Freshwater Mussel Habitat Assessment and Survey

Lawrence Project (FERC No. 2800)

Prepared For
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1 Introduction

Essex Company, LLC (Essex), a subsidiary of Patriot Hydro, LLC, is the Licensee, owner, and operator of the Lawrence Hydroelectric Project (Project or Lawrence Project), which is Federal Energy Regulatory Commission (FERC or Commission) Project No. 2800. The Project was licensed by the Commission on December 4, 1978 (with an effective date of December 1, 1978), and the license expires on November 30, 2028. The Lawrence Project is located on the Merrimack River in the City of Lawrence in Essex County, Massachusetts.

In accordance with 18 C.F.R. § 5.15, Essex has initiated studies and information gathering activities as provided in the study plan and schedule approved by the Commission. Among the studies completed during 2024 was the Freshwater Mussel Habitat Assessment and Survey (Mussel Study), the methodologies of which were outlined in the Revised Study Plan (RSP) filed by Essex with the Commission on April 10, 2024, and approved with modifications by FERC in their May 10, 2024, Study Plan Determination (SPD). This report describes the Licensee's implementation of the study plan and schedule, the data collected, and any variances from the study plan and schedule.

1.1 Existing Information

Surveys were previously performed in the Merrimack River by Mass Wildlife in the Haverhill reach downstream from the Project in 1996-1997. Surveys covered a limited area from just upstream of Hales Island (Haverhill) and downstream of the I-495 bridge in Haverhill. As described in the previously conducted Mass Wildlife surveys and from citizen scientist observations, mussel species which occur in the Merrimack River include eastern elliptio (*Elliptio complanata*), eastern floater (*Pyganodon cataracta*), alewife floater (*Utterbackiana implicata*; SGCN) and eastern lampmussel (*Lampsilis radiata*; SGCN). One historical record of the State Special Concern eastern pondmussel (*Sagittunio nasutus*; MESA) also occurs within the Merrimack River. Freshwater mussel populations found in nearby tributaries to the Project include the above listed species including extant populations of *S. nasutus*, and historical records of the State Special Concern tidewater mucket (*Leptodea ochracea*) and State Endangered brook floater (*Alasmidonta varicosa*). Based on these records and species extant in the Connecticut River, the other similar large rivers in Massachusetts, the Project-affected area has the potential to support multiple state-listed species and Massachusetts' SGCN particularly *U. implicata, L. radiata, S. nasutus, L. ochracea*, and the State Endangered yellow lampmussel (*Lampsilis cariosa*) (PAD, SD1 October 2023).

2 Goals and Objectives

The goal of the Mussel Study was to determine the presence, location, and species of freshwater mussels that inhabit Project-affected aquatic habitats within Merrimack River. The study consisted of both field and desktop-based tasks. Field efforts focused on surveys to characterize the distribution, composition, and relative abundance of freshwater mussels and non-native bivalves in the Lawrence Project area. The desktop analysis focused on a review of potential host-fish for documented mussel species through review of relevant publications and concurrent fish data collected in the Project area. The specific field-based objectives of this study were to:

- Determine the species composition, relative distribution, and abundance of freshwater mussel species in the Project area,
- Assess the available habitat within the nearshore areas; and
- Document the presence/absence of *Corbicula* (a non-native, invasive species) in the designated survey areas.

3 Project Description and Study Area

The Lawrence Project works consist of: (1) the 35-foot-high by 900-foot-long gravity Essex Dam of stone masonry construction (also known as the Great Stone Dam), with a five-foot-high pneumatic crest gate system mounted on the spillway crest; (2) a 9.8-mile-long impoundment having a surface area of 655 acres at a normal water elevation of 44.17 feet National Geodetic Vertical Datum of 1929 at the top of the crest gates, and gross storage capacity of approximately 19,900 acre-feet; (3) a powerhouse located at the end of a small forebay adjacent to the south abutment of the Essex Dam containing two 8.4 megawatt generating units and a tailrace channel extending into the Merrimack River channel; (4) fish passage facilities integral with the powerhouse, including a fish lift, downstream fish bypass, an eel lift at the left abutment of the dam, and an eel ladder at the right abutment of the dam; (5) the North Canal, approximately 5,300 feet long by 95 feet wide by 15 feet deep, originating at the north abutment of the dam and paralleling the Merrimack River downstream of the Essex Dam; (6) the South Canal, approximately 2,750 feet long by 35 feet wide by 10 feet deep, originating at the south abutment of the Essex Dam and generally paralleling the Merrimack River downstream of the Essex Dam; (7) a single-circuit, underground/underwater 23.0-kilovolt transmission line to the Massachusetts Electric Company's Lawrence No. 1 substation; and (8) appurtenant facilities.

The study area included the mainstem Merrimack River from the upper extent of the Project impoundment (9.8 miles upstream of Essex Dam and immediately downstream of the Lowell hydroelectric project [FERC No. 2790]) to the Lawrence I-495 Bridge located approximately 1.5 miles below Essex Dam (Figure 3-1)

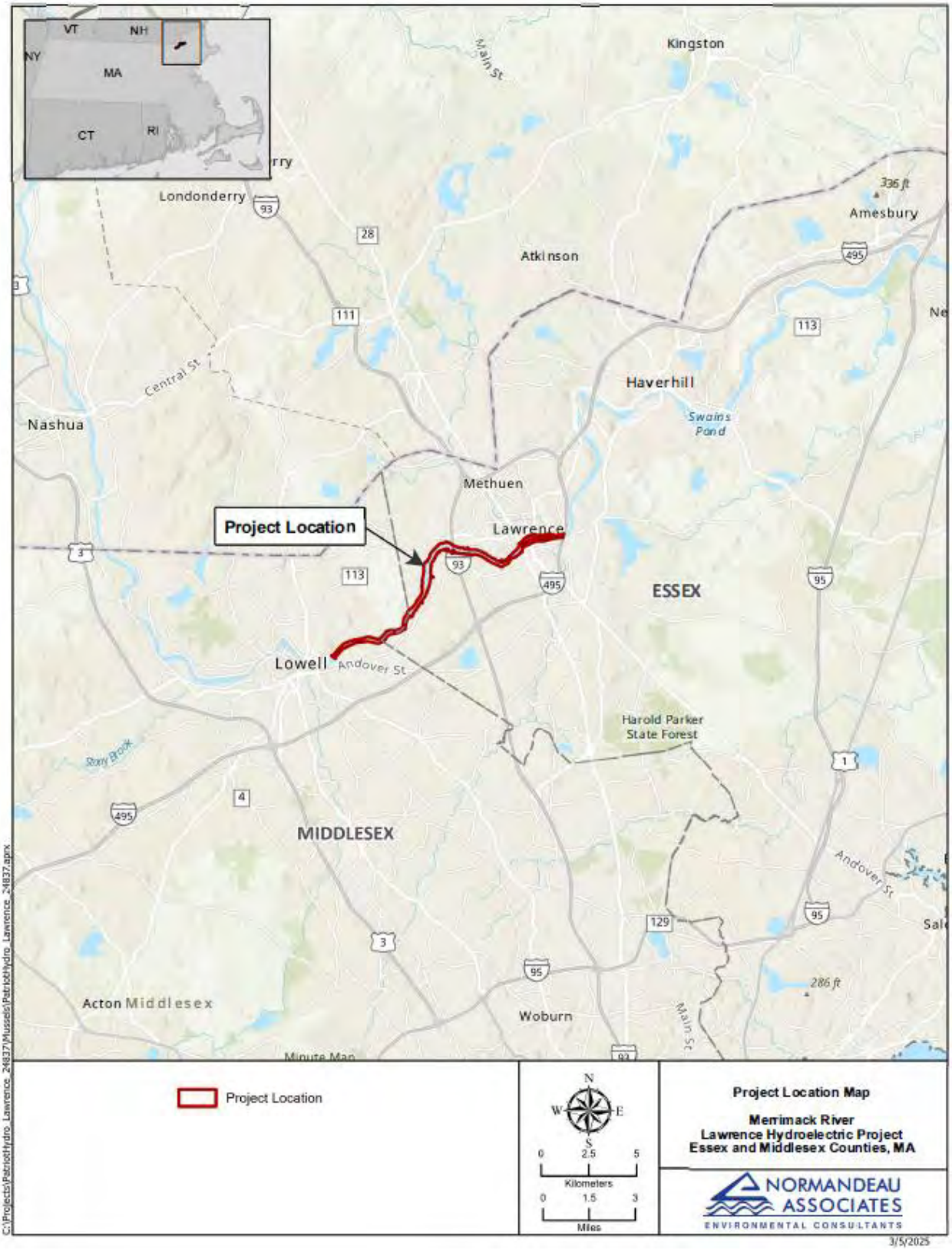

Figure 3-1.Study area for the 2024 Lawrence Hydroelectric Project Freshwater Mussel Habitat Assessment Survey.

4 Methodology

Survey methodology consisted of semi-quantitative, timed searches using snorkel or diving depending on water depth. The Massachusetts Division of Fisheries and Wildlife (MADFW) Freshwater Mussel Survey Guidelines were reviewed as part of this study plan development. It should be noted that MADFW does not define studies associated with water usage or level fluctuation in their guidelines. This study was considered atypical for the purposes of the MADFW methodologies. Therefore, the methodologies followed the survey rates and data collection methodologies outlined in Smith et al. (2001). As the Lawrence Project is operated in a run-of-river (ROR) mode, it is not anticipated that any direct impacts to mussels would occur during normal water fluctuations and Project operations. No mussel relocations were proposed as part of the approved Study Plan. Therefore, no mussel relocation recipient areas were reviewed as part of this mussel survey effort. Details of the methodologies utilized are described below.

A semi-quantitative freshwater mussel survey at 31 sites, above and below the hydroelectric facility, was initiated on August 19-23 and completed on September 10-11, 2024 in the Merrimack River, Lawrence/Lowell, Massachusetts (Figure 1). These surveys consisted of visual and tactile surveys of the river bottom by several biologists using mask and snorkel and diving where necessary. For search locations within the Project impoundment, the targeted survey range covered up to seven (7) feet of water depth from the existing water level at the time of survey. This represented the likely range of effects when considering both operation and maintenance related effects for crest gate repairs. Survey crews dove selected areas where water depths exceeded three feet. Search locations downstream of the Essex Dam also covered up to seven feet of water depth. Additional details are described in the RSP filed with FERC on April 10, 2024.[1]

A total of 31 transects were established at representative locations within the Project area reach (Figure 4-1). Survey teams reviewed each reach before selecting the final transect location in search of either heterogenous substrate suitable to support mussel communities or the best available substrate present in that reach. As a targeted survey design for potential effects associated with a run of river operation, site selection was adjusted in the field to cover suitable and productive mussel habitat areas and not randomly selected to best maximize the mussel distribution assessment and characterization of the mussel community. Center channel areas that remain watered during operation and maintenance events (i.e., deeper than 7 feet) were not targeted as part of this survey.

Each transect was 50 meters in length and oriented parallel to the shoreline and covered the area potentially impacted by water level fluctuations (i.e., down to seven feet of water depth). Qualified biologists surveyed each search location to assess available habitat as well as search for evidence of live mussel populations. Mussel searches were conducted using both visual and tactile search

[1] Accession Number 20240410-5169

methods. The width of each 50-meter segment depended on river contours and bathymetry and on the number of surveyors per transect and habitat type. Habitat and mussel catch were recorded for each 10-meter transect interval. Each surveyor searched a one-meter-wide area along the transect (1 surveyor = 1 meter; 2 surveyors = 2 meters, etc.). Survey rates ranged from 0.5 to 1 minute per square meter in suitable mussel habitat. Faster survey rates were applied in areas of unproductive habitat (e.g., poor clay or silt areas, ledge, etc.).

An additional 39 spot dives (i.e., serpentine transects) were conducted to further assess observed mussel communities adjacent to or in between transect areas. Spot dives conducted as part of this study were intended to further define mussel distributions in the Project area by following productive habitat to detect additional species. Spot dives were conducted in 10-minute intervals in areas where notable species were observed or where habitat suitable for those species were documented (Figure 4-1).

Within each survey area, surveyors started at the downstream limit of the selected area and slowly progressed upstream in a meandering pattern (one meter in width), visually searching for mussels. Given the shallow areas, transects and spot dives were oriented parallel to the shoreline to maximize the search areas along the shallower margins at selected locations. Areas of fine or loose substrates were probed by hand and aquatic and emergent vegetation was moved or probed in search of mussels. No diving or survey occurred in areas 500 ft or closer to the dam, in the South Canal, or in areas where water velocities exceeded 2.0 feet per second (fps).

At each search location, the crew identified all live mussels observed. Identified mussels were then returned to the river bottom. Two representative photographs of each live species encountered during the study were recorded (dorsal and lateral views). Care was taken to minimize exposure of live mussels to air during processing (e.g., no longer than 5 minutes). Total shell length (in millimeters [mm]) was recorded for any imperiled species observed. Up to 50 individuals of common species (e.g., eastern elliptio, eastern floater) were measured to the nearest millimeter. Relative abundances were determined using data from the transect intervals and spot dives. Any notable observations of freshwater mussel sex, gravidity, or lure display was noted. Habitat parameters such as substrate and cover type, average stream width and depth, aquatic vegetation, and presence of invasive mollusk species such as *Corbicula* or zebra/quagga mussels were noted on field data sheets. No quantitative sampling (i.e., quadrat sampling) was conducted as part of this survey.

The following data was recorded for each transect interval or spot dive:

- total survey time expended;
- number, condition and shell length of any state-listed species (up to 50 per common species);
- numbers of other live mussel species (relative abundances for common species observed in high numbers – e.g. > 0.5/square meter);

- two photographs of each live species observed (dorsal and lateral views);
- GPS coordinates for transects and spot dives;
- maximum water depth per transect interval/spot dive;
- water clarity;
- estimate of substrate composition (Wentworth Scale);
- estimate of large woody debris per transect interval;
- presence of Asiatic clam (*Corbicula fluminea*);
- anecdotal observations of fish species, and
- estimate of aquatic vegetation presence percentage per interval/spot dive.

Substrate composition was characterized at each interval along each transect, and at nearby shorelines above the observed water level, based on a visual percentage as defined by the Wentworth scale (Wentworth 1922), a widely accepted method of describing mineral substrate for freshwater mussel surveys. The substrate abbreviations include:

- BR – bedrock
- BO – boulder (>256mm)
- CB – cobble (64mm – 256mm)
- GR – gravel (2mm – 64mm)
- SD – sand (<2mm and gritty)
- ST – silt (smooth and loosely binding)
- CL – clay (smooth and tightly binding or malleable)

Substrate composition, CPUE, and species distribution figures for each transect and spot dive are provided in Appendix A. Relative abundance, substrate composition, CPUE, and species distribution tables are provided in Appendix B. Normandeau's Scientific Collectors Permit is provided in Appendix C. Photographs of the survey transects, species observed, and other notable features are provided in Appendix D.

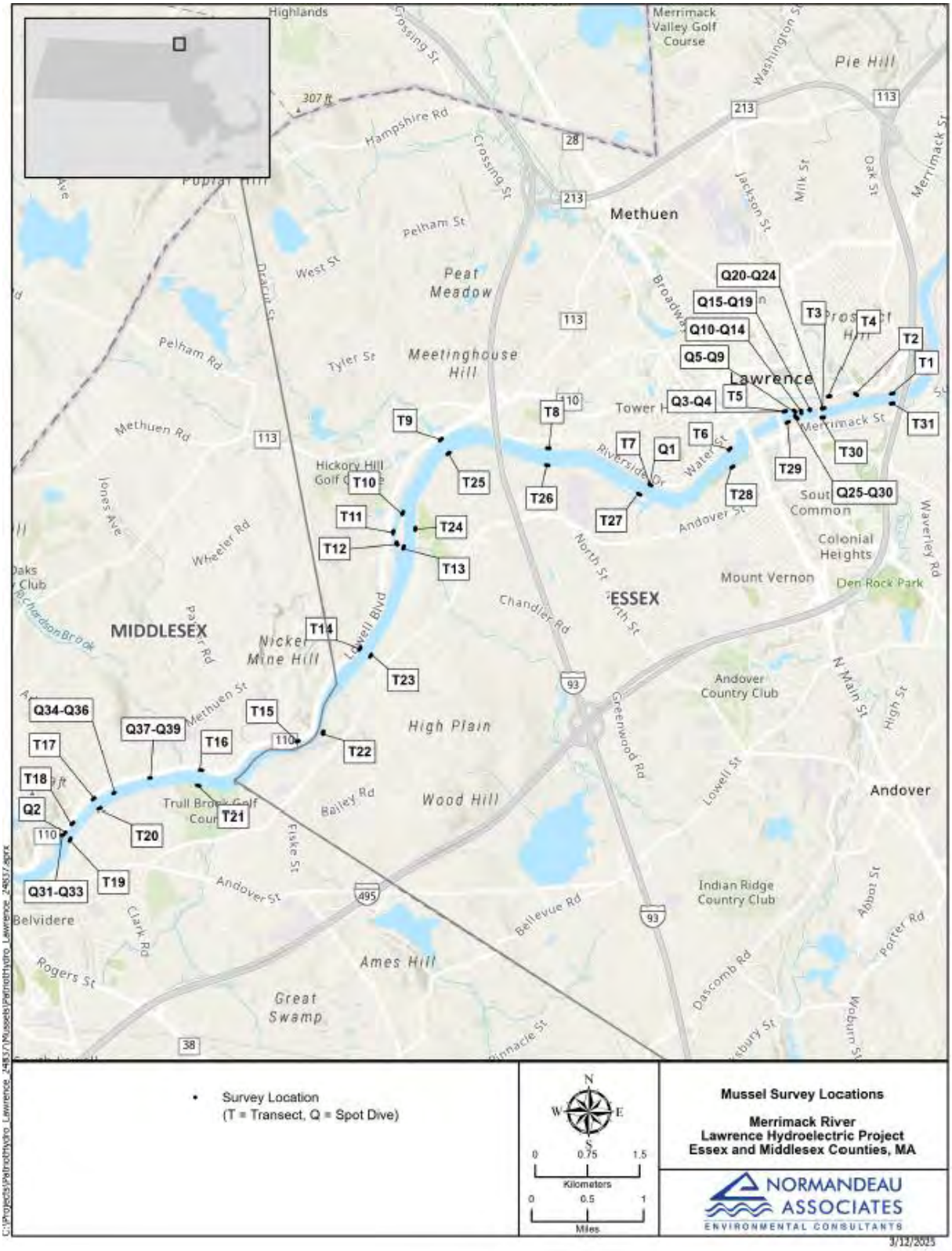

Figure 4-1.Transect and spot dive locations sampled during the 2024 Lawrence Hydroelectric Project Freshwater Mussel Habitat Assessment Survey.

5 Results

The mussel survey was conducted during two periods: August 19-23 (transect sampling) and September 10-11 (supplemental spot dives). A total of 31 transects and 39 spot dives were conducted. Coordinates for the selected transect and spot dive locations were recorded once established in the field and are provided in Table 5-1.

Table 5–1. Transect and spot dive GPS locations during the 2024 Lawrence Hydroelectric Project Freshwater Mussel Habitat Assessment Survey.

Transect (T)	Longitude	Latitude
T1	-71.14051	42.70675
T2	-71.14689	42.70651
T3	-71.15238	42.70488
T4	-71.15132	42.70642
T5	-71.15910	42.70454
T6	-71.16891	42.69980
T7	-71.18277	42.69494
T8	-71.20063	42.69980
T9	-71.21955	42.70113
T10	-71.22640	42.69172
T11	-71.22811	42.68929
T12	-71.22764	42.68780
T13	-71.22629	42.68729
T14	-71.23394	42.67422
T15	-71.24478	42.66218
T16	-71.26169	42.65841
T17	-71.28065	42.65491
T18	-71.28437	42.65186
T19	-71.28487	42.64982
T20	-71.27958	42.65362
T21	-71.26222	42.65636
T22	-71.24054	42.66342
T23	-71.23205	42.67332
T24	-71.22428	42.68971
T25	-71.21819	42.69934
T26	-71.20080	42.69758
T27	-71.18475	42.69373
T28	-71.16836	42.69743
T29	-71.15865	42.70315
T30	-71.15247	42.70367
T31	-71.14052	42.70546

Spot Dive (Q)	Longitude	Latitude
Q1	-71.18318	42.69506
Q2	-71.28579	42.65056
Q3	-71.15922	42.70448
Q4	-71.15945	42.70444
Q5-9	-71.15785	42.70459
Q10-14	-71.46680	42.94226
Q15-19	-71.15498	42.70474
Q20-24	-71.15271	42.70486
Q25-30	-71.15752	42.70351
Q31-33	-71.28619	42.65023
Q34-36	-71.27715	42.65555
Q37-39	-71.27082	42.65743

The overall survey effort expended was 20 survey hours, resulting in approximately 12,610 live mussels observed (Table 5-2). Data tables containing the relative abundance, substrate composition, CPUE, and species distribution are provided in Appendix C. The subsections below describe the conditions encountered, habitat documented, the mussel community found, and

information on the distribution of those species. Figures visualizing the results for substrate composition, CPUE, and species distribution for each transect and spot dive are included in Appendix D.

Table 5–2. Summary of live Unionids, species, and relative abundance observed in the Merrimack River at the Lawrence Hydroelectric Project, August 19-23 and September 10-11, 2024.

Species	Total Live by Species	Rel. Ab. (%)
Pyganodon cataracta	5,013	39.8
Elliptio complanata	4,603	36.5
Utterbackiana implicata	2,982	23.6
Lampsilis radiata	6	0.05
Alasmidonta undulata	5	0.04
Strophitus undulatus [1]	1	0.01
Lampsilis cariosa [2]	0	0.00
Species Richness Total	7	
Species Richness Live	6	
Total Live Relocated	0	
Total Unionids	12,610	
Survey Effort - hr(min)	20.0 (1,197)	
Total Search Area (m^2)	2,145	
Overall CPUE (no./hour)3	632.1	

[1] Species of Special Concern

[2] State Endangered Species

[3] CPUE (Catch Per Unit Effort) = number live per work person hour (no. live / (Tot time/60 min)

5.1 Weather and Water Level Conditions

Weather conditions consisted of overcast skies, with showers after survey efforts were completed. Air temperatures ranged from 53-82 degrees Fahrenheit. Water temperature during the survey ranged between 70-74 degrees Fahrenheit. Visibility was optimal throughout the survey at greater than two meters. Despite ideal water clarity, submerged aquatic vegetation (SAV) did affect observation of the full community in some locations.

Inflow at the Project and reported impoundment water surface elevations during the survey dates are provided in Figure 5-1. Relative to the normal elevation of 44.17 ft, the impoundment was full over the duration of both the August and September sampling periods. Inflow at the Project ranged between 2,900 and 4,000 cfs during the August sampling event and around 1,200 for the September sample dates. River elevation information for the Merrimack River downstream of the Essex Dam is summarized in Figure 5-2 and was obtained from USGS gage 01100500. Recorded gage elevations were approximately two feet lower during the September sample events than was observed during the August transect dives.

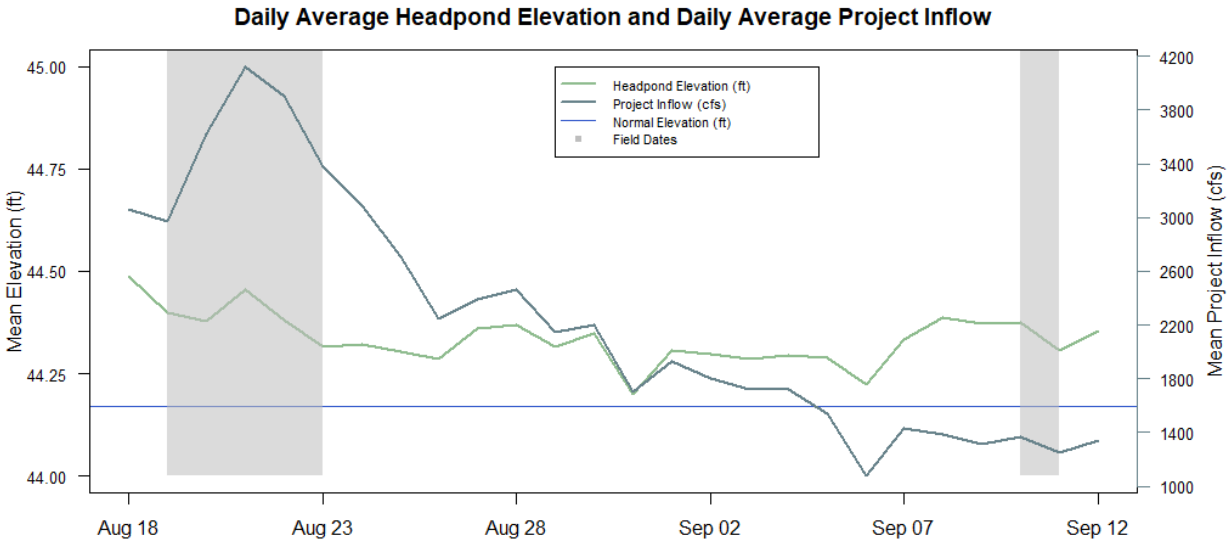

Figure 5-1.Daily average impoundment elevation and Project inflow during the 2024 Lawrence Hydroelectric Project Freshwater Mussel Habitat Assessment Survey.

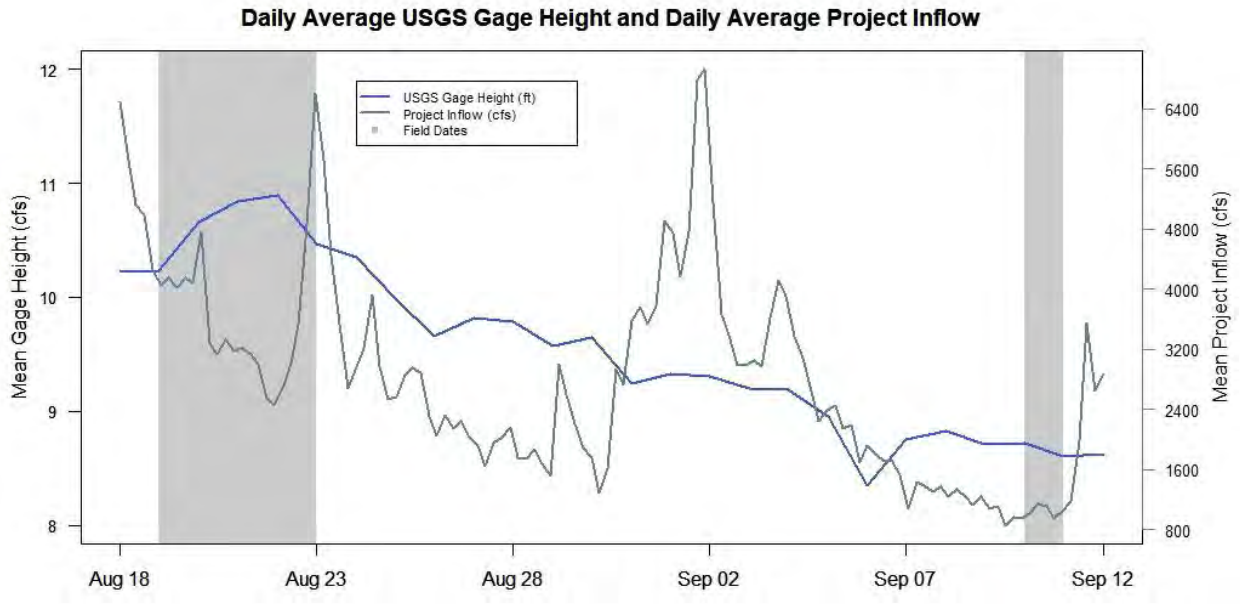

Figure 5-2.Daily Merrimack River USGS gage elevation downstream of Essex Dam and Project inflow as recorded for the 2024 Lawrence Hydroelectric Project Freshwater Mussel Habitat Assessment Survey.

5.2 Aquatic Habitat

Substrate throughout the Project area ranged from sand and silt dominated habitats, to areas of heterogenous substrate consisting of cobble, gravel, and sand. Figures showing substrate composition, and maximum water depths are provided in Appendix A; tables showing substrate composition, maximum depth, and number of live mussels are provided in Appendix B.

Substrate in the section of the Merrimack River from the Essex Dam downstream to the Lawrence I-495 Bridge consisted of heterogenous proportions of cobble, gravel, sand, and silt, with some areas having high densities of SAV (*Vallisneria americana*). SAV was substantial and unavoidable in some locations downstream of the dam. Although mussels were readily observed amongst the SAV beds, the SAV density affected observation of all mussels in those areas. However, mussels observed in open areas of habitat downstream of the dam provided an accurate representation of the mussel community in those locations. Habitat downstream of the dam was ideal for mussel colonization and recruitment, with high densities of adult and juvenile mussels observed during sampling. Overall, the transects surveyed downstream of the dam contained consistent habitat characteristics and survey depths ranged from two to seven feet. During the second survey effort in September, flows and water levels were lower than observed in the same reach during August due to seasonally dry conditions. This allowed surveyors to search further toward the center channel during their spot dive selection and allow for better characterization of the mussel community at those locations.

Habitat within the North Canal was dominated by gravel with proportions of sand. The North Canal contained consolidated substrate, with little interstitial space, other portions were unstable gravel and sand bars that would give out when stepped on. The reach of the Spicket River from the discharge of the North Canal, downstream to its confluence with the Merrimack River, was characterized as cobble/sand substrate.

Transects surveyed within the impoundment were characterized by steep slopes along the shoreline, consisting of sand and silt and contained proportions of large woody debris and detritus. Transects 6-14 and 22-28 were characterized by high proportions of sand and silt (Appendices A and B). Further upstream at Transects 15 and 21, where higher flows were observed, substrate characteristics shifted to heterogenous proportions of cobble, gravel, and sand. Survey depths of transects ranged from 5 to 7 feet but depths of 20-40 feet were observed from a depth finder in the center channel.

The average width of the Merrimack River at survey locations upstream of the dam was 176 meters, downstream of the dam was 145 meters, and within the North Canal was 14 meters.

5.3 Mussel Community

A total of 20 search hours, covering approximately 2,145 m^2, yielded approximately 12,610 live mussels (Table 5-2). Live species observed included eastern floater representing 39.8 percent (n=5,013), eastern elliptio representing 36.5 percent (n=4,603), and alewife floater representing 23.6 percent (n=2,982). The remaining 0.1 percent was represented by eastern lampmussel (n=6), triangle floater (n=6), and creeper (n=1). Additionally, yellow lampmussel was only observed as a relic shell in the surveyed section of the Merrimack River downstream of Essex Dam.

In the surveyed section of the Merrimack River downstream of the Essex Dam, select transects exhibited very dense mussel communities. At some transects, mussel densities were estimated to be over 100 mussels per m^2. The mussel assemblage downstream of the Essex Dam was dominated by very dense populations of eastern elliptio, eastern floater, and alewife floater. Live triangle floater, creeper, eastern lampmussel were also observed in low numbers along with one yellow lampmussel shell. Additional spot dives were conducted in areas with suitable habitat and areas where mussel densities were high or notable species such as triangle floater, creeper, yellow lampmussel shell were observed. Counts of common species were recorded but particular focus was placed on detection of rarer species known to occur in the Merrimack River. Notably, spot dives Q5-9 had CPUE values exceeding 4,000 mussels per hour (Appendix B).

The mussel assemblage in the impoundment primarily consisted of moderately dense populations of eastern elliptio, eastern floater, and alewife floater. Habitat transitions were observed at Transect 15, 21 and upstream, where flow increased. In these areas, higher proportions of juvenile eastern elliptio, eastern floater, and alewife floater were observed. Additionally, eastern lampmussel, a Massachusetts species of concern creeper, and relic shells of triangle floater were observed along

the left descending bank in the upper section of the impoundment (Appendix B). Surveyors searched along the margins on the impoundment and observed no live mussels from the shoreline to approximately 2.5-3 ft in depth. Live mussels were generally observed at water depths of three feet and deeper at the impoundment transect and spot dive locations.

Observed mussel assemblages in the North canal consisted of relatively low densities of eastern elliptio. Habitat suitability varied throughout the North Canal transect, with some sections having consolidated substrate with limited burrowable areas, to sections that were unstable and gave out when stepped on. At the confluence of the Spicket River and the Merrimack River, only one live eastern elliptio was observed. Similar to sections of the North Canal, substrate was consolidated, with little interstitial space between cobble.

Various age-size ranges of eastern elliptio (12-110 mm), eastern floater (15-160 mm), alewife floater (13-154 mm), and triangle floater (34-51 mm) were observed in the Project area. High relative densities of juvenile eastern elliptio, eastern floater, and alewife floater, ranging from 12-30 mm, was observed in the SAV beds along the right descending bank in the riffles (Appendix D; Photo 30).

Asiatic clams (Corbicula fluminea) were observed throughout the Project area in low densities. No transects or spot dives indicated that they occurred in dense communities. Live *Corbicula*, or shell material, were observed in low numbers at 19 of the transects surveyed upstream and downstream of the dam, and most spot dive locations. No corbicula were observed within the North canal.

No evidence of federal or state listed threatened or endangered species was observed in the Project area during this survey. As discussed in the Smith et al. (2001) protocols, detection of rare species are dependent on a number of factors including resident density of common mussel species assemblages. In communities where densities approach and exceed 100 mussels/m^2, detection rates of rare species are much lower. If rare species are present in low numbers, rare species may not be detected at all, without substantial additional efforts. It is fair to say that with the dense mussel community and SAV coverage below the dam, that additional species may occur but were not detected in the Project area based on the habitat observed. Specific focus was placed on detection of additional species including evidence of shell during this survey. Evidence of yellow lampmussel shell and one live creeper indicate that these species are present in very low numbers amongst robust mussel community dominated by more common species.

6 Discussion

6.1 Host Fish Presence

Freshwater mussels require a fish host to complete their life cycle. Fertilized adults release tiny glochidia (parasitic larvae) into the water column. The parasitic larvae require a specific host species (typically fish) to attach to and continue development. The larvae attach to gills and/or fins of the host fish where they become blood parasites for a period before transforming into juvenile mussels. The juveniles then release from the host fish and fall into the substrate where they grow into adults (Williams et. al. 1993). Mussel communities that are sparse or not well-established experience reduced fertilization success and fish host interaction that prevent community expansion and persistence. Mussels are sessile and semi-fossorial in nature resulting in patchy distributions. Mussel community expansion is assisted by downstream movement of individuals in riverine systems, transport via fish hosts or physical introduction. Long term mussel community success is based on the acceptance of the surrounding water quality and physical habitat availability by the species.

Observations of fish species during mussel surveys at the transects and spot dive locations were limited to centrarchid species (i.e., black bass and sunfish) upstream of the dam and juvenile eels and Tessellated Darter downstream of the dam. As reported in the American Eel Upstream Passage Siting Study report, electrofish sampling was conducted in the section of the Merrimack River downstream of the Essex Dam to its confluence with the Spicket River. Resident fish species observed during those surveys included (in order of relative abundance) Smallmouth Bass, Spottail Shiner, White Sucker, Common Carp, Bluegill, Redbreast Sunfish, Fallfish, Pumpkinseed, Green Sunfish, Largemouth Bass, Margined Madtom, Tessellated Darter, Golden Shiner, and Yellow Bullhead. Diadromous fish species, including American Shad, river herring (i.e., Alewife and Blueback Herring), Sea Lamprey, American Eel, and Striped Bass, are observed annually at the upstream fish lift at the Project.

It was clear from the number of smaller individuals and size ranges that populations of eastern elliptio, alewife floater, and eastern floater have access to their fish hosts for full life cycle completion. Rarer species are likely to have similar access to suitable fish host but the differences in mussel density to fish host encounters may be influenced by a number of factors beyond the goals of this study.

6.2 Physical Habitat

Mussels typically require clean, stable substrates comprised of stable, heterogenous mixtures of small, cobble, gravel, clays, and sand. Substrate stability and suitability can be a major limiting factor for mussel species richness and abundance (Allen and Vaughn, 2010). The substrate observed in the impoundment, up to Transects 14 and 23 consisted of predominantly sand and silt, with high proportions of large woody debris and organic debris. Mussels were observed along

these sand/silt slopes but were limited to common species in moderate or low densities. The upstream sections of the Project area and downstream of the dam transitioned to cobble, gravel, and sand with increased flow in these reaches. These habitats appeared to be stable during high flow events and provide interstitial space in between cobble and gravel for juveniles to develop. Habitat in these areas were consistent in their suitable qualities and reflected by the mussel assemblages observed in each location.

6.3 Impoundment Water Levels

Activities that change water flow and water level can result in both direct and indirect effects to mussels. Direct and indirect effects to mussels may alter their reproduction, growth, and survival. Direct effects may include physical injury or mortality resulting from significant changes in flow that create scour or deposition, dewatering, or excavation and removal of mussels. Indirect effects may cause interruptions in reproductive activity, loss of fish host availability, or dislodgement of mussels into unfavorable habitat conditions. Currently this facility operates as a run of river generation facility. Normal operations do not appear to have a substantial effect on the existing mussel community. In fact, this community appears to be thriving at this location. Substantial and rapid reductions to water levels for maintenance events may expose portions of this community if exposure lasts for more than a few days. However, assemblages toward the center channel were equally robust (confirmed by spot dives) as those observed in the targeted water depths. These assemblages provide resiliency for the extant communities in the event of unexpected low-water events associated with maintenance operations.

