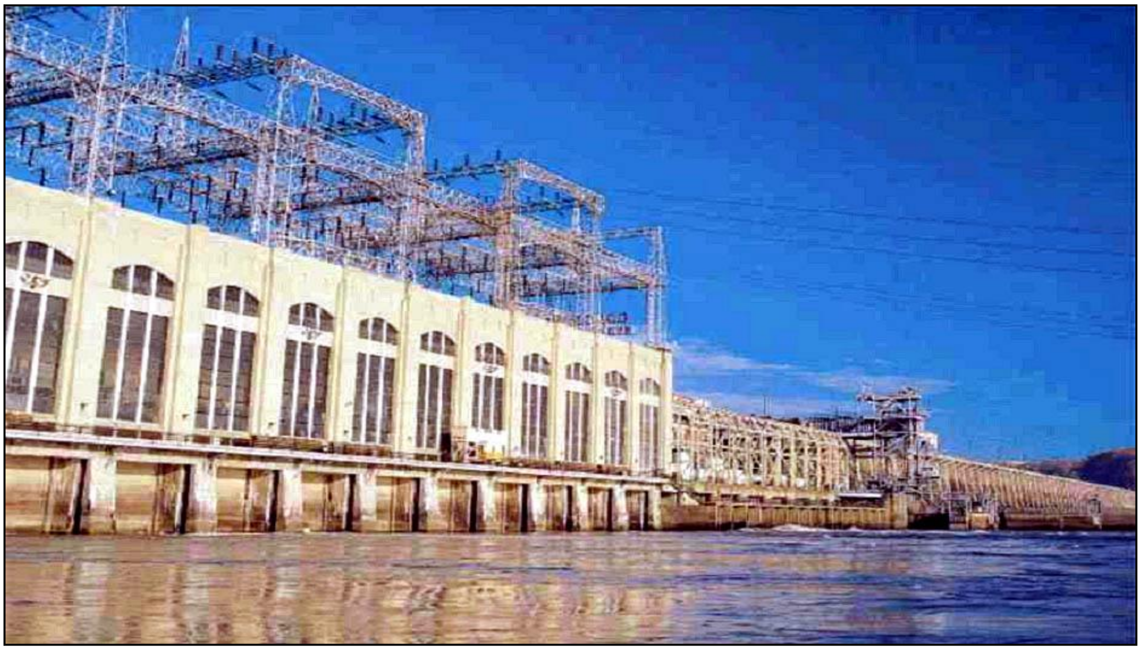
FRESHWATER MUSSEL CHARACTERIZATION STUDY BELOW CONOWINGO DAM

RSP 3.19

CONOWINGO HYDROELECTRIC PROJECT

FERC PROJECT NUMBER 405



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EXECUTIVE SUMMARY

A freshwater mussel study was conducted in a 4.5-mile reach of the Susquehanna River below Conowingo Dam in Maryland, as required for the FERC relicensing process for the Exelon Conowingo Hydroelectric Project (FERC No. 405). The objectives of this study were to characterize the mussel community in the Susquehanna River below Conowingo Dam, and to determine if plant operations at the dam affect the mussel community in this river reach.

Fieldwork was conducted in two phases, including a 2010 survey conducted by Normandeau Associates during the period from August 9-September 3, and a 2012 survey conducted by Biodrawversity from July 16-19. Fieldwork included semi-quantitative (i.e., timed searches) surveys conducted by wading, snorkeling, or SCUBA diving at 128 stations distributed throughout the study reach, as well as quantitative (i.e., quadrat sampling) surveys at six locations. Descriptive statistics were used to examine relationships between mussel distribution, abundance, and parameters related to location or habitat. Quantitative surveys yielded population estimates for each species at six sites. Shell lengths of each species were recorded and the data were used for a length-frequency analysis. The 2010 and 2012 field studies were supplemented with a search for historic records, as well as results of recent surveys conducted by Maryland Department of Natural Resources and Marshall University.

During semi-quantitative surveys, five native species were observed and a total of 6,301 mussels were counted. Mussels were detected at 121 of 128 stations (94.5 percent), and a mean of 1.8 species (range = 0-5 species) were found per station. Species included eastern elliptio (*Elliptio complanata*; 6,069 individuals found, at 120 stations), alewife floater (*Anodonta implicata*; 133 individuals found, at 46 stations), eastern floater (*Pyganodon cataracta*; 67 individuals found, at 29 stations), tidewater mucket (*Leptodea ochracea*; 25 individuals found, at 22 stations), and eastern lampmussel (*Lampsilis radiata*; seven individuals found, at seven stations). For all species combined, catch-per-unit-effort (CPUE) ranged from 0-612 mussels/hour (mean = 64.1 mussels/hour, standard deviation = 94.5) among the stations. In addition to the five native mussel species, the non-native zebra mussel (*Dreissena polymorpha*) was detected at nine stations and the Asian clam (*Corbicula fluminea*) was detected at nearly every station.

The predominant habitat characteristics of the study reach were boulder and bedrock formations, shallow depths, and moderate to strong flow velocities. Although these features are not generally ideal for most freshwater mussels, a significant amount of fine-scale habitat heterogeneity was present, including patches of more suitable habitat such as hydraulic refugia behind boulders, bedrock outcrops, and islands; and interstitial sand and gravel. Mussel densities in these small patches often exceeded 10-20 per square meter. Mussel CPUE was nearly three times higher in tidal areas than non-tidal areas (115.1 vs. 38.3 mussels/hour), and both alewife floater and tidewater mucket were nearly five times more abundant in tidal areas. Within non-tidal areas, mussel CPUE was typically highest in pools and side channels, and lowest in shallow runs and riffles. There was a strong inverse relationship between mussel CPUE and Low Flow Shear Stress, and a weaker inverse relationship between mussel CPUE and High Flow Shear Stress. There was a significant trend of higher mussel CPUE, as well as higher variability in CPUE, with increasing distance from the dam.

Population estimates (of all species combined) for the 450m^2 (15x30 meters) quantitative survey plots ranged from 50 mussels (90% Confidence Interval (CI) = -32-132 mussels) to 1,920 mussels (90% CI = 623-3,217 mussels). The highest population estimates were for two sites (QS-3 and QS-4) in the secondary channel of McGibney Island. A total of 117 mussels were observed during quantitative surveys, including 111 eastern elliptio (95.7 percent), and three individuals each of alewife floater and eastern floater. Mussels were generally associated with quadrats where relatively fine materials (silt, sand, and gravel) accounted for between 30-80 percent of total substrate.

A distinct lack of juveniles and young mussels was noted for all species, particularly for alewife floater, tidewater mucket, eastern floater, and eastern lampmussel. Eastern elliptio exhibited a broad range of sizes –11.8-170.0 mm – yet only eight (1.1 percent of the 691 measured) were smaller than 40.0 mm in length. These skewed size distributions may be partly attributed to sampling bias, as both buried mussels and those living under rocks would have been undersurveyed during the semi-quantitative surveys.

The study documents a regionally significant mussel assemblage downstream of the Conowingo Dam. Three of the five species present are ranked with respect to rarity by the state of Maryland, although none are on the state's official Threatened and Endangered Species List and none are federally endangered. Findings indicate that mussels occur throughout the project area, and at highly variable abundances. Freshwater mussel CPUE increased with distance from Conowingo Dam and was particularly high in tidal areas of the study reach. The patchy distribution of mussels in the study reach is likely influenced by a combination of factors, including zones of unsuitable flow conditions related to the dam and associated hydropower operations as well as zones of naturally unsuitable flow conditions and substrate. These factors are confounded, and are difficult to measure or fully characterize with a descriptive mussel survey such as this. As a result, the specific magnitude or direction of the dam's influence on freshwater mussels downstream could not be determined.

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Exelon	Exelon Generation Company, LLC
FERC	Federal Energy Regulatory Commission
GPS	Global Positioning System
m	meter
mm	millimeter
MDNR	Maryland Department of Natural Resources
MW	Megawatt
NHP	Natural Heritage Program
SCUBA	self contained underwater breathing apparatus

1. INTRODUCTION

Exelon Generation Company, LLC (Exelon) has initiated with the Federal Energy Regulatory Commission (FERC) the process of relicensing the 573-megawatt Conowingo Hydroelectric Project. Exelon is applying for a new license using FERC's Integrated Licensing Process, and filed its Pre-Application Document and Notice of Intent with FERC in March 2009. In February 2010, FERC issued the final study plan determination that required Exelon to conduct a freshwater mussel study in the Susquehanna River below Conowingo Dam. The objectives of this study were to characterize the freshwater mussel community in the Susquehanna River below Conowingo Dam, and to determine if plant operations at the dam affect the mussel community in this river reach. Field studies included both semi-quantitative and quantitative mussel surveys in a 4.5-mile reach of the Susquehanna River. Habitat maps and models, historic mussel records from the study reach, and field data collected by Maryland Department of Natural Resources (MDNR) and Marshall University supplemented Exelon's field studies. This report integrates results of Exelon's 2010 mussel survey and a second mussel survey in 2012 to fill gaps from the 2010 survey; it also includes a re-analysis of the full dataset.

2. BACKGROUND

2.1 Freshwater Mussels

Freshwater mussels are some of the most imperiled animals in North America, having experienced significant declines in species diversity and abundance during the past several decades (Williams et al. 1993, Wilcove et al. 1998) due largely to pollution, water quality degradation, and habitat loss (Strayer et al. 2004). These long-lived animals are important sentinels of the health of aquatic ecosystems and they are subjects of research and monitoring. Their importance to aquatic ecosystems has been well described (Strayer et al. 2004, Strayer 2008). Freshwater mussels provide important ecosystem services by filtering algae and bacteria from the water column and benthic environment, and influencing nutrient dynamics through excretion and biodeposition (Vaughn and Hakenkamp 2001).

Adult freshwater mussels are relatively sessile, benthic organisms, but dispersal and migration are fundamental components of their unique life history (Strayer 2008). As larvae (called glochidia), most freshwater mussel species must attach to the gills or fins of a host fish for several weeks before transforming into juvenile mussels (Kat 1984, Barnhart et al. 2008). The parasitic phase is also one of the only periods in a mussel's life cycle when long-distance dispersal is possible (Haag and Warren 1998). Adult mussels live at the bottom of rivers and lakes, remaining partially or fully buried in the substrate. They are long-lived animals; some species in the Susquehanna watershed may live longer than 50 years. The biology and ecology of freshwater mussels, including species that occur in the lower Susquehanna watershed, is reviewed in Strayer and Jirka (1997), Nedeau et al. (2000), Nedeau (2008), and Strayer (2008).

Fourteen freshwater mussel species occur in the Susquehanna River watershed (Bogan and Proch 1997, Strayer and Fetterman 1999) and two additional species are found in parts of rivers close to the Chesapeake Bay elsewhere in Maryland's coastal plain (Ashton 2010). Twelve of these sixteen species are thought to occur in the general region of the lower Susquehanna River and freshwater Chesapeake Bay, but only 7 species have been documented in close proximity to the study reach (Table 2.1-1; Table 4.1-2; Ashton 2009; Ashton 2011).

2.2 Study Area Description

The study area encompasses a 4.5-mile reach of the Susquehanna River directly downstream of Conowingo Dam (Figure 2.2-1), extending from the dam to the southern tip of Spencer Island. The lower 1.7 miles of this reach is tidally influenced. The predominant habitat characteristics of the reach include extensive boulder and bedrock formations, a wide (>4,000 feet across in tidal areas), shallow river channel, and moderate to fast water velocities. The coarse, rocky river bottom is interspersed with small areas of mixed sand, gravel, and cobble; these substrate types typically occur near shorelines and islands, in hydraulic refugia behind boulders and bedrock formations, and in low points, or on top of bedrock formations. Water depth is typically less than 5-6 feet deep during baseflow conditions. Hydropower operations at Conowingo Dam subject this reach to wide subdaily flow fluctuations, ranging from a low of 3,500 cubic feet per second (cfs) to as much as 86,000 cfs during peak generation. Water velocities are generally fast, particularly along the western side of the river where habitat is classified as shallow riffle and run. Deeper pools and runs with slower water velocities are also present, particularly toward the downstream end of the study reach, where tidal influence regularly creates additional large areas of relatively deep water and slow water velocities. Submerged aquatic vegetation is sparse, confined to areas of hydraulic refuge near islands in the downstream end of the study reach. Emergent vegetation, notably American water-willow (*Justicia americana*) is abundant on low islands and near shorelines that are subjected to daily flooding.

3. METHODS

3.1 Search for Published and Unpublished Locality Records

Historic records for mussels in the Susquehanna River downstream of Conowingo Dam were compiled from data provided by MDNR, a web-based search for published records, and the following museums:

- The Academy of Natural Sciences of Philadelphia, PA;
- The American Museum of Natural History in New York City, NY;
- The Canadian Museum of Nature in Ottawa, Canada;
- The Carnegie Museum in Pittsburgh, PA;
- The Delaware Museum of Natural History in Wilmington, DE;
- The Illinois Natural History Survey in Champaign, IL;
- The National Museum of Natural History in Washington, DC;
- The North Carolina Museum of Natural Sciences in Raleigh, NC; and
- The Ohio State Museum of Biological Diversity in Columbus, OH.

3.2 Semi-Quantitative Mussel Survey

Site Selection: A total of 128 stations were surveyed (Figure 3.2-1, Appendix A). Stations were selected to cover as much of the project area as possible and to represent the range of habitat conditions present. A map of habitat compartments (i.e., areas with similar habitat features) was developed for non-tidal areas of the study reach and stations were selected within each of the compartment types (Table 3.2-1). For the 2010 survey, stations were selected in the field and locations were biased toward those with conditions that personnel considered suitable for mussels. For the 2012 survey, stations were selected to fill gaps in survey coverage from the 2010 survey. Stations were selected in advance using Geographic Information Systems (GIS); geographic coordinates were entered into GPS devices and then located in the field.

Field Survey: The 2010 semi-quantitative survey was completed from August 9-13, when river discharge was approximately 5,500 cubic feet per second. The 2012 semi-quantitative survey was completed from July 16-19, at similar river discharge levels. Surveyors accessed each station by motorboat, kayaks, or by overland access points. Surveys were conducted using a combination of wading, snorkeling, and SCUBA diving. A consistent search pattern was not applied at all stations due to surveyor bias (e.g., multiple teams often working independently, without a pre-determined protocol for how the searches would be conducted), methodological constraints (e.g., wading versus SCUBA diving), and specific habitat characteristics at each station. Generally, however, surveys consisted of perimeter searches around a central point, short transects, or meander surveys generally within 30 meters of the recorded location. The duration of these surveys was recorded to generate values of relative abundance as catch-per-unit-effort (CPUE), expressed in mussels/hour. Survey duration at each station typically ranged from 0.25-2.0 person-hours. During the 2012 survey, predominant habitat characteristics of each station were noted, particularly water depth, types and prevalence of each substrate type, flow conditions, and other noteworthy observations. Many of these stations were also photographed. Coordinates for each station were taken using a GPS field instrument.

Live mussels found at each station were identified to species and counted. Shell lengths were measured for a subset of each species to allow for assessment of length-frequency in subsequent analyses. In addition, a subset of two species considered rare in Maryland—alewife floater (S3) and tidewater mucket (S1/S2) were marked with numbered plastic tags before being returned to the river. During the 2012 survey, surveyors recorded additional information on alewife floater, tidewater mucket, and other uncommon species: microhabitat (water depth, substrate, flow conditions), a voucher photograph, and GPS coordinates for the precise location where tagged animals were placed. All live mussels of other species were also returned to the river bottom. Shells of dead mussels encountered were identified and a subsample was retained as vouchers; vouchers were delivered to MDNR in August 2011. Live zebra mussels encountered in the 2012 survey were collected and preserved, and the locations of these animals were recorded.

Data Analysis: Data were compiled in a spreadsheet and imported into GIS to generate maps of species distribution and relative abundance throughout the project area. Descriptive statistics were computed to examine the relationships between mussel distribution, abundance, and parameters related to location or habitat. Graphs were plotted to illustrate the relationship between CPUE and some of the location and habitat variables. Regression analysis was conducted to assess relationships between CPUE and distance from the dam using SAS v9.1 (SAS 2002-2003).

3.3 Quantitative Sampling

Site Selection: Quantitative surveys were conducted near a small subset (six) of the 128 semi-quantitative stations (Figure 3.2-1). Five of the quantitative sites were surveyed in 2010; these were generally located near semi-quantitative stations that had CPUE values toward the middle or upper end of the range for the 2010 surveys. One quantitative site was surveyed in 2012; it was located near semi-quantitative stations that had CPUE values at the low end of the range for 2010 and 2012 surveys. When selecting sites during the 2010 survey, areas with strong flows, deep water, and boulder or bedrock substrate were avoided. The 2012 quantitative survey was selected in a deeper area in the tidal section of the study reach.

Field Survey: The 2010 quantitative surveys were completed between August 31-September 3, when river discharge was approximately 5,500 cfs. The 2012 survey was conducted on July 19, under similar levels of river discharge. A 15x30 meter grid was established at each of quantitative survey sites. A total of 30-36 (30 for the 2010 sites, 36 for the 2012 site) $0.25m^2$ quadrats were distributed within the grid using a systematic sampling design with 2-3 random starts, as described in Strayer and Smith (2003). In each quadrat, all mussels visible on the substrate surface were identified and their lengths were measured. The substrate was then excavated to a depth of 10 centimeters and washed through a sieve containing 1.5-millimeter screen. Subsurface mussels were then identified and measured. For each quadrat location, surveyors also measured water depth, flow velocity, substrate (percent of each type), and cover (e.g., vegetation or woody debris).

Data Analysis: Field data were entered into a spreadsheet to generate population estimates (with variance estimates and confidence intervals) for each species and all species combined at each of the six quantitative survey sites. Descriptive statistics for measured habitat parameters were also computed and compared to mussel densities.

3.4 Instream Flow Habitat Assessment Study

A separate study (Conowingo Study 3.16: Instream Flow Habitat Assessment Below Conowingo Dam) modeled water depth, flow velocity, and shear stress parameters at various discharge levels (2,000-86,000 cfs). These model outputs were used to explain some variation in mussel CPUE. Low-flow shear stress (LFSS) used to analyze mussel survey results was computed as the mean shear stress at the four lowest modeled flows (2,000, 3,500, 5,000, and 7,500 cfs). Similarly, high-flow shear stress (HFSS) was computed as the mean shear stress at the four highest modeled flows (60,000, 70,000, 80,000, and 86,000 cfs). Literature on shear stress requirements for freshwater mussels was reviewed (e.g., Layzer and Madison 1995, Hardison and Layzer 2001, Morales et al. 2006, Allen and Vaughn 2010, Daraio et al. 2010, and numerous references therein) and, with additional input from experts, habitat suitability categories for both LFSS and HFSS were established:

Optimum: LFSS <15, HFSS <100

Good: LFSS 16-30, HFSS 101-150

Marginal: LFSS 31-50, HFSS 151-200

Poor: LFSS >50, HFSS >200

Each of the semi-quantitative survey sites were classified as one of the four categories based on the location of the survey site and the closest datapoint(s) in the model. In other words, none of these habitat parameters were measured concurrent with the mussel survey, and the analysis of mussel CPUE and instream flow attempted to match mussel survey data with modeled parameters.

