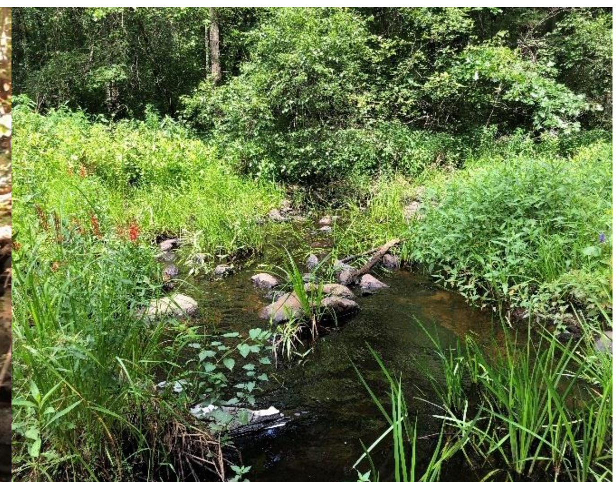
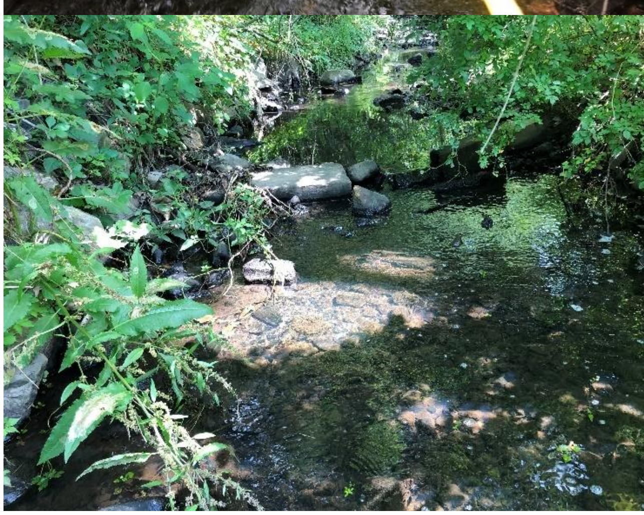
# City of Cambridge Water Department

# 2019 BENTHIC MACROINVERTEBRATE REPORT

February 2021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# Executive Summary

This report presents results from the City of Cambridge Water Department (CWD)'s Benthic Macroinvertebrate (BMI) sampling program in 2019. The program is modeled after the Charles River Watershed Association (CRWA)'s BMI volunteer program and developed using U.S. Environmental Protection Agency (EPA) methods (Barbour and others, 1999; U.S. Environmental Protection Agency, 1997). In 2019, CWD selected four sites throughout the Cambridge watershed to sample for macroinvertebrates. CWD assessed stream habitats and identified macroinvertebrate specimens for the purpose of calculating stream habitat and water quality scores for each site.

Out of four categories (poor, marginal, suboptimal, and optimal), habitats at the four sites scored in the suboptimal and optimal ranges. Water quality scores placed the sites in the fair and good categories (out of three categories: poor, fair, and good). None of the sites had water quality scores in the poor range. Higher water quality scores showed a moderately strong positive correlation with higher habitat scores.

This effort was the first year that CWD systematically sampled for macroinvertebrates in the water supply watershed. More years of study are required to determine if water quality is changing over time with respect to macroinvertebrate indicators. As recommended in the CRWA sampling program, CWD collected macroinvertebrate samples in July 2019. Sampling for the summer of 2020 was put on hold due to the Coronavirus pandemic. CWD plans to continue collecting macroinvertebrate samples at sites throughout the watershed in the summer of 2021.

# Introduction to Macroinvertebrates

The term benthic macroinvertebrate (BMI) is a broad term that describes a group of organisms that live on the bottom of streams, rivers, ponds, and lakes. As the name suggests, these organisms do not have internal skeletons. They are often small, yet large enough to be seen by the unaided eye. Many macroinvertebrates are the larval stages of familiar insects such as dragonflies. Others are organisms like leeches, snails, and crayfish.

Macroinvertebrates thrive in different types of underwater habitats. They like to live on submerged roots, take shelter in the crevices of rocks, and feast on woody debris. Riffles in streams often host the greatest diversity of macroinvertebrates (Voshell, 2002). The bottom substrate of loose cobbles and pebbles with an occasional boulder creates several types microhabitats such as pockets with differing flow rates, shelter spots, varied surfaces on which to attach, and pockets of captured sediment and woody debris that support this diversity (Voshell, 2002).

Collecting and identifying macroinvertebrates can be a useful way to understand stream water quality. Generally, the more macroinvertebrates present in a stream, the better the water quality. Their presence is a good sign of a healthy ecosystem, but the specific type of macroinvertebrate offers even more clues to water quality. Every type of macroinvertebrate has a different tolerance for water quality. Some, such as mayfly larvae, are very sensitive and are only found in very pristine water. Other types of macroinvertebrates, such as aquatic worms, are very tolerant of pollution and can be expected to thrive in nearly any body of water (Voshell, 2002).

Identifying macroinvertebrates is a relatively easy and inexpensive way to get a picture of water quality. This makes it a great method for citizen scientists, students, or curious naturalists alike. CWD has a robust water quality monitoring program that tests for many parameters such as pH, dissolved oxygen, and nutrients in all weather conditions. Adding a biological component provides CWD another perspective and means to characterize water supply water quality.

## CWD Water Quality and BMI Monitoring Overview

The Cambridge source water supply watershed is a 24 square mile basin located within the municipalities of Lexington, Lincoln, Waltham, and Weston (Figure 1). The drinking water supply system includes three reservoirs, with dam releases from the Hobbs Brook Reservoir feeding the Stony Brook Reservoir through natural stream channels, and the Stony Brook Reservoir connected to Fresh Pond Reservoir in Cambridge via an underground conduit (Figure 1). The Cambridge Source Water Quality Monitoring Program (SWQMP) includes regular water quality sampling at 12 tributary stations and the three reservoirs. CWD also supports 13 U.S. Geological Survey (USGS) tributary and reservoir monitoring stations in the watershed through a joint funding agreement. CWD selected four sites for the BMI program: Lex Brook (Lexington), Harrington Property (Linoln), SB @ Viles (Weston), and Summer St also in Weston (Figure 2). Lex Brook, SB @ Viles, and Summer St are CWD and USGS monitoring stations (Figure 2). The Harrington Property is not part of the SWQMP but resides in a parcel of protected land owned by CWD.

