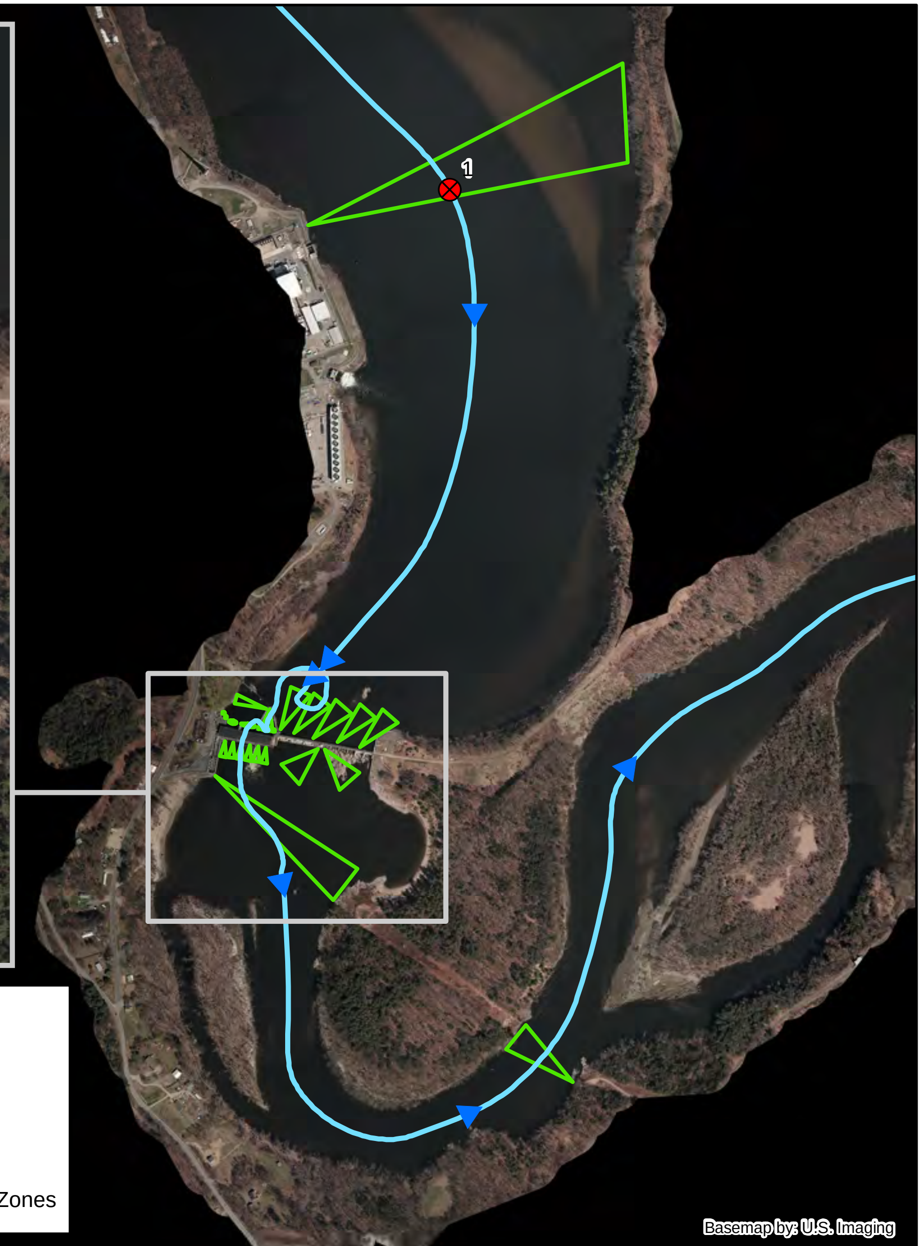

Timetable					
Detection	Date	Time	Detection	Date	Time
1	11/8/2015	20:18	5	11/8/2015	21:08
2	11/8/2015	20:57	6	11/8/2015	21:08
3	11/8/2015	21:02	7	11/8/2015	21:12
4	11/8/2015	21:07			

Site Features

- Detection
- Fish Path
- Reciever Zones

TransCanada Hydro Northeast Inc.
ILP Study 19
Vernon Dam

N

1 in = 1,200 feet

0 600 1,200 2,400 Feet

Study 19 Fish Number: 36-139
Release: Riverside Industrial Complex
Brattleboro, VT
Date Released: 11/5/15
Time Released: 15:35

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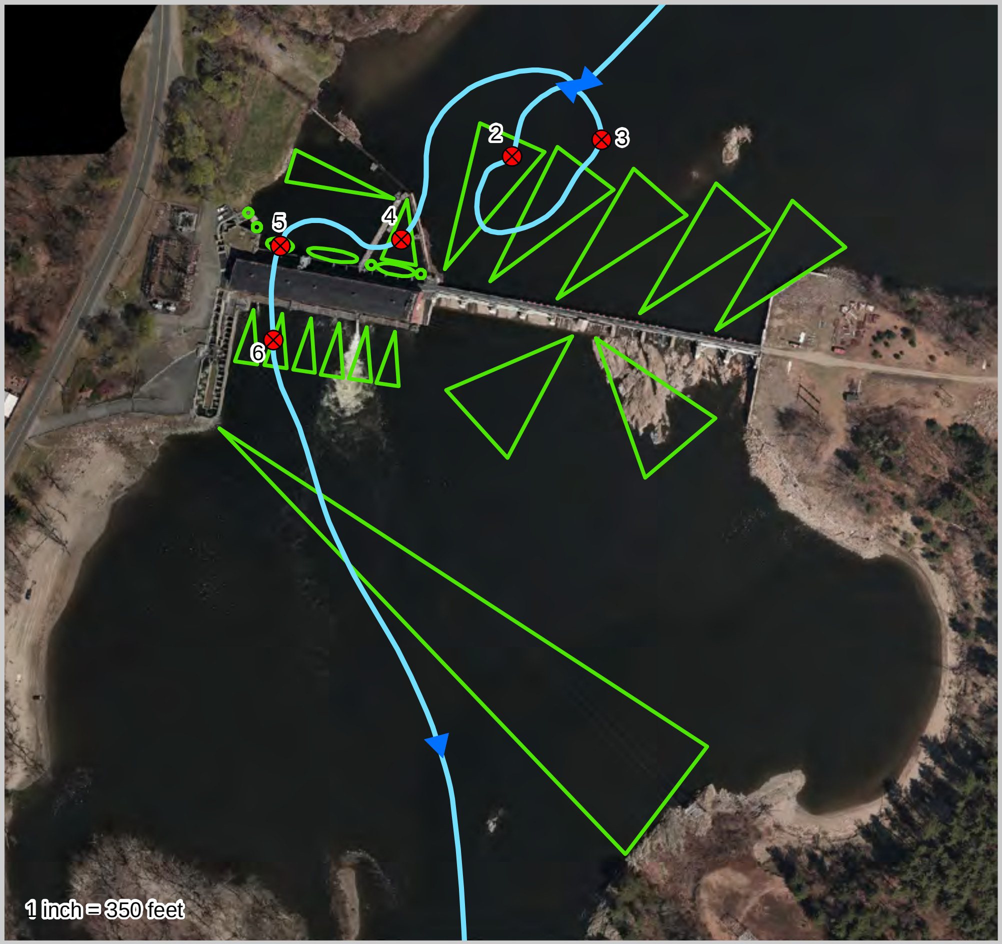

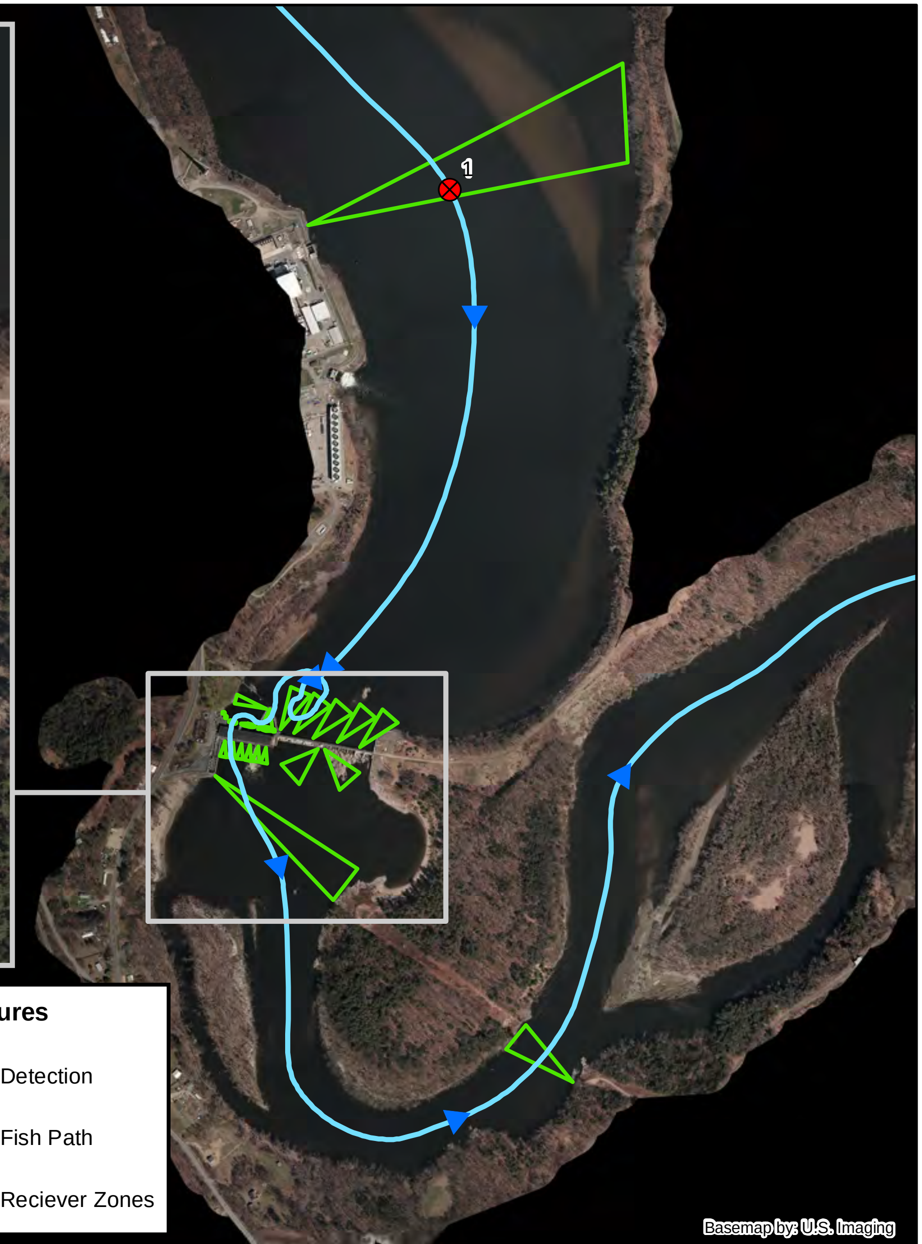

Timetable					
Detection	Date	Time	Detection	Date	Time
1	11/7/2015	23:42	4	11/8/2015	0:30
2	11/8/2015	0:22	5	11/8/2015	0:36
3	11/8/2015	0:25	6	11/8/2015	0:42

Site Features

- Detection
- Fish Path
- Reciever Zones

TransCanada Hydro Northeast Inc.
ILP Study 19
Vernon Dam

N

1 in = 1,200 feet

0 600 1,200 2,400 Feet

Study 19 Fish Number: 36-140
Release: Riverside Industrial Complex
Brattleboro, VT
Date Released: 11/5/15
Time Released: 15:35

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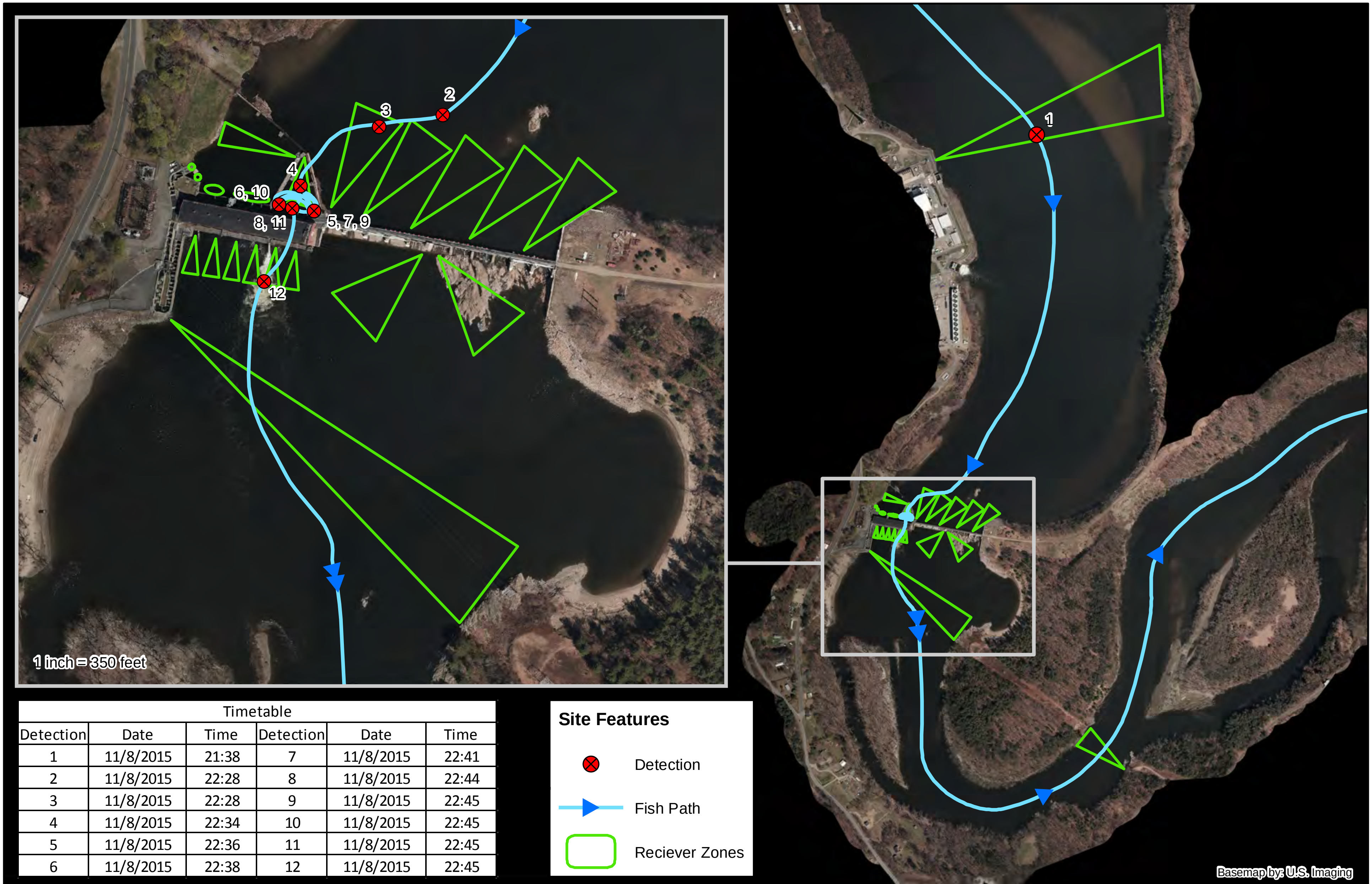

Detection	Date	Time	Detection	Date	Time
1	11/8/2015	21:38	7	11/8/2015	22:41
2	11/8/2015	22:28	8	11/8/2015	22:44
3	11/8/2015	22:28	9	11/8/2015	22:45
4	11/8/2015	22:34	10	11/8/2015	22:45
5	11/8/2015	22:36	11	11/8/2015	22:45
6	11/8/2015	22:38	12	11/8/2015	22:45

Timetable

Site Features

- Detection
- Fish Path
- Reciever Zones

TransCanada Hydro Northeast Inc.
ILP Study 19
Vernon Dam

1 in = 1,200 feet

0 600 1,200 2,400 Feet

Study 19 Fish Number: 36-141

Release: Herricks Cove, VT
Date Released: 11/5/15
Time Released: 16:20

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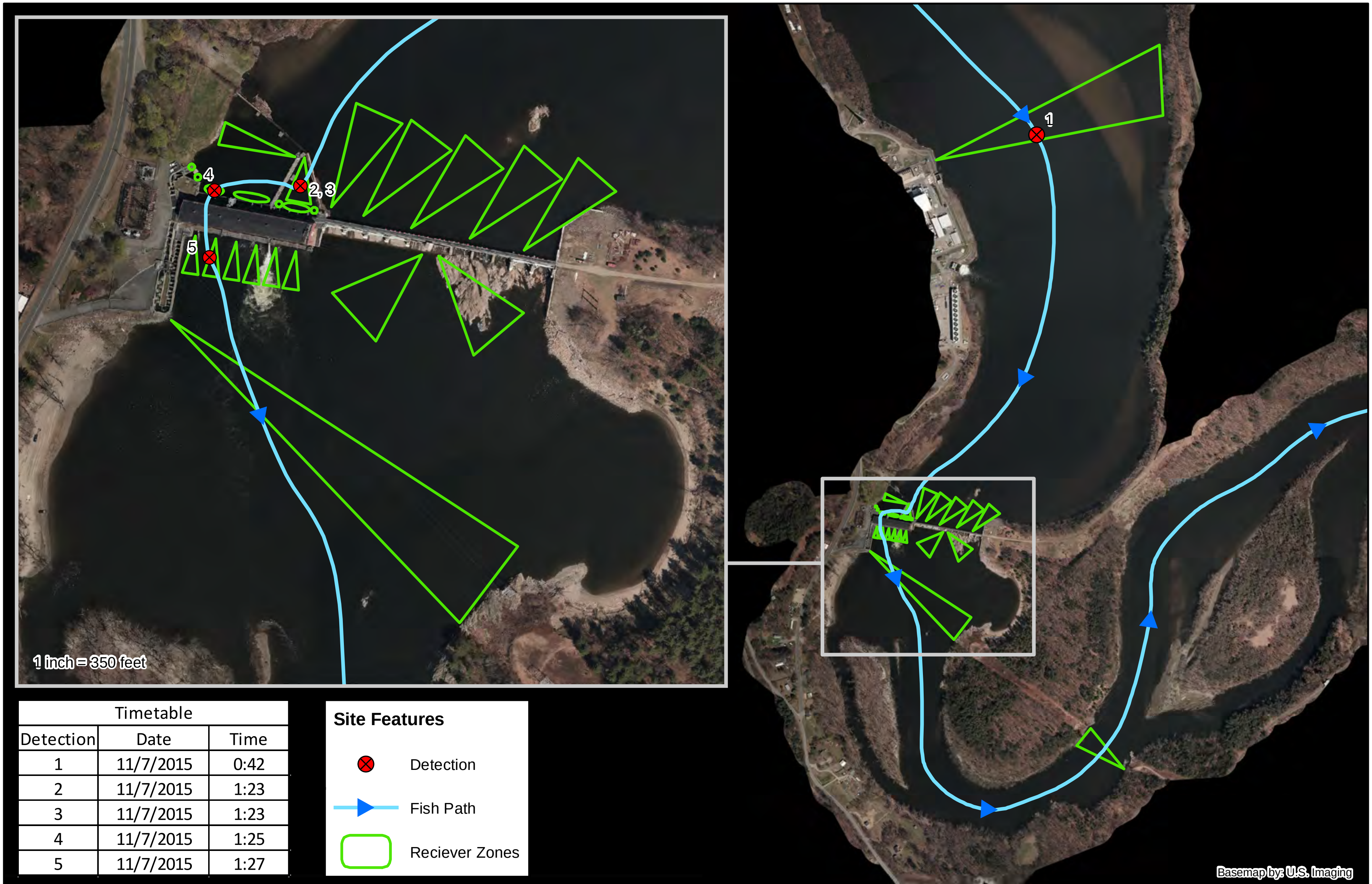

Timetable		
Detection	Date	Time
1	11/7/2015	0:42
2	11/7/2015	1:23
3	11/7/2015	1:23
4	11/7/2015	1:25
5	11/7/2015	1:27

Site Features

- Detection
- Fish Path
- Reciever Zones

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TransCanada Hydro Northeast Inc.
ILP Study 19
Vernon Dam

N

1 in = 1,200 feet

0 600 1,200 2,400 Feet

Study 19 Fish Number: 36-144

Release: Herricks Cove, VT
Date Released: 10/29/15
Time Released: 17:52

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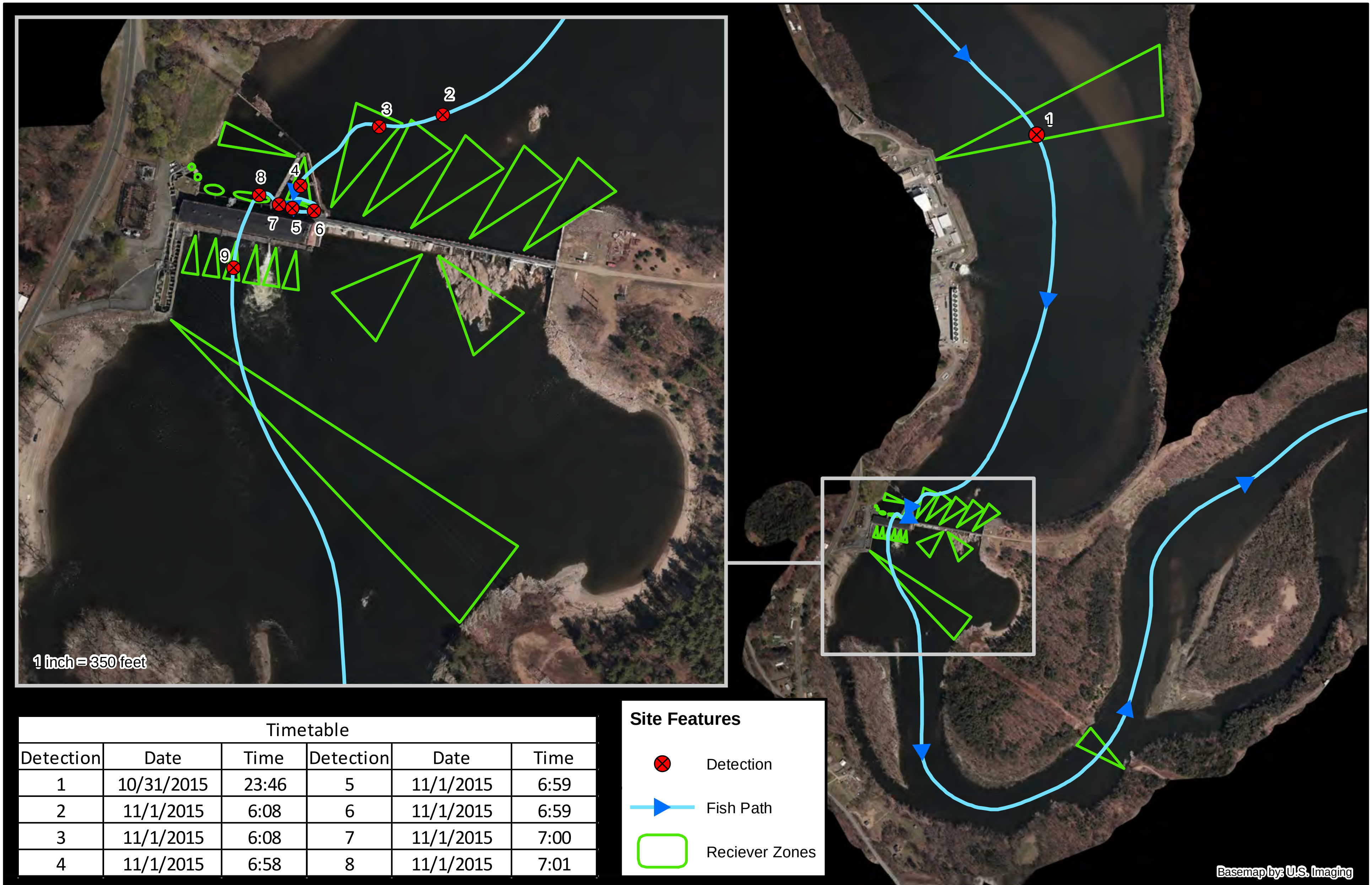
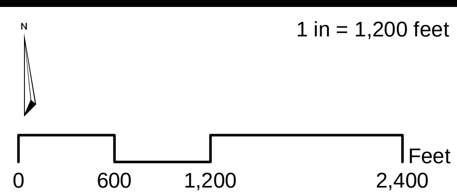


Timetable					
Detection	Date	Time	Detection	Date	Time
1	10/31/2015	23:46	5	11/1/2015	6:59
2	11/1/2015	6:08	6	11/1/2015	6:59
3	11/1/2015	6:08	7	11/1/2015	7:00
4	11/1/2015	6:58	8	11/1/2015	7:01

Site Features

- Detection
- Fish Path
- Reciever Zones

TransCanada Hydro Northeast Inc.
ILP Study 19
Vernon Dam



Study 19 Fish Number: 36-146

Release: Herricks Cove, VT
Date Released: 10/29/15
Time Released: 17:52

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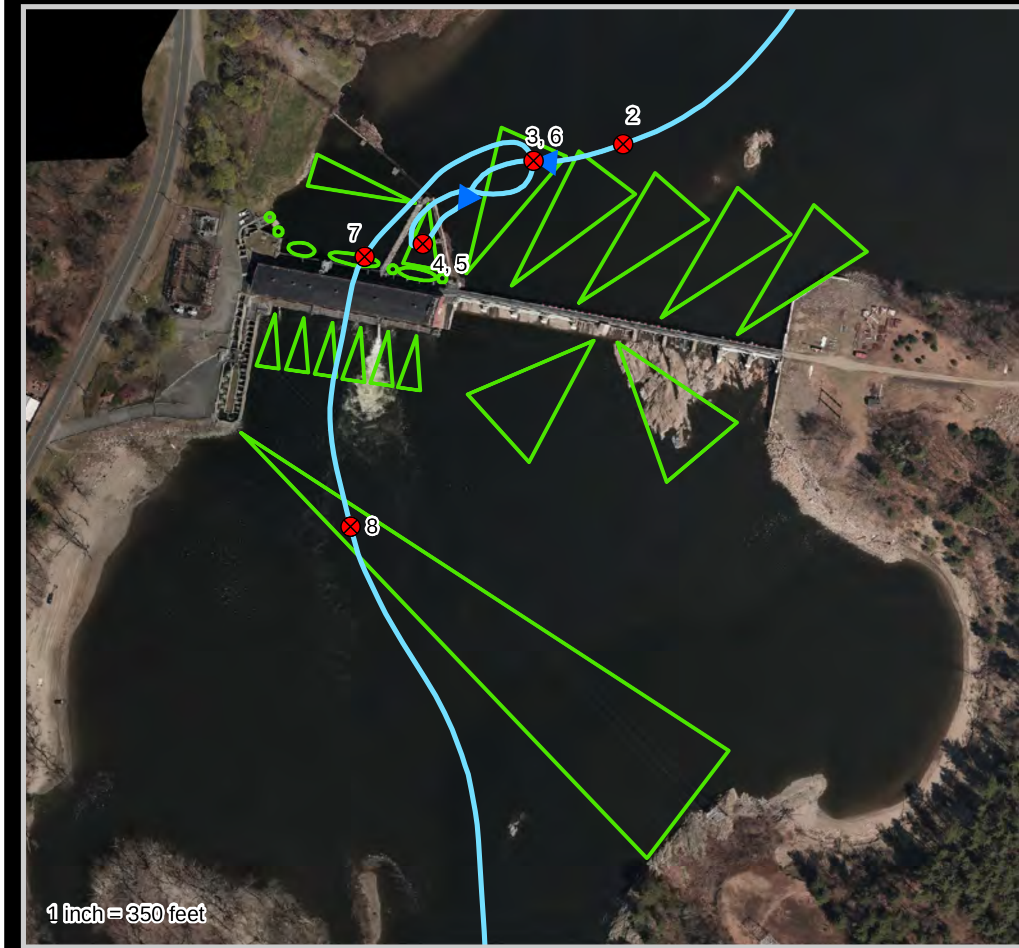

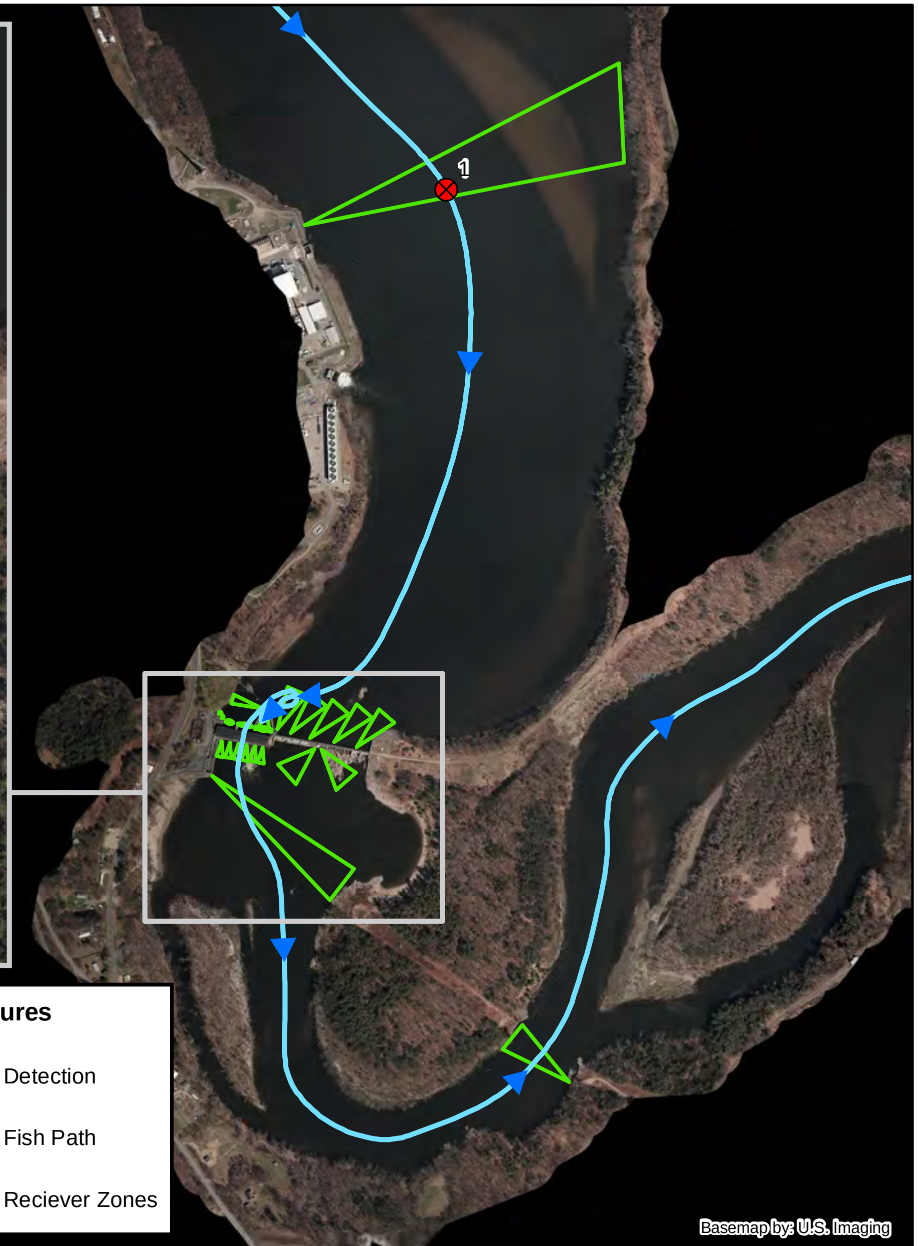

Timetable					
Detection	Date	Time	Detection	Date	Time
1	11/20/2015	19:47	5	11/20/2015	20:41
2	11/20/2015	20:26	6	11/20/2015	20:42
3	11/20/2015	20:36	7	11/20/2015	20:43
4	11/20/2015	20:40	8	11/20/2015	20:44

Site Features

- Detection
- Fish Path
- Reciever Zones

TransCanada Hydro Northeast Inc.
ILP Study 19
Vernon Dam

N

1 in = 1,200 feet

0 600 1,200 2,400 Feet

Study 19 Fish Number: 36-147

Release: Herricks Cove, VT
Date Released: 10/29/15
Time Released: 17:52

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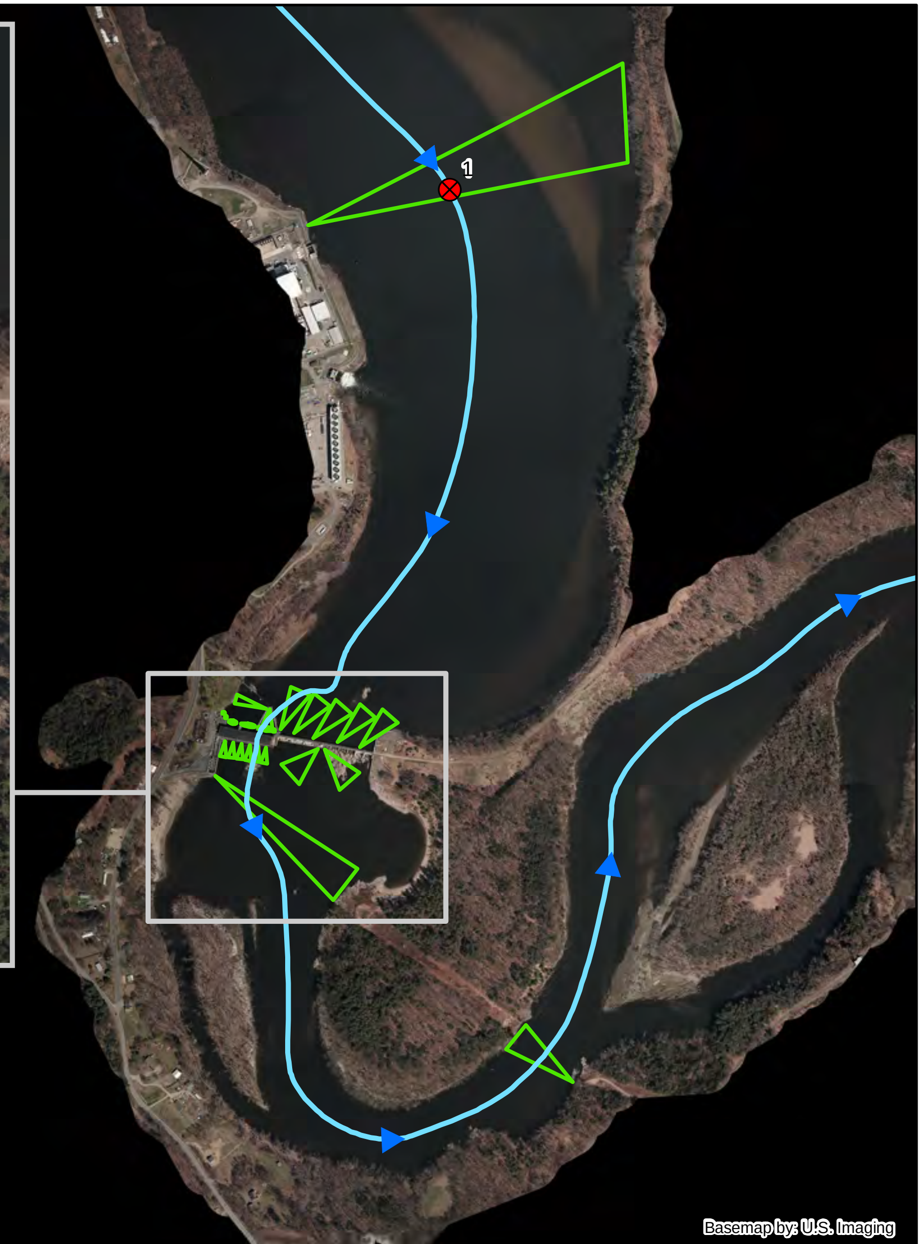

Timetable		
Detection	Date	Time
1	11/5/2015	23:14
2	11/5/2015	23:56
3	11/6/2015	0:00
4	11/6/2015	0:01
5	11/6/2015	0:05

Site Features

- Detection
- Fish Path
- Reciever Zones

TransCanada Hydro Northeast Inc.
ILP Study 19
Vernon Dam

N

1 in = 1,200 feet

0 600 1,200 2,400 Feet

Study 19 Fish Number: 36-155

Release: Norwich, VT
Date Released: 10/29/15
Time Released: 18:43

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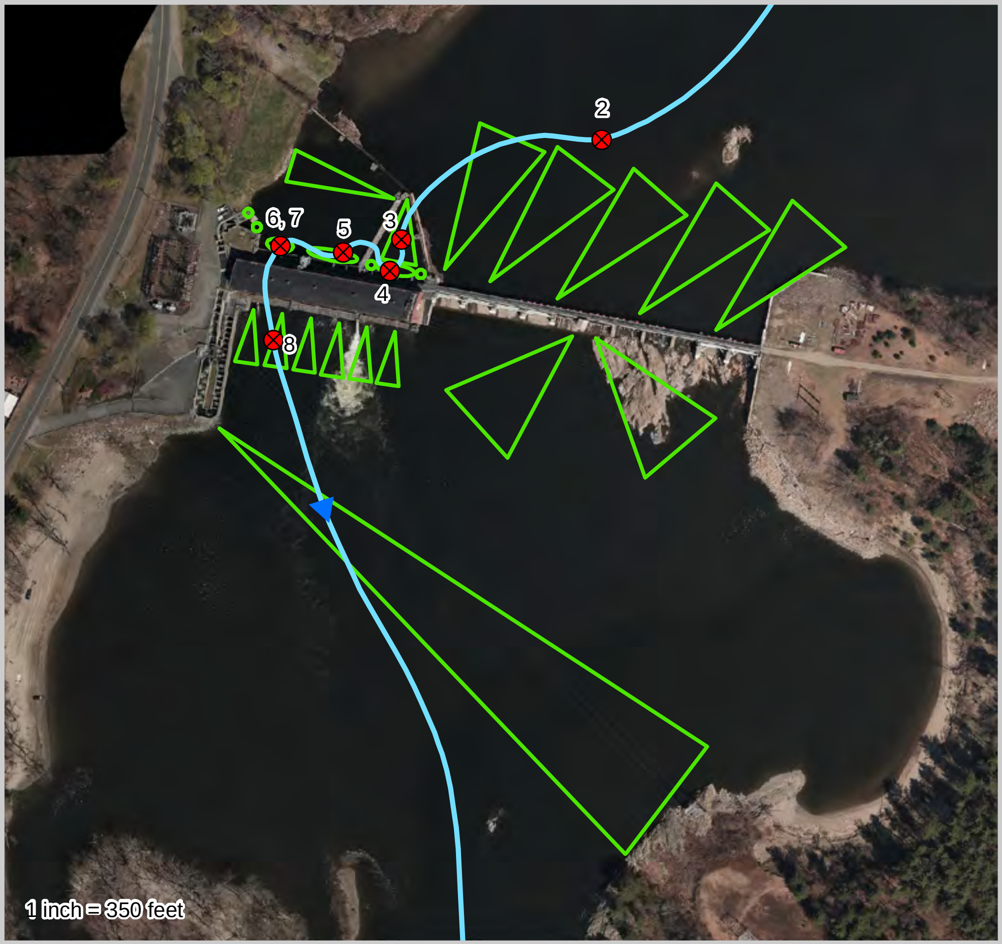

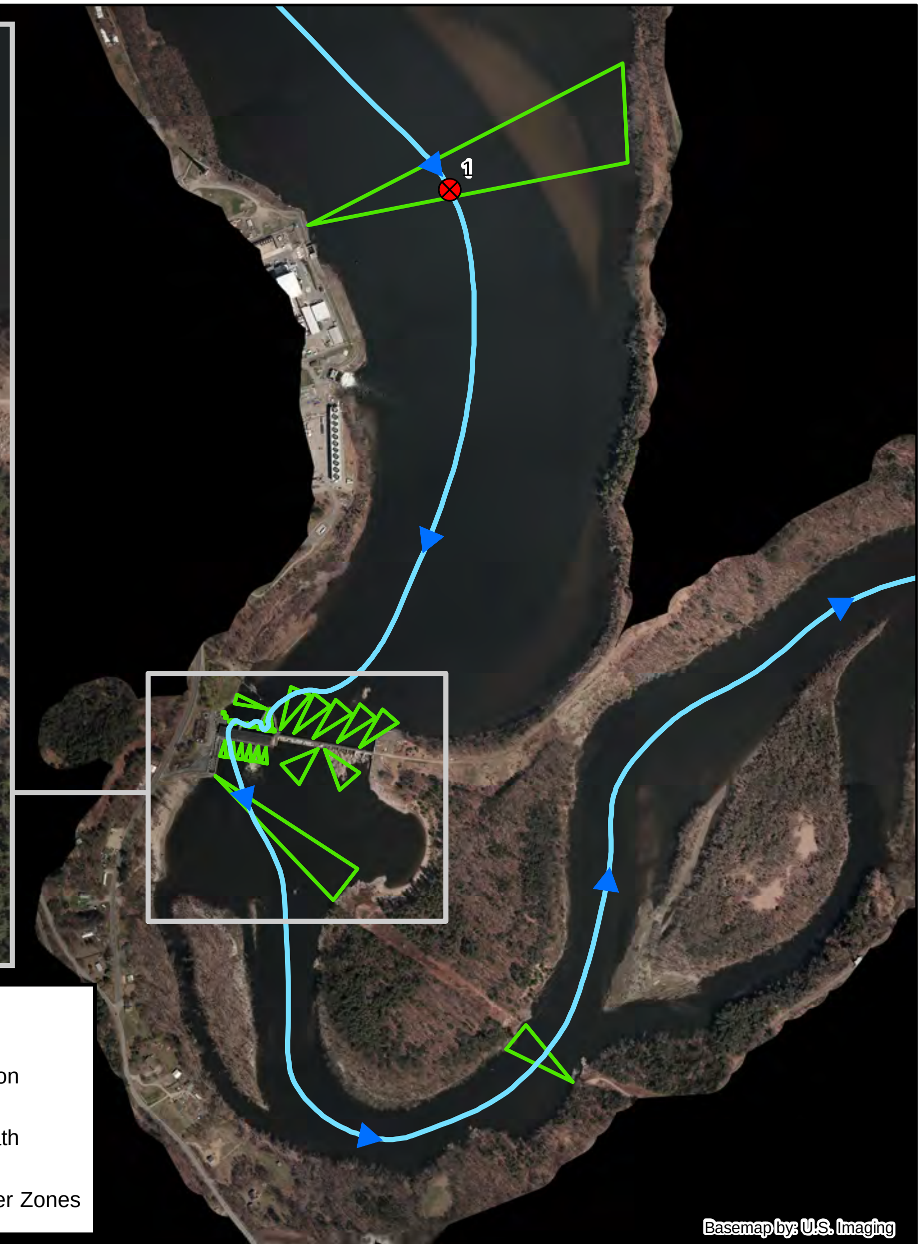

Timetable					
Detection	Date	Time	Detection	Date	Time
1	11/4/2015	4:44	5	11/4/2015	6:06
2	11/4/2015	5:52	6	11/4/2015	6:08
3	11/4/2015	6:00	7	11/4/2015	6:11
4	11/4/2015	6:04	8	11/4/2015	6:11