4. RESULTS

4.1 Historic Records

Searches for historic freshwater mussel data in the project area yielded records for eight mussel species. The earliest collections were made just after Conowingo Dam was constructed (Marshall 1930), while the most recent collections were made during the past four years (Ashton 2009; Ashton 2011). Records are summarized in Table 4.1-1 and Table 4.1-2, and are discussed in detail below.

Museum Records: Contact with nine museums known to maintain substantial mussel collections yielded fewer than 10 locality records within the project area. The Canadian Museum of Nature had two records from the Susquehanna River near the mouth of Deer Creek. One record is for eastern elliptio and the other is for *Anodonta fluviatilis*, a taxon that is no longer recognized. The latter record may be either eastern floater (*Pyganodon cataracta*) or eastern elliptio, based on synonymies in Strayer and Jirka (1997), but it is more likely that the species is eastern floater because of the independent record of eastern elliptio from the same location by the same collector (F. Wayne Grimm). Two additional records at the Canadian Museum of Nature are from the Susquehanna River near the Pennsylvania Railroad Bridge at Havre de Grace. One record is for eastern elliptio and the other is for eastern lampmussel (*Lampsilis radiata radiata*). The exact location of the Pennsylvania Railroad Bridge is uncertain. However, it is believed to be located just downstream of the U.S. Route 40 Bridge, approximately 4.2 miles downstream of the study reach. Three records from the National Museum of Natural History are from upper Chesapeake Bay approximately 8-10 miles downstream from the study reach; one record is for tidewater mucket (*Leptodea ochracea*) and two records are for eastern lampmussel.

Literature: Marshall (1930) was the first to describe mussels downstream of Conowingo Dam; he conducted a survey in September 1929, not long after Conowingo Dam was built. The author lists records of five snail species and three mussel species. Two living eastern elliptio (*Elliptio complanatus* in the article; now *E. complanata*) were observed. Yellow lampmussel (*Lampsilis cariosus* in the article; now *L. cariosa*) and eastern lampmussel (*Lampsilis radiatus* in the article; now *L. radiata*) were identified on the basis of one dead (presumed to be empty) shell and four dead shells of each species, respectively.

More recently, Ashton (2009) described the findings of three sampling efforts conducted in the project area during 2008 and 2009. These efforts include benthic trawling and SCUBA diving by Tom Jones of Marshall University and personnel from MDNR's Monitoring and Non-tidal Assessment Division. Live individuals and dead shells of six species were found in both years, including eastern elliptio, alewife floater, eastern floater, tidewater mucket, northern lance, and creeper. In addition, Ashton (2009) reported that eastern lampmussel was collected in 1990 and 1998 by the MDNR's Natural Heritage Program. Ashton (2011) reported the collection of these species and yellow lampmussel in surveys conducted in summer 2010. Since the 2010 surveys when both MDNR and Exelon reported finding yellow lampmussel in the study area, regional mussel experts analyzed voucher shells, photographs, and tissue samples and the consensus was that these animals were tidewater muckets, not yellow lampmussels. This was also confirmed by Exelon's 2012 field survey.

4.2 **Semi-Quantitative Mussel Survey: Species Summaries**

During semi-quantitative surveys, five native species were observed and a total of 6,301 mussels were counted. In addition to the five native mussel species, the non-native zebra mussel (*Dreissena polymorpha*) was detected at nine stations and the Asian clam (*Corbicula fluminea*) was detected at nearly every station. The distribution, abundance, habitat, and demographics are described for each species and summarized in Table 4.2-1. The complete semi-quantitative dataset is provided in Appendix A and Appendix B.

4.2.1 Eastern Elliptio

Distribution: Eastern elliptio was widely distributed in the study reach; it was found at 120 stations (93.8 percent of survey stations) (Appendix B)

Abundance: A total of 6,069 individuals were found. The average CPUE was 61.7 mussels/hour (standard deviation = 91.8) and ranged from 0-592 mussels/hour. Larger concentrations were located in the middle and lower sections of the study area. Concentrations were particularly high in tidal areas, near Robert, Wood, and Spencer Islands, and in other flow refugia. Eastern elliptio were generally least abundant in the upstream end of the study reach, some mid-channel stations in the middle sections of the study reach, and near the Deer Creek confluence.

Habitat: Eastern elliptio were found in a wide range of substrate types, water depths, and flow velocities. They were usually patchily distributed within any given area, often in small patches of sand in gravel behind or under larger rocks.

Demographics: Mean shell length of animals collected during the semi-quantitative surveys was 101.8 mm (n = 580, standard deviation = 18.96), and lengths ranged from 11.8-170.0 mm. Only two animals less than 40 mm were found, and 95.2 percent of all elliptio found were between 60-130 mm in length. During the quantitative study, shell lengths of an additional 111 eastern elliptio were measured; their average length was 92.2 mm (standard deviation = 25.81) and lengths ranged from 16.0-129.0 mm. Six of these animals were smaller than 40 mm. Juveniles were detected but recruitment appears to be low.

4.2.2 Alewife Floater

Distribution: Although alewife floaters were widely distributed in the study reach, they were more consistently encountered in the downstream half of the reach and particularly in tidal areas. It was found at 46 stations (35.9 percent of all stations). (Appendix B)

Abundance: A total of 133 individuals were found. Average CPUE was 1.55 mussels/hour (standard deviation = 2.99) and ranged from 0-16 mussels/hour. Average CPUE in tidal stations was five times higher than in non-tidal stations (3.30 vs. 0.66 mussels/hour).

Habitat: Alewife floater were found in sand, gravel, and cobble substrates, usually in depths from 2-8 feet, and typically in slow to moderate water velocities.

Demographics: Mean shell length of animals measured during the semi-quantitative surveys was 106.3 mm (n = 126, standard deviation = 12.9), and lengths ranged from 72.0-137.0 mm. The lack of any animals smaller than 70 mm suggests lack of recruitment in the study reach.

Note: Maryland DNR (Matt Ashton) and the Biodrawversity project leader (Ethan Nedeau) agree that the ratio of alewife floater to eastern floater in the study reach is at least 8:1, possibly 10:1. During the 2012 field study, Biodrawversity found 55 alewife floater and seven eastern floater. The ratio of alewife floater to eastern floater for the 2010 field study was 1.2:1, but this result appears to be the result of misidentification (Matt Ashton, personal communication). There is no way to determine the exact number of live mussels that were misidentified, and the catch statistics presented in this report have not been adjusted to account for this discrepancy. Between the 2010 and 2012 studies, a total of 100 alewife floater were tagged before being released; data collected for these animals is provided in Appendix C.

4.2.3 Eastern Floater

Distribution: Eastern floater were found in a cluster near the upper end of the study reach, along the eastern shoreline, and in tidal areas particularly near Robert, Wood, and Spencer Islands. They were reported at 29 stations (22.7 percent of all stations) (Appendix B).

Abundance: A total of 67 individuals were found. Average CPUE was 0.47 mussels/hour (standard deviation = 1.11) and ranged from 0.0-6.3 mussels/hour.

Habitat: Eastern floater were found in sand, gravel, and cobble substrates, usually in depths from 2-8 feet, and typically in slow to moderate water velocities.

Demographics: Mean shell length of animals measured during the semi-quantitative surveys was 95.9 mm (n = 50, standard deviation = 18.72), and lengths ranged from 32.0-135.0 mm. Only seven animals smaller than 80 mm were observed, suggesting a near lack of recruitment in the study reach.

Note: See note for alewife floater.

4.2.4 Tidewater Mucket

Distribution: Tidewater mucket were found at 22 stations (17.2 percent of all stations), and they occurred primarily in tidal areas, in a small area at the upper end of the study reach, and sporadically throughout the study reach. (Appendix B)

Abundance: A total of 25 individuals were found. Average CPUE was 0.25 mussels/hour (standard deviation = 0.69) and ranged from 0.0-4.0 mussels/hour. Average CPUE in tidal stations was 4.7 times higher than in non-tidal stations (0.52 vs. 0.11 mussels/hour).

Habitat: Tidewater mucket were found in sand, gravel, and cobble substrates, usually in depths from 2-8 feet, and typically in slow to moderate water velocities.

Demographics: Mean shell length was 83.0 mm (n = 25, standard deviation = 13.56), and lengths ranged from 63.0-106.5 mm. Lack of any juvenile tidewater muckets suggests lack of recruitment in the study reach.

Note: During the 2010 survey, the Normandeau field team reported finding only one shell of tidewater mucket and 16 yellow lampmussels. Based on voucher material examination, parallel verification of Maryland DNR voucher specimens, and discovery of only tidewater muckets during the 2012 field study, it was determined that the 2010 survey misidentified tidewater muckets as yellow lampmussels. The final dataset presented in this report is corrected. Eight tidewater muckets observed during the 2012 survey were tagged before being released; data collected for these animals is provided in Appendix 4.

4.2.5 Eastern Lampmussel

Distribution: Eastern lampmussel were found very infrequently in the study reach, at only seven stations (5.5 percent of all stations). (Appendix B)

Abundance: Only seven animals were found; these were all isolated occurrences. Average CPUE was 0.10 mussels/hour (standard deviation = 0.48) and ranged from 0.0-4.0 mussels/hour. Average CPUE was almost two times higher in tidal areas than non-tidal areas (0.14 vs. 0.08 mussels/hour).

Habitat: Too few animals were found to say anything meaningful about habitat preference, but eastern lampmussels generally prefer sand and gravel substrates, relatively deep water, and slow to moderate flow velocities.

Demographics: Only four eastern lampmussels were measured; these ranged in length from 95.0-115.0 mm (mean = 105.8, standard deviation = 9.78). There was a distinct lack of recruitment for this species, combined with extremely low population density.

4.3 Semi-Quantitative Mussel Survey: Distribution and Habitat

Mussels were detected at 121 of 128 stations (94.5 percent), and a mean of 1.8 species (range = 0-5) were found per station. For all species combined, catch-per-unit-effort (CPUE) ranged from 0-612 mussels/hour (mean = 64.1 mussels/hour, standard deviation = 94.5) among the stations (Table 4.2-1, Figure 4.3-1). CPUE exceeded 100 mussels/hour at 25 stations (19.5 percent). Most of the stations with highest mussel densities were located within or near tidal areas at the downstream end of the study reach, particularly near Robert, McGibney, Spencer, and Sterret Islands. CPUE values of less than 5.0 mussels/hour were recorded at 27 stations (21.1 percent). Although stations with low CPUE were found throughout the study reach, most were located near the mouth of Octoraro Creek, near Bird Island, Rowland Island, or in the back channel of Mud Island at the upstream end of the study reach. A few were located mid-river in the middle of the study reach, and a few were located near the Deer Creek confluence.

In general, mussels were distributed as expected among different habitat compartments (Table 4.3-1), occurring more frequently in pools and side channels, and less frequently in faster-moving runs and riffles. In general, the highest densities of mussels were predictably located in areas with suitable substrate, such as small patches of mixed gravel and sand within areas that were predominantly bedrock. There was a strong inverse relationship between mussel CPUE and Low Flow Shear Stress (LFSS), and a weaker inverse relationship between mussel CPUE and High Flow Shear Stress (HFSS) (Table 4.3-2, Figure 4.3-2). Few mussels were found in high velocity areas (and therefore higher shear stress), such as directly downstream of the dam along the west side of the river. Shallow areas that regularly become dewatered also tended to support fewer mussels. Areas not subjected to dewatering that also have relatively low shear stress supported the highest densities of mussels. Such areas were most frequently located in the eastern half of the river and throughout the tidal portion of the study area.

Mussels were significantly more abundant in tidal areas (Table 4.3-1). Mussel CPUE was nearly three times higher in tidal areas than non-tidal areas (115.1 vs. 38.3 mussels/hour), and both alewife floater and tidewater mucket were nearly five times more abundant in tidal areas. Overall, there was a significant trend of higher mussel CPUE, as well as higher variability in CPUE, with increasing distance from the dam (Table 4.3-3, Figure 4.3-3). Another trend was of decreasing CPUE with distance from the left (east) bank, more so in the middle and upper reaches of the survey area. This may be related to generally stronger flow velocities toward the middle and right (west) bank of the river. It may also be partly related to sampling bias, as the water clarity on the east side of the river was far clearer than it was on the west side, and greater clarity can result in higher catch rates during visual surveys.

4.4 Quantitative Mussel Survey

Population estimates (of all species combined) for the $450m^2$ (15x30 meters) quantitative survey plots ranged from 50 mussels (90% Confidence Interval (CI) = -32-132 mussels) to 1,920 mussels (90% CI = 623-3,217 mussels). The highest population estimates were for two sites (QS-3 and QS-4) in the secondary channel of McGibney Island. Results for all six stations are summarized in Table 4.4-1. Full results of the quantitative mussel survey are listed (by both surface collection and excavation in all quadrat samples) in Appendix D.

A total of 117 mussels were observed during quantitative surveys, including 111 eastern elliptio (95.7 percent), and three individuals each of alewife floater and eastern floater. Similar total numbers of mussels were observed in surface collections (60 mussels) and in excavations (57 mussels). Mussels were generally associated with quadrats where relatively fine materials (silt, sand, and gravel) comprised 30-80 percent of total substrate.

5. DISCUSSION

5.1 Presence of Rare Species

Live individuals of five mussel species were observed in this study. Three are ranked with respect to rarity by the state of Maryland (Maryland Natural Heritage Program 2010), although none are on the state's official Threatened and Endangered Species List, and none are federally endangered. The rare species and their ranks include:

- Alewife floater (S3): 133 animals found.
- Eastern lampmussel (SU): 7 animals found.
- Tidewater mucket (S1/S2): 25 animals found.

The total size and viability of each of these rare species populations within the study reach, as well as in adjacent tidal areas and nearby tributaries, remains unknown.

5.2 Comparison with Prior Surveys

Findings of this study were similar to those of other recent (since 2008) semi-quantitative and quantitative studies of freshwater mussels conducted within and just downstream of the project area. These studies were led by Matt Ashton of MDNR, or by Tom Jones of Marshall University. Similar species, abundances, and densities were observed in those studies. Some relatively minor differences in length distributions were observed, however, and they are described below.

5.2.1 Prior Semi-Quantitative Surveys

Five mussel species—the same five found during Exelon's surveys—were observed in the recent semi-quantitative surveys conducted within the study area. Eastern elliptio dominated the mussel assemblages, and its densities varied significantly among sites (Figure 3.2-1, Table 5.2-1). Some of the highest overall CPUE values (>320 mussels/hour), driven primarily by high eastern elliptio abundance, were recorded near the upstream end of Robert Island. In other areas, CPUE was generally <50 mussels per search hour.

Length distributions of common species in one of the previous studies were somewhat comparable to those observed in the current study, with a few minor differences (Jones, unpublished data). In surveys conducted by Jones, shell length of eastern elliptio ranged from 58.0-126.0 mm. A broader range of 11.8-170.0 mm was documented for eastern elliptio in the current survey. In Jones' survey, shell length for alewife floater ranged from 35.0-197.0 mm, indicating the presence of both young and old mussels. Results of the current survey showed a narrower length range of 72.0-137.0 mm for alewife floater. Jones also found six tidewater muckets ranging from 53.0-87.0 mm in length, whereas this study documented a length range of 63.0-106.0 mm for this species.

5.2.2 Prior Quantitative Surveys

In 2010, MDNR (Matt Ashton) led a quantitative mussel survey in a gravel-cobble shoal along the northeastern shoreline of the river, opposite Robert Island, approximately 0.3 miles downstream of the tidal boundary (Figure 3.2-1) (Ashton and Devers, unpublished data). A total of 396 0.25m^2 quadrats were sampled using a systematic sampling design with multiple random starts, similar (but with a larger sample size) to the quantitative studies that Exelon completed in 2010 and 2012. A total of 292 mussels of five species were identified in the MDNR study, including (in order of abundance) eastern elliptio (274, 93.8 percent), alewife floater (15, 5.1 percent), and one individual apiece for eastern floater, eastern lampmussel, and tidewater mucket. These relative proportions of each species are similar to data obtained during Exelon's quantitative studies. For the MDNR study, average mussel density was 2.95 mussels/m^2, which was similar to the average mussel density of mussels in Exelon's quantitative studies (2.52 mussels/m^2). For the MDNR study, the shell lengths of eastern elliptio ranged from 29-170 mm, which again was similar to the length range of eastern elliptio in Exelon's quantitative studies (16-129 mm). Collectively, these data suggest that the different survey teams, working independently and with different objectives, achieved similar results for mussel relative abundance and density, and for the length ranges of eastern elliptio.

5.3 Summary of Mussel Distribution, Abundance, and Habitat

Because eastern elliptio was so dominant in the mussel community, the relationships between CPUE, habitat, and location parameters were based largely on this one species. Other species were too uncommon to provide meaningful insight into specific habitat preference; however, densities of eastern elliptio and other species were often correlated, suggesting that eastern elliptio may serve as a reliable proxy for all species. If so, it could provide insight into habitat preferences for the entire community.

The distribution of freshwater mussels below Conowingo Dam is likely influenced by a combination of factors that are difficult to measure or fully characterize with descriptive and short-duration mussel surveys. Location and habitat parameters—such as distance from the dam, proximity to tidal influence, substrate conditions, and hydraulic conditions—are correlated and confounded. Data suggest that stream velocity, shear stress, and substrate type may strongly influence mussels in the study reach. Mussels were usually uncommon in areas prone to frequent dewatering, areas with poor substrate, and areas with high shear stress.

Limiting factors related to streamflow have been shown to vary among different mussel species (Allen and Vaughn 2010), stream sizes (Gangloff and Feminella 2008), and river systems (Layzer and Madison 1995); however, one of the most important limiting factors is thought to be shear stress. Recent studies have shown that mussels are more prevalent in stable areas with suitable substrates and low shear stress (Layzer and Madison 1995, Strayer 1999, Morales *et al*. 2006, Allen and Vaughn 2010). As adult mussels must remain buried in the substrate to survive, they generally cannot tolerate shear stresses that mobilize substrates and disrupt mussel beds (Howard and Cuffey 2003, Allen and Vaughn 2010). Mussels in the Susquehanna River downstream of Conowingo Dam are more prevalent in areas where modeled shear stress is relatively low. Areas of highest CPUE observed in this study were typically along the east side of the river in the downstream half of the project area, where flow is considerably less than near the dam in the upstream half of the project area. In addition to this overall trend, the several stations with highest CPUE values in the project area also occurred in zones of local flow refugia, where stream flow models showed shear stress to be lower than in immediate surrounding areas.