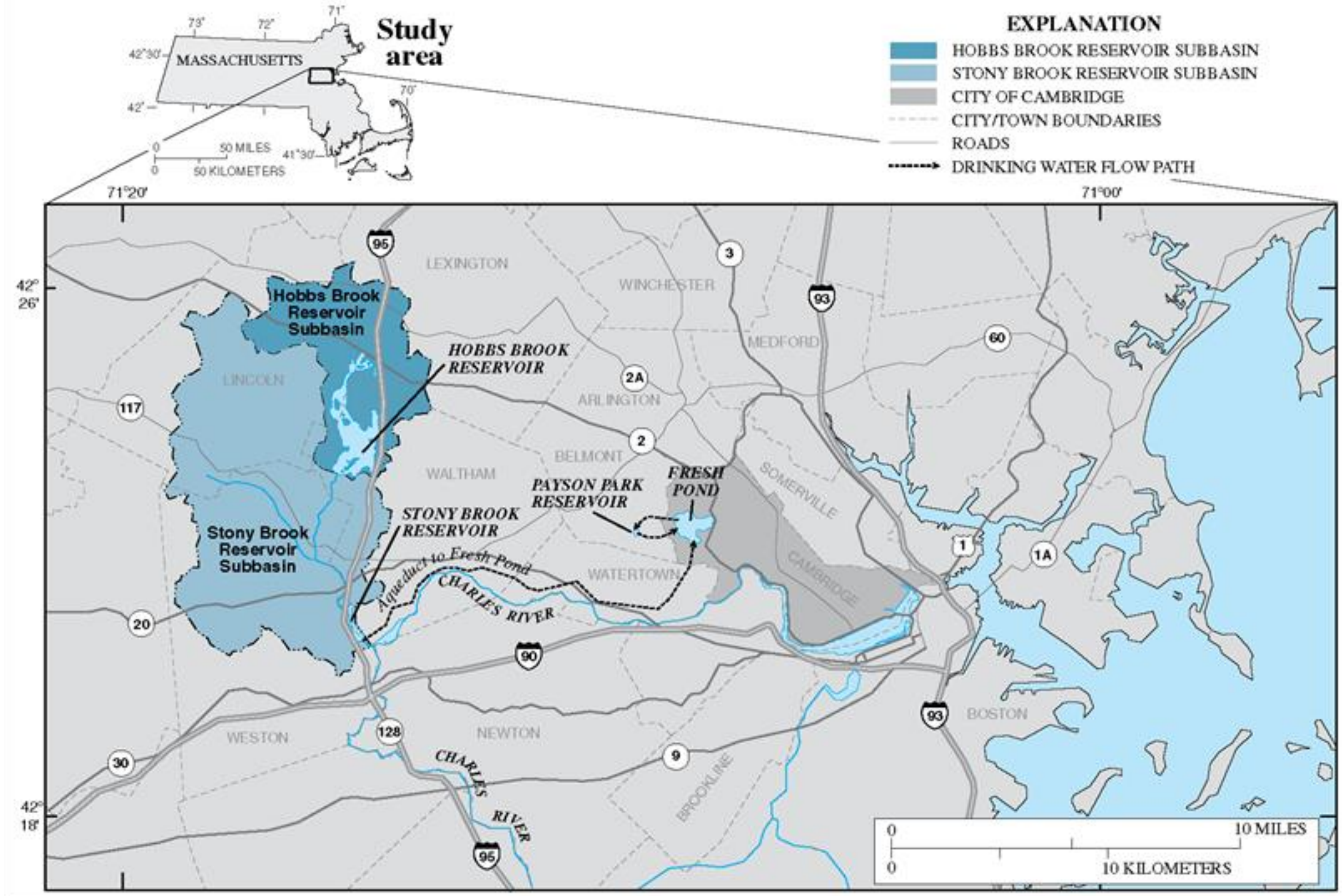



*Figure 1: Cambridge Water Supply Source Area*

Figure from: U. S. Geological Survey Scientific Investigations Report 2000-4262

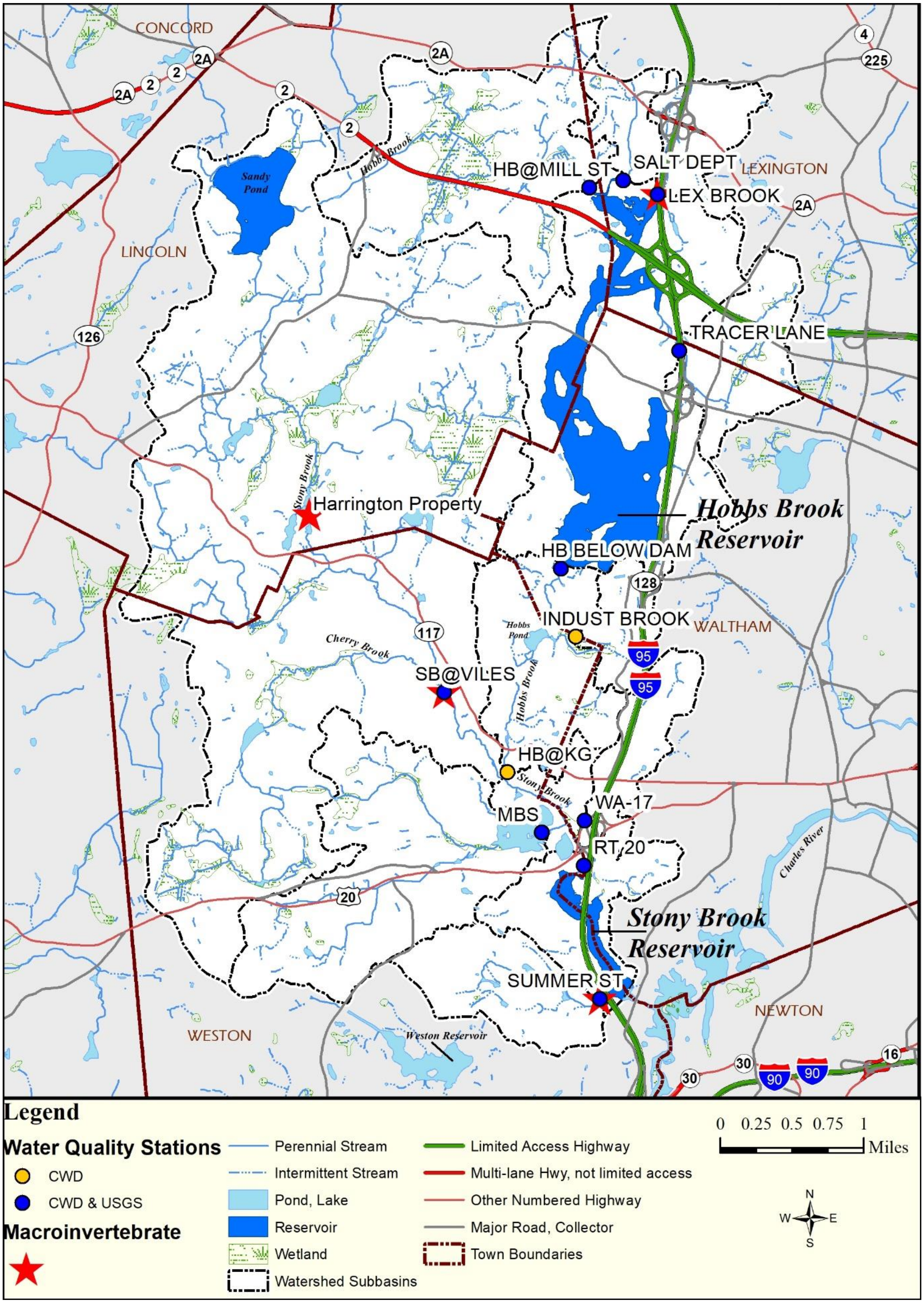


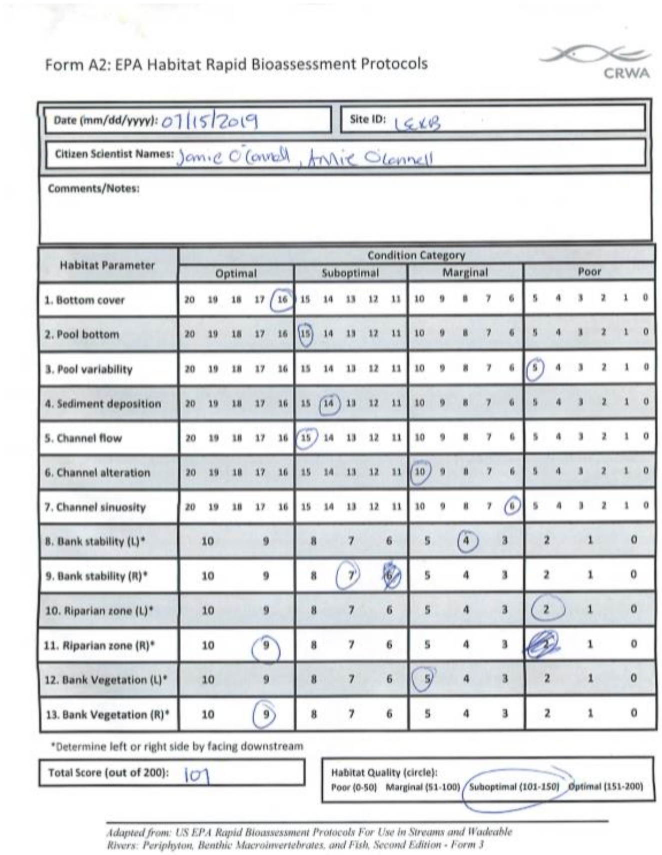

*Figure 2: Cambridge watershed tributary water quality and macroinvertebrate monitoring sites*