Site Features

- Detection
- Fish Path
- Reciever Zones

TransCanada Hydro Northeast Inc.
ILP Study 19
Vernon Dam

N

1 in = 1,200 feet

0 600 1,200 2,400 Feet

Study 19 Fish Number: 36-156

Release:Norwich, VT
Date Released: 10/29/15
Time Released: 18:43

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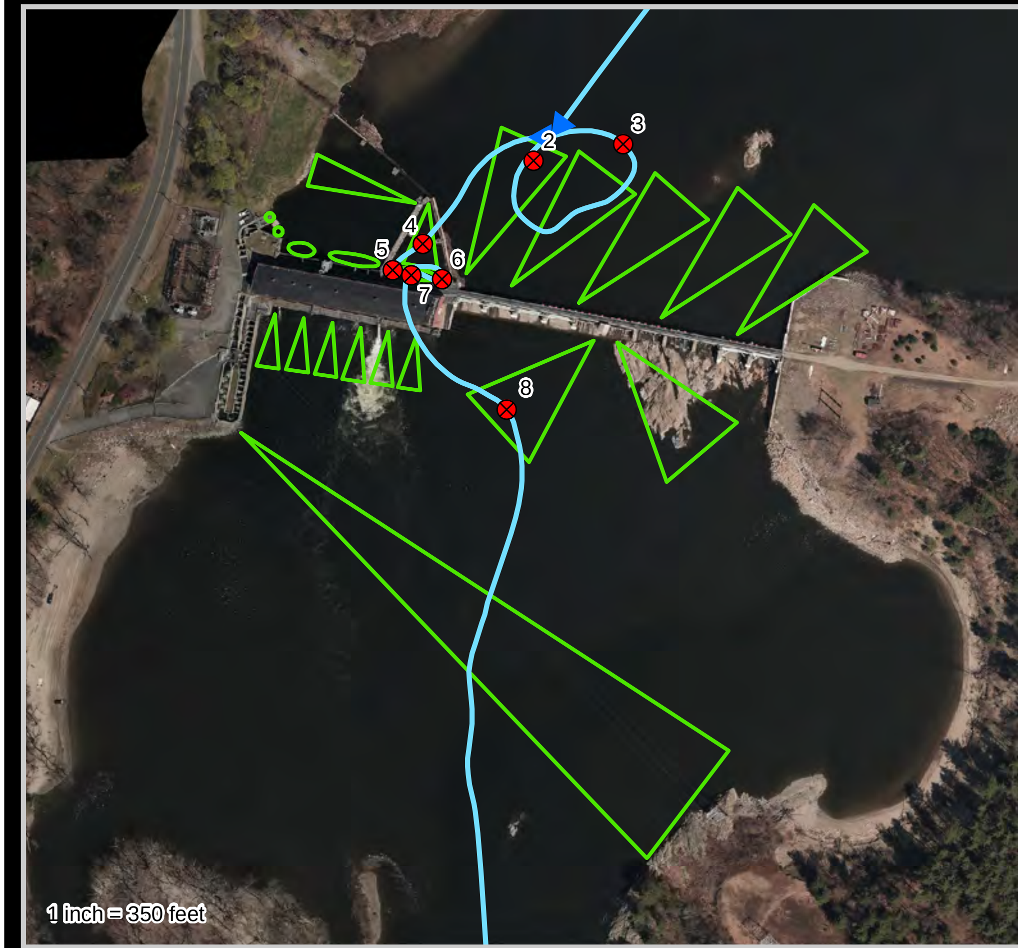

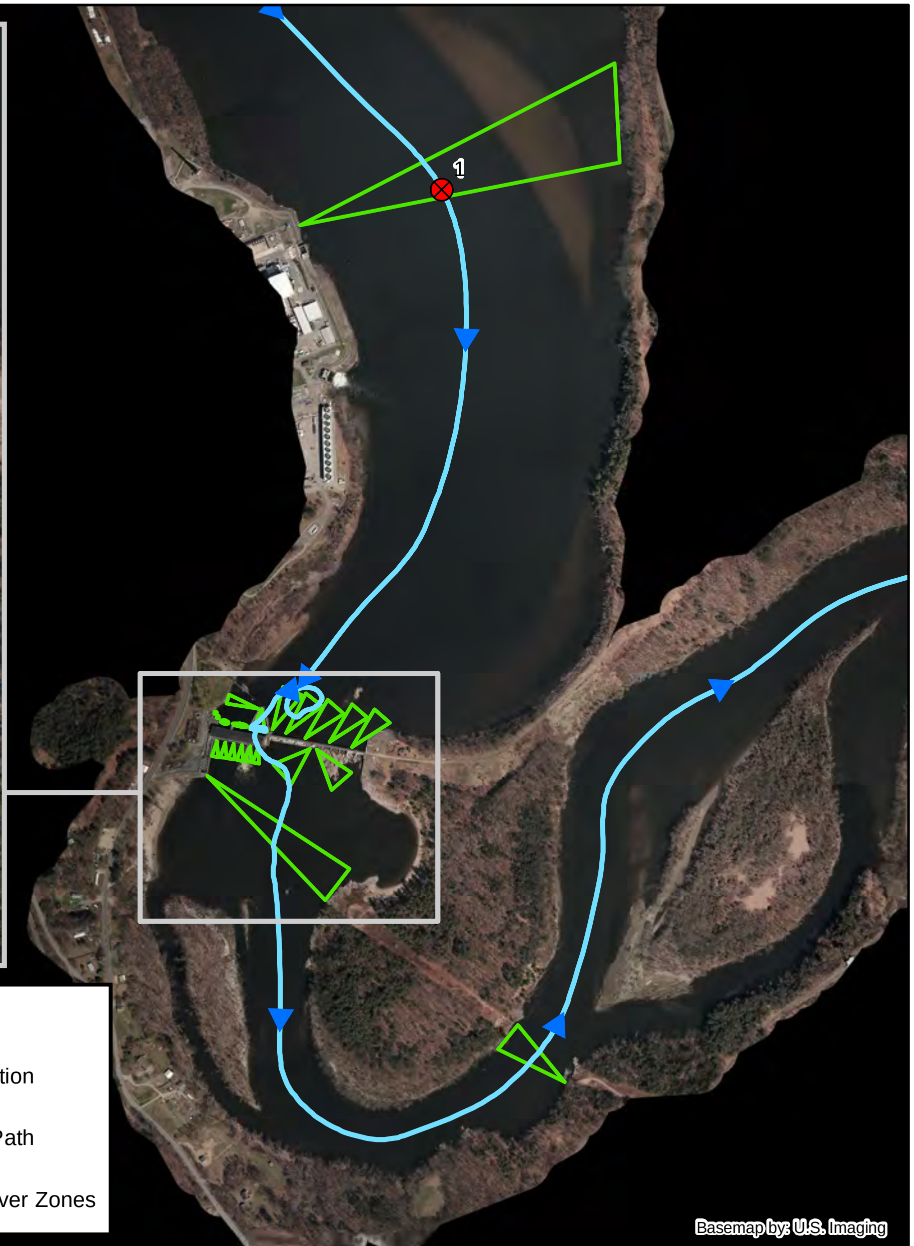

Timetable					
Detection	Date	Time	Detection	Date	Time
1	11/12/2015	17:50	5	11/12/2015	18:45
2	11/12/2015	18:34	6	11/12/2015	18:45
3	11/12/2015	18:35	7	11/12/2015	18:45
4	11/12/2015	18:40	8	11/12/2015	18:45

Site Features

- Detection
- Fish Path
- Reciever Zones

TransCanada Hydro Northeast Inc.
ILP Study 19
Vernon Dam

N

1 in = 1,200 feet

0 600 1,200 2,400 Feet

Study 19 Fish Number: 36-158

Release: Norwich, VT
Date Released: 11/5/15
Time Released: 17:05

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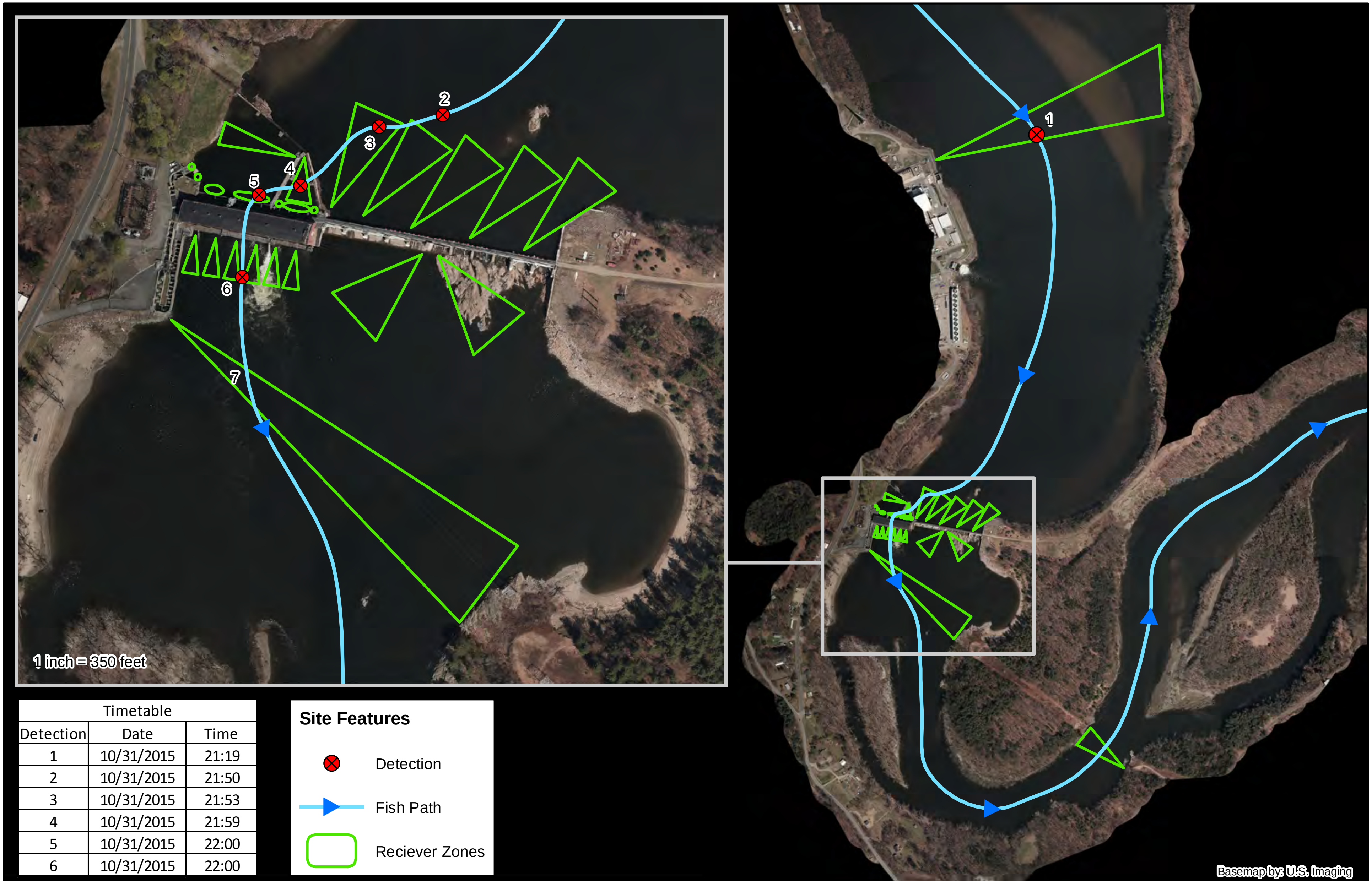

Timetable		
Detection	Date	Time
1	10/31/2015	21:19
2	10/31/2015	21:50
3	10/31/2015	21:53
4	10/31/2015	21:59
5	10/31/2015	22:00
6	10/31/2015	22:00

Site Features

- Detection
- Fish Path
- Reciever Zones

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TransCanada Hydro Northeast Inc.
ILP Study 19
Vernon Dam

N

1 in = 1,200 feet

0 600 1,200 2,400 Feet

Study 19 Fish Number: 36-164
Release: Riverside Industrial Complex
Brattleboro, VT
Date Released: 10/31/15
Time Released: 13:40

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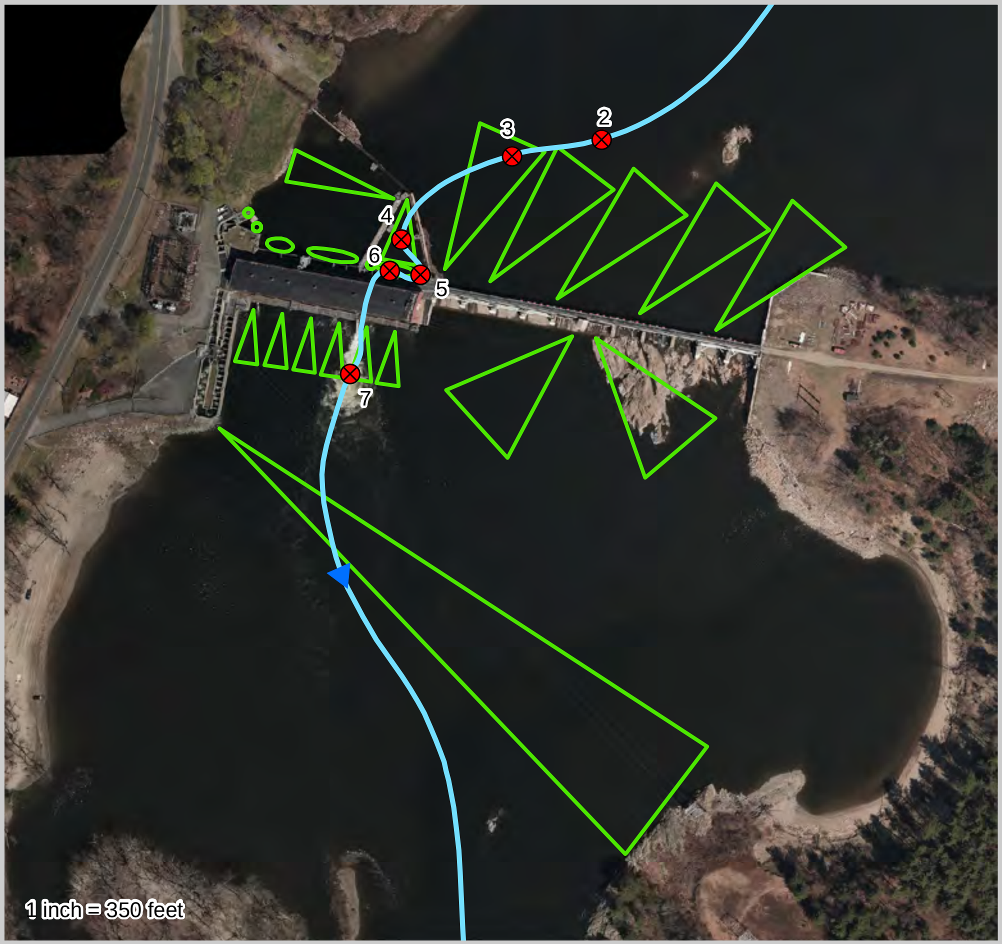

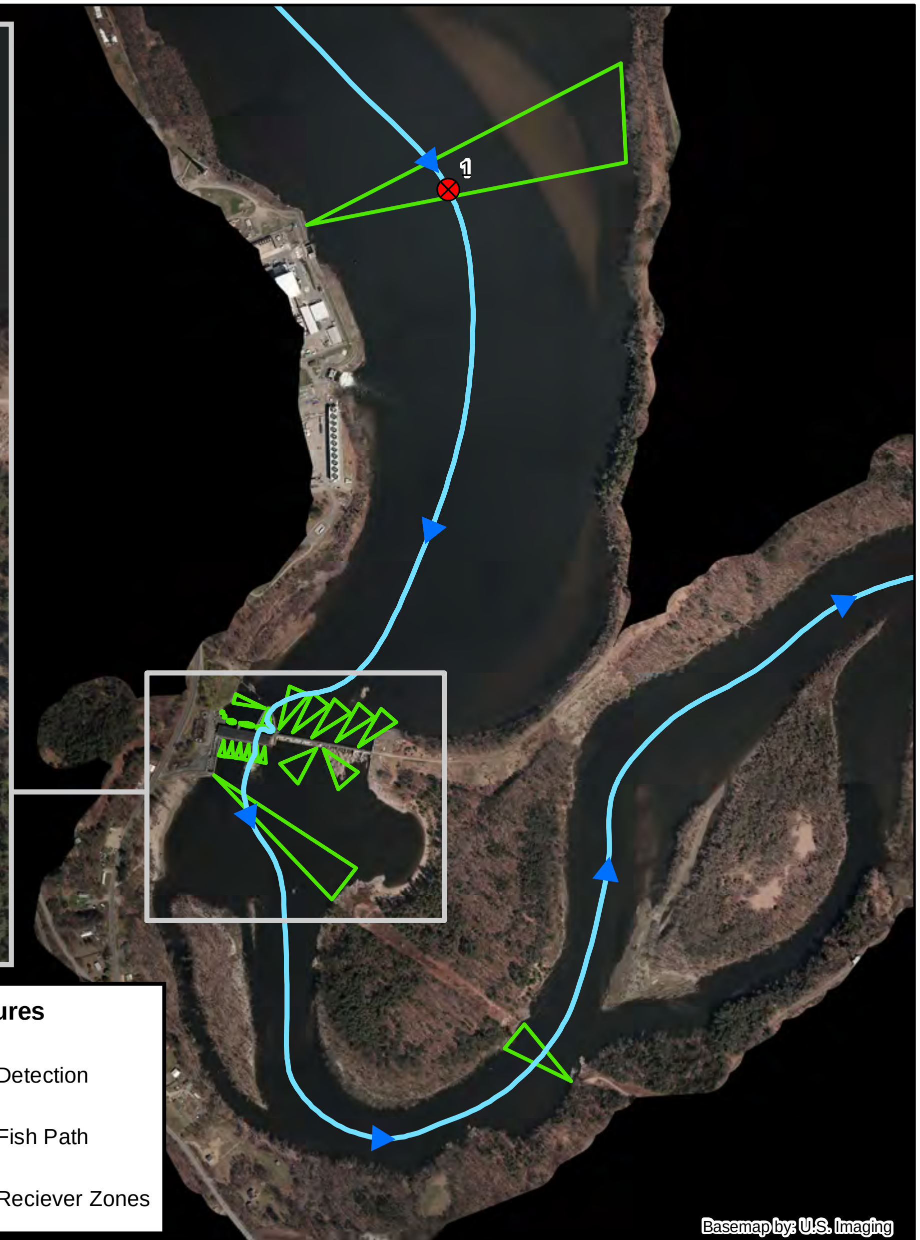

Timetable					
Detection	Date	Time	Detection	Date	Time
1	10/31/2015	21:20	5	11/2/2015	21:13
2	11/2/2015	20:59	6	11/2/2015	21:13
3	11/2/2015	21:06	7	11/2/2015	21:13
4	11/2/2015	21:07			

Site Features

- Detection
- Fish Path
- Reciever Zones

TransCanada Hydro Northeast Inc.
ILP Study 19
Vernon Dam

N

1 in = 1,200 feet

0 600 1,200 2,400 Feet

Study 19 Fish Number: 36-165
Release: Riverside Industrial Complex
Brattleboro, VT
Date Released: 10/31/15
Time Released: 13:40

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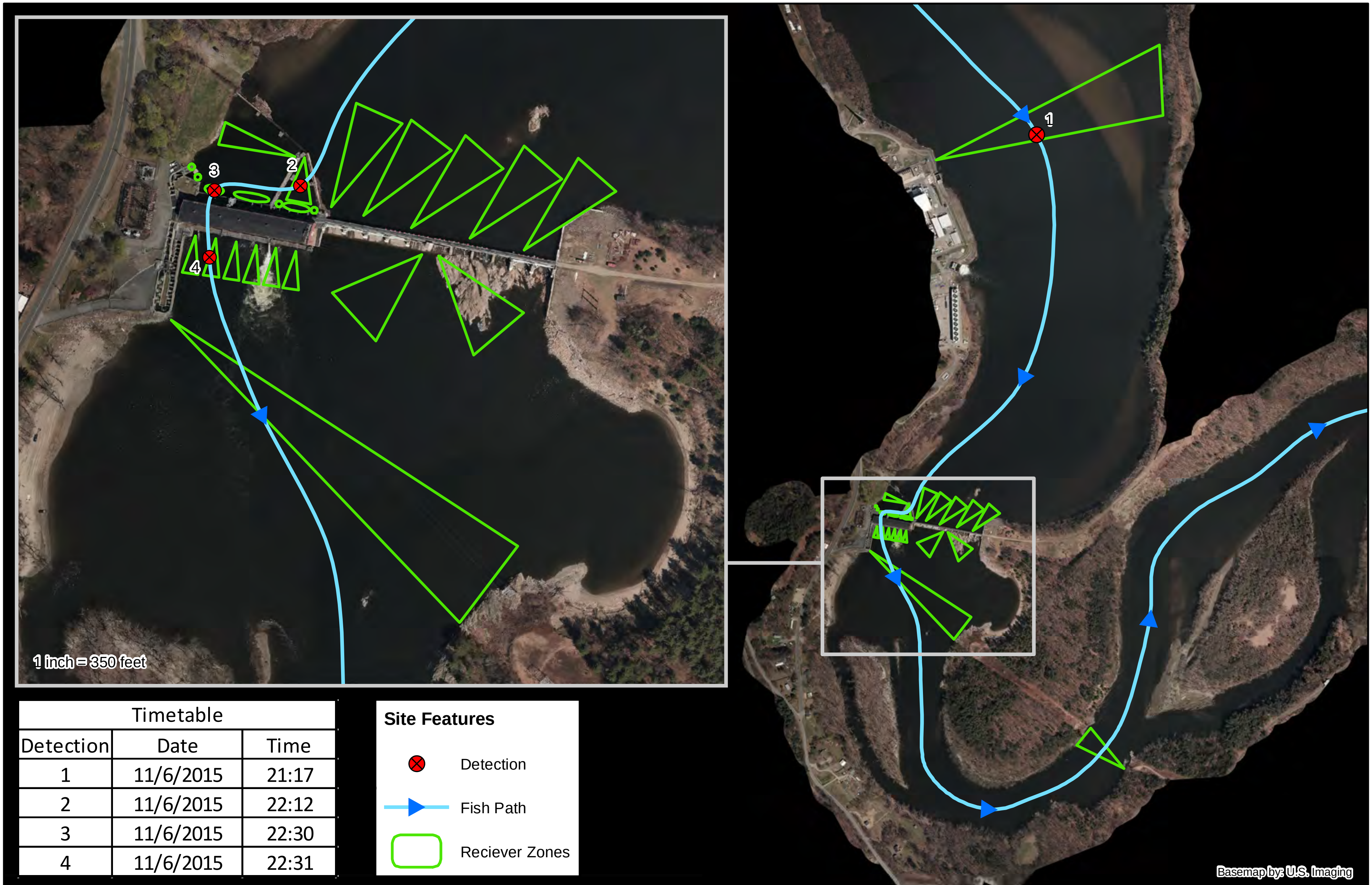

Timetable		
Detection	Date	Time
1	11/6/2015	21:17
2	11/6/2015	22:12
3	11/6/2015	22:30
4	11/6/2015	22:31

Site Features

- Detection
- Fish Path
- Reciever Zones

TransCanada Hydro Northeast Inc.
ILP Study 19
Vernon Dam

N

1 in = 1,200 feet

0 600 1,200 2,400 Feet

Study 19 Fish Number: 36-166
Release: Riverside Industrial Complex
Brattleboro, VT
Date Released: 10/31/15
Time Released: 13:40

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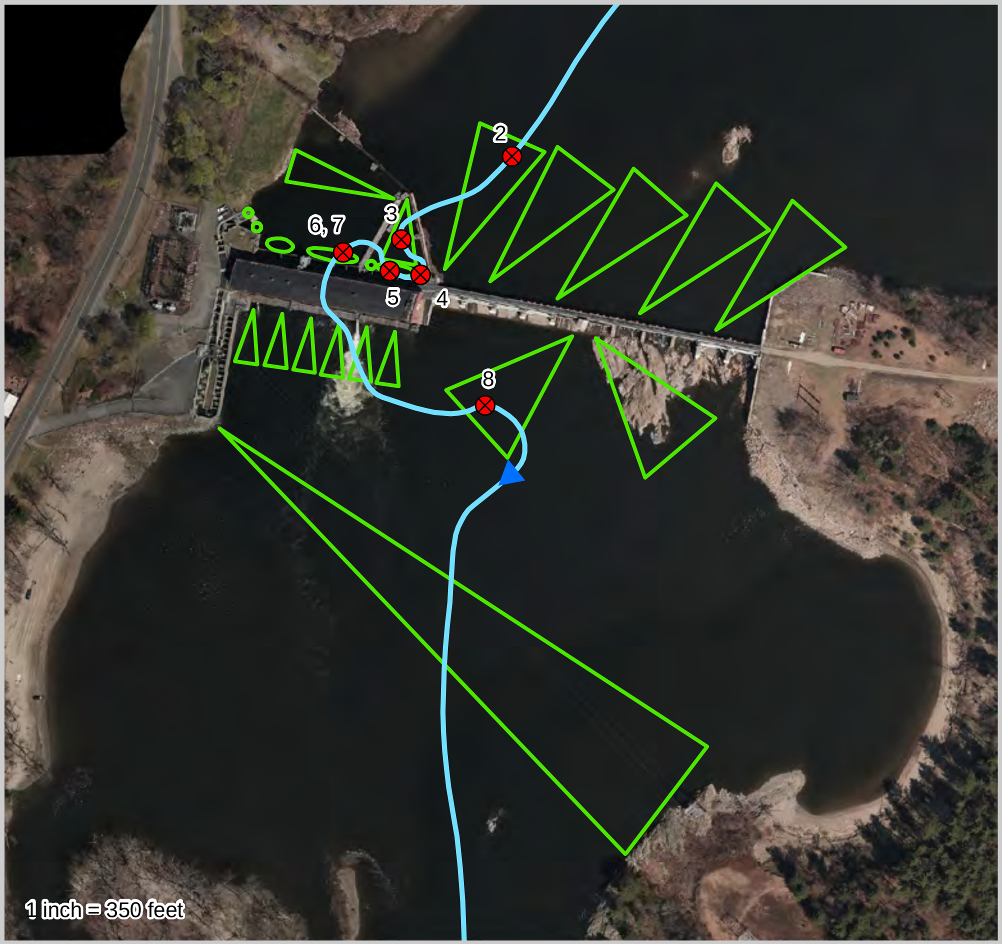

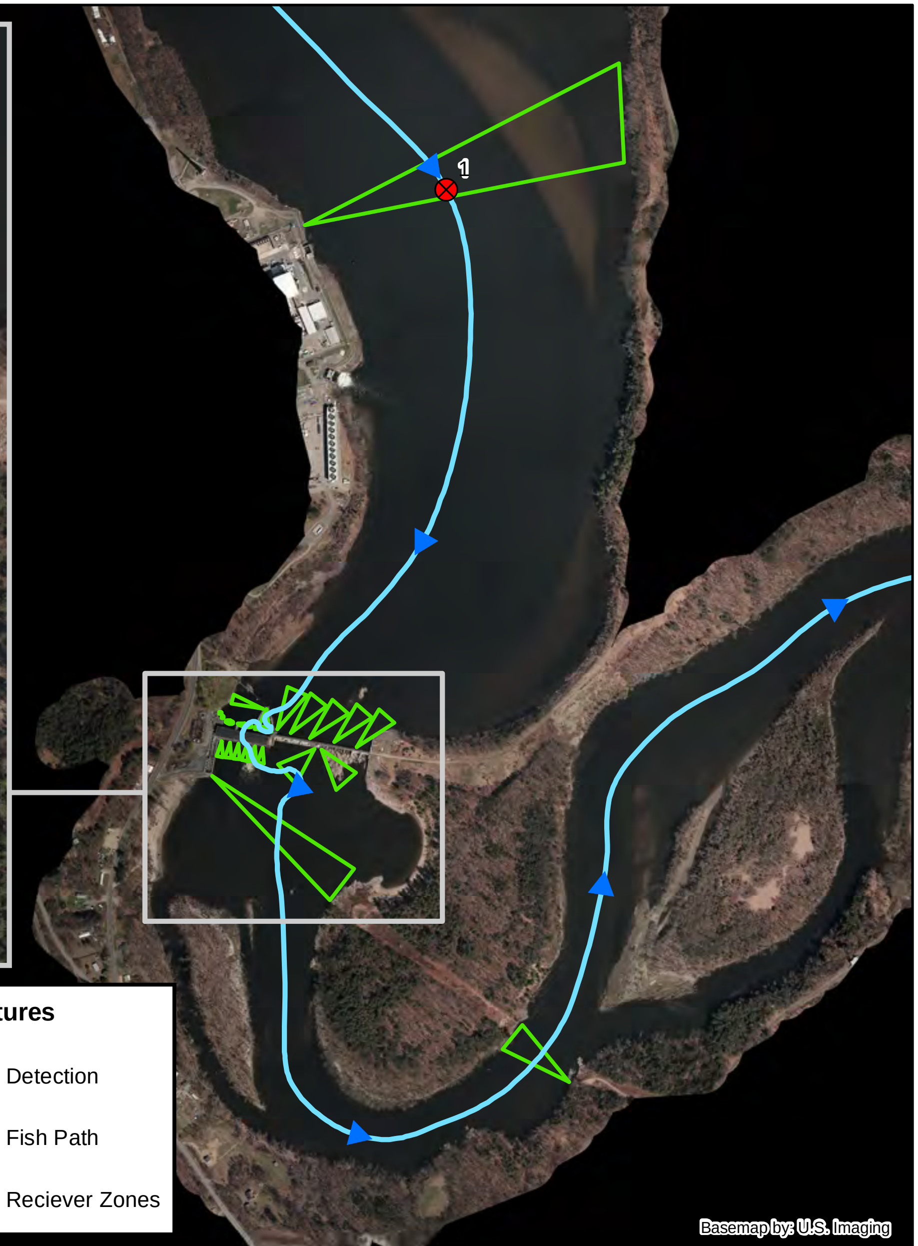

Timetable					
Detection	Date	Time	Detection	Date	Time
1	11/9/2015	20:00	5	11/9/2015	22:44
2	11/9/2015	20:59	6	11/9/2015	22:46
3	11/9/2015	21:07	7	11/9/2015	22:54
4	11/9/2015	22:43	8	11/9/2015	23:00

Site Features

- Detection
- Fish Path
- Reciever Zones

TransCanada Hydro Northeast Inc.
ILP Study 19
Vernon Dam

N

1 in = 1,200 feet

0 600 1,200 2,400 Feet

Study 19 Fish Number: 36-175

Release: Herricks Cove, VT
Date Released: 10/31/15
Time Released: 18:22

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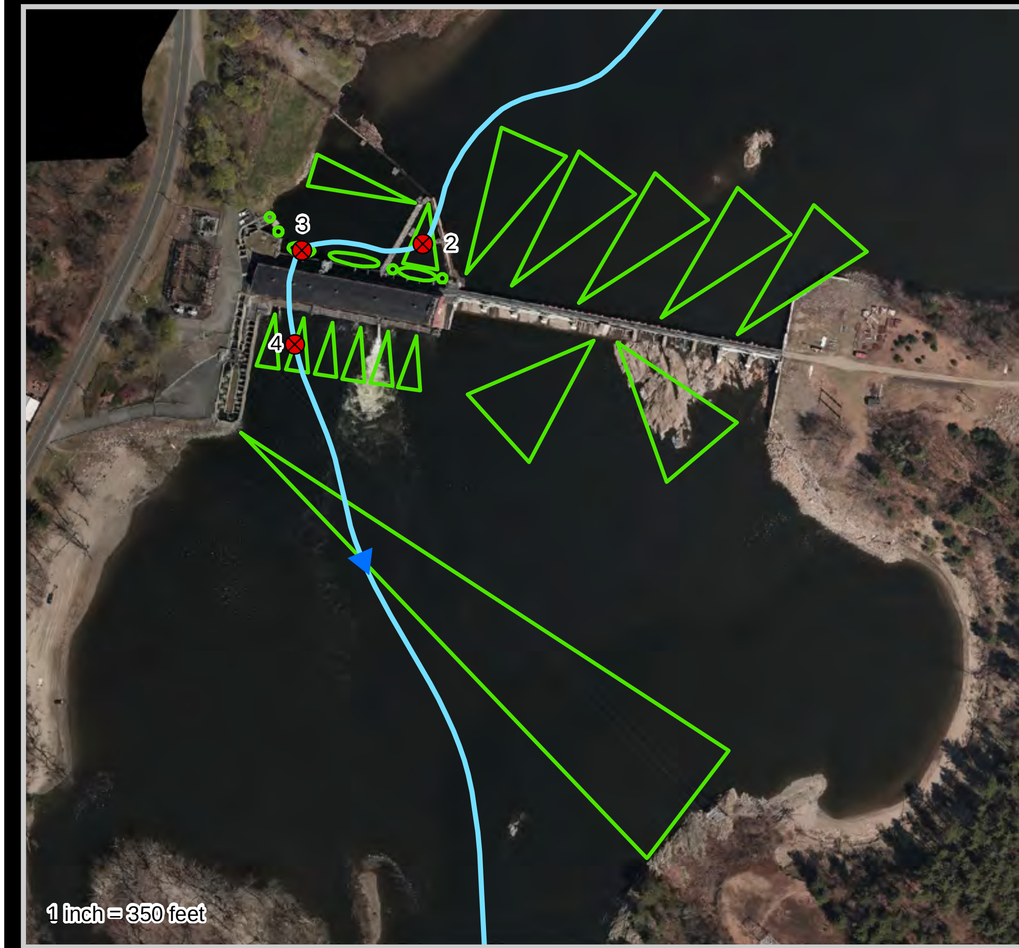

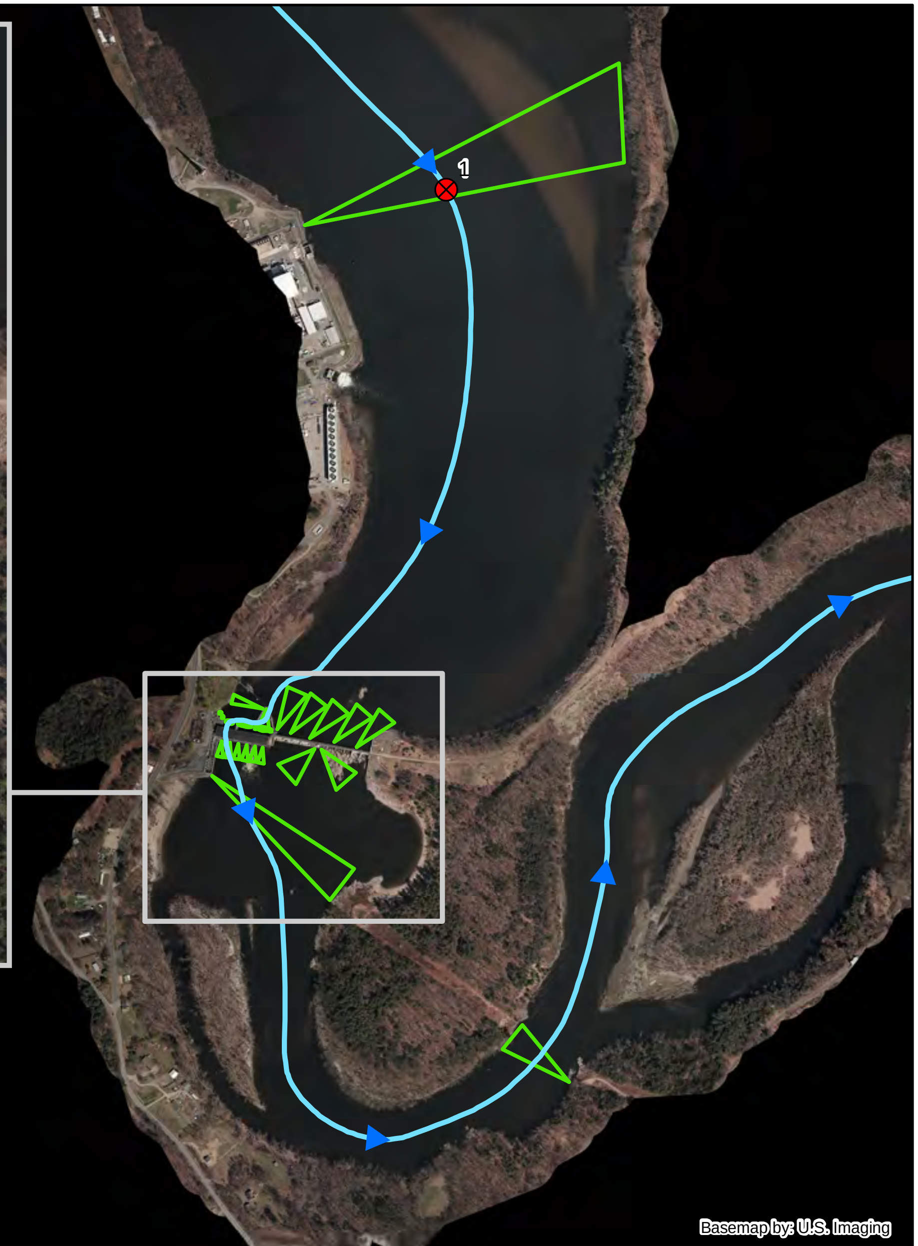

Timetable		
Detection	Date	Time
1	11/2/2015	2:24
2	11/2/2015	3:08
3	11/2/2015	3:08
4	11/2/2015	3:11

Site Features

- Detection
- Fish Path
- Reciever Zones

TransCanada Hydro Northeast Inc.
ILP Study 19
Vernon Dam

N

1 in = 1,200 feet

0 600 1,200 2,400 Feet

Study 19 Fish Number: 36-176

Release: Herricks Cove, VT
Date Released: 10/31/15
Time Released: 18:22

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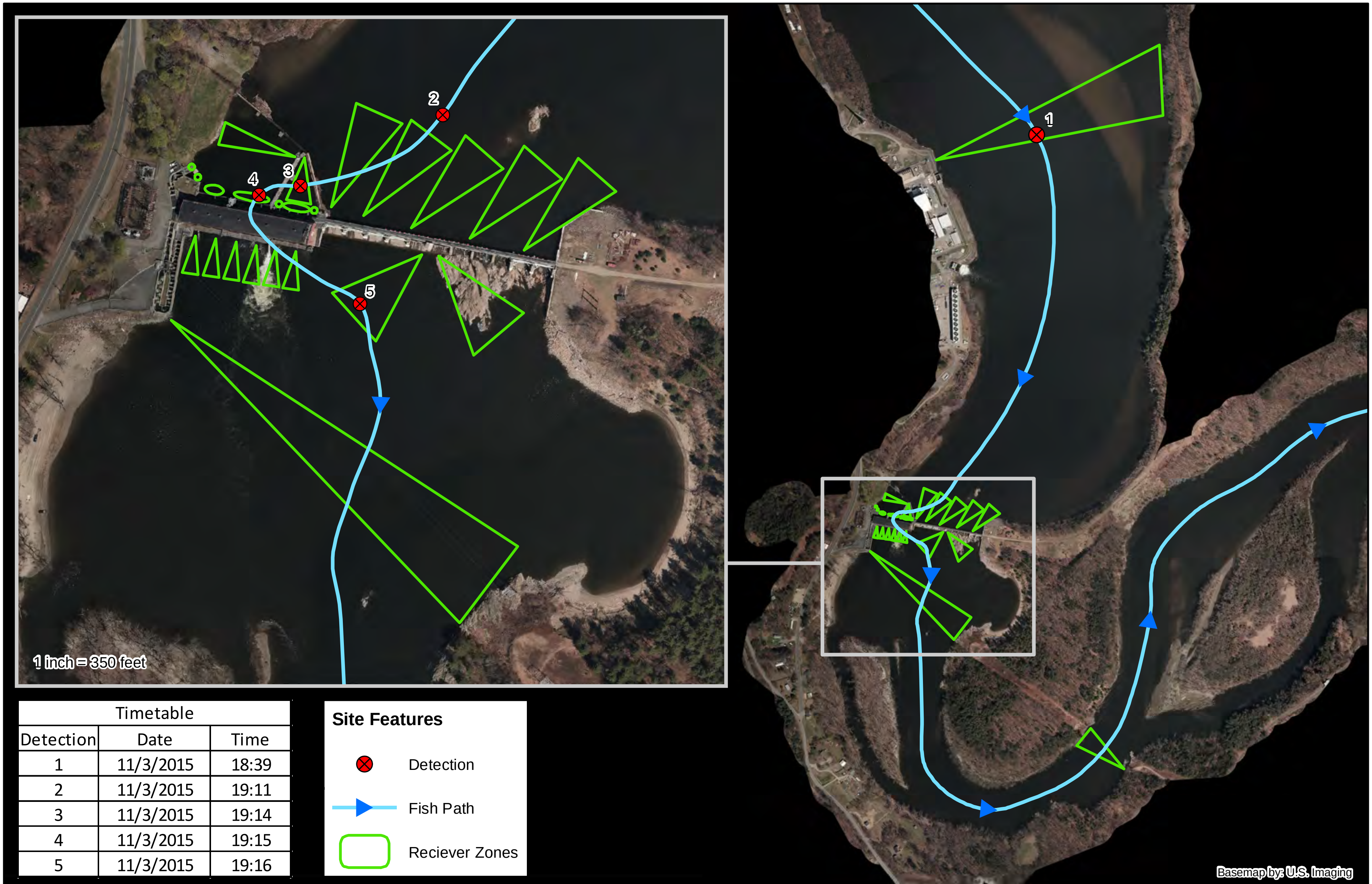