Substrate was an important parameter for describing variation in mussel density and abundance. Substrate was not recorded during the 2010 semi-quantitative mussel study, and the subsequent analysis of CPUE versus substrate was based on coarse-scale models of substrate rather than actual field measurements. Models did not adequately describe fine-scale substrate distribution, especially patches of fine sediments (sand and gravel) among the predominant boulder and bedrock. For the 56 semi-quantitative stations surveyed in 2012, the mean proportions (percentage) of bedrock, boulder, cobble, gravel, and sand were 23.7, 28.6, 29.2, 14.5, and 3.9, respectively. Despite most of these areas being modeled as bedrock and boulder, these two substrate types comprised only 52.2 percent of the substrate observed in the field. During the 2012 survey, the 17 stations with CPUE greater than 100 mussels/hour contained an average of 42 percent bedrock+boulder, 34 percent cobble, and 24 percent gravel+sand.

The discrepancy between modeled versus observed substrate was also illustrated by the habitat data for the quantitative survey. For the six quantitative study plots, fine substrates (combined percentage of silt, sand, and gravel) comprised an average of nearly 50 percent coverage within quadrats (range among the five plots: 26.4-62.5 percent), despite models indicating that these plots were found in bedrock or cobble/rubble substrates. These data suggest that while much of the study reach was modeled, or generally described, as having boulder and bedrock-dominated substrates, which are generally poor substrates for mussels, much of the area may be more suitable for mussels than the models or coarse-scale descriptions indicate.

Results of this study showed that mussel CPUE increased with distance from the dam. This is due in part to variations in streamflow and shear stress discussed above, as areas of strong flow near the dam (or areas where flow is highly variable) provide less suitable habitat than areas downstream with more moderate, stable flow regimes. In addition, areas of mixed sand and gravel substrate were observed more frequently in downstream areas. In a separate study assessing mussels downstream of Conowingo Dam, Ashton (2011) also noted increased presence of sand and gravel in downstream reaches and suggested these conditions might provide better habitat for mussels than upstream reaches. Tidal influence might also help explain the longitudinal variation in CPUE with increasing distance from the dam.

In addition to habitat variables, presence of suitable host fish may influence the freshwater mussel species assemblage below Conowingo Dam. The Susquehanna River between Conowingo Dam and Chesapeake Bay may support the river's most significant remaining population of the alewife floater, a species whose hosts include American shad, alewife, and other migratory clupeids (Smith 1985). Downstream of the dam, eastern elliptio have access to American eel, which have been shown in laboratory studies to be a host for this species (Lellis *et al*. 2009). Striped bass, white perch, and smallmouth bass—all present in the study area—may be hosts for species such as eastern lampmussel and tidewater mucket (reviewed in Nedeau 2008).

In summary, despite some potential habitat-related limitations to freshwater mussel distribution in the project area, particularly zones of unsuitable substrate and flow conditions, findings indicate that mussels occur throughout the reach downstream of Conowingo Dam. Five species were detected in the project area. Eastern elliptio, alewife floater, and eastern floater were widespread, albeit at low densities in some areas. Large numbers of eastern elliptio were observed at several locations, and relatively young animals were observed during both semi-quantitative and quantitative surveys, indicating low rates of recruitment may be occurring in the project area. Rare species were also detected, although the size and viability of these populations remains unknown.

5.4 **Effects of Dam Operations**

Conowingo Dam and associated hydropower operations define certain characteristics of instream aquatic habitat downstream of the dam; however, causal effects on freshwater mussels are difficult to isolate. Conowingo Dam alters flow regimes and reduces connectivity with upstream areas of the Susquehanna River, and therefore likely influences both upstream and downstream mussel communities to some extent. However, these factors are difficult to measure or fully characterize with a descriptive mussel survey such as this. As a result, the dam’s specific influence on freshwater mussels downstream is difficult to determine.

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TABLE 2.1-1: MUSSEL SPECIES KNOWN TO OCCUR IN THE CONOWINGO DAM REGION.

Common Name	Latin Name
Triangle Floater	*Alasmidonta undulata*
Brook Floater	*Alasmidonta varicosa*
Alewife Floater	*Anodonta implicata*
Eastern Elliptio	*Elliptio complanata*
Northern Lance	*Elliptio fisheriana*
Yellow Lampmussel	*Lampsilis cariosa*
Eastern Lampmussel	*Lampsilis radiata*
Green Floater	*Lasmigona subviridis*
Tidewater Mucket	*Leptodea ochracea*
Eastern Pondmussel	*Ligumia nasuta*
Eastern Floater	*Pyganodon cataracta*
Creeper	*Strophitus undulatus*

TABLE 3.2-1:SEMI-QUANTITATIVE STATION BREAKDOWN, BY SPECIFIC COMPARTMENT AND COMPARTMENT TYPE.

Habitat Compartment	Symbol	Total Acres	% Composition	# Stations	Stations/Acre
Specific Compartments					
Run (Deep)	P1	24.8	1.7	2	0.081
Run (Shallow)	P2	17.7	1.2	1	0.056
Run (Shallow)	P3	28.5	1.9	0	0.000
Pool (Shallow)	P4	15.6	1.0	0	0.000
Ruffle	P5	695.2	46.3	40	0.058
Run (Shallow)	P6	32.0	2.1	7	0.219
Backwater	P7	4.2	0.3	1	0.238
Pool (Deep)	P9	70.9	4.7	9	0.127
Pool (Shallow)	P10	37.9	2.5	3	0.079
Pool (Deep)	P11	25.0	1.7	4	0.160
Side Channel	P12-P14	20.0	1.3	17	0.850
Riffle	O2-O5	2.0	0.1	1	0.500
Pool (Shallow)	O6	2.9	0.2	4	1.379
Riffle	O7	0.3	0.0	1	3.333
Pool (Shallow)	O8-O9	8.7	0.6	2	0.230
Pool (Deep)	O10	0.7	0.0	0	0.000
Tidal	-	516.0	34.4	38	0.074
Compartment Type					
Backwater	-	4.2	0.3	1	0.238
Pool (Deep)	-	96.6	6.4	13	0.135
Pool (Shallow)	-	65.1	4.3	9	0.138
Riffle	-	2.3	0.2	2	0.870
Ruffle	-	695.2	46.3	40	0.058
Run (Deep)	-	24.8	1.7	2	0.081
Run (Shallow)	-	78.2	5.2	8	0.102
Side Channel	-	20.0	1.3	17	0.850
Tidal	-	516.0	34.4	38	0.074

TABLE 4.1-1: SUMMARY OF HISTORIC MUSSEL RECORDS NEAR CONOWINGO DAM

Common Name	Latin Name	Museum	Locality	Collection Date	Notes
Eastern Elliptio	*Elliptio complanata*	CMN	Susquehanna River near mouth of Deer Creek	15-Jun-63	Acquisition No. 1968-141; Catalogue No. CMNML 046709
Eastern Elliptio	*Elliptio complanata*	CMN	Susquehanna River, Havre de Grace, near PA Railroad Bridge	18-Oct-58	Acquisition No. 1968-073; Catalogue No. CMNML 059547
-	*Anodonta fluviatilis*	CMN	Susquehanna River near mouth of Deer Creek	16-Sep-62	Acquisition No. 1968-073; Catalogue No. CMNML 058227
Eastern Lampmussel	*Lampsilis r. radiata*	CMN	Susquehanna River, Havre de Grace, near PA Railroad Bridge	18-Oct-58	Acquisition No. 1968-141; Catalogue No. CMNML 059548
Tidewater Mucket	*Leptodea ochracea*	NMH	Chesapeake Bay, 3 miles SW of Charlestown	-	Catalogue No. 521838
Eastern Lampmussel	*Lampsilis r. radiata*	NMH	Chesapeake Bay, 5 miles SW of Charlestown	-	Catalogue No. 521841
Eastern Lampmussel	*Lampsilis r. radiata*	NMH	Chesapeake Bay, 3 miles SW of Charlestown	-	Catalogue No. 521879
CMN = Canadian Museum of Nature, Ottawa, Canada					
NMH = National Museum of Natural History, Washington D.C.					

TABLE 4.1-2: SUMMARY OF SPECIES PRESENCE/ABSENCE IN RECENT MUSSEL SURVEYS

Common Name	Latin Name	2008	2009	2010	2012
Alewife Floater	*Anodonta implicata*	x	x	x	x
Eastern Elliptio	*Elliptio complanata*	x	x	x	x
Yellow Lampmussel	*Lampsilis cariosa*	x (1)	x (1)	x (1)	
Eastern Lampmussel	*Lampsilis radiata*			x	x
Tidewater Mucket	*Leptodea ochracea*	x	x	x	x
Eastern Floater	*Pyganodon cataracta*	x	x	x	x
Creeper	*Strophitus undulatus*			x (2)	

1. Based on examination of voucher photos and shells, and consultation with regional experts, prior reports of yellow lampmussels have been changed to tidewater mucket.
2. Matt Ashton (MDNR) reported finding one shell.

TABLE 4.2-1: SUMMARY OF MUSSEL DISTRIBUTION, ABUDANCE, HABITAT AND DEMOGRAPHICS, BY SPECIES

	Species													
	ElCo		**ElCo**		**AnIm**		**LeOc**		**PyCa**		**LaRa**		**All**	
Parameter	(Semi-Quant)		(Quantitative)		(Semi-Quant)		(Semi-Quant)		(Semi-Quant)		(Semi-Quant)		(Semi-Quant)	
Catch Statistics														
# Stations Where Found	120		6		46		22		29		7		121	
% Stations Where Found	93.8		100.0		35.9		17.2		22.7		5.5		94.5	
Total Number of Animals	6069		111		133		25		67		7		6301	
Mean Count	47.41		-		1.04		0.20		0.52		0.05		49.23	
Mean CPUE (mussels/hour)	61.74		-		1.55		0.25		0.47		0.10		64.10	
Min CPUE (mussels/hour)	0.0		-		0.0		0.0		0.0		0.0		0.0	
Max CPUE (mussels/hour)	592.0		-		16.0		4.0		6.3		4.0		612.0	
Shell Length Statistics														
Sample Size (n)	580		111		126		25		50		4		-	
Mean Length (mm)	101.8		92.2		106.3		83.0		96.7		105.8		-	
Min Length (mm)	11.8		16.0		72.0		63.0		32.0		95.0		-	
Max Length (mm)	170.0		129.0		137.0		106.5		135.0		115.0		-	
Standard Deviation	18.96		25.81		12.90		13.56		18.72		9.78		-	
Length Class (mm)	#	%	#	%	#	%	#	%	#	%	#	%	#	%
<20.0	1	0.17	1	0.90	0	0.00	0	0.00	0	0.00	0	0.00	-	
20.0-29.9	0	0.00	1	0.90	0	0.00	0	0.00	0	0.00	0	0.00	-	
30.0-39.9	1	0.17	4	3.60	0	0.00	0	0.00	1	2.00	0	0.00	-	
40.0-49.9	8	1.38	2	1.80	0	0.00	0	0.00	0	0.00	0	0.00	-	
50.0-59.9	8	1.38	3	2.70	0	0.00	0	0.00	1	2.00	0	0.00	-	
60.0-69.9	23	3.97	11	9.91	0	0.00	5	20.00	1	2.00	0	0.00	-	
70.0-79.9	27	4.66	14	12.61	3	2.38	7	28.00	4	8.00	0	0.00	-	
80.0-89.9	51	8.79	7	6.31	12	9.52	5	20.00	7	14.00	0	0.00	-	
90.0-99.9	75	12.93	11	9.91	24	19.05	4	16.00	10	20.00	1	25.00	-	
100.0-109.9	117	20.17	19	17.12	32	25.40	4	16.00	10	20.00	1	25.00	-	
110.0-119.9	174	30.00	27	24.32	41	32.54	0	0.00	13	26.00	2	50.00	-	
120.0-129.9	85	14.66	11	9.91	9	7.14	0	0.00	2	4.00	0	0.00	-	
130.0-139.9	6	1.03	0	0.00	5	3.97	0	0.00	1	2.00	0	0.00	-	
140.0-149.9	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	-	
>149.9	4	0.69	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	-	

TABLE 4.3-1: MUSSEL DISTRIBUTION, BY HABITAT COMPARTMENT OR TIDAL INFLUENCE

Habitat Area		Stations	ElCo	AnIm	LeOc	PyCa	LaRa	All
			Species CPUE					
Specific Habitat Compartments								
P1	Run (Deep)	2	13.75	0.00	0.00	0.00	0.00	13.75
P2	Run (Shallow)	1	0.00	0.00	0.00	0.00	0.00	0.00
P5	Ruffle	40	30.75	0.47	0.13	0.49	0.10	31.93
P6	Run (Shallow)	7	26.79	0.41	0.18	0.00	0.00	27.38
P7	Backwater	1	48.67	0.00	0.00	0.00	0.00	48.67
P9	Pool (Deep)	9	29.39	0.81	0.14	0.53	0.22	31.08
P10	Pool (Shallow)	3	128.67	3.00	0.00	1.33	0.00	133.00
P11	Pool (Deep)	4	114.40	1.50	0.33	1.00	0.00	117.23
P12	Side Channel	2	25.39	0.89	0.00	0.18	0.00	26.46
P13	Side Channel	9	81.04	1.10	0.00	0.22	0.00	82.35
P14	Side Channel	6	13.39	0.00	0.36	1.53	0.09	15.37
O5	Riffle	1	0.00	0.00	0.00	0.00	0.00	0.00
O6	Pool (Shallow)	4	26.19	0.00	0.00	0.00	0.00	26.19
O7	Riffle	1	0.67	0.00	0.00	0.00	0.00	0.67
Habitat Compartment Types								
	Backwater	1	48.67	0.00	0.00	0.00	0.00	48.67
	Pool (Deep)	13	55.54	1.02	0.20	0.67	0.15	57.59
	Pool (Shallow)	7	70.11	1.29	0.00	0.57	0.00	71.97
	Riffle	2	0.33	0.00	0.00	0.00	0.00	0.33
	Ruffle	40	30.75	0.47	0.13	0.49	0.10	31.93
	Run (Deep)	2	13.75	0.00	0.00	0.00	0.00	13.75
	Run (Shallow)	8	23.44	0.36	0.16	0.00	0.00	23.96
	Side Channel	17	50.61	0.69	0.13	0.68	0.03	52.13
Tidal Influence								
	Tidal	43	110.65	3.30	0.52	0.52	0.14	115.14
	Non-tidal	85	36.99	0.66	0.11	0.44	0.08	38.28

TABLE 4.3-2: MUSSEL CPUE VERSUS HIGH AND LOW FLOW SHEAR STRESS, BY SPECIES

Shear Stress	Category	# Stations	ElCo	AnIm	LeOc	PyCa	LaRa	All
			Mean CPUE by Species (mussels/hour)					
LFSS	Optimum	79	82.22	2.14	0.31	0.56	0.16	85.39
	Good	12	64.03	0.60	0.26	0.72	0.00	65.61
	Marginal	11	24.35	1.40	0.00	0.18	0.00	25.93
	Poor	26	14.28	0.25	0.15	0.20	0.00	14.88
HFSS	Optimum	40	70.44	1.75	0.34	0.86	0.11	73.51
	Good	30	82.04	2.20	0.28	0.29	0.13	84.95
	Marginal	16	67.84	1.73	0.36	0.39	0.09	70.41
	Poor	42	36.63	0.83	0.09	0.24	0.06	37.85

TABLE 4.3-3: MUSSEL DISTRIBUTION, BY DISTNACE FROM CONOWINGO DAM

Statistic	Distance from Dam (miles)				
	0-1	1-2	2-3	3-4	4-5
# Stations	26	27	25	35	15
Mean CPUE (mussels/hour)	13.5	19.5	68.5	102.9	134.3
Standard Deviation	22.77	22.81	96.82	121.57	97.03
Min CPUE (mussels/hour)	0.0	2.0	0.0	0.0	15.0
Max CPUE (mussels/hour)	100.0	91.5	384.0	612.0	316.8

TABLE 4.4-1: SUMMARY OF QUANTITATIVE SURVEY RESULTS

Plot	Species	Number Observed	Relative Abundance (%)	Density (animals/m^2)	90% Confidence Interval	Population Estimate (animals/plot)	90% Confidence Interval
		Parameter					
QS1	ElCo	15	93.75	2.00	0.92 - 3.08	900	415 - 1385
	AnIm	1	6.25	0.13	-0.09 - 0.35	60	-38 - 158
	PyCa	0	0.00	0.00	-	0	-
	All	16	100.00	2.13	1.01 - 3.26	960	455 - 1465
QS2	ElCo	13	81.25	1.73	0.92 - 2.55	780	414 - 1146
	AnIm	1	6.25	0.13	-0.09 - 0.35	60	-38 - 158
	PyCa	2	12.50	0.27	-0.04 - 0.57	120	-17 - 257
	All	16	100.00	2.13	1.32 - 2.95	960	593 - 1327
QS3	ElCo	30	96.77	4.00	2.87 - 5.13	1800	1290 - 2310
	AnIm	0	0.00	0.00	-	0	-
	PyCa	1	3.23	0.13	-0.09 - 0.35	60	-38 - 158
	All	31	100.00	4.13	3.23 - 5.03	1860	1454 - 2266
QS4	ElCo	31	96.88	4.13	1.24 - 7.02	1860	559 - 3161
	AnIm	1	3.13	0.13	-0.09 - 0.35	60	-38 - 158
	PyCa	0	0.00	0.00	-	0	-
	All	32	100.00	4.26	1.39 - 7.15	1920	623 - 3217
QS5	ElCo	21	100.00	2.80	1.7 - 3.9	1260	767 - 1753
	AnIm	0	0.00	0.00	-	0	-
	PyCa	0	0.00	0.00	-	0	-
	All	21	100.00	2.80	1.7 - 3.9	1260	767 - 1753
QS6	ElCo	1	100.00	0.11	-0.07 - 0.29	50	-32 - 132
	AnIm	0	0.00	0.00	-	0	-
	PyCa	0	0.00	0.00	-	0	-
	All	1	100.00	0.11	-0.07 - 0.29	50	-32 - 132