# BMI Sampling and Evaluation Methods

The Charles River Watershed Association (CRWA) runs a volunteer-based biological monitoring program which recruits citizen scientists to collect and identify samples of macroinvertebrates at different stream sites throughout the Charles River watershed. The Cambridge watershed is a subasin of the Charles River watershed. As such, CWD worked with CRWA to model its macroinvertebrate sampling program after the CRWA program. CWD staff attended CRWA volunteer training programs and shared 2019 BMI findings with CRWA.

## Habitat Assessment

CRWA trains volunteers to evaluate stream quality based on two different methods. The first method is an evaluation of the stream habitat based on the EPA Rapid Bioassessment Protocols (Barbour and others, 1999). Streams are evaluated on 13 different physical parameters such as bottom cover, channel alteration, and sinuosity (Figure 3). This yields a score on a scale of 0-200 that places a habitat in broad categories of Poor (0-50), Marginal (50-100), Suboptimal (100-150), and Optimal (150-200).



Form A2: EPA Habitat Rapid Bioassessment Protocols

CRWA

Date (mm/dd/yyyy): 07/15/2019 Site ID: LS&B

Citizen Scientist Names: Jamie O'Connell, Annie O'Connell

Comments/Notes:

| Habitat Parameter | Condition Category: Optimal | Suboptimal | Marginal | Poor |
|---|---|---|---|---|
| 1. Bottom cover | 20 19 18 17 16 | 15 14 13 12 11 | 10 9 8 7 6 | 5 4 3 2 1 0 |
| 2. Pool bottom | 20 19 18 17 16 | 15 14 13 12 11 | 10 9 8 7 6 | 5 4 3 2 1 0 |
| 3. Pool variability | 20 19 18 17 16 | 15 14 13 12 11 | 10 9 8 7 6 | 5 4 3 2 1 0 |
| 4. Sediment deposition | 20 19 18 17 16 | 15 14 13 12 11 | 10 9 8 7 6 | 5 4 3 2 1 0 |
| 5. Channel flow | 20 19 18 17 16 | 15 14 13 12 11 | 10 9 8 7 6 | 5 4 3 2 1 0 |
| 6. Channel alteration | 20 19 18 17 16 | 15 14 13 12 11 | 10 9 8 7 6 | 5 4 3 2 1 0 |
| 7. Channel sinuosity | 20 19 18 17 16 | 15 14 13 12 11 | 10 9 8 7 6 | 5 4 3 2 1 0 |
| 8. Bank stability (L)* | 10 9 | 8 7 6 | 5 4 3 | 2 1 0 |
| 9. Bank stability (R)* | 10 9 | 8 7 6 | 5 4 3 | 2 1 0 |
| 10. Riparian zone (L)* | 10 9 | 8 7 6 | 5 4 3 | 2 1 0 |
| 11. Riparian zone (R)* | 10 9 | 8 7 6 | 5 4 3 | 2 1 0 |
| 12. Bank Vegetation (L)* | 10 9 | 8 7 6 | 5 4 3 | 2 1 0 |
| 13. Bank Vegetation (R)* | 10 9 | 8 7 6 | 5 4 3 | 2 1 0 |

*Determine left or right side by facing downstream

Total Score (out of 200): 107

Habitat Quality (circle): Poor (0-50) Marginal (51-100) Suboptimal (101-150) Optimal (151-200)

*Adapted from: US EPA Rapid Bioassessment Protocols For Use in Streams and Wadeable Rivers: Periphyton, Benthic Macroinvertebrates, and Fish, Second Edition - Form 3*

*Figure 3: Example of CRWA habitat assessment datasheet, adapted from the EPA Rapid Habitat Bioassessment Protocol*

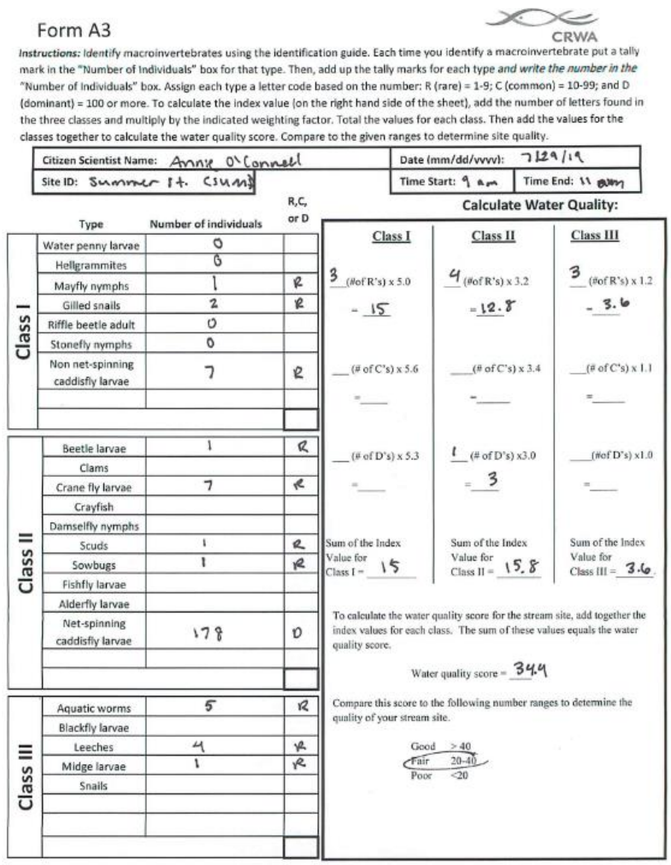
## Water Quality Score

The second evaluation is to generate a water quality score by collecting and identifying macroinvertebrates. First, the whole stream segment is assessed to determine the proportion of different macroinvertebrate habitats present. Riffles, runs, pools, overhanging vegetation, submerged vegetation, submerged roots, and woody debris are all different habitats that attract macroinvertebrates.

Next, a D-frame dip net is used to collect macroinvertebrates by disturbing the substrate upstream of the net's mouth, freeing macroinvertebrates from the bottom of the stream or target substrate and catching them in the net. A total of 20 "jabs", or collections, are made for each site. The 20 jabs are allotted proportionally to the composition of different habitats found in the stream. For example, if a stream is estimated to be 25% pools, 5 of 20 collections will be taken from the pools in the stream section.

Any macroinvertebrates collected in the net as a result of disturbing the stream bottom are carefully picked off the net and collected in a jar filled with isopropyl alcohol, which preserves the specimens until they can be identified later in the lab. CWD staff then identify the macroinvertebrates, typically to the Order or Family level with advice from CRWA personnel as needed.

The final step is to calculate a water quality score based on the presence and abundance of different macroinvertebrate types found while sampling. Figure 4 is an example of the CRWA datasheet used to calculate this score. The scoring template is described in Chapter 4 of the EPA's methods manual for volunteer water quality monitoring programs (U.S. Environmental Protection Agency, 1997). Macroinvertebrate types commonly found in rivers and streams are listed in three "classes" based on water quality tolerance. Types in Class I are most sensitive to poor water quality, whereas types in Class III are least sensitive to poor water quality. The scoring system takes this into account as well as the relative abundance of the macroinvertebrates and generates water quality scores of Poor (< 20), Fair (20 – 40), and Good (> 40).