Timetable		
Detection	Date	Time
1	11/3/2015	18:39
2	11/3/2015	19:11
3	11/3/2015	19:14
4	11/3/2015	19:15
5	11/3/2015	19:16

Site Features

Detection

Fish Path

Reciever Zones

TransCanada Hydro Northeast Inc.
ILP Study 19
Vernon Dam

N

1 in = 1,200 feet

0 600 1,200 2,400 Feet

Study 19 Fish Number: 36-177

Release: Herricks Cove, VT
Date Released: 10/31/15
Time Released: 18:22

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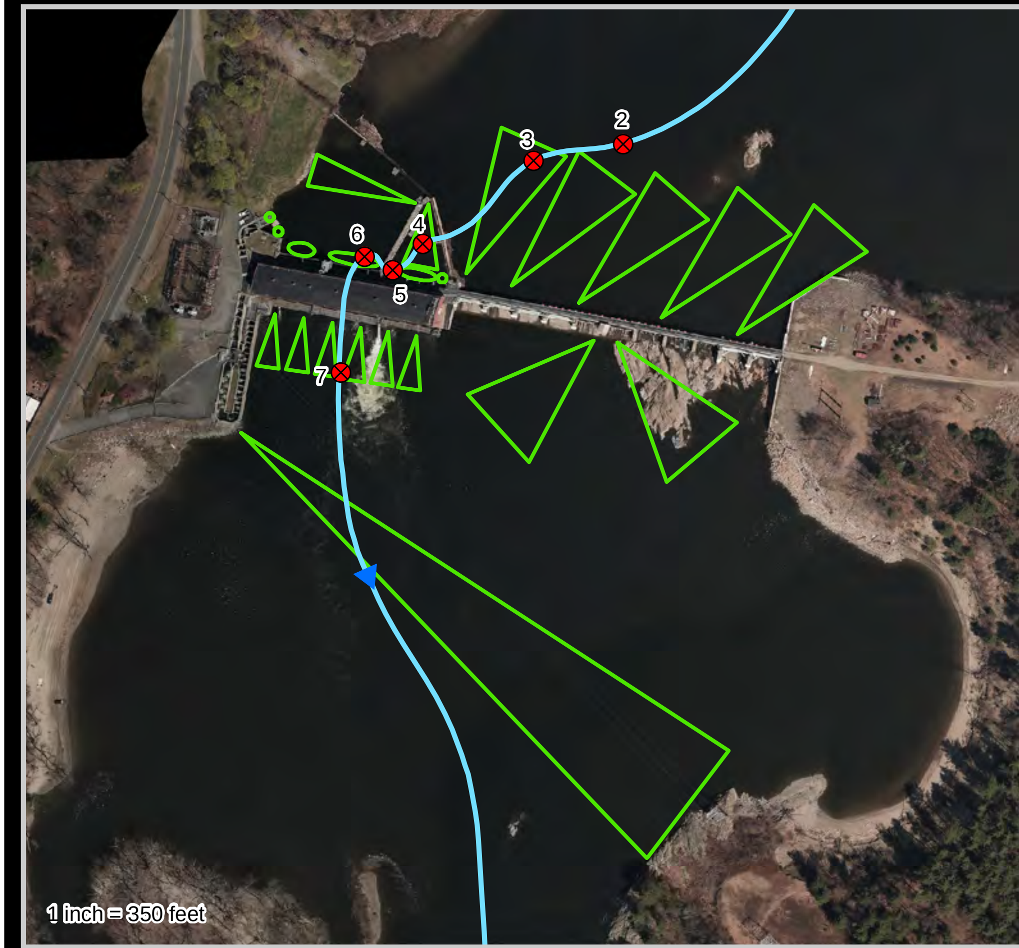

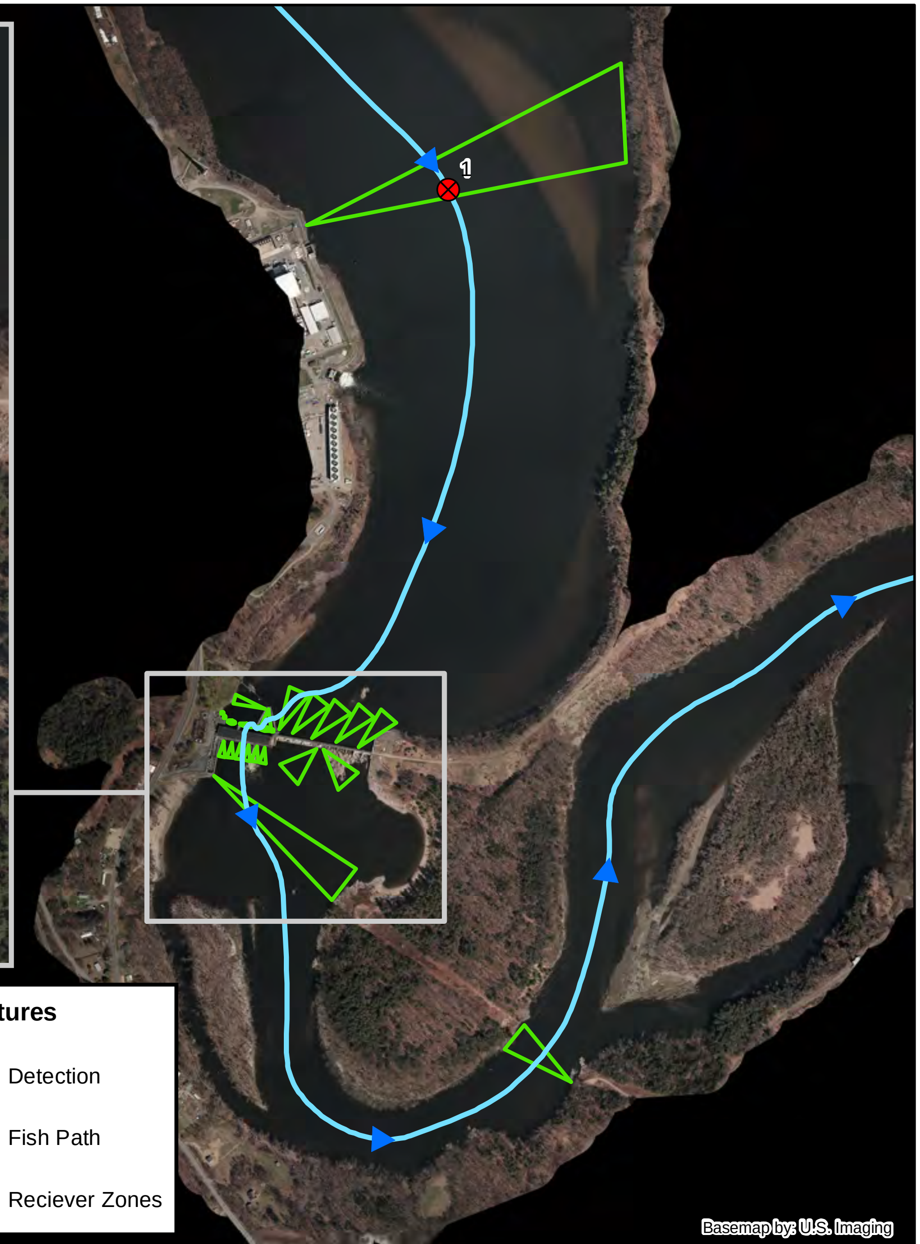

Timetable					
Detection	Date	Time	Detection	Date	Time
1	11/4/2015	18:39	5	11/4/2015	19:12
2	11/4/2015	19:05	6	11/4/2015	19:13
3	11/4/2015	19:08	7	11/4/2015	19:13
4	11/4/2015	19:11			

Site Features

Detection

Fish Path

Reciever Zones

TransCanada Hydro Northeast Inc.
ILP Study 19
Vernon Dam

N

1 in = 1,200 feet

0 600 1,200 2,400 Feet

Study 19 Fish Number: 36-184

Release: Norwich, VT
Date Released: 10/31/15
Time Released: 19:21

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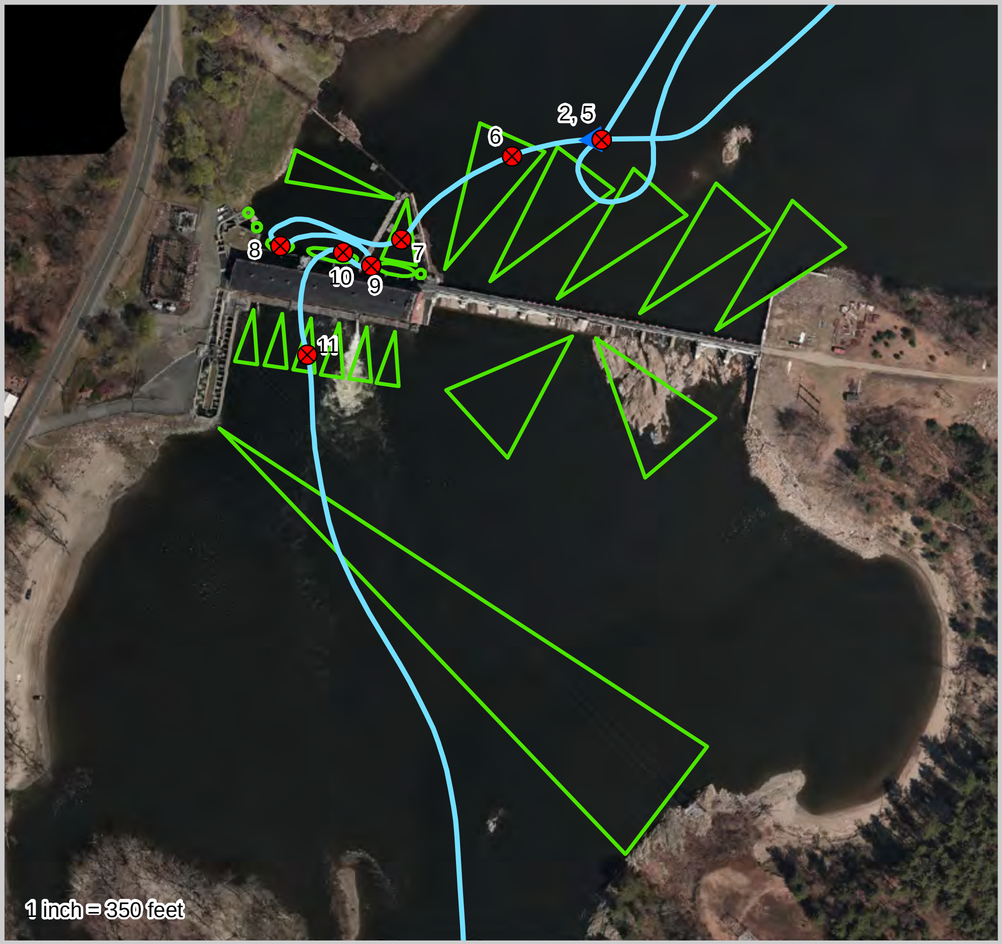

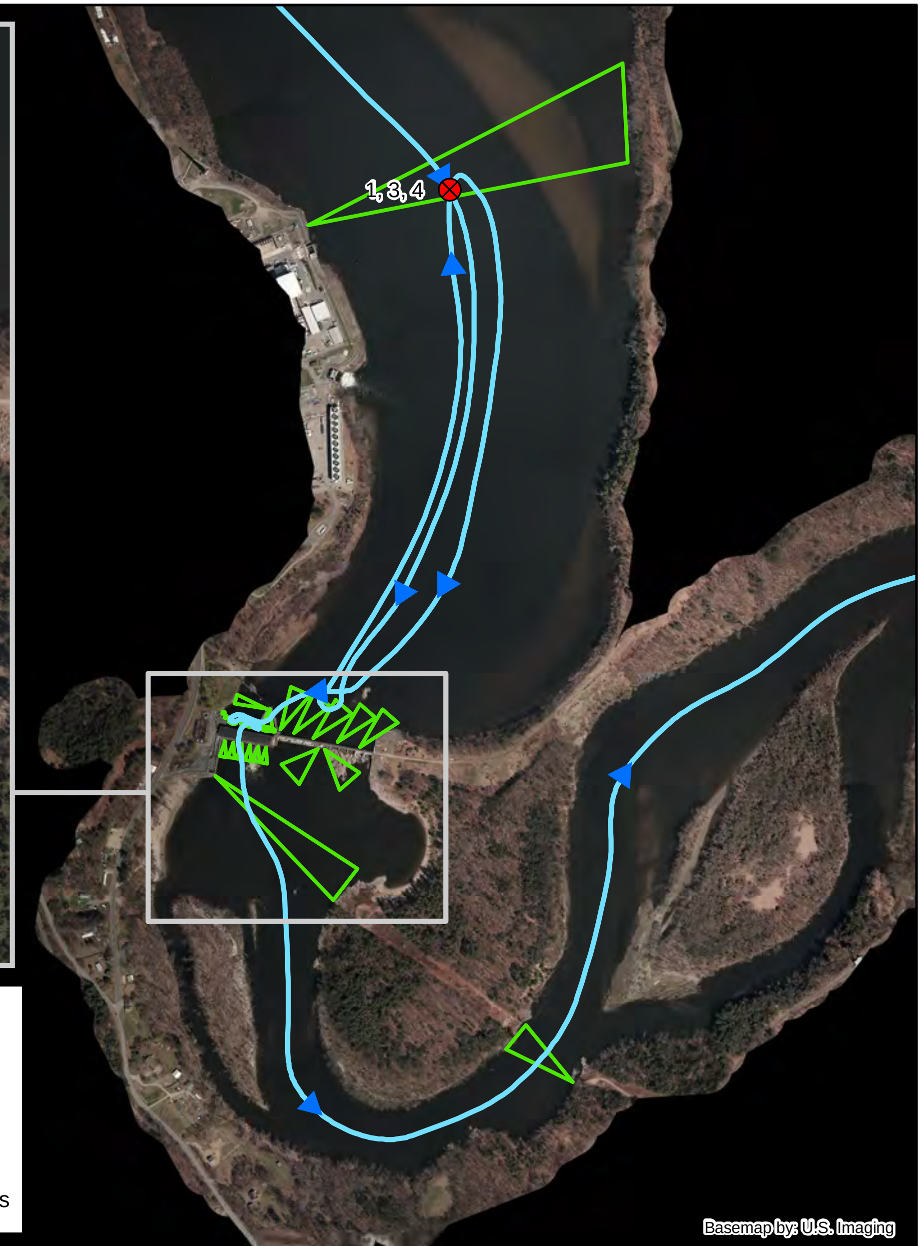

Timetable					
Detection	Date	Time	Detection	Date	Time
1	11/5/2015	3:37	7	11/6/2015	1:10
2	11/5/2015	4:27	8	11/6/2015	1:13
3	11/6/2015	5:07	9	11/6/2015	1:14
4	11/6/2015	0:31	10	11/6/2015	1:15
5	11/6/2015	1:00	11	11/6/2015	1:15
6	11/6/2015	1:10			

Site Features

- Detection
- Fish Path
- Reciever Zones

TransCanada Hydro Northeast Inc.
ILP Study 19
Vernon Dam

N

1 in = 1,200 feet

0 600 1,200 2,400 Feet

Study 19 Fish Number: 36-187

Release: Norwich, VT
Date Released: 10/31/15
Time Released: 19:21

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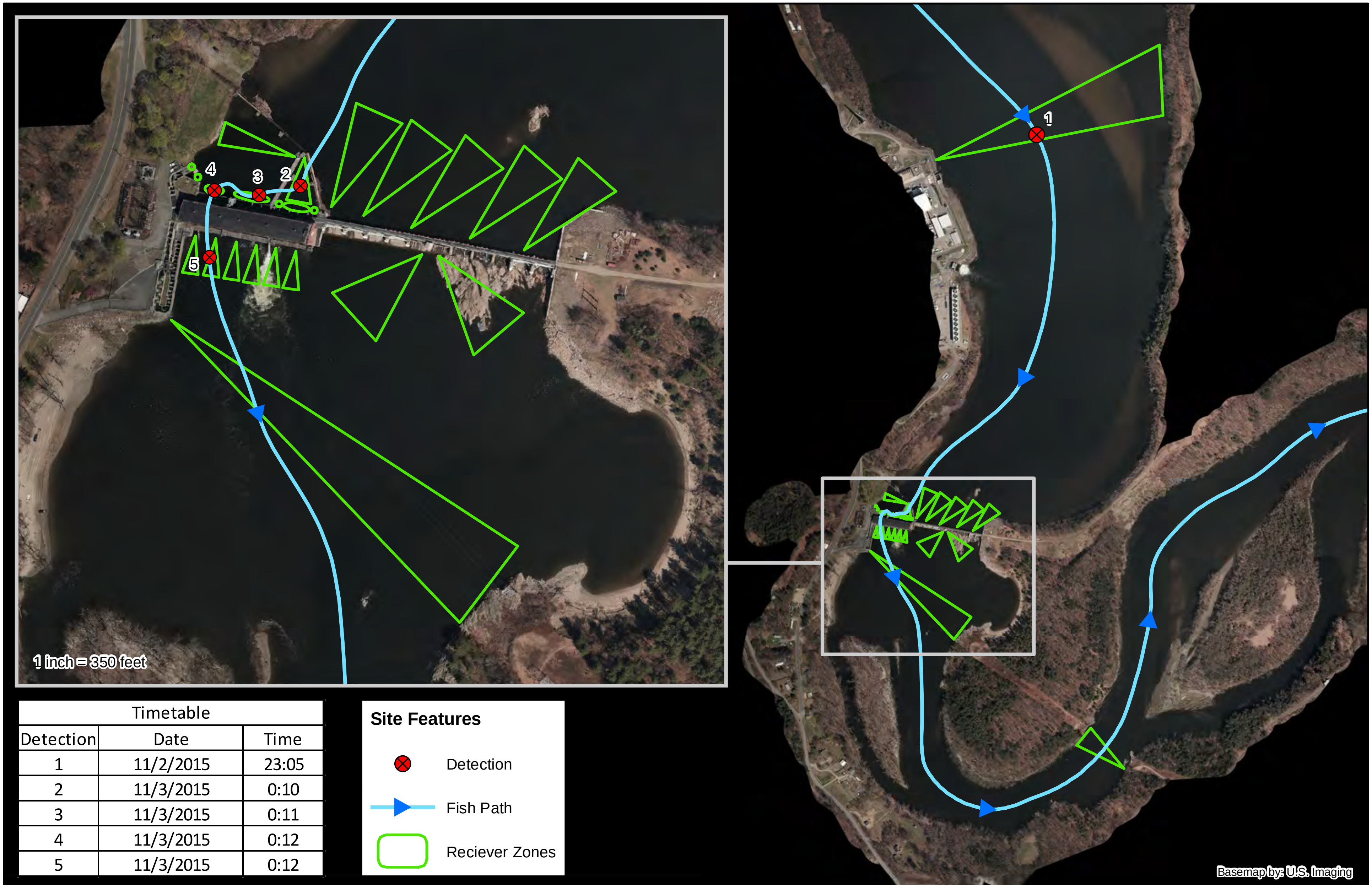

Timetable		
Detection	Date	Time
1	11/2/2015	23:05
2	11/3/2015	0:10
3	11/3/2015	0:11
4	11/3/2015	0:12
5	11/3/2015	0:12

Site Features

- Detection
- Fish Path
- Reciever Zones

TransCanada Hydro Northeast Inc.
ILP Study 19
Vernon Dam

N

1 in = 1,200 feet

0 600 1,200 2,400 Feet

Study 19 Fish Number: 36-51

Release: Bellows Falls Canal
Date Released: 10/31/2015
Time Released: 18:05

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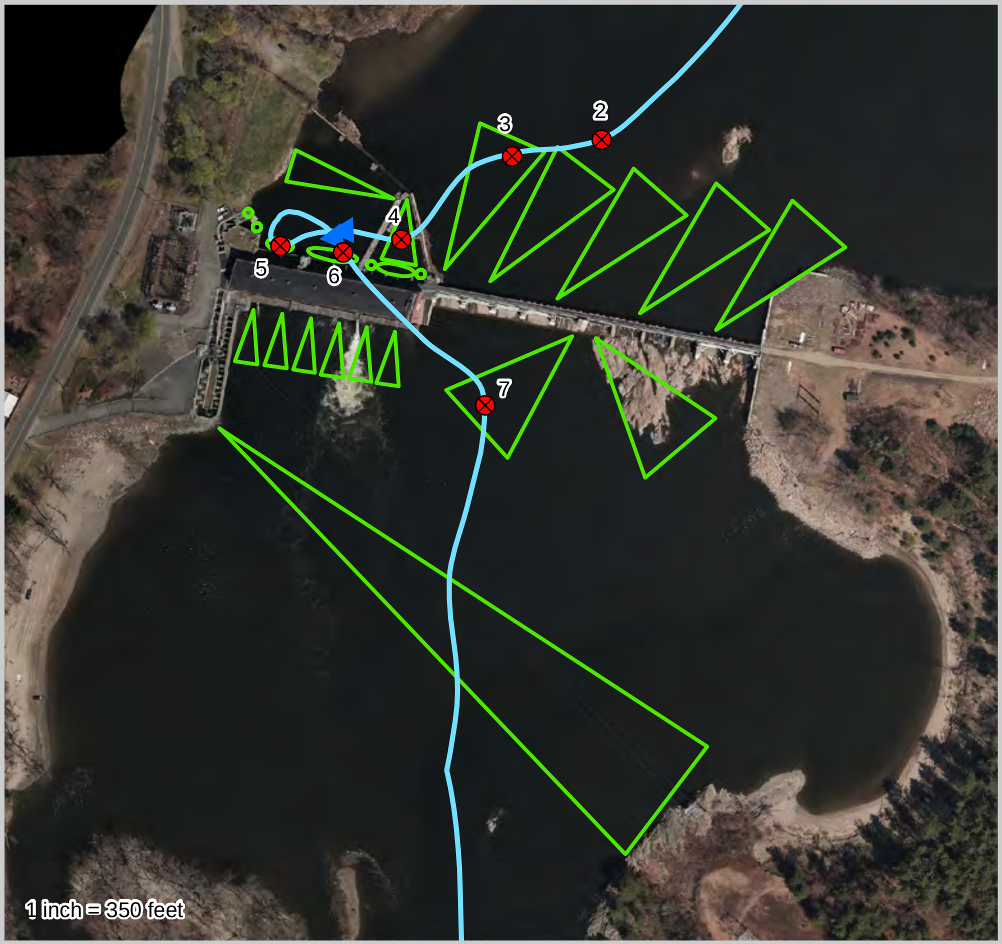

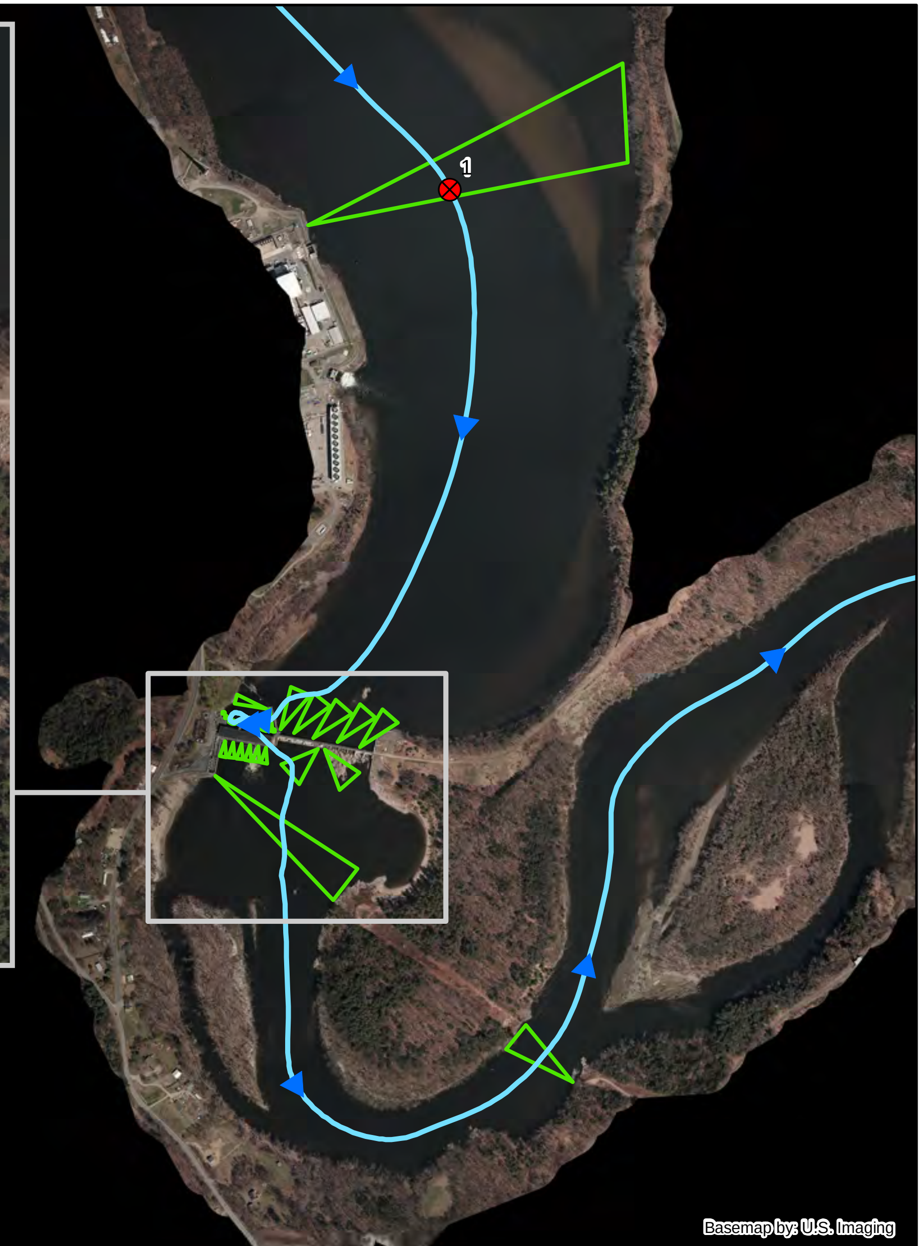

Timetable		
Detection	Date	Time
1	11/2/2015	21:32
2	11/2/2015	22:04
3	11/2/2015	22:09
4	11/2/2015	22:11
5	11/2/2015	22:14
6	11/2/2015	22:15
7	11/2/2015	22:16

Site Features

- Detection
- Fish Path
- Reciever Zones

TransCanada Hydro Northeast Inc.
ILP Study 19
Vernon Dam

N

1 in = 1,200 feet

0 600 1,200 2,400 Feet

Study 19 Fish Number: 36-52

Release: Bellows Falls Canal
Date Released: 10/31/2015
Time Released: 18:05

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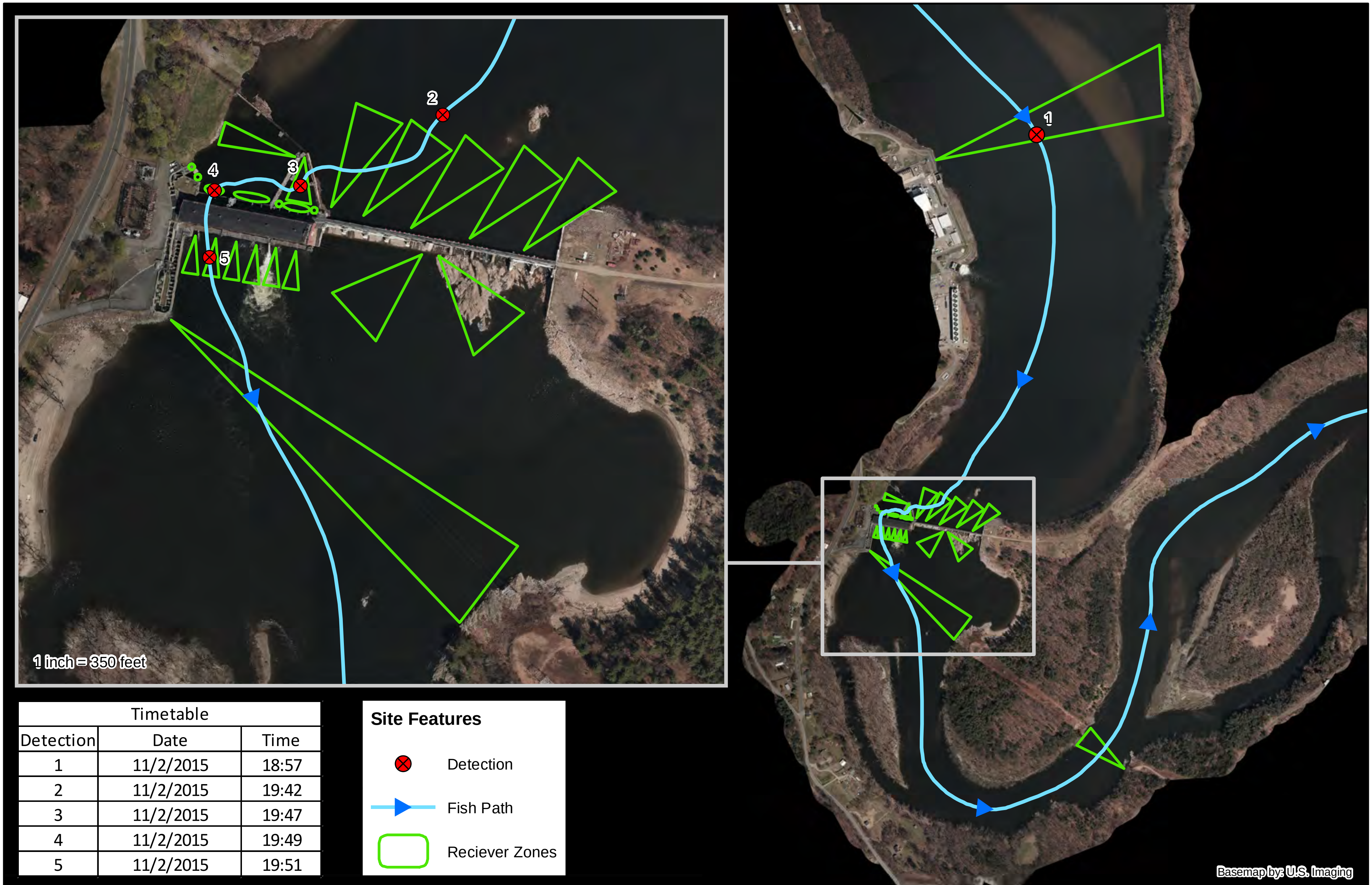

Timetable		
Detection	Date	Time
1	11/2/2015	18:57
2	11/2/2015	19:42
3	11/2/2015	19:47
4	11/2/2015	19:49
5	11/2/2015	19:51

Site Features

Detection

Fish Path

Reciever Zones

TransCanada Hydro Northeast Inc.
ILP Study 19
Vernon Dam

N

1 in = 1,200 feet

0 600 1,200 2,400 Feet

Study 19 Fish Number: 36-53

Release: Bellows Falls Canal
Date Released: 10/31/2015
Time Released: 18:05

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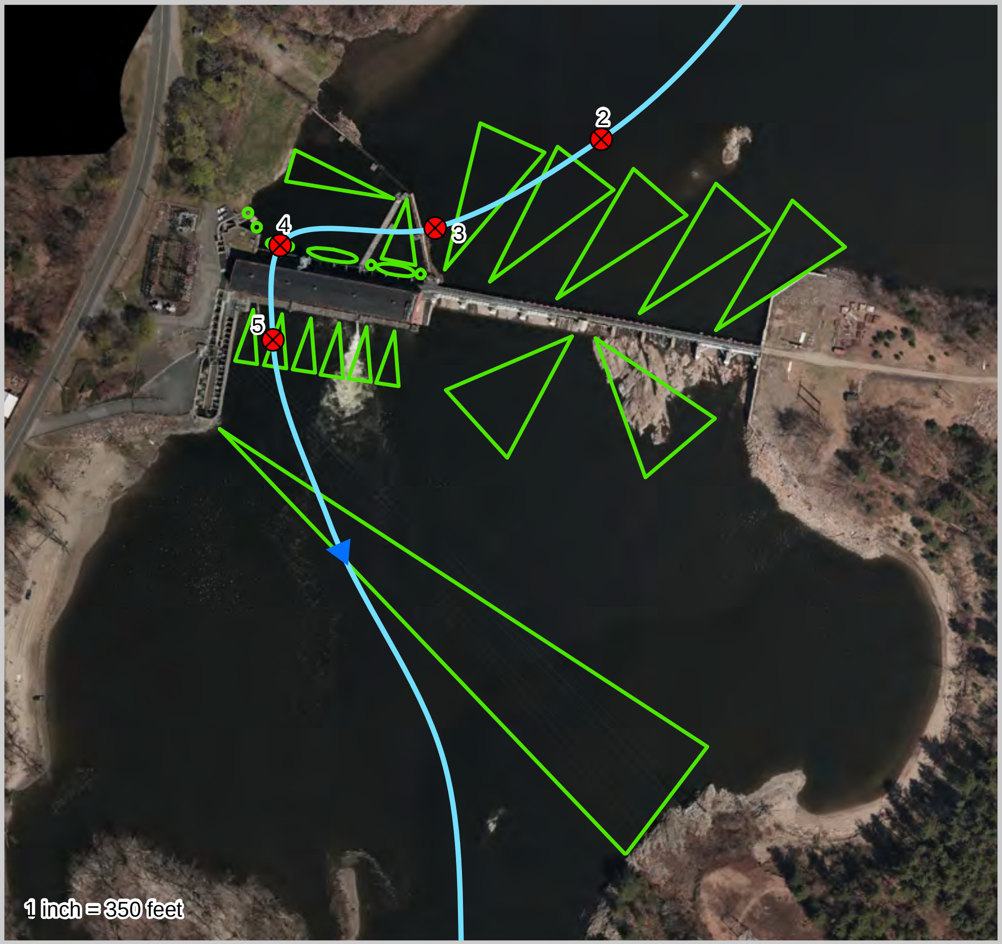

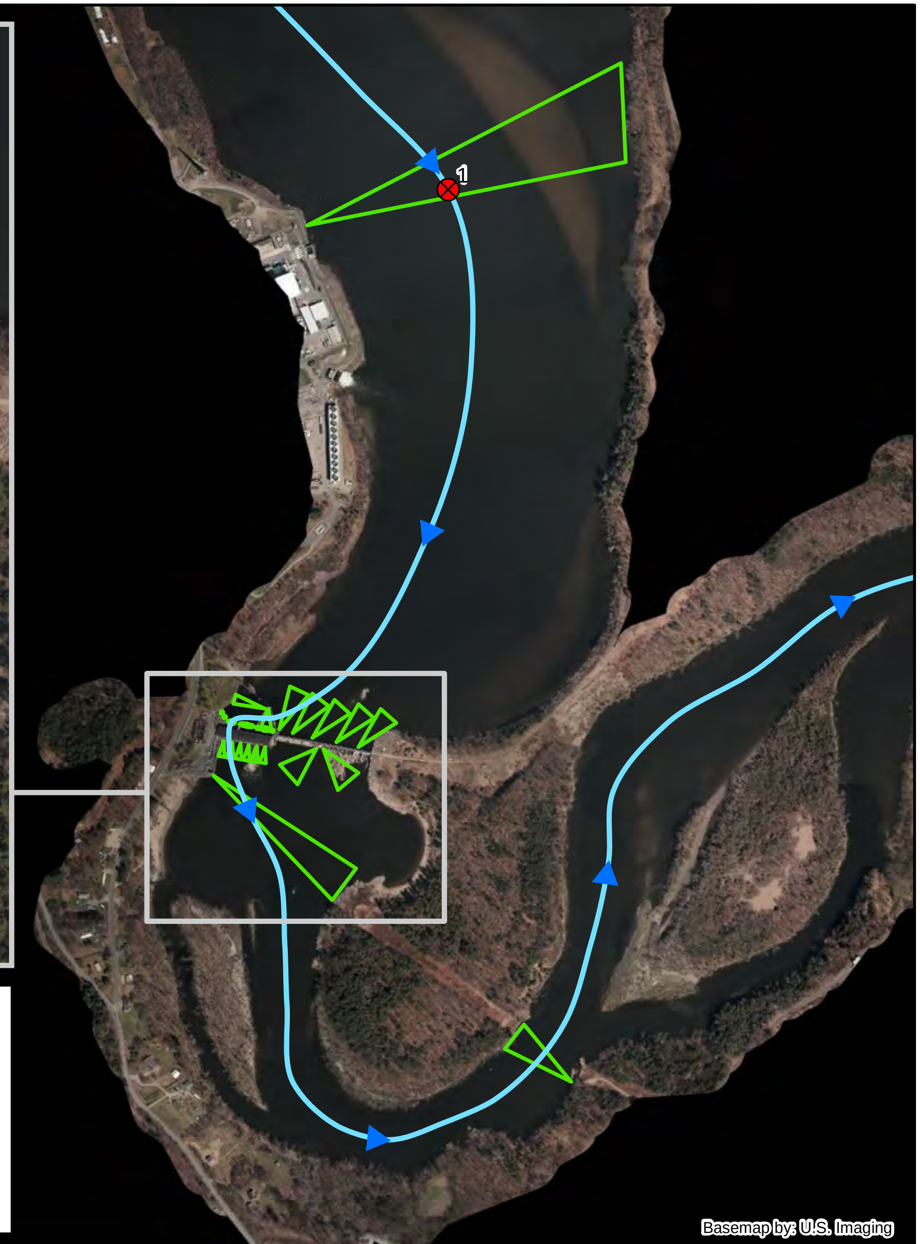

Timetable		
Detection	Date	Time
1	11/3/2015	22:12
2	11/3/2015	22:50
3	11/3/2015	23:04
4	11/3/2015	23:06
5	11/3/2015	23:07

Site Features

- Detection
- Fish Path
- Reciever Zones

TransCanada Hydro Northeast Inc.
ILP Study 19
Vernon Dam

N

1 in = 1,200 feet

0 600 1,200 2,400 Feet

Study 19 Fish Number: 38-101
Release: Riverside Industrial Complex
Brattleboro, VT
Date Released: 11/03/2015
Time Released: 15:55

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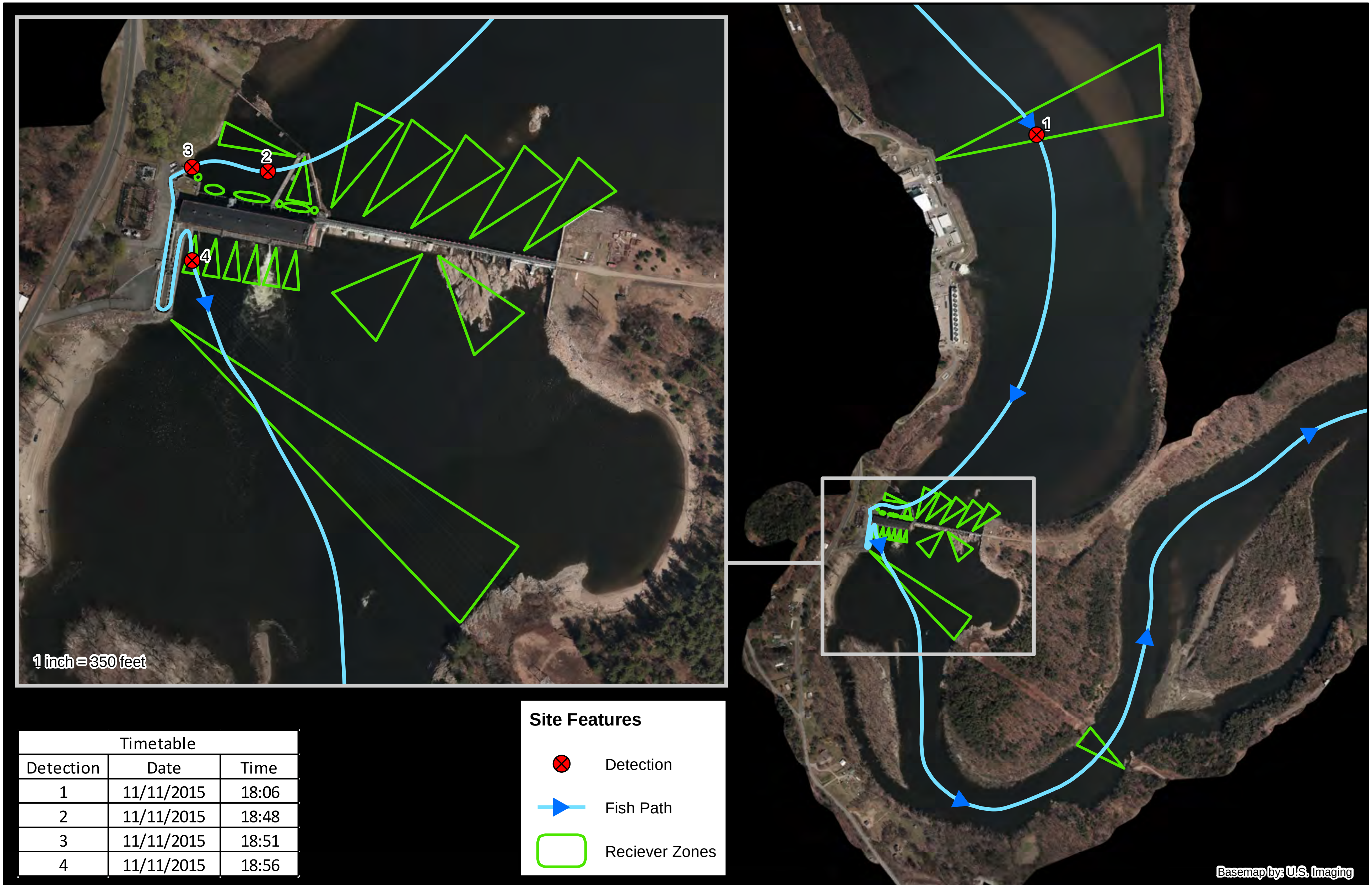