TABLE 5.2-1: SUMMARY OF MUSSEL DISTRIBUTION IN PRIOR SEMI-QUANTITATIVE MUSSEL SURVEYS

Station	Within Study Reach?	Species ElCo	AnIm	LeOc	Total	Search Time (hrs)	CPUE (mussels/hour)
SQ109	Yes	4	0	0	4	-	-
SQ111	Yes	8	0	0	8	-	-
SQ112	Yes	6	1	0	7	-	-
SQ113	Yes	0	0	0	0	-	-
SQ101	No	9	0	0	9	1.3	6.9
SQ102	No	16	1	1	18	1.4	12.9
SQ103	No	56	0	0	56	1.3	43.1
SQ104	No	11	4	0	15	1.1	13.6
SQ105	No	1	1	1	3	2.0	1.5
SQ106	No	2	2	1	5	1.0	5.0
SQ107	No	2	1	2	5	1.3	3.8
SQ108	No	1	3	1	5	1.3	3.8
SQ110	No	5	6	0	11	0.5	22.0
Total		**121**	**19**	**6**	**146**	**11.2**	**13.0**

N

0 0.25 0.5 1 Miles

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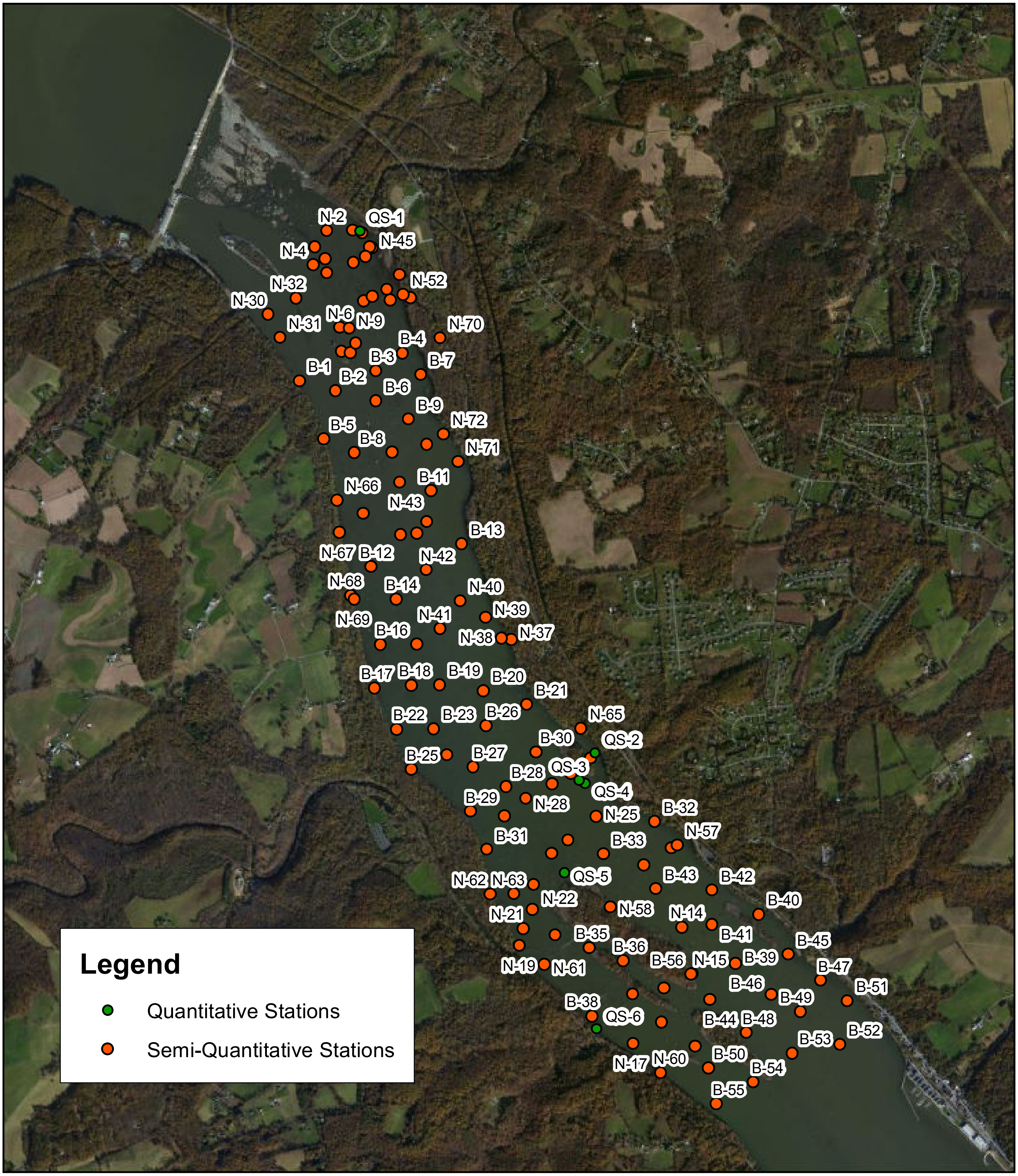
CONOWINGO HYDROELECTRIC PROJECT
PROJECT NO. 405

Figure 2.2-1: Study reach downstream of Conowingo Dam.

1 inch = 0.56 miles

Path: X:\GISMaps\project_maps\study_plan\conowingo\study_3.19\3.19 Fig 2.2-1.mxd



N

EXELON GENERATION COMPANY, LLC

CONOWINGO HYDROELECTRIC PROJECT

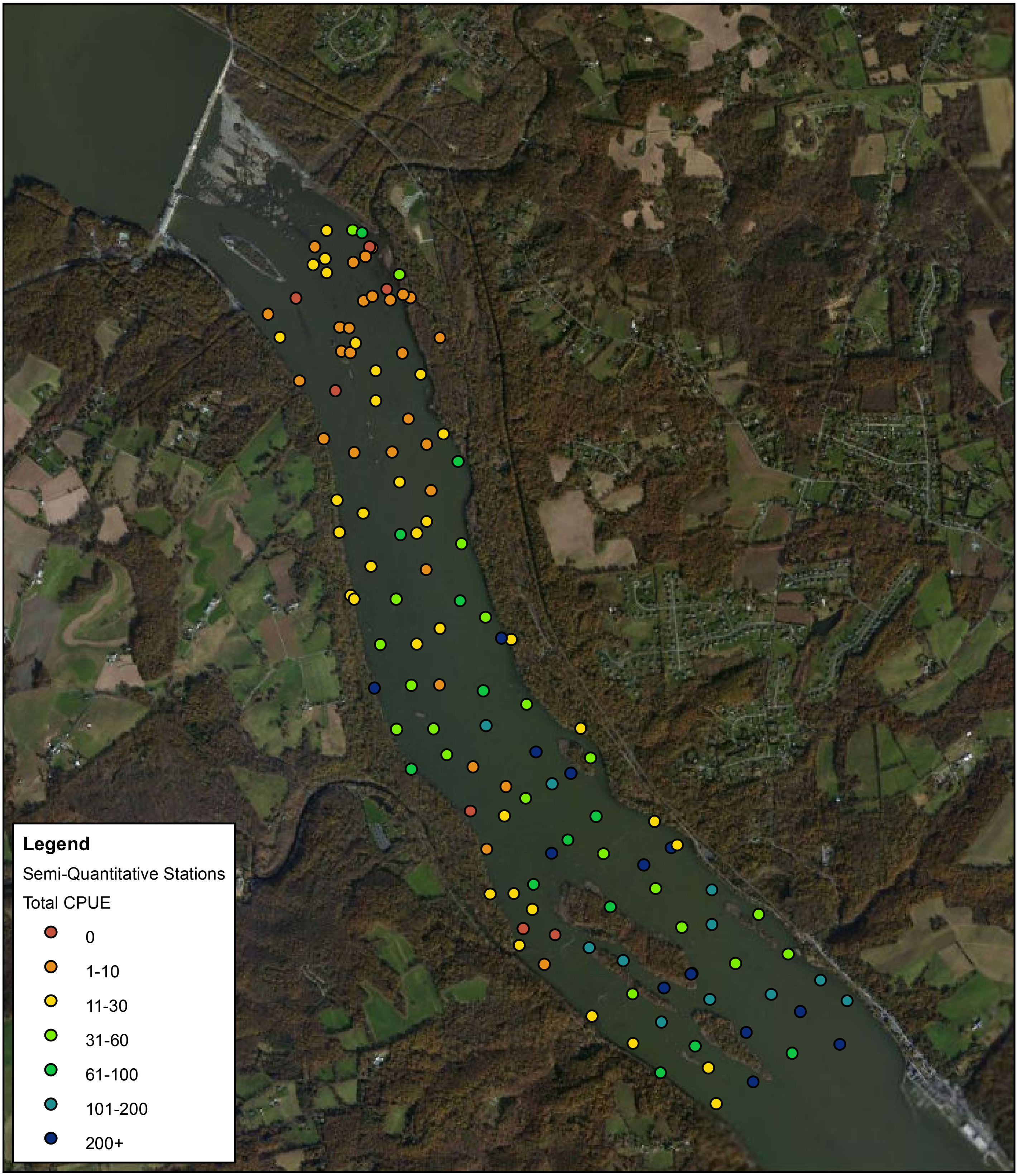
PROJECT NO. 405

Figure 3.2-1: Semi-quantitative and quantitative mussel survey stations

0 0.25 0.5 1 Miles

1 inch = 0.56 miles

Path: X:\GISMaps\project_maps\study_plan\conowingo\study_3.19\3.19 Fig 3.2-1.mxd



N

0 0.25 0.5 1 Miles

Exelon

EXELON GENERATION COMPANY, LLC
CONOWINGO HYDROELECTRIC PROJECT
PROJECT NO. 405

Figure 4.3-1: Semi-quantitative survey stations, classified by total CPUE.

1 inch = 0.56 miles

Path: X:\GISMaps\project_maps\study_plan\conowingo\study_3.19\3.19 Fig 4.3-1.mxd

FIGURE 4.3-2: COMPARISON OF TOTAL CPUE VERSUS (A) LOW FLOW SHEAR STRESS; AND (B) HIGH FLOW SHEAR STRESS

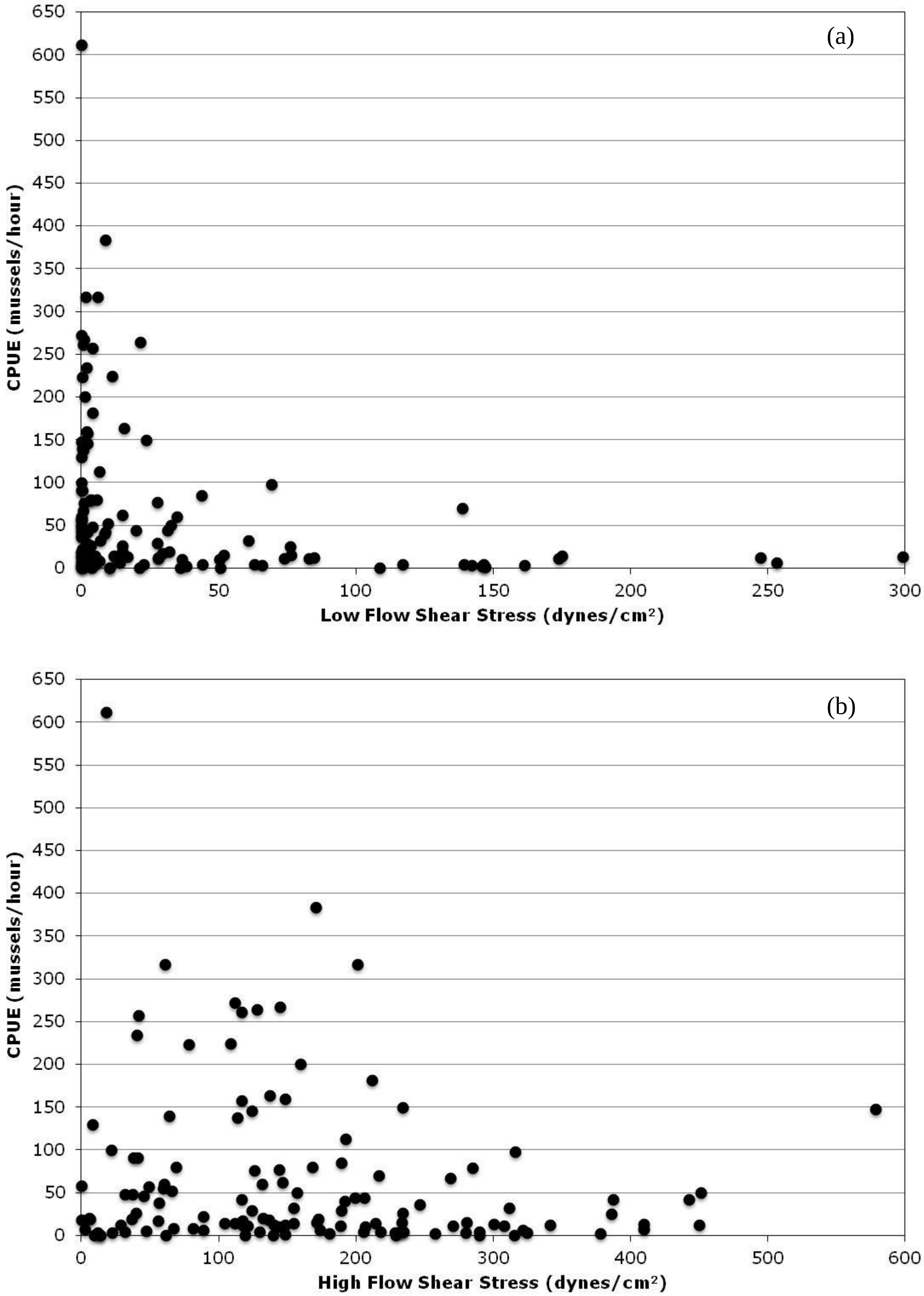
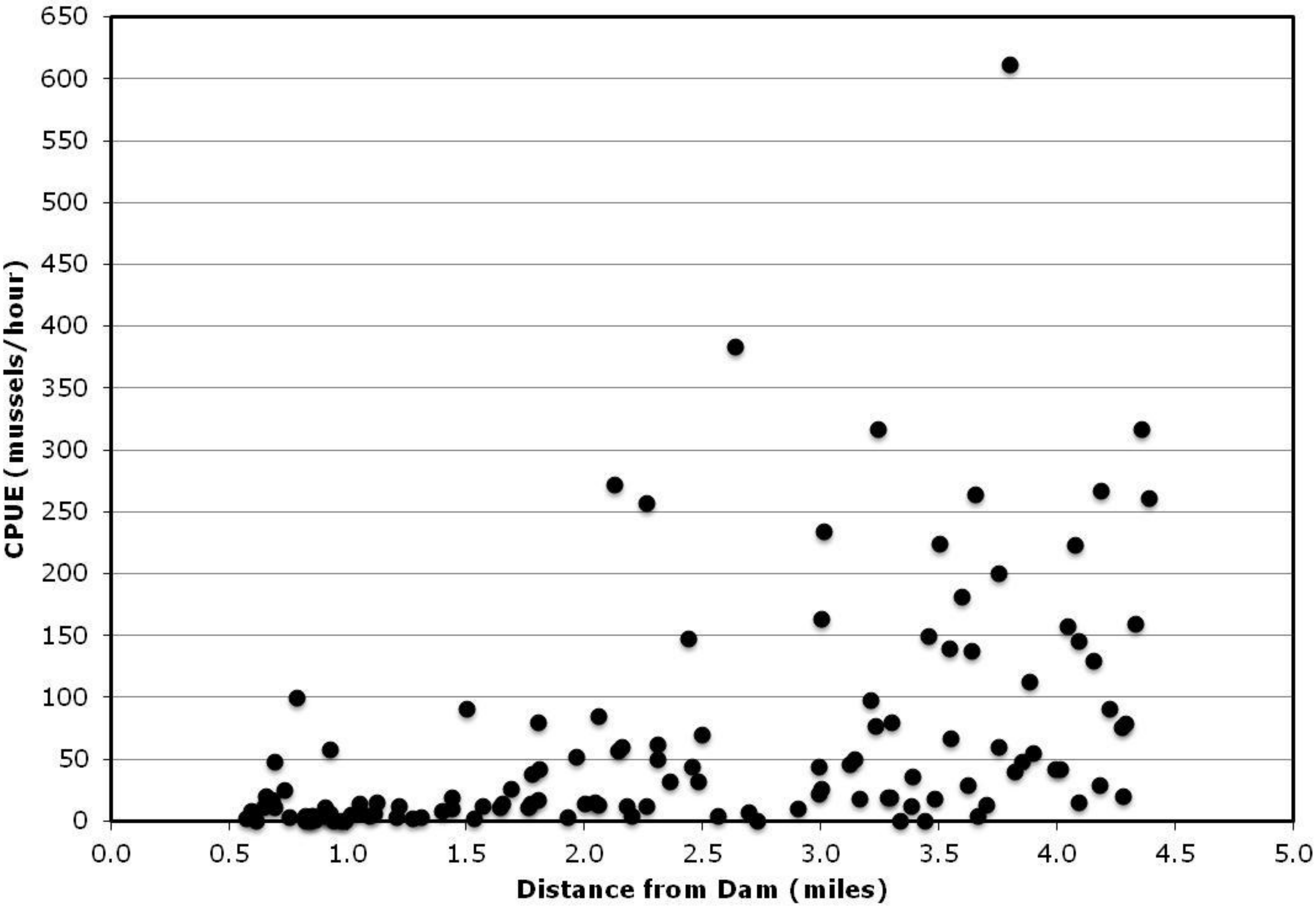


FIGURE 4.3-3: PLOT OF TOTAL CPUE VERSUS DISTANCE DOWNSTREAM FROM CONOWINGO DAM.