Water levels were notably lower during the September survey period due to prolonged dry periods in the region (Appendix B). During this seasonally dry period, the channel-maintained water coverage despite the lack of rainfall in the basin for a number of weeks.

7 Summary

A total of 20 search hours yielded approximately 12,610 live mussels, representing six live species in the Merrimack River at the Project area. A variety of substrate compositions were observed throughout the Project area. Downstream of the dam, available habitat consisted of cobble, gravel and sand, with high proportions of submerged aquatic vegetation. Habitat in the impoundment consisted of sand/silt dominated shoreline margins, with steep slopes to the thalweg. The upstream portion of the Project area exhibited similar substrate characteristics to that of the downstream section, although lacking the dense SAV beds. Key findings from the 2024 survey include:

- Suitable habitat was widespread though the Project area and readily available for fish host and mussel colonization.
- Robust mussel communities were observed downstream of the dam and in the upper portion of the impoundment where flow was observed, and substrate was suitable for mussel colonization and juvenile recruitment.
- Mussel communities were dominated by common species including eastern elliptio, eastern floater, and alewife floater. Live rare species including triangle floater, creeper, eastern lampmussel, and yellow lampmussel shell were also observed.
- Yellow lampmussel and creeper are present in very low numbers amongst robust mussel community dominated by more common species.

In mussel communities of this size and density, rare species in low numbers are difficult to detect. Additional rare species may be present outside of those observed in this study.

It is unlikely that Project operations, under normal conditions, will negatively affect freshwater mussel communities based on the observed distributions of mussel communities observed upstream and downstream of the dam. The existing community is dense and robust throughout this system with active recruitment. The combination of ideal habitat and robust actively recruiting populations in nearly all areas of the study area make this community not only stable but resilient.

8 Variances from the FERC Approved Study Plan

The Freshwater Mussel Habitat Assessment and Survey was conducted following the methodology described in the April 10, 2024, RSP and approved by FERC in their May 10, 2024, SPD with several exceptions:

- In their May 10, 2024 SPD, FERC recommended that the licensee survey the North and South Canals for potential suitable mussel habitat and characterization of the distribution, composition, and relative abundance of mussels and non-native bivalves. Habitat and mussel information was collected from the North Canal. Due to safety concerns with the ability for staff to access and exit the South Canal in the event of loss of control at the intake structure, no habitat or mussel data was collected from that Project section.

- Measurements were recorded for all rare mussel species and limited to 50 measurements of the most common species, due to their high abundance and wide range in size. Over 12,000 individuals were observed and the time diverted to measure all individuals would detract from supplementing survey coverage and additional species detection through spot dives and yield little additional value to the stated goals of this study.

- In their May 10, 2024 SPD, FERC requested that Essex report the occurrence of all invasive plant species while conducting field sampling conducted as part of the Recreation Facilities, Use, and Aesthetics Study and the Freshwater Mussel Habitat Assessment and Survey. Although invasive plant data was not collected during the 2024 Mussel Study, Essex is collecting observational information on invasive plant species during the Recreation Facilities, Use, and Aesthetics Study and will supplement that with observational data collected during the 2025 Water Quality Study field effort.

9 References

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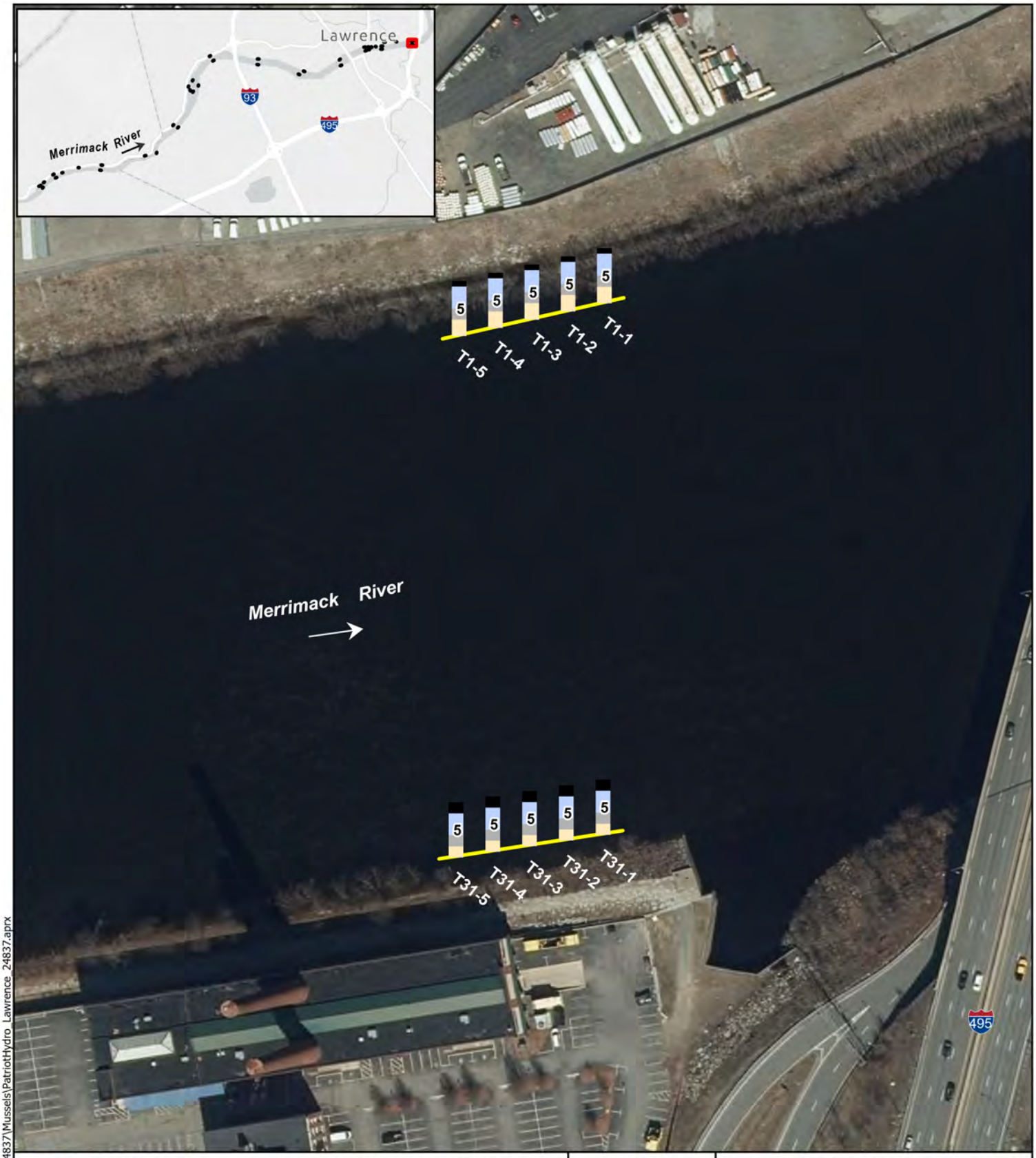
Appendix A: Report Figures



Spot Dive (Q)

Survey Transect (T)

% Substrate (water depth in feet)

- Bedrock (BR)
- Boulder (BO)
- Cobble (CB)
- Gravel (GR)
- Sand (SD)
- Silt (ST)
- Clay (CL)
- Other

N W E S

0 10 20
Meters

0 50 100
Feet

Appendix A - Figure 1
T1 and T31
Substrate and Maximum Water Depth (ft)

Merrimack River
Lawrence Hydroelectric Project
Essex and Middlesex Counties, MA

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Spot Dive (Q)

Survey Transect (T)

% Substrate (water depth in feet)

- Bedrock (BR)
- Boulder (BO)
- Cobble (CB)
- Gravel (GR)
- Sand (SD)
- Silt (ST)
- Clay (CL)
- Other

N
W E
S

0 10 20
Meters

0 50 100
Feet

Appendix A - Figure 1
T2
Substrate and Maximum Water Depth (ft)

Merrimack River
Lawrence Hydroelectric Project
Essex and Middlesex Counties, MA

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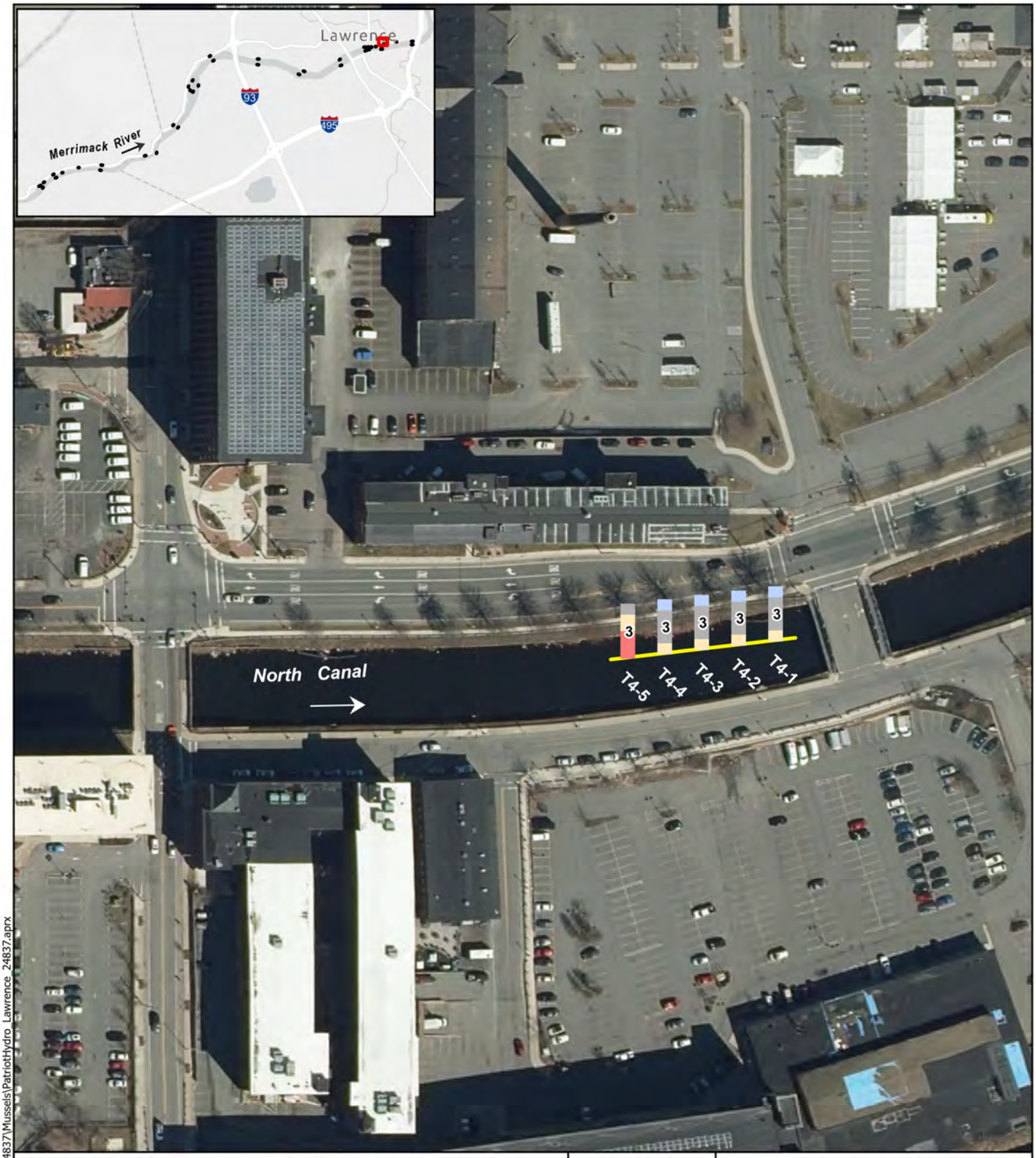

Spot Dive (Q)

Survey Transect (T)

% Substrate (water depth in feet)

- Bedrock (BR)
- Boulder (BO)
- Cobble (CB)
- Gravel (GR)
- Sand (SD)
- Silt (ST)
- Clay (CL)
- Other

N W E S

0 10 20
Meters

0 50 100
Feet

Appendix A - Figure 1
T4
Substrate and Maximum Water Depth (ft)

Merrimack River
Lawrence Hydroelectric Project
Essex and Middlesex Counties, MA

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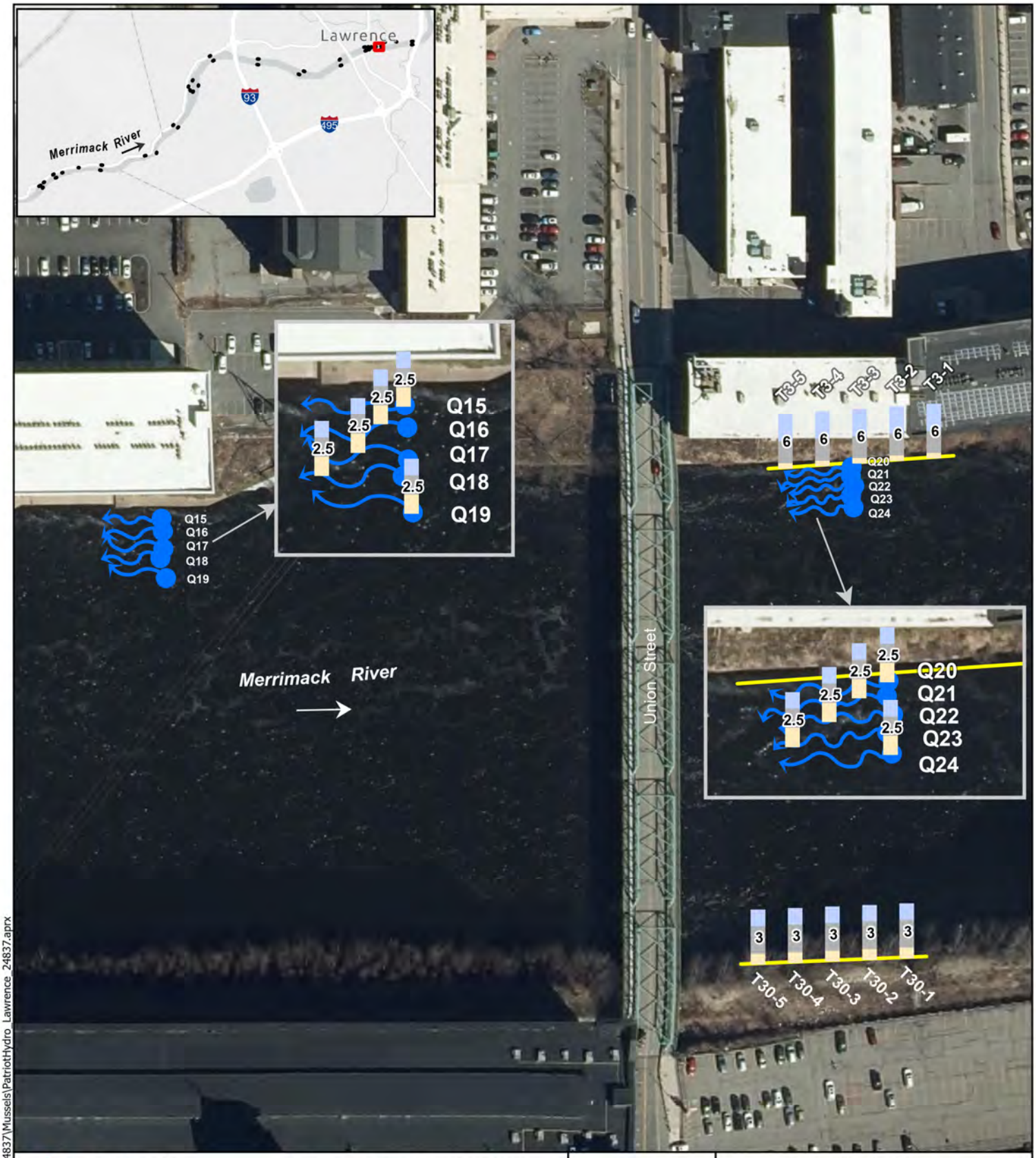

Spot Dive (Q)

Survey Transect (T)

% Substrate (water depth in feet)

- Bedrock (BR)
- Boulder (BO)
- Cobble (CB)
- Gravel (GR)
- Sand (SD)
- Silt (ST)
- Clay (CL)
- Other

N W E S

0 10 20 Meters

0 50 100 Feet

Appendix A - Figure 1
T3, T30 and Q15 - Q24
Substrate and Maximum Water Depth (ft)

Merrimack River
Lawrence Hydroelectric Project
Essex and Middlesex Counties, MA

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Spot Dive (Q)

Survey Transect (T)

% Substrate (water depth in feet)

- Bedrock (BR)
- Boulder (BO)
- Cobble (CB)
- Gravel (GR)
- Sand (SD)
- Silt (ST)
- Clay (CL)
- Other

N W E S

0 10 20
Meters

0 50 100
Feet

Appendix A - Figure 1
T5, T29, Q3 - Q14, and Q25 - Q30
Substrate and Maximum Water Depth (ft)

Merrimack River
Lawrence Hydroelectric Project
Essex and Middlesex Counties, MA

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Spot Dive (Q)

Survey Transect (T)

% Substrate (water depth in feet)

- Bedrock (BR)
- Boulder (BO)
- Cobble (CB)
- Gravel (GR)
- Sand (SD)
- Silt (ST)
- Clay (CL)
- Other

N W E S

0 10 20
Meters

0 50 100
Feet

Appendix A - Figure 1
T6 and T28
Substrate and Maximum Water Depth (ft)

Merrimack River
Lawrence Hydroelectric Project
Essex and Middlesex Counties, MA

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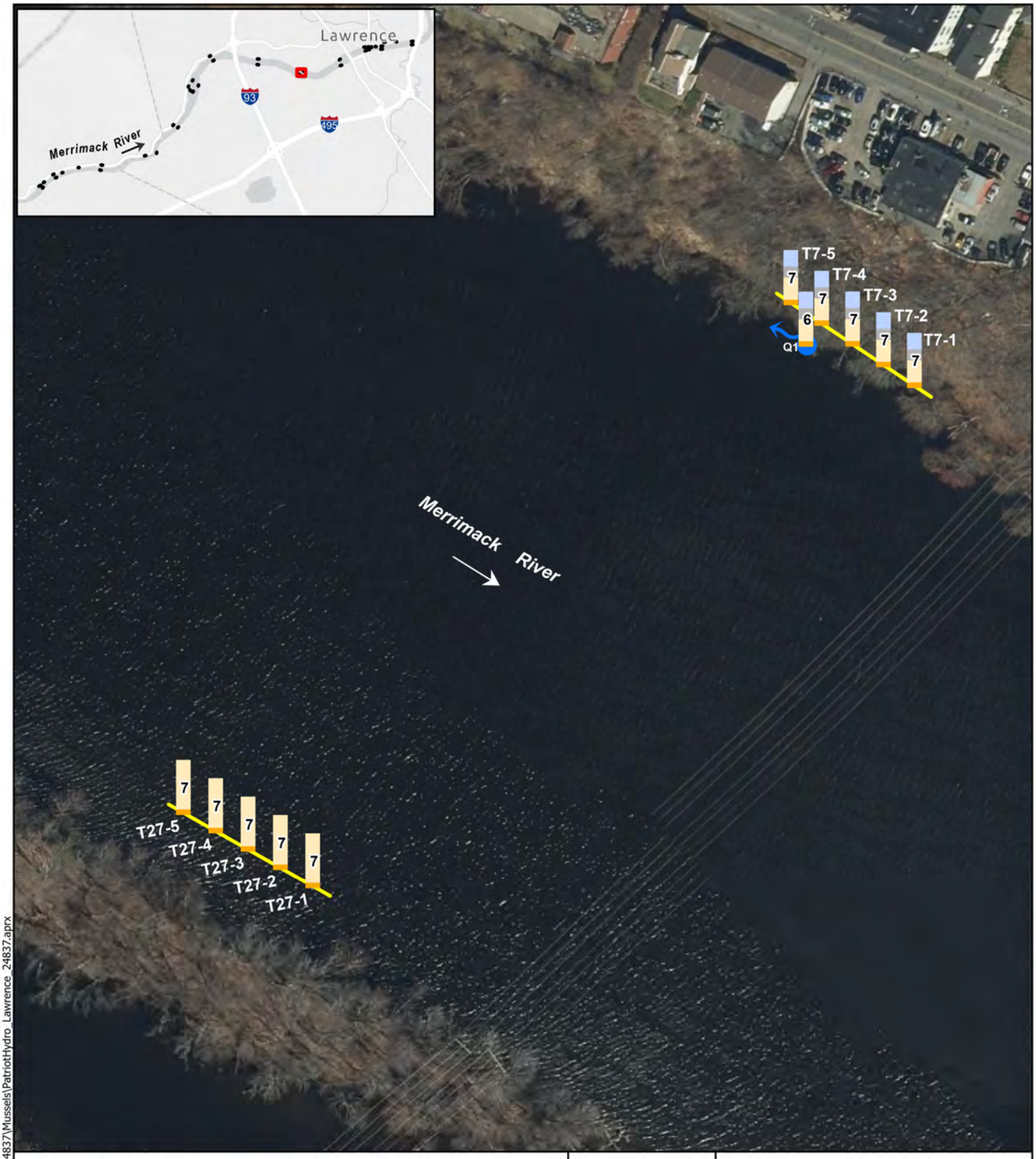

Spot Dive (Q)

Survey Transect (T)

% Substrate (water depth in feet)

- Bedrock (BR)
- Boulder (BO)
- Cobble (CB)
- Gravel (GR)
- Sand (SD)
- Silt (ST)
- Clay (CL)
- Other

N W E S

0 10 20
Meters

0 50 100
Feet

Appendix A - Figure 1
T7, T27 and Q1
Substrate and Maximum Water Depth (ft)

Merrimack River
Lawrence Hydroelectric Project
Essex and Middlesex Counties, MA

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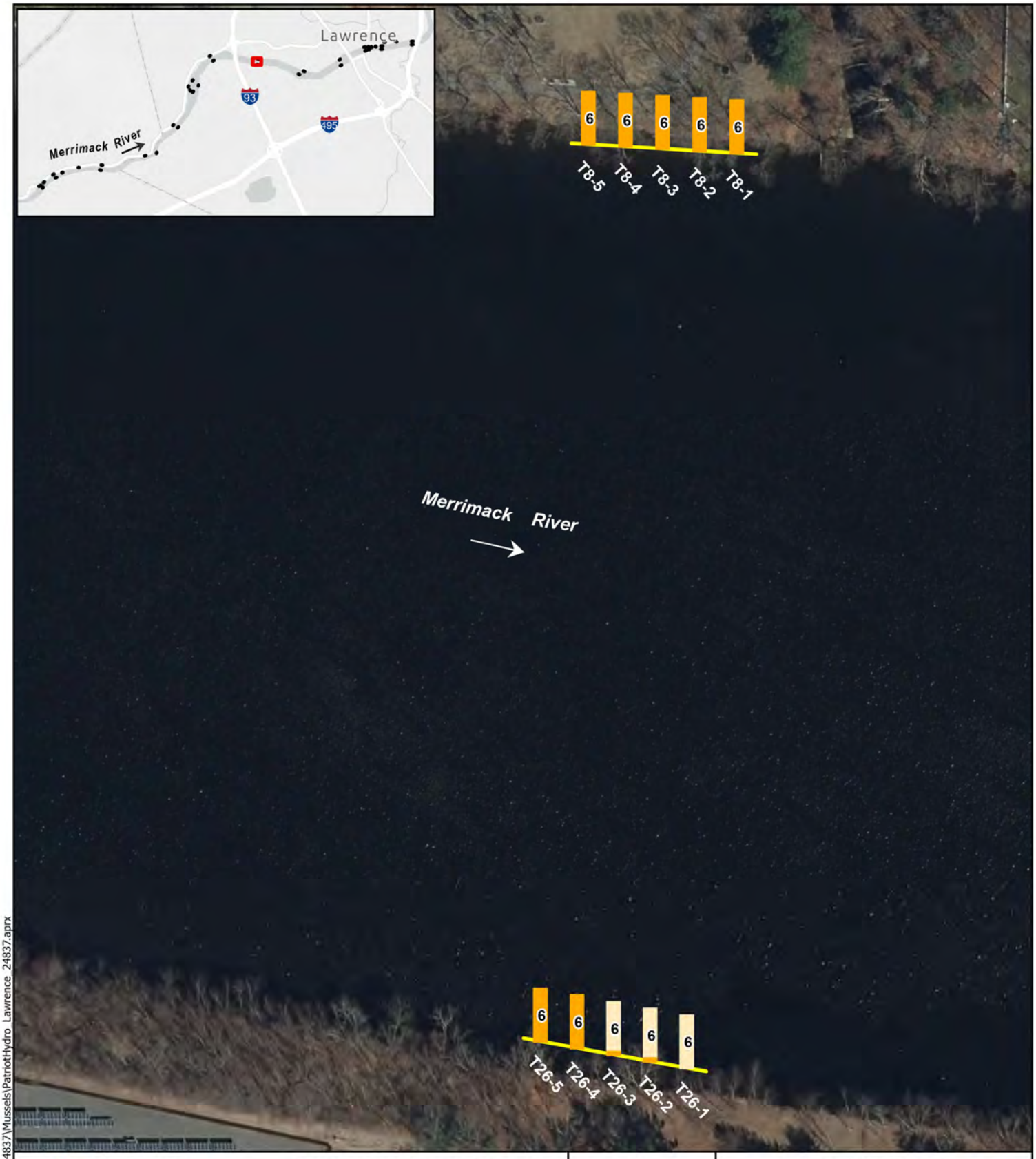

Spot Dive (Q)

Survey Transect (T)

% Substrate (water depth in feet)

- Bedrock (BR)
- Boulder (BO)
- Cobble (CB)
- Gravel (GR)
- Sand (SD)
- Silt (ST)
- Clay (CL)
- Other

N W E S

0 10 20
Meters

0 50 100
Feet

Appendix A - Figure 1
T8 and T26
Substrate and Maximum Water Depth (ft)

Merrimack River
Lawrence Hydroelectric Project
Essex and Middlesex Counties, MA

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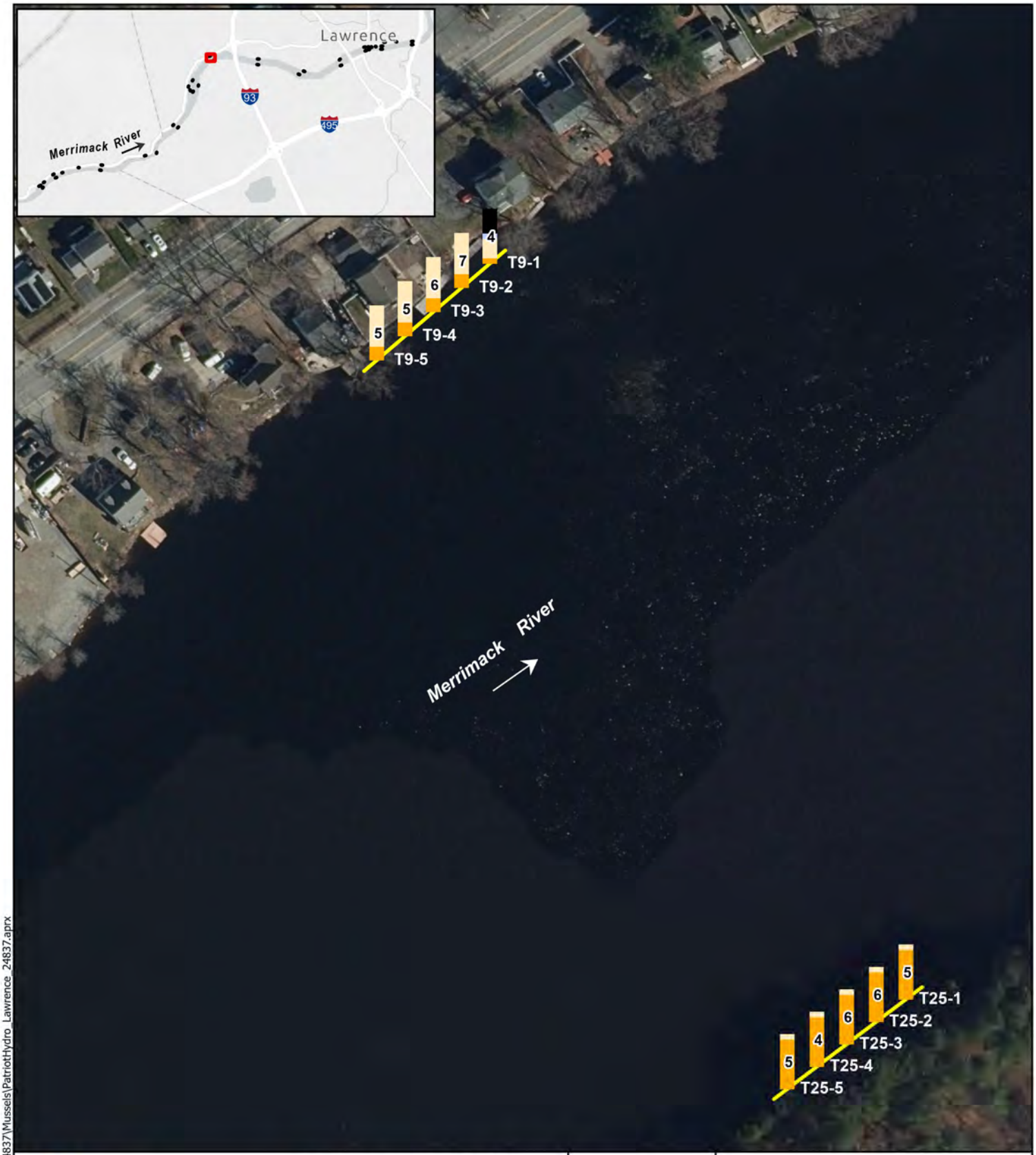

Spot Dive (Q)

Survey Transect (T)

% Substrate (water depth in feet)

- Bedrock (BR)
- Boulder (BO)
- Cobble (CB)
- Gravel (GR)
- Sand (SD)
- Silt (ST)
- Clay (CL)
- Other

N W E S

0 10 20
Meters

0 50 100
Feet

Appendix A - Figure 1
T9 and T25
Substrate and Maximum Water Depth (ft)

Merrimack River
Lawrence Hydroelectric Project
Essex and Middlesex Counties, MA

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Spot Dive (Q)

Survey Transect (T)

% Substrate (water depth in feet)

- Bedrock (BR)
- Boulder (BO)
- Cobble (CB)
- Gravel (GR)
- Sand (SD)
- Silt (ST)
- Clay (CL)
- Other

N W E S

0 10 20
Meters

0 50 100
Feet

Appendix A - Figure 1
T10
Substrate and Maximum Water Depth (ft)

Merrimack River
Lawrence Hydroelectric Project
Essex and Middlesex Counties, MA

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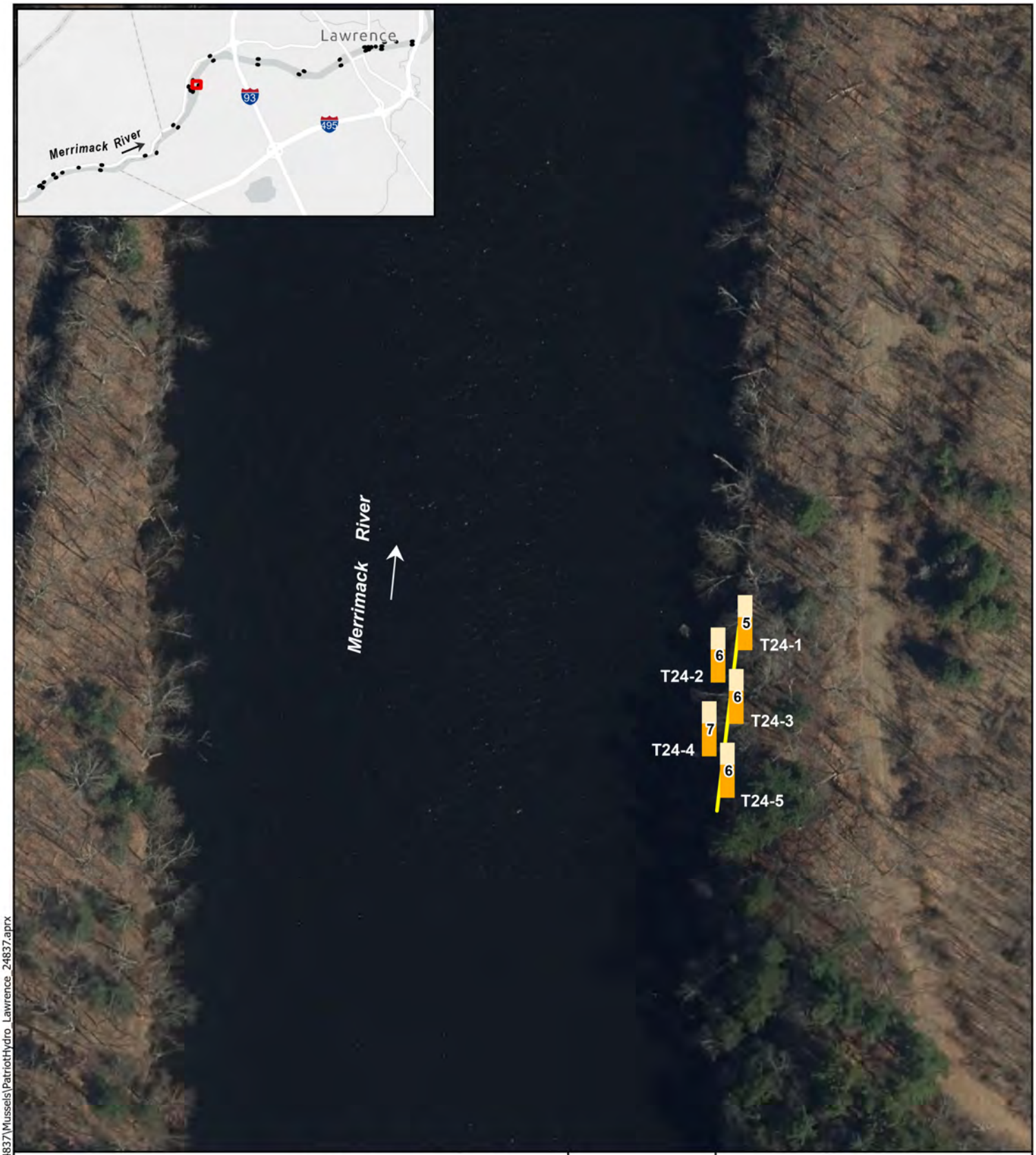

Spot Dive (Q)

Survey Transect (T)

% Substrate (water depth in feet)

- Bedrock (BR)
- Boulder (BO)
- Cobble (CB)
- Gravel (GR)
- Sand (SD)
- Silt (ST)
- Clay (CL)
- Other

N W E S

0 10 20
Meters

0 50 100
Feet

Appendix A - Figure 1
T24
Substrate and Maximum Water Depth (ft)

Merrimack River
Lawrence Hydroelectric Project
Essex and Middlesex Counties, MA

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Spot Dive (Q)

Survey Transect (T)

% Substrate (water depth in feet)

- Bedrock (BR)
- Boulder (BO)
- Cobble (CB)
- Gravel (GR)
- Sand (SD)
- Silt (ST)
- Clay (CL)
- Other

N W E S

0 10 20
Meters

0 50 100
Feet

Appendix A - Figure 1
T11
Substrate and Maximum Water Depth (ft)