Timetable		
Detection	Date	Time
1	11/11/2015	18:06
2	11/11/2015	18:48
3	11/11/2015	18:51
4	11/11/2015	18:56

Site Features

- Detection
- Fish Path
- Reciever Zones

TransCanada Hydro Northeast Inc.
ILP Study 19
Vernon Dam

N

1 in = 1,200 feet

0 600 1,200 2,400 Feet

Study 19 Fish Number: 38-102
Release: Riverside Industrial Complex
Brattleboro, VT
Date Released: 11/03/2015
Time Released: 15:55

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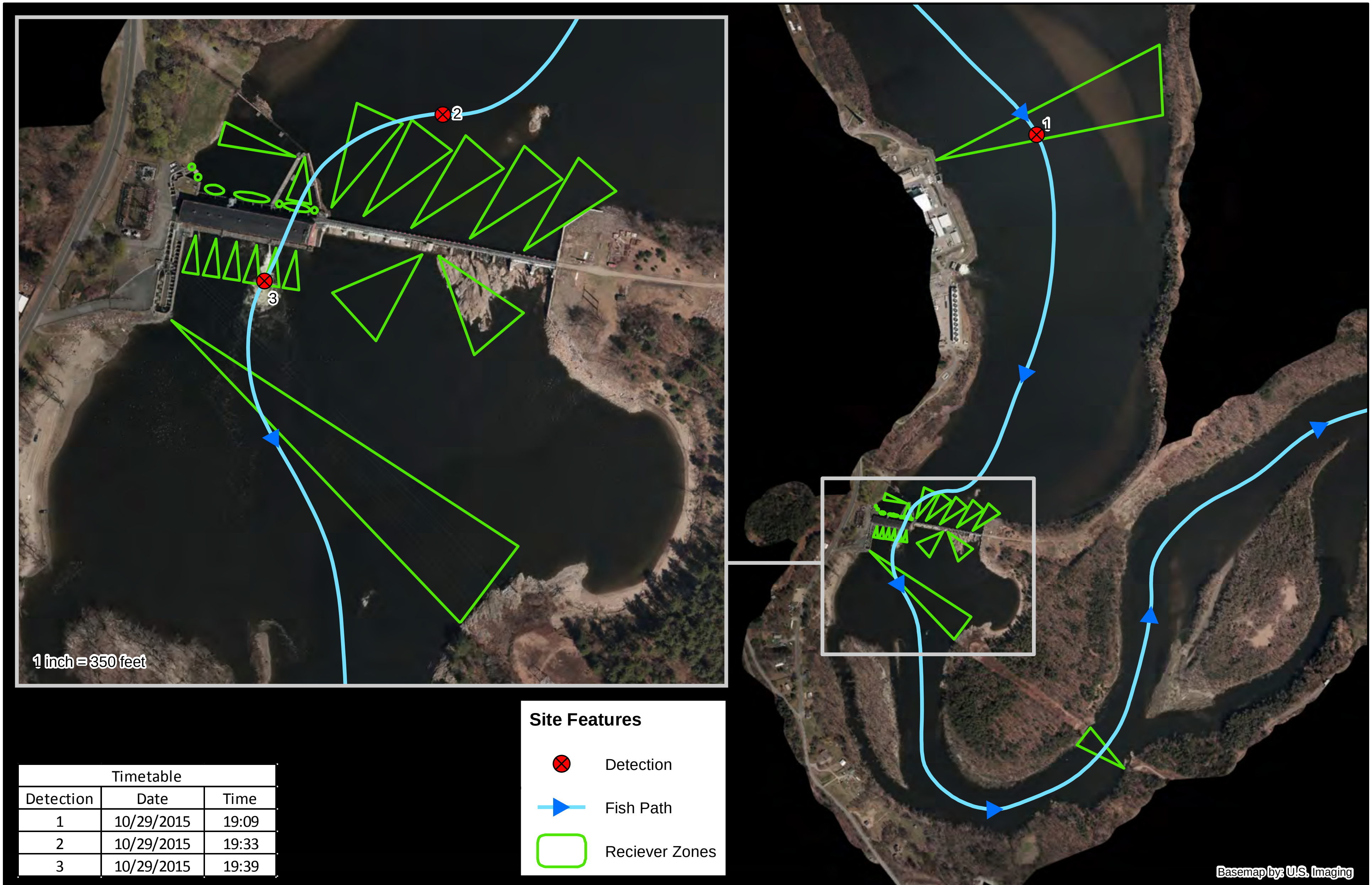

Timetable		
Detection	Date	Time
1	10/29/2015	19:09
2	10/29/2015	19:33
3	10/29/2015	19:39

Site Features

- Detection
- Fish Path
- Reciever Zones

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TransCanada Hydro Northeast Inc.
ILP Study 19
Vernon Dam

N

1 in = 1,200 feet

0 600 1,200 2,400 Feet

Study 19 Fish Number: 38-108
Release: Riverside Industrial Complex
Brattleboro, VT
Date Released: 10/27/2015
Time Released: 17:45

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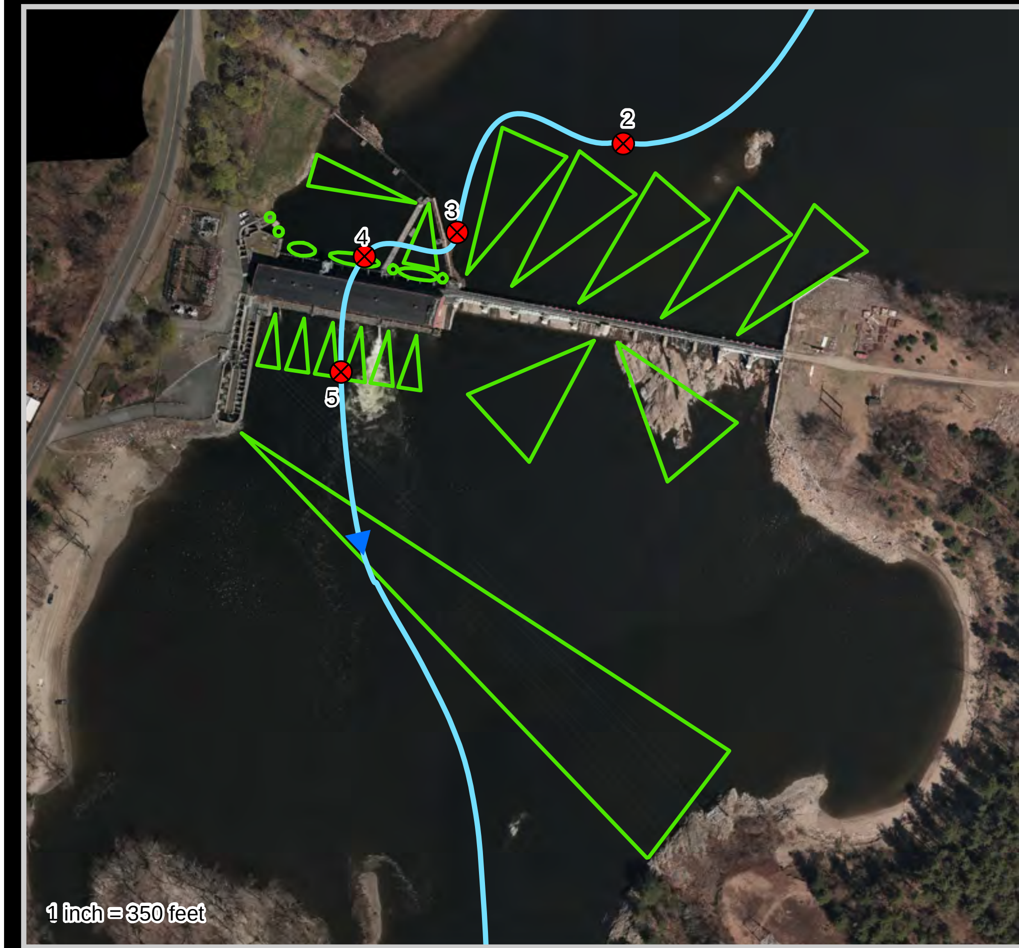

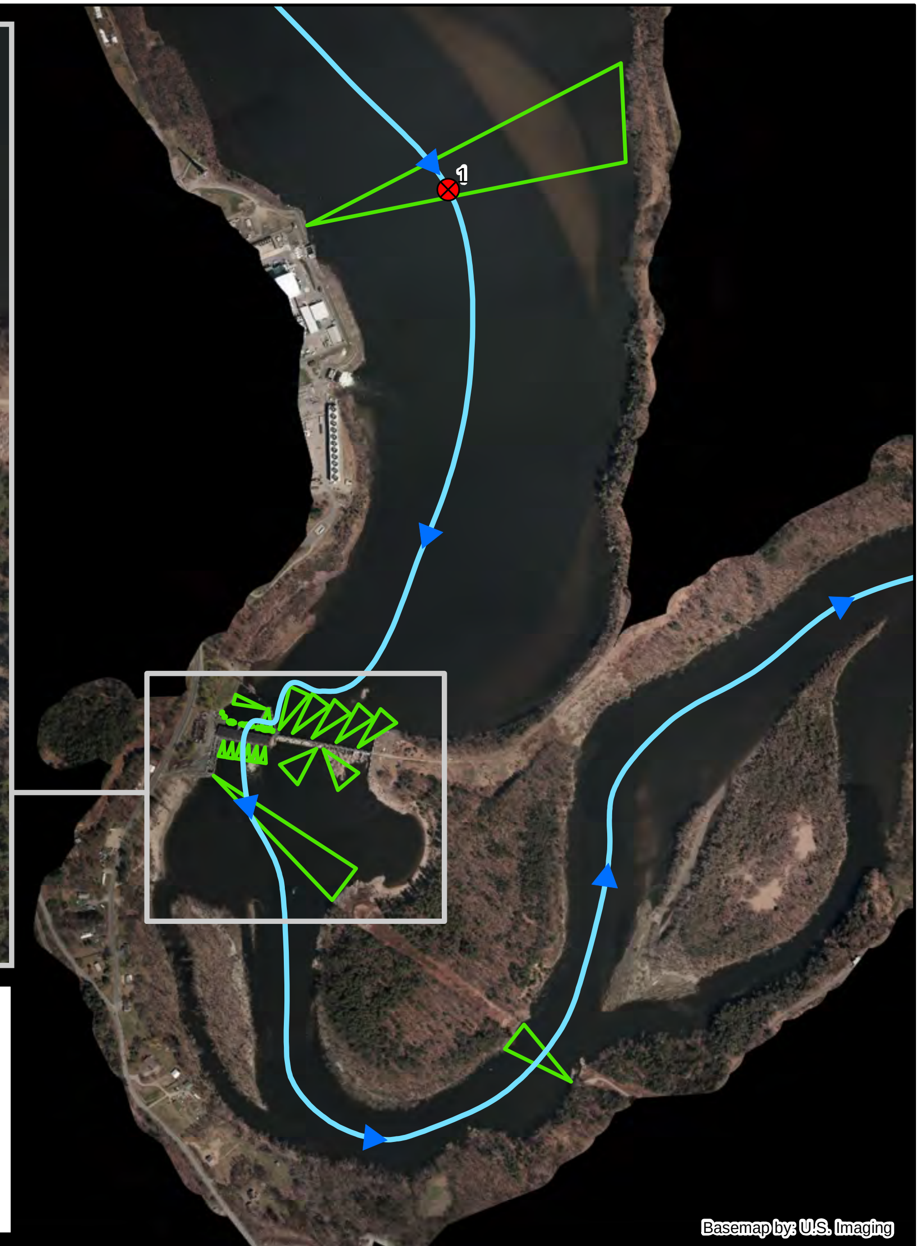

Timetable		
Detection	Date	Time
1	10/29/2015	23:52
2	10/30/2015	0:25
3	10/30/2015	0:33
4	10/30/2015	0:34
5	10/30/2015	0:35

Site Features

- Detection
- Fish Path
- Reciever Zones

TransCanada Hydro Northeast Inc.
ILP Study 19
Vernon Dam

N

1 in = 1,200 feet

0 600 1,200 2,400 Feet

Study 19 Fish Number: 38-109
Release: Riverside Industrial Complex
Brattleboro, VT
Date Released: 10/27/2015
Time Released: 17:45

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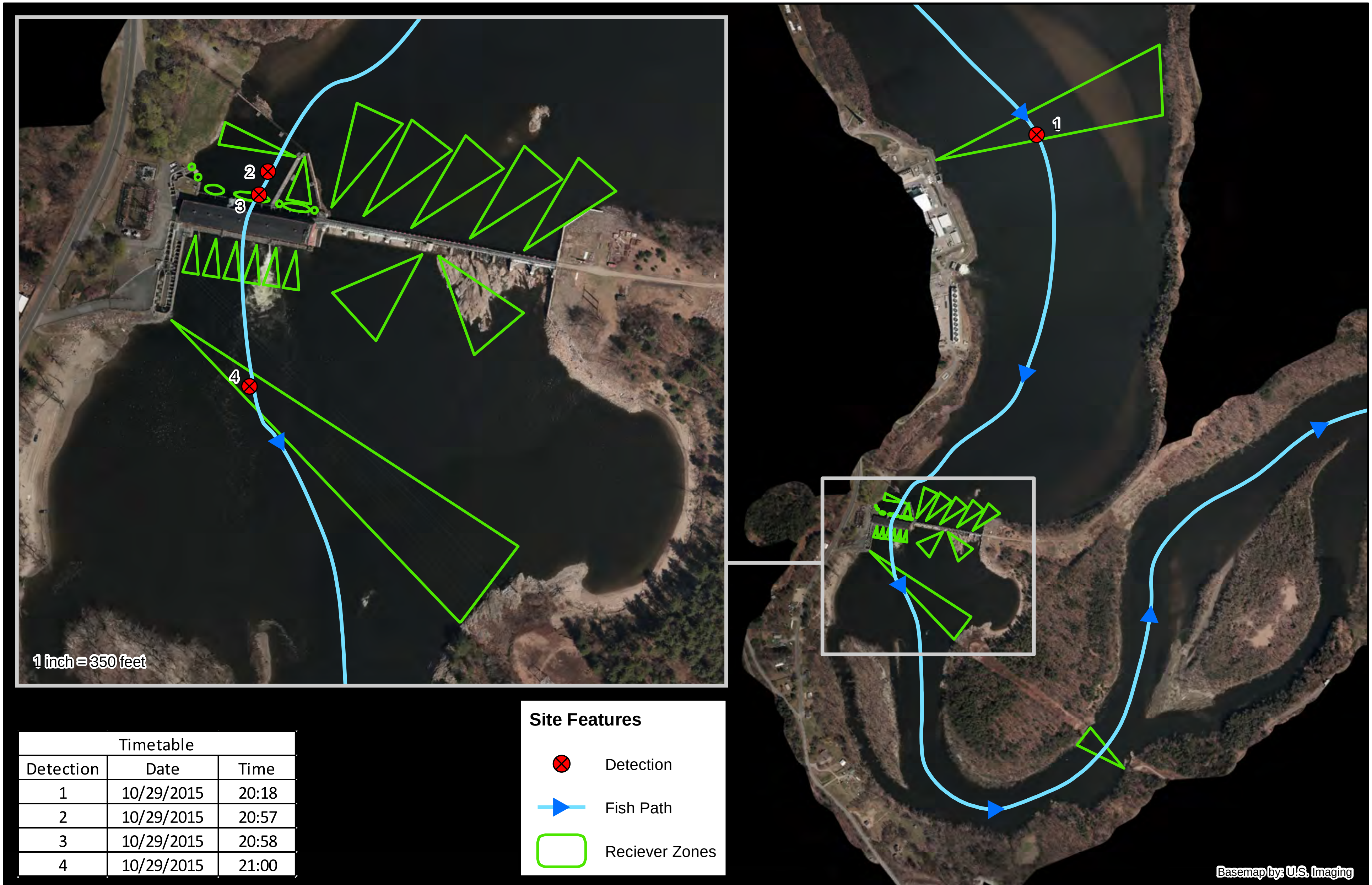

Timetable		
Detection	Date	Time
1	10/29/2015	20:18
2	10/29/2015	20:57
3	10/29/2015	20:58
4	10/29/2015	21:00

Site Features

- Detection
- Fish Path
- Reciever Zones

TransCanada Hydro Northeast Inc.
ILP Study 19
Vernon Dam

N

1 in = 1,200 feet

0 600 1,200 2,400 Feet

Study 19 Fish Number: 38-110
Release: Riverside Industrial Complex
Brattleboro, VT
Date Released: 10/27/2015
Time Released: 17:45

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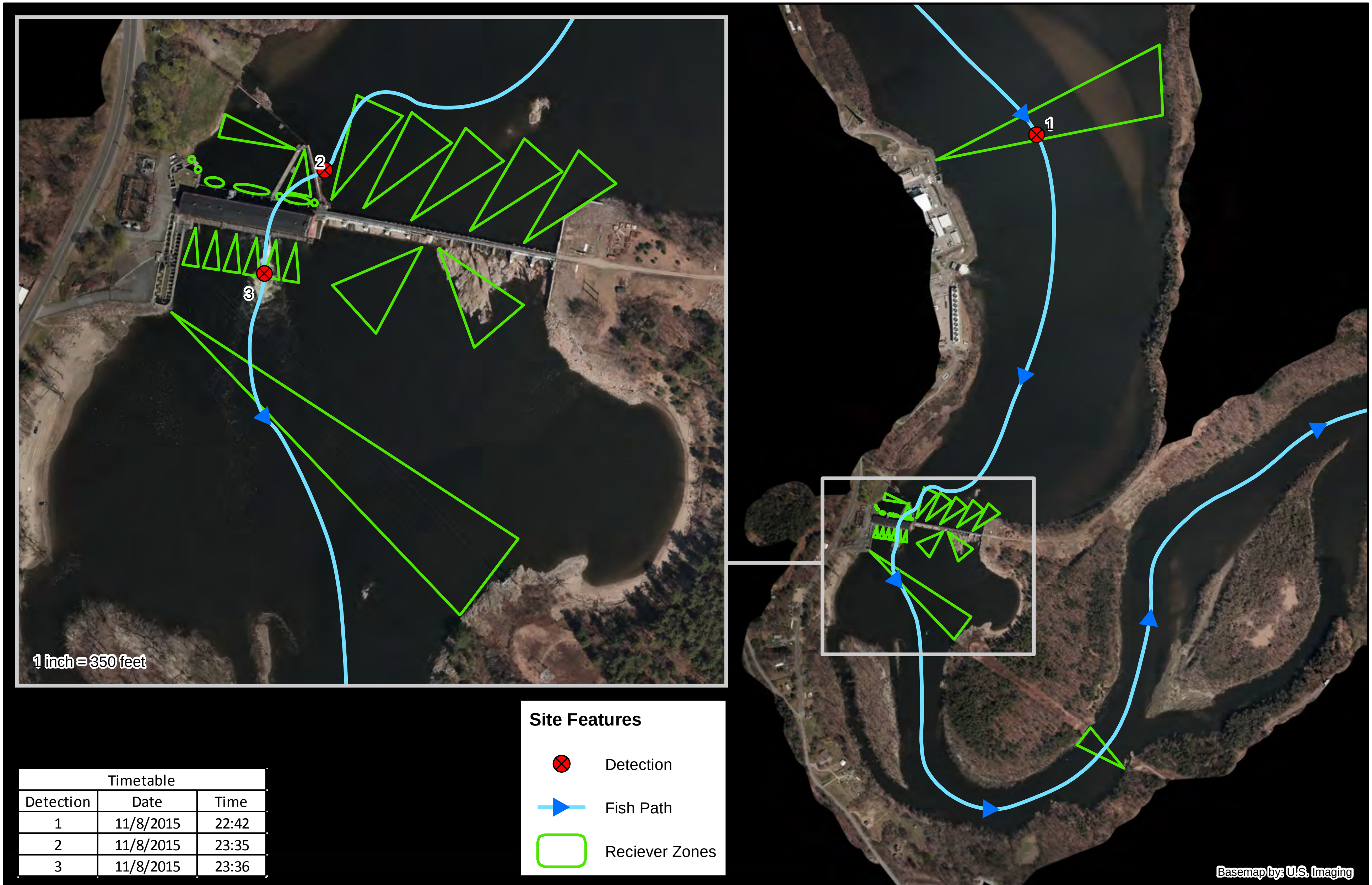

Timetable		
Detection	Date	Time
1	11/8/2015	22:42
2	11/8/2015	23:35
3	11/8/2015	23:36

Site Features

- Detection
- Fish Path
- Reciever Zones

TransCanada Hydro Northeast Inc.
ILP Study 19
Vernon Dam

N

1 in = 1,200 feet

0 600 1,200 2,400 Feet

Study 19 Fish Number: 38-111

Release: Herricks Cove, VT
Date Released: 11/03/2015
Time Released: 16:45

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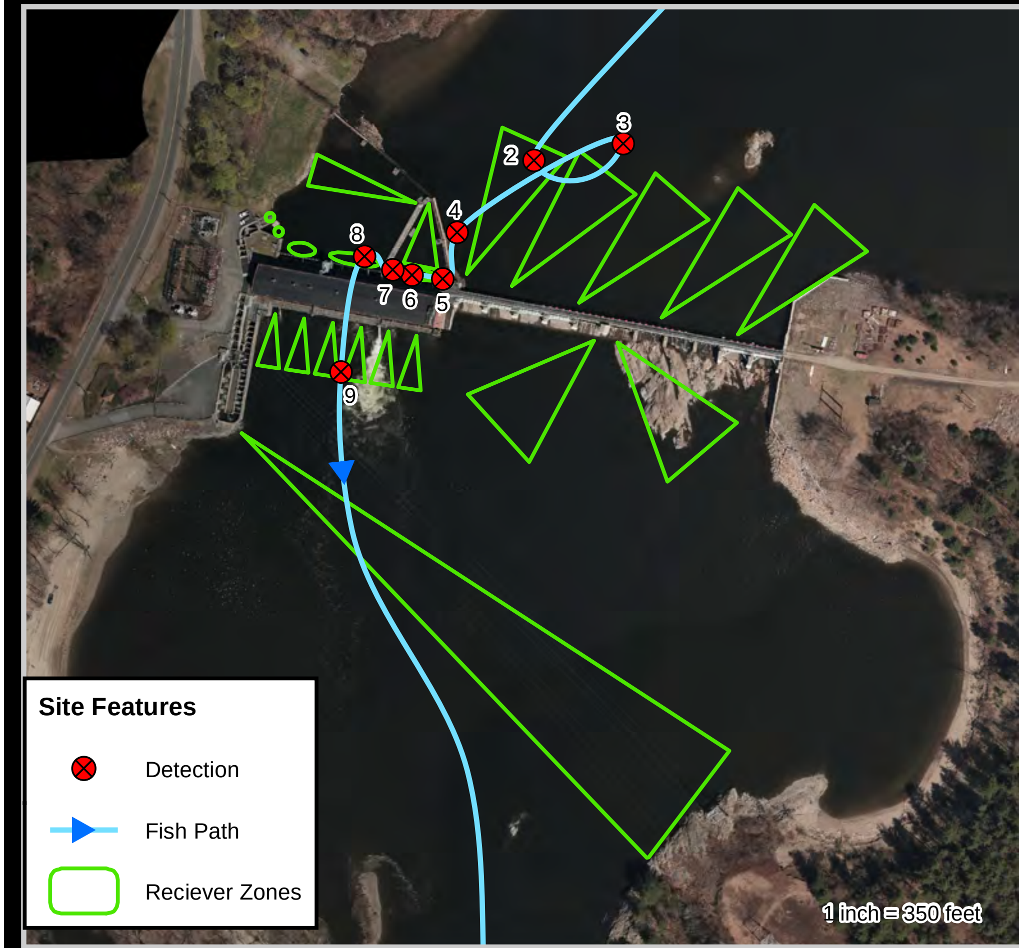

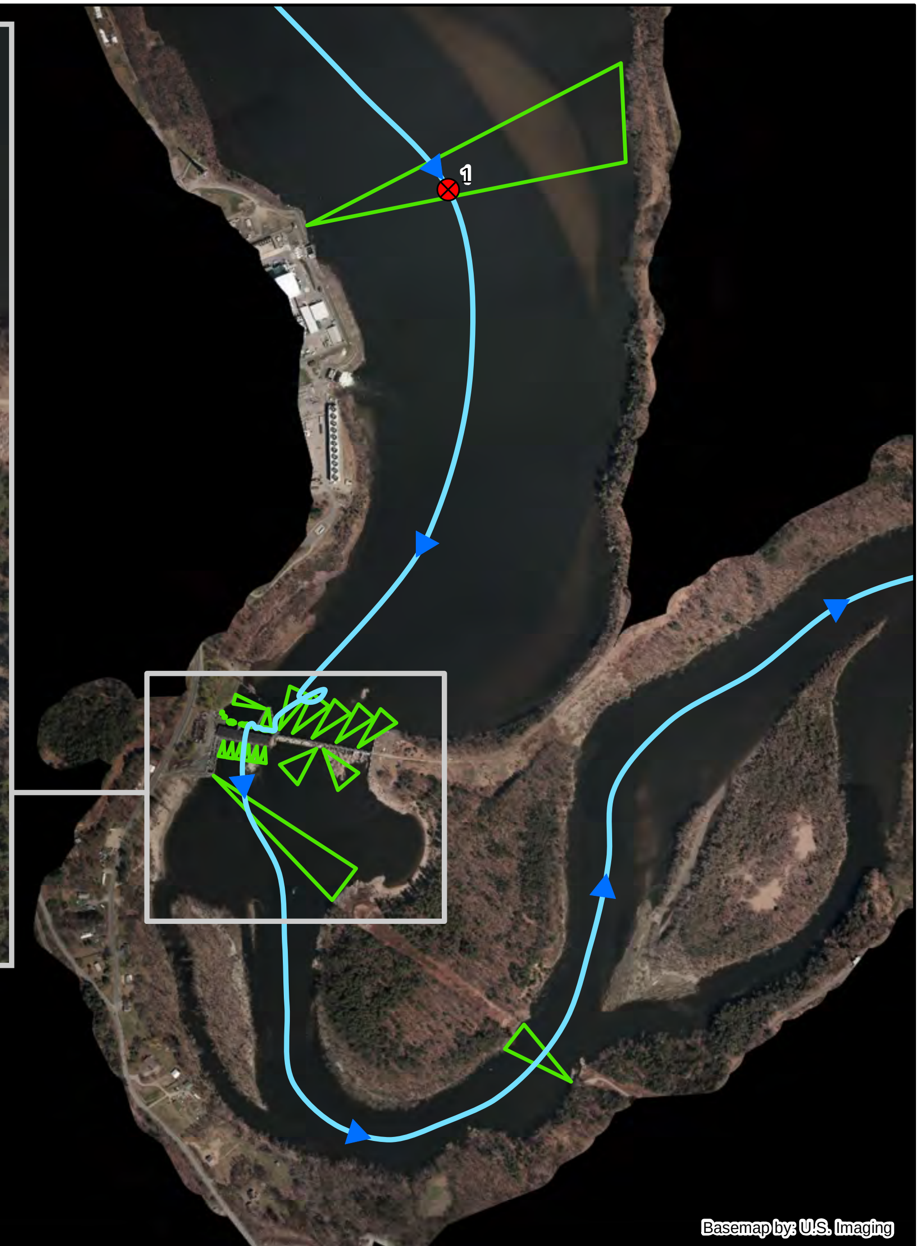

Timetable					
Detection	Date	Time	Detection	Date	Time
1	11/7/2015	0:41	6	11/7/2015	18:41
2	11/7/2015	18:22	7	11/7/2015	18:42
3	11/7/2015	18:27	8	11/7/2015	18:43
4	11/7/2015	18:39	9	11/7/2015	18:43
5	11/7/2015	18:41			

TransCanada Hydro Northeast Inc.
ILP Study 19
Vernon Dam

N

1 in = 1,200 feet

0 600 1,200 2,400 Feet

Study 19 Fish Number: 38-112

Release: Herricks Cove, VT
Date Released: 11/03/2015
Time Released: 16:45

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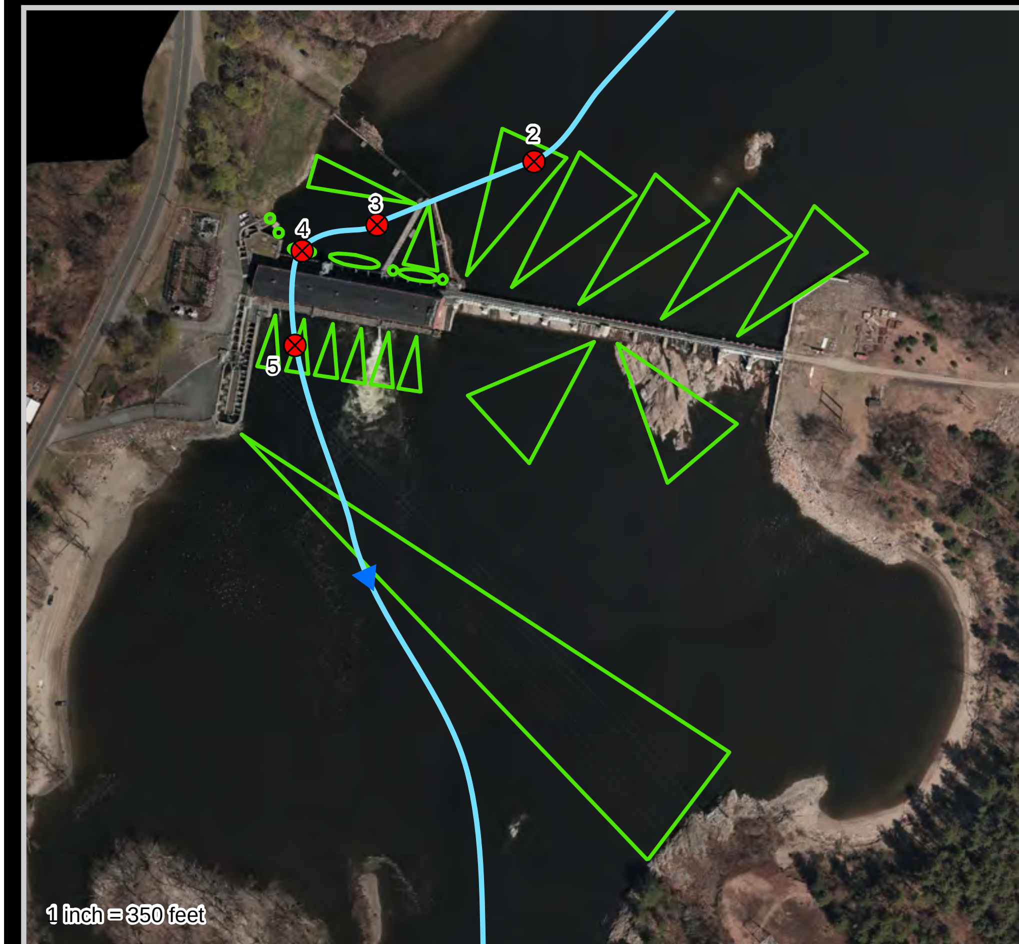

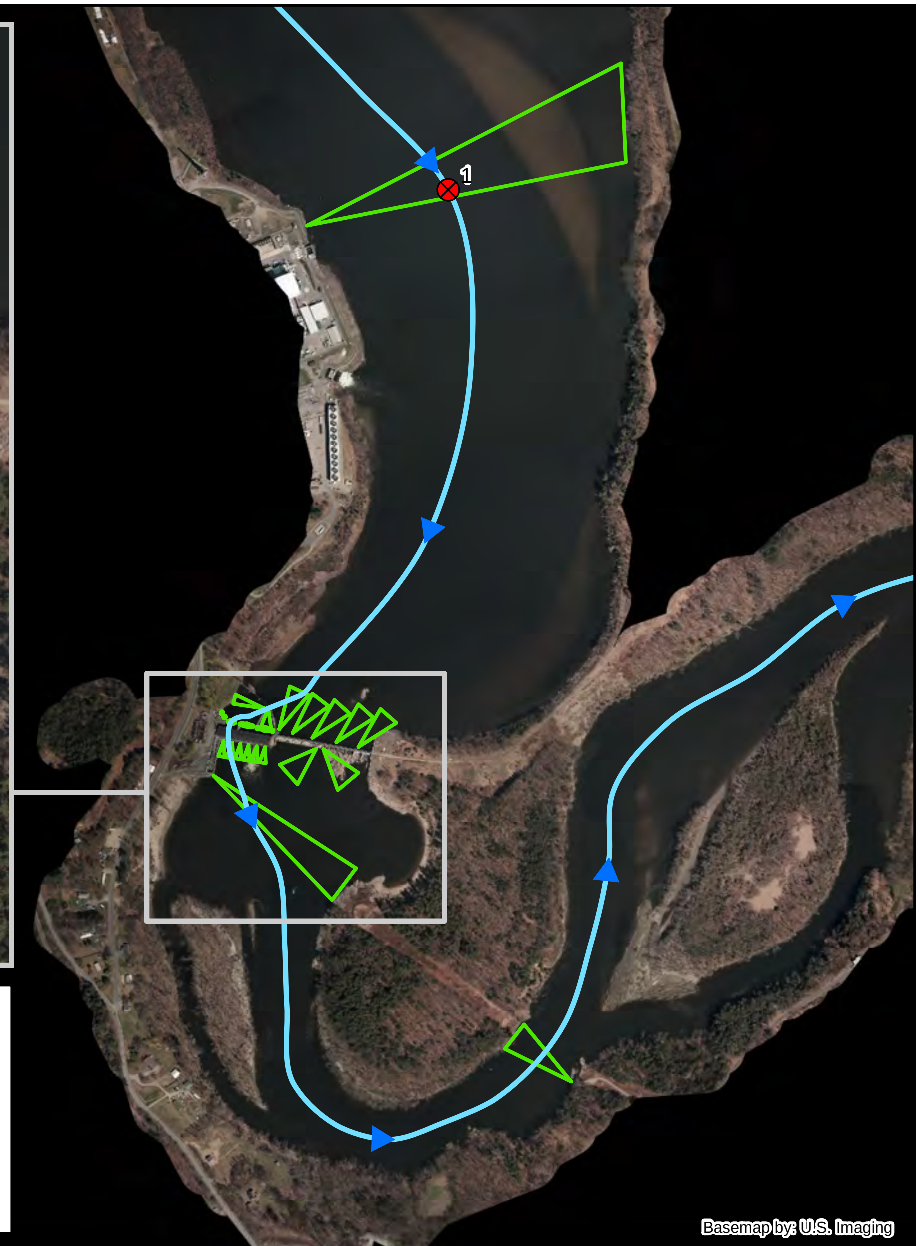

Timetable		
Detection	Date	Time
1	11/6/2015	19:03
2	11/6/2015	19:39
3	11/6/2015	19:42
4	11/6/2015	19:43
5	11/6/2015	19:44

Site Features

- Detection
- Fish Path
- Reciever Zones

TransCanada Hydro Northeast Inc.
ILP Study 19
Vernon Dam

N

1 in = 1,200 feet

0 600 1,200 2,400 Feet

Study 19 Fish Number: 38-113

Release: Herricks Cove, VT
Date Released: 11/03/2015
Time Released: 16:45

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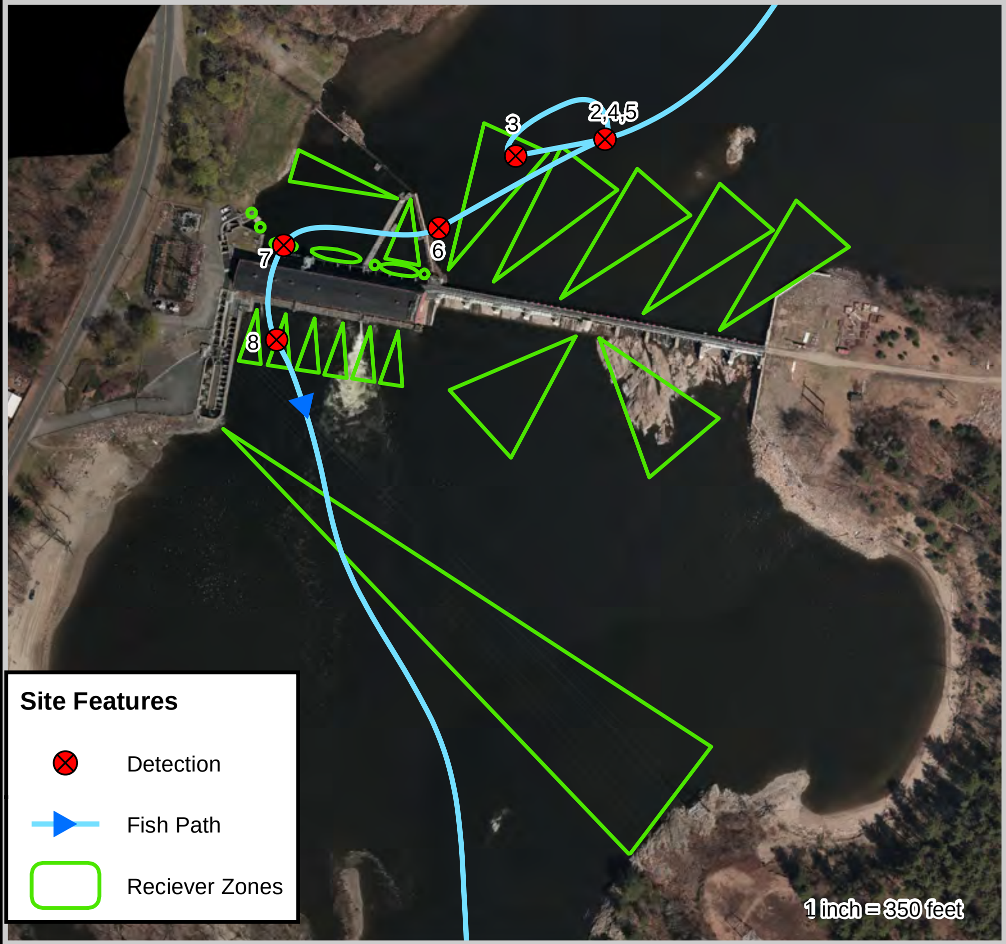

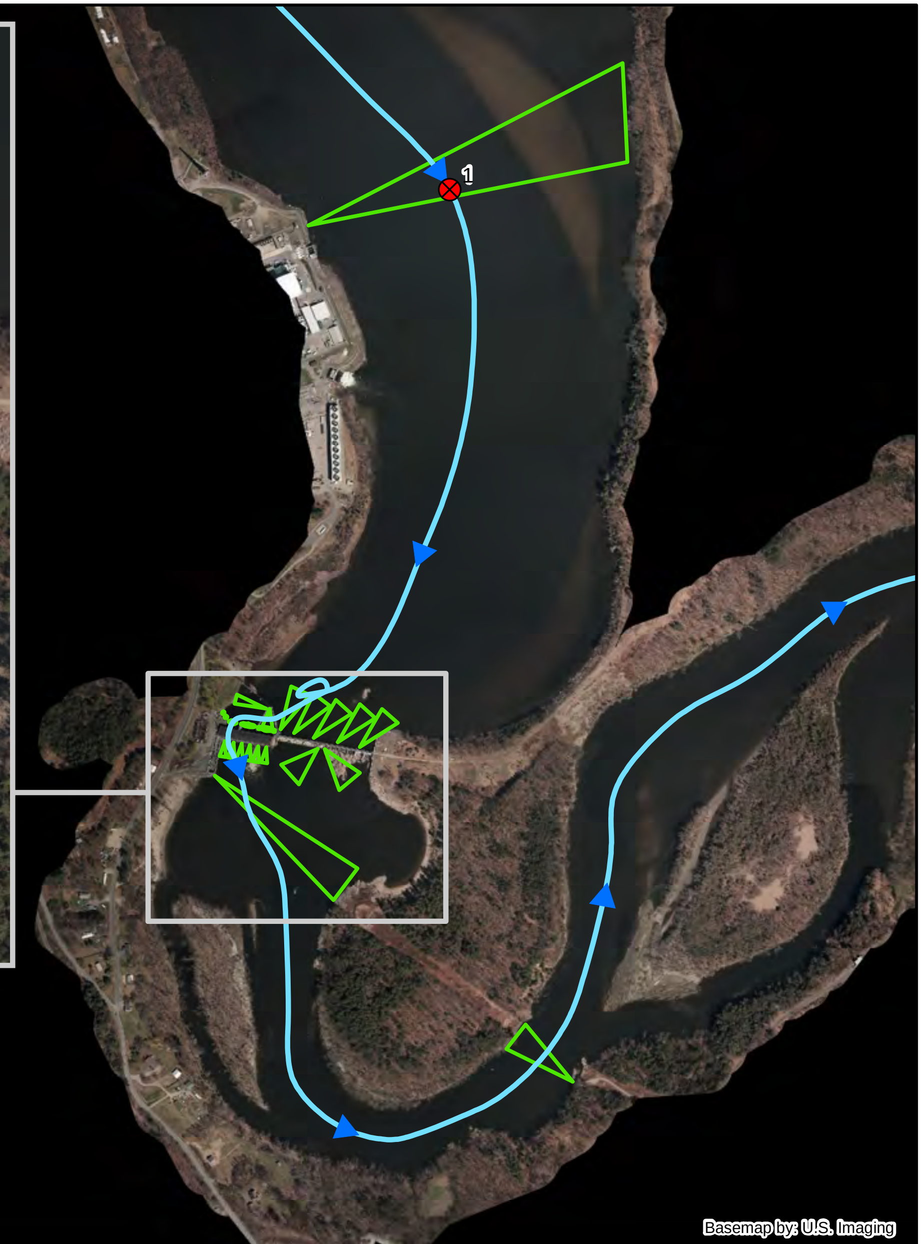

Timetable					
Detection	Date	Time	Detection	Date	Time
1	11/24/2015	1:22	6	12/28/2015	21:02
2	11/24/2015	2:05	7	12/28/2015	21:05
3	11/24/2015	2:12	8	12/28/2015	21:06
4	11/24/2015	2:15			
5	12/28/2015	11:21			