APPENDIX A: SEMI-QUANTITATIVE MUSSEL SURVEY LOCATIONS

ID	Team	Site	Latitude	Longitude	Date	Method	Duration (hr)
1	Normandeau	N-1	39.656527	-76.160555	8/--/10	Snorkel/SCUBA	1.50
2	Normandeau	N-2	39.656513	-76.162527	8/--/10	Snorkel/SCUBA	1.50
3	Normandeau	N-3	39.655569	-76.163472	8/--/10	Snorkel/SCUBA	1.50
4	Normandeau	N-4	39.654486	-76.163638	8/--/10	Snorkel/SCUBA	0.80
5	Normandeau	N-5	39.654847	-76.162708	8/--/10	Snorkel/SCUBA	1.50
6	Normandeau	N-6	39.650750	-76.161625	8/--/10	Snorkel/SCUBA	1.50
7	Normandeau	N-7	39.649333	-76.161486	8/--/10	Snorkel/SCUBA	1.50
8	Normandeau	N-8	39.649263	-76.160833	8/--/10	Snorkel/SCUBA	1.50
9	Normandeau	N-9	39.650694	-76.160902	8/--/10	Snorkel/SCUBA	1.50
10	Normandeau	N-10	39.649833	-76.160388	8/--/10	Snorkel/SCUBA	1.50
11	Normandeau	N-11	39.653999	-76.162583	8/--/10	Snorkel/SCUBA	0.80
12	Normandeau	N-12	39.619638	-76.136527	8/--/10	Snorkel/SCUBA	1.50
13	Normandeau	N-13	39.618666	-76.138680	8/--/10	Snorkel/SCUBA	1.50
14	Normandeau	N-14	39.614944	-76.135777	8/--/10	Snorkel/SCUBA	1.00
15	Normandeau	N-15	39.612180	-76.135027	8/--/10	Snorkel/SCUBA	1.50
16	Normandeau	N-16	39.609319	-76.137402	8/--/10	Snorkel/SCUBA	1.50
17	Normandeau	N-17	39.608055	-76.139624	8/--/10	Snorkel/SCUBA	0.80
18	Normandeau	N-18	39.607847	-76.134874	8/--/10	Snorkel/SCUBA	1.50
19	Normandeau	N-19	39.613944	-76.148250	8/--/10	Snorkel/SCUBA	0.80
20	Normandeau	N-20	39.614944	-76.147972	8/--/10	Snorkel/SCUBA	0.80
21	Normandeau	N-21	39.616083	-76.147250	8/--/10	Snorkel/SCUBA	0.80
22	Normandeau	N-22	39.617555	-76.147138	8/--/10	Snorkel/SCUBA	0.70
23	Normandeau	N-23	39.619388	-76.145749	8/--/10	Snorkel/SCUBA	0.80
24	Normandeau	N-24	39.620166	-76.144444	8/--/10	Snorkel/SCUBA	0.80
25	Normandeau	N-25	39.621583	-76.142277	8/--/10	Snorkel/SCUBA	0.80
26	Normandeau	N-26	39.624138	-76.144194	8/--/10	Snorkel/SCUBA	1.50
27	Normandeau	N-27	39.623527	-76.145666	8/--/10	Snorkel/SCUBA	1.50
28	Normandeau	N-28	39.622666	-76.147652	8/--/10	Snorkel/SCUBA	1.50
29	Normandeau	N-29	39.621652	-76.149347	8/--/10	Snorkel/SCUBA	0.80
30	Normandeau	N-30	39.651583	-76.167111	8/--/10	Snorkel/SCUBA	0.80
31	Normandeau	N-31	39.650180	-76.166194	8/--/10	Snorkel/SCUBA	0.80
32	Normandeau	N-32	39.652527	-76.164944	8/--/10	Snorkel/SCUBA	0.50
33	Normandeau	N-33	39.639166	-76.155055	8/--/10	Snorkel/SCUBA	0.80
34	Normandeau	N-34	39.638486	-76.155847	8/--/10	Snorkel/SCUBA	0.80
35	Normandeau	N-35	39.638430	-76.157083	8/--/10	Snorkel/SCUBA	0.80
36	Normandeau	N-36	39.639694	-76.159944	8/--/10	Snorkel/SCUBA	0.80
37	Normandeau	N-37	39.632138	-76.148694	8/--/10	Snorkel/SCUBA	0.50
38	Normandeau	N-38	39.632222	-76.149430	8/--/10	Snorkel/SCUBA	1.00
39	Normandeau	N-39	39.633444	-76.150638	8/--/10	Snorkel/SCUBA	1.00
40	Normandeau	N-40	39.634444	-76.152555	8/--/10	Snorkel/SCUBA	1.00
41	Normandeau	N-41	39.632805	-76.154138	8/--/10	Snorkel/SCUBA	0.80
42	Normandeau	N-42	39.636305	-76.155138	8/--/10	Snorkel/SCUBA	0.80
43	Normandeau	N-43	39.641527	-76.157111	8/--/10	Snorkel/SCUBA	0.80
44	Normandeau	N-44	39.643333	-76.157694	8/--/10	Snorkel/SCUBA	0.80
45	Normandeau	N-45	39.655481	-76.159102	8/--/10	Wading	1.50
46	Normandeau	N-46	39.655530	-76.159266	8/--/10	Wading	0.30
47	Normandeau	N-47	39.654954	-76.159587	8/--/10	Wading	0.50
48	Normandeau	N-48	39.652985	-76.157961	8/--/10	Wading	0.80

ID	Team	Site	Latitude	Longitude	Date	Method	Duration (hr)
49	Normandeau	N-49	39.654607	-76.160515	8/--/10	Wading	3.50
50	Normandeau	N-50	39.653867	-76.156994	8/--/10	Wading	1.80
51	Normandeau	N-51	39.652486	-76.156164	8/--/10	Wading	0.70
52	Normandeau	N-52	39.652682	-76.156741	8/--/10	Wading	0.20
53	Normandeau	N-53	39.652353	-76.157743	8/--/10	Wading	1.30
54	Normandeau	N-54	39.652324	-76.159775	8/--/10	Wading	3.00
55	Normandeau	N-55	39.652601	-76.159102	8/--/10	Wading	2.80
56	Normandeau	N-56	39.656340	-76.159850	8/--/10	Wading	0.20
57	Normandeau	N-57	39.619813	-76.136077	8/--/10	Wading	2.50
58	Normandeau	N-58	39.616180	-76.141256	8/--/10	Wading	3.20
59	Normandeau	N-59	39.610978	-76.139601	8/--/10	Wading	1.70
60	Normandeau	N-60	39.606300	-76.137523	8/--/10	Wading	1.80
61	Normandeau	N-61	39.612798	-76.146386	8/--/10	Wading	1.20
62	Normandeau	N-62	39.617008	-76.150487	8/--/10	Wading	1.80
63	Normandeau	N-63	39.617008	-76.148636	8/--/10	Wading	1.20
64	Normandeau	N-64	39.625029	-76.142677	8/--/10	Wading	2.80
65	Normandeau	N-65	39.626808	-76.143377	8/--/10	Wading	0.50
66	Normandeau	N-66	39.640499	-76.161967	8/--/10	Wading	0.70
67	Normandeau	N-67	39.638581	-76.161804	8/--/10	Wading	0.50
68	Normandeau	N-68	39.634827	-76.160983	8/--/10	Wading	0.70
69	Normandeau	N-69	39.634605	-76.160703	8/--/10	Wading	0.70
70	Normandeau	N-70	39.650070	-76.153920	8/--/10	Wading	0.30
71	Normandeau	N-71	39.642728	-76.152622	8/--/10	Wading	2.00
72	Normandeau	N-72	39.644364	-76.153730	8/--/10	Wading	2.00
73	Biodrawversity	B-1	39.647606	-76.164768	7/19/2012	Snorkel	0.25
74	Biodrawversity	B-2	39.647013	-76.161974	7/19/2012	Snorkel	0.17
75	Biodrawversity	B-3	39.648161	-76.158888	7/18/2012	Snorkel	0.50
76	Biodrawversity	B-4	39.649204	-76.156808	7/18/2012	Snorkel	0.47
77	Biodrawversity	B-5	39.644147	-76.162931	7/19/2012	Snorkel	0.25
78	Biodrawversity	B-6	39.646373	-76.158894	7/18/2012	Snorkel	0.20
79	Biodrawversity	B-7	39.647911	-76.155439	7/18/2012	Snorkel	0.50
80	Biodrawversity	B-8	39.643310	-76.160591	7/19/2012	Snorkel	0.33
81	Biodrawversity	B-9	39.645269	-76.156413	7/18/2012	Snorkel	0.42
82	Biodrawversity	B-10	39.643766	-76.155013	7/18/2012	Snorkel	0.50
83	Biodrawversity	B-11	39.641009	-76.154735	7/18/2012	Snorkel	0.50
84	Biodrawversity	B-12	39.636520	-76.159407	7/18/2012	Snorkel	0.50
85	Biodrawversity	B-13	39.637831	-76.152399	7/18/2012	Snorkel	0.50
86	Biodrawversity	B-14	39.634586	-76.157484	7/18/2012	Snorkel	0.17
87	Biodrawversity	B-15	39.631916	-76.155940	7/18/2012	Snorkel	0.50
88	Biodrawversity	B-16	39.631899	-76.158725	7/17/2012	Snorkel	0.25
89	Biodrawversity	B-17	39.629323	-76.159198	7/17/2012	Snorkel	0.25
90	Biodrawversity	B-18	39.629461	-76.156399	7/18/2012	Snorkel	0.12
91	Biodrawversity	B-19	39.629483	-76.154205	7/19/2012	Snorkel	0.25
92	Biodrawversity	B-20	39.629102	-76.150862	7/19/2012	Snorkel	0.50
93	Biodrawversity	B-21	39.628252	-76.147511	7/19/2012	Snorkel	0.52
94	Biodrawversity	B-22	39.626856	-76.157551	7/18/2012	Snorkel	0.42
95	Biodrawversity	B-23	39.626869	-76.154707	7/18/2012	Snorkel	0.22
96	Biodrawversity	B-24	39.625306	-76.153702	7/18/2012	Snorkel	0.22
97	Biodrawversity	B-25	39.624466	-76.156459	7/17/2012	Snorkel	0.50
98	Biodrawversity	B-26	39.627021	-76.150667	7/19/2012	Snorkel	0.25

ID	Team	Site	Latitude	Longitude	Date	Method	Duration (hr)
99	Biodrawversity	B-27	39.624569	-76.151679	7/19/2012	Snorkel	0.25
100	Biodrawversity	B-28	39.623379	-76.149179	7/19/2012	Snorkel	0.42
101	Biodrawversity	B-29	39.621931	-76.151921	7/17/2012	Snorkel	0.50
102	Biodrawversity	B-30	39.625416	-76.146876	7/19/2012	Snorkel	0.25
103	Biodrawversity	B-31	39.619681	-76.150688	7/17/2012	Snorkel	0.50
104	Biodrawversity	B-32	39.621228	-76.137797	7/18/2012	Snorkel	0.17
105	Biodrawversity	B-33	39.619327	-76.141744	7/16/2012	Snorkel	0.50
106	Biodrawversity	B-34	39.614531	-76.145501	7/17/2012	SCUBA	0.25
107	Biodrawversity	B-35	39.613773	-76.142912	7/17/2012	Snorkel	0.50
108	Biodrawversity	B-36	39.612986	-76.140312	7/17/2012	SCUBA	0.50
109	Biodrawversity	B-37	39.611331	-76.137222	7/17/2012	SCUBA	0.50
110	Biodrawversity	B-38	39.609718	-76.142746	7/17/2012	SCUBA	0.67
111	Biodrawversity	B-39	39.612751	-76.131701	7/16/2012	SCUBA	0.40
112	Biodrawversity	B-40	39.615666	-76.129857	7/16/2012	Snorkel	0.50
113	Biodrawversity	B-41	39.615093	-76.133469	7/17/2012	SCUBA	0.50
114	Biodrawversity	B-42	39.617121	-76.133449	7/16/2012	Snorkel	0.50
115	Biodrawversity	B-43	39.617231	-76.137768	7/16/2012	Snorkel	0.50
116	Biodrawversity	B-44	39.610628	-76.133697	7/16/2012	Snorkel	0.43
117	Biodrawversity	B-45	39.613259	-76.127660	7/16/2012	SCUBA	0.50
118	Biodrawversity	B-46	39.610885	-76.128973	7/16/2012	SCUBA	0.45
119	Biodrawversity	B-47	39.611694	-76.125155	7/16/2012	SCUBA	0.50
120	Biodrawversity	B-48	39.608626	-76.130902	7/16/2012	SCUBA	0.30
121	Biodrawversity	B-49	39.609865	-76.126736	7/16/2012	SCUBA	0.43
122	Biodrawversity	B-50	39.606560	-76.133865	7/17/2012	SCUBA	0.42
123	Biodrawversity	B-51	39.610472	-76.123137	7/16/2012	SCUBA	0.50
124	Biodrawversity	B-52	39.607879	-76.123753	7/16/2012	SCUBA	0.42
125	Biodrawversity	B-53	39.607398	-76.127401	7/16/2012	SCUBA	0.38
126	Biodrawversity	B-54	39.605702	-76.130426	7/17/2012	SCUBA	0.42
127	Biodrawversity	B-55	39.604427	-76.133295	7/17/2012	SCUBA	0.50
128	Biodrawversity	B-56	39.612147	-76.135123	7/17/2012	SCUBA	0.67

APPENDIX B: SEMI-QUANTITATIVE SURVEY RESULTS AND ASSOCIATED HABITAT CHARACTERISTICS.

		Species Counts								Species CPUE						Distance to Dam	Distance to Left	Modeled Habitat				LFSS (dynes/cm2)		HFSS (dynes/cm2)	
ID	Site	ElCo	AnIm	LeOc	PyCa	LaRa	Total	Taxa	DrPo	ElCo	AnIm	LeOc	PyCa	LaRa	Total	(m)	Bank (m)	Tidal/Not	Compartment	Symbol	Substrate	Value	Category	Value	Category
1	N-1	73	0	0	0	0	73	2		48.7	0.0	0.0	0.0	0.0	48.7	1110	34	Non-Tidal	Backwater	P7	Bedrock (US)	4	Optimum	32	Optimum
2	N-2	21	0	1	8	0	30	4		14.0	0.0	0.7	5.3	0.0	20.0	1046	149	Non-Tidal	Ruffle	P5	Bedrock (US)	1	Optimum	6	Optimum
3	N-3	10	0	1	1	0	12	4		6.7	0.0	0.7	0.7	0.0	8.0	950	280	Non-Tidal	Ruffle	P5	Bedrock (DS)	6	Optimum	67	Optimum
4	N-4	7	0	1	1	0	9	4		8.8	0.0	1.3	1.3	0.0	11.3	1030	382	Non-Tidal	Ruffle	P5	Bedrock (US)	74	Poor	308	Poor
5	N-5	14	0	1	2	0	17	4		9.3	0.0	0.7	1.3	0.0	11.3	1110	301	Non-Tidal	Ruffle	P5	Bedrock (US)	28	Good	121	Good
6	N-6	7	0	0	0	0	7	2		4.7	0.0	0.0	0.0	0.0	4.7	1368	432	Non-Tidal	Ruffle	P5	Bedrock (US)	146	Poor	235	Poor
7	N-7	9	0	0	0	0	9	2		6.0	0.0	0.0	0.0	0.0	6.0	1481	458	Non-Tidal	Ruffle	P5	Bedrock (DS)	0	Optimum	89	Optimum
8	N-8	5	0	0	0	0	5	2		3.3	0.0	0.0	0.0	0.0	3.3	1481	404	Non-Tidal	Ruffle	P5	Bedrock (US)	161	Poor	229	Poor
9	N-9	8	0	0	2	0	10	3		5.3	0.0	0.0	1.3	0.0	6.7	1448	377	Non-Tidal	Ruffle	P5	Bedrock (US)	253	Poor	321	Poor
10	N-10	16	0	0	1	0	17	3		10.7	0.0	0.0	0.7	0.0	11.3	1448	355	Non-Tidal	Ruffle	P5	Bedrock (US)	83	Poor	189	Marginal
11	N-11	14	0	0	0	0	14	2		17.5	0.0	0.0	0.0	0.0	17.5	1094	373	Non-Tidal	Ruffle	P5	Bedrock (US)	1	Optimum	56	Optimum
12	N-12	395	0	1	0	0	396	3		263.3	0.0	0.7	0.0	0.0	264.0	5874	98	Tidal	Tidal	--	Bedrock (DS)	21	Good	128	Good
13	N-13	331	6	0	0	0	337	3		220.7	4.0	0.0	0.0	0.0	224.7	5633	300	Tidal	Tidal	--	Bedrock (DS)	11	Optimum	109	Good
14	N-14	38	2	0	0	0	40	3		38.0	2.0	0.0	0.0	0.0	40.0	6148	375	Tidal	Tidal	--	Bedrock (DS)	8	Optimum	192	Marginal
15	N-15	60	3	1	0	0	64	4		40.0	2.0	0.7	0.0	0.0	42.7	6453	592	Tidal	Tidal	--	Gravel	2	Optimum	117	Good
16	N-16	207	10	1	0	0	218	4		138.0	6.7	0.7	0.0	0.0	145.3	6582	986	Tidal	Tidal	--	Bedrock (DS)	2	Optimum	124	Good
17	N-17	12	0	0	0	0	12	2		15.0	0.0	0.0	0.0	0.0	15.0	6582	1201	Tidal	Tidal	--	Bedrock (DS)	4	Optimum	172	Marginal
18	N-18	116	1	0	0	1	118	4		77.3	0.7	0.0	0.0	0.7	78.7	6904	952	Tidal	Tidal	--	Bedrock (DS)	3	Optimum	285	Poor
19	N-19	15	0	0	0	0	15	2		18.8	0.0	0.0	0.0	0.0	18.8	5601	1171	Tidal	Tidal	--	Boulder	1	Optimum	137	Good
20	N-20	0	0	0	0	0	0	0		0.0	0.0	0.0	0.0	0.0	0.0	5536	1060	Tidal	Run (Shallow)	P6	Bedrock (DS)	51	Marginal	290	Poor
21	N-21	9	0	1	0	0	10	3		11.3	0.0	1.3	0.0	0.0	12.5	5440	917	Tidal	Run (Shallow)	P6	Bedrock (DS)	247	Poor	341	Poor
22	N-22	54	2	0	0	0	56	3		77.1	2.9	0.0	0.0	0.0	80.0	5311	750	Tidal	Run (Shallow)	P6	Bedrock (DS)	4	Optimum	168	Marginal
23	N-23	247	2	0	5	0	254	4		308.8	2.5	0.0	6.3	0.0	317.5	5214	532	Tidal	Ruffle	P5	Bedrock (DS)	6	Optimum	61	Optimum
24	N-24	61	1	0	0	0	62	3		76.3	1.3	0.0	0.0	0.0	77.5	5198	382	Non-Tidal	Ruffle	P5	Bedrock (US)	28	Good	144	Good
25	N-25	75	3	0	0	0	78	3		93.8	3.8	0.0	0.0	0.0	97.5	5166	141	Non-Tidal	Ruffle	P5	Bedrock (US)	69	Poor	316	Poor
26	N-26	346	6	0	0	0	352	3		230.7	4.0	0.0	0.0	0.0	234.7	4844	206	Non-Tidal	Pool (Deep)	P11	Bedrock (US)	2	Optimum	41	Optimum
27	N-27	240	2	1	3	0	246	5		160.0	1.3	0.7	2.0	0.0	164.0	4828	351	Non-Tidal	Pool (Deep)	P11	Bedrock (US)	15	Good	137	Good
28	N-28	61	1	1	3	0	66	5		40.7	0.7	0.7	2.0	0.0	44.0	4812	544	Non-Tidal	Pool (Deep)	P11	Bedrock (US)	20	Good	199	Marginal
29	N-29	21	0	0	0	0	21	2		26.3	0.0	0.0	0.0	0.0	26.3	4828	737	Non-Tidal	Pool (Deep)	P11	Bedrock (US)	15	Optimum	234	Poor
30	N-30	2	0	0	0	0	2	2		2.5	0.0	0.0	0.0	0.0	2.5	917	834	Non-Tidal	Run (Deep)	P1	Bedrock (US)	38	Marginal	378	Poor
31	N-31	20	0	0	0	0	20	2		25.0	0.0	0.0	0.0	0.0	25.0	1175	833	Non-Tidal	Run (Deep)	P1	Bedrock (US)	76	Poor	386	Poor
32	N-32	0	0	0	0	0	0	0		0.0	0.0	0.0	0.0	0.0	0.0	982	649	Non-Tidal	Run (Shallow)	P2	Cobble/Rubble	21	Good	139	Good
33	N-33	8	1	0	0	0	9	3		10.0	1.3	0.0	0.0	0.0	11.3	2832	219	Non-Tidal	Pool (Deep)	P9	Bedrock (US)	13	Optimum	118	Good
34	N-34	13	0	0	1	0	14	3		16.3	0.0	0.0	1.3	0.0	17.5	2897	291	Non-Tidal	Pool (Deep)	P9	Bedrock (US)	30	Good	117	Good
35	N-35	63	0	1	0	0	64	3		78.8	0.0	1.3	0.0	0.0	80.0	2897	392	Non-Tidal	Pool (Deep)	P9	Bedrock (US)	6	Optimum	69	Optimum
36	N-36	21	0	0	0	0	21	2		26.3	0.0	0.0	0.0	0.0	26.3	2720	647	Non-Tidal	Ruffle	P5	Bedrock (US)	4	Optimum	40	Optimum
37	N-37	5	1	0	0	0	6	3		10.0	2.0	0.0	0.0	0.0	12.0	3637	-44	Non-Tidal	Side Channel	P13	Cobble/Rubble	0	Optimum	29	Optimum
38	N-38	252	2	0	3	0	257	4		252.0	2.0	0.0	3.0	0.0	257.0	3637	20	Non-Tidal	Pool (Shallow)	P10	Cobble/Rubble	4	Optimum	41	Optimum
39	N-39	52	4	0	1	0	57	4		52.0	4.0	0.0	1.0	0.0	57.0	3444	38	Non-Tidal	Pool (Shallow)	P10	Boulder	0	Optimum	49	Optimum
40	N-40	82	3	0	0	0	85	3		82.0	3.0	0.0	0.0	0.0	85.0	3315	162	Non-Tidal	Pool (Shallow)	P10	Bedrock (US)	44	Marginal	189	Marginal
41	N-41	10	0	0	0	0	10	2		12.5	0.0	0.0	0.0	0.0	12.5	3508	348	Non-Tidal	Ruffle	P5	Bedrock (US)	1	Optimum	140	Good
42	N-42	2	1	0	0	0	3	3		2.5	1.3	0.0	0.0	0.0	3.8	3106	299	Non-Tidal	Ruffle	P5	Bedrock (US)	142	Poor	280	Poor
43	N-43	10	0	0	0	0	10	2		12.5	0.0	0.0	0.0	0.0	12.5	2527	445	Non-Tidal	Pool (Deep)	P9	Bedrock (US)	28	Good	149	Good
44	N-44	8	0	0	0	0	8	2		10.0	0.0	0.0	0.0	0.0	10.0	2317	378	Non-Tidal	Ruffle	P5	Bedrock (US)	37	Marginal	144	Good
45	N-45	1	0	0	0	0	1	2		0.7	0.0	0.0	0.0	0.0	0.7	1352	97	Non-Tidal	Riffle (Shallow)	O7	Gravel	0	Optimum	9	Optimum
46	N-46	0	0	0	0	0	0	0		0.0	0.0	0.0	0.0	0.0	0.0	1320	113	Non-Tidal	Riffle (Shallow)	O5	Gravel	1	Optimum	13	Optimum
47	N-47	2	0	0	0	0	2	2		4.0	0.0	0.0	0.0	0.0	4.0	1320	154	Non-Tidal	Pool (Shallow)	O6	Boulder	3	Optimum	32	Optimum