Form A3

CRWA

*Instructions:* Identify macroinvertebrates using the identification guide. Each time you identify a macroinvertebrate put a tally mark in the "Number of Individuals" box for that type. Then, add up the tally marks for each type *and write the number in the* "Number of Individuals" box. Assign each type a letter code based on the number: R (rare) = 1-9; C (common) = 10-99; and D (dominant) = 100 or more. To calculate the index value (on the right hand side of the sheet), add the number of letters found in the three classes and multiply by the indicated weighting factor. Total the values for each class. Then add the values for the classes together to calculate the water quality score. Compare to the given ranges to determine site quality.

| | |
|---|---|
| Citizen Scientist Name: Annie O'Connell | Date (mm/dd/yyyy): 7/29/19 |
| Site ID: Summer St. (sum) | Time Start: 9 am / Time End: 11 am |

| Class | Type | Number of individuals | R,C, or D |
|---|---|---|---|
| Class I | Water penny larvae | 0 | |
| | Hellgrammites | 0 | |
| | Mayfly nymphs | 1 | R |
| | Gilled snails | 2 | R |
| | Riffle beetle adult | 0 | |
| | Stonefly nymphs | 0 | |
| | Non net-spinning caddisfly larvae | 7 | R |
| Class II | Beetle larvae | 1 | R |
| | Clams | | |
| | Crane fly larvae | 7 | R |
| | Crayfish | | |
| | Damselfly nymphs | | |
| | Scuds | 1 | R |
| | Sowbugs | 1 | R |
| | Fishfly larvae | | |
| | Alderfly larvae | | |
| | Net-spinning caddisfly larvae | 178 | D |
| Class III | Aquatic worms | 5 | R |
| | Blackfly larvae | | |
| | Leeches | 4 | R |
| | Midge larvae | 1 | R |
| | Snails | | |

Calculate Water Quality:

| Class I | Class II | Class III |
|---|---|---|
| 3 (# of R's) x 5.0 = 15 | 4 (# of R's) x 3.2 = 12.8 | 3 (# of R's) x 1.2 = 3.6 |
| ___ (# of C's) x 5.6 = ___ | ___ (# of C's) x 3.4 = ___ | ___ (# of C's) x 1.1 = ___ |
| ___ (# of D's) x 5.3 = ___ | 1 (# of D's) x3.0 = 3 | ___ (# of D's) x1.0 = ___ |
| Sum of the Index Value for Class I = 15 | Sum of the Index Value for Class II = 15.8 | Sum of the Index Value for Class III = 3.6 |

To calculate the water quality score for the stream site, add together the index values for each class. The sum of these values equals the water quality score.

Water quality score = 34.4

Compare this score to the following number ranges to determine the quality of your stream site.

Good > 40
Fair 20-40
Poor <20

*Figure 4: Example of CRWA water quality score datasheet*

## Reference Sites

A reference site represents conditions in an area considered to be in a natural state. It can be useful to compare conditions to a reference location to determine how water quality and habitat scores are similar or different to "natural" conditions. In 2019, CWD attempted to sample macroinvertebrates at the reference station used by USGS (01104305) for the Cambridge watershed (Smith, 2017). USGS selected this station due to the low percentage of roadways and parking lots (0.2 percent) in the catchment compared to the 2.8 to 20.7 percent in the other watershed subcatchments studied by USGS (Smith, 2017).

However, CWD found that the small stream (catchment area of only 0.09 square miles according to Smith (2017)) had a very low gradient and the substrate consisted almost entirely of loose, soft sediment and organic debris. It had few riffles and much looser substrates than

CWD found in the four 2019 sampling reaches. For these reasons, CWD determined that the USGS reference site would not serve as a good reference reach for BMI sampling. CWD also evaluated other potential reference reaches in subcatchments with low development density. However, CWD found similar challenges with low gradient streams with loose, organic bottom substrates or found evidence of human alteration of the stream, such as up or downstream flow restrictions from culverts and dams. Although the CWD BMI program does not have a reference site, the four BMI sampling reach catchments have a range of development intensities and are representative of conditions throughout the watershed.

## Land Cover and BMI Monitoring Catchments

Land cover in this report was calculated based on the Massachusetts Bureau of Geographic Information (MassGIS) 2016 GIS Land Cover/Land Use dataset. These spatial data categorize land cover into 16 different categories. For the purposes of discussing land cover in the Cambridge watershed, the classes have been grouped into 7 categories: agricultural, natural, impervious, wetland, water, open, and bare land (Table 1).

*Table 1: MassGIS 2016 land cover name and corresponding CWD category*

| CWD Category | MassGIS Land Cover 2016 Name |
|---|---|
| Agricultural Land | Cultivated, Pasture/Hay |
| Natural Land | Grassland, Deciduous Forest, Evergreen Forest, Scrub/Shrub |
| Impervious | Impervious |
| Wetland | Palustrine Forested Wetland, Palustrine Scrub/Shrub Wetland, Palustrine Emergent Wetland, Estuarine Emergent Wetland, Unconsolidated Shore |
| Water | Water, Palustrine Aquatic Bed |
| Open | Developed Open Space |
| Bare | Bare Land |

### Lex Brook

The Lex Brook sampling reach has a small catchment area of only 0.47 square miles. It lies at the northeast tip of the Cambridge watershed and contains a CWD water quality monitoring station (USGS monitoring station 01104415) (Figure 2). CWD selected this site for BMI monitoring because the catchment area is among the more developed in the watershed at 33 percent impervious cover (Figure 5). The upstream end of the stream segment begins at a headwall outlet that drains runoff from areas that include the I-95 highway (Figure 6). The stream parallels the highway embankment before crossing under Lincoln Street in Lexington and discharging into the Hobbs Brook Reservoir (Figure 6). In 2019, the reach was dominated by riffles (9 jabs) and runs (6 jabs) but jabs were also collected from shallow pools and overhanging vegetation.