Merrimack River
Lawrence Hydroelectric Project
Essex and Middlesex Counties, MA

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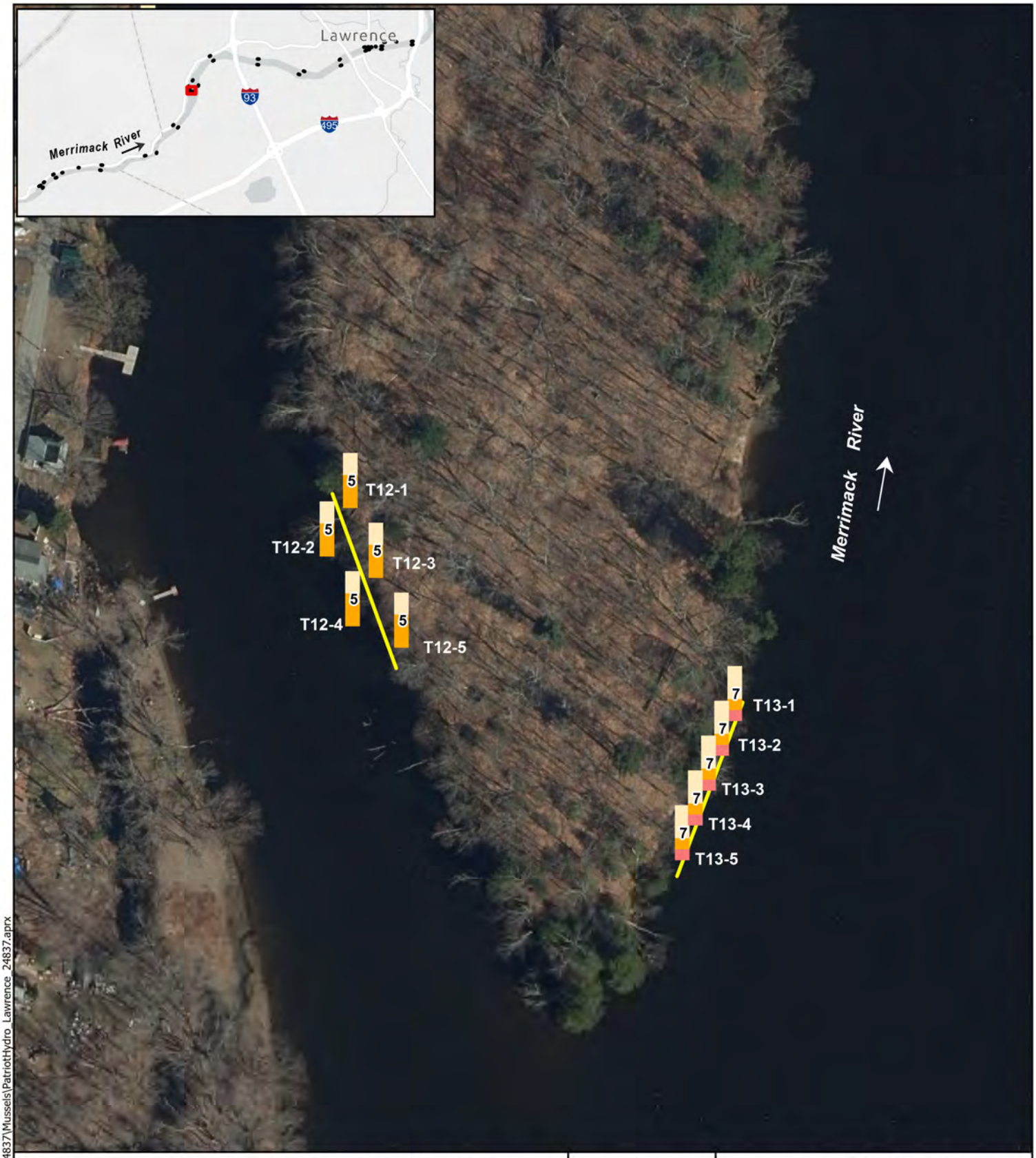

Spot Dive (Q)

Survey Transect (T)

% Substrate (water depth in feet)

- Bedrock (BR)
- Boulder (BO)
- Cobble (CB)
- Gravel (GR)
- Sand (SD)
- Silt (ST)
- Clay (CL)
- Other

N W E S

0 10 20
Meters

0 50 100
Feet

Appendix A - Figure 1
T12 and T13
Substrate and Maximum Water Depth (ft)

Merrimack River
Lawrence Hydroelectric Project
Essex and Middlesex Counties, MA

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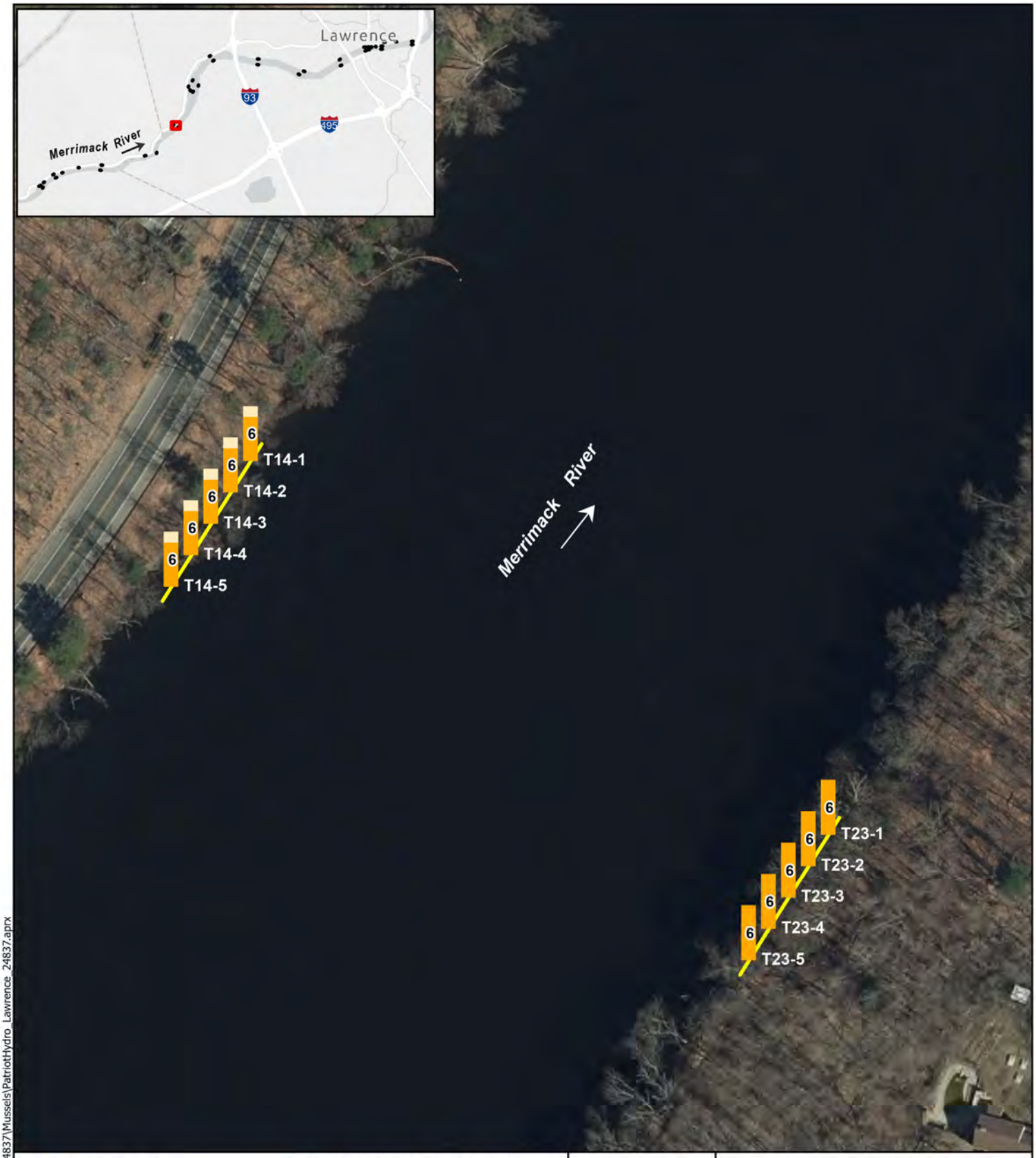

Spot Dive (Q)

Survey Transect (T)

% Substrate (water depth in feet)

- Bedrock (BR)
- Boulder (BO)
- Cobble (CB)
- Gravel (GR)
- Sand (SD)
- Silt (ST)
- Clay (CL)
- Other

N W E S

0 10 20
Meters

0 50 100
Feet

Appendix A - Figure 1
T14 and T23
Substrate and Maximum Water Depth (ft)

Merrimack River
Lawrence Hydroelectric Project
Essex and Middlesex Counties, MA

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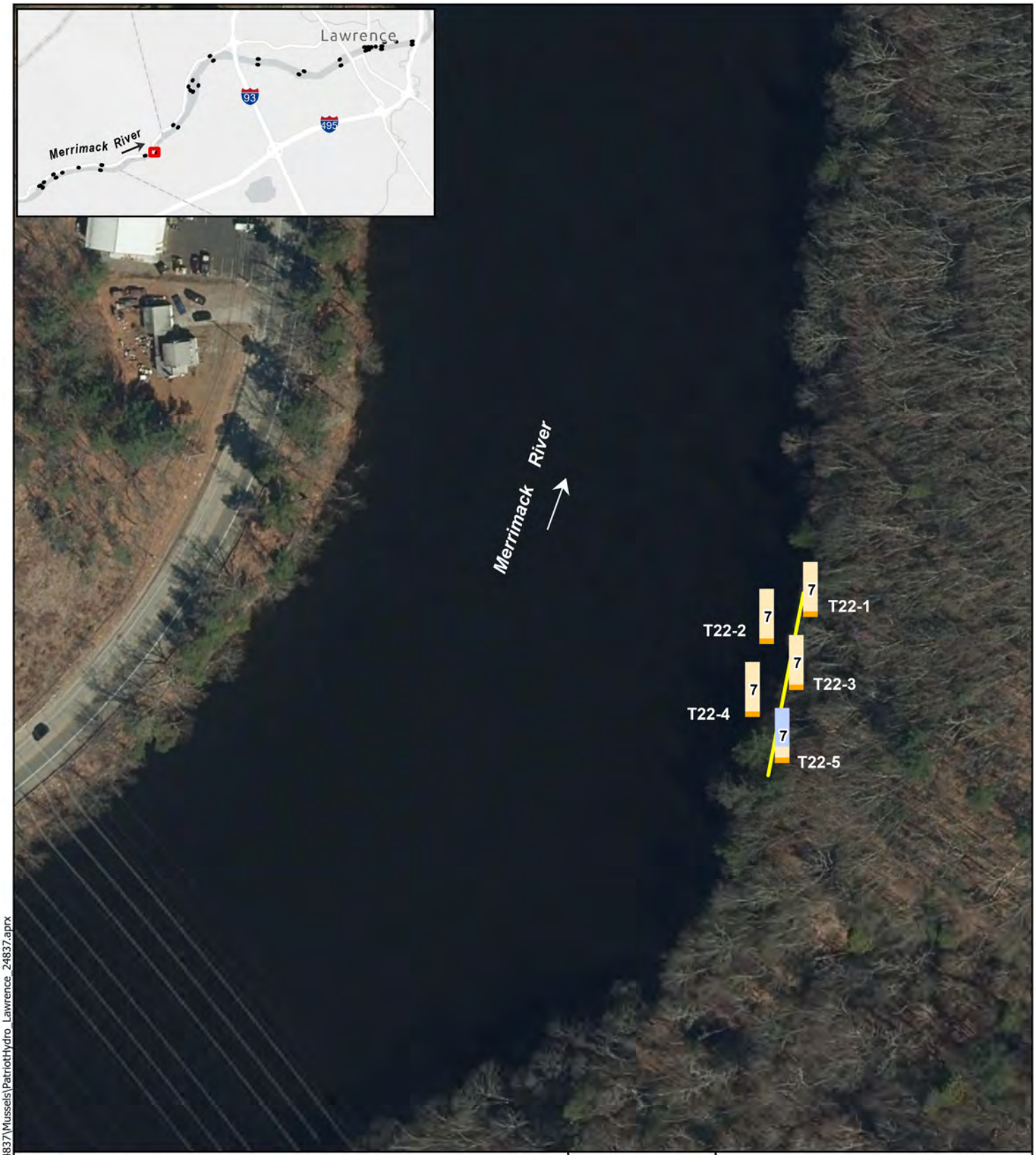

Spot Dive (Q)

Survey Transect (T)

% Substrate (water depth in feet)

- Bedrock (BR)
- Boulder (BO)
- Cobble (CB)
- Gravel (GR)
- Sand (SD)
- Silt (ST)
- Clay (CL)
- Other

N W E S

0 10 20
Meters

0 50 100
Feet

Appendix A - Figure 1
T22
Substrate and Maximum Water Depth (ft)

Merrimack River
Lawrence Hydroelectric Project
Essex and Middlesex Counties, MA

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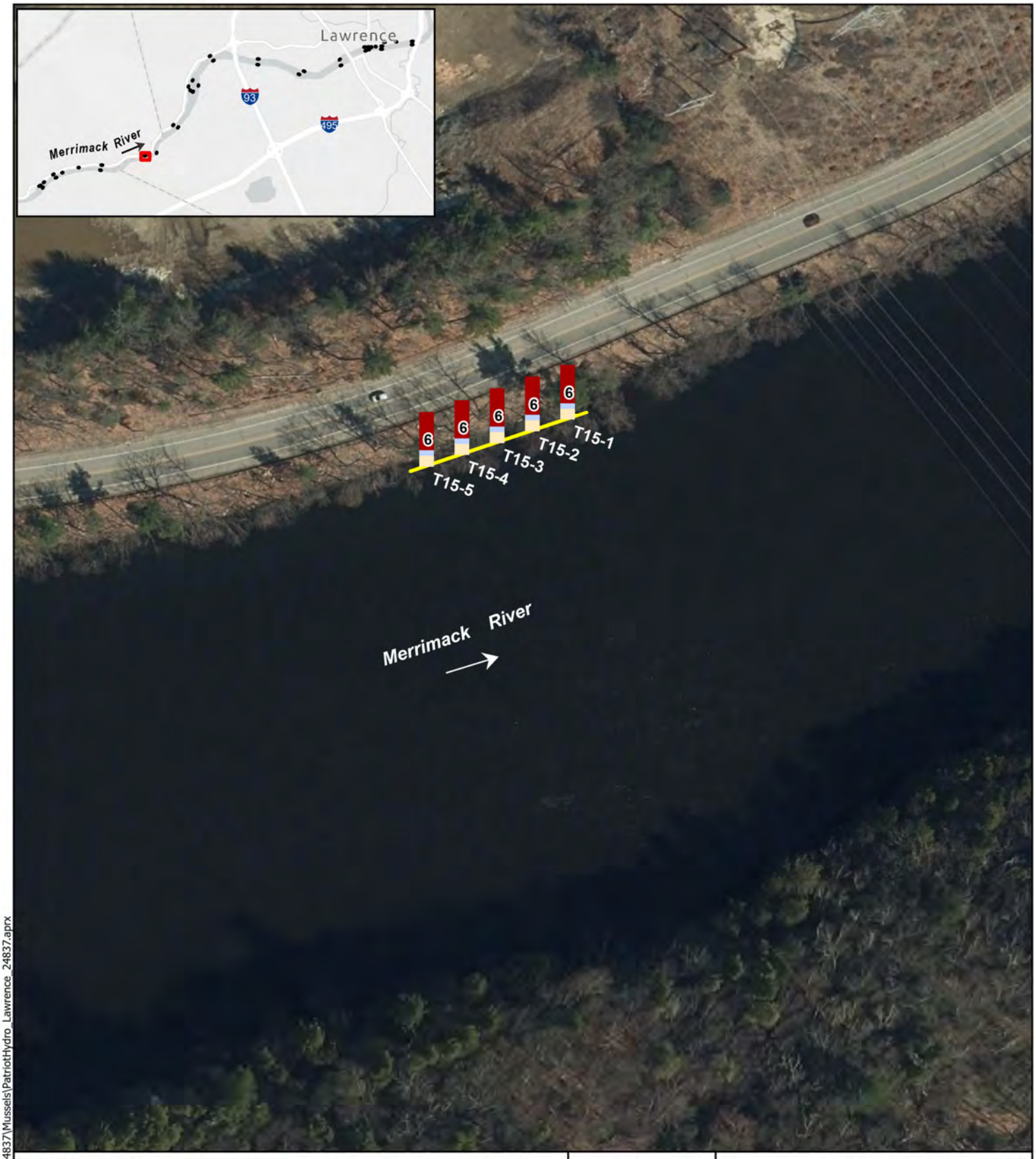

Spot Dive (Q)

Survey Transect (T)

% Substrate (water depth in feet)

- Bedrock (BR)
- Boulder (BO)
- Cobble (CB)
- Gravel (GR)
- Sand (SD)
- Silt (ST)
- Clay (CL)
- Other

N W E S

0 10 20
Meters

0 50 100
Feet

Appendix A - Figure 1
T15
Substrate and Maximum Water Depth (ft)

Merrimack River
Lawrence Hydroelectric Project
Essex and Middlesex Counties, MA

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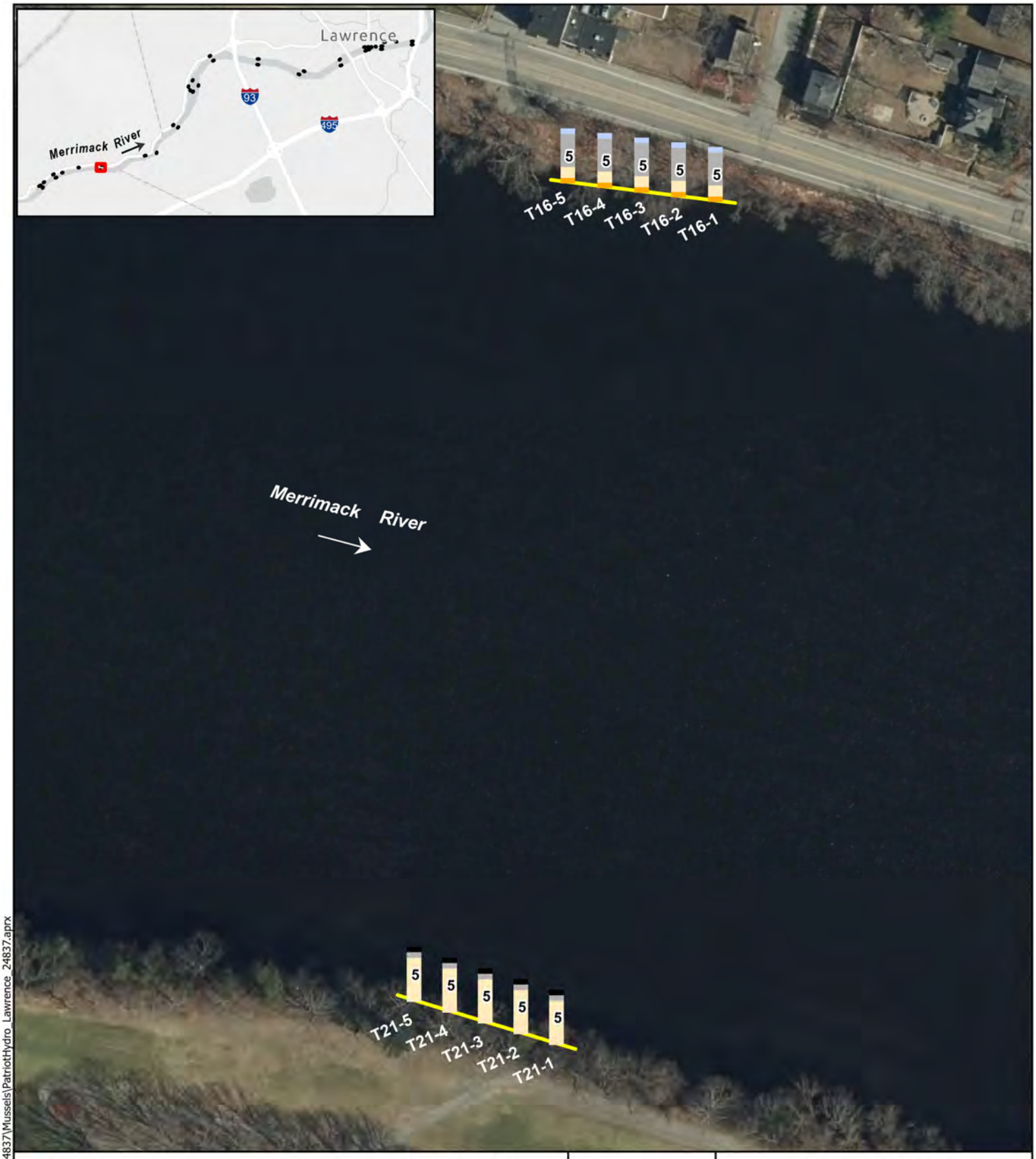

Spot Dive (Q)

Survey Transect (T)

% Substrate (water depth in feet)

- Bedrock (BR)
- Boulder (BO)
- Cobble (CB)
- Gravel (GR)
- Sand (SD)
- Silt (ST)
- Clay (CL)
- Other

N W E S

0 10 20
Meters

0 50 100
Feet

Appendix A - Figure 1
T16 and T21
Substrate and Maximum Water Depth (ft)

Merrimack River
Lawrence Hydroelectric Project
Essex and Middlesex Counties, MA

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Spot Dive (Q)

Survey Transect (T)

% Substrate (water depth in feet)

- Bedrock (BR)
- Boulder (BO)
- Cobble (CB)
- Gravel (GR)
- Sand (SD)
- Silt (ST)
- Clay (CL)
- Other

N W E S

0 10 20
Meters

0 50 100
Feet

Appendix A - Figure 1
Q37 - Q39
Substrate and Maximum Water Depth (ft)

Merrimack River
Lawrence Hydroelectric Project
Essex and Middlesex Counties, MA

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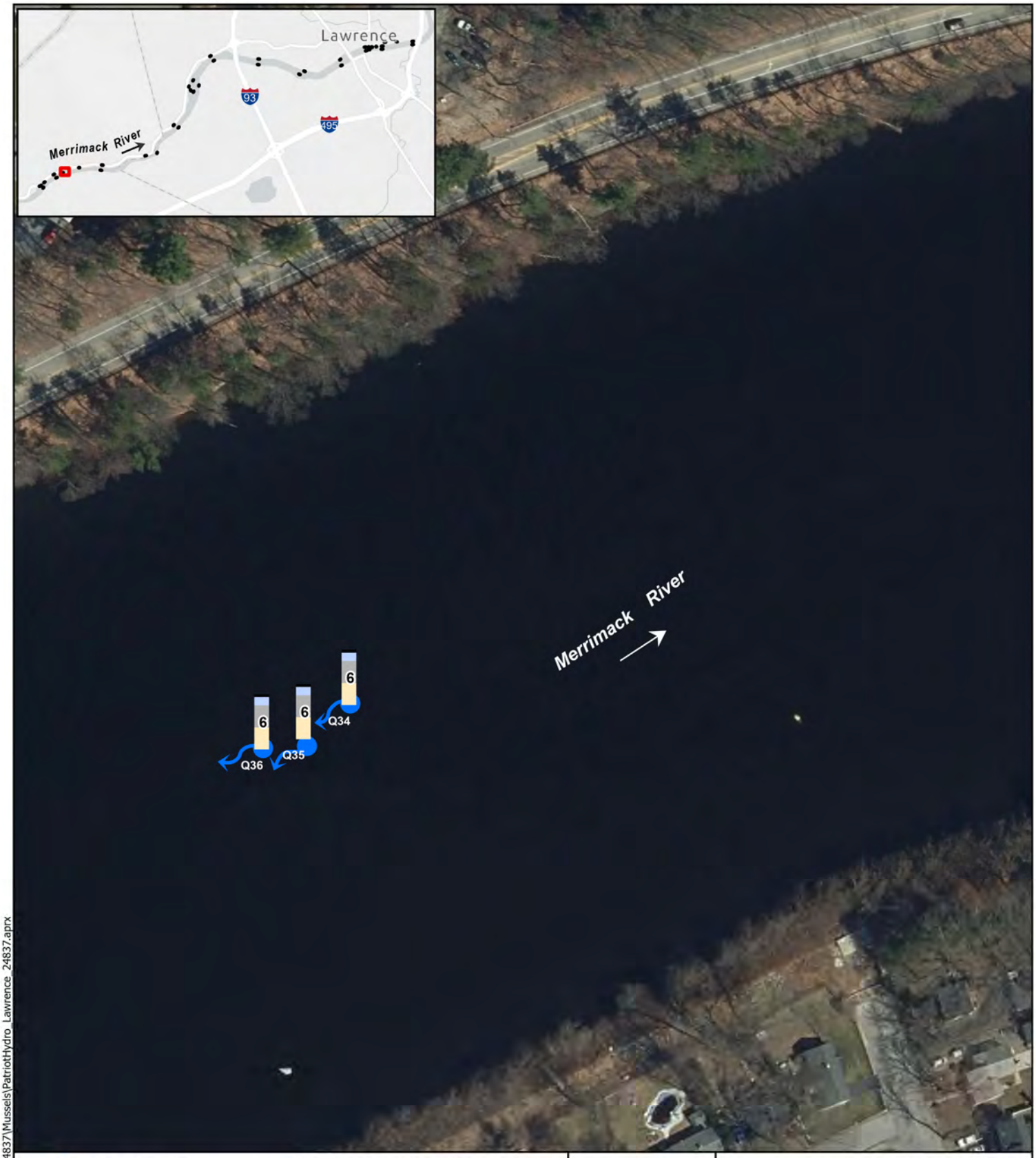

Spot Dive (Q)

Survey Transect (T)

% Substrate (water depth in feet)

- Bedrock (BR)
- Boulder (BO)
- Cobble (CB)
- Gravel (GR)
- Sand (SD)
- Silt (ST)
- Clay (CL)
- Other

N
W E
S

0 10 20
Meters

0 50 100
Feet

Appendix A - Figure 1
Q34-Q36
Substrate and Maximum Water Depth (ft)

Merrimack River
Lawrence Hydroelectric Project
Essex and Middlesex Counties, MA

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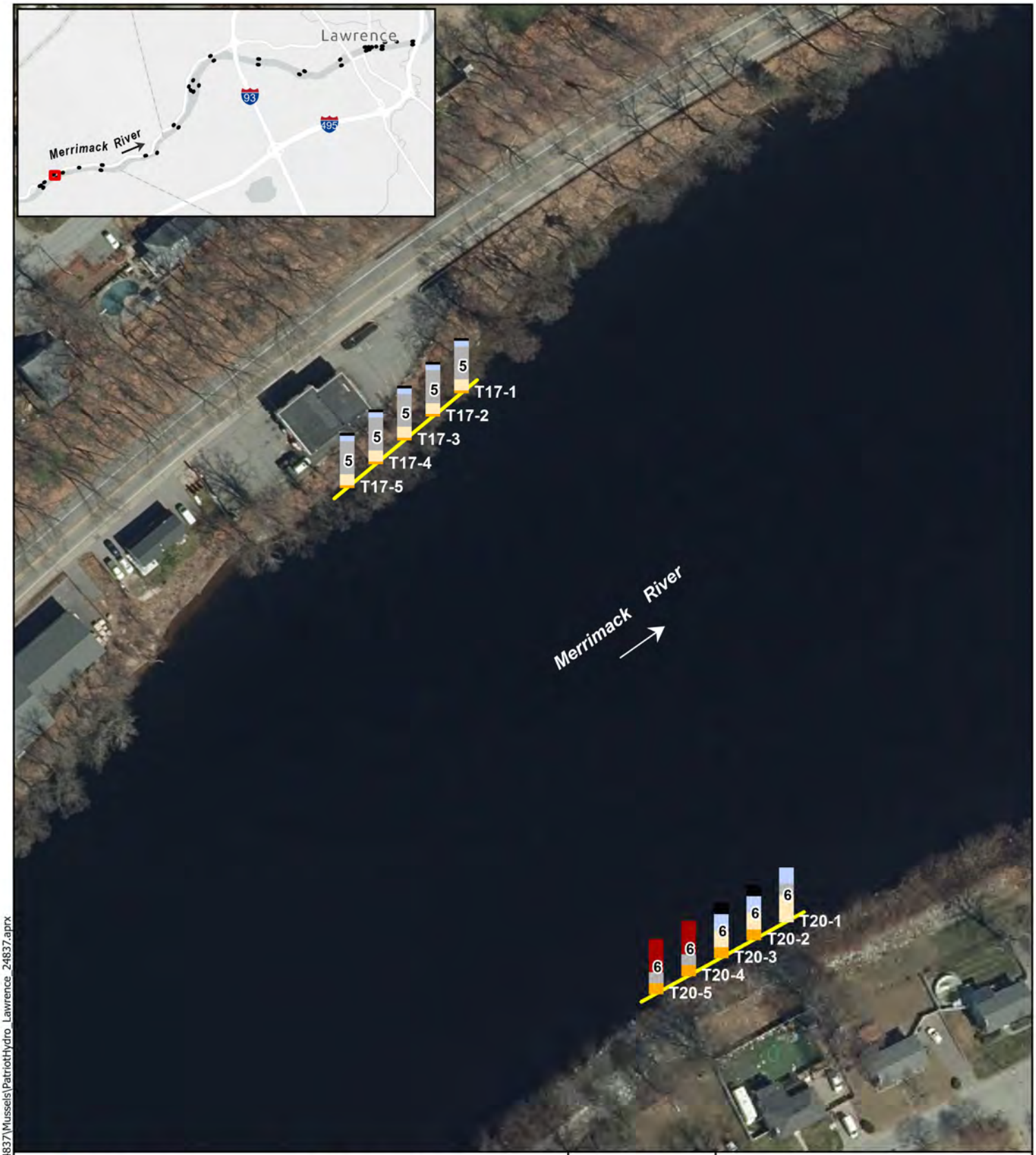

Spot Dive (Q)

Survey Transect (T)

% Substrate (water depth in feet)

- Bedrock (BR)
- Boulder (BO)
- Cobble (CB)
- Gravel (GR)
- Sand (SD)
- Silt (ST)
- Clay (CL)
- Other

N W E S

0 10 20
Meters

0 50 100
Feet

Appendix - Figure 1
T17 and T20
Substrate and Maximum Water Depth (ft)

Merrimack River
Lawrence Hydroelectric Project
Essex and Middlesex Counties, MA

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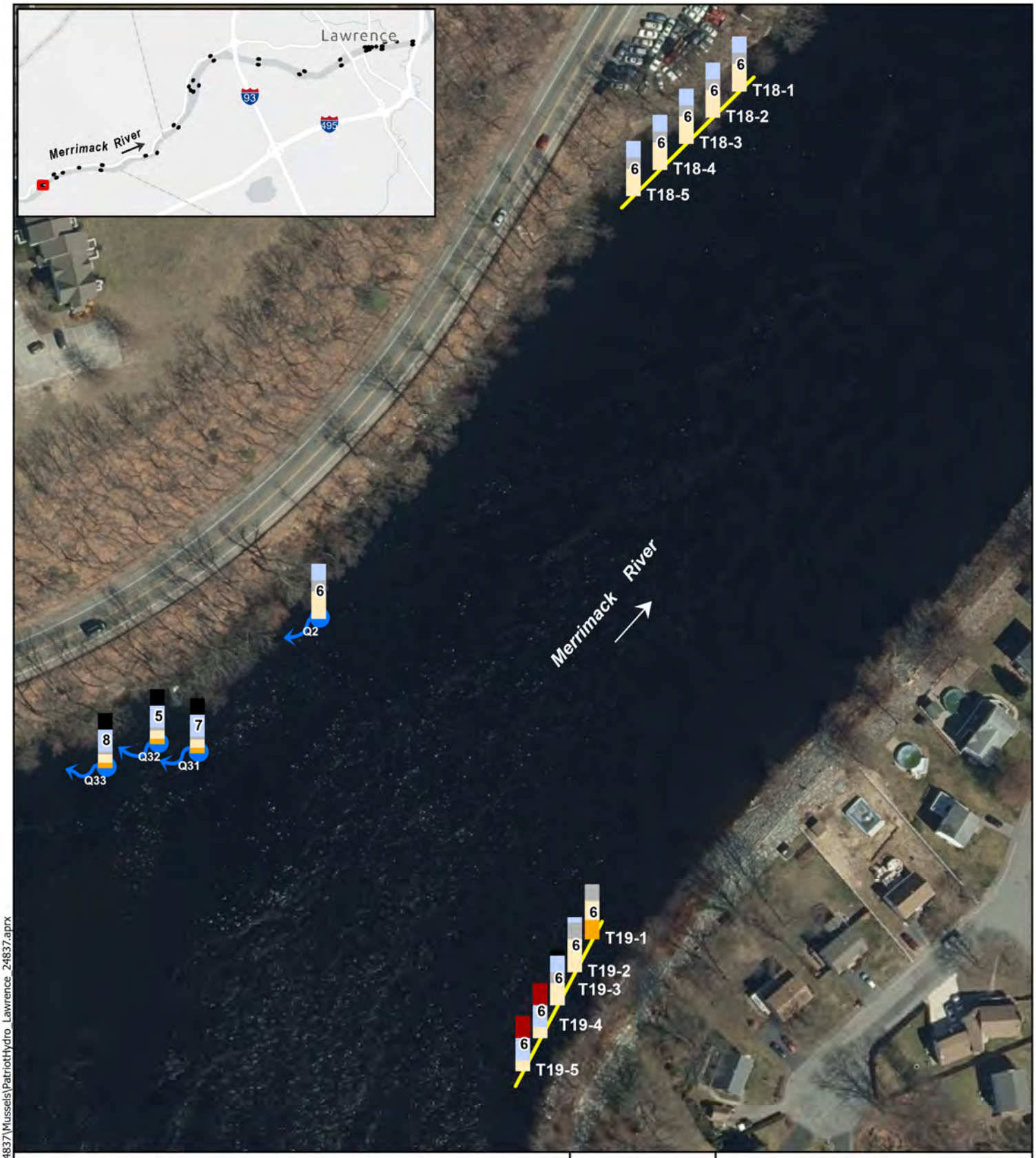

Spot Dive (Q)

Survey Transect (T)

% Substrate (water depth in feet)

- Bedrock (BR)
- Boulder (BO)
- Cobble (CB)
- Gravel (GR)
- Sand (SD)
- Silt (ST)
- Clay (CL)
- Other

N W E S

0 10 20
Meters

0 50 100
Feet

Appendix A - Figure 1
T18, T19 and Q2, Q31 - Q33
Substrate and Maximum Water Depth (ft)

Merrimack River
Lawrence Hydroelectric Project
Essex and Middlesex Counties, MA

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Spot Dive (Q)

Survey Transect (T)

Catch Per Unit Effort (CPUE)
(No. Live/Hour)

- 0
- 0.1 - 500
- 500.1 - 1000
- 1000.1 - 2000
- 2000.1 - 4500

N
W E
S

0 10 20
Meters

0 50 100
Feet

Appendix A - Figure 2
T1 and T31
Catch Per Unit Effort (CPUE)

Merrimack River
Lawrence Hydroelectric Project
Essex and Middlesex Counties, MA

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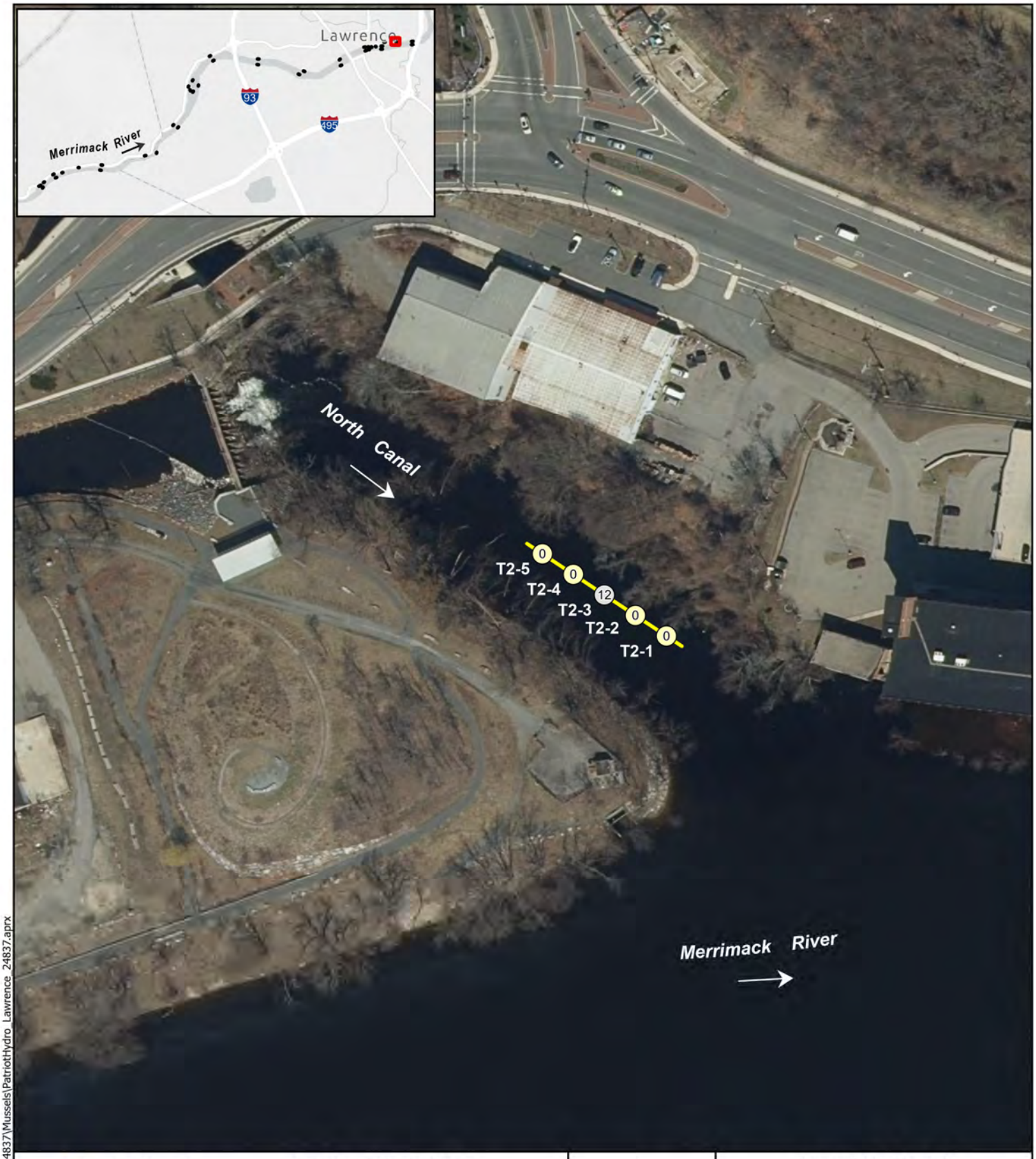