		Species Counts								Species CPUE						Distance to Dam	Distance to Left	Modeled Habitat				LFSS (dynes/cm2)		HFSS (dynes/cm2)	
ID	Site	ElCo	AnIm	LeOc	PyCa	LaRa	Total	Taxa	DrPo	ElCo	AnIm	LeOc	PyCa	LaRa	Total	(m)	Bank (m)	Tidal/Not	Compartment	Symbol	Substrate	Value	Category	Value	Category
48	N-48	0	0	0	0	0	0	0		0.0	0.0	0.0	0.0	0.0	0.0	1513	52	Non-Tidal	Pool (Shallow)	O6	Cobble/Rubble	10	Optimum	62	Optimum
49	N-49	9	0	0	2	0	11	3		2.6	0.0	0.0	0.6	0.0	3.1	1207	239	Non-Tidal	Ruffle	P5	Bedrock (US)	0	Optimum	12	Optimum
50	N-50	96	0	0	8	1	105	4		53.3	0.0	0.0	4.4	0.6	58.3	1481	-53	Non-Tidal	Side Channel	P14	Silt	0	Optimum	0	Optimum
51	N-51	4	0	0	1	0	5	3		5.7	0.0	0.0	1.4	0.0	7.1	1674	-70	Non-Tidal	Side Channel	P14	Silt	0	Optimum	2	Optimum
52	N-52	1	0	0	0	0	1	2		5.0	0.0	0.0	0.0	0.0	5.0	1625	-31	Non-Tidal	Side Channel	P14	Silt	0	Optimum	47	Optimum
53	N-53	1	0	0	0	0	1	2		0.8	0.0	0.0	0.0	0.0	0.8	1561	72	Non-Tidal	Pool (Shallow)	O6	Cobble/Rubble	4	Optimum	14	Optimum
54	N-54	3	0	0	0	0	3	2		1.0	0.0	0.0	0.0	0.0	1.0	1384	227	Non-Tidal	Ruffle	P5	Bedrock (US)	147	Poor	148	Good
55	N-55	11	0	0	0	0	11	2		3.9	0.0	0.0	0.0	0.0	3.9	1448	161	Non-Tidal	Ruffle	P5	Bedrock (US)	139	Poor	232	Poor
56	N-56	20	0	0	0	0	20	2		100.0	0.0	0.0	0.0	0.0	100.0	1255	20	Non-Tidal	Pool (Shallow)	O6	Bedrock (US)	0	Optimum	22	Optimum
57	N-57	71	0	1	0	0	72	3		28.4	0.0	0.4	0.0	0.0	28.8	5826	54	Tidal	Tidal	--	Bedrock (DS)	28	Good	124	Good
58	N-58	207	3	0	4	0	214	4		64.7	0.9	0.0	1.3	0.0	66.9	5713	644	Tidal	Tidal	--	Boulder	1	Optimum	269	Poor
59	N-59	72	0	2	8	0	82	4		42.4	0.0	1.2	4.7	0.0	48.2	6196	929	Tidal	Tidal	--	Bedrock (US)	0	Optimum	37	Optimum
60	N-60	161	3	0	0	0	164	3		89.4	1.7	0.0	0.0	0.0	91.1	6791	1235	Tidal	Tidal	--	Bedrock (DS)	0	Optimum	38	Optimum
61	N-61	5	0	0	0	0	5	2		4.2	0.0	0.0	0.0	0.0	4.2	5890	1229	Tidal	Tidal	--	Bedrock (DS)	23	Good	218	Poor
62	N-62	34	0	1	0	0	35	3		18.9	0.0	0.6	0.0	0.0	19.4	5279	1007	Tidal	Ruffle	P5	Bedrock (US)	0	Optimum	37	Optimum
63	N-63	23	0	0	0	0	23	2		19.2	0.0	0.0	0.0	0.0	19.2	5295	907	Tidal	Run (Shallow)	P6	Bedrock (DS)	32	Marginal	173	Marginal
64	N-64	122	5	0	1	0	128	4		43.6	1.8	0.0	0.4	0.0	45.7	5021	36	Non-Tidal	Side Channel	P12	Cobble/Rubble	0	Optimum	46	Optimum
65	N-65	11	0	0	0	0	11	2		22.0	0.0	0.0	0.0	0.0	22.0	4812	-62	Non-Tidal	Side Channel	P13	Cobble/Rubble	0	Optimum	89	Optimum
66	N-66	8	0	0	0	0	8	2		11.4	0.0	0.0	0.0	0.0	11.4	2639	882	Non-Tidal	Ruffle	P5	Bedrock (US)	174	Poor	271	Poor
67	N-67	6	0	0	1	0	7	3		12.0	0.0	0.0	2.0	0.0	14.0	2849	809	Non-Tidal	Ruffle	P5	Bedrock (US)	175	Poor	154	Marginal
68	N-68	9	1	1	0	0	11	4		12.9	1.4	1.4	0.0	0.0	15.7	3283	835	Non-Tidal	Ruffle	P5	Bedrock (US)	52	Poor	280	Poor
69	N-69	9	0	0	0	0	9	2		12.9	0.0	0.0	0.0	0.0	12.9	3315	822	Non-Tidal	Ruffle	P5	Bedrock (US)	299	Poor	300	Poor
70	N-70	0	0	0	1	0	1	2		0.0	0.0	0.0	3.3	0.0	3.3	2108	188	Non-Tidal	Side Channel	P14	Silt	0	Optimum	23	Optimum
71	N-71	177	4	0	2	0	183	4		88.5	2.0	0.0	1.0	0.0	91.5	2414	21	Non-Tidal	Pool (Deep)	P9	Bedrock (US)	0	Optimum	41	Optimum
72	N-72	33	4	0	1	0	38	4		16.5	2.0	0.0	0.5	0.0	19.0	2317	14	Non-Tidal	Pool (Deep)	P9	Bedrock (US)	15	Optimum	6	Optimum
73	B-1	1	0	0	0	0	1	2		4.0	0.0	0.0	0.0	0.0	4.0	1361	797	Non-Tidal	Ruffle	P5	Bedrock (US)	117	Poor	290	Poor
74	B-2	0	0	0	0	0	0	0		0.0	0.0	0.0	0.0	0.0	0.0	1583	600	Non-Tidal	Ruffle	P5	Bedrock (US)	10	Optimum	119	Good
75	B-3	7	0	0	0	0	7	2	X	14.0	0.0	0.0	0.0	0.0	14.0	1685	306	Non-Tidal	Ruffle	P5	Bedrock (US)	12	Optimum	112	Good
76	B-4	2	0	1	0	0	3	3	X	4.3	0.0	2.1	0.0	0.0	6.4	1783	95	Non-Tidal	Side Channel	P14	Bedrock (US)	14	Optimum	174	Marginal
77	B-5	1	0	0	0	0	1	2		4.0	0.0	0.0	0.0	0.0	4.0	1749	735	Non-Tidal	Ruffle	P5	Bedrock (US)	5	Optimum	130	Good
78	B-6	3	0	0	0	0	3	2		15.0	0.0	0.0	0.0	0.0	15.0	1801	357	Non-Tidal	Ruffle	P5	Bedrock (US)	76	Poor	233	Poor
79	B-7	6	0	0	0	0	6	2	X	12.0	0.0	0.0	0.0	0.0	12.0	1954	31	Non-Tidal	Side Channel	P14	Bedrock (US)	85	Poor	450	Poor
80	B-8	1	0	0	0	0	1	2		3.0	0.0	0.0	0.0	0.0	3.0	1935	579	Non-Tidal	Ruffle	P5	Bedrock (US)	66	Poor	324	Poor
81	B-9	1	0	0	0	0	1	2		2.4	0.0	0.0	0.0	0.0	2.4	2045	164	Non-Tidal	Ruffle	P5	Bedrock (US)	146	Poor	258	Poor
82	B-10	3	1	0	0	0	4	3	X	6.0	2.0	0.0	0.0	0.0	8.0	2243	154	Non-Tidal	Pool (Deep)	P9	Bedrock (US)	7	Optimum	82	Optimum
83	B-11	1	0	0	0	0	1	2		2.0	0.0	0.0	0.0	0.0	2.0	2464	237	Non-Tidal	Pool (Deep)	P9	Bedrock (US)	1366	Poor	180	Marginal
84	B-12	7	0	0	0	0	7	2		14.0	0.0	0.0	0.0	0.0	14.0	2654	658	Non-Tidal	Ruffle	P5	Bedrock (US)	5	Optimum	105	Good
85	B-13	17	0	0	1	1	19	4		34.0	0.0	0.0	2.0	2.0	38.0	2859	40	Non-Tidal	Pool (Deep)	P9	Bedrock (US)	0	Optimum	56	Optimum
86	B-14	7	0	0	0	0	7	2		42.0	0.0	0.0	0.0	0.0	42.0	2908	580	Non-Tidal	Ruffle	P5	Bedrock (US)	0	Optimum	442	Poor
87	B-15	7	0	0	0	0	7	2		14.0	0.0	0.0	0.0	0.0	14.0	3223	540	Non-Tidal	Ruffle	P5	Bedrock (US)	0	Optimum	214	Poor
88	B-16	13	0	0	0	0	13	2		52.0	0.0	0.0	0.0	0.0	52.0	3162	761	Non-Tidal	Ruffle	P5	Bedrock (US)	10	Optimum	66	Optimum
89	B-17	67	0	0	0	1	68	3	X	268.0	0.0	0.0	0.0	4.0	272.0	3420	916	Non-Tidal	Ruffle	P5	Bedrock (US)	0	Optimum	112	Good
90	B-18	6	1	0	0	0	7	3		51.4	8.6	0.0	0.0	0.0	60.0	3472	691	Non-Tidal	Ruffle	P5	Bedrock (US)	35	Marginal	131	Good
91	B-19	1	0	0	0	0	1	2		4.0	0.0	0.0	0.0	0.0	4.0	3540	506	Non-Tidal	Ruffle	P5	Bedrock (US)	44	Marginal	206	Poor
92	B-20	31	0	0	0	0	31	2		62.0	0.0	0.0	0.0	0.0	62.0	3711	249	Non-Tidal	Side Channel	P13	Bedrock (US)	15	Optimum	147	Good
93	B-21	20	2	0	1	0	23	4		38.7	3.9	0.0	1.9	0.0	44.5	3950	48	Non-Tidal	Side Channel	P13	Bedrock (US)	31	Marginal	206	Poor
94	B-22	21	0	0	0	0	21	2		50.4	0.0	0.0	0.0	0.0	50.4	3717	876	Non-Tidal	Ruffle	P5	Bedrock (US)	0	Optimum	157	Marginal
95	B-23	7	0	0	0	0	7	2		32.3	0.0	0.0	0.0	0.0	32.3	3796	653	Non-Tidal	Side Channel	P13	Bedrock (US)	7	Optimum	154	Marginal
96	B-24	7	0	0	0	0	7	2		32.3	0.0	0.0	0.0	0.0	32.3	3988	671	Non-Tidal	Side Channel	P13	Bedrock (US)	61	Poor	311	Poor
97	B-25	35	0	0	0	0	35	2		70.0	0.0	0.0	0.0	0.0	70.0	4019	919	Non-Tidal	Run (Shallow)	P6	Bedrock (US)	139	Poor	217	Poor

		Species Counts								Species CPUE						Distance to Dam (m)	Distance to Left Bank (m)	Modeled Habitat				LFSS (dynes/cm2)		HFSS (dynes/cm2)	
ID	Site	ElCo	AnIm	LeOc	PyCa	LaRa	Total	Taxa	DrPo	ElCo	AnIm	LeOc	PyCa	LaRa	Total			Tidal/Not	Compartment	Symbol	Substrate	Value	Category	Value	Category
98	B-26	37	0	0	0	0	37	2		148.0	0.0	0.0	0.0	0.0	148.0	3926	349	Non-Tidal	Side Channel	P13	Bedrock (US)	0	Optimum	578	Poor
99	B-27	1	0	0	0	0	1	2		4.0	0.0	0.0	0.0	0.0	4.0	4127	591	Non-Tidal	Side Channel	P13	Bedrock (US)	63	Poor	234	Poor
100	B-28	3	0	0	0	0	3	2		7.2	0.0	0.0	0.0	0.0	7.2	4336	536	Non-Tidal	Side Channel	P12	Bedrock (US)	480	Poor	410	Poor
101	B-29	0	0	0	0	0	0	0		0.0	0.0	0.0	0.0	0.0	0.0	4392	812	Non-Tidal	Run (Shallow)	P6	Bedrock (US)	109	Poor	315	Poor
102	B-30	95	1	0	0	0	96	3		380.0	4.0	0.0	0.0	0.0	384.0	4240	236	Non-Tidal	Side Channel	P13	Bedrock (US)	9	Optimum	171	Marginal
103	B-31	5	0	0	0	0	5	2		10.0	0.0	0.0	0.0	0.0	10.0	4668	887	Non-Tidal	Run (Shallow)	P6	Bedrock (US)	50	Marginal	207	Poor
104	B-32	2	1	0	0	0	3	3		12.0	6.0	0.0	0.0	0.0	18.0	5091	17	Non-Tidal	Tidal	--	Organic/Detritus	0	Optimum	0	Optimum
105	B-33	25	0	0	0	0	25	2		50.0	0.0	0.0	0.0	0.0	50.0	5058	347	Tidal	Tidal	--	Bedrock (DS)	33	Marginal	451	Poor
106	B-34	0	0	0	0	0	0	0		0.0	0.0	0.0	0.0	0.0	0.0	5369	970	Tidal	Tidal	--	Bedrock (DS)	36	Marginal	229	Poor
107	B-35	72	2	0	1	0	75	4		144.0	4.0	0.0	2.0	0.0	150.0	5558	915	Tidal	Tidal	--	Bedrock (DS)	24	Good	234	Poor
108	B-36	84	6	0	0	1	91	4	X	168.0	12.0	0.0	0.0	2.0	182.0	5782	808	Tidal	Tidal	--	Bedrock (DS)	4	Optimum	211	Poor
109	B-37	296	8	2	0	0	306	4		592.0	16.0	4.0	0.0	0.0	612.0	6111	770	Tidal	Tidal	--	Boulder	0	Optimum	18	Optimum
110	B-38	9	0	0	0	0	9	2		13.5	0.0	0.0	0.0	0.0	13.5	5954	1214	Tidal	Tidal	--	Bedrock (DS)	17	Good	410	Poor
111	B-39	22	0	0	0	0	22	2		55.0	0.0	0.0	0.0	0.0	55.0	6274	381	Tidal	Tidal	--	Bedrock (DS)	0	Optimum	60	Optimum
112	B-40	26	4	0	0	0	30	3		52.0	8.0	0.0	0.0	0.0	60.0	6033	34	Tidal	Tidal	--	Boulder	0	Optimum	60	Optimum
113	B-41	65	3	0	1	0	69	4		130.0	6.0	0.0	2.0	0.0	138.0	5849	242	Tidal	Tidal	--	Bedrock (DS)	1	Optimum	113	Good
114	B-42	68	1	1	0	0	70	4		136.0	2.0	2.0	0.0	0.0	140.0	5699	69	Tidal	Tidal	--	Bedrock (DS)	0	Optimum	64	Optimum
115	B-43	18	0	0	0	0	18	2		36.0	0.0	0.0	0.0	0.0	36.0	5447	330	Tidal	Tidal	--	Bedrock (DS)	0	Optimum	246	Poor
116	B-44	47	2	0	0	0	49	3		108.5	4.6	0.0	0.0	0.0	113.1	6246	653	Tidal	Tidal	--	Bedrock (DS)	6	Optimum	193	Marginal
117	B-45	20	1	0	0	0	21	3		40.0	2.0	0.0	0.0	0.0	42.0	6421	66	Tidal	Tidal	--	Bedrock (DS)	9	Optimum	387	Poor
118	B-46	69	1	0	1	0	71	4		153.3	2.2	0.0	2.2	0.0	157.8	6507	304	Tidal	Tidal	--	Gravel	2	Optimum	117	Good
119	B-47	62	2	0	0	1	65	4		124.0	4.0	0.0	0.0	2.0	130.0	6679	74	Tidal	Tidal	--	Cobble/Rubble	0	Optimum	8	Optimum
120	B-48	63	3	1	0	0	67	4		210.0	10.0	3.3	0.0	0.0	223.3	6558	602	Tidal	Tidal	--	Bedrock (DS)	0	Optimum	78	Optimum
121	B-49	109	6	1	0	0	116	4		251.5	13.8	2.3	0.0	0.0	267.7	6729	318	Tidal	Tidal	--	Bedrock (DS)	1	Optimum	145	Good
122	B-50	12	0	0	0	0	12	2		28.8	0.0	0.0	0.0	0.0	28.8	6725	943	Tidal	Tidal	--	Bedrock (DS)	2	Optimum	189	Marginal
123	B-51	78	2	0	0	0	80	3		156.0	4.0	0.0	0.0	0.0	160.0	6968	50	Tidal	Tidal	--	Bedrock (DS)	2	Optimum	148	Good
124	B-52	104	4	1	0	0	109	4	X	249.6	9.6	2.4	0.0	0.0	261.6	7057	267	Tidal	Tidal	--	Bedrock (DS)	1	Optimum	117	Good
125	B-53	27	2	0	0	0	29	3		70.4	5.2	0.0	0.0	0.0	75.7	6877	552	Tidal	Tidal	--	Bedrock (DS)	1	Optimum	126	Good
126	B-54	129	2	0	1	0	132	4	X	309.6	4.8	0.0	2.4	0.0	316.8	7008	861	Tidal	Tidal	--	Bedrock (DS)	2	Optimum	201	Poor
127	B-55	10	0	0	0	0	10	2		20.0	0.0	0.0	0.0	0.0	20.0	6881	1103	Tidal	Tidal	--	Bedrock (DS)	1	Optimum	132	Good
128	B-56	123	7	2	1	1	134	6		184.5	10.5	3.0	1.5	1.5	201.0	6035	589	Tidal	Tidal	--	Bedrock (DS)	1	Optimum	160	Marginal