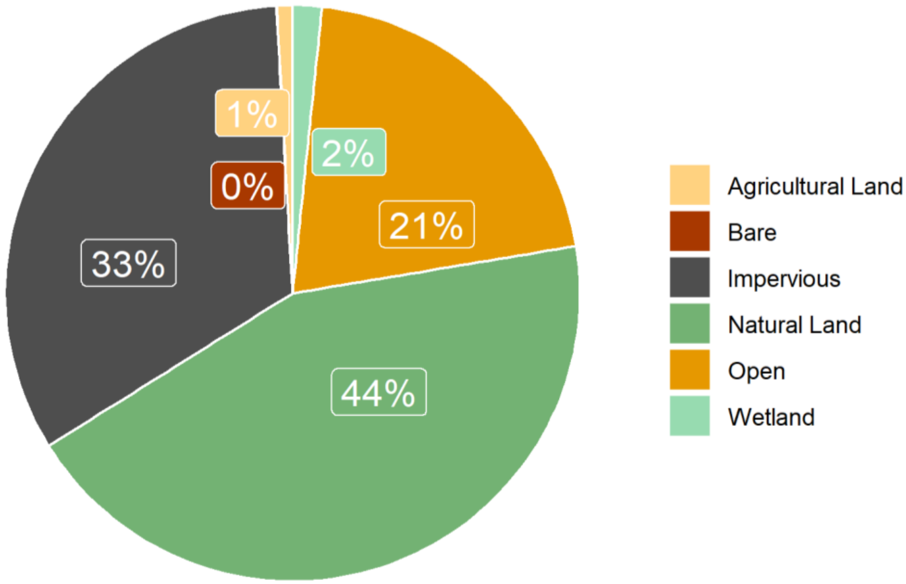



*Figure 5: Lex Brook catchment land cover, 2016 data*

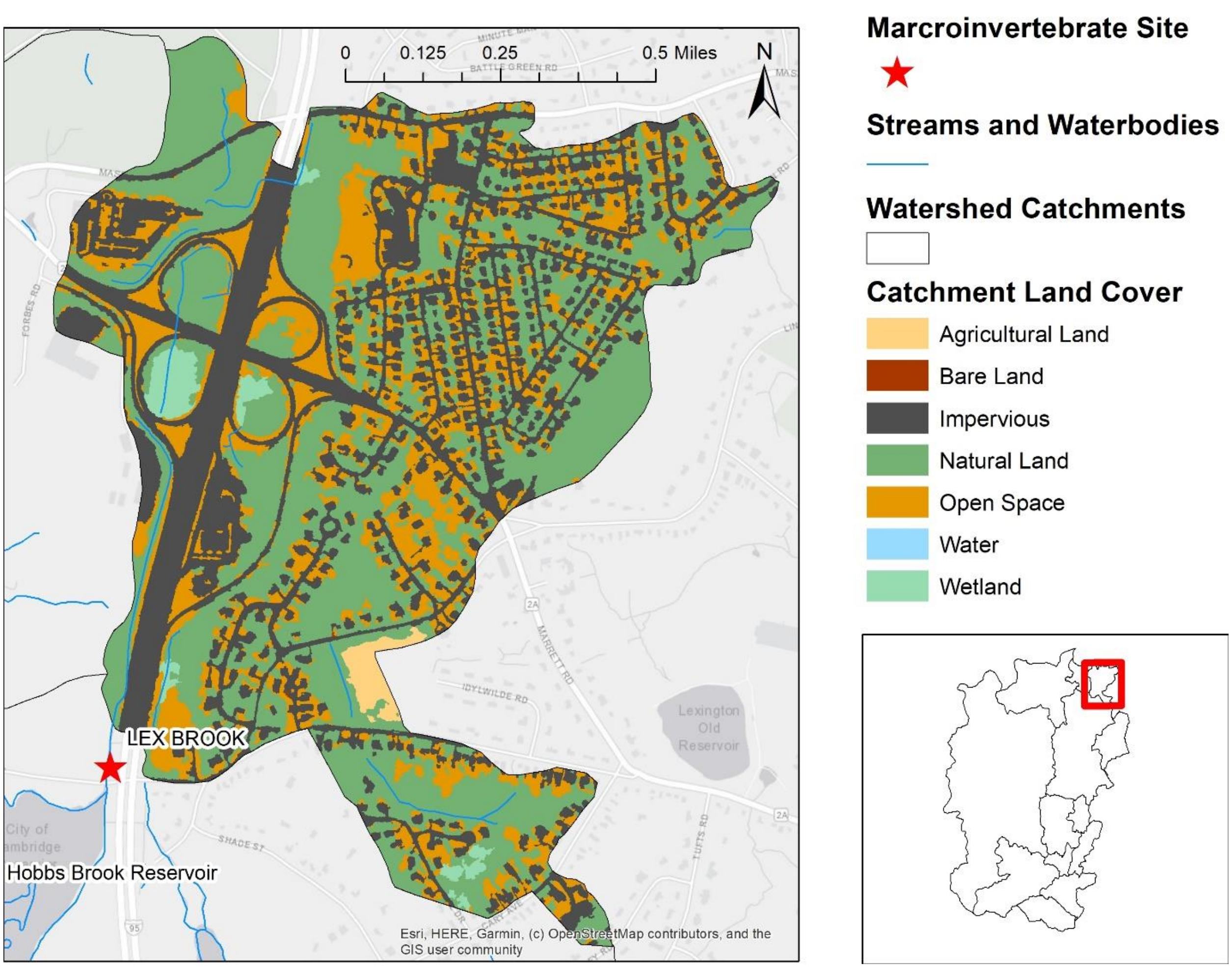



*Figure 6: Lex Brook catchment land cover map*

According to the EPA Rapid Bioassessment Protocols for Use in Wadeable Streams and Rivers, stream segments for evaluation should either be 100 meters long, or alternatively can be 40 times the stream width (Barbour and others, 1999). For Lex Brook, CWD choose a reach length of 40 times the width of the stream, beginning approximately 100 feet downstream of the USGS monitoring station staff gage and ending 20 feet downstream of the upstream headwall. CWD collected four stream width measurements which averaged to 6.75 feet. Forty times this length comes to 270 feet, which allowed the segment to begin upstream of the crossing with Lincoln Street while ending short of the headwall.

## Summer Street

The Summer Street reach also contains a regular CWD water quality sampling site and USGS monitoring station (01104475) (Figure 2). It has a small catchment area of 0.80 square miles and lies at the southeast end of the Cambridge watershed, draining directly into Stony Brook Reservoir (Figure 2). Within the catchment, 57 percent of the land cover is natural land and an additional 5 percent is wetland (Figure 7 and Figure 8). Open space represents the next largest portion of land in the catchment at 23 percent; most of this open space is a golf course. The catchment is 12 percent impervious surfaces. In 2019, the predominant habitat type was riffle (12 jabs). The remaining jabs were collected from run, pool, and woody debris habitats.

CWD decided to use the 100-meter reach length for this site. The average stream width was measured to be 9.25 ft. Multiplied by 40, the length of the reach would be 370 feet (113 meters). The habitats in the reach appeared relatively consistent so a 100-meter reach was used for simplicity. The sampling reach has a culvert in the middle allowing the stream to cross under Summer Street. The 100-meter reach consists of the entire stream segment beginning near a chain link fence 62 feet downstream of the USGS monitoring station staff gage and continuing upstream to the opening of the Summer Street culvert.  On the upstream side of the culvert, the segment continues for another 185 feet.