Spot Dive (Q)

Survey Transect (T)

Catch Per Unit Effort (CPUE)
(No. Live/Hour)

- 0
- 0.1 - 500
- 500.1 - 1000
- 1000.1 - 2000
- 2000.1 - 4500

N
W E
S

0 10 20
Meters

0 50 100
Feet

Appendix A - Figure 2
T2
Catch Per Unit Effort (CPUE)

Merrimack River
Lawrence Hydroelectric Project
Essex and Middlesex Counties, MA

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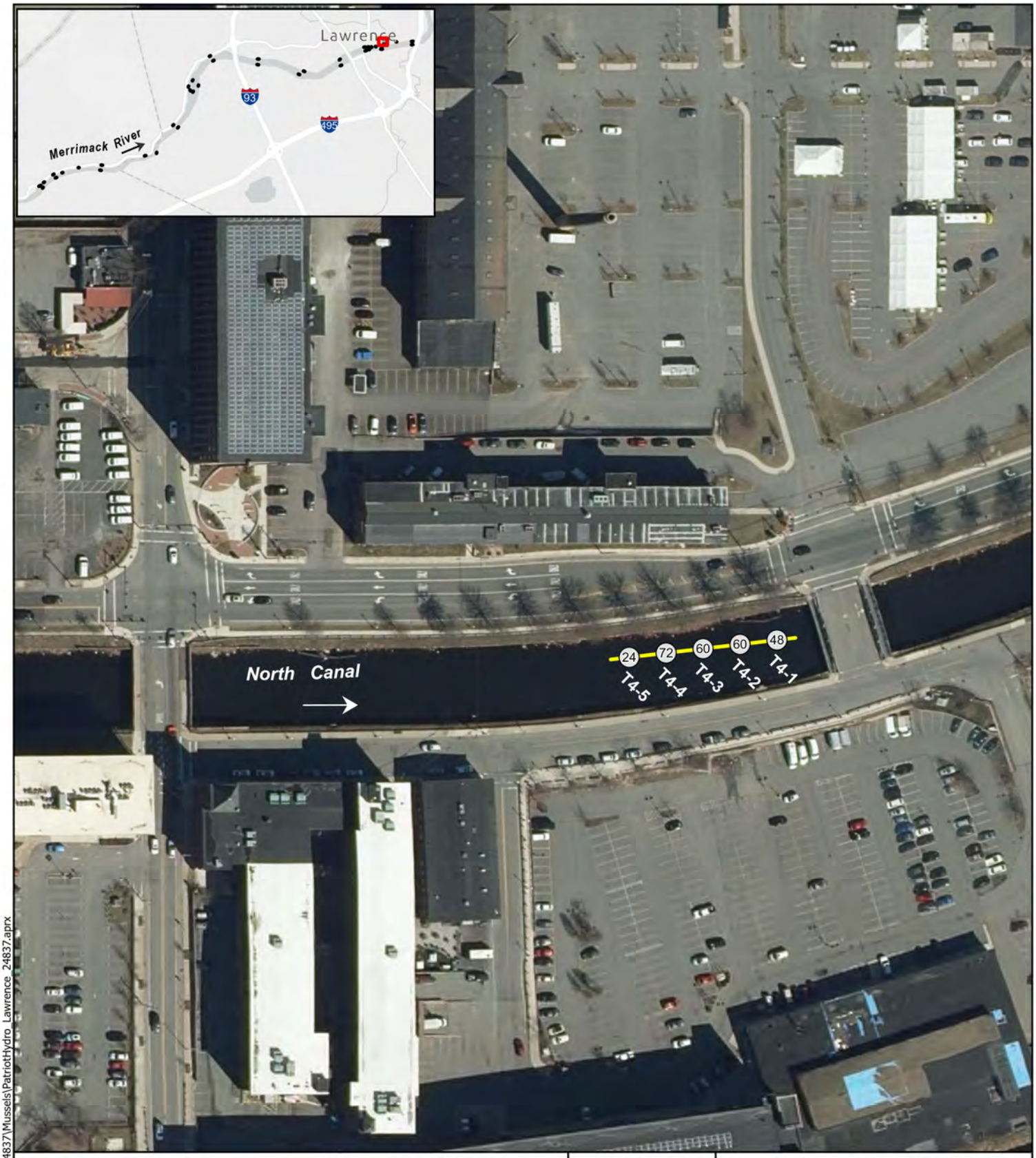

Spot Dive (Q)

Survey Transect (T)

Catch Per Unit Effort (CPUE)
(No. Live/Hour)

- 0
- 0.1 - 500
- 500.1 - 1000
- 1000.1 - 2000
- 2000.1 - 4500

N
W E
S

0 10 20
Meters

0 50 100
Feet

Appendix A - Figure 2
T4
Catch Per Unit Effort (CPUE)

Merrimack River
Lawrence Hydroelectric Project
Essex and Middlesex Counties, MA

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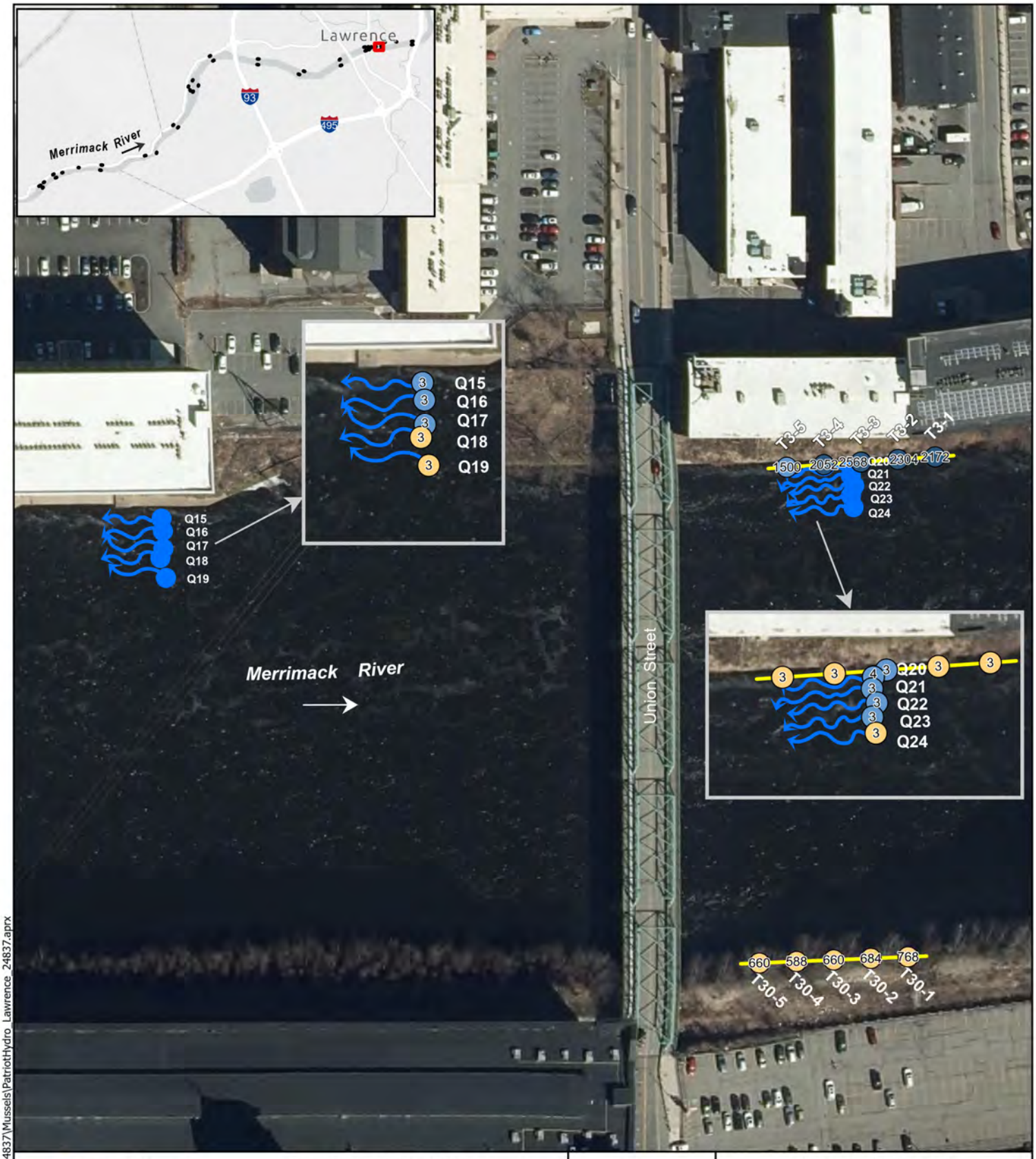

Spot Dive (Q)

Survey Transect (T)

Catch Per Unit Effort (CPUE)
(No. Live/Hour)

- 0
- 0.1 - 500
- 500.1 - 1000
- 1000.1 - 2000
- 2000.1 - 4500

N
W E
S

0 10 20
Meters

0 50 100
Feet

Appendix A - Figure 2
T3, T30, and Q15 - Q24
Catch Per Unit Effort (CPUE)

Merrimack River
Lawrence Hydroelectric Project
Essex and Middlesex Counties, MA

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Spot Dive (Q)

Survey Transect (T)

Catch Per Unit Effort (CPUE)
(No. Live/Hour)

- 0
- 0.1 - 500
- 500.1 - 1000
- 1000.1 - 2000
- 2000.1 - 4500

N
W E
S

0 10 20
Meters

0 50 100
Feet

Appendix A - Figure 2
T5, T29, Q3 - Q14, and Q25 - Q30
Catch Per Unit Effort (CPUE)

Merrimack River
Lawrence Hydroelectric Project
Essex and Middlesex Counties, MA

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Spot Dive (Q)

Survey Transect (T)

Catch Per Unit Effort (CPUE)
(No. Live/Hour)

- 0
- 0.1 - 500
- 500.1 - 1000
- 1000.1 - 2000
- 2000.1 - 4500

N
W E
S

0 10 20
Meters

0 50 100
Feet

Appendix A - Figure 2
T6 and T28
Catch Per Unit Effort (CPUE)

Merrimack River
Lawrence Hydroelectric Project
Essex and Middlesex Counties, MA

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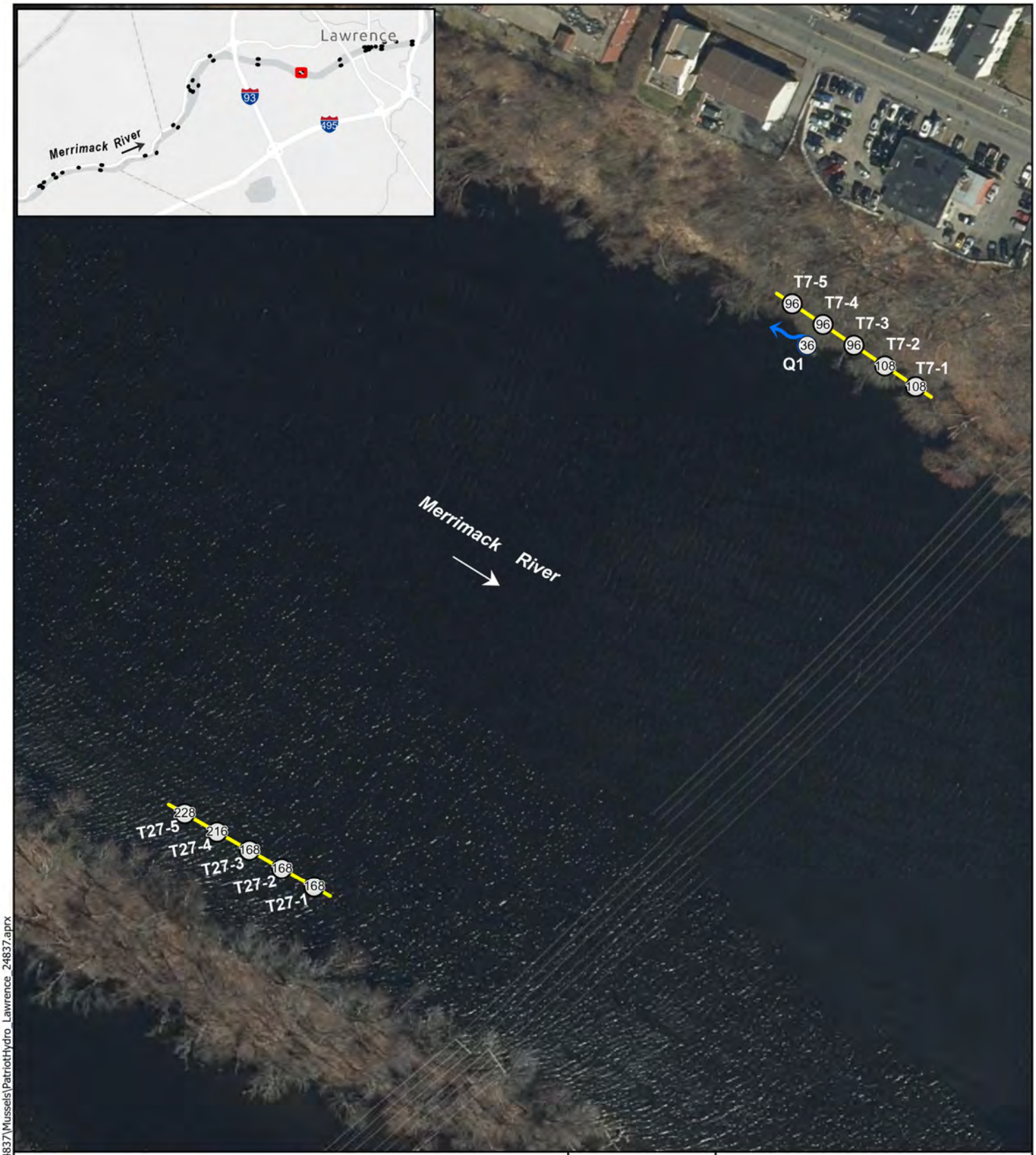

Spot Dive (Q)

Survey Transect (T)

Catch Per Unit Effort (CPUE)
(No. Live/Hour)

- 0
- 0.1 - 500
- 500.1 - 1000
- 1000.1 - 2000
- 2000.1 - 4500

N
W E
S

0 10 20
Meters

0 50 100
Feet

Appendix A - Figure 2
T7, T27 and Q1
Catch Per Unit Effort (CPUE)

Merrimack River
Lawrence Hydroelectric Project
Essex and Middlesex Counties, MA

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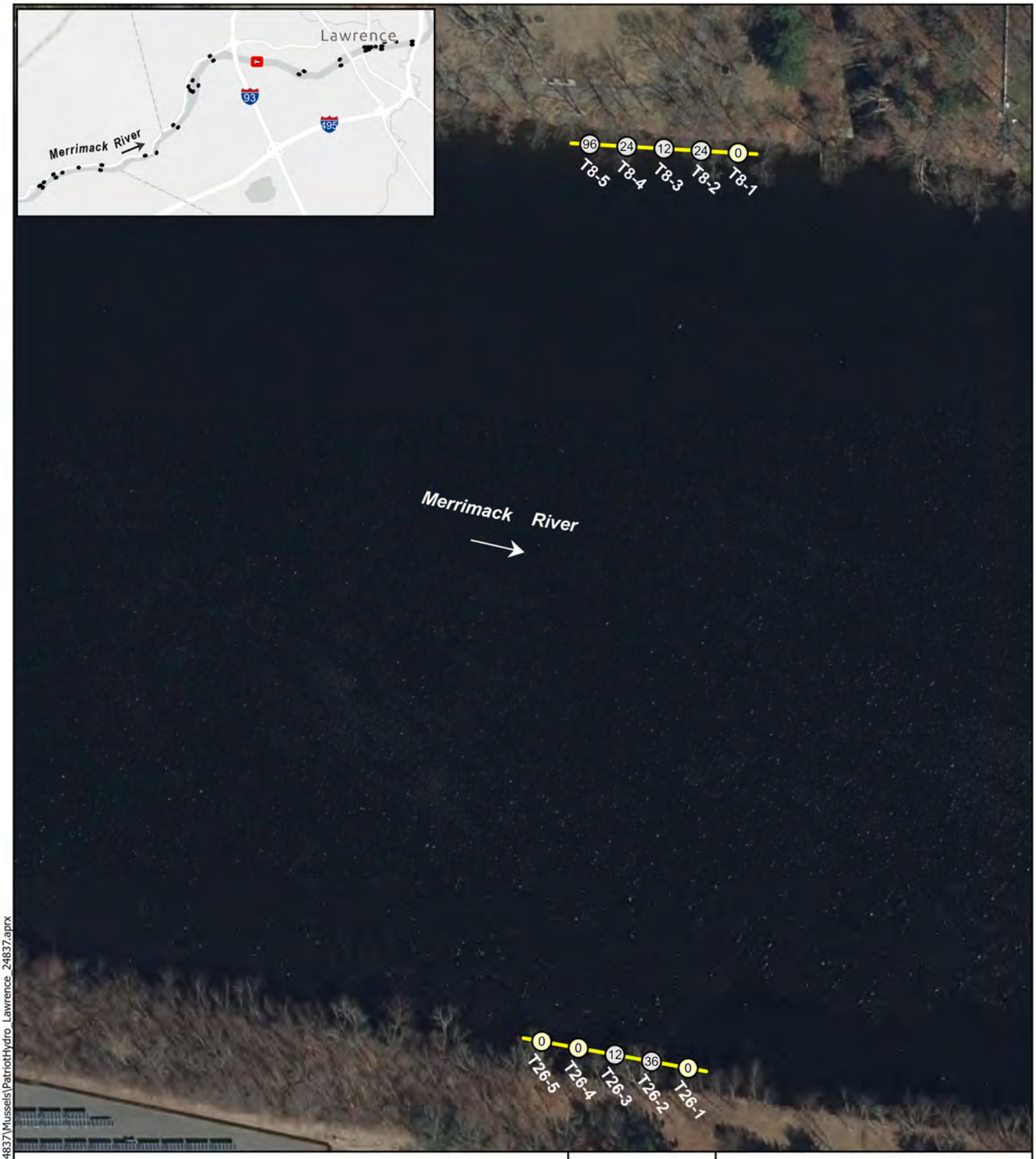

Spot Dive (Q)

Survey Transect (T)

Catch Per Unit Effort (CPUE)
(No. Live/Hour)

- 0
- 0.1 - 500
- 500.1 - 1000
- 1000.1 - 2000
- 2000.1 - 4500

N
W E
S

0 10 20
Meters

0 50 100
Feet

Appendix A - Figure 2
T8 and T26
Catch Per Unit Effort (CPUE)

Merrimack River
Lawrence Hydroelectric Project
Essex and Middlesex Counties, MA

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Spot Dive (Q)

Survey Transect (T)

Catch Per Unit Effort (CPUE)
(No. Live/Hour)

- 0
- 0.1 - 500
- 500.1 - 1000
- 1000.1 - 2000
- 2000.1 - 4500

N
W E
S

0 10 20
Meters

0 50 100
Feet

Appendix A - Figure 2
T9 and T25
Catch Per Unit Effort (CPUE)

Merrimack River
Lawrence Hydroelectric Project
Essex and Middlesex Counties, MA

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Spot Dive (Q)

Survey Transect (T)

Catch Per Unit Effort (CPUE)
(No. Live/Hour)

- 0
- 0.1 - 500
- 500.1 - 1000
- 1000.1 - 2000
- 2000.1 - 4500

N
W E
S

0 10 20
Meters

0 50 100
Feet

Appendix A - Figure 2
T10
Catch Per Unit Effort (CPUE)

Merrimack River
Lawrence Hydroelectric Project
Essex and Middlesex Counties, MA

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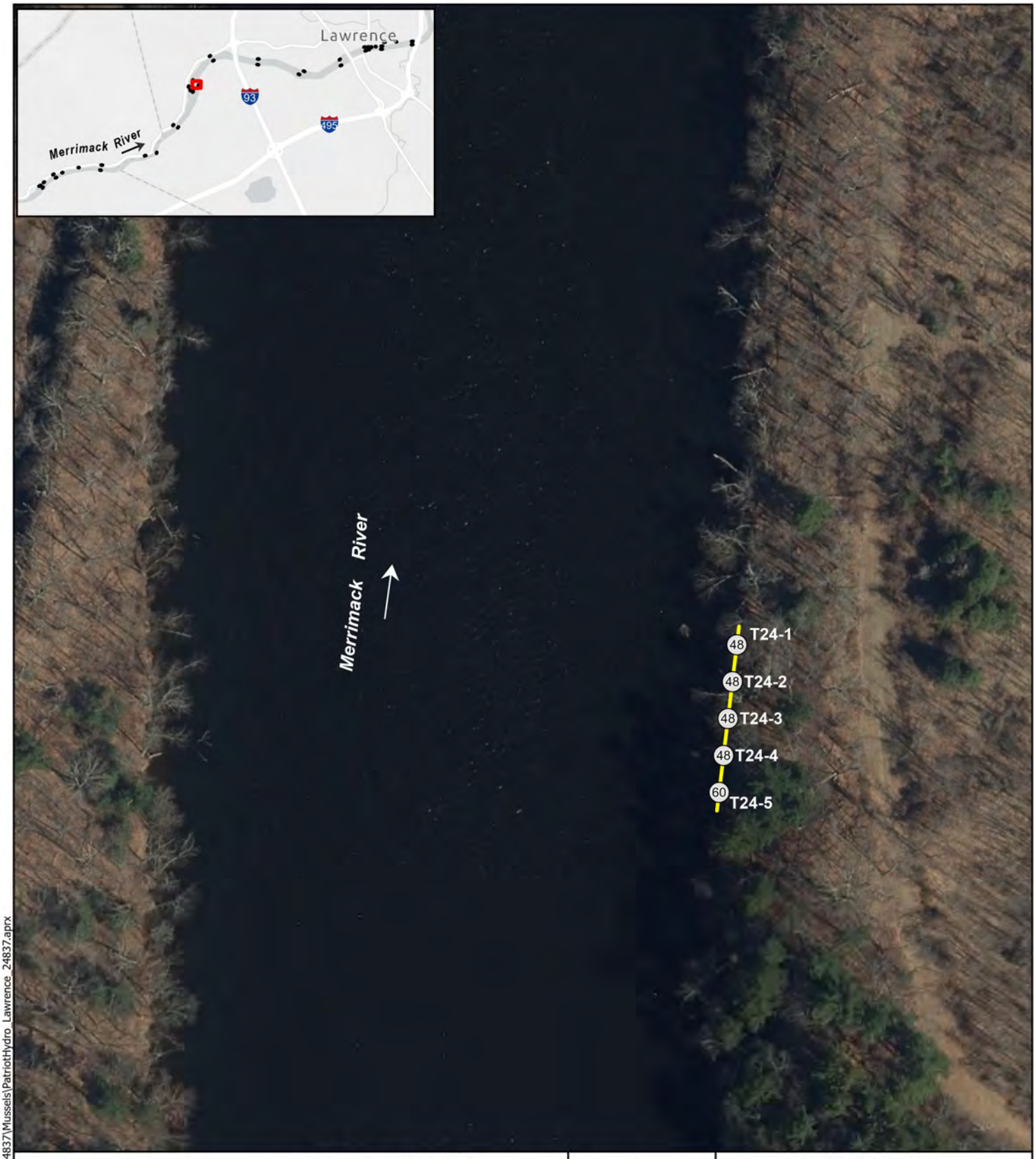

Spot Dive (Q)

Survey Transect (T)

Catch Per Unit Effort (CPUE)
(No. Live/Hour)

- 0
- 0.1 - 500
- 500.1 - 1000
- 1000.1 - 2000
- 2000.1 - 4500

N
W E
S

0 10 20
Meters

0 50 100
Feet

Appendix A - Figure 2
T24
Catch Per Unit Effort (CPUE)

Merrimack River
Lawrence Hydroelectric Project
Essex and Middlesex Counties, MA

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Spot Dive (Q)

Survey Transect (T)

Catch Per Unit Effort (CPUE)
(No. Live/Hour)

- 0
- 0.1 - 500
- 500.1 - 1000
- 1000.1 - 2000
- 2000.1 - 4500

N
W E
S

0 10 20
Meters

0 50 100
Feet

Appendix A - Figure 2
T11
Catch Per Unit Effort (CPUE)

Merrimack River
Lawrence Hydroelectric Project
Essex and Middlesex Counties, MA

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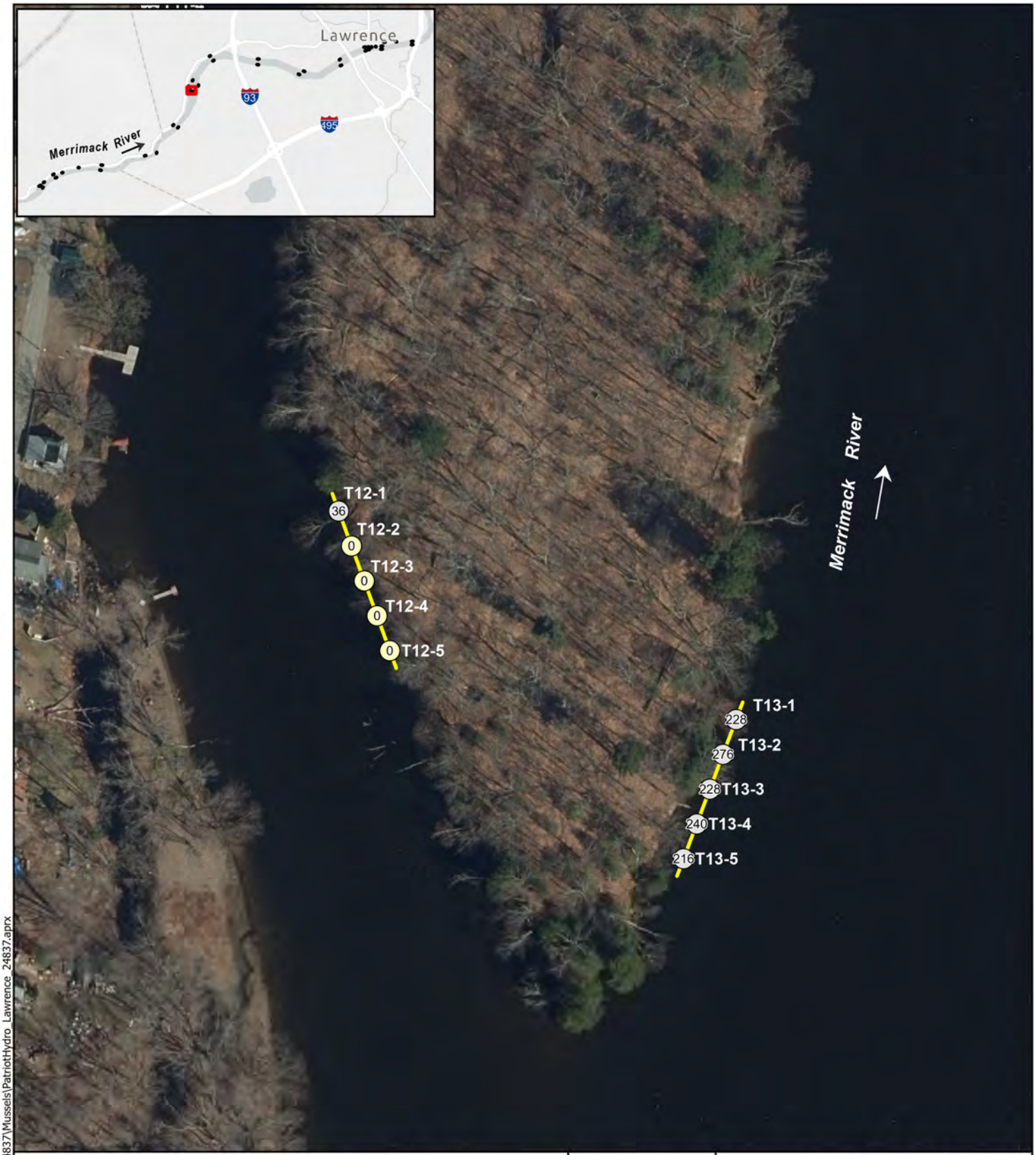

Spot Dive (Q)

Survey Transect (T)

Catch Per Unit Effort (CPUE)
(No. Live/Hour)

- 0
- 0.1 - 500
- 500.1 - 1000
- 1000.1 - 2000
- 2000.1 - 4500

N
W E
S

0 10 20
Meters

0 50 100
Feet

Appendix A - Figure 2
T12 and T13
Catch Per Unit Effort (CPUE)

Merrimack River
Lawrence Hydroelectric Project
Essex and Middlesex Counties, MA

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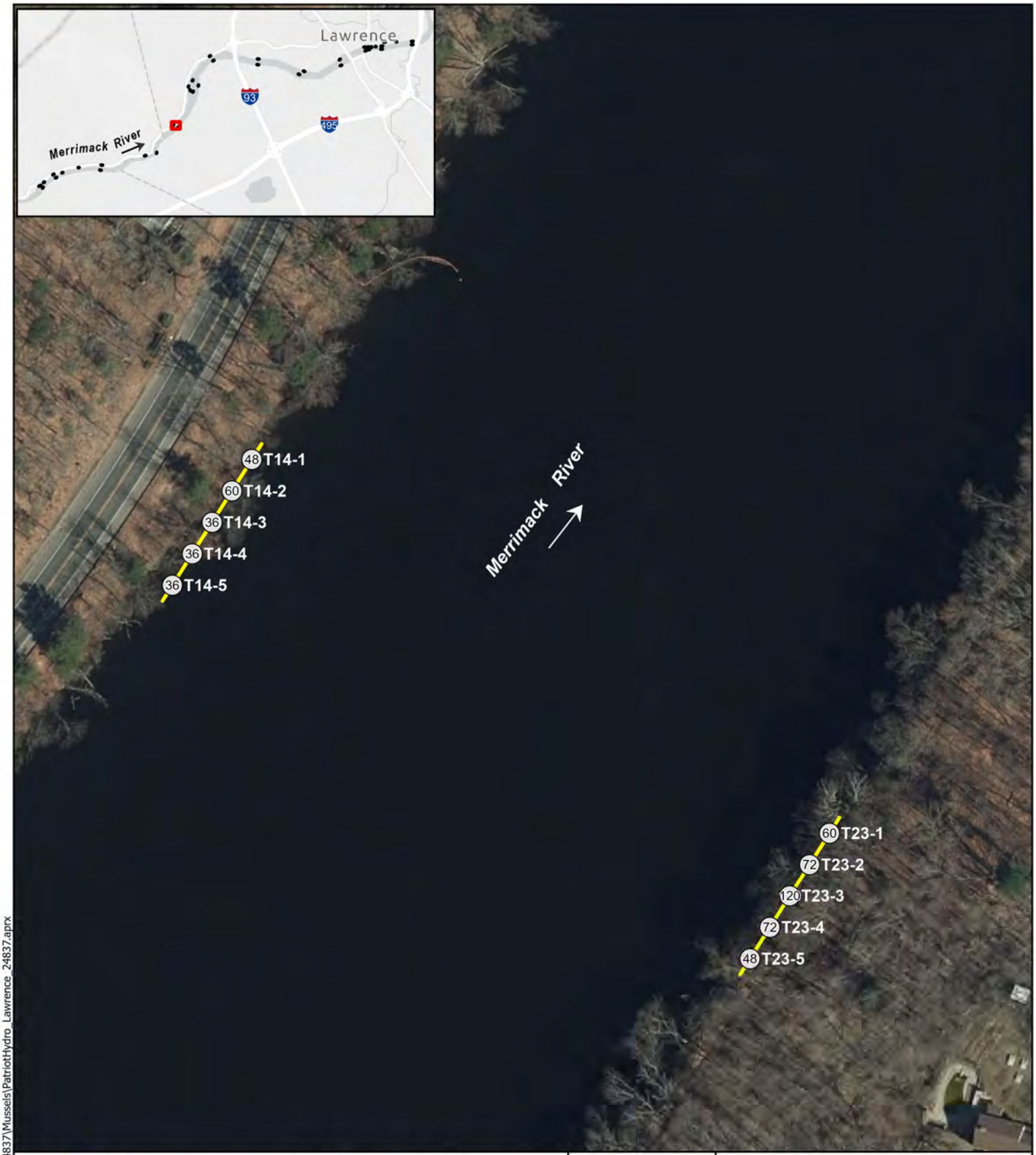

Spot Dive (Q)

Survey Transect (T)

Catch Per Unit Effort (CPUE)
(No. Live/Hour)

- 0
- 0.1 - 500
- 500.1 - 1000
- 1000.1 - 2000
- 2000.1 - 4500

N
W E
S

0 10 20
Meters

0 50 100
Feet

Appendix A - Figure 2
T14 and T23
Catch Per Unit Effort (CPUE)

Merrimack River
Lawrence Hydroelectric Project
Essex and Middlesex Counties, MA

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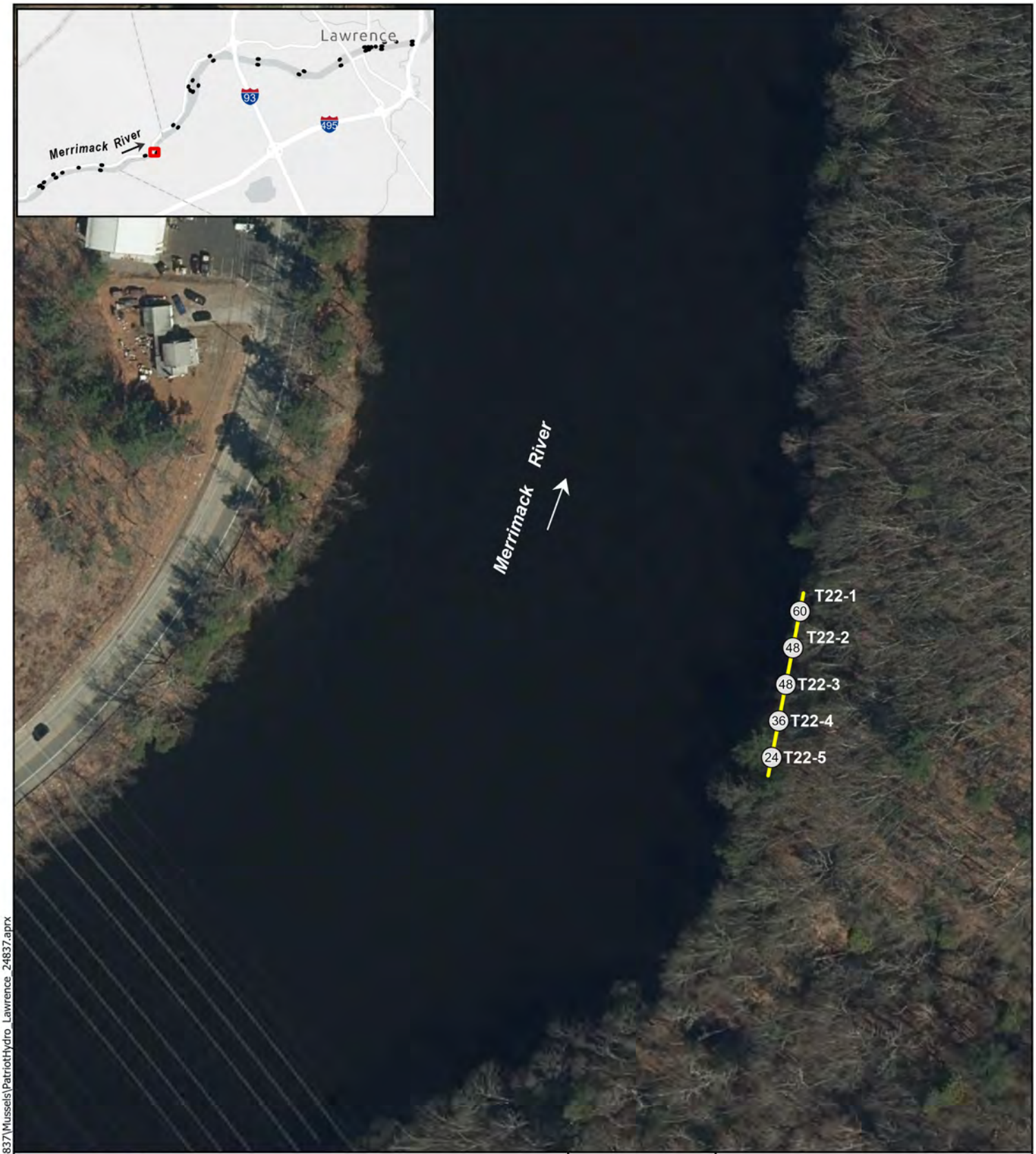

Spot Dive (Q)

Survey Transect (T)

Catch Per Unit Effort (CPUE)
(No. Live/Hour)

- 0
- 0.1 - 500
- 500.1 - 1000
- 1000.1 - 2000
- 2000.1 - 4500

N
W E
S

0 10 20
Meters

0 50 100
Feet

Appendix A - Figure 2
T22
Catch Per Unit Effort (CPUE)