APPENDIX C: HABITAT DETAILS FOR ALEWIFE FLOATER AND EASTERN FLOATER

							Habitat				
Team	Site	Species	Length (mm)	Tag #	Depth (m)	Flow Velocity	Bedrock (%)	Boulder (%)	Cobble (%)	Gravel (%)	Sand (%)
Biodrawversity	B-10	AnIm	98.0	456	0.9	Medium	0	10	60	30	0
Biodrawversity	B-18	AnIm	86.0	-	1.0	Medium	0	10	70	20	0
Biodrawversity	B-21	AnIm	82.0	-	0.5	Medium	0	0	90	0	10
Biodrawversity	B-21	AnIm	115.0	-	0.5	Medium	0	0	90	0	10
Biodrawversity	B-30	AnIm	104.0	-	1.0	Medium	0	0	50	50	0
Biodrawversity	B-32	AnIm	116.0	-	0.6	High	0	0	30	40	30
Biodrawversity	B-35	AnIm	100.8	454	0.7	Medium	10	25	35	25	5
Biodrawversity	B-35	AnIm	105.3	453	0.7	Medium	10	25	35	25	5
Biodrawversity	B-36	AnIm	83.3	445	1.1	Medium	20	25	25	25	5
Biodrawversity	B-36	AnIm	85.3	447	1.1	Medium	20	25	25	25	5
Biodrawversity	B-36	AnIm	86.1	448	1.1	Medium	20	25	25	25	5
Biodrawversity	B-36	AnIm	89.0	449	1.1	Medium	20	25	25	25	5
Biodrawversity	B-36	AnIm	95.8	444	1.1	Medium	20	25	25	25	5
Biodrawversity	B-36	AnIm	100.4	446	1.1	Medium	20	25	25	25	5
Biodrawversity	B-37	AnIm	94.3	443	2.0	Low	0	0	35	35	30
Biodrawversity	B-37	AnIm	95.9	440	2.0	Low	0	0	35	35	30
Biodrawversity	B-37	AnIm	97.2	441	2.0	Low	0	0	35	35	30
Biodrawversity	B-37	AnIm	97.2	439	2.0	Low	0	0	35	35	30
Biodrawversity	B-37	AnIm	108.6	437	2.0	Low	0	0	35	35	30
Biodrawversity	B-37	AnIm	116.6	436	2.0	Low	0	0	35	35	30
Biodrawversity	B-37	AnIm	118.9	442	2.0	Low	0	0	35	35	30
Biodrawversity	B-40	AnIm	72.0	-	1.1	Low	5	45	45	0	5
Biodrawversity	B-40	AnIm	84.0	-	1.1	Low	5	45	45	0	5
Biodrawversity	B-40	AnIm	88.0	-	1.1	Low	5	45	45	0	5
Biodrawversity	B-40	AnIm	115.0	-	1.1	Low	5	45	45	0	5
Biodrawversity	B-41	AnIm	99.6	451	1.2	Low	0	0	10	85	5
Biodrawversity	B-41	AnIm	106.3	452	1.2	Low	0	0	10	85	5
Biodrawversity	B-41	AnIm	113.8	450	1.2	Low	0	0	10	85	5
Biodrawversity	B-42	AnIm	110.0	-	0.8	Medium	0	35	45	15	5
Biodrawversity	B-44	AnIm	94.7	415	0.9	Low	0	50	50	0	0
Biodrawversity	B-44	AnIm	115.8	416	0.9	Low	0	50	50	0	0
Biodrawversity	B-45	AnIm	125.0	-	1.8	Low	15	25	30	20	10
Biodrawversity	B-46	AnIm	101.6	413	1.5	Low	0	0	50	50	0

Team	Site	Species	Length (mm)	Tag #	Depth (m)	Flow Velocity	Habitat Bedrock (%)	Boulder (%)	Cobble (%)	Gravel (%)	Sand (%)
Biodrawversity	B-47	AnIm	113.0	-	1.2	Low	0	0	50	50	0
Biodrawversity	B-47	AnIm	135.0	-	1.2	Low	0	0	50	50	0
Biodrawversity	B-48	AnIm	95.8	418	1.8	Low	25	25	25	25	0
Biodrawversity	B-48	AnIm	118.0	417	1.8	Low	25	25	25	25	0
Biodrawversity	B-48	AnIm	135.3	419	1.8	Low	25	25	25	25	0
Biodrawversity	B-49	AnIm	89.7	407	1.8	Low	0	0	50	50	0
Biodrawversity	B-49	AnIm	95.0	406	1.8	Low	0	0	50	50	0
Biodrawversity	B-49	AnIm	99.8	410	1.8	Low	0	0	50	50	0
Biodrawversity	B-49	AnIm	108.5	409	1.8	Low	0	0	50	50	0
Biodrawversity	B-49	AnIm	111.5	412	1.8	Low	0	0	50	50	0
Biodrawversity	B-49	AnIm	127.8	408	1.8	Low	0	0	50	50	0
Biodrawversity	B-51	AnIm	120.0	-	1.3	Low	0	40	35	15	10
Biodrawversity	B-51	AnIm	120.0	-	1.3	Low	0	40	35	15	10
Biodrawversity	B-52	AnIm	106.2	401	2.2	Low	0	20	50	20	10
Biodrawversity	B-52	AnIm	108.5	402	2.0	Low	0	20	50	20	10
Biodrawversity	B-52	AnIm	116.3	403	2.0	Low	0	20	50	20	10
Biodrawversity	B-52	AnIm	119.1	404	2.2	Low	0	20	50	20	10
Biodrawversity	B-53	AnIm	115.6	422	2.1	Low	0	0	100	0	0
Biodrawversity	B-53	AnIm	128.9	421	2.1	Low	0	0	100	0	0
Biodrawversity	B-54	AnIm	78.9	425	2.9	Low	20	40	30	10	0
Biodrawversity	B-54	AnIm	109.7	424	2.9	Low	20	40	30	10	0
Biodrawversity	B-56	AnIm	80.0	431	1.0	Low	0	0	10	75	15
Biodrawversity	B-56	AnIm	102.3	433	1.0	Low	0	0	10	75	15
Biodrawversity	B-56	AnIm	110.5	430	1.0	Low	0	0	10	75	15
Biodrawversity	B-56	AnIm	110.9	427	1.0	Low	0	0	10	75	15
Biodrawversity	B-56	AnIm	114.5	428	1.0	Low	0	0	10	75	15
Biodrawversity	B-56	AnIm	116.4	426	1.0	Low	0	0	10	75	15
Biodrawversity	B-56	AnIm	136.5	429	1.0	Low	0	0	10	75	15
Normandeau	NR	AnIm	92.0	0	NR	NR	NR	NR	NR	NR	NR
Normandeau	NR	AnIm	108.0	1	NR	NR	NR	NR	NR	NR	NR
Normandeau	NR	AnIm	105.0	2	NR	NR	NR	NR	NR	NR	NR
Normandeau	NR	AnIm	87.0	3	NR	NR	NR	NR	NR	NR	NR
Normandeau	NR	AnIm	106.0	4	NR	NR	NR	NR	NR	NR	NR
Normandeau	NR	AnIm	96.0	5	NR	NR	NR	NR	NR	NR	NR
Normandeau	NR	AnIm	98.0	6	NR	NR	NR	NR	NR	NR	NR

Team	Site	Species	Length (mm)	Tag #	Depth (m)	Flow Velocity	Habitat Bedrock (%)	Boulder (%)	Cobble (%)	Gravel (%)	Sand (%)
Normandeau	NR	AnIm	104.0	7	NR	NR	NR	NR	NR	NR	NR
Normandeau	NR	AnIm	104.0	8	NR	NR	NR	NR	NR	NR	NR
Normandeau	NR	AnIm	99.0	9	NR	NR	NR	NR	NR	NR	NR
Normandeau	NR	AnIm	100.0	10	NR	NR	NR	NR	NR	NR	NR
Normandeau	NR	AnIm	114.0	11	NR	NR	NR	NR	NR	NR	NR
Normandeau	NR	AnIm	108.0	12	NR	NR	NR	NR	NR	NR	NR
Normandeau	NR	AnIm	104.0	13	NR	NR	NR	NR	NR	NR	NR
Normandeau	NR	AnIm	99.0	14	NR	NR	NR	NR	NR	NR	NR
Normandeau	NR	AnIm	98.0	15	NR	NR	NR	NR	NR	NR	NR
Normandeau	NR	AnIm	95.0	16	NR	NR	NR	NR	NR	NR	NR
Normandeau	NR	AnIm	104.0	17	NR	NR	NR	NR	NR	NR	NR
Normandeau	NR	AnIm	117.0	18	NR	NR	NR	NR	NR	NR	NR
Normandeau	NR	AnIm	110.0	19	NR	NR	NR	NR	NR	NR	NR
Normandeau	NR	AnIm	100.0	20	NR	NR	NR	NR	NR	NR	NR
Normandeau	NR	AnIm	115.0	21	NR	NR	NR	NR	NR	NR	NR
Normandeau	NR	AnIm	117.0	22	NR	NR	NR	NR	NR	NR	NR
Normandeau	NR	AnIm	115.0	23	NR	NR	NR	NR	NR	NR	NR
Normandeau	NR	AnIm	107.0	24	NR	NR	NR	NR	NR	NR	NR
Normandeau	NR	AnIm	93.0	25	NR	NR	NR	NR	NR	NR	NR
Normandeau	NR	AnIm	94.0	26	NR	NR	NR	NR	NR	NR	NR
Normandeau	NR	AnIm	116.0	27	NR	NR	NR	NR	NR	NR	NR
Normandeau	NR	AnIm	119.0	28	NR	NR	NR	NR	NR	NR	NR
Normandeau	NR	AnIm	104.0	29	NR	NR	NR	NR	NR	NR	NR
Normandeau	NR	AnIm	110.0	30	NR	NR	NR	NR	NR	NR	NR
Normandeau	NR	AnIm	94.0	31	NR	NR	NR	NR	NR	NR	NR
Normandeau	NR	AnIm	106.0	32	NR	NR	NR	NR	NR	NR	NR
Normandeau	NR	AnIm	114.0	33	NR	NR	NR	NR	NR	NR	NR
Normandeau	NR	AnIm	114.0	34	NR	NR	NR	NR	NR	NR	NR
Normandeau	NR	AnIm	113.0	35	NR	NR	NR	NR	NR	NR	NR
Normandeau	NR	AnIm	111.0	50	NR	NR	NR	NR	NR	NR	NR
Normandeau	NR	AnIm	113.0	51	NR	NR	NR	NR	NR	NR	NR
Normandeau	NR	AnIm	120.0	52	NR	NR	NR	NR	NR	NR	NR
Normandeau	NR	AnIm	107.0	53	NR	NR	NR	NR	NR	NR	NR
Normandeau	NR	AnIm	132.0	54	NR	NR	NR	NR	NR	NR	NR
Normandeau	NR	AnIm	116.0	55	NR	NR	NR	NR	NR	NR	NR

Team	Site	Species	Length (mm)	Tag #	Depth (m)	Flow Velocity	Habitat Bedrock (%)	Boulder (%)	Cobble (%)	Gravel (%)	Sand (%)
Normandeau	NR	AnIm	111.0	56	NR	NR	NR	NR	NR	NR	NR
Normandeau	NR	AnIm	106.0	57	NR	NR	NR	NR	NR	NR	NR
Normandeau	NR	AnIm	88.0	58	NR	NR	NR	NR	NR	NR	NR
Normandeau	NR	AnIm	121.0	59	NR	NR	NR	NR	NR	NR	NR
Normandeau	NR	AnIm	115.0	60	NR	NR	NR	NR	NR	NR	NR
Normandeau	NR	AnIm	102.0	61	NR	NR	NR	NR	NR	NR	NR
Normandeau	NR	AnIm	116.0	62	NR	NR	NR	NR	NR	NR	NR
Normandeau	NR	AnIm	92.0	63	NR	NR	NR	NR	NR	NR	NR
Normandeau	NR	AnIm	100.0	64	NR	NR	NR	NR	NR	NR	NR
Normandeau	NR	AnIm	114.0	65	NR	NR	NR	NR	NR	NR	NR
Normandeau	NR	AnIm	104.0	67	NR	NR	NR	NR	NR	NR	NR
Normandeau	NR	AnIm	90.0	68	NR	NR	NR	NR	NR	NR	NR
Biodrawversity	B-4	LeOc	69.8	455	1.1	Low	0	0	30	50	20
Biodrawversity	B-37	LeOc	97.3	438	2.0	Low	0	0	10	45	45
Biodrawversity	B-37	LeOc	106.0	435	2.0	Low	0	0	50	0	50
Biodrawversity	B-42	LeOc	68.0	423	1.0	Medium	0	35	45	15	5
Biodrawversity	B-48	LeOc	91.0	420	2.0	Low	25	25	25	25	0
Biodrawversity	B-49	LeOc	73.9	411	1.8	Low	0	0	50	50	0
Biodrawversity	B-52	LeOc	87.1	405	2.0	Low	0	20	50	20	10
Biodrawversity	B-56	LeOc	84.4	434	1.0	Low	0	0	10	75	15
Biodrawversity	B-56	LeOc	106.5	432	1.0	Low	0	0	10	75	15

APPENDIX D: QUANTITATIVE SURVEY RESULTS

		Position				Substrate Percentages							Species Counts			
Station	Random Start	Across	Up	Depth (m)	Velocity (m/s)	Silt	Sand	Gravel	Cobble	Boulder	Bedrock	Cover	ElCo	AnIm	PyCa	All
QS-1	1	3	2	0.34	0.00	5	20	65	10	0	0	Vegetation	0	0	0	0
QS-1	1	3	8.5	0.58	0.00	0	5	5	40	0	50	None	0	0	0	0
QS-1	1	3	15	0.37	0.00	0	5	20	0	0	75	None	1	0	0	1
QS-1	1	3	21.5	0.49	0.00	10	20	40	30	0	0	None	2	0	0	2
QS-1	1	3	28	0.37	0.00	5	5	45	15	0	30	Vegetation	0	0	0	0
QS-1	1	9.5	2	0.43	0.00	5	20	65	10	0	0	Vegetation	1	0	0	1
QS-1	1	9.5	8.5	0.40	0.00	15	25	30	30	0	0	None	0	0	0	0
QS-1	1	9.5	15	0.43	0.00	10	20	50	20	0	0	None	1	0	0	1
QS-1	1	9.5	21.5	0.37	0.00	10	10	20	60	0	0	None	0	0	0	0
QS-1	1	9.5	28	0.30	0.00	10	20	20	10	20	20	None	0	0	0	0
QS-1	2	4	3	0.27	0.00	5	5	0	10	0	75	Boulders	0	0	0	0
QS-1	2	4	9.5	0.37	0.00	5	5	0	20	0	70	None	0	0	0	0
QS-1	2	4	16	0.43	0.00	15	25	40	20	0	0	None	4	0	0	4
QS-1	2	4	22.5	0.52	0.00	20	30	30	20	0	0	None	1	1	0	2
QS-1	2	4	29	0.46	0.00	5	5	20	30	0	30	None	2	0	0	2
QS-1	2	10.5	3	0.37	0.00	5	5	40	40	10	0	None	0	0	0	0
QS-1	2	10.5	9.5	0.34	0.00	5	5	20	20	50	0	None	0	0	0	0
QS-1	2	10.5	16	0.43	0.00	10	10	30	5	0	45	None	0	0	0	0
QS-1	2	10.5	22.5	0.55	0.00	10	10	50	10	0	20	None	0	0	0	0
QS-1	2	10.5	29	0.46	0.00	5	5	30	50	0	10	Vegetation	0	0	0	0
QS-1	3	6	0	0.34	0.00	5	20	70	5	0	0	Vegetation	1	0	0	1
QS-1	3	6	6.5	0.64	0.00	5	15	40	30	10	0	None	0	0	0	0
QS-1	3	6	13	0.43	0.00	10	10	30	5	0	45	None	0	0	0	0
QS-1	3	6	19.5	0.37	0.00	10	15	65	10	0	0	Vegetation	0	0	0	0
QS-1	3	6	26	0.49	0.00	5	5	35	15	0	40	None	1	0	0	1
QS-1	3	12.5	0	0.40	0.00	5	20	70	5	0	0	Boulders	0	0	0	0
QS-1	3	12.5	6.5	0.06	0.00	0	0	0	0	0	100	None	0	0	0	0
QS-1	3	12.5	13	0.34	0.00	5	20	75	0	0	0	None	1	0	0	1
QS-1	3	12.5	19.5	0.49	0.00	10	10	70	10	0	0	Vegetation	0	0	0	0
QS-1	3	12.5	26	0.43	0.00	5	5	45	5	0	40	Vegetation	0	0	0	0
QS-2	1	3	2	0.79	0.00	10	10	20	30	0	30	Vegetation	1	0	0	1
QS-2	1	3	8.5	0.58	0.00	20	20	40	20	0	0	Vegetation	1	0	0	1
QS-2	1	3	15	0.46	0.00	10	20	50	0	10	10	Vegetation	0	0	0	0