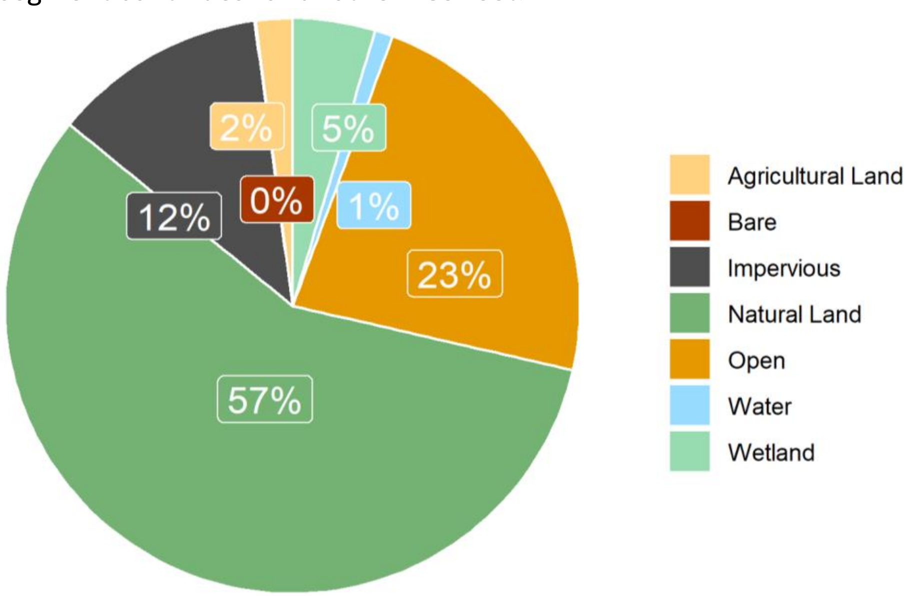



*Figure 7: Summer Street catchment land cover, 2016 data*

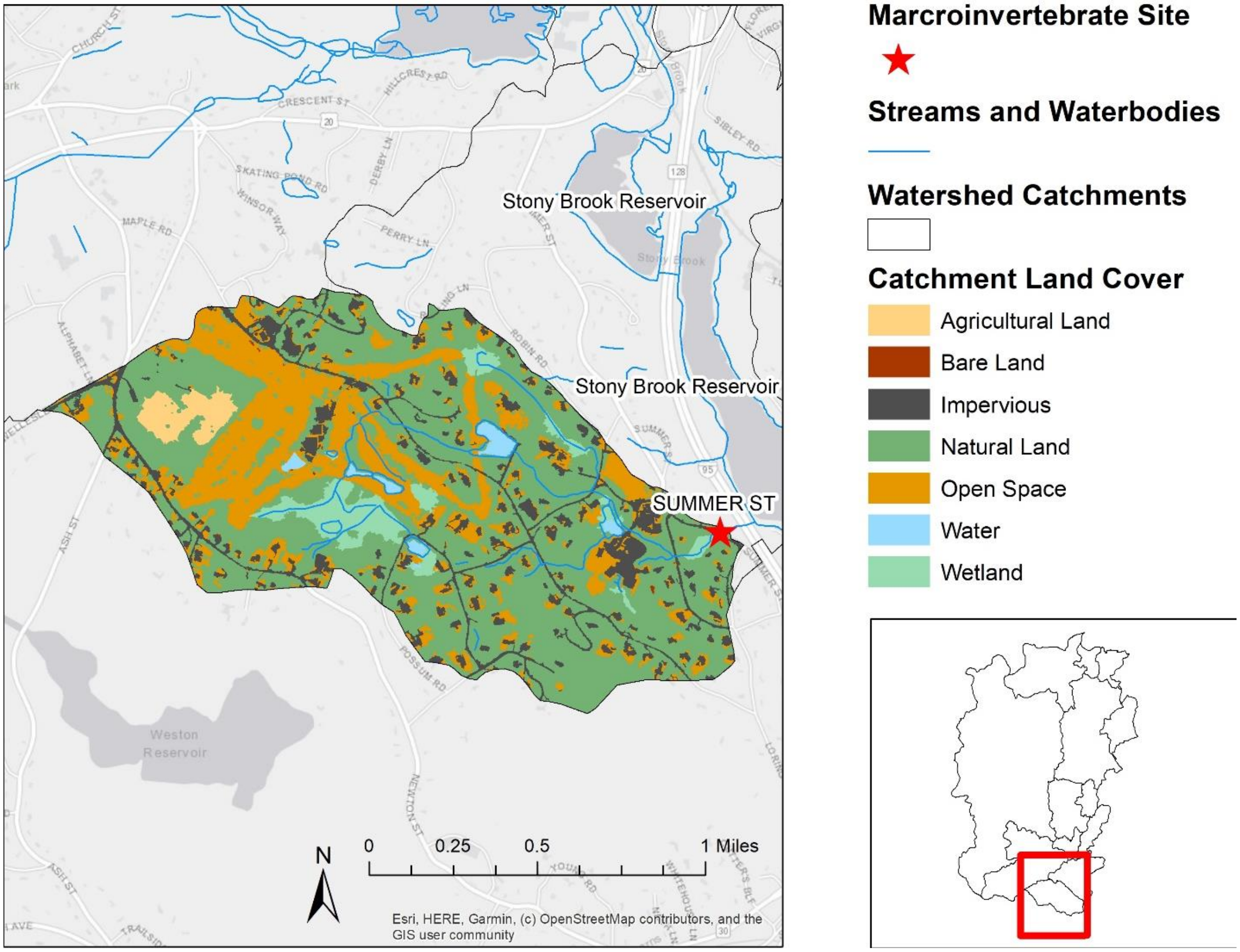



*Figure 8: Summer St catchment land cover map*

## Stony Brook at Viles Street (SB @ Viles)

The Stony Brook at Viles Street (SB @ Viles) reach contains CWD and USGS (01104370) water quality sampling stations (Figure 2). The sampling reach is along the Stony Brook, the largest tributary draining to Stony Brook Reservoir. The SB @ Viles catchment is the largest of the four catchments sampled at 10.4 square miles. Land cover in this catchment is less developed than others in the Cambridge watershed. Fifty-six percent of land in the catchment is natural land and an additional 19 percent of land is wetland (Figure 9 and Figure 10). Only 8 percent of land in this catchment is covered by impervious surfaces.

Since the SB @ Viles is a wide stream, CWD elected to use a 40x stream width reach length, calculated at 670 ft. This encompassed many different macroinvertebrate habitat types whereas a shorter reach of 100 meters would have failed to capture the habitat diversity of the stream.