Merrimack River
Lawrence Hydroelectric Project
Essex and Middlesex Counties, MA

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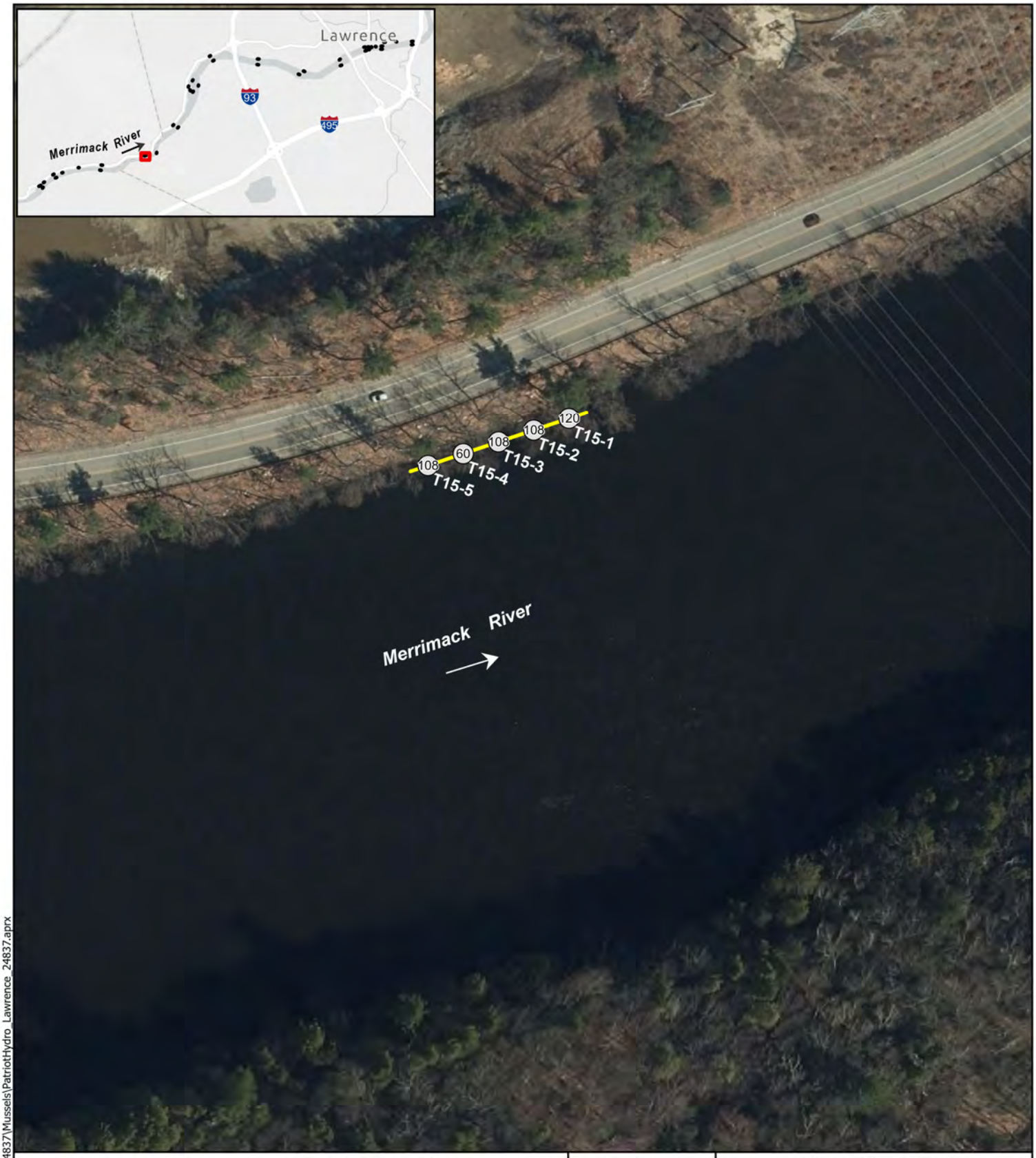

Spot Dive (Q)

Survey Transect (T)

Catch Per Unit Effort (CPUE)
(No. Live/Hour)

- 0
- 0.1 - 500
- 500.1 - 1000
- 1000.1 - 2000
- 2000.1 - 4500

N
W E
S

0 10 20
Meters

0 50 100
Feet

Appendix A - Figure 2
T15
Catch Per Unit Effort (CPUE)

Merrimack River
Lawrence Hydroelectric Project
Essex and Middlesex Counties, MA

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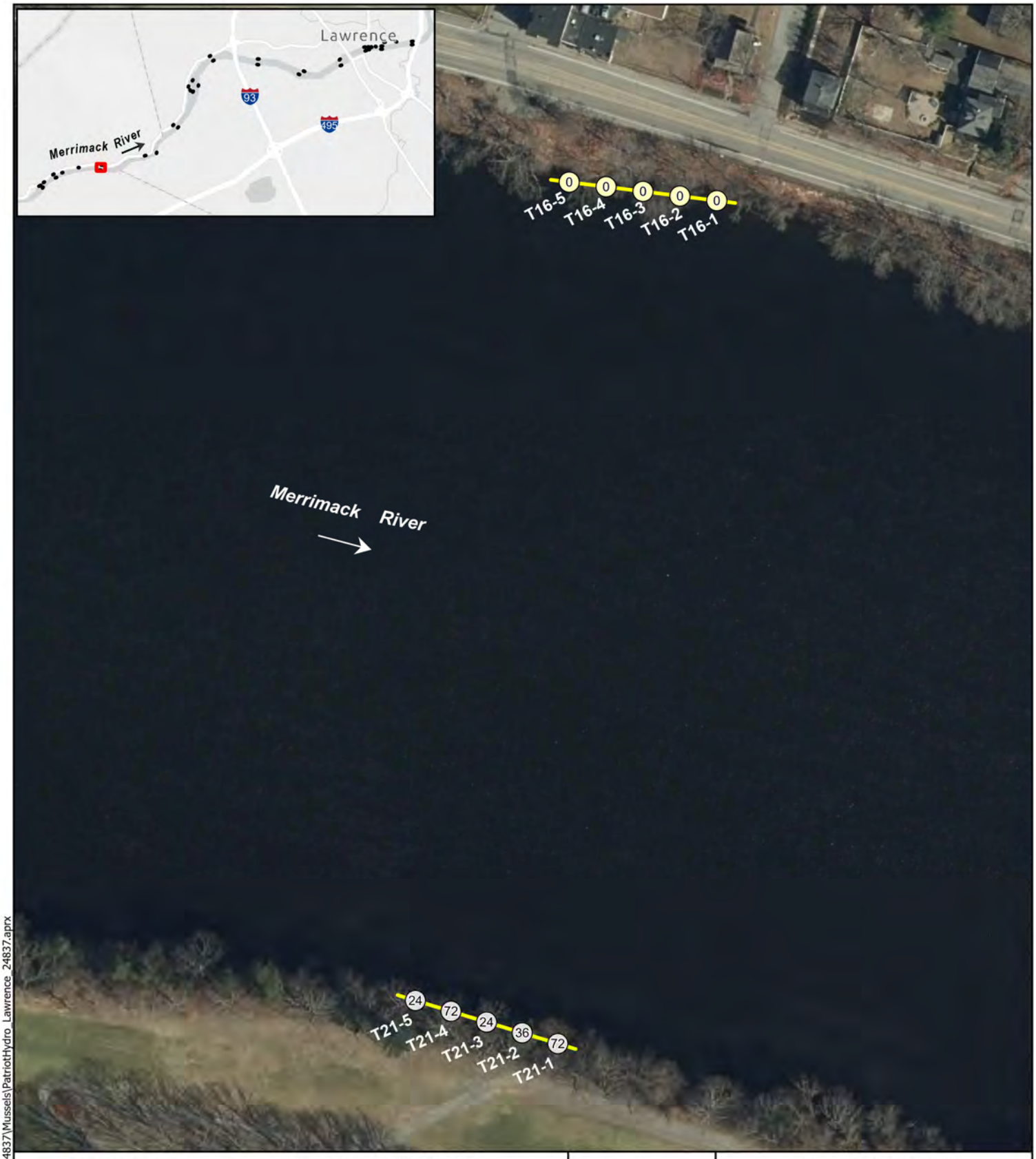

Spot Dive (Q)

Survey Transect (T)

Catch Per Unit Effort (CPUE)
(No. Live/Hour)

- 0
- 0.1 - 500
- 500.1 - 1000
- 1000.1 - 2000
- 2000.1 - 4500

N
W E
S

0 10 20
Meters

0 50 100
Feet

Appendix A - Figure 2
T16 and T21
Catch Per Unit Effort (CPUE)

Merrimack River
Lawrence Hydroelectric Project
Essex and Middlesex Counties, MA

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Spot Dive (Q)

Survey Transect (T)

Catch Per Unit Effort (CPUE)
(No. Live/Hour)

- 0
- 0.1 - 500
- 500.1 - 1000
- 1000.1 - 2000
- 2000.1 - 4500

N
W E
S

0 10 20
Meters

0 50 100
Feet

Appendix A - Figure 2
Q37 - Q39
Catch Per Unit Effort (CPUE)

Merrimack River
Lawrence Hydroelectric Project
Essex and Middlesex Counties, MA

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Spot Dive (Q)

Survey Transect (T)

Catch Per Unit Effort (CPUE)
(No. Live/Hour)

- 0
- 0.1 - 500
- 500.1 - 1000
- 1000.1 - 2000
- 2000.1 - 4500

N
W E
S

0 10 20
Meters

0 50 100
Feet

Appendix A - Figure 2
Q34 - Q36
Catch Per Unit Effort (CPUE)

Merrimack River
Lawrence Hydroelectric Project
Essex and Middlesex Counties, MA

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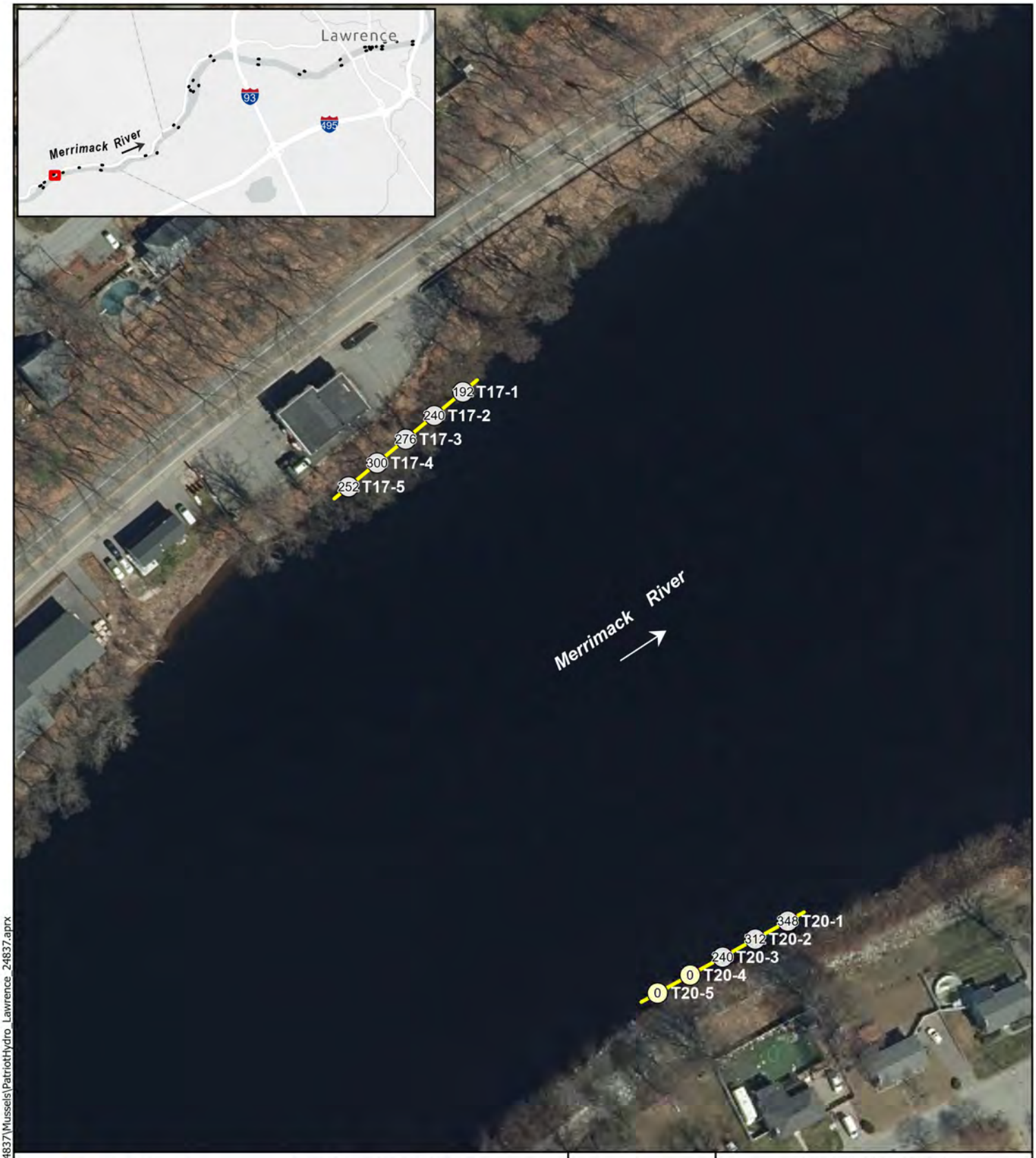

Spot Dive (Q)

Survey Transect (T)

Catch Per Unit Effort (CPUE)
(No. Live/Hour)

- 0
- 0.1 - 500
- 500.1 - 1000
- 1000.1 - 2000
- 2000.1 - 4500

N
W E
S

0 10 20
Meters

0 50 100
Feet

Appendix A - Figure 2
T17 and T20
Catch Per Unit Effort (CPUE)

Merrimack River
Lawrence Hydroelectric Project
Essex and Middlesex Counties, MA

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Spot Dive (Q)

Survey Transect (T)

Catch Per Unit Effort (CPUE)
(No. Live/Hour)

- 0
- 0.1 - 500
- 500.1 - 1000
- 1000.1 - 2000
- 2000.1 - 4500

N
W E
S

0 10 20
Meters

0 50 100
Feet

Appendix A - Figure 2
T18, T19 and Q2, Q31-Q33
Catch Per Unit Effort (CPUE)

Merrimack River
Lawrence Hydroelectric Project
Essex and Middlesex Counties, MA

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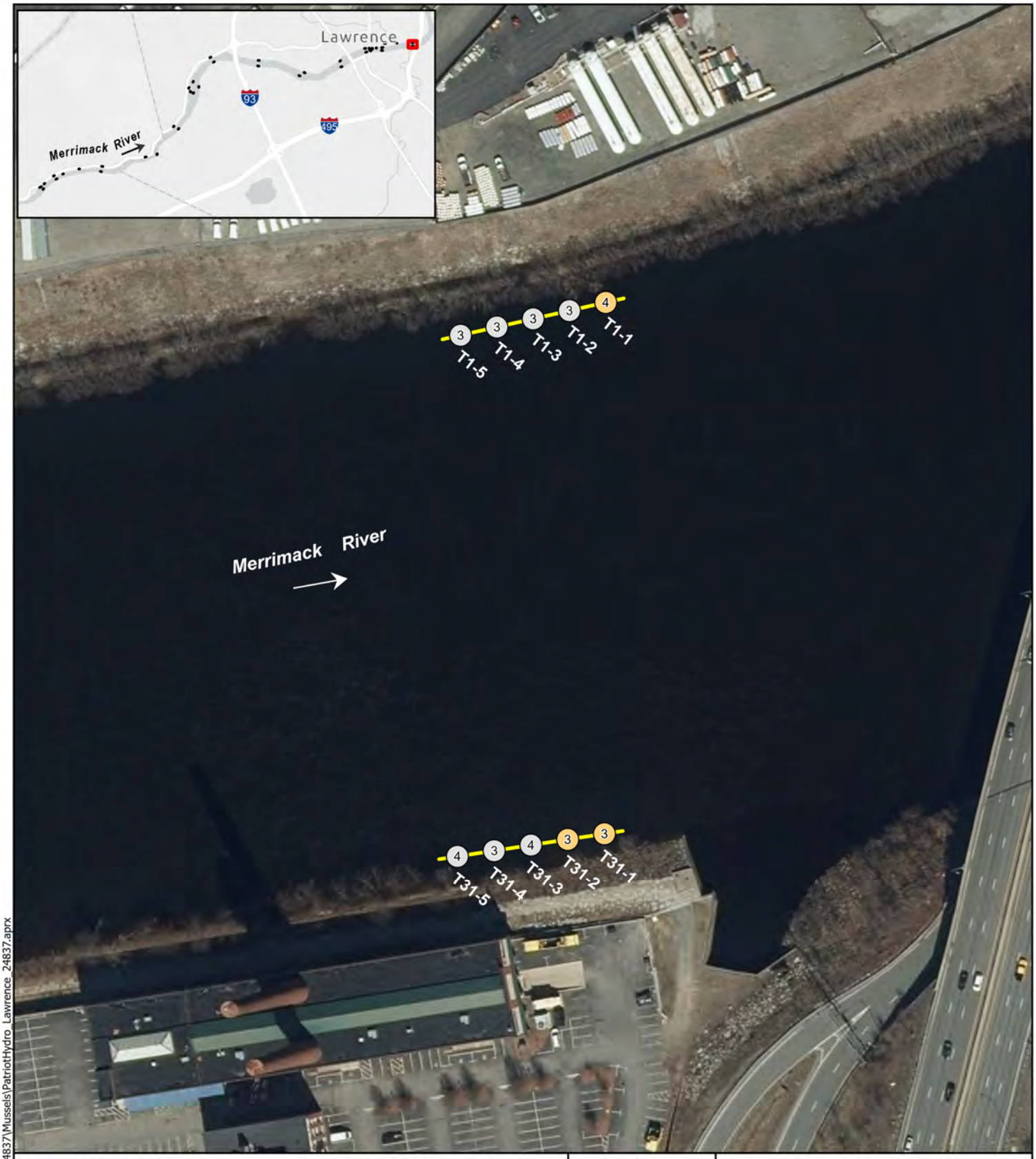

Spot Dive (Q)

Survey Transect (T)

Live Unionids (No. of Species)

- 0 - 10
- 11 - 50
- 51 - 200
- 201 - 400
- 401 - 900

N
W E
S

0 10 20
Meters

0 50 100
Feet

Appendix A - Figure 3
T1 and T31
Live Unionids and Species Distribution

Merrimack River
Lawrence Hydroelectric Project
Essex and Middlesex Counties, MA

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Spot Dive (Q)

Survey Transect (T)

Live Unionids (No. of Species)

- 0 - 10
- 11 - 50
- 51 - 200
- 201 - 400
- 401 - 900

N W E S

0 10 20
Meters

0 50 100
Feet

Appendix A - Figure 3
T2
Live Unionids and Species Distribution

Merrimack River
Lawrence Hydroelectric Project
Essex and Middlesex Counties, MA

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Spot Dive (Q)

Survey Transect (T)

Live Unionids (No. of Species)

- 0 - 10
- 11 - 50
- 51 - 200
- 201 - 400
- 401 - 900

N
W E
S

0 10 20
Meters

0 50 100
Feet

Appendix A - Figure 3
T4
Live Unionids and Species Distribution

Merrimack River
Lawrence Hydroelectric Project
Essex and Middlesex Counties, MA

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Spot Dive (Q)

Survey Transect (T)

Live Unionids (No. of Species)

- 0 - 10
- 11 - 50
- 51 - 200
- 201 - 400
- 401 - 900

N
W E
S

0 10 20
Meters

0 50 100
Feet

Appendix A - Figure 3
T3, T30 and Q15 - Q24
Live Unionids and Species Distribution

Merrimack River
Lawrence Hydroelectric Project
Essex and Middlesex Counties, MA

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Spot Dive (Q)

Survey Transect (T)

Live Unionids (No. of Species)

- 0 - 10
- 11 - 50
- 51 - 200
- 201 - 400
- 401 - 900

N

W E

S

0 10 20

Meters

0 50 100

Feet

Appendix A - Figure 3
T5, T29, Q3 - Q14 and Q25 - Q30
Live Unionids and Species Distribution

Merrimack River
Lawrence Hydroelectric Project
Essex and Middlesex Counties, MA

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Spot Dive (Q)

Survey Transect (T)

Live Unionids (No. of Species)

- 0 - 10
- 11 - 50
- 51 - 200
- 201 - 400
- 401 - 900

N
W E
S

0 10 20
Meters

0 50 100
Feet

Appendix A - Figure 3
T6 and T28
Live Unionids and Species Distribution

Merrimack River
Lawrence Hydroelectric Project
Essex and Middlesex Counties, MA

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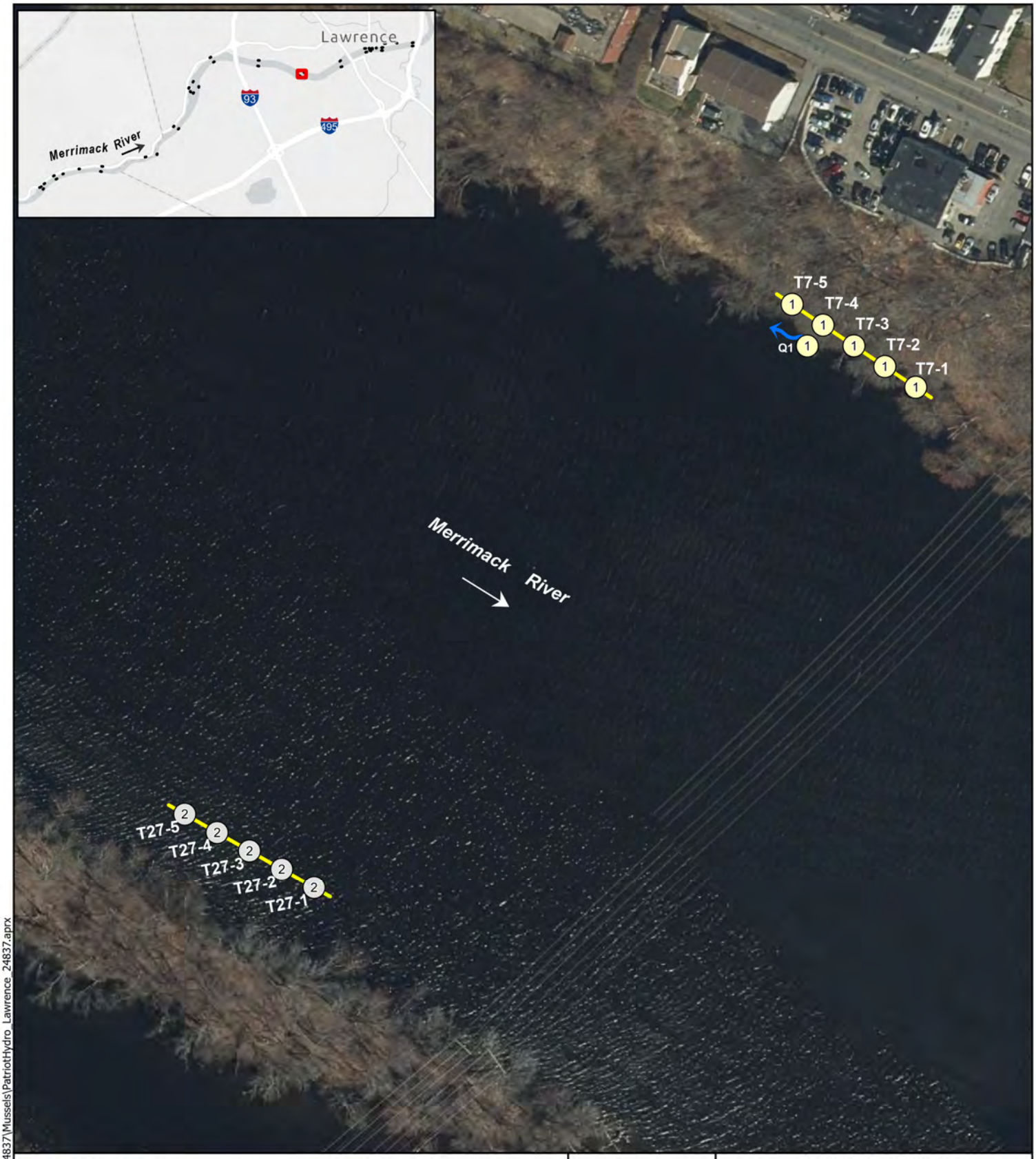

Spot Dive (Q)

Survey Transect (T)

Live Unionids (No. of Species)

- 0 - 10
- 11 - 50
- 51 - 200
- 201 - 400
- 401 - 900

N
W E
S

0 10 20
Meters

0 50 100
Feet

Appendix A - Figure 3
T7, T27 and Q1
Live Unionids and Species Distribution

Merrimack River
Lawrence Hydroelectric Project
Essex and Middlesex Counties, MA

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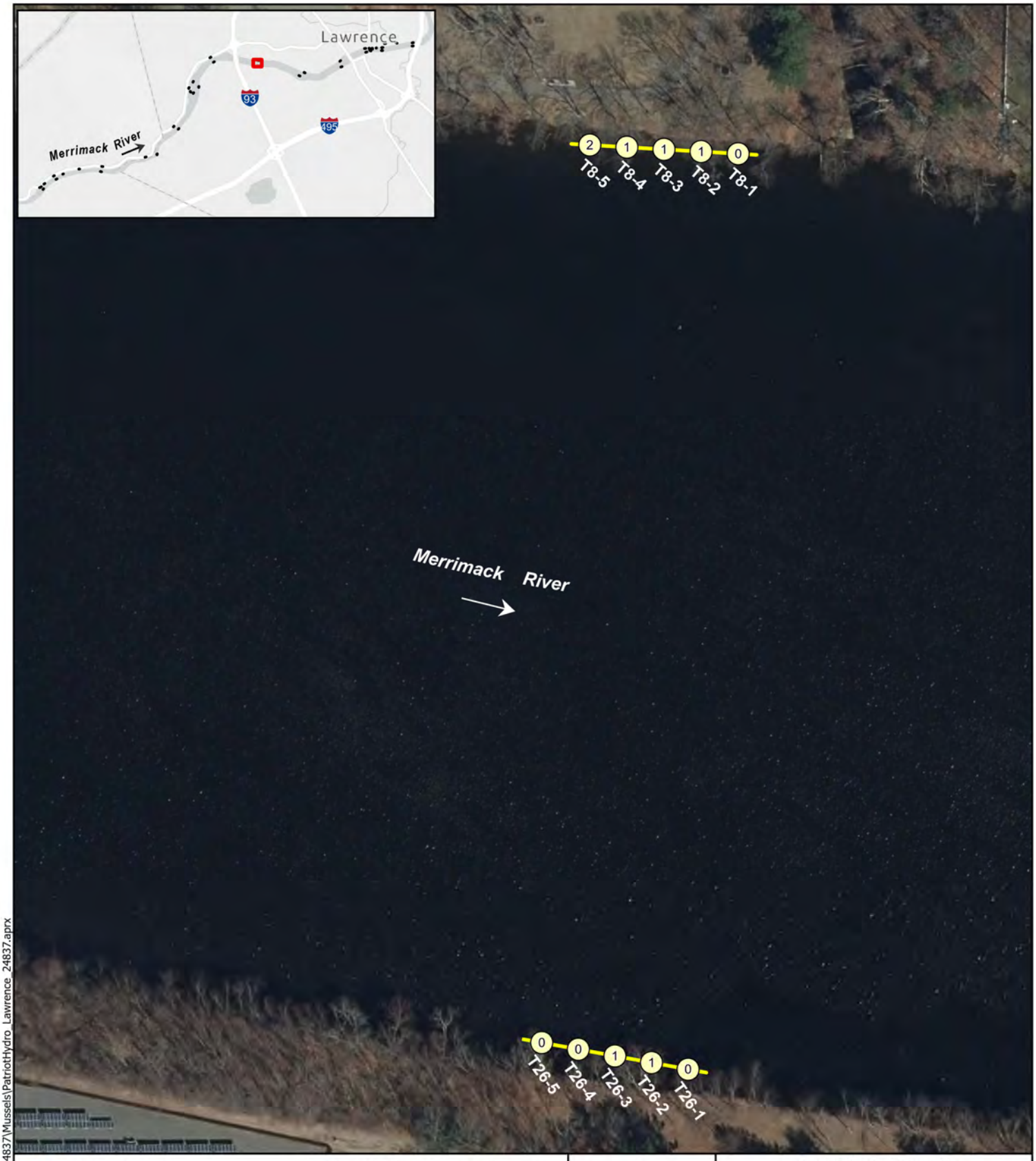

Spot Dive (Q)

Survey Transect (T)

Live Unionids (No. of Species)

- 0 - 10
- 11 - 50
- 51 - 200
- 201 - 400
- 401 - 900

N

W E

S

0 10 20

Meters

0 50 100

Feet

Appendix A - Figure 3
T8 and T26
Live Unionids and Species Distribution

Merrimack River
Lawrence Hydroelectric Project
Essex and Middlesex Counties, MA

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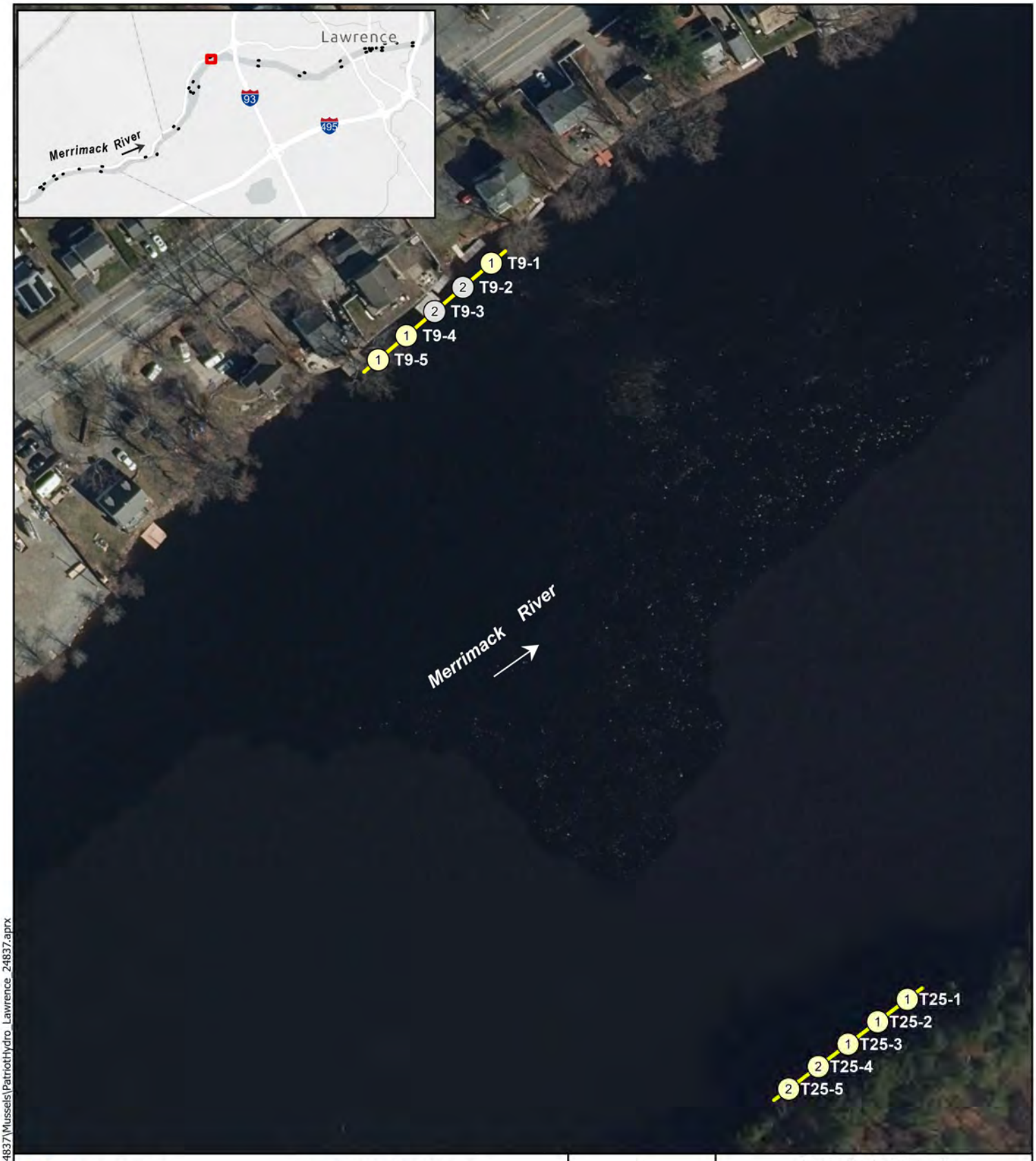

Spot Dive (Q)

Survey Transect (T)

Live Unionids (No. of Species)

- 0 - 10
- 11 - 50
- 51 - 200
- 201 - 400
- 401 - 900

N
W E
S

0 10 20
Meters

0 50 100
Feet

Appendix A - Figure 3
T9 and T25
Live Unionids and Species Distribution

Merrimack River
Lawrence Hydroelectric Project
Essex and Middlesex Counties, MA

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Spot Dive (Q)

Survey Transect (T)

Live Unionids (No. of Species)

0 - 10

11 - 50

51 - 200

201 - 400

401 - 900

N

W E

S

0 10 20

Meters

0 50 100

Feet

Appendix A - Figure 3
T10
Live Unionids and Species Distribution

Merrimack River
Lawrence Hydroelectric Project
Essex and Middlesex Counties, MA

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Spot Dive (Q)

Survey Transect (T)

Live Unionids (No. of Species)

0 - 10

11 - 50

51 - 200

201 - 400

401 - 900

N

W E

S

0 10 20

Meters

0 50 100

Feet

Appendix A - Figure 3
T24
Live Unionids and Species Distribution

Merrimack River
Lawrence Hydroelectric Project
Essex and Middlesex Counties, MA

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Spot Dive (Q)

Survey Transect (T)

Live Unionids (No. of Species)

- 0 - 10
- 11 - 50
- 51 - 200
- 201 - 400
- 401 - 900

N

W E

S

0 10 20

Meters

0 50 100

Feet

Appendix A - Figure 3
T11
Live Unionids and Species Distribution

Merrimack River
Lawrence Hydroelectric Project
Essex and Middlesex Counties, MA

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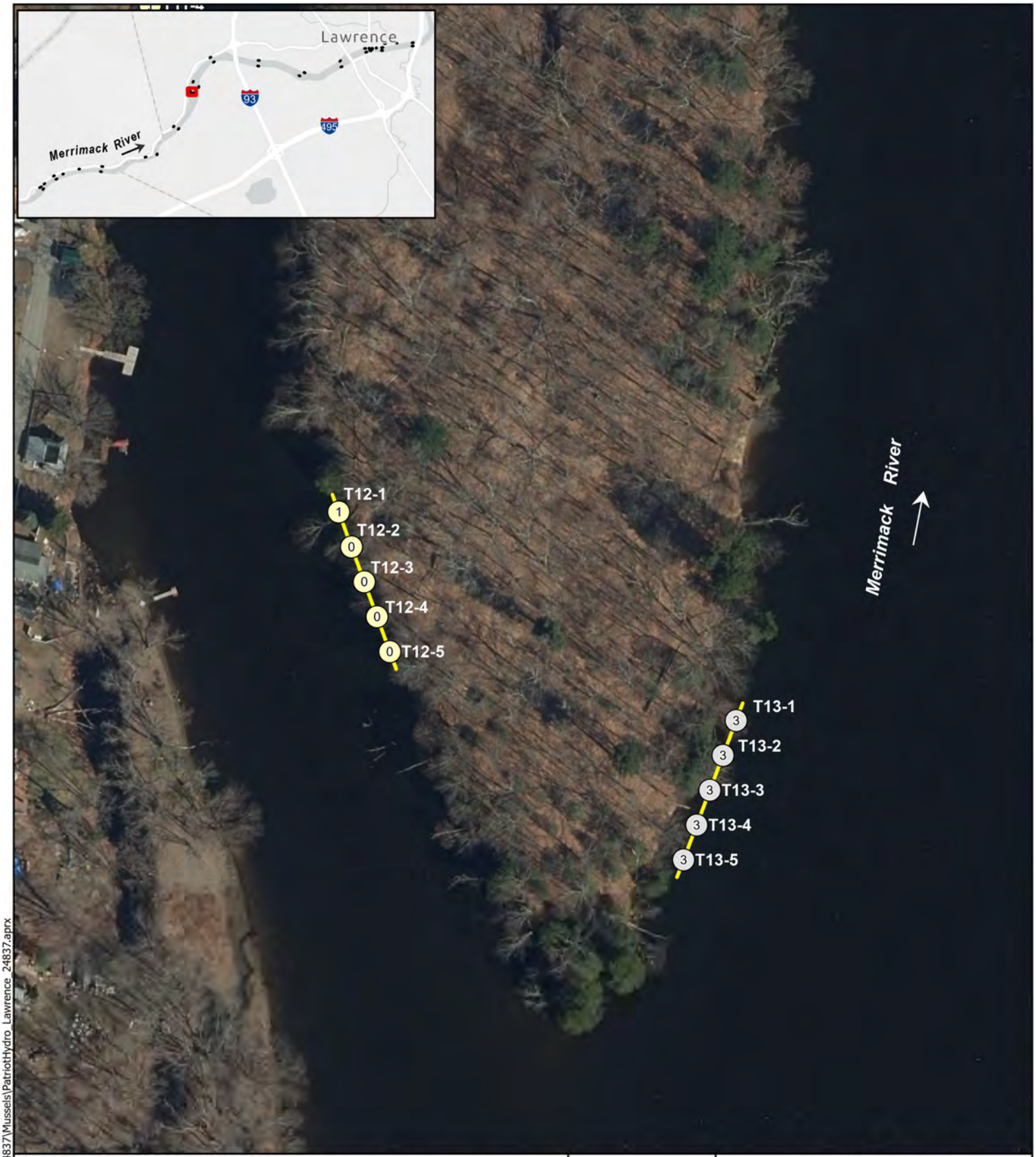