TransCanada Hydro Northeast Inc.
ILP Study 19
Vernon Dam

N

1 in = 1,200 feet

0 600 1,200 2,400 Feet

Study 19 Fish Number: 38-114

Release: Herricks Cove, VT
Date Released: 11/03/2015
Time Released: 16:45

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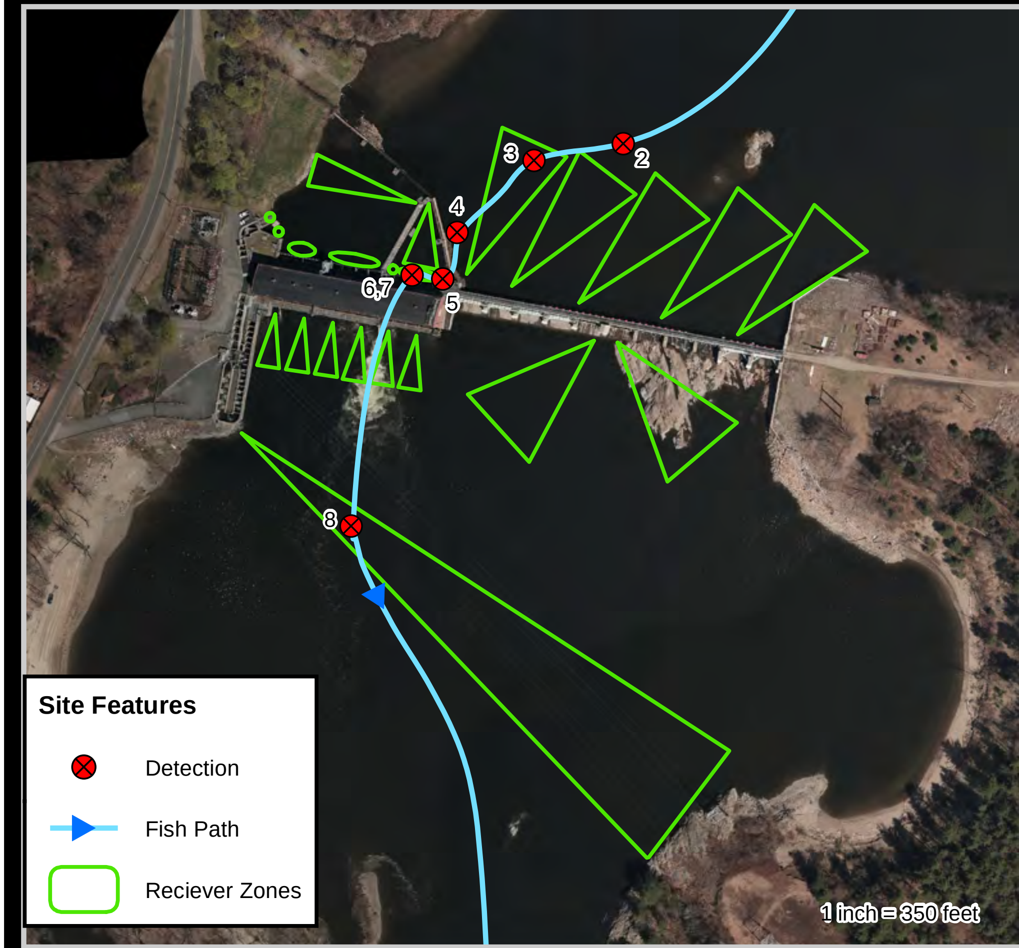

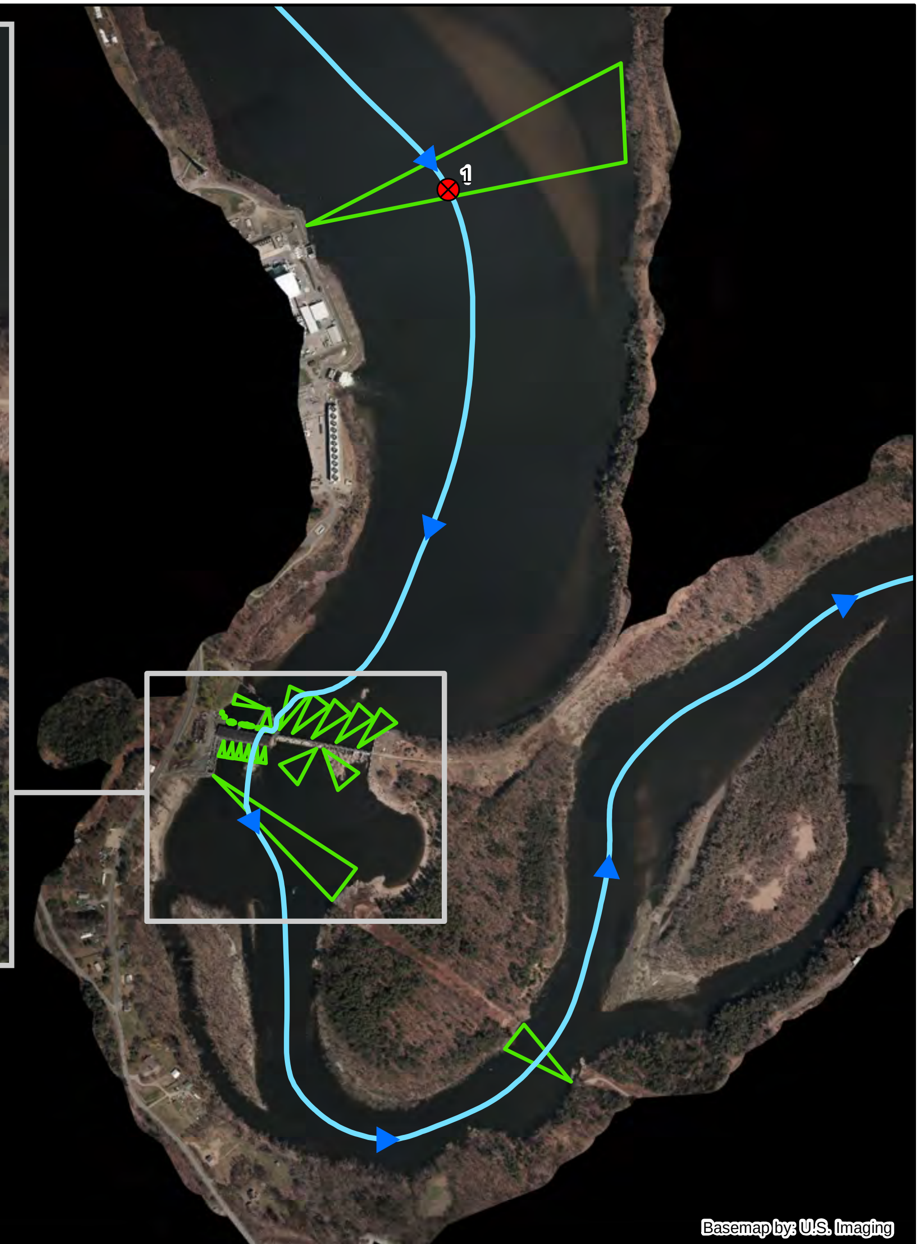

Timetable					
Detection	Date	Time	Detection	Date	Time
1	11/6/2015	11:04	6	11/6/2015	23:30
2	11/6/2015	22:57	7	11/6/2015	23:38
3	11/6/2015	22:57	8	11/6/2015	23:40
4	11/6/2015	23:02			
5	11/6/2015	23:12			

TransCanada Hydro Northeast Inc.
ILP Study 19
Vernon Dam

N

1 in = 1,200 feet

0 600 1,200 2,400 Feet

Study 19 Fish Number: 38-118

Release: Herricks Cove, VT
Date Released: 10/27/2015
Time Released: 18:20

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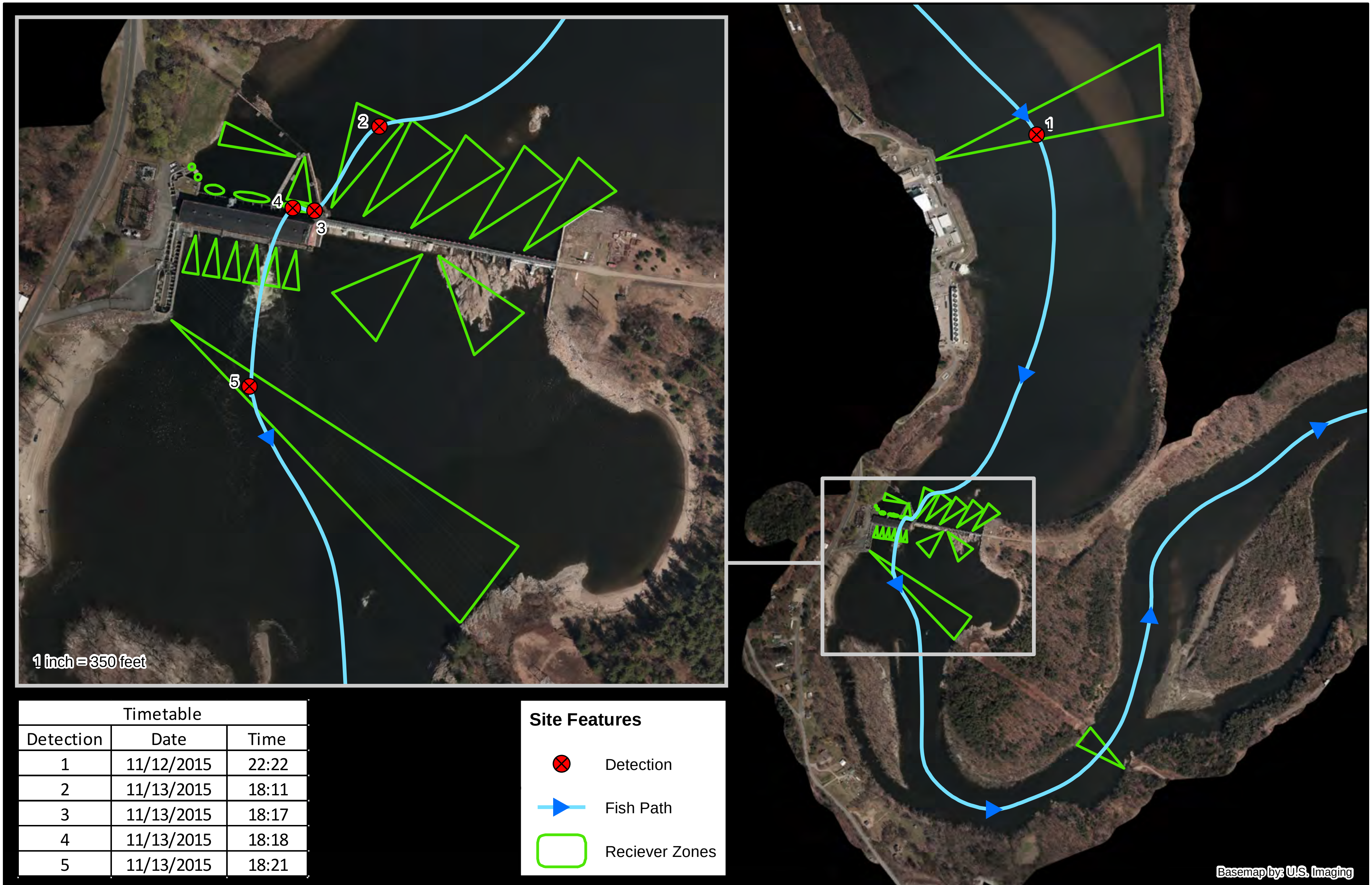

Timetable		
Detection	Date	Time
1	11/12/2015	22:22
2	11/13/2015	18:11
3	11/13/2015	18:17
4	11/13/2015	18:18
5	11/13/2015	18:21

Site Features

- Detection
- Fish Path
- Reciever Zones

TransCanada Hydro Northeast Inc.
ILP Study 19
Vernon Dam

1 in = 1,200 feet

0 600 1,200 2,400 Feet

Study 19 Fish Number: 38-119

Release: Herricks Cove, VT
Date Released: 10/27/2015
Time Released: 18:20

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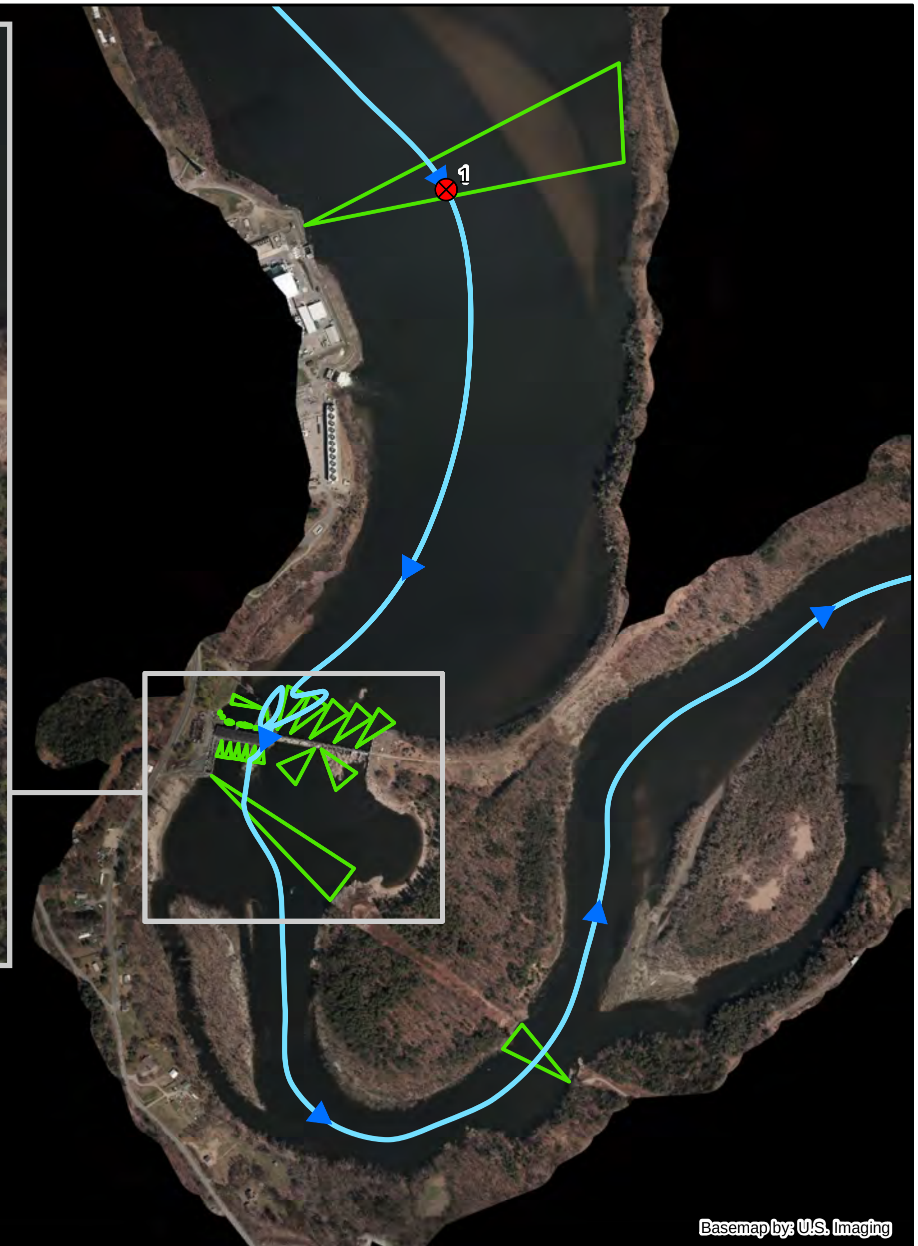

Timetable					
Detection	Date	Time	Detection	Date	Time
1	11/13/2015	20:39	6	11/13/2015	23:55
2	11/13/2015	21:37	7	11/13/2015	23:56
3	11/13/2015	21:40	8	11/13/2015	23:56
4	11/13/2015	23:03	9	11/13/2015	23:57
5	11/13/2015	23:55	10	11/13/2015	23:57

TransCanada Hydro Northeast Inc.
ILP Study 19
Vernon Dam

N

1 in = 1,200 feet

0 600 1,200 2,400 Feet

Study 19 Fish Number: 38-120

Release: Herricks Cove, VT
Date Released: 10/27/2015
Time Released: 18:20

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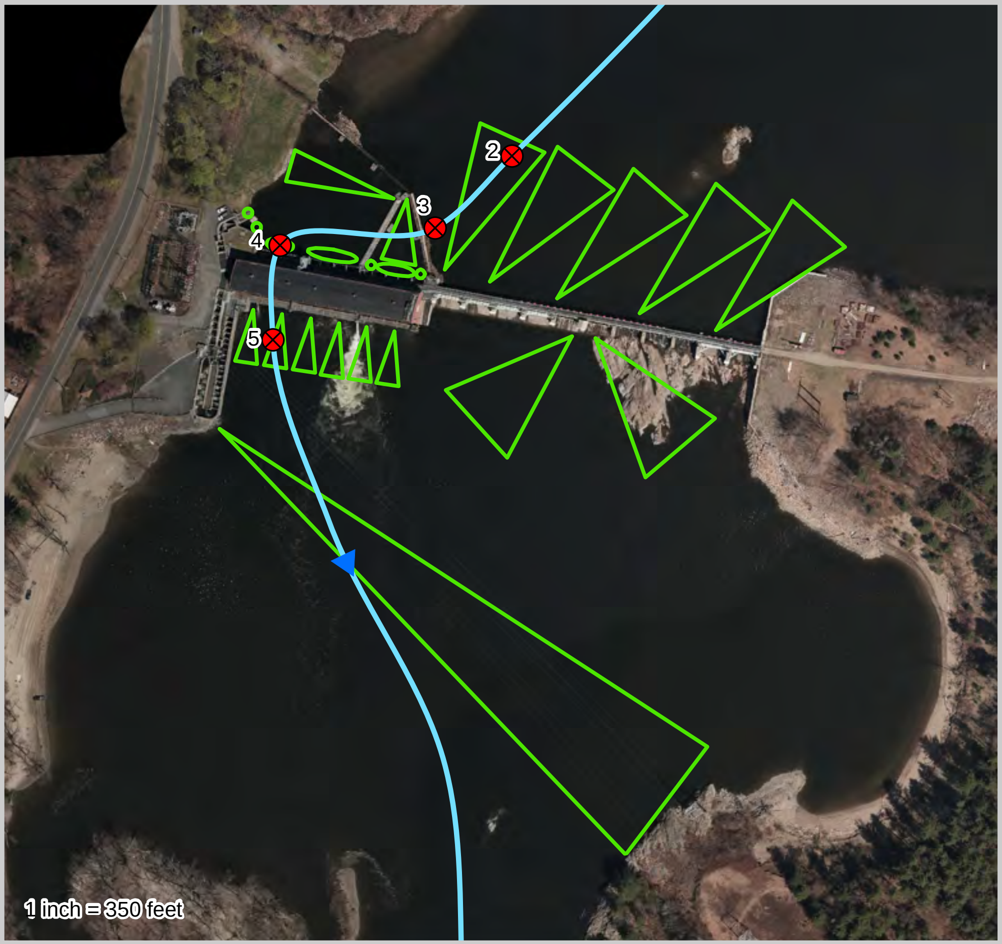

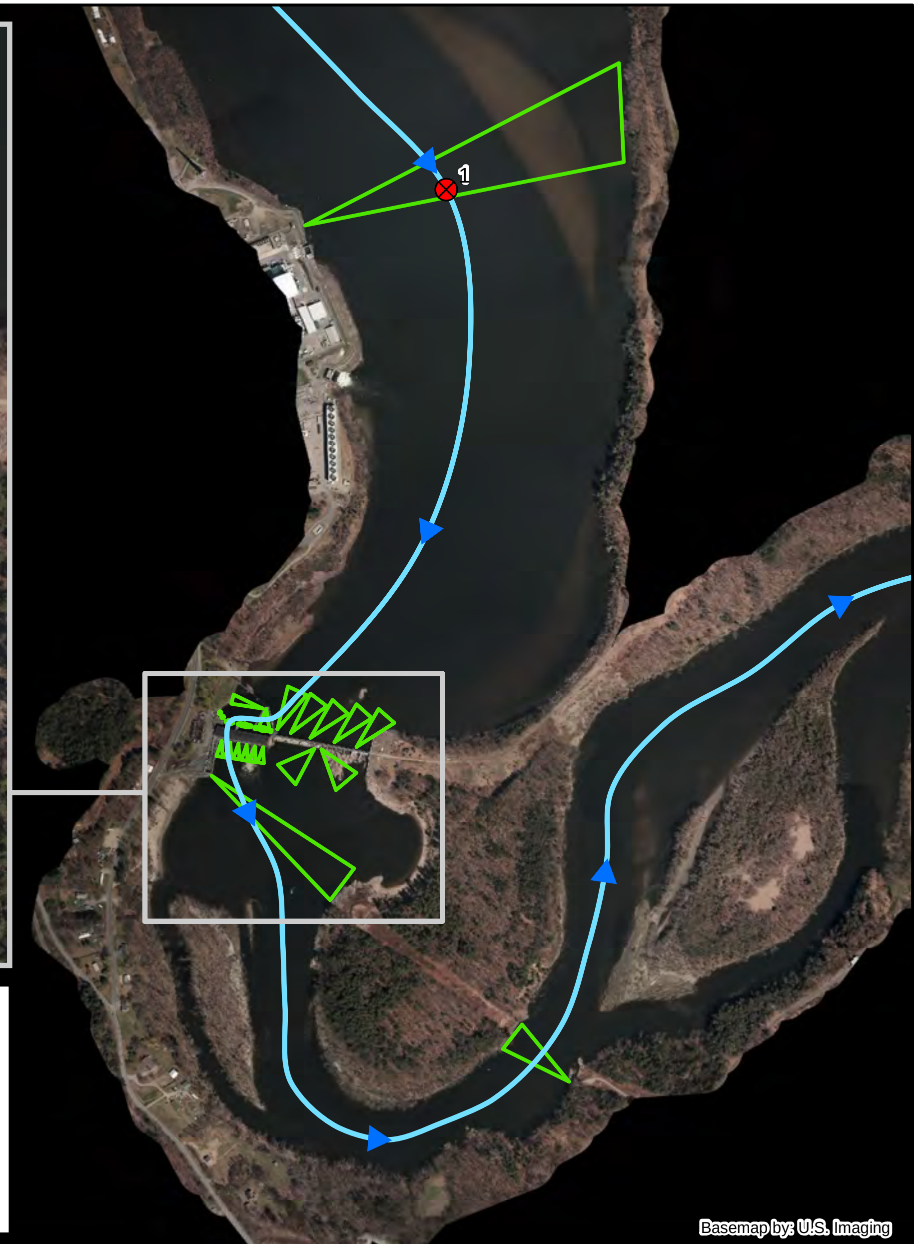

Timetable		
Detection	Date	Time
1	11/7/2015	20:48
2	11/7/2015	21:25
3	11/7/2015	21:25
4	11/7/2015	21:33
5	11/7/2015	21:34

Site Features

- Detection
- Fish Path
- Reciever Zones

TransCanada Hydro Northeast Inc.
ILP Study 19
Vernon Dam

N

1 in = 1,200 feet

0 600 1,200 2,400 Feet

Study 19 Fish Number: 38-124

Release: Norwich, VT
Date Released: 11/03/2015
Time Released: 17:32

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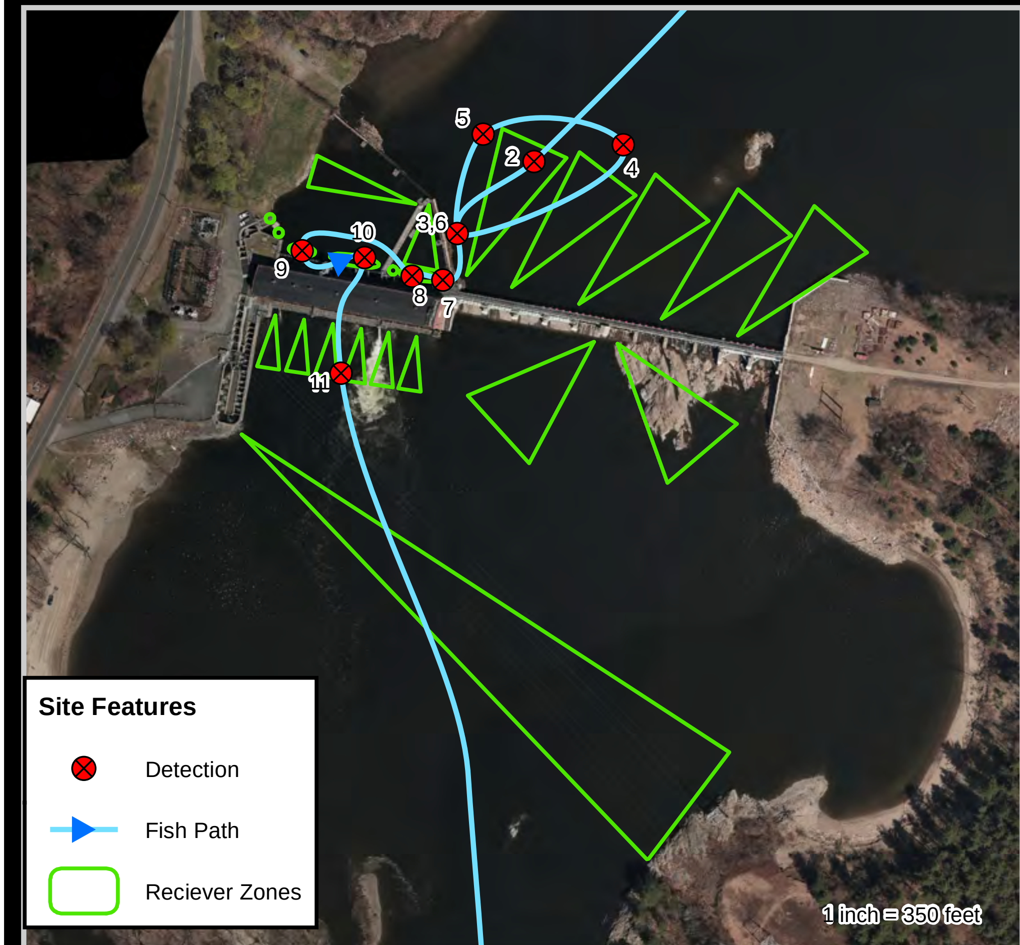

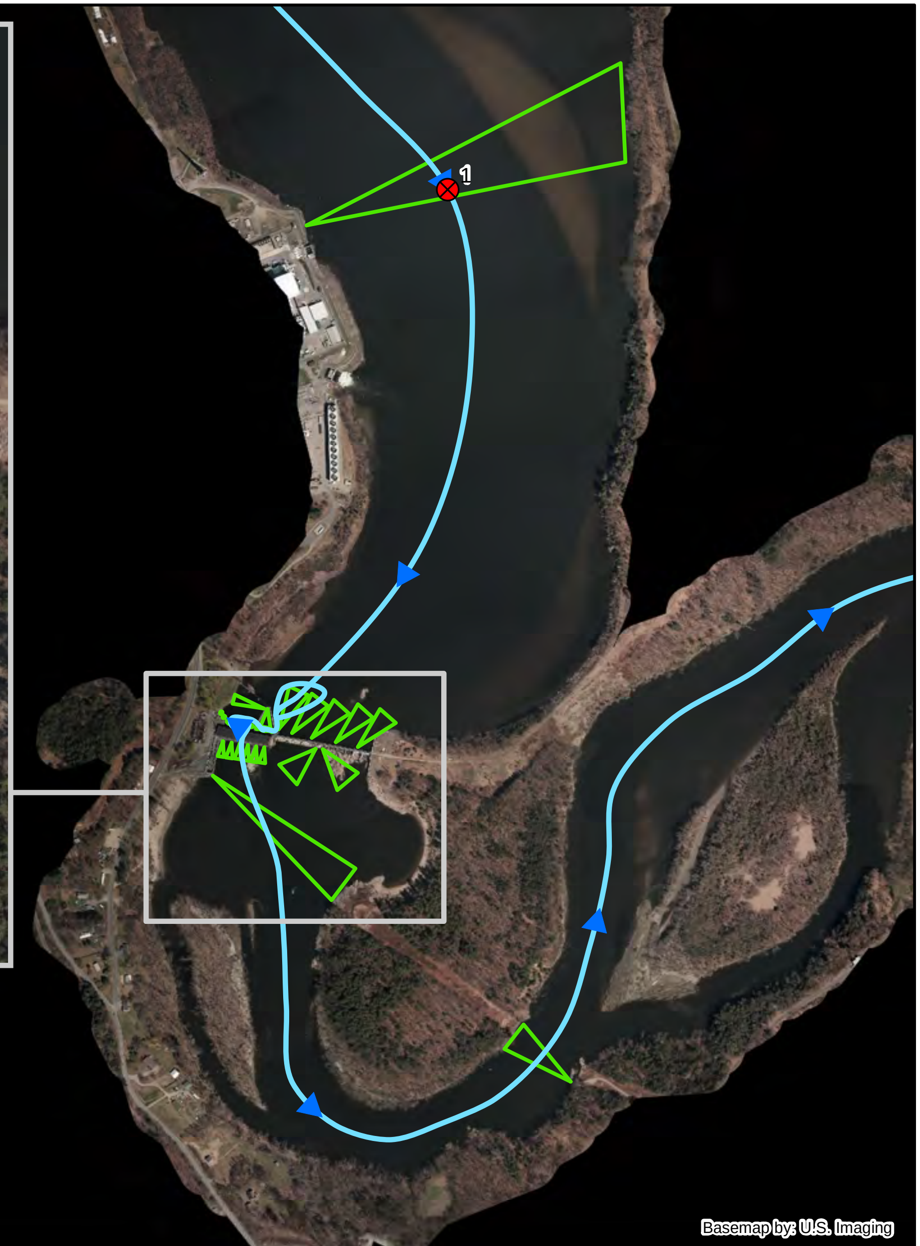

Timetable					
Detection	Date	Time	Detection	Date	Time
1	11/8/2015	21:23	7	11/8/2015	22:54
2	11/8/2015	22:23	8	11/8/2015	22:54
3	11/8/2015	22:24	9	11/8/2015	23:00
4	11/8/2015	22:46	10	11/8/2015	23:01
5	11/8/2015	22:52	11	11/8/2015	23:01
6	11/8/2015	22:53			

TransCanada Hydro Northeast Inc.
ILP Study 19
Vernon Dam

N

1 in = 1,200 feet

0 600 1,200 2,400 Feet

Study 19 Fish Number: 38-131
Release: Riverside Industrial Complex
Brattleboro, VT
Date Released: 11/05/2015
Time Released: 15:35

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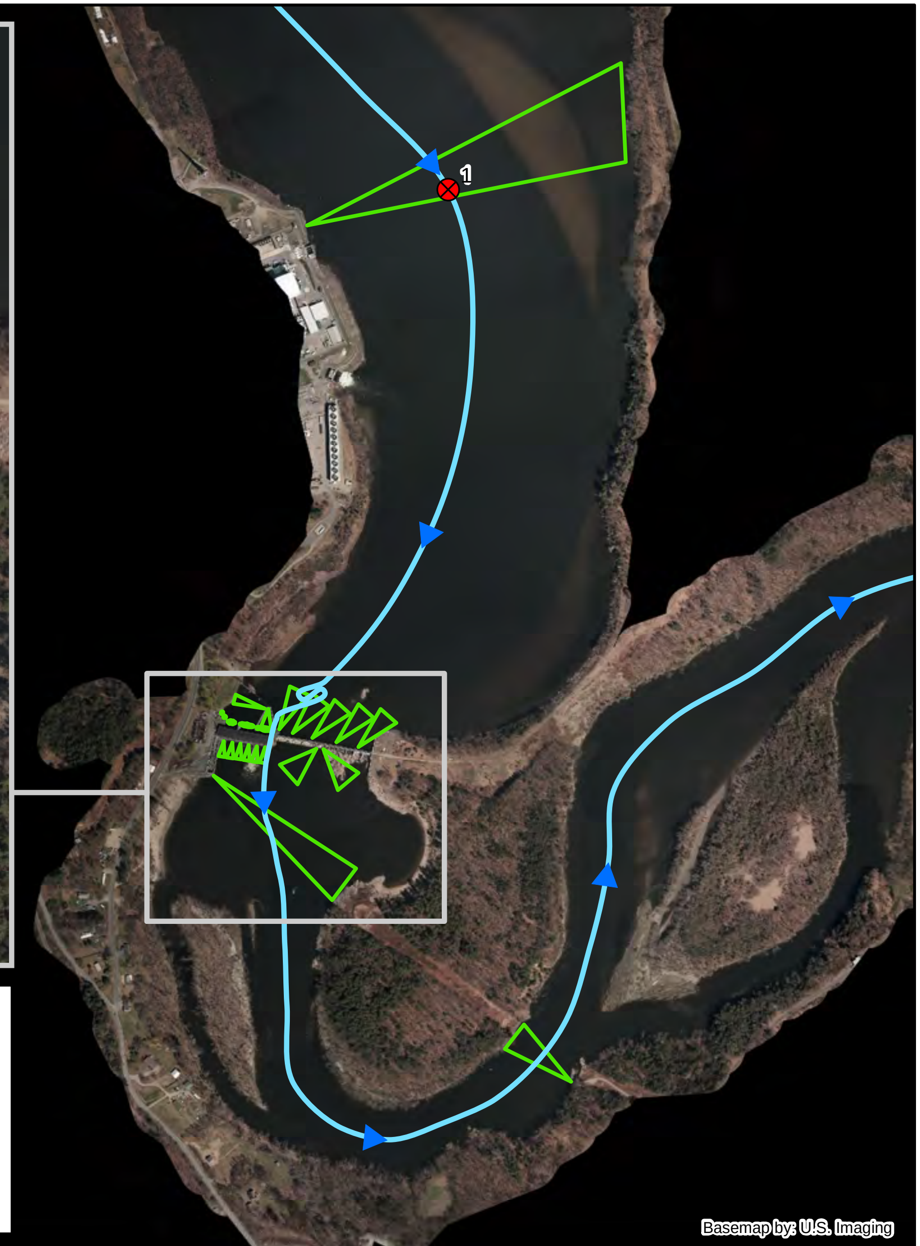
Timetable		
Detection	Date	Time
1	11/13/2015	19:52
2	11/13/2015	20:57
3	11/13/2015	21:00
4	11/13/2015	21:08
5	11/13/2015	21:37
6	11/13/2015	21:37

Site Features

- Detection
- Fish Path
- Reciever Zones



TransCanada Hydro Northeast Inc.
ILP Study 19
Vernon Dam

N

1 in = 1,200 feet

0 600 1,200 2,400 Feet

Study 19 Fish Number: 38-132
Release: Riverside Industrial Complex
Brattleboro, VT
Date Released: 11/05/2015
Time Released: 15:35

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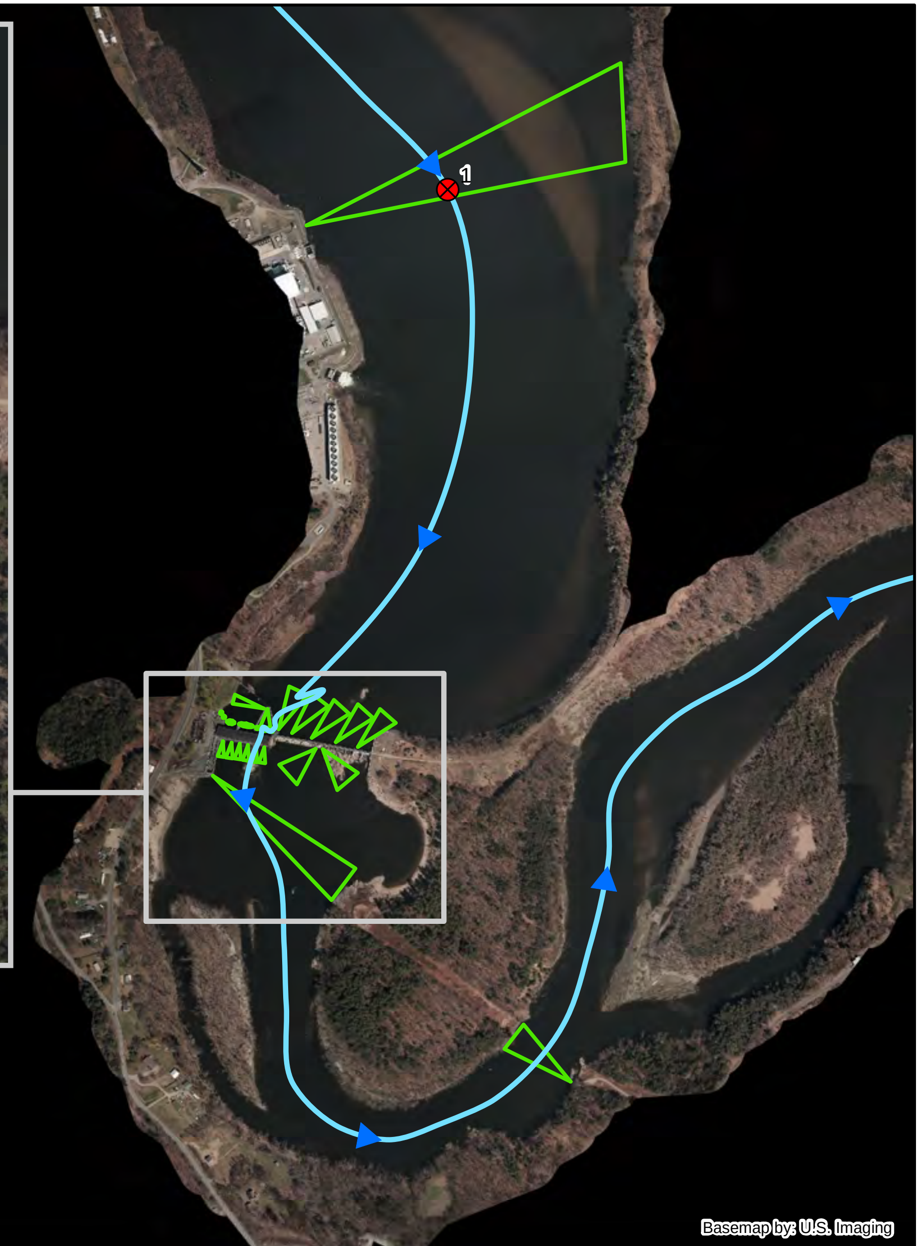

Timetable					
Detection	Date	Time	Detection	Date	Time
1	11/7/2015	2:02	6	11/7/2015	4:19
2	11/7/2015	2:44	7	11/7/2015	4:20
3	11/7/2015	2:45			
4	11/7/2015	2:47			
5	11/7/2015	4:19			

TransCanada Hydro Northeast Inc.
ILP Study 19
Vernon Dam

N

1 in = 1,200 feet

0 600 1,200 2,400 Feet

Study 19 Fish Number: 38-133
Release: Riverside Industrial Complex
Brattleboro, VT
Date Released: 11/05/2015
Time Released: 15:35

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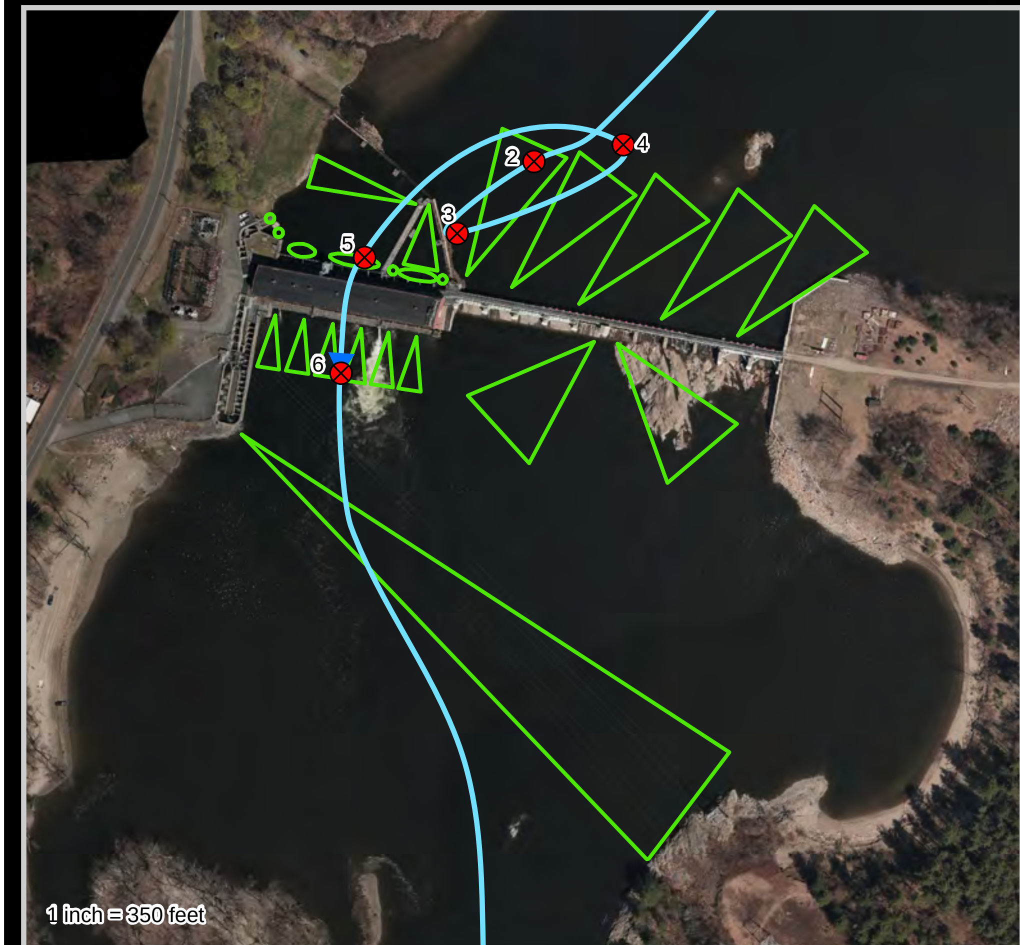