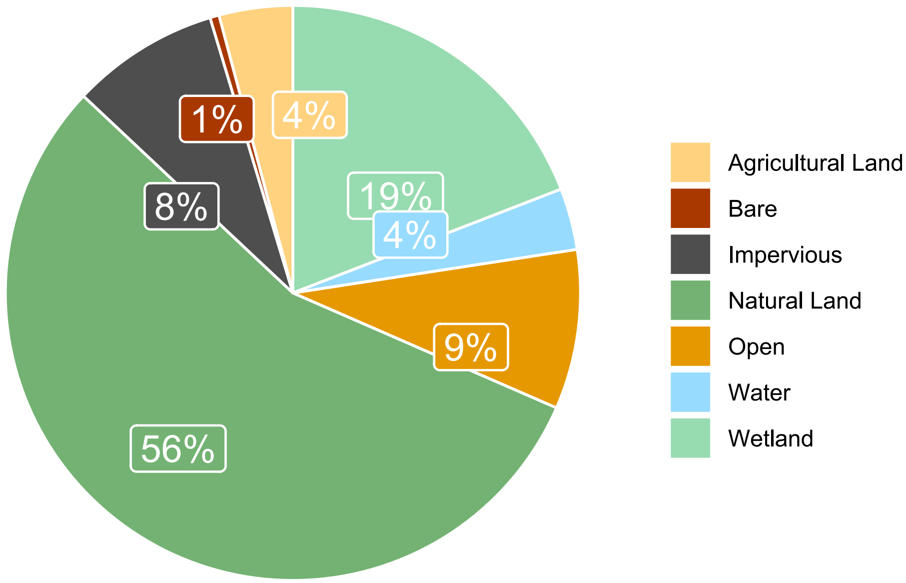



*Figure 9: SB @ Viles catchment land cover, 2016 data*

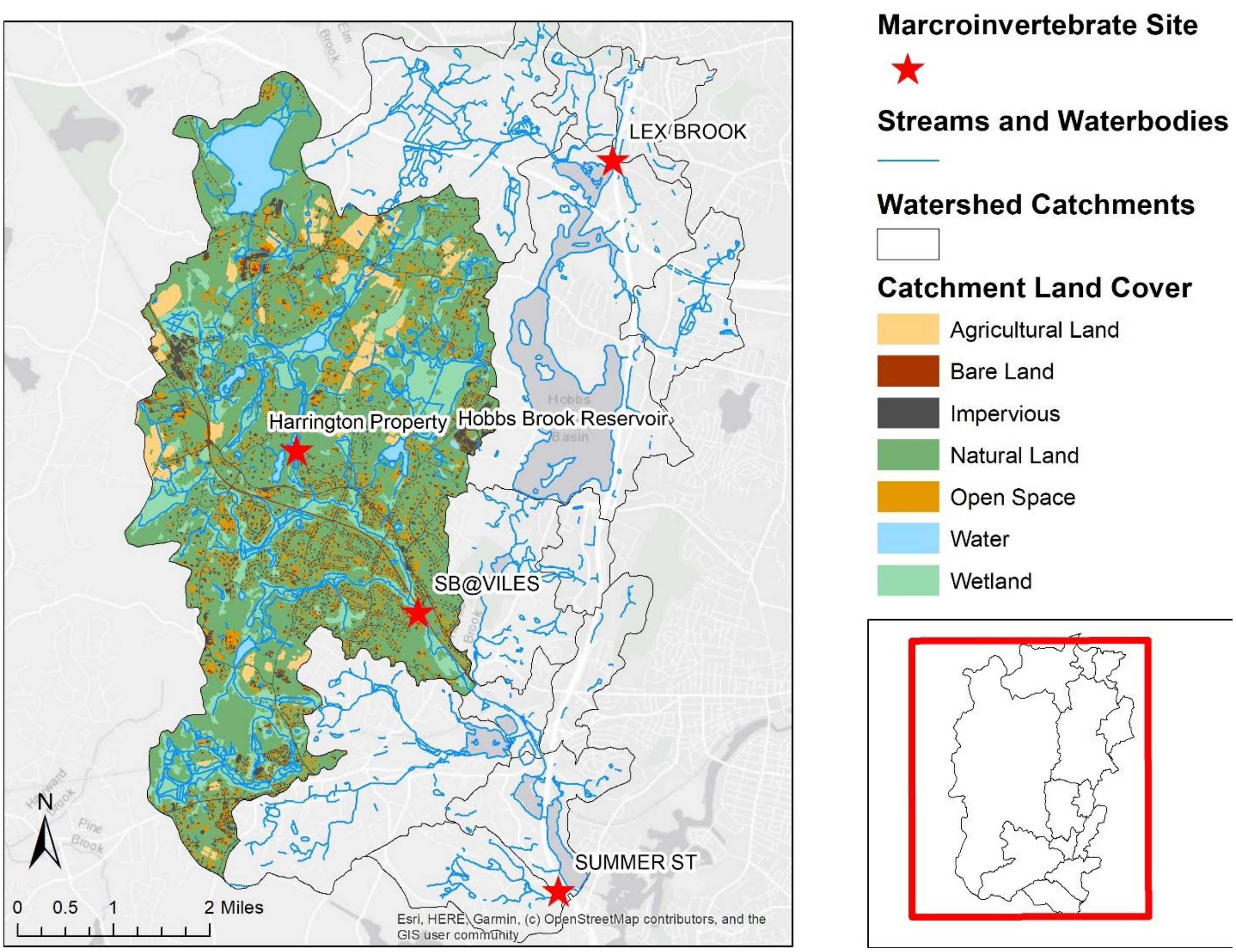



*Figure 10: SB @ Viles catchment land cover*

## Harrington Property

The Harrington Property catchment is part of the larger SB @ Viles catchment (Figure 10). It has an area of 4.2 square miles. The reach is not sampled as part of the CWD or USGS water quality monitoring programs. The site was selected for CWD's BMI monitoring program because it lies within a protected parcel owned by CWD. The reach is predominately riffles, a habitat favorable to macroinvertebrates. Although the catchment is sparsely developed compared to the Cambridge watershed as a whole, with proportionally less impervious cover than the larger SB @ Viles catchment, the sampling reach begins 50 feet downstream of a small dam (Figure 9 and Figure 11). The presence of this dam prevented CWD from using this site as a reference location.

Land cover is proportionally similar between the SB @ Viles catchment and the nested Harrington Property subcatchment (Figure 9 and Figure 11). In the Harrington Property catchment, 56 percent of land cover is natural land and 16 percent of land is wetland (Figure 11 and Figure 12). It has an even lower proportion of impervious land (6 percent) than the SB @ Viles catchment (8 percent). The sampling reach begins 50 feet downstream of a small dam and ends shortly upstream of a wetland. CWD elected to use the 100-meter reach length as it aligned well with the distance between the dam and wetland. The habitat types found in this reach are primarily riffles (7 jabs) and runs (10 jabs), with the remaining three jabs collected from woody debris and a pool. CWD staff observed a significant amount of woody and organic debris in the stream bed downstream of the dam. However, the stream segment began 50 feet downstream of the dam to minimize the influence of the dam on the sampling reach.