Spot Dive (Q)

Survey Transect (T)

Live Unionids (No. of Species)

- 0 - 10
- 11 - 50
- 51 - 200
- 201 - 400
- 401 - 900

N

W E

S

0 10 20

Meters

0 50 100

Feet

Appendix A - Figure 3
T12 and T13
Live Unionids and Species Distribution

Merrimack River
Lawrence Hydroelectric Project
Essex and Middlesex Counties, MA

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Spot Dive (Q)

Survey Transect (T)

Live Unionids (No. of Species)

- 0 - 10
- 11 - 50
- 51 - 200
- 201 - 400
- 401 - 900

N
W E
S

0 10 20
Meters

0 50 100
Feet

Appendix A - Figure 3
T14 and T23
Live Unionids and Species Distribution

Merrimack River
Lawrence Hydroelectric Project
Essex and Middlesex Counties, MA

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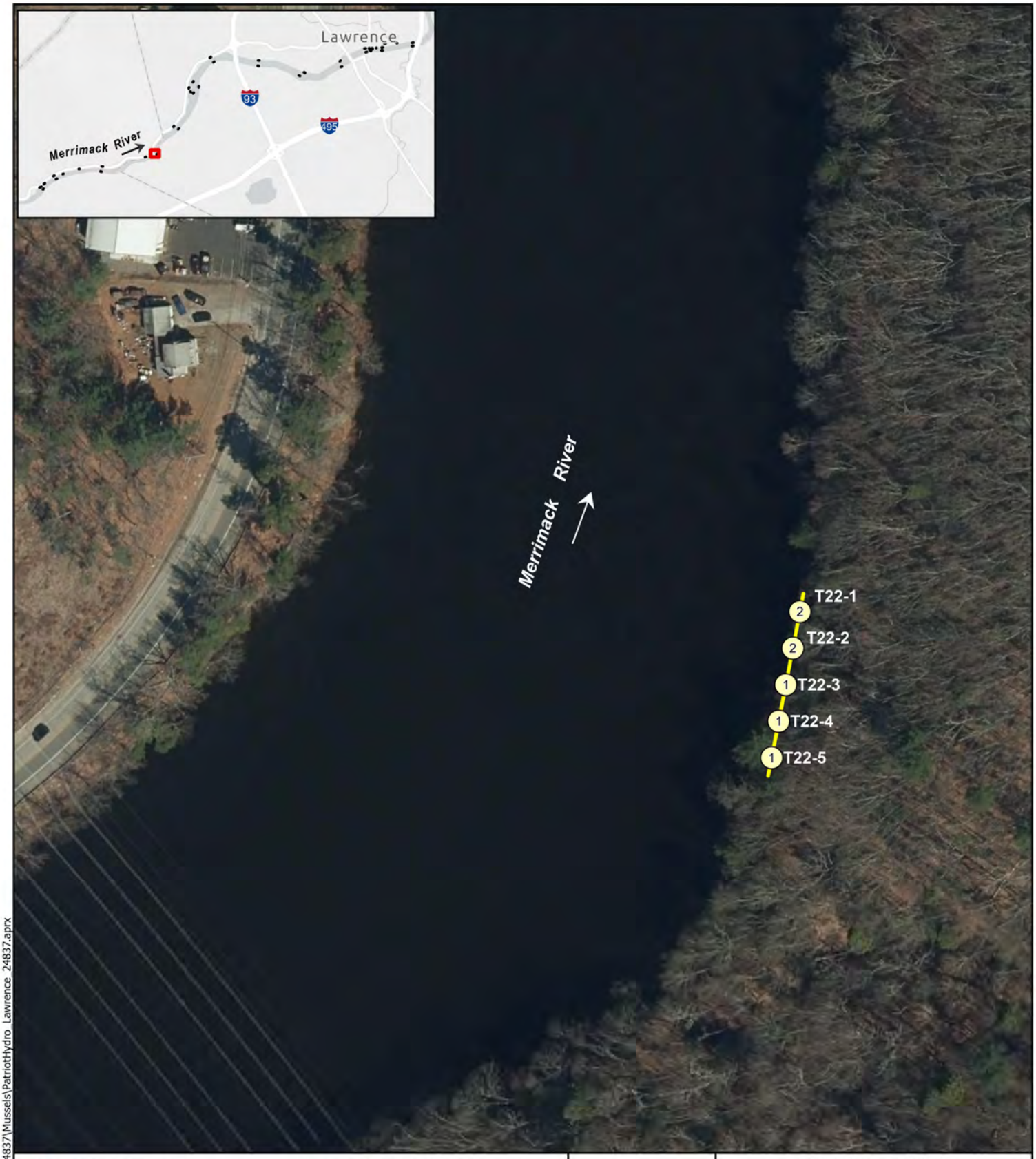

Spot Dive (Q)

Survey Transect (T)

Live Unionids (No. of Species)

0 - 10

11 - 50

51 - 200

201 - 400

401 - 900

N

W E

S

0 10 20

Meters

0 50 100

Feet

Appendix A - Figure 3
T22
Live Unionids and Species Distribution

Merrimack River
Lawrence Hydroelectric Project
Essex and Middlesex Counties, MA

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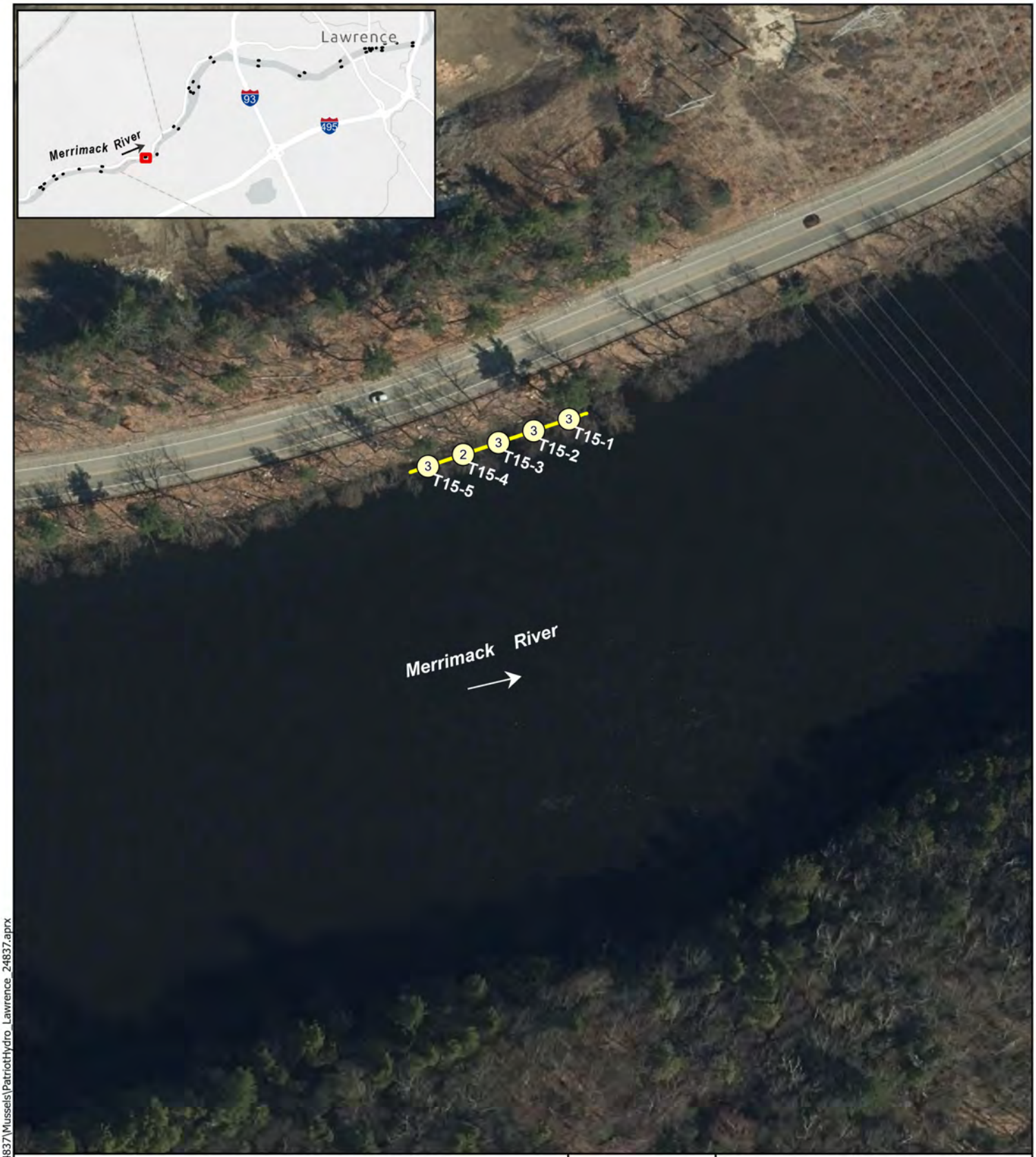

Spot Dive (Q)

Survey Transect (T)

Live Unionids (No. of Species)

- 0 - 10
- 11 - 50
- 51 - 200
- 201 - 400
- 401 - 900

N
W E
S

0 10 20
Meters

0 50 100
Feet

Appendix A - Figure 3
T15
Live Unionids and Species Distribution

Merrimack River
Lawrence Hydroelectric Project
Essex and Middlesex Counties, MA

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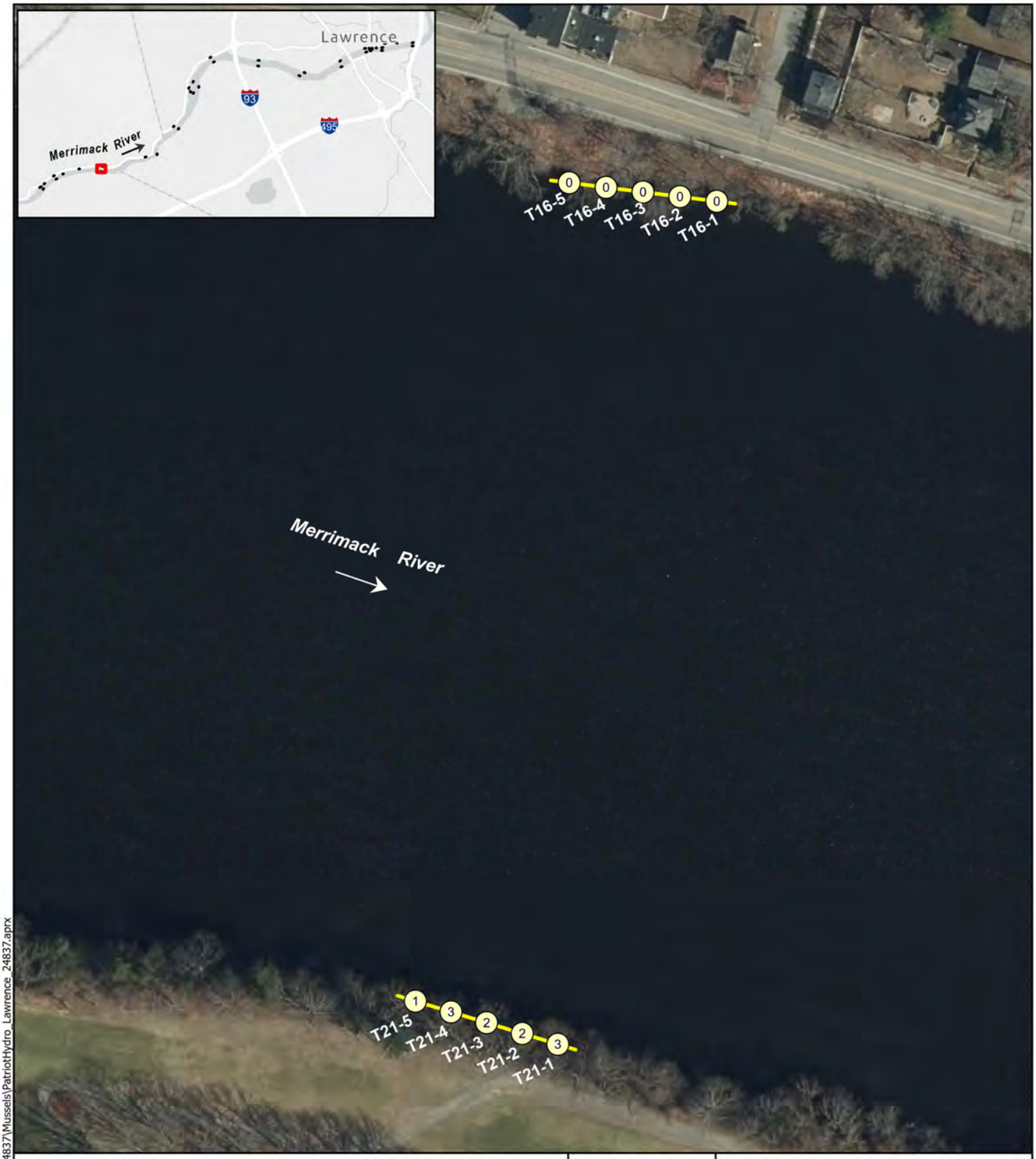

Spot Dive (Q)

Survey Transect (T)

Live Unionids (No. of Species)

- 0 - 10
- 11 - 50
- 51 - 200
- 201 - 400
- 401 - 900

N

W E

S

0 10 20

Meters

0 50 100

Feet

Appendix A - Figure 3
T16 and T21
Live Unionids and Species Distribution

Merrimack River
Lawrence Hydroelectric Project
Essex and Middlesex Counties, MA

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Spot Dive (Q)

Survey Transect (T)

Live Unionids (No. of Species)

- 0 - 10
- 11 - 50
- 51 - 200
- 201 - 400
- 401 - 900

N

W E

S

0 10 20

Meters

0 50 100

Feet

Appendix A - Figure 3
Q37 - Q39
Live Unionids and Species Distribution

Merrimack River
Lawrence Hydroelectric Project
Essex and Middlesex Counties, MA

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Spot Dive (Q)

Survey Transect (T)

Live Unionids (No. of Species)

0 - 10

11 - 50

51 - 200

201 - 400

401 - 900

N

W E

S

0 10 20

Meters

0 50 100

Feet

Appendix A - Figure 3
Q34 - Q36
Live Unionids and Species Distribution

Merrimack River
Lawrence Hydroelectric Project
Essex and Middlesex Counties, MA

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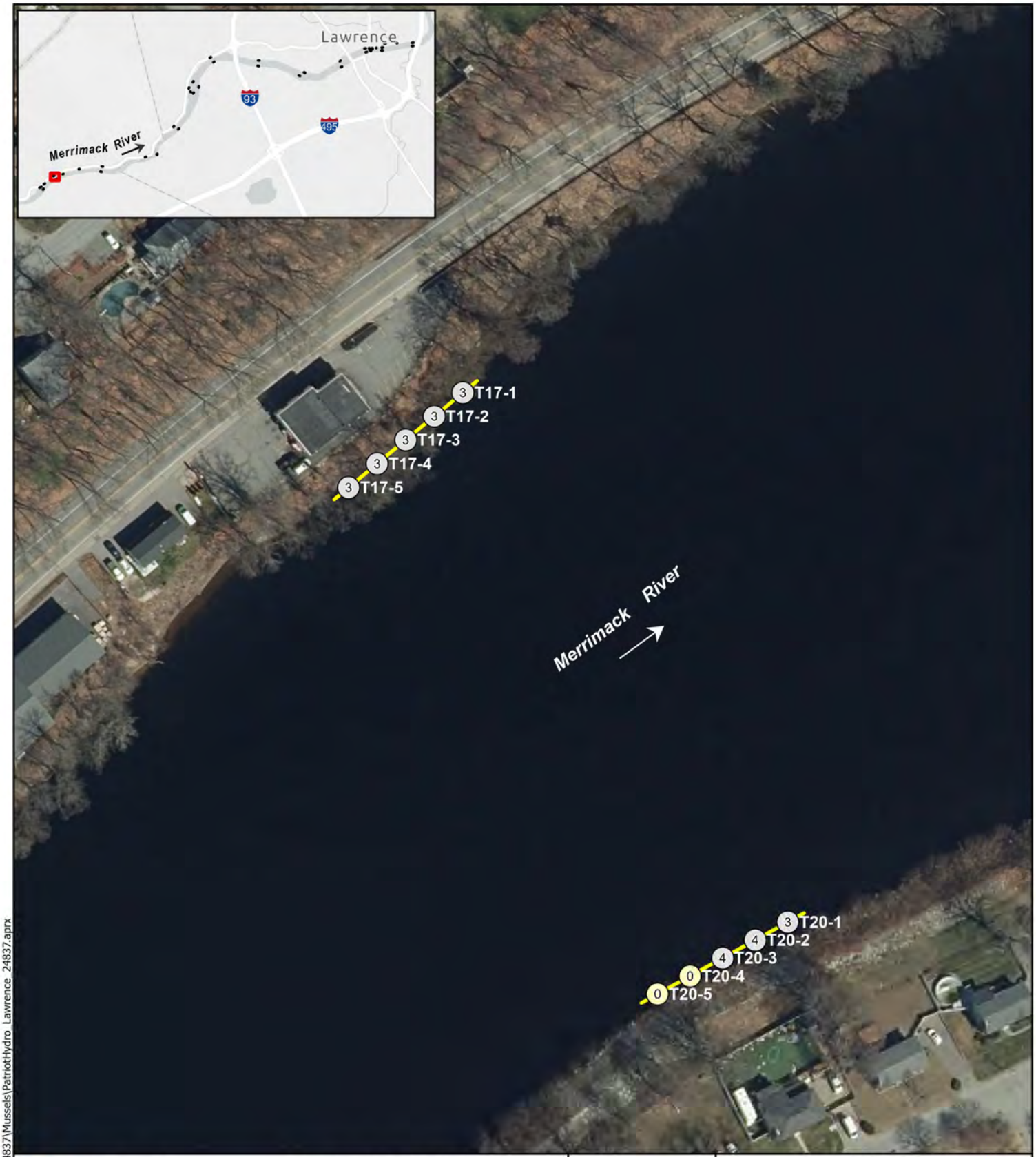

Spot Dive (Q)

Survey Transect (T)

Live Unionids (No. of Species)

- 0 - 10
- 11 - 50
- 51 - 200
- 201 - 400
- 401 - 900

N
W E
S

0 10 20
Meters

0 50 100
Feet

Appendix A - Figure 3
T17 and T20
Live Unionids and Species Distribution

Merrimack River
Lawrence Hydroelectric Project
Essex and Middlesex Counties, MA

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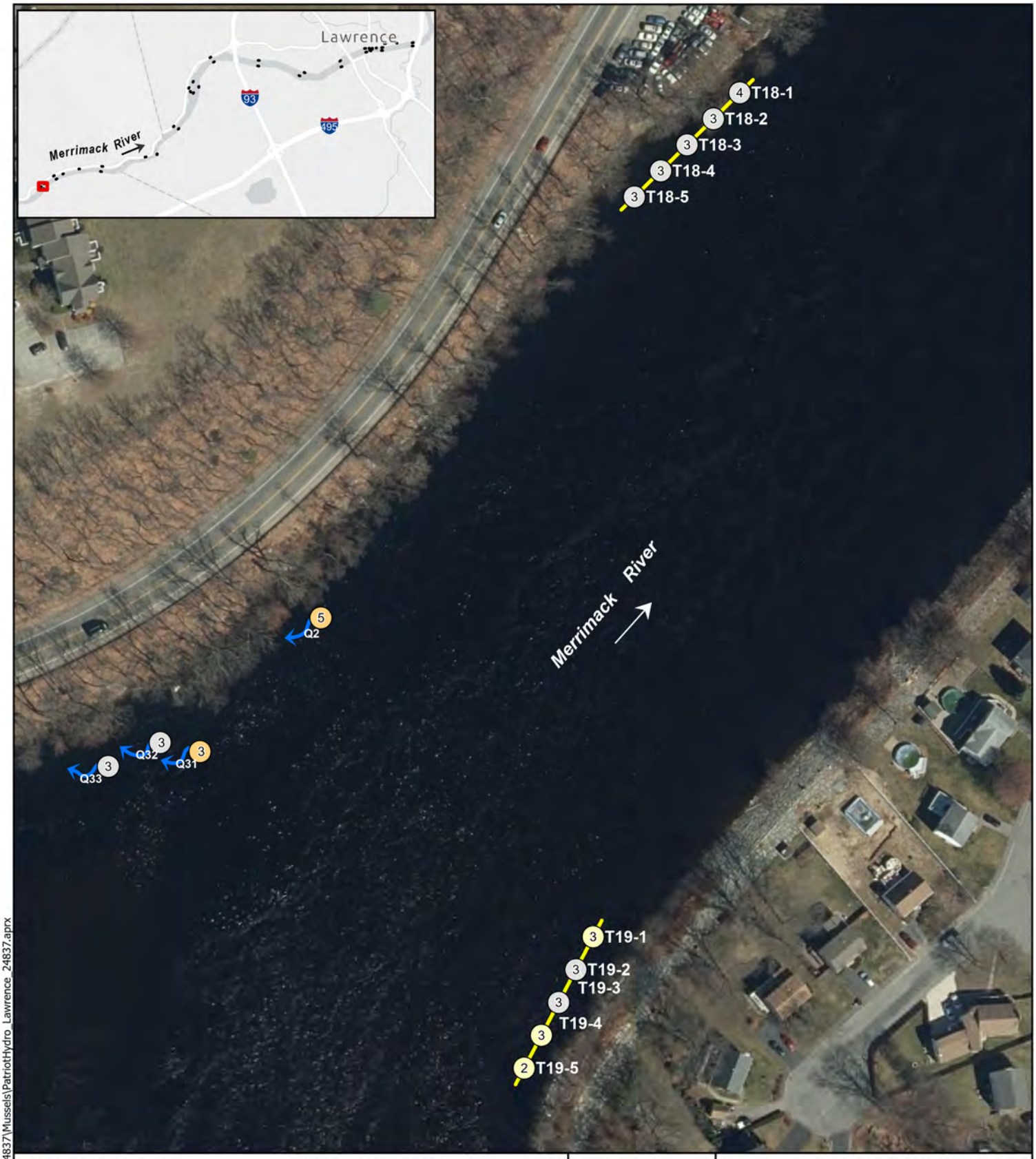

Spot Dive (Q)

Survey Transect (T)

Live Unionids (No. of Species)

- 0 - 10
- 11 - 50
- 51 - 200
- 201 - 400
- 401 - 900

N W E S

0 10 20
Meters

0 50 100
Feet

Appendix A - Figure 3
T18, T19, and Q2, Q31 - Q33
Live Unionids and Species Distribution

Merrimack River
Lawrence Hydroelectric Project
Essex and Middlesex Counties, MA

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Appendix B: Report Tables

Appendix B. Table 1. Maximum Depth, Number of Live Unionids, and Substrate Composition in the Merrimack River, Lawrence Hydroelectric Project, Essex and Middlesex Counties, MA, August 19-23 and September 10-11, 2024

			Average Substrate Composition (%)[1]							Other (%)	
Survey Location	Maximum Depth (ft.)	Live Unionids	BR	BO	CB	GR	SD	ST	CL	LWD	SAV
Transect 1											
T1-1	5	89	0	10	40	20	30	0	0	0	5
T1-2	5	43	0	10	40	20	30	0	0	0	5
T1-3	5	43	0	10	40	20	30	0	0	0	5
T1-4	5	20	0	10	40	20	30	0	0	0	5
T1-5	5	22	0	10	40	20	30	0	0	0	5
Subtotal	**5**	**217**	**0**	**10**	**40**	**20**	**30**	**0**	**0**	**0**	**5**
Transect 2											
T2-1	1.5	0	0	0	0	70	30	0	0	0	0
T2-2	1.5	0	0	0	0	70	30	0	0	0	0
T2-3	1.5	1	0	0	0	70	30	0	0	0	0
T2-4	1.5	0	0	0	0	70	30	0	0	0	0
T2-5	1.5	0	0	0	0	70	30	0	0	0	0
Subtotal	**1.5**	**1**	**0**	**0**	**0**	**70**	**30**	**0**	**0**	**0**	**0**
Transect 3											
T3-1	6	181	0	0	50	40	10	0	0	0	95
T3-2	6	192	0	0	50	40	10	0	0	0	95
T3-3	6	214	0	0	50	40	10	0	0	0	95
T3-4	6	171	0	0	50	40	10	0	0	0	95
T3-5	6	125	0	0	50	40	10	0	0	0	95
Subtotal	**6**	**883**	**0**	**0**	**50**	**40**	**10**	**0**	**0**	**0**	**95**
Transect 4											
T4-1	3	4	0	0	20	60	20	0	0	0	30
T4-2	3	5	0	0	20	60	20	0	0	0	30
T4-3	3	5	0	0	20	60	20	0	0	0	30
T4-4	3	6	0	0	20	60	20	0	0	0	30
T4-5	3	2	0	0	0	20	30	0	50	0	30
Subtotal	**3**	**22**	**0**	**0**	**16**	**52**	**22**	**0**	**10**	**0**	**30**
Transect 5											
T5-1	3	218	0	0	5	75	20	0	0	0	20
T5-2	3	183	0	0	5	75	20	0	0	0	20
T5-3	3	215	0	0	5	75	20	0	0	0	20
T5-4	3	146	0	0	5	75	20	0	0	0	20
T5-5	3	121	0	0	5	75	20	0	0	0	20
Subtotal	**3**	**883**	**0**	**0**	**5**	**75**	**20**	**0**	**0**	**0**	**20**
Transect 6											
T6-1	8	6	0	30	0	50	10	10	0	0	10
T6-2	7	2	0	0	0	0	0	100	0	0	0
T6-3	7	3	0	0	0	0	0	100	0	0	0

[1] Wentworth scale (Wentworth 1922)

BR = bed rock, BO = boulder, CB = cobble, GR = gravel, SD = sand, ST = silt, CL = clay, Other = shell material, detritus etc. LWD = large woody debris, SAV = submerged aquatic vegitation

T = Transect

Appendix B. Table 1. Maximum Depth, Number of Live Unionids, and Substrate Composition in the Merrimack River, Lawrence Hydroelectric Project, Essex and Middlesex Counties, MA, August 19-23 and September 10-11, 2024

			Average Substrate Composition (%)[1]							Other (%)	
Survey Location	Maximum Depth (ft.)	Live Unionids	BR	BO	CB	GR	SD	ST	CL	LWD	SAV
Transect 6 (cont)											
T6-4	7	2	0	0	0	0	0	100	0	0	0
T6-5	7	1	0	0	0	0	0	100	0	0	0
Subtotal	**8**	**14**	**0**	**6**	**0**	**10**	**2**	**82**	**0**	**0**	**2**
Transect 7											
T7-1	7	9	0	0	30	20	40	10	0	0	25
T7-2	7	9	0	0	30	20	40	10	0	0	25
T7-3	7	8	0	0	30	20	40	10	0	0	25
T7-4	7	8	0	0	30	20	40	10	0	0	25
T7-5	7	8	0	0	30	20	40	10	0	0	25
Subtotal	**7**	**42**	**0**	**0**	**30**	**20**	**40**	**10**	**0**	**0**	**25**
Transect 8											
T8-1	6	0	0	0	0	0	0	100	0	0	75
T8-2	6	2	0	0	0	0	0	100	0	0	75
T8-3	6	1	0	0	0	0	0	100	0	0	75
T8-4	6	2	0	0	0	0	0	100	0	0	75
T8-5	6	8	0	0	0	0	0	100	0	0	75
Subtotal	**6**	**13**	**0**	**0**	**0**	**0**	**0**	**100**	**0**	**0**	**75**
Transect 9											
T9-1	4	10	0	45	10	0	35	10	0	20	20
T9-2	7	11	0	0	0	0	75	25	0	0	30
T9-3	6	14	0	0	0	0	75	25	0	0	0
T9-4	5	4	0	0	0	0	75	25	0	0	0
T9-5	5	5	0	0	0	0	75	25	0	0	0
Subtotal	**7**	**44**	**0**	**9**	**2**	**0**	**67**	**22**	**0**	**4**	**10**
Transect 10											
T10-1	5	5	0	0	0	0	60	40	0	30	0
T10-2	6	4	0	0	0	0	60	40	0	30	0
T10-3	4	6	0	0	0	0	60	40	0	30	0
T10-4	7	9	0	0	0	0	60	40	0	30	0
T10-5	7	6	0	0	0	0	60	40	0	30	0
Subtotal	**7**	**30**	**0**	**0**	**0**	**0**	**60**	**40**	**0**	**30**	**0**
Transect 11											
T11-1	5	0	0	0	0	0	50	50	0	0	5
T11-2	5	0	0	0	0	0	50	50	0	0	0
T11-3	5	3	0	0	0	0	50	50	0	0	0
T11-4	5	1	0	0	0	0	50	50	0	0	0
T11-5	5	0	0	0	0	0	40	60	0	5	50
Subtotal	**5**	**4**	**0**	**0**	**0**	**0**	**48**	**52**	**0**	**1**	**11**

[1] Wentworth scale (Wentworth 1922)

BR = bed rock, BO = boulder, CB = cobble, GR = gravel, SD = sand, ST = silt, CL = clay, Other = shell material, detritus etc. LWD = large woody debris, SAV = submerged aquatic vegitation

T = Transect

Appendix B. Table 1. Maximum Depth, Number of Live Unionids, and Substrate Composition in the Merrimack River, Lawrence Hydroelectric Project, Essex and Middlesex Counties, MA, August 19-23 and September 10-11, 2024

			Average Substrate Composition (%)[1]							Other (%)	
Survey Location	Maximum Depth (ft.)	Live Unionids	BR	BO	CB	GR	SD	ST	CL	LWD	SAV
Transect 12											
T12-1	5	3	0	0	0	0	40	60	0	0	55
T12-2	5	0	0	0	0	0	40	60	0	0	55
T12-3	5	0	0	0	0	0	40	60	0	0	55
T12-4	5	0	0	0	0	0	40	60	0	0	55
T12-5	5	0	0	0	0	0	40	60	0	0	55
Subtotal	**5**	**3**	**0**	**0**	**0**	**0**	**40**	**60**	**0**	**0**	**55**
Transect 13											
T13-1	7	19	0	0	0	0	60	20	20	20	0
T13-2	7	23	0	0	0	0	60	20	20	20	0
T13-3	7	19	0	0	0	0	60	20	20	20	0
T13-4	7	20	0	0	0	0	60	20	20	20	0
T13-5	7	18	0	0	0	0	60	20	20	20	0
Subtotal	**7**	**99**	**0**	**0**	**0**	**0**	**60**	**20**	**20**	**20**	**0**
Transect 14											
T14-1	6	4	0	0	0	0	20	80	0	0	0
T14-2	6	5	0	0	0	0	20	80	0	0	0
T14-3	6	3	0	0	0	0	20	80	0	0	0
T14-4	6	3	0	0	0	0	20	80	0	0	0
T14-5	6	3	0	0	0	0	20	80	0	0	0
Subtotal	**6**	**18**	**0**	**0**	**0**	**0**	**20**	**80**	**0**	**0**	**0**
Transect 15											
T15-1	6	10	70	0	10	0	20	0	0	0	0
T15-2	6	9	70	0	10	0	20	0	0	0	0
T15-3	6	9	70	0	10	0	20	0	0	0	0
T15-4	6	5	70	0	10	0	20	0	0	40	0
T15-5	6	9	70	0	10	0	20	0	0	40	0
Subtotal	**6**	**42**	**70**	**0**	**10**	**0**	**20**	**0**	**0**	**16**	**0**
Transect 16											
T16-1	5	0	0	0	10	60	20	10	0	0	30
T16-2	5	0	0	0	10	60	20	10	0	0	30
T16-3	5	0	0	0	10	60	20	10	0	0	30
T16-4	5	0	0	0	10	60	20	10	0	0	30
T16-5	5	0	0	0	10	60	20	10	0	0	30
Subtotal	**5**	**0**	**0**	**0**	**10**	**60**	**20**	**10**	**0**	**0**	**30**
Transect 17											
T17-1	5	16	0	5	10	60	20	5	0	0	0
T17-2	5	20	0	5	10	60	20	5	0	0	0
T17-3	5	23	0	5	10	60	20	5	0	0	0

[1] Wentworth scale (Wentworth 1922)

BR = bed rock, BO = boulder, CB = cobble, GR = gravel, SD = sand, ST = silt, CL = clay, Other = shell material, detritus etc. LWD = large woody debris, SAV = submerged aquatic vegitation

T = Transect

Appendix B. Table 1. Maximum Depth, Number of Live Unionids, and Substrate Composition in the Merrimack River, Lawrence Hydroelectric Project, Essex and Middlesex Counties, MA, August 19-23 and September 10-11, 2024

			Average Substrate Composition (%)[1]							Other (%)	
Survey Location	Maximum Depth (ft.)	Live Unionids	BR	BO	CB	GR	SD	ST	CL	LWD	SAV
Transect 17 (cont)											
T17-4	5	25	0	5	10	60	20	5	0	0	0
T17-5	5	21	0	5	10	60	20	5	0	0	0
Subtotal	**5**	**105**	**0**	**5**	**10**	**60**	**20**	**5**	**0**	**0**	**0**
Transect 18											
T18-1	6	17	0	0	30	20	50	0	0	0	0
T18-2	6	13	0	0	30	20	50	0	0	0	0
T18-3	6	15	0	0	30	20	50	0	0	0	0
T18-4	6	18	0	0	30	20	50	0	0	0	0
T18-5	6	20	0	0	30	20	50	0	0	0	0
Subtotal	**6**	**83**	**0**	**0**	**30**	**20**	**50**	**0**	**0**	**0**	**0**
Transect 19											
T19-1	6	10	0	0	0	30	35	35	0	0	0
T19-2	6	15	0	0	10	30	60	0	0	0	0
T19-3	6	16	0	10	30	20	40	0	0	0	0
T19-4	6	5	40	0	40	0	20	0	0	0	0
T19-5	6	4	40	0	40	0	20	0	0	0	0
Subtotal	**6**	**50**	**16**	**2**	**24**	**16**	**35**	**7**	**0**	**0**	**0**
Transect 20											
T20-1	6	29	0	0	30	20	50	0	0	10	5
T20-2	6	26	0	20	30	0	30	20	0	10	5
T20-3	6	20	0	20	30	0	30	20	0	10	5
T20-4	6	0	60	0	0	20	0	20	0	10	5
T20-5	6	0	60	0	0	20	0	20	0	10	5
Subtotal	**6**	**75**	**24**	**8**	**18**	**12**	**22**	**16**	**0**	**10**	**5**
Transect 21											
T21-1	5	6	0	10	0	10	80	0	0	20	0
T21-2	5	3	0	10	0	10	80	0	0	20	0
T21-3	5	2	0	10	0	10	80	0	0	20	0
T21-4	5	6	0	10	0	10	80	0	0	20	0
T21-5	5	2	0	10	0	10	80	0	0	20	0
Subtotal	**5**	**19**	**0**	**10**	**0**	**10**	**80**	**0**	**0**	**20**	**0**
Transect 22											
T22-1	7	5	0	0	0	0	90	10	0	0	0
T22-2	7	4	0	0	0	0	90	10	0	0	0
T22-3	7	4	0	0	0	0	90	10	0	0	0
T22-4	7	3	0	0	0	0	90	10	0	0	0
T22-5	7	2	0	0	70	0	20	10	0	0	0
Subtotal	**7**	**18**	**0**	**0**	**14**	**0**	**76**	**10**	**0**	**0**	**0**

[1] Wentworth scale (Wentworth 1922)

BR = bed rock, BO = boulder, CB = cobble, GR = gravel, SD = sand, ST = silt, CL = clay, Other = shell material, detritus etc. LWD = large woody debris, SAV = submerged aquatic vegitation

T = Transect

Appendix B. Table 1. Maximum Depth, Number of Live Unionids, and Substrate Composition in the Merrimack River, Lawrence Hydroelectric Project, Essex and Middlesex Counties, MA, August 19-23 and September 10-11, 2024