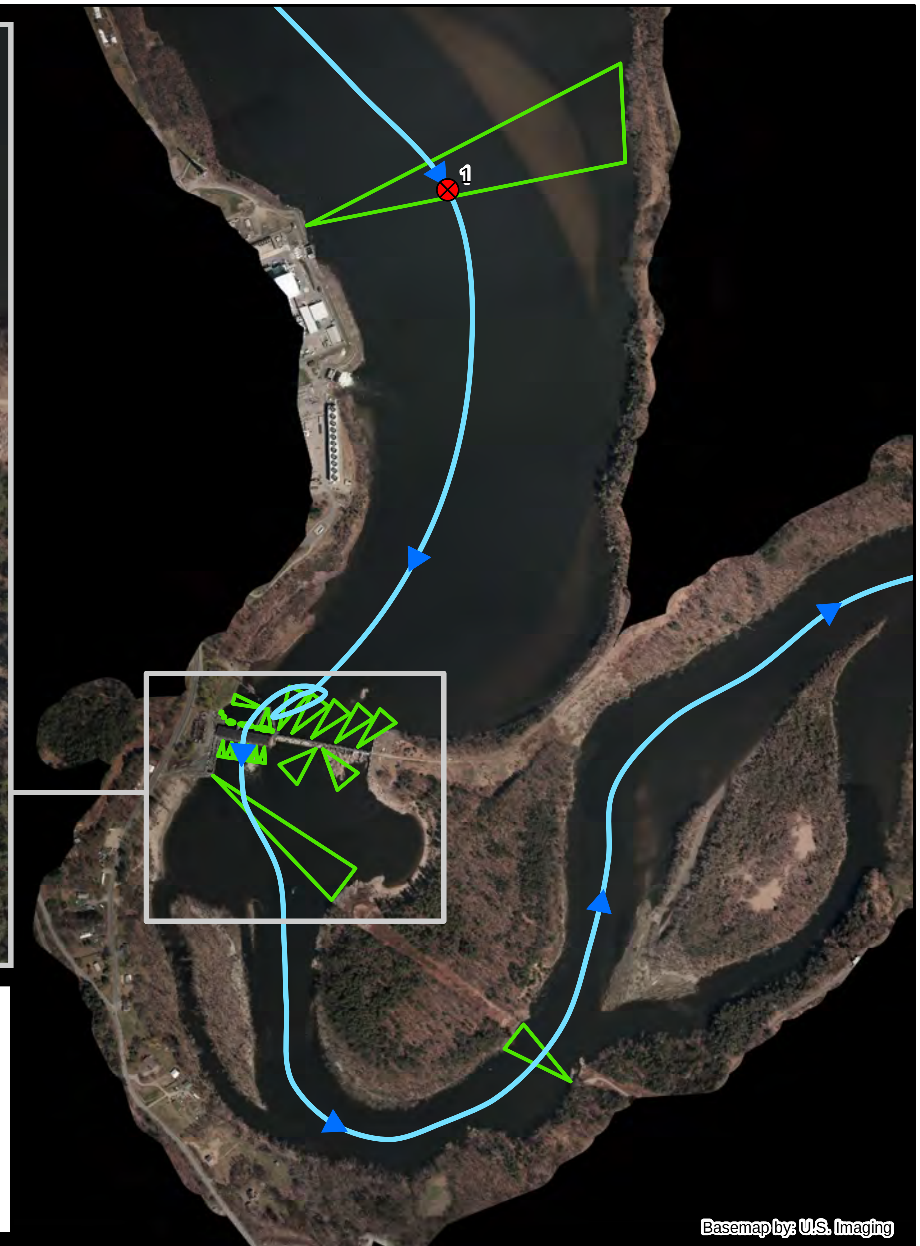

Timetable		
Detection	Date	Time
1	11/5/2015	22:26
2	11/5/2015	22:58
3	11/5/2015	23:01
4	11/5/2015	23:03
5	11/5/2015	23:06
6	11/5/2015	23:06

Site Features

- Detection
- Fish Path
- Reciever Zones

TransCanada Hydro Northeast Inc.
ILP Study 19
Vernon Dam

N

1 in = 1,200 feet

0 600 1,200 2,400 Feet

Study 19 Fish Number: 38-134
Release: Riverside Industrial Complex
Brattleboro, VT
Date Released: 11/05/2015
Time Released: 15:35

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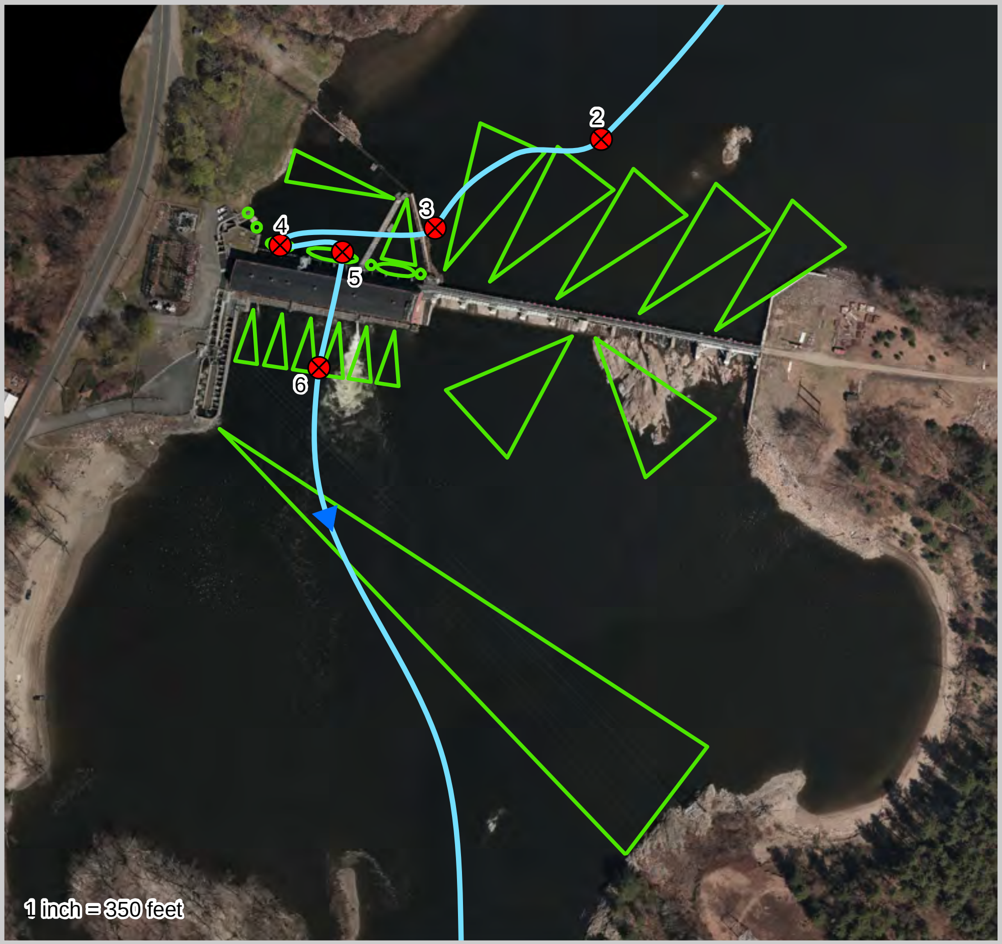

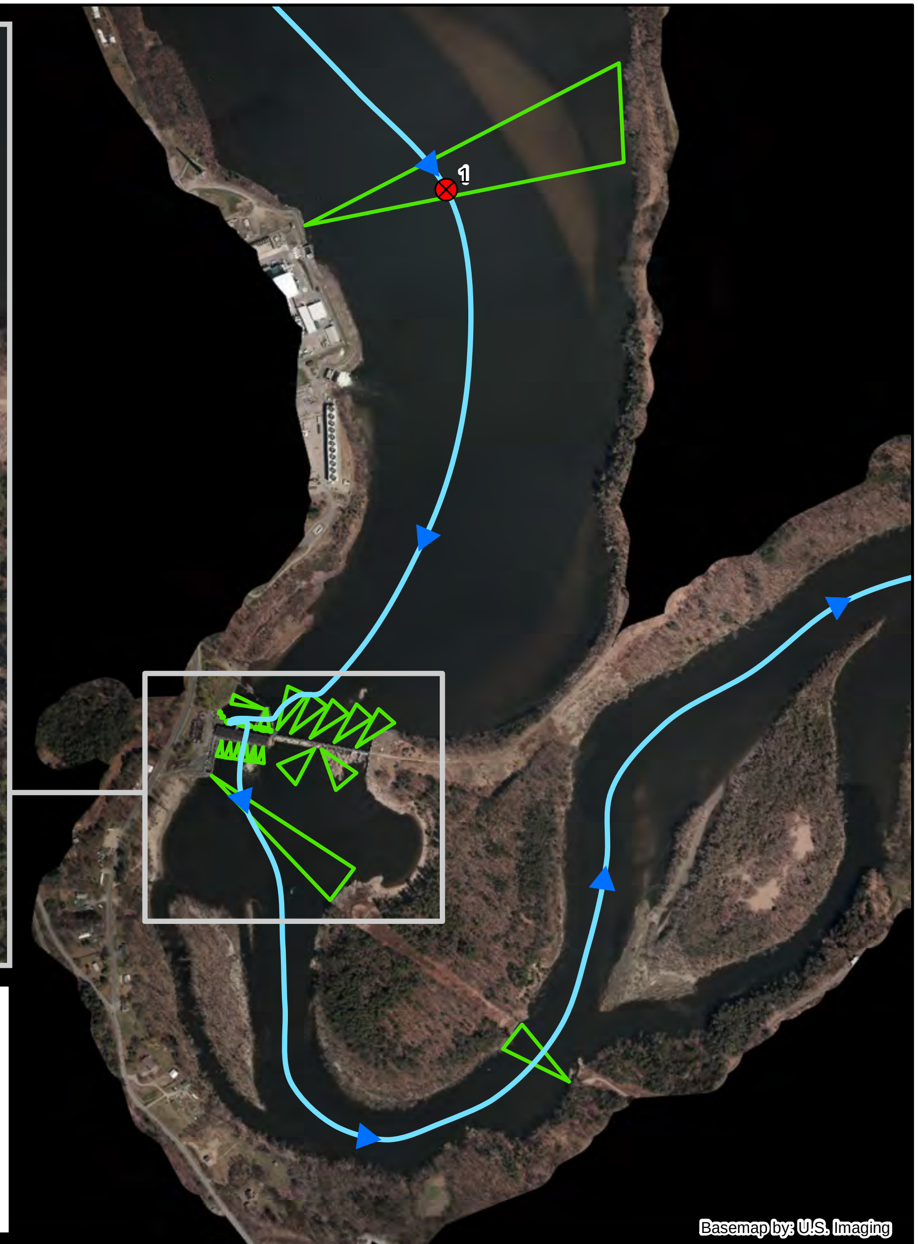

Timetable		
Detection	Date	Time
1	10/29/2015	21:18
2	10/29/2015	21:45
3	10/29/2015	21:53
4	10/29/2015	21:53
5	10/29/2015	21:55
6	10/29/2015	21:55

Site Features

- Detection
- Fish Path
- Reciever Zones

TransCanada Hydro Northeast Inc.
ILP Study 19
Vernon Dam

N

1 in = 1,200 feet

0 600 1,200 2,400 Feet

Study 19 Fish Number: 38-138
Release: Riverside Industrial Complex
Brattleboro, VT
Date Released: 10/29/2015
Time Released: 13:05

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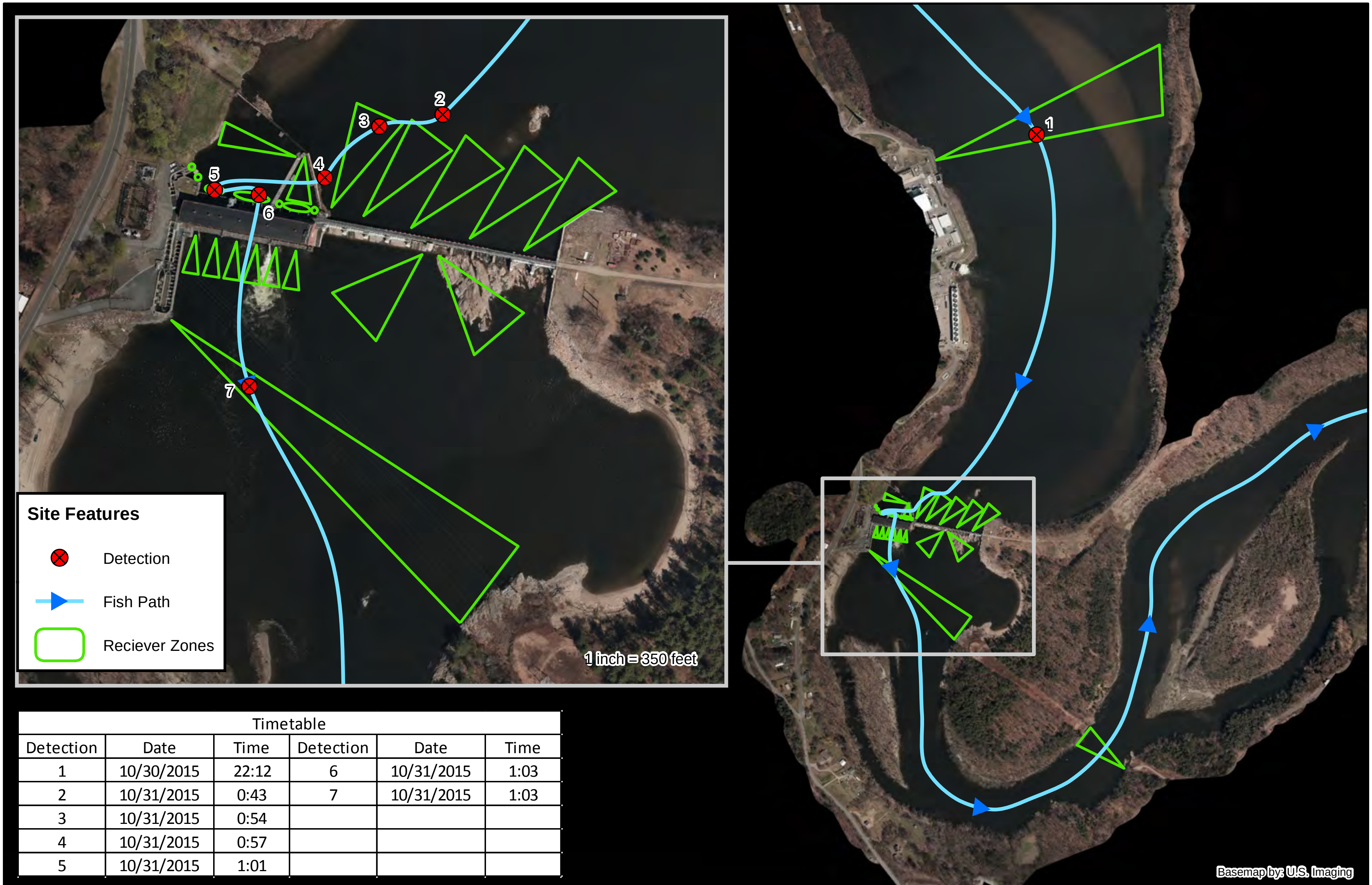

Timetable					
Detection	Date	Time	Detection	Date	Time
1	10/30/2015	22:12	6	10/31/2015	1:03
2	10/31/2015	0:43	7	10/31/2015	1:03
3	10/31/2015	0:54			
4	10/31/2015	0:57			
5	10/31/2015	1:01			

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ILP Study 19
Vernon Dam

N

1 in = 1,200 feet

0 600 1,200 2,400 Feet

Study 19 Fish Number: 38-139
Release: Riverside Industrial Complex
Brattleboro, VT
Date Released: 10/29/2015
Time Released: 13:05

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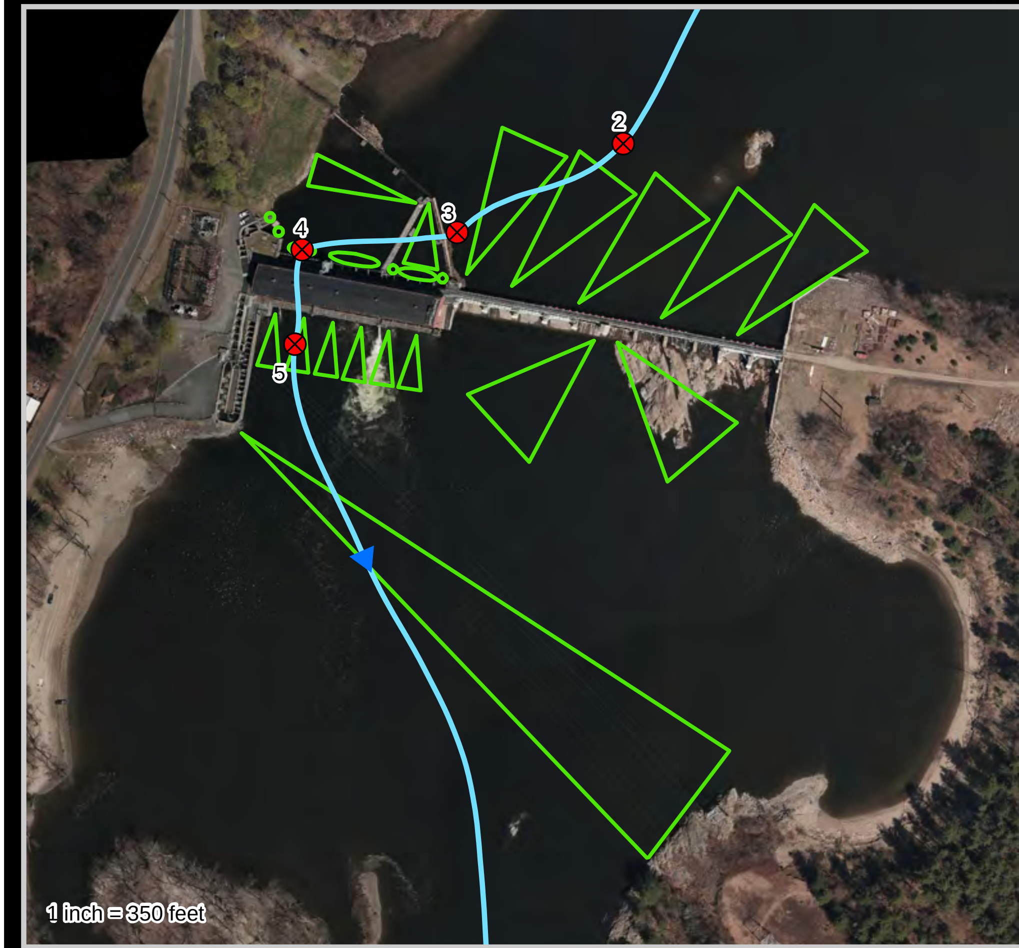

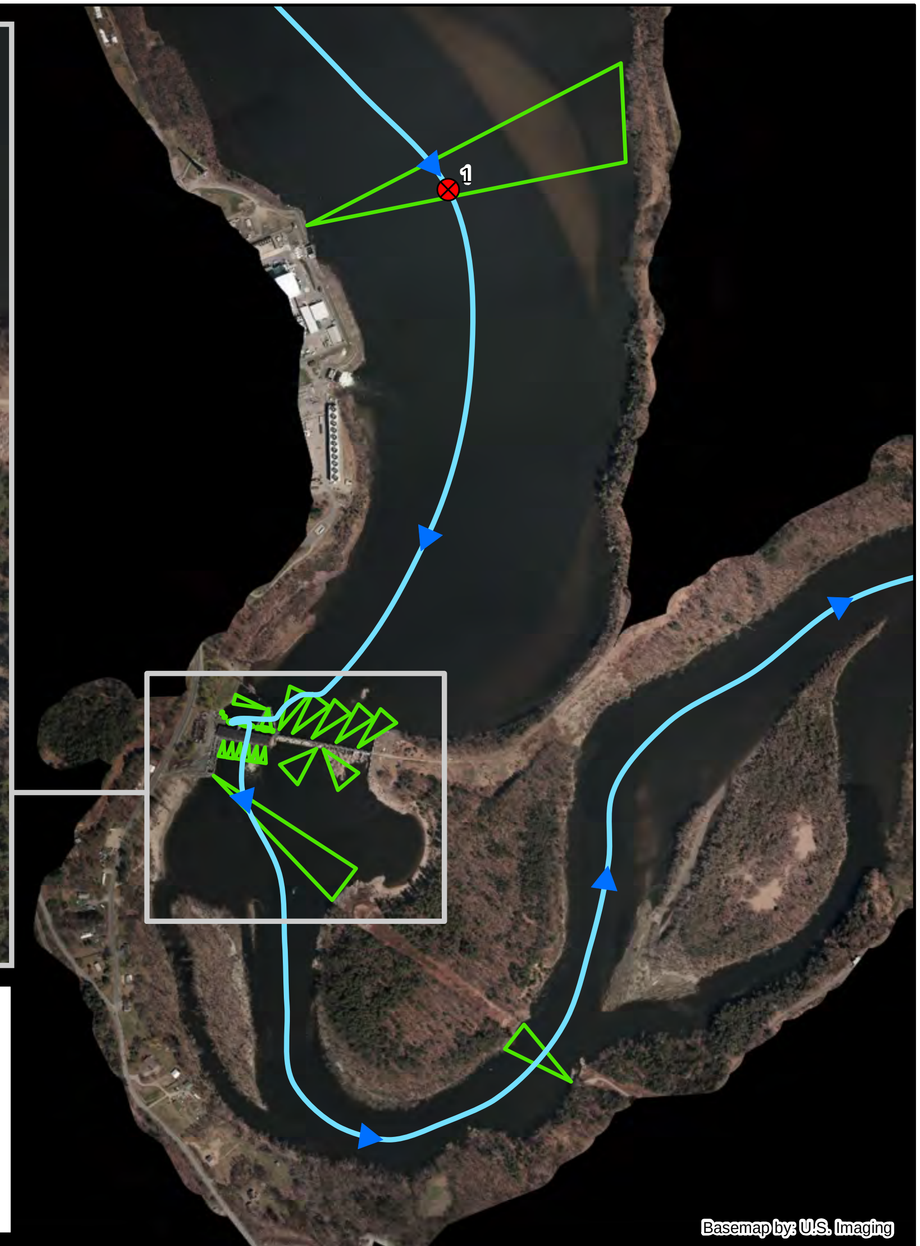

Timetable		
Detection	Date	Time
1	10/29/2015	18:28
2	10/29/2015	18:58
3	10/29/2015	19:03
4	10/29/2015	19:05
5	10/29/2015	19:07

Site Features

- Detection
- Fish Path
- Reciever Zones

TransCanada Hydro Northeast Inc.
ILP Study 19
Vernon Dam

N

1 in = 1,200 feet

0 600 1,200 2,400 Feet

Study 19 Fish Number: 38-140
Release: Riverside Industrial Complex
Brattleboro, VT
Date Released: 10/29/2015
Time Released: 13:05

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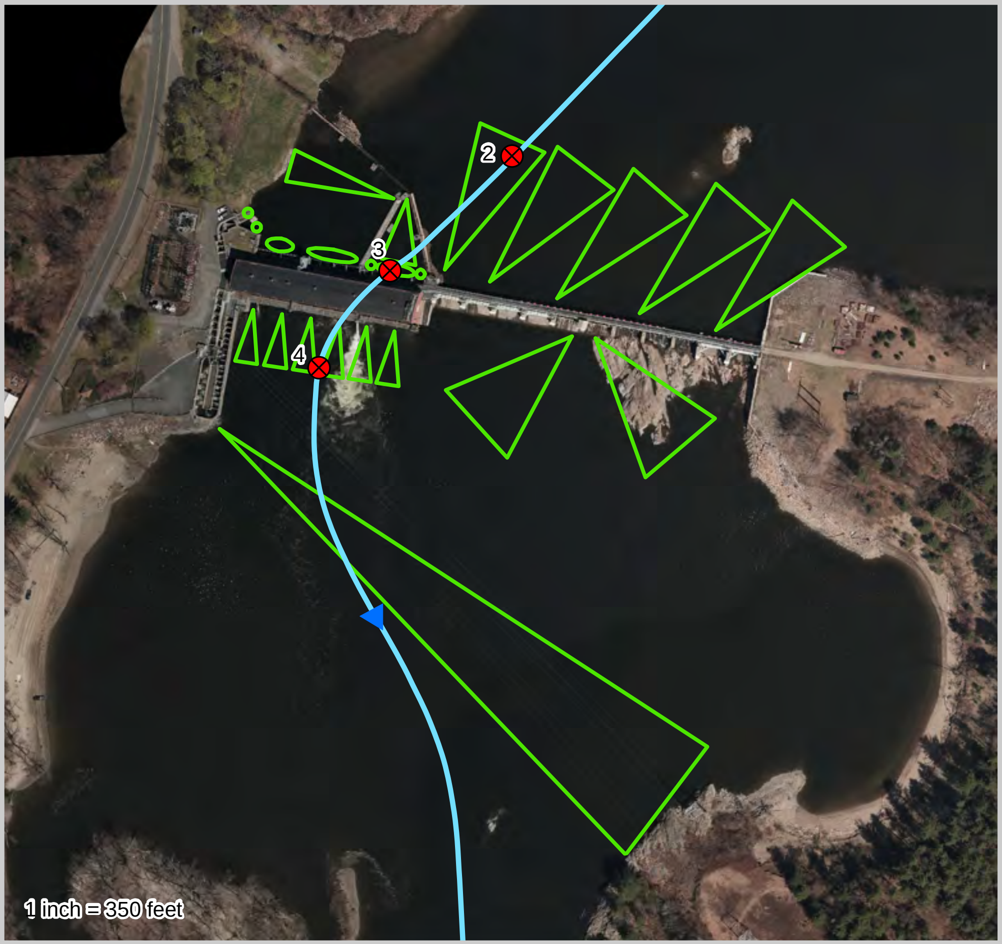

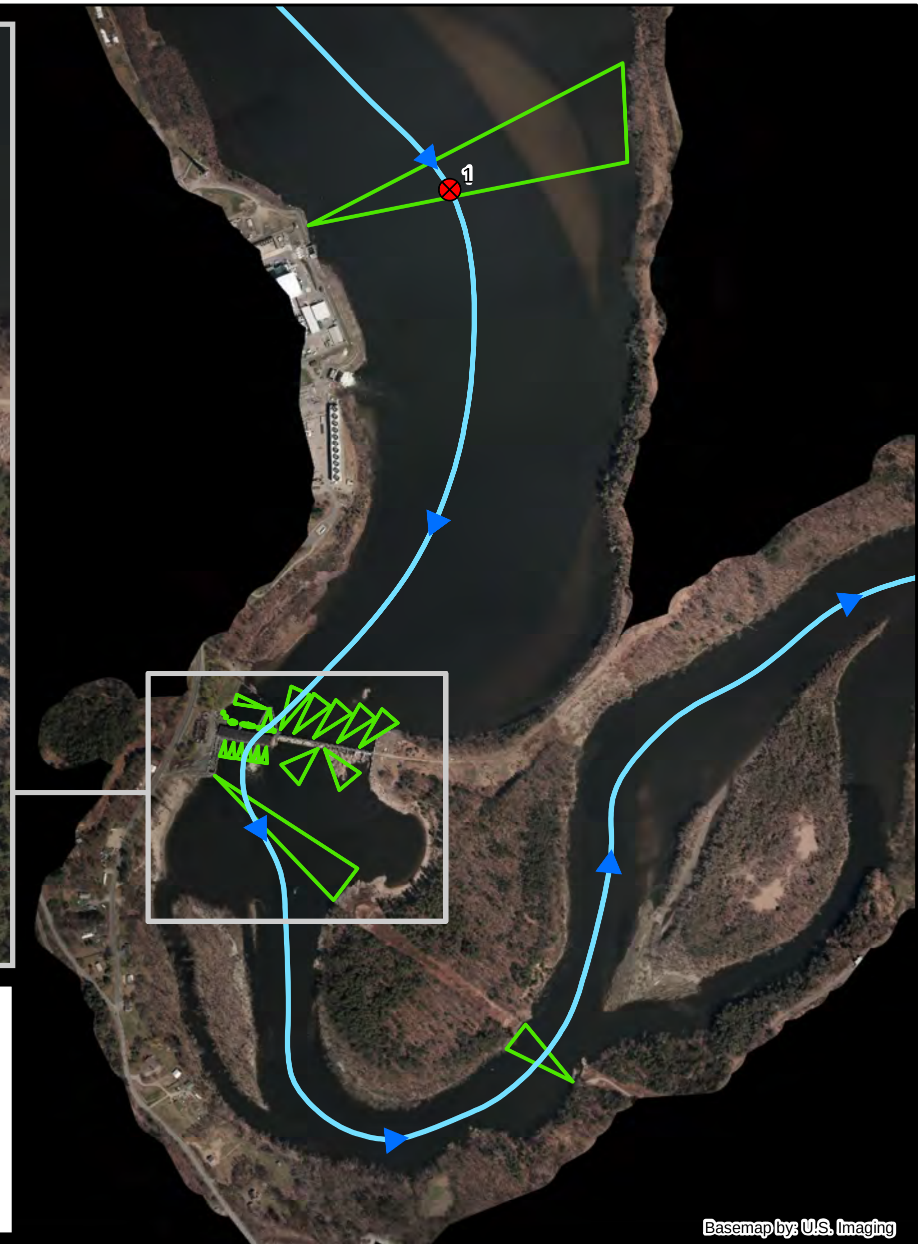

Timetable		
Detection	Date	Time
1	11/7/2015	6:16
2	11/7/2015	19:22
3	11/7/2015	19:26
4	11/7/2015	19:27

Site Features

Detection

Fish Path

Reciever Zones

TransCanada Hydro Northeast Inc.
ILP Study 19
Vernon Dam

N

1 in = 1,200 feet

0 600 1,200 2,400 Feet

Study 19 Fish Number: 38-146

Release: Herricks Cove, VT
Date Released: 11/05/2015
Time Released: 16:20

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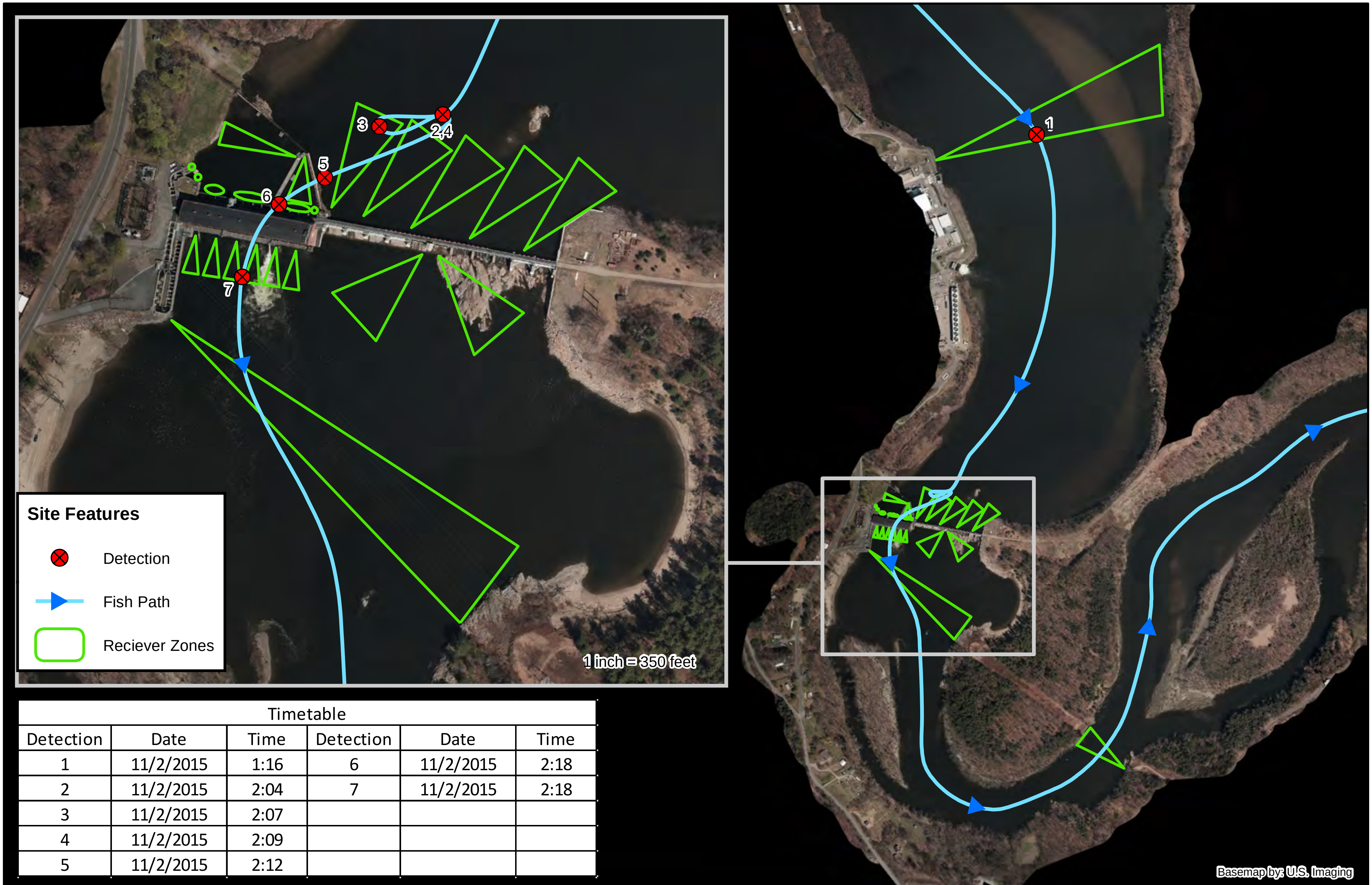

Timetable					
Detection	Date	Time	Detection	Date	Time
1	11/2/2015	1:16	6	11/2/2015	2:18
2	11/2/2015	2:04	7	11/2/2015	2:18
3	11/2/2015	2:07			
4	11/2/2015	2:09			
5	11/2/2015	2:12			

J:\Jen_TEST\TransCanada\S19\REV_2017\Vernon\MXD\TC_Vernon_38_149_T1_022117.mxd

TransCanada Hydro Northeast Inc.
ILP Study 19
Vernon Dam

N

1 in = 1,200 feet

0 600 1,200 2,400 Feet

Study 19 Fish Number: 38-149

Release: Herricks Cove, VT
Date Released: 10/29/2015
Time Released: 17:52

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Environmental Consultants

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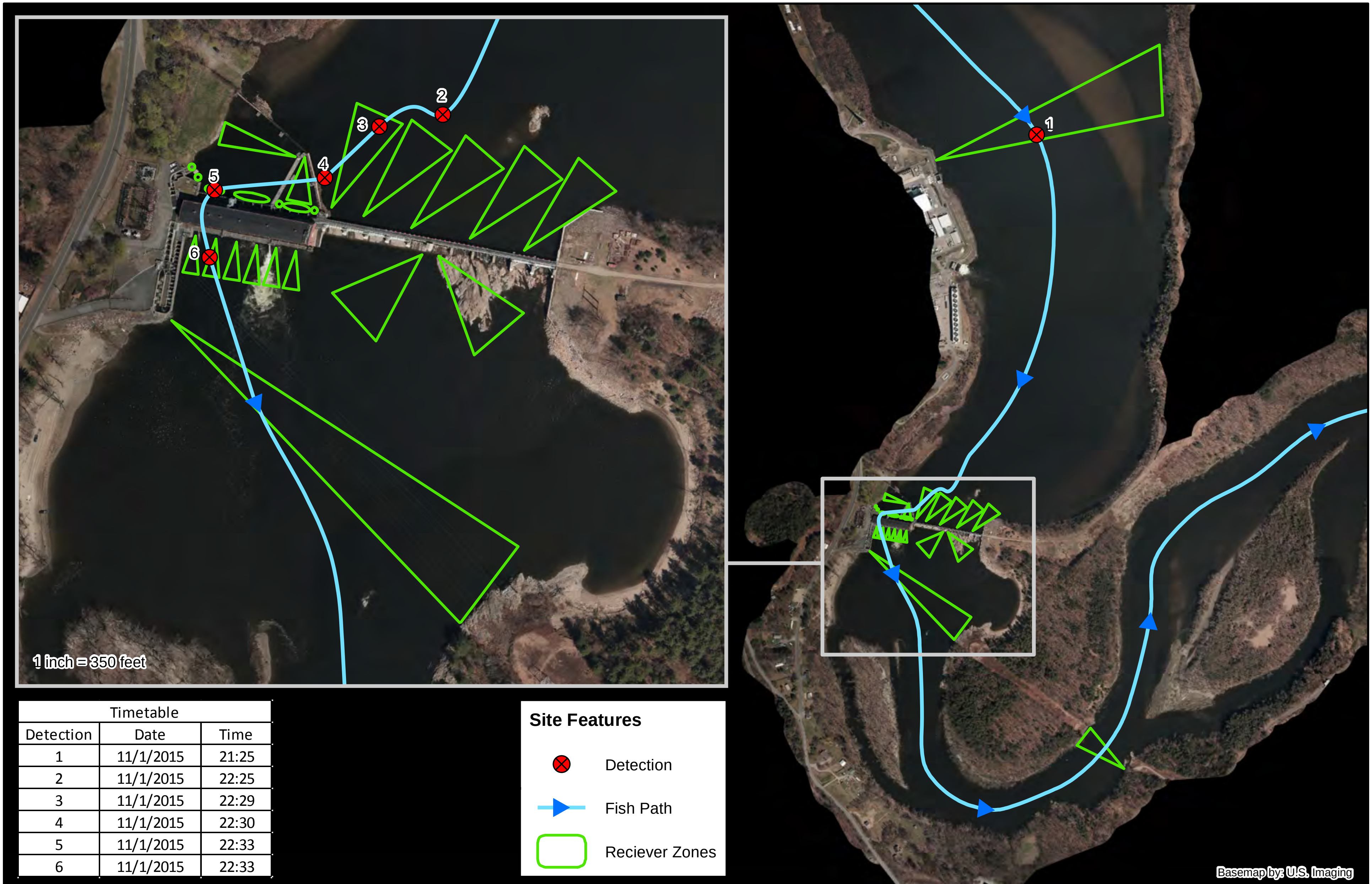

Timetable		
Detection	Date	Time
1	11/1/2015	21:25
2	11/1/2015	22:25
3	11/1/2015	22:29
4	11/1/2015	22:30
5	11/1/2015	22:33
6	11/1/2015	22:33

Site Features

- Detection
- Fish Path
- Reciever Zones

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TransCanada Hydro Northeast Inc.
ILP Study 19
Vernon Dam

N

1 in = 1,200 feet

0 600 1,200 2,400 Feet

Study 19 Fish Number: 38-150

Release: Herricks Cove, VT
Date Released: 10/29/2015
Time Released: 17:52

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Bedford, NH USA
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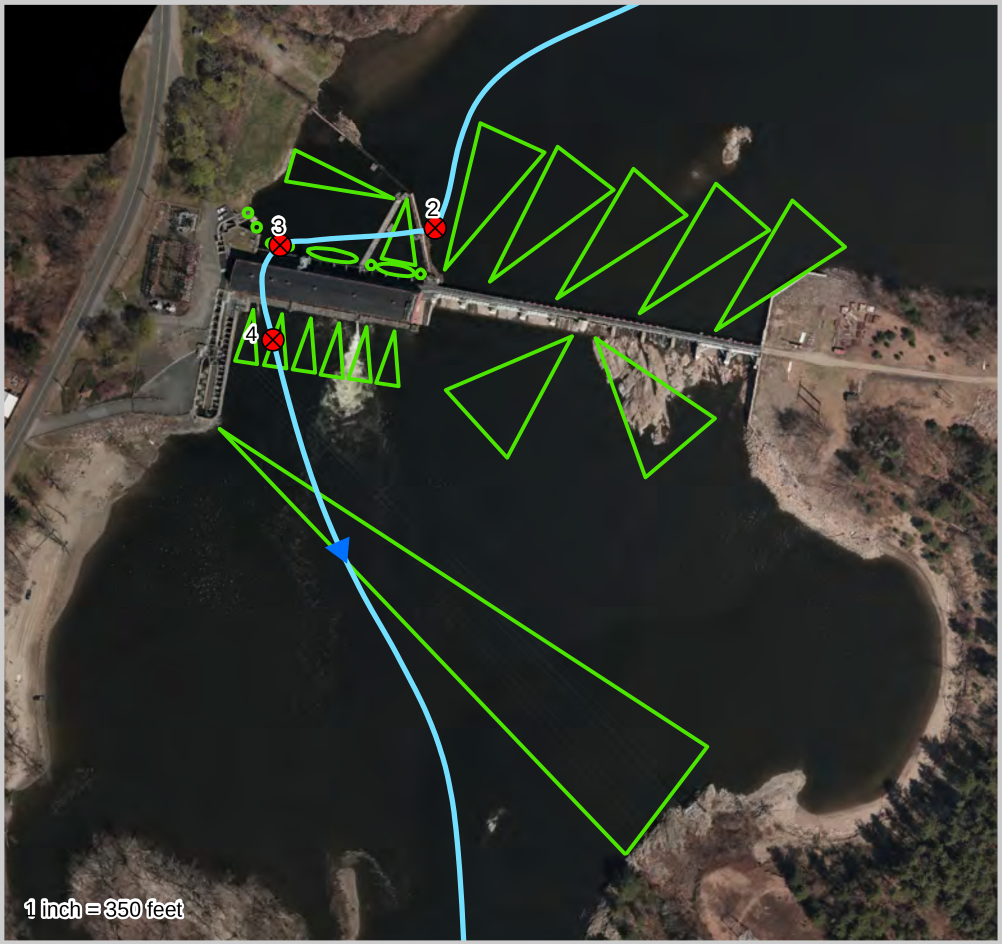