		Position				Substrate Percentages							Species Counts			
Station	Random Start	Across	Up	Depth (m)	Velocity (m/s)	Silt	Sand	Gravel	Cobble	Boulder	Bedrock	Cover	ElCo	AnIm	PyCa	All
QS-2	1	3	21.5	0.76	0.00	10	20	70	0	0	0	Vegetation	0	0	0	0
QS-2	1	3	28	0.37	0.00	10	10	10	0	0	70	Vegetation	0	0	0	0
QS-2	1	9.5	2	0.73	0.00	10	10	25	5	50	0	Wood	1	0	0	1
QS-2	1	9.5	8.5	0.64	0.00	15	15	20	30	0	20	Vegetation	0	0	1	1
QS-2	1	9.5	15	0.61	0.00	10	10	60	20	0	0	None	0	0	0	0
QS-2	1	9.5	21.5	0.55	0.00	10	15	55	20	0	0	Vegetation	0	0	0	0
QS-2	1	9.5	28	0.24	0.00	10	5	10	15	0	60	Vegetation	0	0	0	0
QS-2	2	4	3	0.82	0.00	10	20	50	20	0	0	Vegetation	0	0	0	0
QS-2	2	4	9.5	0.58	0.00	10	10	70	10	0	0	Vegetation	1	0	0	1
QS-2	2	4	16	0.55	0.00	10	10	20	0	0	60	Vegetation	0	0	0	0
QS-2	2	4	22.5	0.76	0.00	10	10	55	25	0	0	Vegetation	0	0	0	0
QS-2	2	4	29	0.03	0.00	0	0	0	0	0	100	Vegetation	0	0	0	0
QS-2	2	10.5	3	0.67	0.00	10	10	60	10	10	0	Vegetation	2	0	0	2
QS-2	2	10.5	9.5	0.64	0.00	10	10	60	20	0	0	Vegetation	1	0	0	1
QS-2	2	10.5	16	0.61	0.00	10	10	50	20	10	0	Vegetation	0	0	0	0
QS-2	2	10.5	22.5	0.46	0.00	10	10	35	10	10	25	None	1	0	0	1
QS-2	2	10.5	29	0.37	0.00	15	15	50	20	0	0	None	0	1	0	1
QS-2	3	6	0	0.85	0.00	15	15	70	0	0	0	None	0	0	0	0
QS-2	3	6	6.5	0.73	0.00	5	15	60	20	0	0	Vegetation	0	0	0	0
QS-2	3	6	13	0.61	0.00	0	10	65	20	0	5	Vegetation	0	0	0	0
QS-2	3	6	19.5	0.64	0.00	10	10	50	25	5	0	None	0	0	0	0
QS-2	3	6	26	0.61	0.00	15	15	10	0	0	60	Vegetation	0	0	0	0
QS-2	3	12.5	0	0.49	0.00	10	10	35	25	20	0	None	2	0	0	2
QS-2	3	12.5	6.5	0.46	0.00	5	10	10	25	0	50	Vegetation	1	0	0	1
QS-2	3	12.5	13	0.88	0.00	10	10	50	15	15	0	Vegetation	0	0	1	1
QS-2	3	12.5	19.5	0.49	0.00	10	10	20	40	20	0	Vegetation	2	0	0	2
QS-2	3	12.5	26	0.46	0.00	10	10	40	40	0	0	None	0	0	0	0
QS-3	1	3	2	0.67	0.24	0	10	40	5	15	30	None	0	0	0	0
QS-3	1	3	8.5	0.61	0.24	0	10	0	10	5	5	None	1	0	0	1
QS-3	1	3	15	0.73	0.21	0	30	55	15	0	0	None	1	0	0	1
QS-3	1	3	21.5	0.64	0.09	0	10	5	0	0	85	Boulders	0	0	0	0
QS-3	1	3	28	0.70	0.18	0	15	45	15	10	15	None	0	0	0	0
QS-3	1	9.5	2	0.70	0.21	0	20	50	10	20	0	None	1	0	0	1
QS-3	1	9.5	8.5	0.73	0.21	0	20	50	5	0	25	None	2	0	0	2
QS-3	1	9.5	15	0.70	0.21	0	20	35	20	25	0	None	3	0	0	3

		Position				Substrate Percentages							Species Counts			
Station	Random Start	Across	Up	Depth (m)	Velocity (m/s)	Silt	Sand	Gravel	Cobble	Boulder	Bedrock	Cover	ElCo	AnIm	PyCa	All
QS-3	1	9.5	21.5	0.73	0.21	0	30	50	10	10	0	None	2	0	0	2
QS-3	1	9.5	28	0.73	0.18	0	30	40	10	0	20	None	0	0	0	0
QS-3	2	4	3	0.64	0.24	0	20	30	50	0	0	None	2	0	0	2
QS-3	2	4	9.5	0.27	0.27	0	0	0	0	0	100	None	0	0	0	0
QS-3	2	4	16	0.70	0.21	0	20	25	20	35	0	None	1	0	0	1
QS-3	2	4	22.5	0.70	0.21	0	5	5	0	0	90	None	0	0	0	0
QS-3	2	4	29	0.73	0.18	0	30	40	20	10	0	None	1	0	0	1
QS-3	2	10.5	3	0.70	0.21	0	30	35	30	5	0	None	3	0	0	3
QS-3	2	10.5	9.5	0.67	0.24	0	20	55	10	0	15	None	0	0	0	0
QS-3	2	10.5	16	0.61	0.24	0	30	55	15	0	0	None	1	0	0	1
QS-3	2	10.5	22.5	0.70	0.21	0	30	50	10	10	0	None	2	0	0	2
QS-3	2	10.5	29	0.73	0.21	0	30	40	10	20	0	None	1	0	1	2
QS-3	3	6	0	0.70	0.21	0	10	55	10	0	25	None	2	0	0	2
QS-3	3	6	6.5	0.67	0.21	0	20	35	20	25	0	None	1	0	0	1
QS-3	3	6	13	0.67	0.18	0	20	45	0	10	25	None	0	0	0	0
QS-3	3	6	19.5	0.73	0.18	0	20	40	30	10	0	Wood	0	0	0	0
QS-3	3	6	26	0.67	0.15	0	10	10	0	0	80	None	1	0	0	1
QS-3	3	12.5	0	0.64	0.27	0	20	40	30	10	0	None	0	0	0	0
QS-3	3	12.5	6.5	0.73	0.24	0	15	60	15	10	0	None	2	0	0	2
QS-3	3	12.5	13	0.70	0.24	0	30	50	20	0	0	None	1	0	0	1
QS-3	3	12.5	19.5	0.73	0.30	0	25	35	20	20	0	None	0	0	0	0
QS-3	3	12.5	26	0.73	0.34	0	30	60	10	0	0	None	2	0	0	2
QS-4	1	3	2	0.79	0.12	0	0	0	0	100	0	None	0	0	0	0
QS-4	1	3	8.5	0.58	0.24	0	30	55	0	15	0	None	0	0	0	0
QS-4	1	3	15	0.46	0.30	0	30	55	10	5	0	None	0	0	0	0
QS-4	1	3	21.5	0.76	0.21	0	20	25	15	20	20	None	0	1	0	1
QS-4	1	3	28	0.37	0.18	0	10	20	30	40	0	Boulders	0	0	0	0
QS-4	1	9.5	2	0.73	0.27	0	30	55	10	5	0	None	0	0	0	0
QS-4	1	9.5	8.5	0.64	0.21	0	20	15	15	0	50	None	11	0	0	11
QS-4	1	9.5	15	0.61	0.24	0	10	15	0	50	0	None	0	0	0	0
QS-4	1	9.5	21.5	0.55	0.21	0	20	20	0	0	60	None	0	0	0	0
QS-4	1	9.5	28	0.24	0.00	0	30	10	10	0	50	Boulders	0	0	0	0
QS-4	2	4	3	0.82	0.15	0	25	50	15	10	0	None	0	0	0	0
QS-4	2	4	9.5	0.58	0.27	0	30	50	20	0	0	None	0	0	0	0
QS-4	2	4	16	0.55	0.27	0	30	40	15	15	0	None	0	0	0	0

		Position				Substrate Percentages							Species Counts			
Station	Random Start	Across	Up	Depth (m)	Velocity (m/s)	Silt	Sand	Gravel	Cobble	Boulder	Bedrock	Cover	ElCo	AnIm	PyCa	All
QS-4	2	4	22.5	0.76	0.15	0	30	40	30	0	0	None	0	0	0	0
QS-4	2	4	29	0.03	0.21	0	20	30	10	0	40	None	5	0	0	5
QS-4	2	10.5	3	0.67	0.27	0	30	45	10	10	5	None	1	0	0	1
QS-4	2	10.5	9.5	0.64	0.24	0	30	40	0	0	30	None	0	0	0	0
QS-4	2	10.5	16	0.61	0.21	0	30	45	15	10	0	None	1	0	0	1
QS-4	2	10.5	22.5	0.46	0.12	0	5	5	5	0	85	None	6	0	0	6
QS-4	2	10.5	29	0.37	0.15	0	40	50	10	0	0	None	2	0	0	2
QS-4	3	6	0	0.85	0.21	0	20	10	10	0	60	None	0	0	0	0
QS-4	3	6	6.5	0.73	0.24	0	30	50	20	0	0	None	0	0	0	0
QS-4	3	6	13	0.61	0.15	0	30	50	10	0	10	None	0	0	0	0
QS-4	3	6	19.5	0.64	0.18	0	30	60	10	0	0	None	0	0	0	0
QS-4	3	6	26	0.61	0.24	0	30	35	10	25	0	None	0	0	0	0
QS-4	3	12.5	0	0.49	0.21	0	35	15	15	0	0	None	3	0	0	3
QS-4	3	12.5	6.5	0.46	0.21	0	30	70	0	0	0	None	0	0	0	0
QS-4	3	12.5	13	0.88	0.15	0	30	40	10	10	10	None	2	0	0	2
QS-4	3	12.5	19.5	0.49	0.09	5	20	60	10	5	0	None	0	0	0	0
QS-4	3	12.5	26	0.46	0.12	0	30	40	15	15	0	None	0	0	0	0
QS-5	1	3	2	0.55	0.03	0	30	30	0	0	40	Vegetation	1	0	0	1
QS-5	1	3	8.5	0.49	0.15	5	20	50	25	0	0	None	1	0	0	1
QS-5	1	3	15	0.43	0.18	10	15	55	0	0	20	None	1	0	0	1
QS-5	1	3	21.5	0.46	0.21	10	25	35	0	30	0	None	1	0	0	1
QS-5	1	3	28	0.43	0.27	5	0	5	45	0	45	None	0	0	0	0
QS-5	1	9.5	2	0.40	0.09	5	10	45	0	0	40	None	0	0	0	0
QS-5	1	9.5	8.5	0.40	0.09	10	20	50	20	0	0	None	0	0	0	0
QS-5	1	9.5	15	0.55	0.06	10	10	50	0	10	20	None	0	0	0	0
QS-5	1	9.5	21.5	0.64	0.00	5	5	0	0	0	90	None	0	0	0	0
QS-5	1	9.5	28	0.43	0.18	0	0	70	10	0	20	None	0	0	0	0
QS-5	2	4	3	0.58	0.12	5	10	10	0	0	75	None	1	0	0	1
QS-5	2	4	9.5	0.49	0.15	10	20	35	5	0	30	None	1	0	0	1
QS-5	2	4	16	0.43	0.24	10	20	55	10	5	0	None	2	0	0	2
QS-5	2	4	22.5	0.52	0.18	10	20	60	10	0	0	None	0	0	0	0
QS-5	2	4	29	0.49	0.37	5	5	40	20	30	0	None	4	0	0	4
QS-5	2	10.5	3	0.40	0.12	5	35	20	0	0	40	Boulders	1	0	0	1
QS-5	2	10.5	9.5	0.43	0.12	10	10	40	0	0	40	None	0	0	0	0
QS-5	2	10.5	16	0.64	0.09	10	10	30	0	0	50	None	0	0	0	0

		Position				Substrate Percentages							Species Counts			
Station	Random Start	Across	Up	Depth (m)	Velocity (m/s)	Silt	Sand	Gravel	Cobble	Boulder	Bedrock	Cover	ElCo	AnIm	PyCa	All
QS-5	2	10.5	22.5	0.64	0.03	10	10	20	0	10	50	None	0	0	0	0
QS-5	2	10.5	29	0.43	0.12	5	5	10	20	0	60	None	0	0	0	0
QS-5	3	6	0	0.52	0.09	5	5	40	20	0	30	None	0	0	0	0
QS-5	3	6	6.5	0.58	0.09	0	0	10	0	0	90	None	0	0	0	0
QS-5	3	6	13	0.58	0.15	5	25	70	0	0	0	None	0	0	0	0
QS-5	3	6	19.5	0.52	0.24	5	10	35	0	0	50	None	1	0	0	1
QS-5	3	6	26	0.52	0.21	10	20	40	10	20	0	None	1	0	0	1
QS-5	3	12.5	0	0.43	0.09	5	5	50	0	0	40	Wood	1	0	0	1
QS-5	3	12.5	6.5	0.49	0.15	5	15	5	0	0	75	None	0	0	0	0
QS-5	3	12.5	13	0.55	0.09	10	25	45	10	10	0	None	2	0	0	2
QS-5	3	12.5	19.5	0.55	0.03	10	10	25	5	0	50	None	2	0	0	2
QS-5	3	12.5	26	0.52	0.12	10	10	30	0	50	0	None	1	0	0	1
QS-6	1	0	1	1.00	Low	0	10	10	10	70	0	None	0	0	0	0
QS-6	1	0	6	0.83	Low	0	5	5	10	80	0	None	0	0	0	0
QS-6	1	0	11	1.00	Low	0	0	0	0	100	0	None	0	0	0	0
QS-6	1	0	16	1.17	Low	0	10	10	60	20	0	None	0	0	0	0
QS-6	1	0	21	1.00	Low	0	5	5	5	85	0	None	0	0	0	0
QS-6	1	0	26	1.33	Low	0	10	10	70	10	0	None	0	0	0	0
QS-6	1	5	1	1.50	Low	0	10	10	0	80	0	None	0	0	0	0
QS-6	1	5	6	0.83	Low	0	0	20	60	20	0	None	0	0	0	0
QS-6	1	5	11	1.50	Low	0	10	20	50	20	0	None	0	0	0	0
QS-6	1	5	16	1.58	Low	0	10	20	50	20	0	None	0	0	0	0
QS-6	1	5	21	1.58	Low	0	20	30	30	20	0	None	0	0	0	0
QS-6	1	5	26	1.33	Low	0	20	20	60	0	0	None	0	0	0	0
QS-6	1	10	1	1.50	Moderate	0	0	10	70	20	0	None	0	0	0	0
QS-6	1	10	6	1.67	Moderate	0	0	0	0	100	0	None	0	0	0	0
QS-6	1	10	11	1.50	Moderate	0	0	20	50	30	0	None	0	0	0	0
QS-6	1	10	16	1.50	Moderate	0	15	20	15	50	0	None	0	0	0	0
QS-6	1	10	21	1.67	Moderate	10	10	20	40	20	0	None	0	0	0	0
QS-6	1	10	26	1.58	Moderate	10	20	10	60	0	0	None	0	0	0	0
QS-6	2	2	0	1.00	Low	0	10	10	20	60	0	None	0	0	0	0
QS-6	2	2	5	1.33	Low	0	10	10	80	0	0	None	0	0	0	0
QS-6	2	2	10	1.33	Low	10	20	50	20	0	0	None	0	0	0	0
QS-6	2	2	15	1.33	Low	0	10	15	50	25	0	None	0	0	0	0
QS-6	2	2	20	1.33	Low	10	10	20	60	0	0	None	0	0	0	0

		Position				Substrate Percentages							Species Counts			
Station	Random Start	Across	Up	Depth (m)	Velocity (m/s)	Silt	Sand	Gravel	Cobble	Boulder	Bedrock	Cover	ElCo	AnIm	PyCa	All
QS-6	2	2	25	1.33	Low	0	10	10	30	50	0	None	0	0	0	0
QS-6	2	7	0	1.17	Moderate	0	5	15	40	40	0	None	1	0	0	0
QS-6	2	7	5	1.67	Moderate	0	0	0	0	100	0	None	0	0	0	0
QS-6	2	7	10	1.33	Moderate	0	5	5	10	80	0	None	0	0	0	0
QS-6	2	7	15	1.67	Moderate	0	10	20	30	40	0	None	0	0	0	0
QS-6	2	7	20	1.50	Moderate	0	20	30	50	0	0	None	0	0	0	0
QS-6	2	7	25	1.50	Moderate	30	10	20	20	20	0	None	0	0	0	0
QS-6	2	12	0	1.50	Strong	0	10	10	40	40	0	None	0	0	0	0
QS-6	2	12	5	1.50	Strong	0	10	20	60	10	0	None	0	0	0	0
QS-6	2	12	10	1.33	Strong	0	10	20	20	50	0	None	0	0	0	0
QS-6	2	12	15	1.67	Strong	0	0	0	0	100	0	None	0	0	0	0
QS-6	2	12	20	1.67	Strong	20	10	10	60	0	0	None	0	0	0	0
QS-6	2	12	25	1.83	Strong	20	10	10	20	40	0	None	0	0	0	0