			Average Substrate Composition (%)[1]							Other (%)	
Survey Location	Maximum Depth (ft.)	Live Unionids	BR	BO	CB	GR	SD	ST	CL	LWD	SAV
Transect 23											
T23-1	6	5	0	0	0	0	0	100	0	0	0
T23-2	6	6	0	0	0	0	0	100	0	0	0
T23-3	6	10	0	0	0	0	0	100	0	0	0
T23-4	6	6	0	0	0	0	0	100	0	0	0
T23-5	6	4	0	0	0	0	0	100	0	0	0
Subtotal	**6**	**31**	**0**	**0**	**0**	**0**	**0**	**100**	**0**	**0**	**0**
Transect 24											
T24-1	5	4	0	0	0	0	40	60	0	0	5
T24-2	6	4	0	0	0	0	40	60	0	0	5
T24-3	6	4	0	0	0	0	40	60	0	0	5
T24-4	7	4	0	0	0	0	40	60	0	0	5
T24-5	6	5	0	0	0	0	40	60	0	0	5
Subtotal	**7**	**21**	**0**	**0**	**0**	**0**	**40**	**60**	**0**	**0**	**5**
Transect 25											
T25-1	5	4	0	0	0	0	10	90	0	0	5
T25-2	6	6	0	0	0	0	10	90	0	0	5
T25-3	6	7	0	0	0	0	10	90	0	0	5
T25-4	4	9	0	0	0	0	10	90	0	0	5
T25-5	5	9	0	0	0	0	10	90	0	25	5
Subtotal	**6**	**35**	**0**	**0**	**0**	**0**	**10**	**90**	**0**	**5**	**5**
Transect 26											
T26-1	6	0	0	0	0	0	100	0	0	5	100
T26-2	6	3	0	0	0	0	90	10	0	5	95
T26-3	6	1	0	0	0	0	90	10	0	5	95
T26-4	6	0	0	0	0	0	0	100	0	0	0
T26-5	6	0	0	0	0	0	0	100	0	0	0
Subtotal	**6**	**4**	**0**	**0**	**0**	**0**	**56**	**44**	**0**	**3**	**58**
Transect 27											
T27-1	7	14	0	0	0	0	90	10	0	5	0
T27-2	7	14	0	0	0	0	90	10	0	5	0
T27-3	7	14	0	0	0	0	90	10	0	5	0
T27-4	7	18	0	0	0	0	90	10	0	5	0
T27-5	7	19	0	0	0	0	90	10	0	5	0
Subtotal	**7**	**79**	**0**	**0**	**0**	**0**	**90**	**10**	**0**	**5**	**0**
Transect 28											
T28-1	7	2	0	0	0	0	0	100	0	0	50
T28-2	7	9	0	0	0	0	0	100	0	0	50
T28-3	7	8	0	0	0	0	0	100	0	0	50

[1] Wentworth scale (Wentworth 1922)

BR = bed rock, BO = boulder, CB = cobble, GR = gravel, SD = sand, ST = silt, CL = clay, Other = shell material, detritus etc. LWD = large woody debris, SAV = submerged aquatic vegitation

T = Transect

Appendix B. Table 1. Maximum Depth, Number of Live Unionids, and Substrate Composition in the Merrimack River, Lawrence Hydroelectric Project, Essex and Middlesex Counties, MA, August 19-23 and September 10-11, 2024

			Average Substrate Composition (%)[1]							Other (%)	
Survey Location	Maximum Depth (ft.)	Live Unionids	BR	BO	CB	GR	SD	ST	CL	LWD	SAV
Transect 28 (cont)											
T28-4	7	8	0	0	0	0	0	100	0	0	50
T28-5	7	11	0	0	0	0	0	100	0	0	50
Subtotal	**7**	**38**	**0**	**0**	**0**	**0**	**0**	**100**	**0**	**0**	**50**
Transect 29											
T29-1	2	15	0	0	50	40	10	0	0	0	95
T29-2	2	14	0	0	50	40	10	0	0	0	95
T29-3	2	9	0	0	50	40	10	0	0	0	95
T29-4	2	10	0	0	50	40	10	0	0	0	95
T29-5	2	10	0	0	50	40	10	0	0	0	95
Subtotal	**2**	**58**	**0**	**0**	**50**	**40**	**10**	**0**	**0**	**0**	**95**
Transect 30											
T30-1	3	64	0	0	30	50	20	0	0	0	50
T30-2	3	57	0	0	30	50	20	0	0	0	50
T30-3	3	55	0	0	30	50	20	0	0	0	50
T30-4	3	49	0	0	30	50	20	0	0	0	50
T30-5	3	55	0	0	30	50	20	0	0	0	50
Subtotal	**3**	**280**	**0**	**0**	**30**	**50**	**20**	**0**	**0**	**0**	**50**
Transect 31											
T31-1	5	91	0	20	40	20	20	0	0	0	0
T31-2	5	69	0	20	40	20	20	0	0	0	0
T31-3	5	35	0	20	40	20	20	0	0	0	0
T31-4	5	33	0	20	40	20	20	0	0	0	0
T31-5	5	36	0	20	40	20	20	0	0	0	0
Subtotal	**5**	**264**	**0**	**20**	**40**	**20**	**20**	**0**	**0**	**0**	**0**
Transect Total	**8**	**3,475**	**4**	**2**	**12**	**19**	**33**	**30**	**1**	**4**	**20**
Spot Dives											
Q1	6	6	0	0	30	20	40	10	0	0	30
Q2	6	81	0	0	30	20	50	0	0	0	0
Q3	5	40	0	5	10	60	20	5	0	0	0
Q4	3	206	0	0	5	75	20	0	0	0	20
Q5	1	93	0	10	40	20	30	0	0	0	0
Q6	1	111	0	10	40	20	30	0	0	0	0
Q7	1	900	0	10	40	20	30	0	0	0	0
Q8	1.5	850	0	10	40	20	30	0	0	0	0
Q9	2	402	0	10	40	20	30	0	0	0	0
Q10	2.5	620	0	0	30	35	35	0	0	0	0

[1] Wentworth scale (Wentworth 1922)

BR = bed rock, BO = boulder, CB = cobble, GR = gravel, SD = sand, ST = silt, CL = clay, Other = shell material, detritus etc. LWD = large woody debris, SAV = submerged aquatic vegitation

T = Transect, Q = Spot Dive

Appendix B. Table 1. Maximum Depth, Number of Live Unionids, and Substrate Composition in the Merrimack River, Lawrence Hydroelectric Project, Essex and Middlesex Counties, MA, August 19-23 and September 10-11, 2024

			Average Substrate Composition (%)[1]							Other (%)	
Survey Location	Maximum Depth (ft.)	Live Unionids	BR	BO	CB	GR	SD	ST	CL	LWD	SAV
Spot Dives (cont)											
Q11	2.5	130	0	0	30	35	35	0	0	0	0
Q12	2.5	119	0	0	30	35	35	0	0	0	0
Q13	2.5	525	0	0	30	35	35	0	0	0	0
Q14	2.5	445	0	0	30	35	35	0	0	0	75
Q15	2.5	330	0	0	30	35	35	0	0	0	0
Q16	2.5	354	0	0	30	35	35	0	0	0	0
Q17	2.5	268	0	0	30	35	35	0	0	0	0
Q18	2.5	82	0	0	30	35	35	0	0	0	0
Q19	2.5	92	0	0	30	35	35	0	0	0	0
Q20	2.5	201	0	0	30	35	35	0	0	0	0
Q21	2.5	236	0	0	30	35	35	0	0	0	0
Q22	2.5	214	0	0	30	35	35	0	0	0	0
Q23	2.5	340	0	0	30	35	35	0	0	0	0
Q24	2.5	156	0	0	30	35	35	0	0	0	0
Q25	2.5	320	0	5	35	30	30	0	0	0	0
Q26	2.5	400	0	5	35	30	30	0	0	0	0
Q27	2.5	300	0	5	35	30	30	0	0	0	0
Q28	2.5	325	0	5	35	30	30	0	0	0	0
Q29	2.5	310	0	5	35	30	30	0	0	0	0
Q30	2.5	325	0	5	35	30	30	0	0	0	0
Q31	7	62	0	30	40	5	15	10	0	0	0
Q32	5	40	0	30	40	5	15	10	0	0	0
Q33	8	25	0	30	40	5	15	10	0	0	0
Q34	6	55	0	5	15	40	40	0	0	0	5
Q35	6	52	0	5	15	40	40	0	0	0	0
Q36	6	57	0	5	15	40	40	0	0	0	0
Q37	8	21	0	20	20	30	30	0	0	0	40
Q38	8	21	0	50	10	20	20	0	0	0	60
Q39	8	21	0	60	10	10	20	0	0	0	70
Spot Dive Total	**8**	**9,135**	**0**	**8**	**29**	**30**	**31**	**1**	**0**	**0**	**8**
Grand Total	**8**	**12,610**	**2**	**5**	**21**	**24**	**32**	**15**	**0**	**2**	**14**

[1] Wentworth scale (Wentworth 1922)

BR = bed rock, BO = boulder, CB = cobble, GR = gravel, SD = sand, ST = silt, CL = clay, Other = shell material, detritus etc. LWD = large woody debris, SAV = submerged aquatic vegitation

Q = Spot Dive

Appendix B. Table 2. Summary of Live Unionids and CPUE for the Merrimack River, Lawrence Hydroelectric Project, Essex and Middlesex Counties, MA, August 19-23 and September 10-11, 2024

Survey Location	Number Live Mussels	Survey Time (minutes)	[1] CPUE (no./hour) - Total	Search Area (m^2)
Transect 1				
T1-1	89	5	1068	10
T1-2	43	5	516	10
T1-3	43	5	516	10
T1-4	20	5	240	10
T1-5	22	5	264	10
Subtotal/AVG CPUE	217	25	520.8	50
Transect 2				
T2-1	0	5	0	10
T2-2	0	5	0	10
T2-3	1	5	12	10
T2-4	0	5	0	10
T2-5	0	5	0	10
Subtotal/AVG CPUE	1	25	2.4	50
Transect 3				
T3-1	181	5	2172	10
T3-2	192	5	2304	10
T3-3	214	5	2568	10
T3-4	171	5	2052	10
T3-5	125	5	1500	10
Subtotal/AVG CPUE	883	25	2119.2	50
Transect 4				
T4-1	4	5	48	10
T4-2	5	5	60	10
T4-3	5	5	60	10
T4-4	6	5	72	10
T4-5	2	5	24	10
Subtotal/AVG CPUE	22	25	52.8	50
Transect 5				
T5-1	218	5	2616	10
T5-2	183	5	2196	10
T5-3	215	5	2580	10
T5-4	146	5	1752	10
T5-5	121	5	1452	10
Subtotal/AVG CPUE	883	25	2119.2	50
Transect 6				
T6-1	6	5	72	10
T6-2	2	5	24	10
T6-3	3	5	36	10
T6-4	2	5	24	10
T6-5	1	5	12	10
Subtotal/AVG CPUE	14	25	33.6	50
Transect 7				
T7-1	9	5	108	10
T7-2	9	5	108	10
T7-3	8	5	96	10
T7-4	8	5	96	10
T7-5	8	5	96	10
Subtotal/AVG CPUE	42	25	100.8	50

[1] CPUE (Catch Per Unit Effort) = number live per work person hour (no. live / (Tot time/60 min)

T = Transect

Appendix B. Table 2. Summary of Live Unionids and CPUE for the Merrimack River, Lawrence Hydroelectric Project, Essex and Middlesex Counties, MA, August 19-23 and September 10-11, 2024

Survey Location	Number Live Mussels	Survey Time (minutes)	[1] CPUE (no./hour) - Total	Search Area (m^2)
Transect 8				
T8-1	0	5	0	10
T8-2	2	5	24	10
T8-3	1	5	12	10
T8-4	2	5	24	10
T8-5	8	5	96	10
Subtotal/AVG CPUE	13	25	31.2	50
Transect 9				
T9-1	10	5	120	10
T9-2	11	5	132	10
T9-3	14	5	168	10
T9-4	4	5	48	10
T9-5	5	5	60	10
Subtotal/AVG CPUE	44	25	105.6	50
Transect 10				
T10-1	5	5	60	10
T10-2	4	5	48	10
T10-3	6	5	72	10
T10-4	9	5	108	10
T10-5	6	5	72	10
Subtotal/AVG CPUE	30	25	72.0	50
Transect 11				
T11-1	0	5	0	10
T11-2	0	5	0	10
T11-3	3	5	36	10
T11-4	1	5	12	10
T11-5	0	5	0	10
Subtotal/AVG CPUE	4	25	9.6	50
Transect 12				
T12-1	3	5	36	10
T12-2	0	5	0	10
T12-3	0	5	0	10
T12-4	0	5	0	10
T12-5	0	5	0	10
Subtotal/AVG CPUE	3	25	7.2	50
Transect 13				
T13-1	19	5	228	10
T13-2	23	5	276	10
T13-3	19	5	228	10
T13-4	20	5	240	10
T13-5	18	5	216	10
Subtotal/AVG CPUE	99	25	237.6	50
Transect 14				
T14-1	4	5	48	10
T14-2	5	5	60	10
T14-3	3	5	36	10
T14-4	3	5	36	10
T14-5	3	5	36	10
Subtotal/AVG CPUE	18	25	43.2	50
Transect 15				
T15-1	10	5	120	10
T15-2	9	5	108	10
T15-3	9	5	108	10
T15-4	5	5	60	10
T15-5	9	5	108	10
Subtotal/AVG CPUE	42	25	100.8	50

[1] CPUE (Catch Per Unit Effort) = number live per work person hour (no. live / (Tot time/60 min)

T = Transect

Appendix B. Table 2. Summary of Live Unionids and CPUE for the Merrimack River, Lawrence Hydroelectric Project, Essex and Middlesex Counties, MA, August 19-23 and September 10-11, 2024

Survey Location	Number Live Mussels	Survey Time (minutes)	[1] CPUE (no./hour) - Total	Search Area (m^2)
Transect 16				
T16-1	0	5	0	10
T16-2	0	5	0	10
T16-3	0	5	0	10
T16-4	0	5	0	10
T16-5	0	5	0	10
Subtotal/AVG CPUE	0	25	0.0	50
Transect 17				
T17-1	16	5	192	10
T17-2	20	5	240	10
T17-3	23	5	276	10
T17-4	25	5	300	10
T17-5	21	5	252	10
Subtotal/AVG CPUE	105	25	252.0	50
Transect 18				
T18-1	17	5	204	10
T18-2	13	5	156	10
T18-3	15	5	180	10
T18-4	18	5	216	10
T18-5	20	5	240	10
Subtotal/AVG CPUE	83	25	199.2	50
Transect 19				
T19-1	10	5	120	10
T19-2	15	5	180	10
T19-3	16	5	192	10
T19-4	5	5	60	10
T19-5	4	5	48	10
Subtotal/AVG CPUE	50	25	120.0	50
Transect 20				
T20-1	29	5	348	10
T20-2	26	5	312	10
T20-3	20	5	240	10
T20-4	0	5	0	10
T20-5	0	5	0	10
Subtotal/AVG CPUE	75	25	180.0	50
Transect 21				
T21-1	6	5	72	10
T21-2	3	5	36	10
T21-3	2	5	24	10
T21-4	6	5	72	10
T21-5	2	5	24	10
Subtotal/AVG CPUE	19	25	45.6	50
Transect 22				
T22-1	5	5	60	10
T22-2	4	5	48	10
T22-3	4	5	48	10
T22-4	3	5	36	10
T22-5	2	5	24	10
Subtotal/AVG CPUE	18	25	43.2	50
Transect 23				
T23-1	5	5	60	10
T23-2	6	5	72	10
T23-3	10	5	120	10
T23-4	6	5	72	10
T23-5	4	5	48	10
Subtotal/AVG CPUE	31	25	74.4	50

[1] CPUE (Catch Per Unit Effort) = number live per work person hour (no. live / (Tot time/60 min)

T = Transect

Appendix B. Table 2. Summary of Live Unionids and CPUE for the Merrimack River, Lawrence Hydroelectric Project, Essex and Middlesex Counties, MA, August 19-23 and September 10-11, 2024

Survey Location	Number Live Mussels	Survey Time (minutes)	[1] CPUE (no./hour) - Total	Search Area (m^2)
Transect 24				
T24-1	4	5	48	10
T24-2	4	5	48	10
T24-3	4	5	48	10
T24-4	4	5	48	10
T24-5	5	5	60	10
Subtotal/AVG CPUE	21	25	50.4	50
Transect 25				
T25-1	4	5	48	10
T25-2	6	5	72	10
T25-3	7	5	84	10
T25-4	9	5	108	10
T25-5	9	5	108	10
Subtotal/AVG CPUE	35	25	84.0	50
Transect 26				
T26-1	0	5	0	10
T26-2	3	5	36	10
T26-3	1	5	12	10
T26-4	0	5	0	10
T26-5	0	5	0	10
Subtotal/AVG CPUE	4	25	9.6	50
Transect 27				
T27-1	14	5	168	10
T27-2	14	5	168	10
T27-3	14	5	168	10
T27-4	18	5	216	10
T27-5	19	5	228	10
Subtotal/AVG CPUE	79	25	189.6	50
Transect 28				
T28-1	2	5	24	10
T28-2	9	5	108	10
T28-3	8	5	96	10
T28-4	8	5	96	10
T28-5	11	5	132	10
Subtotal/AVG CPUE	38	25	91.2	50
Transect 29				
T29-1	15	5	180	10
T29-2	14	5	168	10
T29-3	9	5	108	10
T29-4	10	5	120	10
T29-5	10	5	120	10
Subtotal/AVG CPUE	58	25	139.2	50
Transect 30				
T30-1	64	5	768	10
T30-2	57	5	684	10
T30-3	55	5	660	10
T30-4	49	5	588	10
T30-5	55	5	660	10
Subtotal/AVG CPUE	280	25	672.0	50
Transect 31				
T31-1	91	5	1092	10
T31-2	69	5	828	10
T31-3	35	5	420	10
T31-4	33	5	396	10
T31-5	36	5	432	10
Subtotal/AVG CPUE	264	25	633.6	50
Transect Total/AVG CPUE	**3,475**	**775**	**269.0**	**1,550**

[1] CPUE (Catch Per Unit Effort) = number live per work person hour (no. live / (Tot time/60 min)

T = Transect

Appendix B. Table 2. Summary of Live Unionids and CPUE for the Merrimack River, Lawrence Hydroelectric Project, Essex and Middlesex Counties, MA, August 19-23 and September 10-11, 2024

Survey Location	Number Live Mussels	Survey Time (minutes)	[1] CPUE (no./hour) - Total	Search Area (m^2)
Spot Dives				
Q1	6	10	36	10
Q2	81	10	486	10
Q3	40	10	240	10
Q4	206	10	1236	10
Q5	93	12	465	15
Q6	111	12	555	15
Q7	900	12	4500	15
Q8	850	12	4250	15
Q9	402	12	2010	15
Q10	620	10	3720	18
Q11	130	10	780	18
Q12	119	10	714	18
Q13	525	10	3150	18
Q14	445	10	2670	18
Q15	330	11	1800	15
Q16	354	11	1930.9	15
Q17	268	11	1461.8	15
Q18	82	11	447.3	15
Q19	92	11	501.8	15
Q20	201	11	1096.4	15
Q21	236	11	1287.3	15
Q22	214	11	1167.3	15
Q23	340	11	1854.5	15
Q24	156	11	850.9	15
Q25	320	12	1600	25
Q26	400	12	2000	25
Q27	300	12	1500	25
Q28	325	12	1625	25
Q29	310	12	1550	25
Q30	325	12	1625	25
Q31	62	10	372	10
Q32	40	10	240	10
Q33	25	10	150	10
Q34	55	10	330	10
Q35	52	10	312	10
Q36	57	10	342	10
Q37	21	10	126	10
Q38	21	10	126	10
Q39	21	10	126	10
Spot Dive Total/AVG CPUE	**9,135**	**422**	**1,298.8**	**595**
Grand Total/AVG CPUE	**12,610**	**1,197**	**632.1**	**2,145**

[1] CPUE (Catch Per Unit Effort) = number live per work person hour (no. live / (Tot time/60 min)

Q = Spot Dive

Appendix B. Table 3. Summary of Unionid Species Observed in the Merrimack River, Lawrence Hydroelectric Project, Essex and Middlesex Counties, MA, August 19-23 and September 10-11, 2024

Survey Location/Species	Live	FD	WD	SF
Transect 1				
T1-1				
Alasmidonta undulata	1	0	0	0
Elliptio complanata	38	0	0	0
Pyganodon cataracta	31	0	0	0
Utterbackiana implicata	19	0	0	0
Subtotal	89	0	0	0
T1-2				
Elliptio complanata	17	0	0	0
Lampsilis cariosa [1]	0	0	1	0
Pyganodon cataracta	14	0	0	0
Utterbackiana implicata	12	0	0	0
Subtotal	43	0	1	0
T1-3				
Elliptio complanata	16	0	0	0
Pyganodon cataracta	17	0	0	0
Utterbackiana implicata	10	0	0	0
Subtotal	43	0	0	0
T1-4				
Elliptio complanata	12	0	0	0
Pyganodon cataracta	5	0	0	0
Utterbackiana implicata	3	0	0	0
Subtotal	20	0	0	0
T1-5				
Elliptio complanata	8	0	0	0
Pyganodon cataracta	8	0	0	0
Utterbackiana implicata	6	0	0	0
Subtotal	22	0	0	0
Transect 1 Total	**217**	**0**	**1**	**0**
Transect 2				
T2-1				
No Live Mussels or Shells	0	0	0	0
Subtotal	0	0	0	0
T2-2				
No Live Mussels or Shells	0	0	0	0
Subtotal	0	0	0	0
T2-3				
Elliptio complanata	1	0	0	0
Subtotal	1	0	0	0
T2-4				
No Live Mussels or Shells	0	0	0	0
Subtotal	0	0	0	0

FD = Fresh Dead; WD = Weathered Dead; SF = Subfossil

T= Transect

[1] State Endangered Spoecies

Appendix B. Table 3. Summary of Unionid Species Observed in the Merrimack River, Lawrence Hydroelectric Project, Essex and Middlesex Counties, MA, August 19-23 and September 10-11, 2024

Survey Location/Species	Live	FD	WD	SF
Transect 2 (cont)				
T2-5				
No Live Mussels or Shells	0	0	0	0
Subtotal	0	0	0	0
Transect 2 Total	**1**	**0**	**0**	**0**
Transect 3				
T3-1				
Elliptio complanata	88	0	0	0
Pyganodon cataracta	50	0	0	0
Utterbackiana implicata	43	0	0	0
Subtotal	181	0	0	0
T3-2				
Elliptio complanata	93	0	0	0
Pyganodon cataracta	54	0	0	0
Utterbackiana implicata	45	0	0	0
Subtotal	192	0	0	0
T3-3				
Elliptio complanata	104	0	0	0
Pyganodon cataracta	61	0	0	0
Utterbackiana implicata	49	0	0	0
Subtotal	214	0	0	0
T3-4				
Elliptio complanata	83	0	0	0
Pyganodon cataracta	52	0	0	0
Utterbackiana implicata	36	0	0	0
Subtotal	171	0	0	0
T3-5				
Elliptio complanata	68	0	0	0
Pyganodon cataracta	25	0	0	0
Utterbackiana implicata	32	0	0	0
Subtotal	125	0	0	0
Transect 3 Total	**883**	**0**	**0**	**0**
Transect 4				
T4-1				
Elliptio complanata	4	0	0	0
Subtotal	4	0	0	0
T4-2				
Elliptio complanata	5	0	0	2
Subtotal	5	0	0	2
T4-3				
Elliptio complanata	5	0	0	1
Subtotal	5	0	0	1
T4-4				
Elliptio complanata	5	0	0	0

FD = Fresh Dead; WD = Weathered Dead; SF = Subfossil

T= Transect

Appendix B. Table 3. Summary of Unionid Species Observed in the Merrimack River, Lawrence Hydroelectric Project, Essex and Middlesex Counties, MA, August 19-23 and September 10-11, 2024

Survey Location/Species	Live	FD	WD	SF
Transect 4 (cont)				
T4-4				
Pyganodon cataracta	1	0	0	0
Subtotal	6	0	0	0
T4-5				
Elliptio complanata	2	0	0	0
Subtotal	2	0	0	0
Transect 4 Total	**22**	**0**	**0**	**3**
Transect 5				
T5-1				
Elliptio complanata	114	0	0	0
Pyganodon cataracta	59	0	0	0
Utterbackiana implicata	45	0	0	0
Subtotal	218	0	0	0
T5-2				
Elliptio complanata	89	0	0	0
Pyganodon cataracta	51	0	0	0
Utterbackiana implicata	43	0	0	0
Subtotal	183	0	0	0
T5-3				
Elliptio complanata	102	0	0	0
Pyganodon cataracta	57	0	0	0
Utterbackiana implicata	56	0	0	0
Subtotal	215	0	0	0
T5-4				
Elliptio complanata	64	0	0	0
Pyganodon cataracta	49	0	0	0
Utterbackiana implicata	33	0	0	0
Subtotal	146	0	0	0
T5-5				
Elliptio complanata	76	0	0	0
Pyganodon cataracta	26	0	0	0
Utterbackiana implicata	19	0	0	0
Subtotal	121	0	0	0
Transect 5 Total	**883**	**0**	**0**	**0**
Transect 6				
T6-1				
Elliptio complanata	5	0	0	0
Pyganodon cataracta	1	0	0	0
Subtotal	6	0	0	0
T6-2				
Elliptio complanata	1	0	1	0
Pyganodon cataracta	1	0	1	0
Subtotal	2	0	2	0

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T= Transect

Appendix B. Table 3. Summary of Unionid Species Observed in the Merrimack River, Lawrence Hydroelectric Project, Essex and Middlesex Counties, MA, August 19-23 and September 10-11, 2024

Survey Location/Species	Live	FD	WD	SF
Transect 6 (cont)				
T6-3				
Elliptio complanata	2	0	0	0
Utterbackiana implicata	1	0	0	0
Subtotal	3	0	0	0
T6-4				
Elliptio complanata	1	0	2	0
Utterbackiana implicata	1	0	0	0
Subtotal	2	0	2	0
T6-5				
Elliptio complanata	1	0	0	0
Subtotal	1	0	0	0
Transect 6 Total	**14**	**0**	**4**	**0**
Transect 7				
T7-1				
Elliptio complanata	9	0	0	0
Subtotal	9	0	0	0
T7-2				
Elliptio complanata	9	0	0	0
Subtotal	9	0	0	0
T7-3				
Elliptio complanata	8	0	0	0
Subtotal	8	0	0	0
T7-4				
Elliptio complanata	8	0	0	0
Subtotal	8	0	0	0
T7-5				
Elliptio complanata	8	0	0	0
Subtotal	8	0	0	0
Transect 7 Total	**42**	**0**	**0**	**0**
Transect 8				
T8-1				
No Live Mussels or Shells	0	0	0	0
Subtotal	0	0	0	0
T8-2				
Elliptio complanata	2	0	0	0
Subtotal	2	0	0	0
T8-3				
Elliptio complanata	1	0	0	0
Subtotal	1	0	0	0
T8-4				
Elliptio complanata	2	0	0	0
Subtotal	2	0	0	0
T8-5				
Pyganodon cataracta	5	0	0	0

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Appendix B. Table 3. Summary of Unionid Species Observed in the Merrimack River, Lawrence Hydroelectric Project, Essex and Middlesex Counties, MA, August 19-23 and September 10-11, 2024

Survey Location/Species	Live	FD	WD	SF
Transect 8 (cont)				
T8-5 (cont)				
Utterbackiana implicata	3	0	0	0
Subtotal	8	0	0	0
Transect 8 Total	**13**	**0**	**0**	**0**
Transect 9				
T9-1				
Elliptio complanata	10	0	0	0
Subtotal	10	0	0	0
T9-2				
Elliptio complanata	8	0	0	0
Utterbackiana implicata	3	0	0	0
Subtotal	11	0	0	0
T9-3				
Elliptio complanata	12	0	0	0
Pyganodon cataracta	2	0	0	0
Subtotal	14	0	0	0
T9-4				
Elliptio complanata	4	0	0	0
Subtotal	4	0	0	0
T9-5				
Elliptio complanata	5	0	0	0
Subtotal	5	0	0	0
Transect 9 Total	**44**	**0**	**0**	**0**
Transect 10				
T10-1				
Elliptio complanata	5	0	0	0
Subtotal	5	0	0	0
T10-2				
Elliptio complanata	4	0	0	0
Subtotal	4	0	0	0
T10-3				
Elliptio complanata	6	0	0	0
Subtotal	6	0	0	0
T10-4				
Elliptio complanata	9	0	0	0
Subtotal	9	0	0	0
T10-5				
Elliptio complanata	5	0	0	0
Pyganodon cataracta	1	0	0	0
Subtotal	6	0	0	0
Transect 10 Total	**30**	**0**	**0**	**0**

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T= Transect

Appendix B. Table 3. Summary of Unionid Species Observed in the Merrimack River, Lawrence Hydroelectric Project, Essex and Middlesex Counties, MA, August 19-23 and September 10-11, 2024

Survey Location/Species	Live	FD	WD	SF
Transect 11				
T11-1				
No Live Mussels or Shells	0	0	0	0
Subtotal	0	0	0	0
T11-2				
No Live Mussels or Shells	0	0	0	0
Subtotal	0	0	0	0
T11-3				
Elliptio complanata	1	0	0	0
Pyganodon cataracta	2	0	0	0
Subtotal	3	0	0	0
T11-4				
Utterbackiana implicata	1	0	0	0
Subtotal	1	0	0	0
T11-5				
No Live Mussels or Shells	0	0	0	0
Subtotal	0	0	0	0
Transect 11 Total	**4**	**0**	**0**	**0**
Transect 12				
T12-1				
Pyganodon cataracta	3	0	0	0
Subtotal	3	0	0	0
T12-2				
No Live Mussels or Shells	0	0	0	0
Subtotal	0	0	0	0
T12-3				
No Live Mussels or Shells	0	0	0	0
Subtotal	0	0	0	0
T12-4				
No Live Mussels or Shells	0	0	0	0
Subtotal	0	0	0	0
T12-5				
No Live Mussels or Shells	0	0	0	0
Subtotal	0	0	0	0
Transect 12 Total	**3**	**0**	**0**	**0**
Transect 13				
T13-1				
Elliptio complanata	8	0	0	0
Pyganodon cataracta	4	0	0	0
Utterbackiana implicata	7	0	0	0
Subtotal	19	0	0	0
T13-2				
Elliptio complanata	12	0	0	0
Pyganodon cataracta	8	0	0	0

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T= Transect

Appendix B. Table 3. Summary of Unionid Species Observed in the Merrimack River, Lawrence Hydroelectric Project, Essex and Middlesex Counties, MA, August 19-23 and September 10-11, 2024

Survey Location/Species	Live	FD	WD	SF
Transect 13 (cont)				
T13-2 (cont)				
Utterbackiana implicata	3	0	0	0
Subtotal	23	0	0	0
T13-3				
Elliptio complanata	8	0	0	0
Pyganodon cataracta	6	0	0	0
Utterbackiana implicata	5	0	0	0
Subtotal	19	0	0	0
T13-4				
Elliptio complanata	9	0	0	0
Pyganodon cataracta	6	0	0	0
Utterbackiana implicata	5	0	0	0
Subtotal	20	0	0	0
T13-5				
Elliptio complanata	7	0	0	0
Pyganodon cataracta	4	0	0	0
Utterbackiana implicata	7	0	0	0
Subtotal	18	0	0	0
Transect 13 Total	**99**	**0**	**0**	**0**
Transect 14				
T14-1				
Elliptio complanata	3	0	0	0
Pyganodon cataracta	1	0	0	0
Subtotal	4	0	0	0
T14-2				
Elliptio complanata	3	0	0	0
Pyganodon cataracta	2	0	0	0
Subtotal	5	0	0	0
T14-3				
Elliptio complanata	3	0	0	0
Subtotal	3	0	0	0
T14-4				
Elliptio complanata	3	0	0	0
Subtotal	3	0	0	0
T14-5				
Elliptio complanata	3	0	0	0
Subtotal	3	0	0	0
Transect 14 Total	**18**	**0**	**0**	**0**
Transect 15				
T15-1				
Elliptio complanata	4	0	0	0
Pyganodon cataracta	3	0	0	0
Utterbackiana implicata	3	0	0	0
Subtotal	10	0	0	0

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T= Transect

Appendix B. Table 3. Summary of Unionid Species Observed in the Merrimack River, Lawrence Hydroelectric Project, Essex and Middlesex Counties, MA, August 19-23 and September 10-11, 2024

Survey Location/Species	Live	FD	WD	SF
Transect 15 (cont)				
T15-2				
Elliptio complanata	4	0	0	0
Pyganodon cataracta	3	0	0	0
Utterbackiana implicata	2	0	0	0
Subtotal	9	0	0	0
T15-3				
Elliptio complanata	6	0	0	0
Pyganodon cataracta	2	0	0	0
Utterbackiana implicata	1	0	0	0
Subtotal	9	0	0	0
T15-4				
Elliptio complanata	2	0	0	0
Utterbackiana implicata	3	0	0	0
Subtotal	5	0	0	0
T15-5				
Elliptio complanata	4	0	0	0
Pyganodon cataracta	3	0	0	0
Utterbackiana implicata	2	0	0	0
Subtotal	9	0	0	0
Transect 15 Total	**42**	**0**	**0**	**0**
Transect 16				
T16-1				
No Live Mussels or Shells	0	0	0	0
Subtotal	0	0	0	0
T16-2				
No Live Mussels or Shells	0	0	0	0
Subtotal	0	0	0	0
T16-3				
No Live Mussels or Shells	0	0	0	0
Subtotal	0	0	0	0
T16-4				
No Live Mussels or Shells	0	0	0	0
Subtotal	0	0	0	0
T16-5				
Alasmidonta undulata	0	0	0	1
Subtotal	0	0	0	1
Transect 16 Total	**0**	**0**	**0**	**1**
Transect 17				
T17-1				
Elliptio complanata	6	0	0	0
Pyganodon cataracta	6	0	0	0
Utterbackiana implicata	4	0	0	0
Subtotal	16	0	0	0

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Appendix B. Table 3. Summary of Unionid Species Observed in the Merrimack River, Lawrence Hydroelectric Project, Essex and Middlesex Counties, MA, August 19-23 and September 10-11, 2024

Survey Location/Species	Live	FD	WD	SF
Transect 17 (cont)				
T17-2				
Elliptio complanata	9	0	0	0
Pyganodon cataracta	6	0	0	0
Utterbackiana implicata	5	0	0	0
Subtotal	20	0	0	0
T17-3				
Elliptio complanata	11	0	0	0
Pyganodon cataracta	5	0	0	0
Utterbackiana implicata	7	0	0	0
Subtotal	23	0	0	0
T17-4				
Elliptio complanata	9	0	0	0
Pyganodon cataracta	9	0	0	0
Utterbackiana implicata	7	0	0	0
Subtotal	25	0	0	0
T17-5				
Elliptio complanata	8	0	0	0
Pyganodon cataracta	8	0	0	0
Utterbackiana implicata	5	0	0	0
Subtotal	21	0	0	0
Transect 17 Total	**105**	**0**	**0**	**0**
Transect 18				
T18-1				
Elliptio complanata	7	0	0	0
Lampsilis radiata	2	0	0	0
Pyganodon cataracta	5	0	0	0
Utterbackiana implicata	3	0	0	0
Subtotal	17	0	0	0
T18-2				
Elliptio complanata	5	0	0	0
Pyganodon cataracta	6	0	0	0
Utterbackiana implicata	2	0	0	0
Subtotal	13	0	0	0
T18-3				
Elliptio complanata	7	0	0	0
Pyganodon cataracta	3	0	0	0
Utterbackiana implicata	5	0	0	0
Subtotal	15	0	0	0
T18-4				
Elliptio complanata	10	0	0	0
Pyganodon cataracta	5	0	0	0
Utterbackiana implicata	3	0	0	0
Subtotal	18	0	0	0

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Appendix B. Table 3. Summary of Unionid Species Observed in the Merrimack River, Lawrence Hydroelectric Project, Essex and Middlesex Counties, MA, August 19-23 and September 10-11, 2024

Survey Location/Species	Live	FD	WD	SF
Transect 18 (cont)				
T18-5				
Elliptio complanata	12	0	0	0
Pyganodon cataracta	4	0	0	0
Utterbackiana implicata	4	0	0	0
Subtotal	20	0	0	0
Transect 18 Total	**83**	**0**	**0**	**0**
Transect 19				
T19-1				
Elliptio complanata	4	0	0	0
Pyganodon cataracta	4	0	0	0
Utterbackiana implicata	2	0	0	0
Subtotal	10	0	0	0
T19-2				
Elliptio complanata	6	0	0	0
Pyganodon cataracta	5	0	0	0
Utterbackiana implicata	4	0	0	0
Subtotal	15	0	0	0
T19-3				
Elliptio complanata	7	0	0	0
Pyganodon cataracta	5	0	0	0
Utterbackiana implicata	4	0	0	0
Subtotal	16	0	0	0
T19-4				
Elliptio complanata	2	0	0	0
Pyganodon cataracta	2	0	0	0
Utterbackiana implicata	1	0	0	0
Subtotal	5	0	0	0
T19-5				
Elliptio complanata	2	0	0	0
Utterbackiana implicata	2	0	0	0
Subtotal	4	0	0	0
Transect 19 Total	**50**	**0**	**0**	**0**
Transect 20				
T20-1				
Elliptio complanata	12	0	0	0
Pyganodon cataracta	10	0	0	0
Utterbackiana implicata	7	0	0	0
Subtotal	29	0	0	0
T20-2				
Elliptio complanata	11	0	0	0
Lampsilis radiata	1	0	0	0
Pyganodon cataracta	8	0	0	0