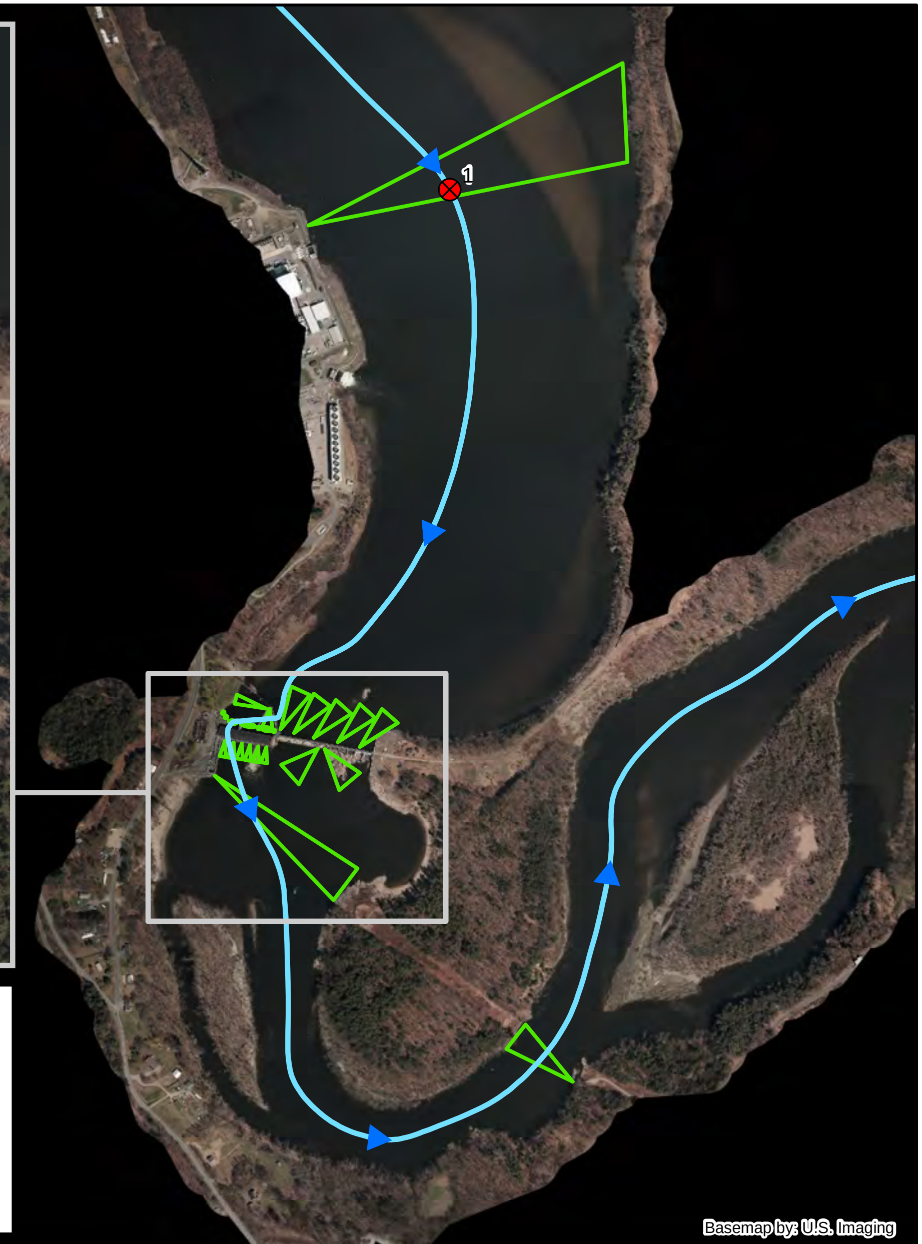

Timetable		
Detection	Date	Time
1	11/10/2015	1:16
2	11/10/2015	18:58
3	11/10/2015	19:00
4	11/10/2015	19:03

Site Features

- Detection
- Fish Path
- Reciever Zones

TransCanada Hydro Northeast Inc.
ILP Study 19
Vernon Dam

N

1 in = 1,200 feet

0 600 1,200 2,400 Feet

Study 19 Fish Number: 38-152

Release: Norwich, VT
Date Released: 11/05/2015
Time Released: 17:05

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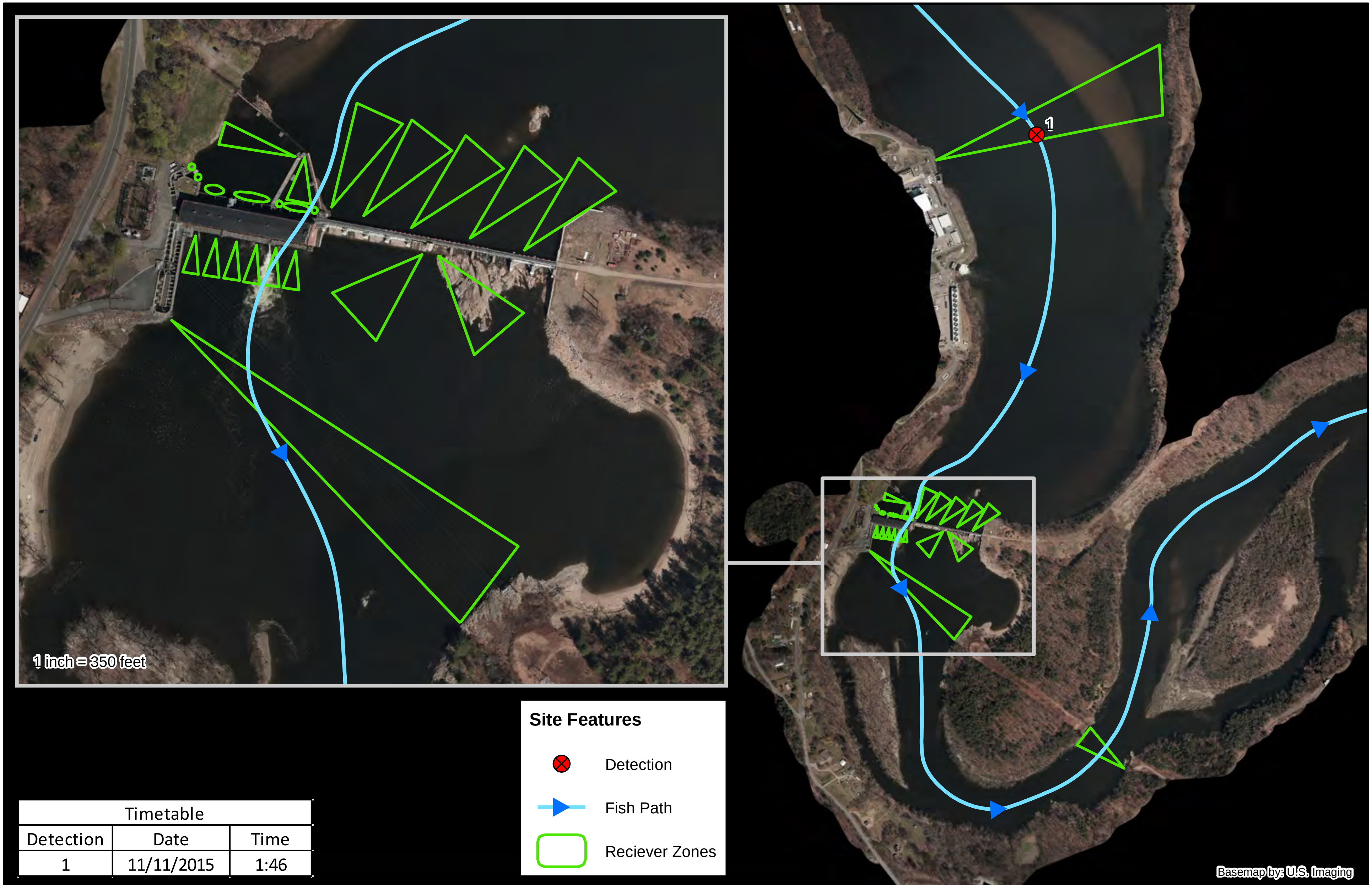

Timetable		
Detection	Date	Time
1	11/11/2015	1:46

TransCanada Hydro Northeast Inc.
ILP Study 19
Vernon Dam

N

1 in = 1,200 feet

0 600 1,200 2,400 Feet

Study 19 Fish Number: 38-153

Release: Norwich, VT
Date Released: 11/05/2015
Time Released: 17:05

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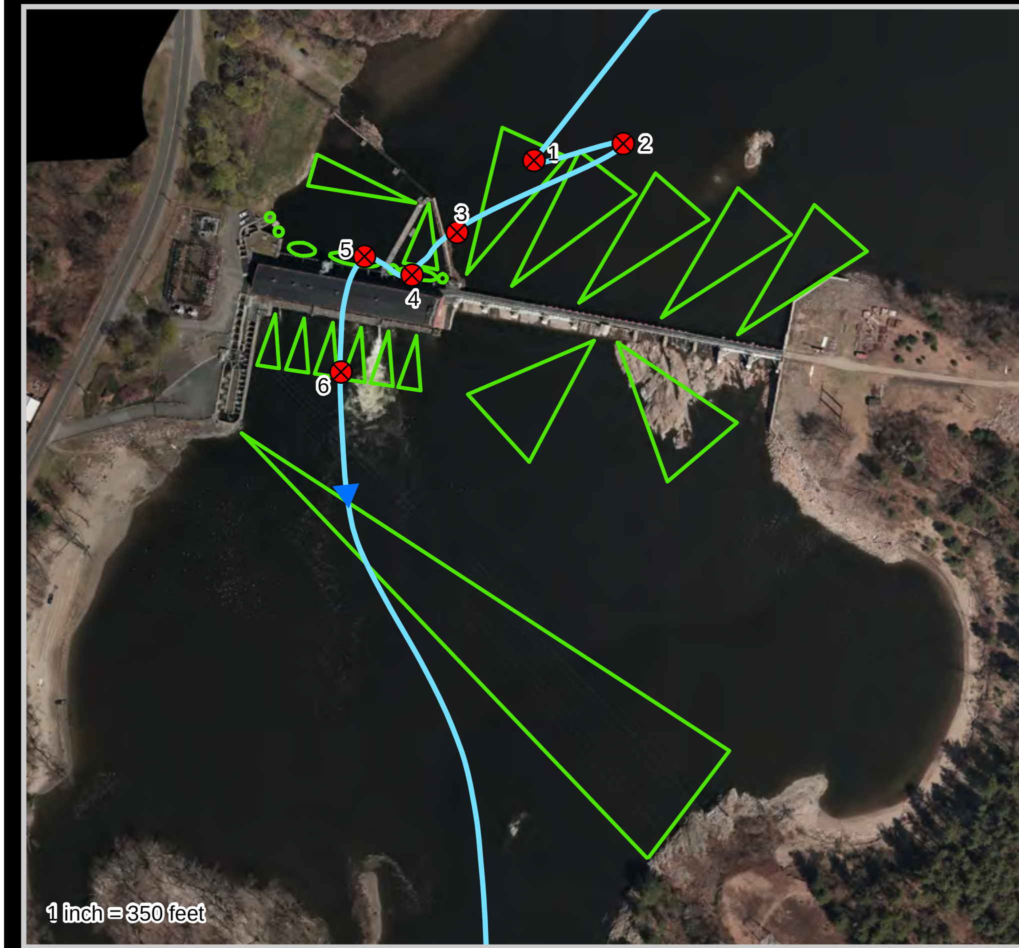

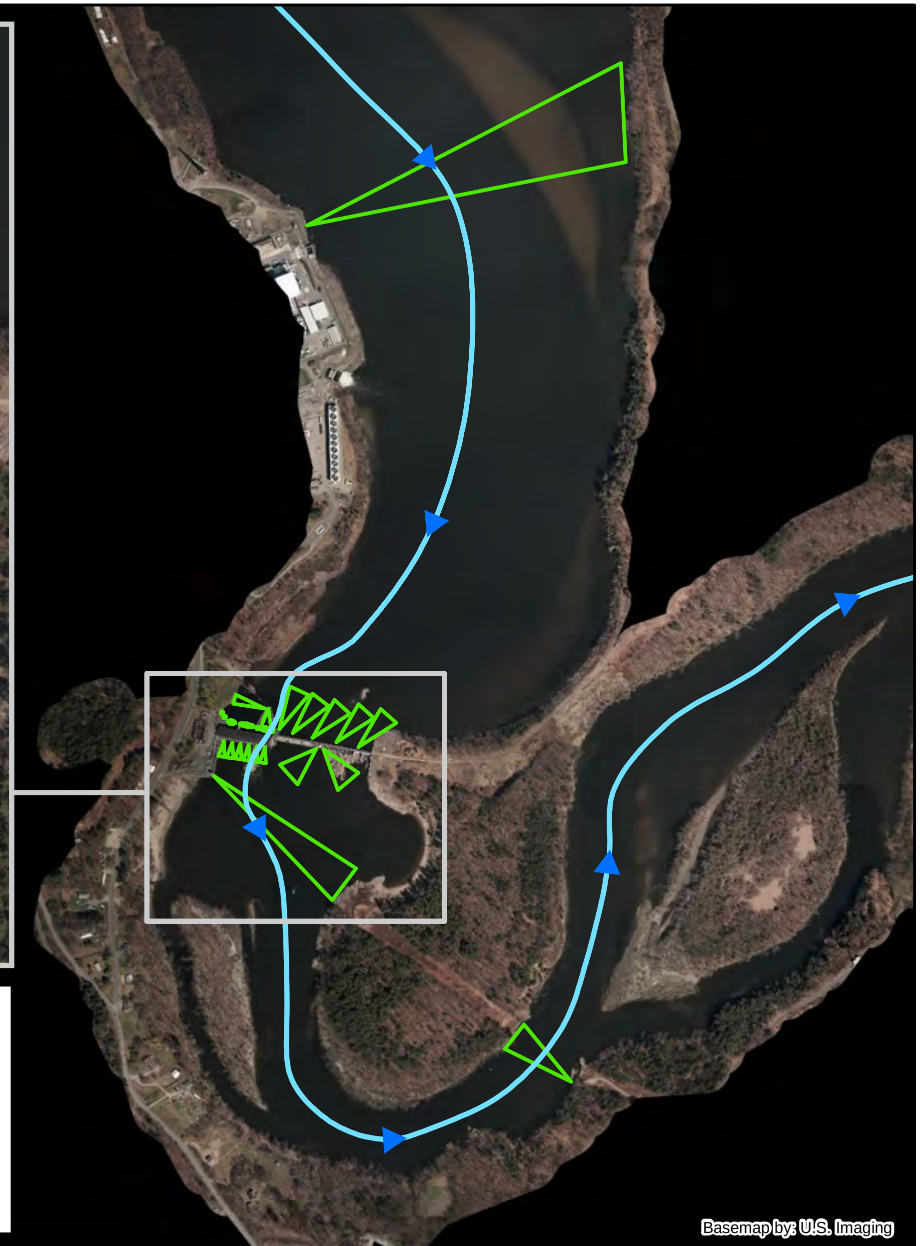

Timetable		
Detection	Date	Time
1	11/7/2015	19:45
2	11/7/2015	19:46
3	11/7/2015	19:48
4	11/7/2015	20:31
5	11/7/2015	20:35
6	11/7/2015	20:35

Site Features

- Detection
- Fish Path
- Reciever Zones

TransCanada Hydro Northeast Inc.
ILP Study 19
Vernon Dam

N

1 in = 1,200 feet

0 600 1,200 2,400 Feet

Study 19 Fish Number: 38-158

Release: Norwich, VT
Date Released: 10/29/2015
Time Released: 18:43

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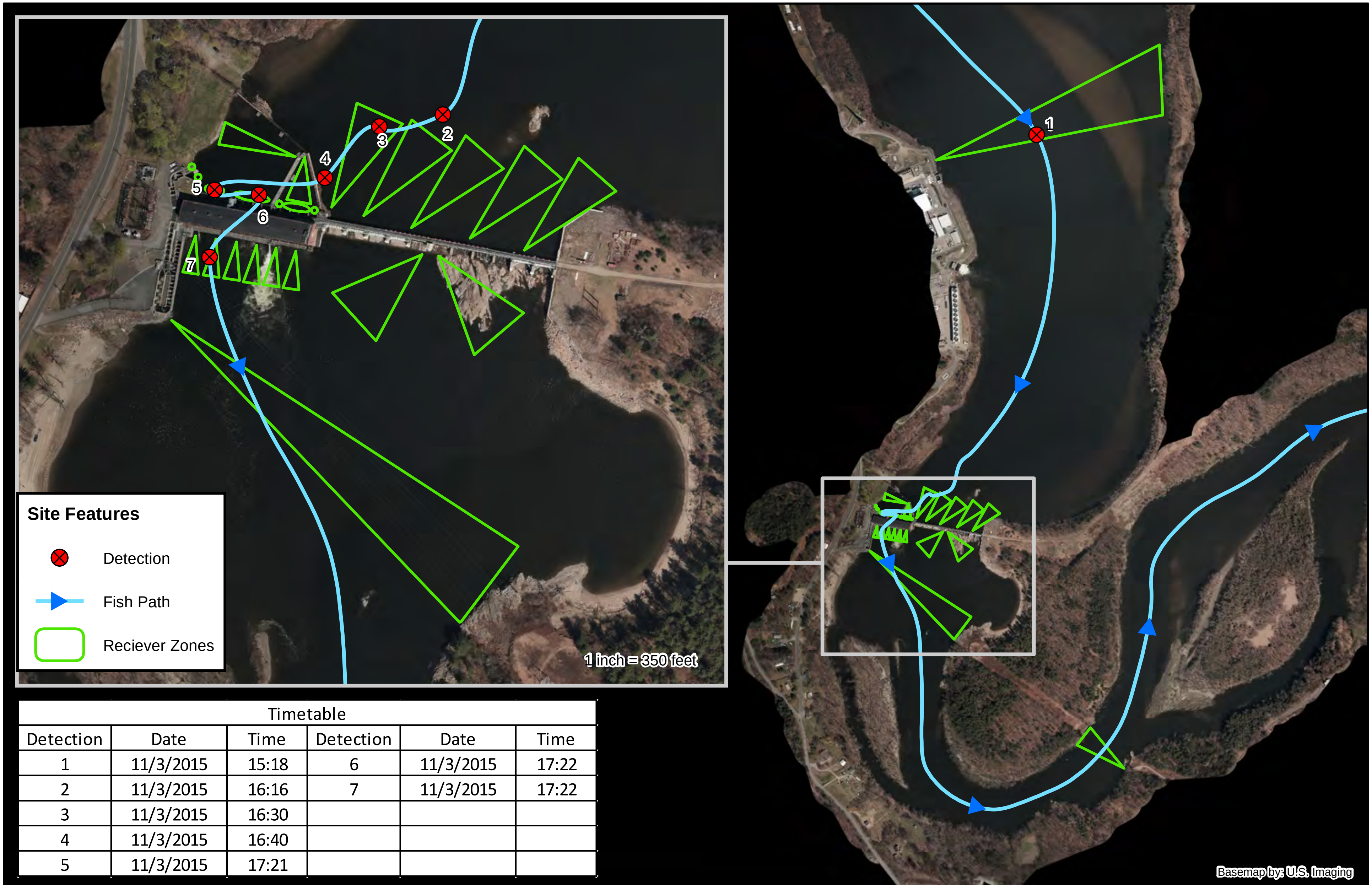

Timetable					
Detection	Date	Time	Detection	Date	Time
1	11/3/2015	15:18	6	11/3/2015	17:22
2	11/3/2015	16:16	7	11/3/2015	17:22
3	11/3/2015	16:30			
4	11/3/2015	16:40			
5	11/3/2015	17:21			

TransCanada Hydro Northeast Inc.
ILP Study 19
Vernon Dam

N

1 in = 1,200 feet

0 600 1,200 2,400 Feet

Study 19 Fish Number: 38-159

Release: Norwich, VT
Date Released: 10/29/2015
Time Released: 18:43

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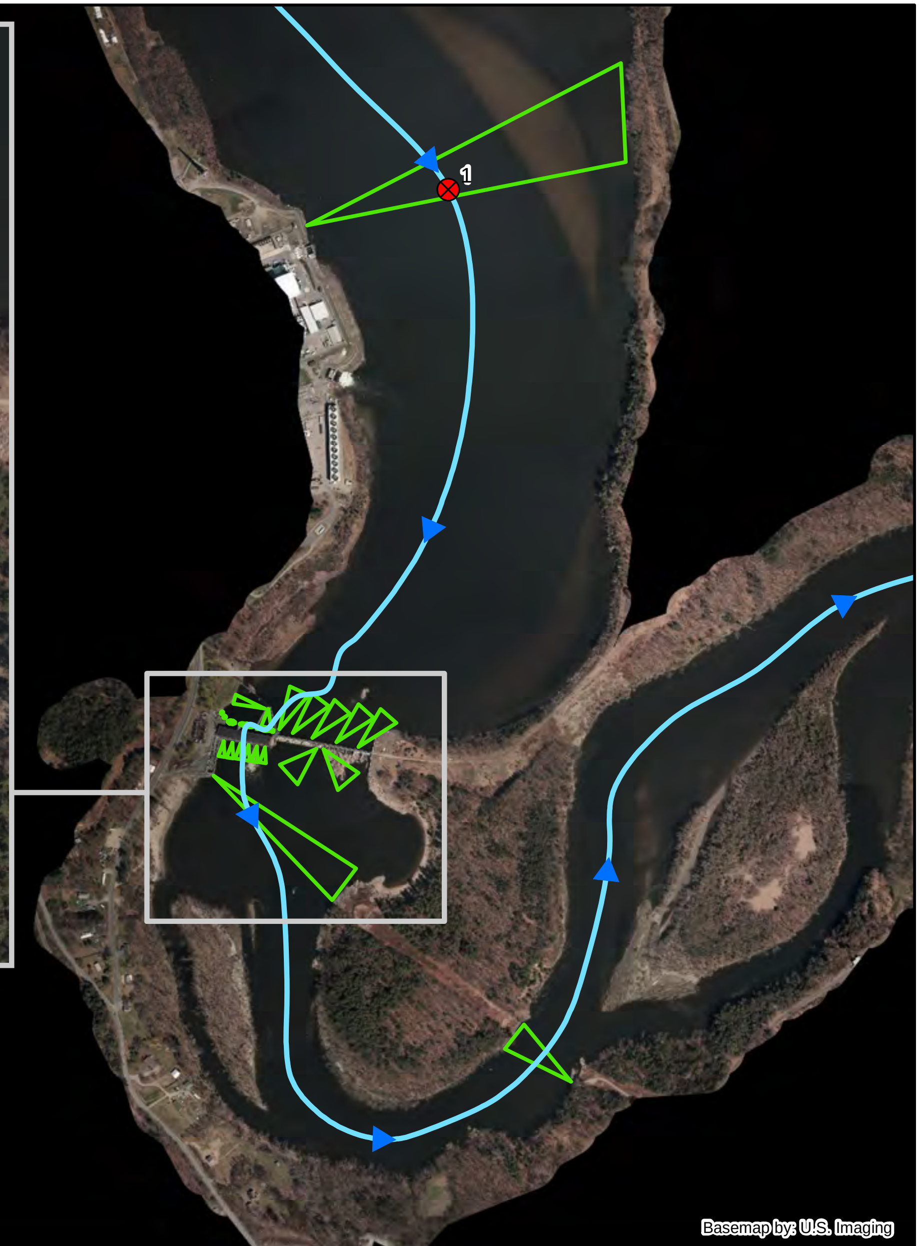

Timetable					
Detection	Date	Time	Detection	Date	Time
1	11/2/2015	19:55	6	11/2/2015	20:39
2	11/2/2015	20:29	7	11/2/2015	20:39
3	11/2/2015	20:30			
4	11/2/2015	20:36			
5	11/2/2015	20:36			

TransCanada Hydro Northeast Inc.
ILP Study 19
Vernon Dam

N

1 in = 1,200 feet

0 600 1,200 2,400 Feet

Study 19 Fish Number: 38-167
Release: Riverside Industrial Complex
Brattleboro, VT
Date Released: 10/31/2015
Time Released: 13:40

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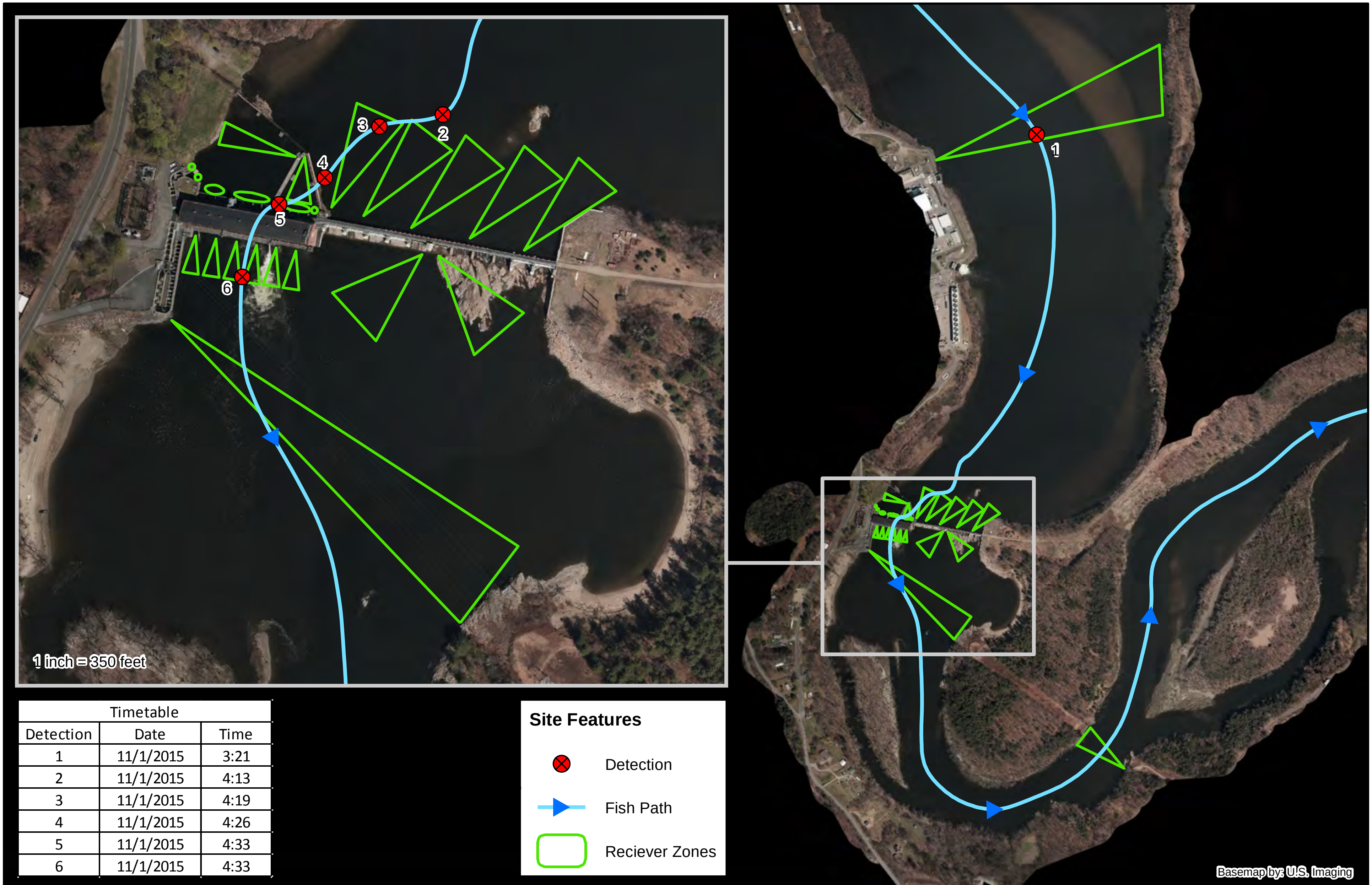

Timetable		
Detection	Date	Time
1	11/1/2015	3:21
2	11/1/2015	4:13
3	11/1/2015	4:19
4	11/1/2015	4:26
5	11/1/2015	4:33
6	11/1/2015	4:33

Site Features

- Detection
- Fish Path
- Reciever Zones

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TransCanada Hydro Northeast Inc.
ILP Study 19
Vernon Dam

1 in = 1,200 feet

0 600 1,200 2,400 Feet

Study 19 Fish Number: 38-170

Release: Vernon
Date Released: 10/31/2015
Time Released: 13:40

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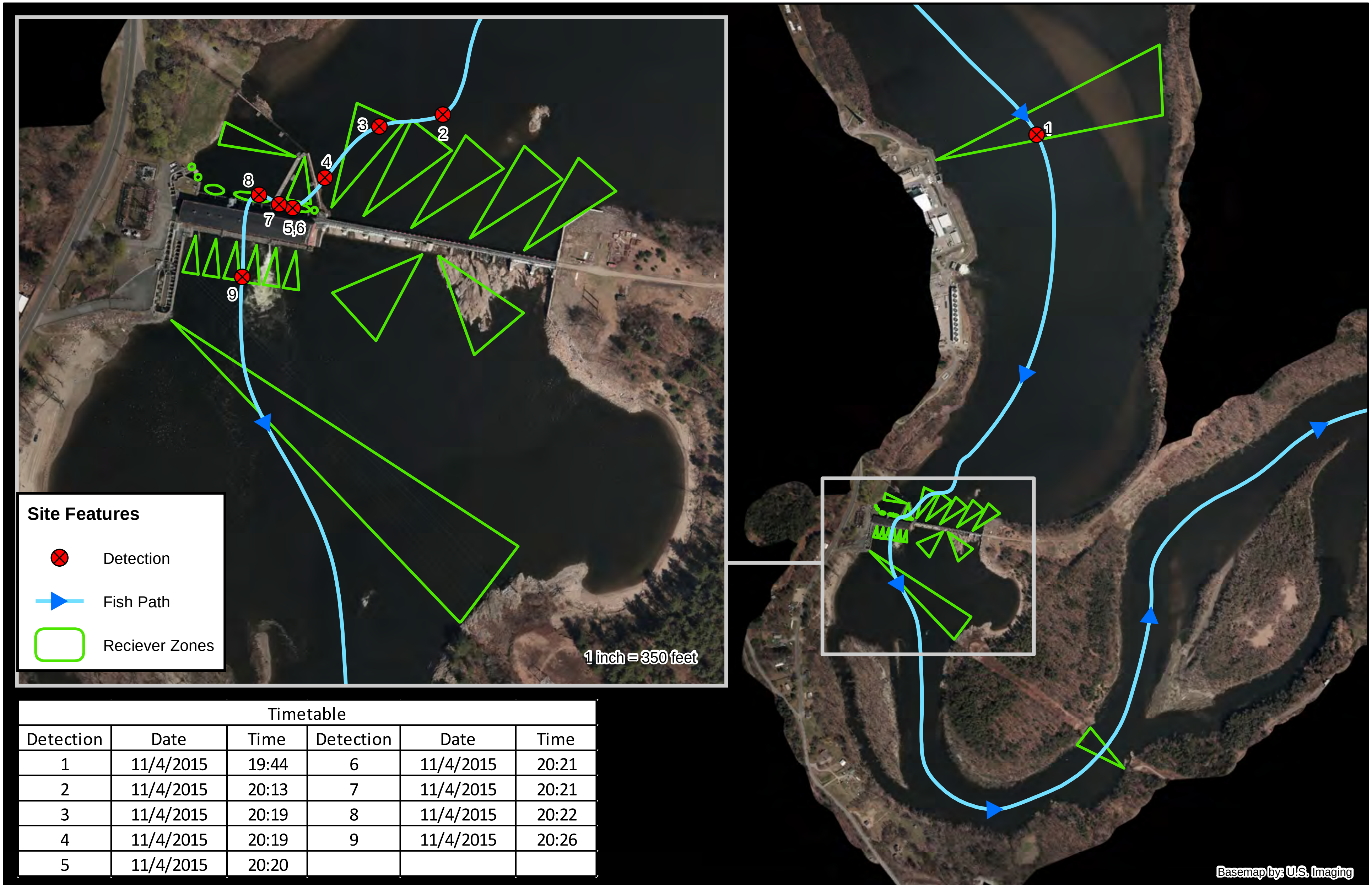

Timetable					
Detection	Date	Time	Detection	Date	Time
1	11/4/2015	19:44	6	11/4/2015	20:21
2	11/4/2015	20:13	7	11/4/2015	20:21
3	11/4/2015	20:19	8	11/4/2015	20:22
4	11/4/2015	20:19	9	11/4/2015	20:26
5	11/4/2015	20:20			

TransCanada Hydro Northeast Inc.
ILP Study 19
Vernon Dam

N

1 in = 1,200 feet

0 600 1,200 2,400 Feet

Study 19 Fish Number: 38-178

Release: Herricks Cove, VT
Date Released: 10/31/2015
Time Released: 18:22

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Bedford, NH USA
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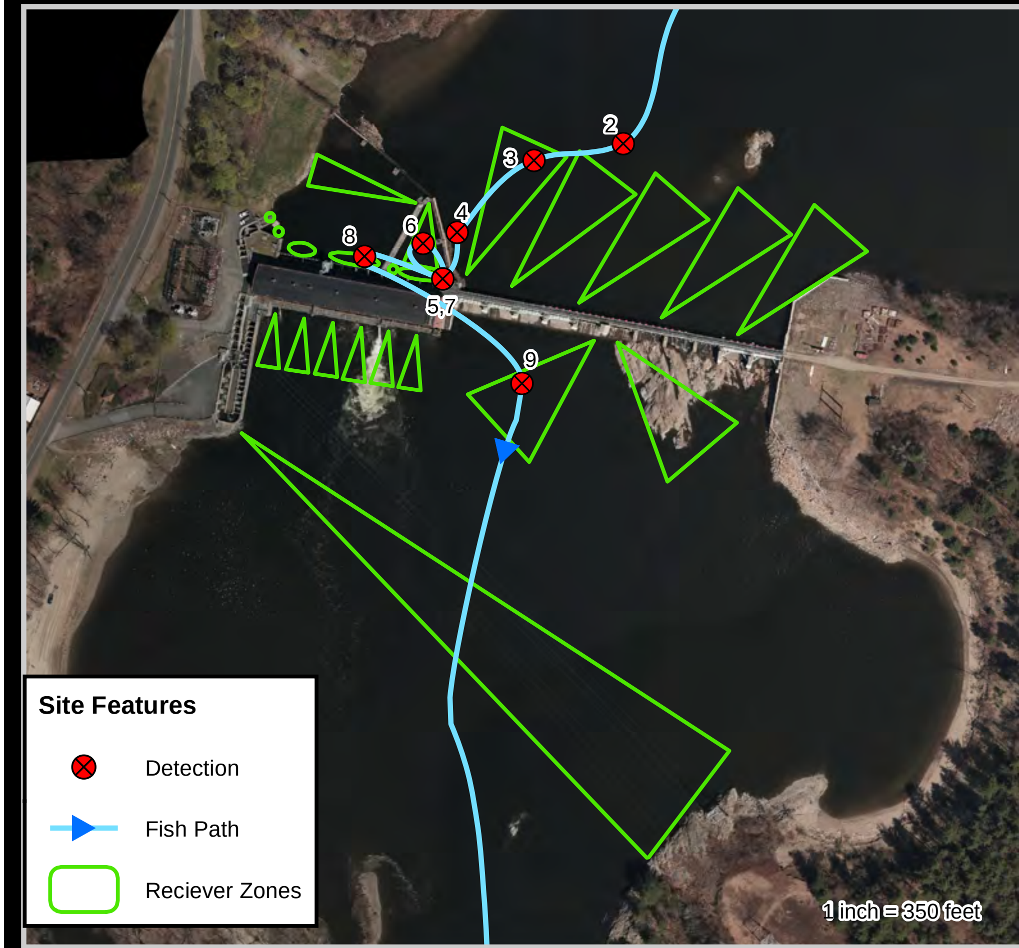
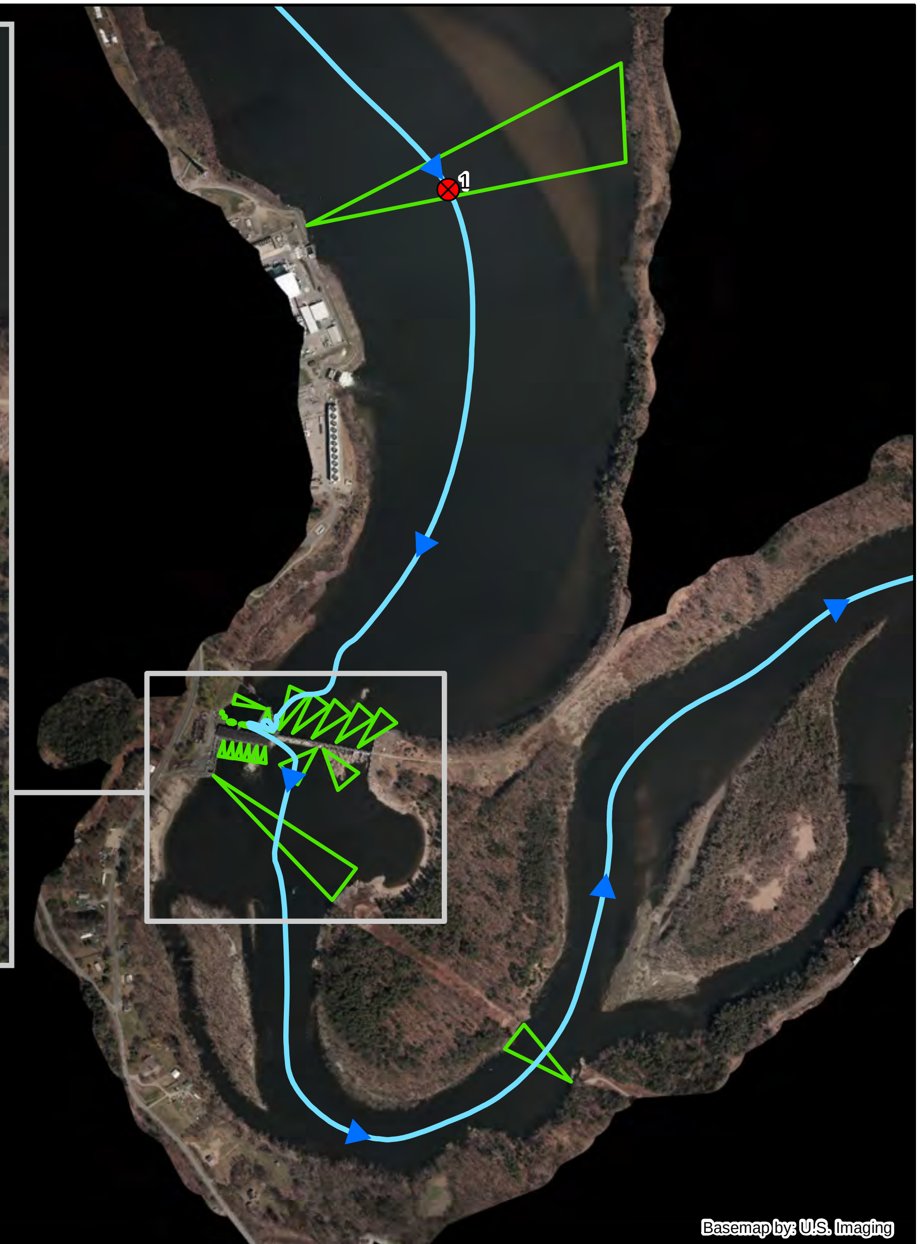
J:\Jen_TEST\TransCanada\S19\REV_2017\VernonMXD\TC_Vernon_38_178_T1_022117.mxd





Timetable					
Detection	Date	Time	Detection	Date	Time
1	11/9/2015	4:31	6	11/10/2015	22:05
2	11/10/2015	21:51	7	11/10/2015	22:06
3	11/10/2015	21:51	8	11/10/2015	22:11
4	11/10/2015	21:58	9	11/10/2015	22:12
5	11/10/2015	21:59			

TransCanada Hydro Northeast Inc.
ILP Study 19
Vernon Dam

N

1 in = 1,200 feet

0 600 1,200 2,400 Feet

Study 19 Fish Number: 38-180

Release: Herricks Cove, VT
Date Released: 10/31/2015
Time Released: 18:22

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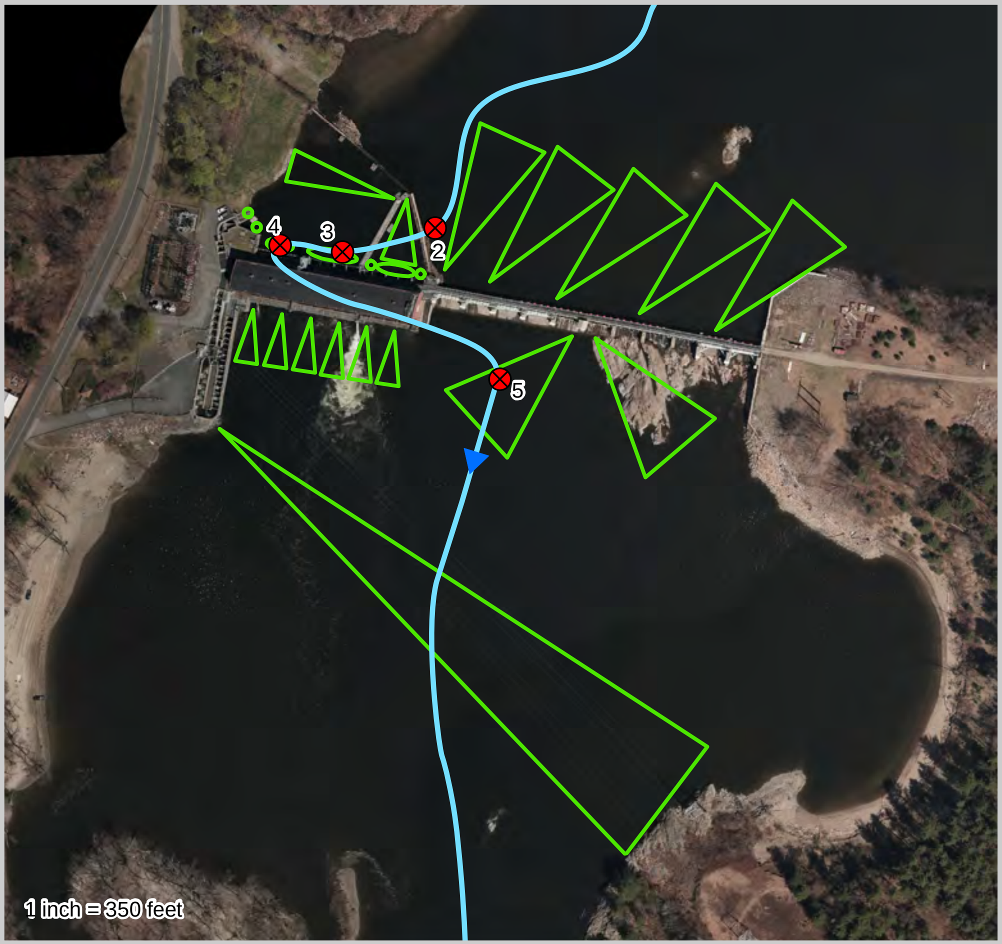