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Appendix B. Table 3. Summary of Unionid Species Observed in the Merrimack River, Lawrence Hydroelectric Project, Essex and Middlesex Counties, MA, August 19-23 and September 10-11, 2024

Survey Location/Species	Live	FD	WD	SF
Transect 20 (cont)				
T20-2 (cont)				
Utterbackiana implicata	6	0	0	0
Subtotal	26	0	0	0
T20-3				
Elliptio complanata	9	0	0	0
Lampsilis radiata	1	0	0	0
Pyganodon cataracta	6	0	0	0
Utterbackiana implicata	4	0	0	0
Subtotal	20	0	0	0
T20-4				
No Live Mussels or Shells	0	0	0	0
Subtotal	0	0	0	0
T20-5				
No Live Mussels or Shells	0	0	0	0
Subtotal	0	0	0	0
Transect 20 Total	**75**	**0**	**0**	**0**
Transect 21				
T21-1				
Elliptio complanata	2	0	0	0
Pyganodon cataracta	1	0	0	0
Utterbackiana implicata	3	0	0	0
Subtotal	6	0	0	0
T21-2				
Elliptio complanata	1	0	0	0
Pyganodon cataracta	2	0	0	0
Subtotal	3	0	0	0
T21-3				
Elliptio complanata	1	0	0	0
Pyganodon cataracta	1	0	0	0
Subtotal	2	0	0	0
T21-4				
Elliptio complanata	3	0	0	0
Pyganodon cataracta	2	0	0	0
Utterbackiana implicata	1	0	0	0
Subtotal	6	0	0	0
T21-5				
Elliptio complanata	2	0	0	0
Subtotal	2	0	0	0
Transect 21 Total	**19**	**0**	**0**	**0**
Transect 22				
T22-1				
Elliptio complanata	4	0	0	0
Pyganodon cataracta	1	0	0	0
Subtotal	5	0	0	0

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T= Transect

Appendix B. Table 3. Summary of Unionid Species Observed in the Merrimack River, Lawrence Hydroelectric Project, Essex and Middlesex Counties, MA, August 19-23 and September 10-11, 2024

Survey Location/Species	Live	FD	WD	SF
Transect 22 (cont)				
T22-2				
Elliptio complanata	3	0	0	0
Pyganodon cataracta	1	0	0	0
Subtotal	4	0	0	0
T22-3				
Elliptio complanata	4	0	0	0
Subtotal	4	0	0	0
T22-4				
Elliptio complanata	3	0	0	0
Subtotal	3	0	0	0
T22-5				
Elliptio complanata	2	0	0	0
Subtotal	2	0	0	0
Transect 22 Total	**18**	**0**	**0**	**0**
Transect 23				
T23-1				
Elliptio complanata	5	0	0	0
Subtotal	5	0	0	0
T23-2				
Elliptio complanata	4	0	0	0
Pyganodon cataracta	2	0	0	0
Subtotal	6	0	0	0
T23-3				
Elliptio complanata	10	0	0	0
Subtotal	10	0	0	0
T23-4				
Elliptio complanata	6	0	0	0
Subtotal	6	0	0	0
T23-5				
Elliptio complanata	4	0	0	0
Subtotal	4	0	0	0
Transect 23 Total	**31**	**0**	**0**	**0**
Transect 24				
T24-1				
Elliptio complanata	4	1	0	0
Subtotal	4	1	0	0
T24-2				
Elliptio complanata	4	0	0	0
Subtotal	4	0	0	0
T24-3				
Elliptio complanata	4	0	0	0
Subtotal	4	0	0	0

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T= Transect

Appendix B. Table 3. Summary of Unionid Species Observed in the Merrimack River, Lawrence Hydroelectric Project, Essex and Middlesex Counties, MA, August 19-23 and September 10-11, 2024

Survey Location/Species	Live	FD	WD	SF
Transect 24 (cont)				
T24-4				
Elliptio complanata	4	0	0	0
Subtotal	4	0	0	0
T24-5				
Elliptio complanata	4	0	0	0
Pyganodon cataracta	1	0	0	0
Subtotal	5	0	0	0
Transect 24 Total	**21**	**1**	**0**	**0**
Transect 25				
T25-1				
Elliptio complanata	4	0	0	0
Subtotal	4	0	0	0
T25-2				
Elliptio complanata	6	0	2	0
Subtotal	6	0	2	0
T25-3				
Elliptio complanata	7	0	0	0
Subtotal	7	0	0	0
T25-4				
Elliptio complanata	7	0	0	0
Pyganodon cataracta	2	0	0	0
Subtotal	9	0	0	0
T25-5				
Elliptio complanata	7	0	0	0
Pyganodon cataracta	2	0	0	0
Subtotal	9	0	0	0
Transect 25 Total	**35**	**0**	**2**	**0**
Transect 26				
T26-1				
No Live Mussels or Shells	0	0	0	0
Subtotal	0	0	0	0
T26-2				
Elliptio complanata	3	0	1	0
Subtotal	3	0	1	0
T26-3				
Elliptio complanata	1	0	1	0
Subtotal	1	0	1	0
T26-4				
No Live Mussels or Shells	0	0	0	0
Subtotal	0	0	0	0
T26-5				
No Live Mussels or Shells	0	0	0	0
Subtotal	0	0	0	0
Transect 26 Total	**4**	**0**	**2**	**0**

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T= Transect

Appendix B. Table 3. Summary of Unionid Species Observed in the Merrimack River, Lawrence Hydroelectric Project, Essex and Middlesex Counties, MA, August 19-23 and September 10-11, 2024

Survey Location/Species	Live	FD	WD	SF
Transect 27				
T27-1				
Elliptio complanata	12	0	0	0
Pyganodon cataracta	2	0	0	0
Subtotal	14	0	0	0
T27-2				
Elliptio complanata	12	0	0	0
Pyganodon cataracta	2	0	0	0
Subtotal	14	0	0	0
T27-3				
Elliptio complanata	12	0	0	0
Pyganodon cataracta	2	0	0	0
Subtotal	14	0	0	0
T27-4				
Elliptio complanata	16	0	0	0
Utterbackiana implicata	2	0	0	0
Subtotal	18	0	0	0
T27-5				
Elliptio complanata	16	0	0	0
Utterbackiana implicata	3	0	0	0
Subtotal	19	0	0	0
Transect 27 Total	**79**	**0**	**0**	**0**
Transect 28				
T28-1	2	0	0	0
Elliptio complanata	2	0	0	0
Subtotal	2	0	0	0
T28-2				
Elliptio complanata	5	0	0	0
Pyganodon cataracta	3	0	0	0
Utterbackiana implicata	1	0	0	0
Subtotal	9	0	0	0
T28-3				
Elliptio complanata	4	1	0	0
Pyganodon cataracta	2	0	0	0
Utterbackiana implicata	2	0	0	0
Subtotal	8	1	0	0
T28-4				
Elliptio complanata	4	0	0	0
Pyganodon cataracta	3	0	0	0
Utterbackiana implicata	1	0	0	0
Subtotal	8	0	0	0
T28-5				
Elliptio complanata	7	0	0	0
Pyganodon cataracta	1	0	0	0

FD = Fresh Dead; WD = Weathered Dead; SF = Subfossil

T= Transect

Appendix B. Table 3. Summary of Unionid Species Observed in the Merrimack River, Lawrence Hydroelectric Project, Essex and Middlesex Counties, MA, August 19-23 and September 10-11, 2024

Survey Location/Species	Live	FD	WD	SF
Transect 28 (cont)				
T28-5 (cont)				
Utterbackiana implicata	3	0	0	0
Subtotal	11	0	0	0
Transect 28 Total	**38**	**1**	**0**	**0**
Transect 29				
T29-1				
Elliptio complanata	3	0	0	0
Pyganodon cataracta	7	0	0	0
Utterbackiana implicata	5	0	0	0
Subtotal	15	0	0	0
T29-2				
Elliptio complanata	4	0	0	0
Pyganodon cataracta	6	0	0	0
Utterbackiana implicata	4	0	0	0
Subtotal	14	0	0	0
T29-3				
Pyganodon cataracta	4	0	0	0
Utterbackiana implicata	5	0	0	0
Subtotal	9	0	0	0
T29-4				
Pyganodon cataracta	4	0	0	0
Utterbackiana implicata	6	0	0	0
Subtotal	10	0	0	0
T29-5				
Pyganodon cataracta	8	0	0	0
Utterbackiana implicata	2	0	0	0
Subtotal	10	0	0	0
Transect 29 Total	**58**	**0**	**0**	**0**
Transect 30				
T30-1				
Pyganodon cataracta	34	0	0	0
Utterbackiana implicata	30	0	0	0
Subtotal	64	0	0	0
T30-2				
Pyganodon cataracta	27	0	0	0
Utterbackiana implicata	30	0	0	0
Subtotal	57	0	0	0
T30-3				
Elliptio complanata	2	0	0	0
Pyganodon cataracta	27	0	0	0
Utterbackiana implicata	26	0	0	0
Subtotal	55	0	0	0

FD = Fresh Dead; WD = Weathered Dead; SF = Subfossil

T= Transect

Appendix B. Table 3. Summary of Unionid Species Observed in the Merrimack River, Lawrence Hydroelectric Project, Essex and Middlesex Counties, MA, August 19-23 and September 10-11, 2024

Survey Location/Species	Live	FD	WD	SF
Transect 30 (cont)				
T30-4				
Pyganodon cataracta	29	0	0	0
Utterbackiana implicata	20	0	0	0
Subtotal	49	0	0	0
T30-5				
Pyganodon cataracta	30	0	0	0
Utterbackiana implicata	25	0	0	0
Subtotal	55	0	0	0
Transect 30 Total	**280**	**0**	**0**	**0**
Transect 31				
T31-1				
Elliptio complanata	34	0	0	0
Pyganodon cataracta	30	0	0	0
Utterbackiana implicata	27	0	0	0
Subtotal	91	0	0	0
T31-2				
Elliptio complanata	17	0	0	0
Pyganodon cataracta	29	0	0	0
Utterbackiana implicata	23	0	0	0
Subtotal	69	0	0	0
T31-3				
Alasmidonta undulata	1	0	0	0
Elliptio complanata	22	0	0	0
Pyganodon cataracta	7	0	0	0
Utterbackiana implicata	5	0	0	0
Subtotal	35	0	0	0
T31-4				
Elliptio complanata	14	0	0	0
Pyganodon cataracta	11	0	0	0
Utterbackiana implicata	8	0	0	0
Subtotal	33	0	0	0
T31-5				
Alasmidonta undulata	1	0	0	0
Elliptio complanata	14	0	0	0
Pyganodon cataracta	12	0	0	0
Utterbackiana implicata	9	0	0	0
Subtotal	36	0	0	0
Transect 31 Total	**264**	**0**	**0**	**0**
Transect Total	**3,475**	**2**	**9**	**4**
Spot Dives				
Q1				
Elliptio complanata	6	0	0	0
Subtotal	6	0	0	0

FD = Fresh Dead; WD = Weathered Dead; SF = Subfossil

T= Transect, Q = Spot Dive

Appendix B. Table 3. Summary of Unionid Species Observed in the Merrimack River, Lawrence Hydroelectric Project, Essex and Middlesex Counties, MA, August 19-23 and September 10-11, 2024

Survey Location/Species	Live	FD	WD	SF
Spot Dives (cont)				
Q2				
Elliptio complanata	29	0	0	0
Lampsilis radiata	2	0	0	0
Pyganodon cataracta	23	0	0	0
Strophitus undulatus [2]	1	0	0	0
Utterbackiana implicata	26	0	0	0
Subtotal	81	0	0	0
Q3				
Elliptio complanata	18	0	0	0
Pyganodon cataracta	13	0	0	0
Utterbackiana implicata	9	0	0	0
Subtotal	40	0	0	0
Q4				
Elliptio complanata	120	0	0	0
Pyganodon cataracta	56	0	0	0
Utterbackiana implicata	30	0	0	0
Subtotal	206	0	0	0
Q5				
Elliptio complanata	3	0	0	0
Pyganodon cataracta	50	0	0	0
Utterbackiana implicata	40	0	0	0
Subtotal	93	0	0	0
Q6				
Elliptio complanata	5	0	0	0
Pyganodon cataracta	68	0	0	0
Utterbackiana implicata	38	0	0	0
Subtotal	111	0	0	0
Q7				
Elliptio complanata	500	0	0	0
Pyganodon cataracta	250	0	0	0
Utterbackiana implicata	150	0	0	0
Subtotal	900	0	0	0
Q8				
Elliptio complanata	500	0	0	0
Pyganodon cataracta	200	0	0	0
Utterbackiana implicata	150	0	0	0
Subtotal	850	0	0	0
Q9				
Elliptio complanata	260	0	0	0
Pyganodon cataracta	83	0	0	0
Utterbackiana implicata	59	0	0	0
Subtotal	402	0	0	0

FD = Fresh Dead; WD = Weathered Dead; SF = Subfossil

Q = Spot Dive

[2] Species of Special Concern

Appendix B. Table 3. Summary of Unionid Species Observed in the Merrimack River, Lawrence Hydroelectric Project, Essex and Middlesex Counties, MA, August 19-23 and September 10-11, 2024

Survey Location/Species	Live	FD	WD	SF
Spot Dives (cont)				
Q10				
Elliptio complanata	200	0	0	0
Pyganodon cataracta	300	0	0	0
Utterbackiana implicata	120	0	0	0
Subtotal	620	0	0	0
Q11				
Elliptio complanata	3	0	0	0
Pyganodon cataracta	91	0	0	0
Utterbackiana implicata	36	0	0	0
Subtotal	130	0	0	0
Q12				
Alasmidonta undulata	1	0	0	0
Elliptio complanata	9	0	0	0
Pyganodon cataracta	78	0	0	0
Utterbackiana implicata	31	0	0	0
Subtotal	119	0	0	0
Q13				
Elliptio complanata	175	0	0	0
Pyganodon cataracta	250	0	0	0
Utterbackiana implicata	100	0	0	0
Subtotal	525	0	0	0
Q14				
Elliptio complanata	25	0	0	0
Pyganodon cataracta	300	0	0	0
Utterbackiana implicata	120	0	0	0
Subtotal	445	0	0	0
Q15				
Elliptio complanata	50	0	0	0
Pyganodon cataracta	200	0	0	0
Utterbackiana implicata	80	0	0	0
Subtotal	330	0	0	0
Q16				
Elliptio complanata	29	0	0	0
Pyganodon cataracta	225	0	0	0
Utterbackiana implicata	100	0	0	0
Subtotal	354	0	0	0
Q17				
Elliptio complanata	38	0	0	0
Pyganodon cataracta	150	0	0	0
Utterbackiana implicata	80	0	0	0
Subtotal	268	0	0	0
Q18				
Elliptio complanata	3	0	0	0

FD = Fresh Dead; WD = Weathered Dead; SF = Subfossil

Q = Spot Dive

Appendix B. Table 3. Summary of Unionid Species Observed in the Merrimack River, Lawrence Hydroelectric Project, Essex and Middlesex Counties, MA, August 19-23 and September 10-11, 2024

Survey Location/Species	Live	FD	WD	SF
Spot Dives (cont)				
Q18 (cont)				
Pyganodon cataracta	56	0	0	0
Utterbackiana implicata	23	0	0	0
Subtotal	82	0	0	0
Q19				
Elliptio complanata	6	0	0	0
Pyganodon cataracta	62	0	0	0
Utterbackiana implicata	24	0	0	0
Subtotal	92	0	0	0
Q20				
Alasmidonta undulata	1	0	0	0
Elliptio complanata	100	0	0	0
Pyganodon cataracta	60	0	0	0
Utterbackiana implicata	40	0	0	0
Subtotal	201	0	0	0
Q21				
Elliptio complanata	6	0	0	0
Pyganodon cataracta	150	0	0	0
Utterbackiana implicata	80	0	0	0
Subtotal	236	0	0	0
Q22				
Elliptio complanata	46	0	0	0
Pyganodon cataracta	92	0	0	0
Utterbackiana implicata	76	0	0	0
Subtotal	214	0	0	0
Q23				
Elliptio complanata	125	0	0	0
Pyganodon cataracta	125	0	0	0
Utterbackiana implicata	90	0	0	0
Subtotal	340	0	0	0
Q24				
Elliptio complanata	34	0	0	0
Pyganodon cataracta	70	0	0	0
Utterbackiana implicata	52	0	0	0
Subtotal	156	0	0	0
Q25				
Elliptio complanata	70	0	0	0
Pyganodon cataracta	150	0	0	0
Utterbackiana implicata	100	0	0	0
Subtotal	320	0	0	0
Q26				
Elliptio complanata	100	0	0	0
Pyganodon cataracta	200	0	0	0

FD = Fresh Dead; WD = Weathered Dead; SF = Subfossil

Q = Spot Dive

Appendix B. Table 3. Summary of Unionid Species Observed in the Merrimack River, Lawrence Hydroelectric Project, Essex and Middlesex Counties, MA, August 19-23 and September 10-11, 2024

Survey Location/Species	Live	FD	WD	SF
Spot Dives (cont)				
Q26 (cont)				
Utterbackiana implicata	100	0	0	0
Subtotal	400	0	0	0
Q27				
Elliptio complanata	75	0	0	0
Pyganodon cataracta	150	0	0	0
Utterbackiana implicata	75	0	0	0
Subtotal	300	0	0	0
Q28				
Elliptio complanata	125	0	0	0
Pyganodon cataracta	125	0	0	0
Utterbackiana implicata	75	0	0	0
Subtotal	325	0	0	0
Q29				
Elliptio complanata	60	0	0	0
Pyganodon cataracta	150	0	0	0
Utterbackiana implicata	100	0	0	0
Subtotal	310	0	0	0
Q30				
Elliptio complanata	75	0	0	0
Pyganodon cataracta	150	0	0	0
Utterbackiana implicata	100	0	0	0
Subtotal	325	0	0	0
Q31				
Elliptio complanata	23	0	0	0
Pyganodon cataracta	26	0	0	0
Utterbackiana implicata	13	0	0	0
Subtotal	62	0	0	0
Q32				
Elliptio complanata	14	0	0	0
Pyganodon cataracta	16	0	0	0
Utterbackiana implicata	10	0	0	0
Subtotal	40	0	0	0
Q33				
Elliptio complanata	13	0	0	0
Pyganodon cataracta	7	0	0	0
Utterbackiana implicata	5	0	0	0
Subtotal	25	0	0	0
Q34				
Elliptio complanata	26	0	0	0
Pyganodon cataracta	17	0	0	0
Utterbackiana implicata	12	0	0	0
Subtotal	55	0	0	0

FD = Fresh Dead; WD = Weathered Dead; SF = Subfossil

Q = Spot Dive

Appendix B. Table 3. Summary of Unionid Species Observed in the Merrimack River, Lawrence Hydroelectric Project, Essex and Middlesex Counties, MA, August 19-23 and September 10-11, 2024

Survey Location/Species	Live	FD	WD	SF
Spot Dives (cont)				
Q35				
Elliptio complanata	23	0	0	0
Pyganodon cataracta	16	0	0	0
Utterbackiana implicata	13	0	0	0
Subtotal	52	0	0	0
Q36				
Elliptio complanata	32	0	0	0
Pyganodon cataracta	14	0	0	0
Utterbackiana implicata	11	0	0	0
Subtotal	57	0	0	0
Q37				
Elliptio complanata	10	0	0	0
Pyganodon cataracta	11	0	0	0
Subtotal	21	0	0	0
Q38				
Elliptio complanata	11	0	0	0
Pyganodon cataracta	10	0	0	0
Subtotal	21	0	0	0
Q39				
Elliptio complanata	11	0	0	0
Pyganodon cataracta	10	0	0	0
Subtotal	21	0	0	0
Spot Dive Total	**9,135**	**0**	**0**	**0**
Grand Total	**12,610**	**2**	**9**	**4**

FD = Fresh Dead; WD = Weathered Dead; SF = Subfossil

Q = Spot Dive

Appendix C: Scientific Collectors Permit

MASSWILDLIFE

DIVISION OF
FISHERIES & WILDLIFE
1 Rabbit Hill Road, Westborough, MA 01581
p: (508) 389-6300 | f: (508) 389-7890
MASS.GOV/MASSWILDLIFE

Scientific Collection Permit

INVERTEBRATES

VALID
2024

Normandeau Associates
Joseph Snavely
156 Echo Drive
Chambersburg,PA 17202

Date: 9/20/2024
NHESP Tracking #: 23-0072
Permit #: 1084.24WI

Subpermittees: Joe Battalgia, Richard Bistline, John Miller, Dan Geiger, Jason Gagnon, Ashley Przybyla, Erik Feldotto, Jack Dovidio, Erik Rydbek

is (are) hereby authorized, in accordance with the provisions of Section 4, Chapter 131 and 131A of the Massachusetts General Laws, to remove from the wild within the Commonwealth, subject to conditions set forth below, the following species and numbers:

May hand capture all species of freshwater mussels and odonates as part of presence/absence survey. Must follow the NHESP endangered species survey guidelines and/or approved scope of work. NHESP species observation forms must be submitted for all state-listed rare species encountered via the Division's online data portal. Within 10 days of the first observation of a given state-listed species, a NHESP species observation form must be submitted to the NHESP. All other NHESP species observation forms reporting subsequent observations of a given species shall be submitted by December 31.

The following method(s) of taking is (are) hereby authorized:

Hand Capture

Collection activities under this permit shall be restricted to the following locations, subject to the approval of private landowners

Merrimack River, Lawrence Hydro

All specimens secured under this permit shall be donated to the following institutions:

All live specimens shall be released. A representative collection of spent shells may be collected and submitted as voucher specimen to NHESP; others may be donated to a university or research institution.

No specimen taken under the authority of this permit may be sold. No specimen may be transferred to another not duly licensed.

This permit of a copy thereof shall be carried at all times by the permittee and subpermittee(s) while engaged in the activities authorized herein.

This permit does not absolve the permittee from compliance in full with any and all other applicable federal, state and local requirements, including the acquisition of a federal endangered species permit if required.

Upon expiration of this permit, a complete report detailing all collection activities shall be filed with this office and must include a listing of all species taken, numbers of specimens, and the disposition of same.

This permit, unless sooner revoked for cause, shall expire on December 31 of the year of issue.

Mark S. Tisa

Mark S. Tisa, Director

Appendix D: Project Photographs

Photo # 1 Date: 22 August 2024

Representative image of water level and typical shoreline habitat upstream of the Essex Dam and in the Project impoundment

Photo # 2 Date: 22 August 2024

Representative image of survey efforts in 5-7 feet of water upstream of the Essex Dam and in the Project impoundment.

NORMANDEAU ASSOCIATES
Environmental Consultants

Project No. 24837.000
Date: 19-23 August and 10-11 September, 2024
Name: Lawrence Hydro
Merrimack River

Photo # 3 Date: 22 August 2024

Representative image of a rocky shoreline upstream of the Essex Dam and in the Project impoundment.

Photo # 4 Date: 30 August 2024

Representative image of the developed shoreline along the left descending bank, downstream of the Essex Dam.

NORMANDEAU ASSOCIATES
Environmental Consultants

Project No. 24837.000
Date: 19-23 August and 10-11 September, 2024
Name: Lawrence Hydro
Merrimack River

Photo # 5 Date: 22 August 2024

Representative image of substrate and submerged aquatic vegetation densities downstream of the Essex Dam.

Photo # 6 Date: 22 August 2024

Confluence of the Spicket River with the mainstem Merrimack River.

Photo # 7 Date: 30 August 2024

Representative image of the shoreline along the right descending bank, downstream of the Essex Dam.

Photo # 8 Date: 10 September 2024

Image of the North Canal.

NORMANDEAU ASSOCIATES
Environmental Consultants

Project No. 24837.000
Date: 19-23 August and 10-11 September, 2024
Name: Lawrence Hydro
Merrimack River

Photo # 9 Date: 10 September 2024
Image of the lower North Canal, facing downstream discharge gates.

Photo # 10 Date: 30 August 2024
Downstream center channel looking upstream towards Essex Dam.

NORMANDEAU ASSOCIATES
Environmental Consultants

Project No. 24837.000
Date: 19-23 August and 10-11 September, 2024
Name: Lawrence Hydro
Merrimack River

Photo # 11 Date: 10 September 2024
Center channel directly downstream of the Essex Dam.

Photo # 12 Date: 10 September 2024
Image of the substrate downstream of Essex Dam.

NORMANDEAU ASSOCIATES
Environmental Consultants

Project No. 24837.000
Date: 19-23 August and 10-11 September, 2024
Name: Lawrence Hydro
Merrimack River

Photo # 13 Date: 10 September 2024

Spot Dive location in the lower end of the survey reach downstream of Essex Dam.

Photo # 14 Date: 10 September 2024

Representative image of the water level downstream of Essex Dam during the September effort.

NORMANDEAU ASSOCIATES
Environmental Consultants

Photo # 15 Date: 22 August 2024
Representative image of a live creeper (*Strophitus undulatus*)- lateral view.

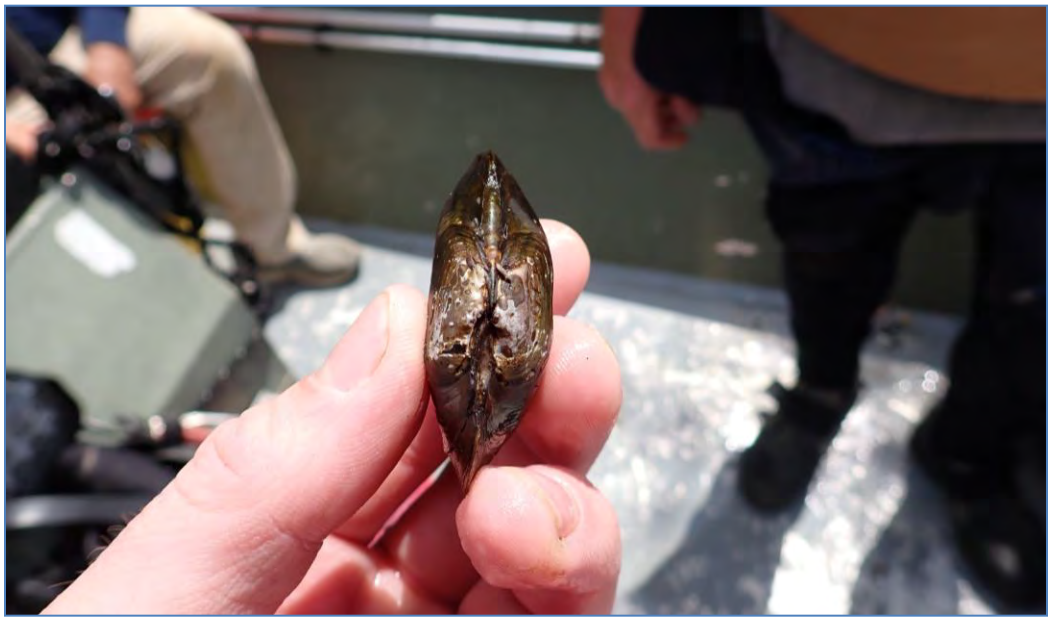

Photo # 16 Date: 22 August 2024
Representative image of a live creeper (*S. undulatus*)- dorsal view.

NORMANDEAU ASSOCIATES
Environmental Consultants

Project No. 24837.000
Date: 19-23 August and 10-11 September, 2024
Name: Lawrence Hydro
Merrimack River

Photo # 17 Date: 10 September 2024

Representative image of a live triangle floater (*Alasmidonta undulata*)- lateral view.

Photo # 18 Date: 10 September 2024

Representative image of a live triangle floater (*A. undulata*)- dorsal view.

NORMANDEAU ASSOCIATES
Environmental Consultants

Project No. 24837.000
Date: 19-23 August and 10-11 September, 2024
Name: Lawrence Hydro
Merrimack River

Photo # 19 Date: 20 August 2024

Representative image of a live eastern elliptio (*Elliptio complanata*)- lateral view.

Photo # 20 Date: 20 August 2024

Representative image of a live eastern elliptio (*E. complanata*)- dorsal view.

Photo # 21 Date: 20 August 2024

Representative image of a live eastern lampmussel (*Lampsilis radiata*)- lateral view.

Photo # 22 Date: 20 August 2024

Representative image of a live eastern lampmussel (*L. radiata*)- dorsal view.

Photo # 23 Date: 18 August 2024

Representative image of a live eastern floater (*Pyganodon cataracta*)- lateral view.

Photo # 24 Date: 18 August 2024

Representative image of a live eastern floater (*P. cataracta*)- dorsal view.

NORMANDEAU ASSOCIATES
Environmental Consultants

Project No. 24837.000
Date: 19-23 August and 10-11 September, 2024
Name: Lawrence Hydro
Merrimack River

Photo # 25 Date: 18 August 2024

Representative image of a live juvenile eastern floater (*P. cataracta*)- lateral view.

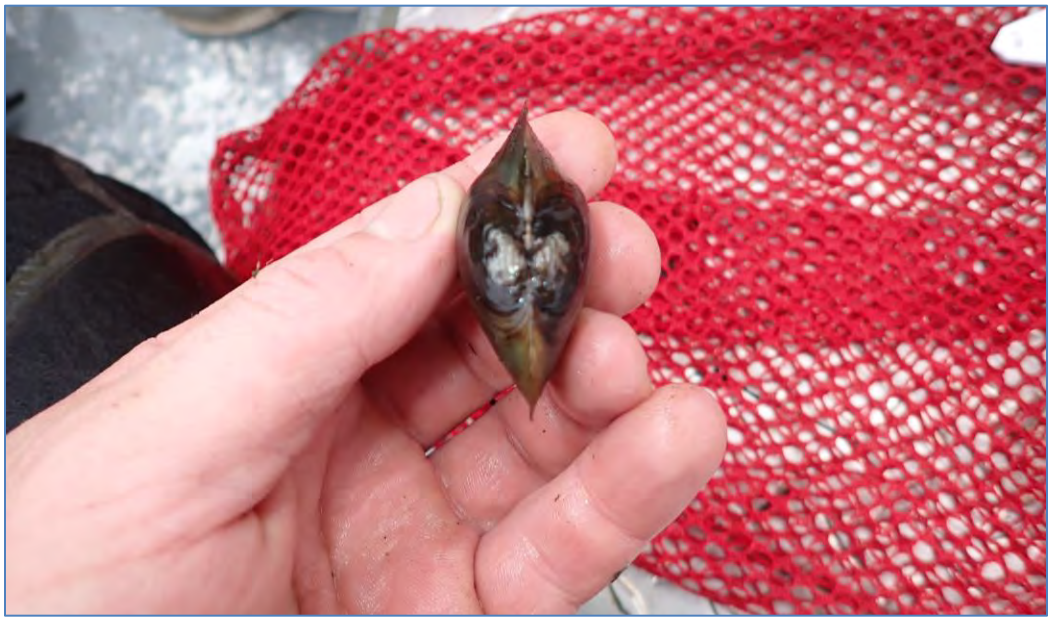

Photo # 26 Date: 18 August 2024

Representative image of a live juvenile eastern floater (*P. cataracta*)- dorsal view.

NORMANDEAU ASSOCIATES
Environmental Consultants

Project No. 24837.000
Date: 19-23 August and 10-11 September, 2024
Name: Lawrence Hydro
Merrimack River

Photo # 27 Date: 22 August 2024

Representative image of a weather dead yellow lampmussel (*Lamplilis cariosa*) shell- lateral view

Photo # 28 Date: 22 August 2024

Representative image of a weather dead yellow lampmussel (*L. cariosa*) shell- internal view.

NORMANDEAU ASSOCIATES
Environmental Consultants

Project No. 24837.000
Date: 19-23 August and 10-11 September, 2024
Name: Lawrence Hydro
Merrimack River

Photo # 29 Date: 22 August 2024

Representative image of a weather dead yellow lampmussel (*L. cariosa*) shell- dorsal view.

Photo # 30 Date: 23 August 2024

Image of a mixed catch of juvenile eastern floater (*P. cataracta*) and alewife floater (*Utterbackiana implicata*).

NORMANDEAU ASSOCIATES
Environmental Consultants

Project No. 24837.000
Date: 19-23 August and 10-11 September, 2024
Name: Lawrence Hydro
Merrimack River

Photo # 31 Date: 23 August 2024
Image of a weathered dead alewife floater (*U. implicata*)- lateral view.

Photo # 32 Date: 23 August 2024
Image of a weathered dead alewife floater (*U. implicata*)- dorsal view.

NORMANDEAU ASSOCIATES
Environmental Consultants

Project No. 24837.000
Date: 19-23 August and 10-11 September, 2024
Name: Lawrence Hydro
Merrimack River

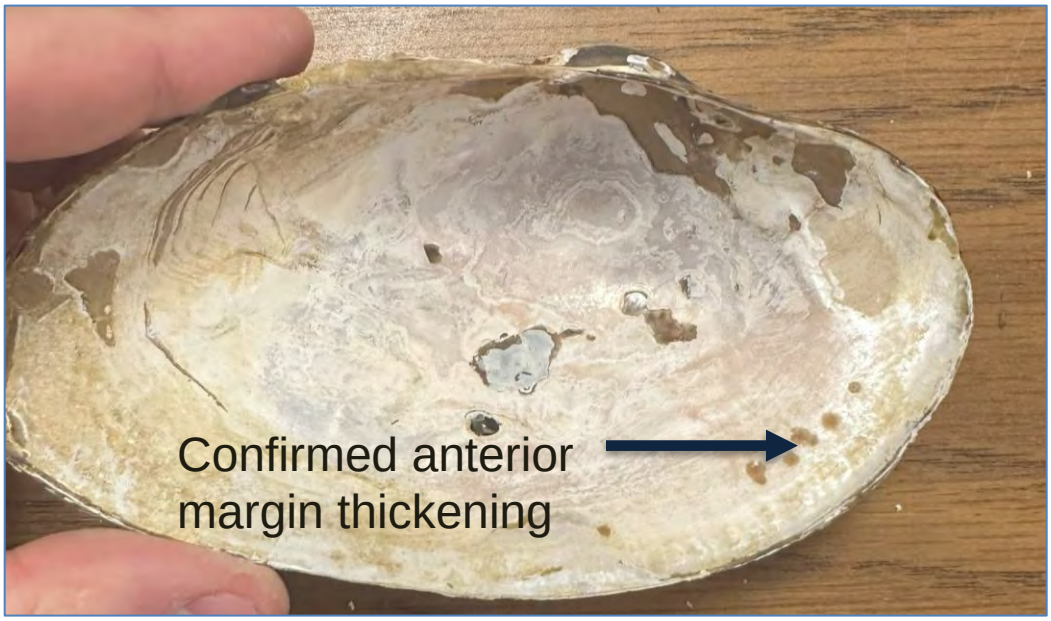

Photo # 33 Date: 23 August 2024

Image of a weathered dead alewife floater (*U. implicata*)- internal view.

Photo # 34 Date: 23 August 2024

Portion of a midden downstream of Essex Dam along the right descending bank.

NORMANDEAU ASSOCIATES
Environmental Consultants

Project No. 24837.000
Date: 19-23 August and 10-11 September, 2024
Name: Lawrence Hydro
Merrimack River

Photo # 35 Date: 23 August 2024

Portion of a midden downstream of Essex Dam along the right descending bank.

Photo # 36 Date: 23 August 2024

Portion of a midden downstream of Essex Dam along the right descending bank.

NORMANDEAU ASSOCIATES
Environmental Consultants

Project No. 24837.000
Date: 19-23 August and 10-11 September, 2024
Name: Lawrence Hydro
Merrimack River

Photo # 37 Date: 18 August 2024

Representative image of a mixed catch of alewife floater (*U. implicata*) and eastern floater (*P. cataracta*)- lateral views.

Photo # 38 Date: 20 August 2024

Representative image of a mixed catch of alewife floater (*U. implicata*), eastern floater (*P. cataracta*) and eastern elliptio *(E. complanata*)- lateral views.

NORMANDEAU ASSOCIATES
Environmental Consultants

Project No. 24837.000
Date: 19-23 August and 10-11 September, 2024
Name: Lawrence Hydro
Merrimack River

Photo # 39 Date: 23 August 2024

Representative image of a mixed catch from Transect 31 of eastern elliptio *(E. complanata*- left) and triangle floater *(A. undulata*- right)- lateral views.

Photo # 40 Date: 20 August 2024

Representative image of a mixed catch of eastern elliptio *(E. complanata*- top) and eastern lampmussel *(L. radiata*- bottom)- lateral views.

Photo # 41 Date: 10 September 2024

Representative image of a mixed catch downstream of Essex Dam.

Photo # 42 Date: 18 August 2024

Representative image of a mixed catch in the lower impoundment upstream of Essex Dam.

NORMANDEAU ASSOCIATES
Environmental Consultants

Project No. 24837.000
Date: 19-23 August and 10-11 September, 2024
Name: Lawrence Hydro
Merrimack River