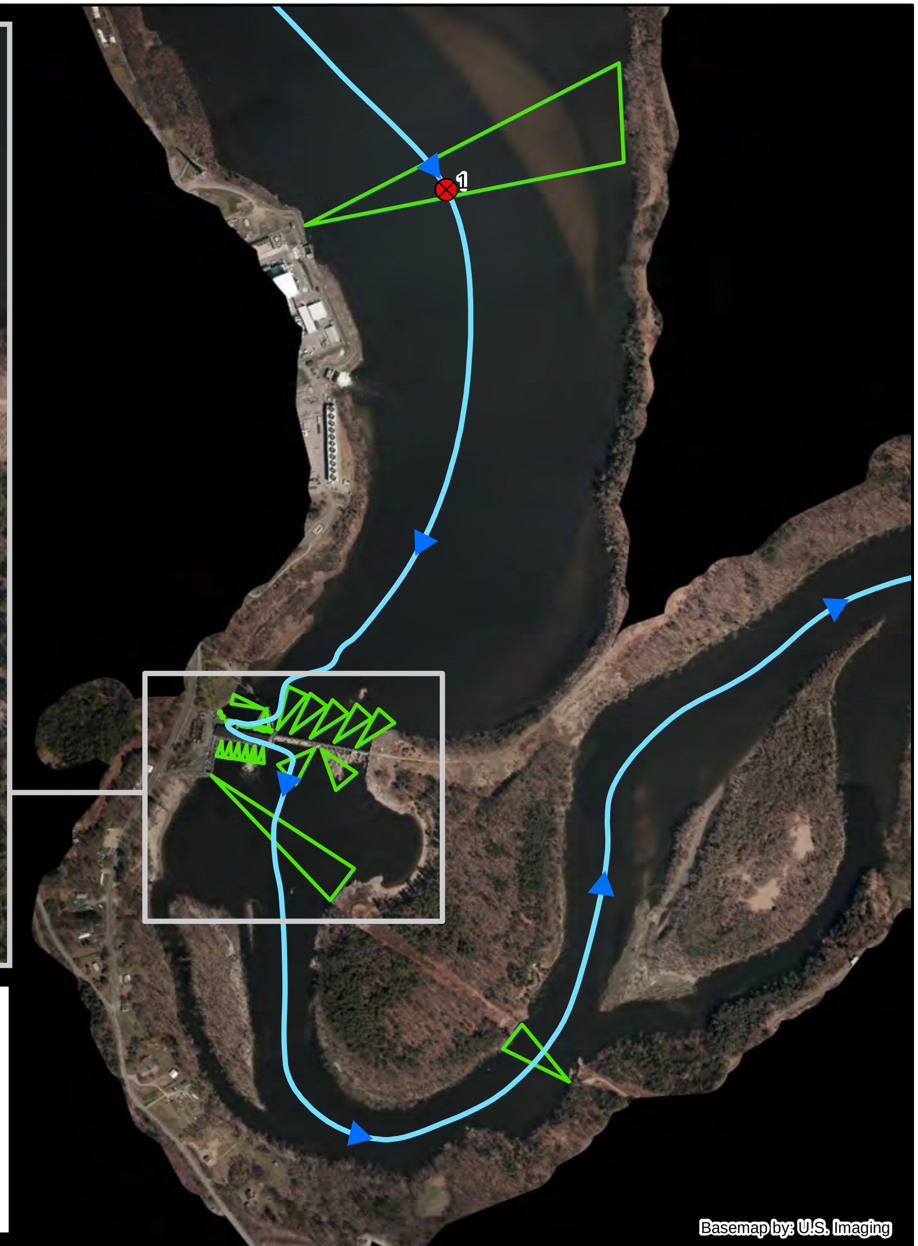

Timetable		
Detection	Date	Time
1	11/6/2015	18:22
2	11/6/2015	19:12
3	11/6/2015	19:13
4	11/6/2015	19:14
5	11/6/2015	19:15

Site Features

- Detection
- Fish Path
- Reciever Zones

TransCanada Hydro Northeast Inc.
ILP Study 19
Vernon Dam

N

1 in = 1,200 feet

0 600 1,200 2,400 Feet

Study 19 Fish Number: 38-188

Release: Norwich, VT
Date Released: 10/31/2015
Time Released: 19:21

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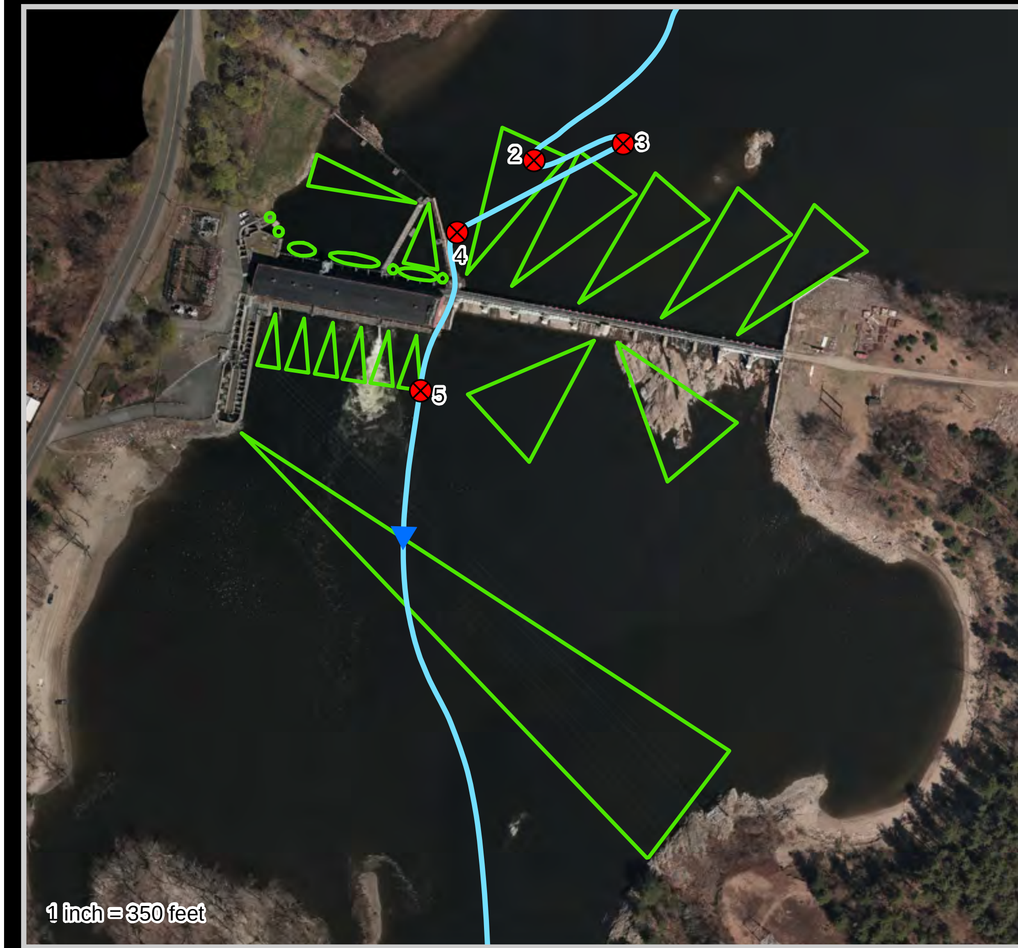

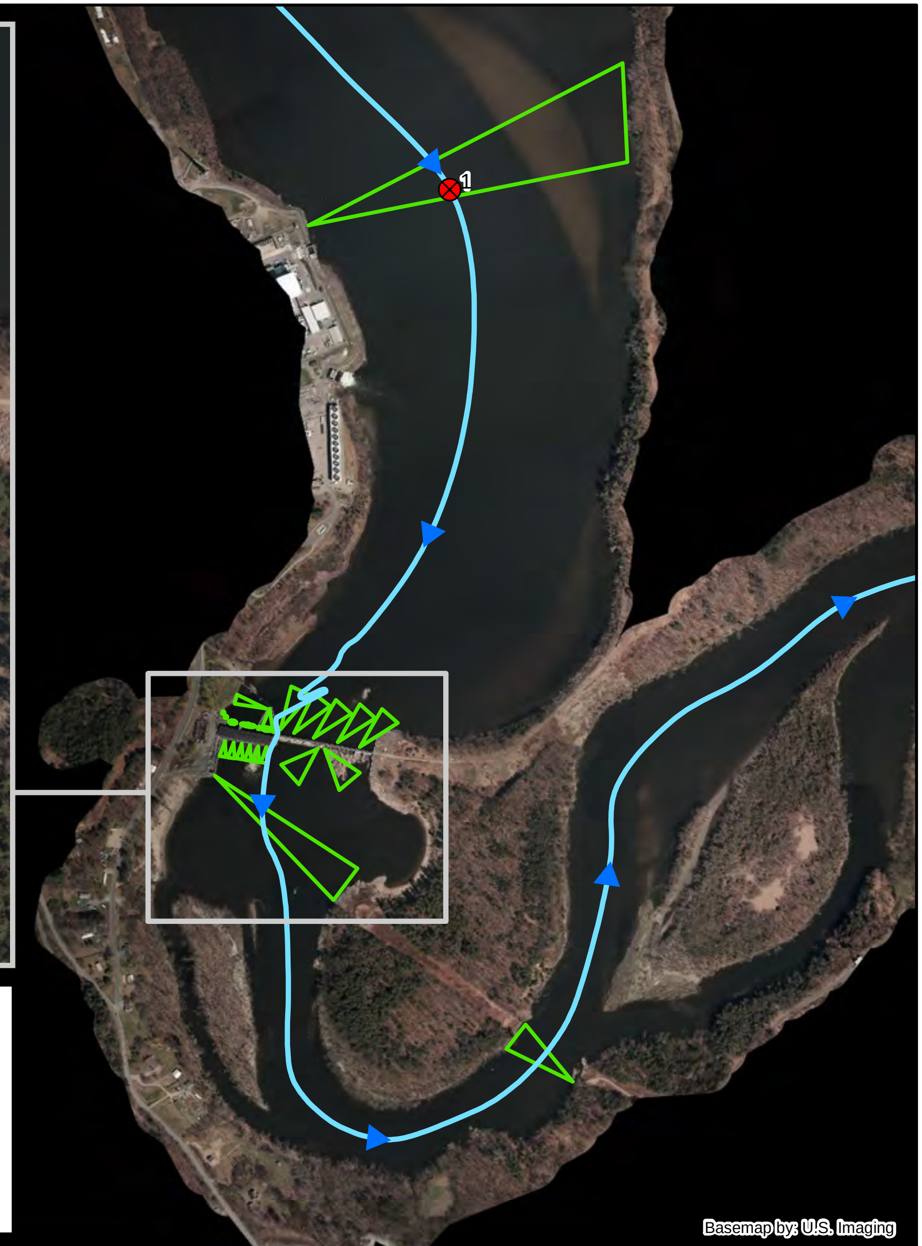

Timetable		
Detection	Date	Time
1	11/7/2015	2:06
2	11/7/2015	6:25
3	11/7/2015	9:28
4	11/7/2015	18:18
5	11/7/2015	18:22

Site Features

- Detection
- Fish Path
- Reciever Zones

TransCanada Hydro Northeast Inc.
ILP Study 19
Vernon Dam

N

1 in = 1,200 feet

0 600 1,200 2,400 Feet

Study 19 Fish Number: 38-189

Release: Norwich, VT
Date Released: 10/31/2015
Time Released: 19:21

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Environmental Consultants
Normandeau Associates Inc.
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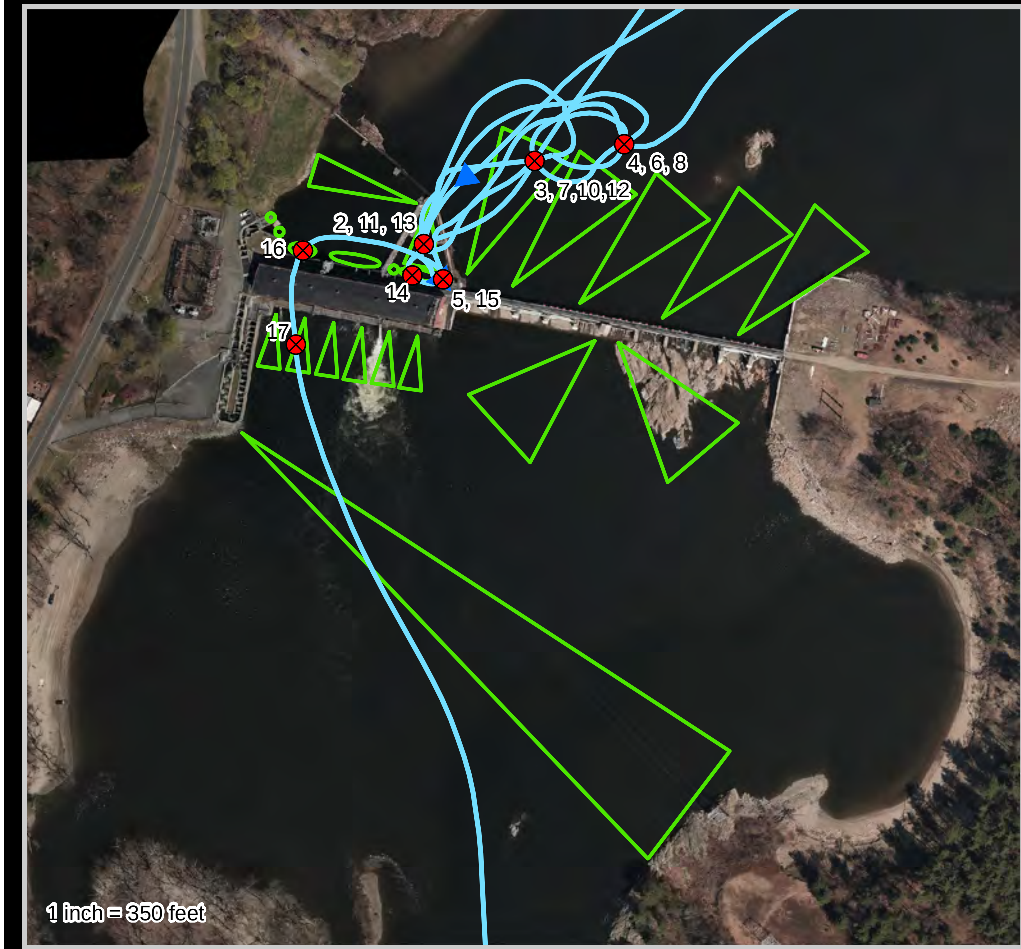

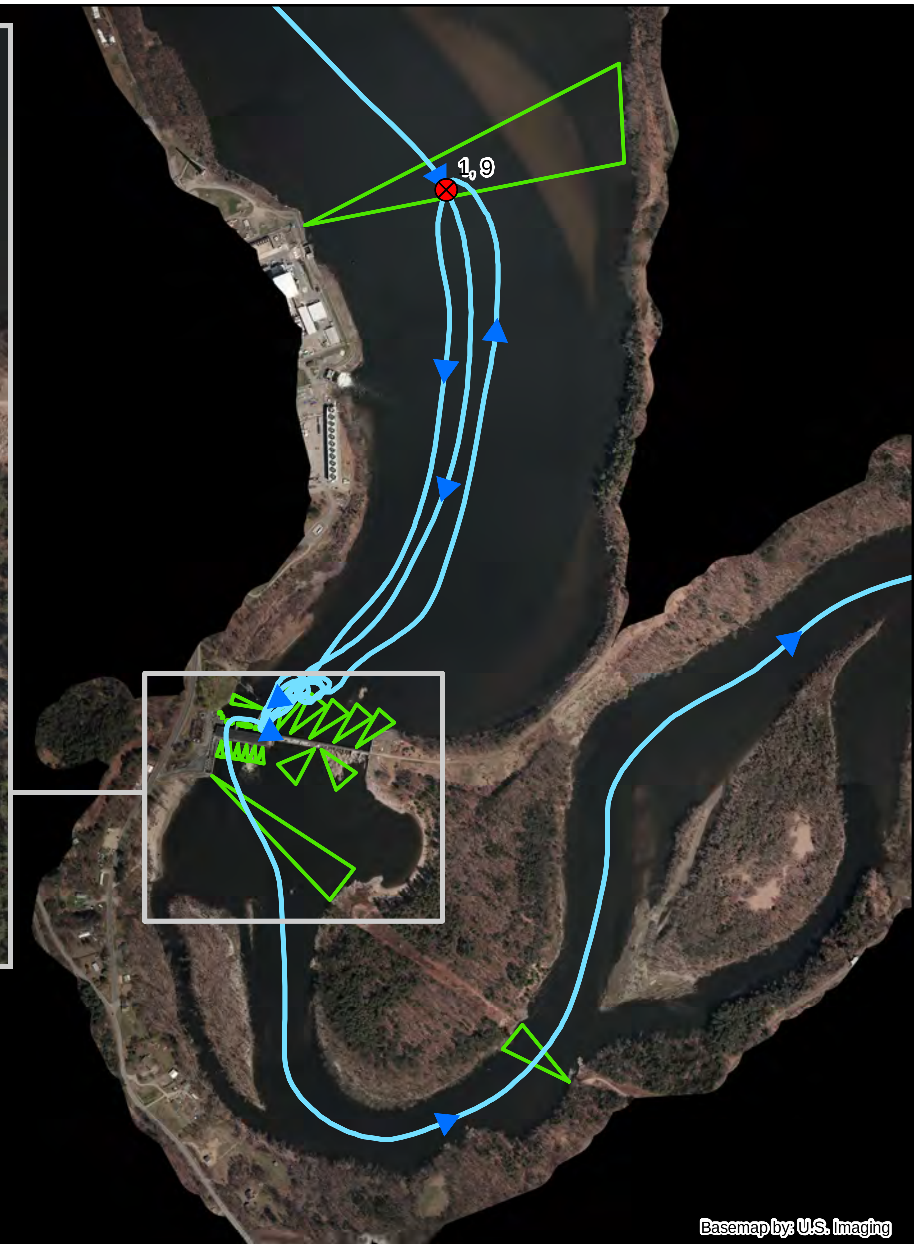

Timetable					
Detection	Date	Time	Detection	Date	Time
1	11/11/2015	3:29	10	11/11/2015	19:09
2	11/11/2015	4:10	11	11/11/2015	19:14
3	11/11/2015	4:13	12	11/11/2015	19:15
4	11/11/2015	4:15	13	11/11/2015	19:24
5	11/11/2015	4:16	14	11/11/2015	19:24
6	11/11/2015	4:20	15	11/11/2015	19:25
7	11/11/2015	4:26	16	11/11/2015	19:29
8	11/11/2015	4:26	17	11/11/2015	19:30
9	11/11/2015	5:03			

Site Features

- Detection
- Fish Path
- Reciever Zones

TransCanada Hydro Northeast Inc.
ILP Study 19
Vernon Dam

N

1 in = 1,200 feet

0 600 1,200 2,400 Feet

Study 19 Fish Number: 38-58

Release: Norwich, VT
Date Released: 11/3/2015
Time Released: 17:32

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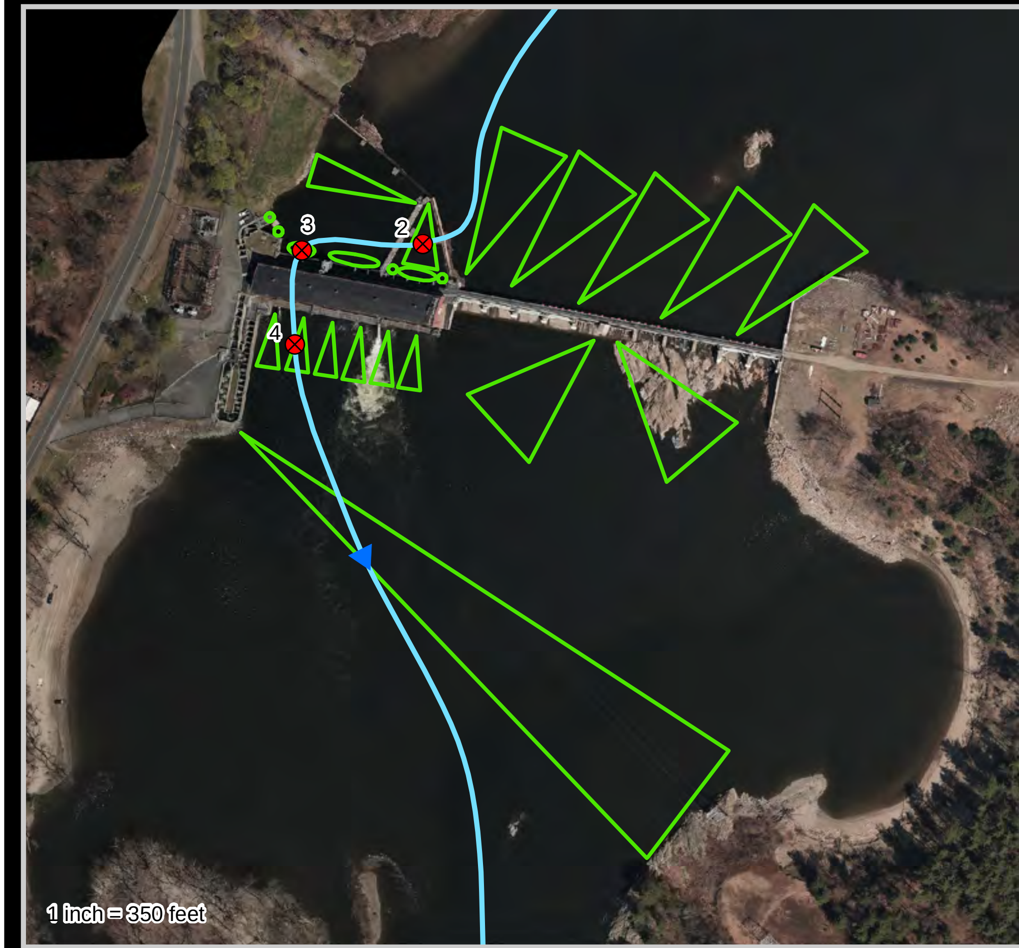

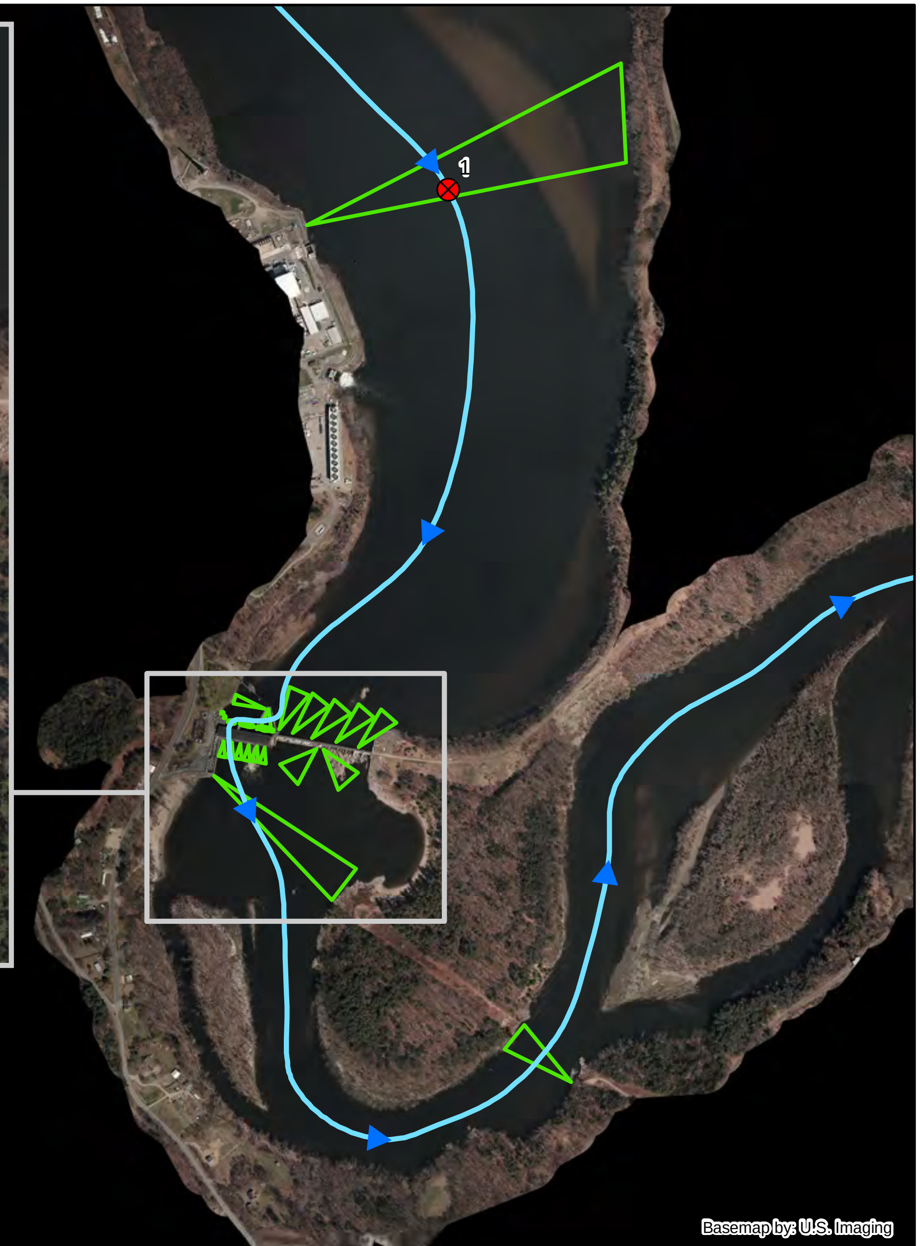

Timetable		
Detection	Date	Time
1	11/5/2015	3:03
2	11/5/2015	3:50
3	11/5/2015	3:51
4	11/5/2015	3:54

Site Features

- Detection
- Fish Path
- Reciever Zones

TransCanada Hydro Northeast Inc.
ILP Study 19
Vernon Dam

N

1 in = 1,200 feet

0 600 1,200 2,400 Feet

Study 19 Fish Number: 38-59

Release: Bellows Falls Canal
Date Released: 10/31/2015
Time Released: 18:05

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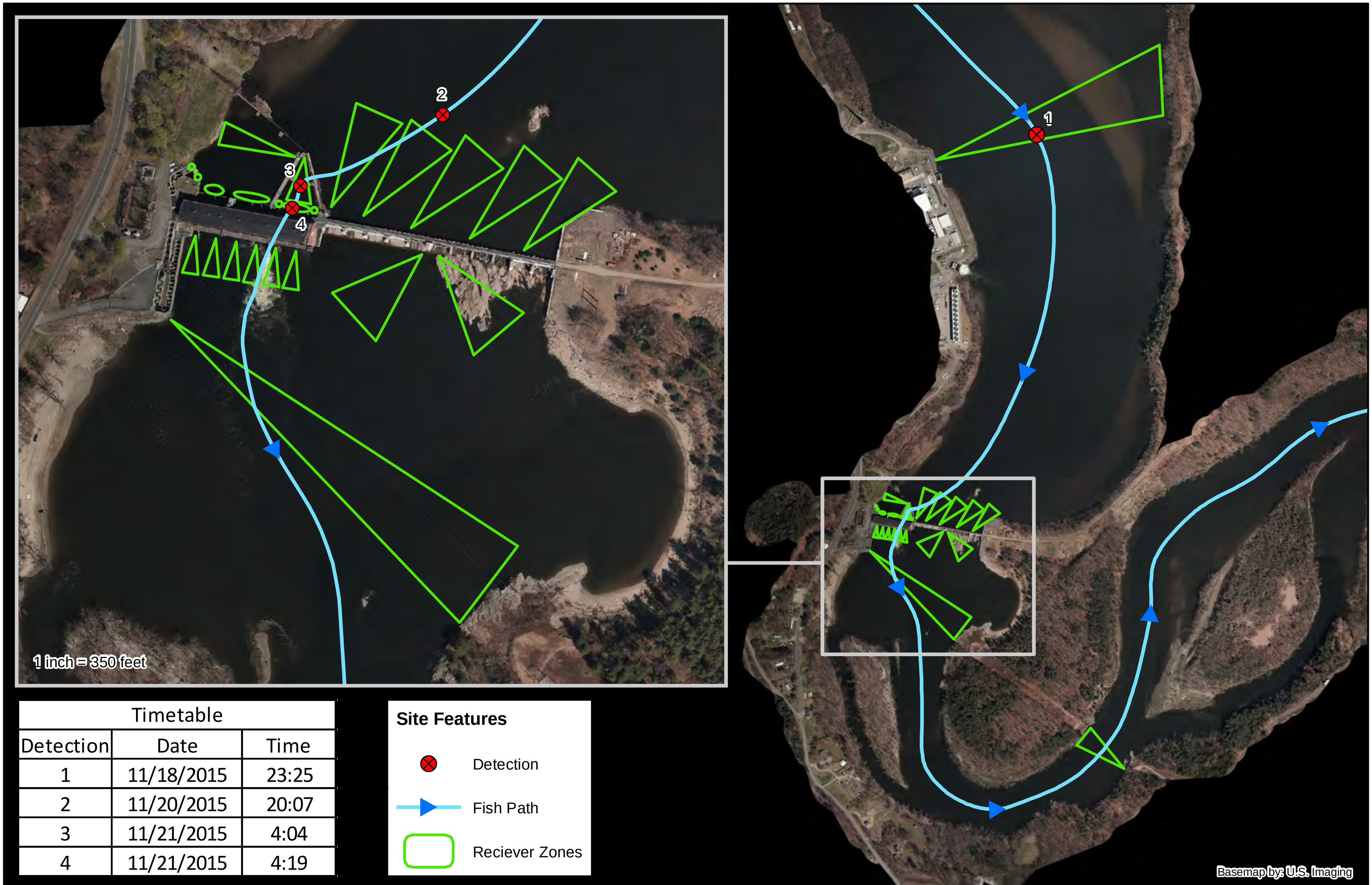

Timetable		
Detection	Date	Time
1	11/18/2015	23:25
2	11/20/2015	20:07
3	11/21/2015	4:04
4	11/21/2015	4:19

Site Features

- Detection
- Fish Path
- Reciever Zones

TransCanada Hydro Northeast Inc.
ILP Study 19
Vernon Dam

1 in = 1,200 feet

0 600 1,200 2,400 Feet

Study 19 Fish Number: 38-60
Release: Bellows Falls Canal
Date Released: 10/31/2015
Time Released: 18:05

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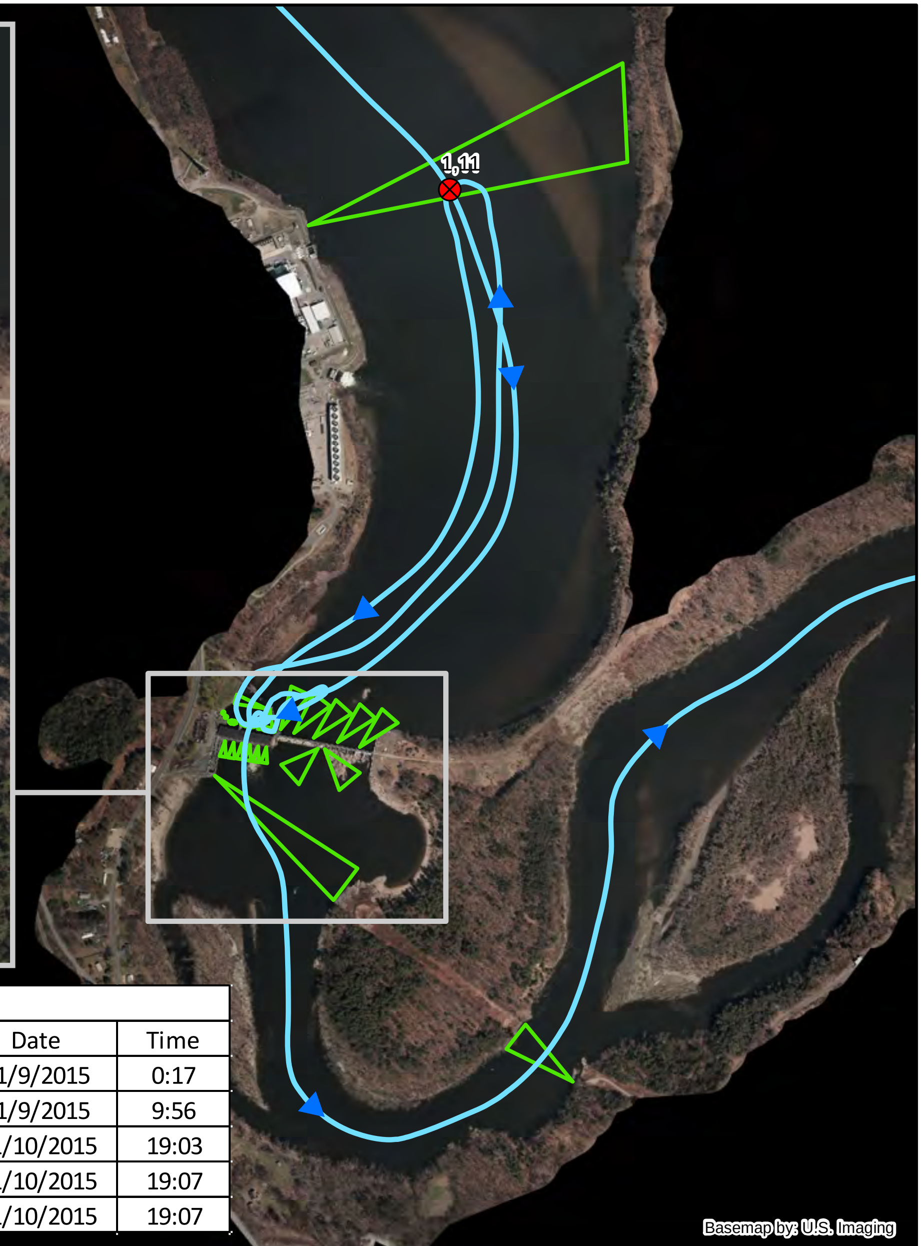

Timetable								
Detection	Date	Time	Detection	Date	Time	Detection	Date	Time
1	11/8/2015	21:39	6	11/8/2015	22:21	11	11/9/2015	0:17
2	11/8/2015	22:12	7	11/8/2015	22:25	12	11/9/2015	9:56
3	11/8/2015	22:13	8	11/8/2015	22:27	13	11/10/2015	19:03
4	11/8/2015	22:20	9	11/8/2015	23:15	14	11/10/2015	19:07
5	11/8/2015	22:21	10	11/8/2015	23:20	15	11/10/2015	19:07

TransCanada Hydro Northeast Inc.
ILP Study 19
Vernon Dam

N

1 in = 1,200 feet

0 600 1,200 2,400 Feet

Study 19 Fish Number: 38-62

Release: Bellows Falls Canal
Date Released: 10/31/2015
Time Released: 18:05

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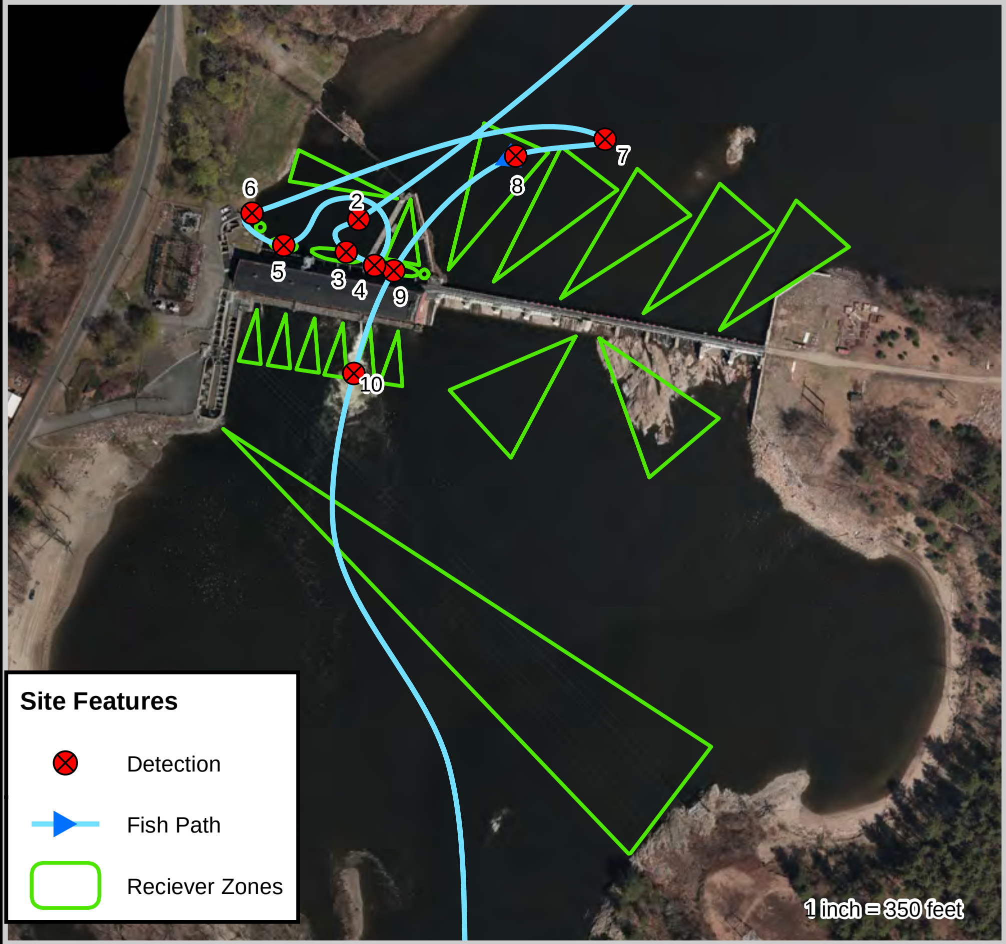

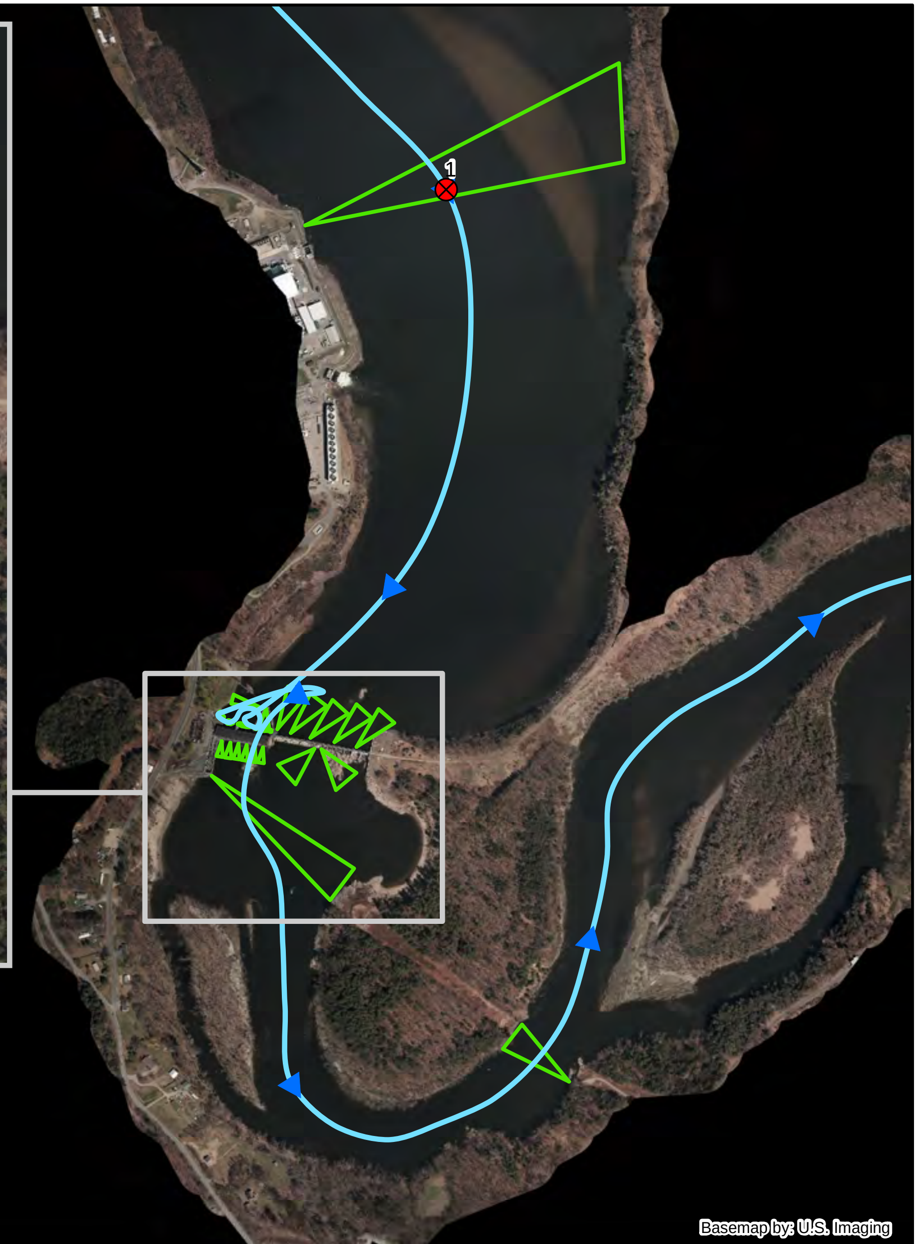

Timetable					
Detection	Date	Time	Detection	Date	Time
1	10/31/2015	0:57	6	10/31/2015	12:43
2	10/31/2015	12:02	7	10/31/2015	18:05
3	10/31/2015	12:03	8	10/31/2015	18:10
4	10/31/2015	12:24	9	10/31/2015	18:19
5	10/31/2015	12:43	10	10/31/2015	18:20

TransCanada Hydro Northeast Inc.
ILP Study 19
Vernon Dam

N

1 in = 1,200 feet

0 600 1,200 2,400 Feet

Study 19 Fish Number: 38-63

Release: Bellows Falls Canal
Date Released: 10/29/2015
Time Released: 17:32

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APPENDIX F – filed separately in Excel format

Radio Telemetry Data