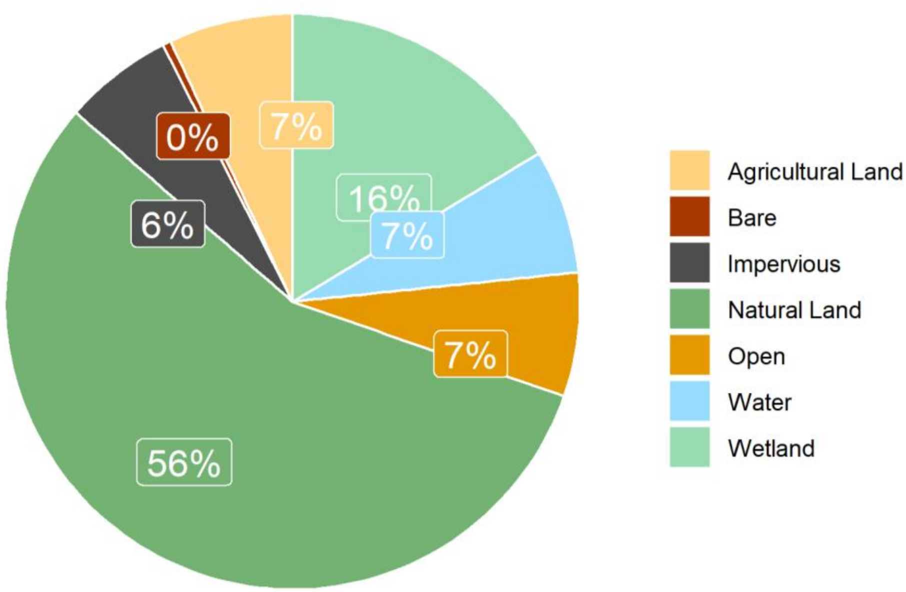



*Figure 11: Harrington Property catchment land cover, 2016 data*

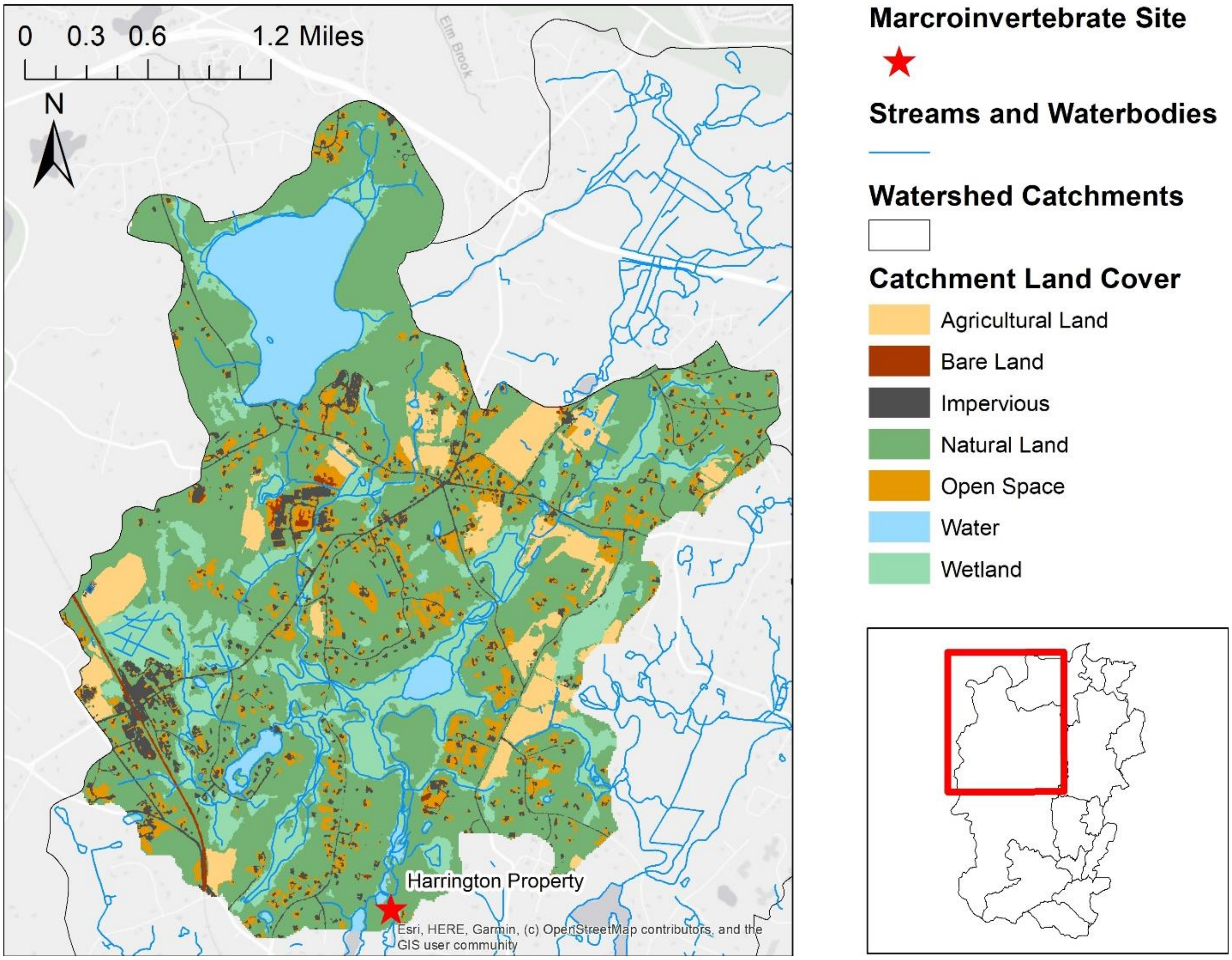



*Figure 12: Harrington Property catchment land cover map*

# Results

## Habitat Assessment

The Summer Street reach received the lowest the habitat score of all four sites (Table 2). It scored low on metrics concerning pool bottom and variability because there were not many pool habitats available for macroinvertebrates at this site. It also scored low for channel flow and alteration, given that the culvert that connects the stream from either side of Summer Street is present and obviously not a natural feature. Finally, the right bank of the stream was less stable than the left bank. These considerations contributed to an overall score of 115, placing it in the Suboptimal habitat range.

The Lexington Brook reach scored just higher than Summer Street at 117, but this still placed it in the Suboptimal habitat category (Table 2). This site scored low for channel alteration and sinuosity due to attempts to straighten the reach being obvious. It also scored very low on the left bank for stability, vegetation, and adequate riparian zone depth due to the proximity of the reach to the I-95 highway. The right bank of the reach scored much better because it is left in a natural state, but the overall score was brought down by the other habitat considerations.

Although the habitat scores for Lex Brook and Summer Street were similar, the land cover types in the catchments were quite different. Impervious cover in the Lex Brook catchment was 33 percent versus only 13 percent at Summer Street (Figure 5 and Figure 7). Similarly, the Lex Brook reach parallels a highway while the Summer Street reach is situated in a suburban neighborhood. These differences in land use may explain why Summer Street received a water quality score 13.1 points higher than at Lex Brook (Table 3).

*Table 2: Summary of 2019 rapid biohabitat assessment scores for Lex Brook, Summer Street, SB @ Viles, and Harrington Property*

| Habitat Parameter | Lex Brook | Summer Street | SB @ Viles | Harrington Property | Maximum Possible Score |
|---|---|---|---|---|---|
| **Bottom Cover** | 16 | 17 | 17 | 17 | 20 |
| **Pool Bottom** | 15 | 7 | 13 | 11 | 20 |
| **Pool Variability** | 5 | 3 | 20 | 13 | 20 |
| **Sediment Deposition** | 14 | 10 | 14 | 15 | 20 |
| **Channel Flow** | 15 | 10 | 19 | 16 | 20 |
| **Channel Alteration** | 10 | 11 | 15 | 15 | 20 |
| **Channel Sinuosity** | 6 | 9 | 11 | 10 | 20 |
| **Left Bank Stability** | 4 | 8 | 6 | 7 | 10 |
| **Right Bank Stability** | 7 | 5 | 5 | 7 | 10 |
| **Left Riparian Zone** | 2 | 9 | 10 | 9 | 10 |
| **Right Riparian Zone** | 9 | 8 | 10 | 9 | 10 |
| **Left Bank Vegetation** | 5 | 9 | 9 | 9 | 10 |
| **Right Bank Vegetation** | 9 | 9 | 9 | 10 | 10 |
| **Total Score** | 117 | 115 | 158 | 148 | 200 |
| **Habitat Quality** | Suboptimal | Suboptimal | Optimal | Suboptimal | Optimal |

The Harrington Property reach scored higher than Lexington Brook and Summer Street, but still in the Suboptimal category at 148 (Table 2). This is just shy of the Optimal habitat category, which begins at scores of 150. The lowest scores for this reach were for pool bottom and variability. Despite the small dam 50 ft from the beginning of the reach, channel alteration still scored high because there were no obvious disturbances to the natural state of the reach beyond the upstream impoundment.

The reach at SB @ Viles scored the highest for BMI habitat of all four sites with a score of 158 (out of 200 possible total points) that placed it in the Optimal habitat category (Table 2). This reach scored high for pool bottom and pool variability, categories in which the other sites lacked points. It also scored high for channel flow, meaning that the flow in the channel used up the majority of the banks. The lowest scores were for bank stability, which CWD rated lower due to undercut banks, areas of loose, fine sediment, and exposed roots on either side of the stream.

## Water Quality

After collection in the field, macroinvertebrate samples were brought back to the lab for specimen identification. Individual specimens of the same type were counted and given an abundance score of “rare”, “common”, or “dominant”. The class (sensitivity) and abundance are both accounted for in the overall water quality score.

Lex Brook had the lowest water quality score of all four sites sampled in 2019 (Table 3). In the Class I category, only 6 water penny larvae were found, which merits a “rare” score (Table 3). In the Class II category, two types of macroinvertebrates were found. Scuds were “rare” and net spinning caddisflies were “common” (Table 3). The highest number of points towards the water quality score came from these Class II macroinvertebrates. Class III macroinvertebrates were more abundant at this site. Enough blackfly larvae, midge larvae, and snails were found for all three types to be considered “common” (Table 3). Overall, 138 individual macroinvertebrates were collected at the Lexington Brook stream reach (Table 3). This was the lowest of all four sites and had the highest abundance of Class III macroinvertebrates. The water quality score was 21.3, placing it on the low end of the “fair” water quality category.

Summer Street had the second lowest water quality score of the four sites at 34.4 (Table 3). This is still in the “fair” water quality category, but on the higher end of the spectrum. Overall, 208 individual macroinvertebrate specimens were collected (Table 3). Macroinvertebrates of all three classes were found at this site, but in low enough quantities that they were all considered to be “rare” except for the Class II net spinning caddisfly larvae (Table 3). These were found in great abundance, enough so that this type of macroinvertebrate was considered “dominant” (100 or more individuals) (Table 3). The specimens sampled at Summer Street included three different types of macroinvertebrates in the Class I category, four in Class II, and three in Class III (Table 3). The majority of the points towards the water quality score came from the Class I (15 points) and Class II (15.8 points) groups of macroinvertebrates. Although vertebrates are not part of the water quality rating system, CWD discovered two late larval stage Northern Two-Lined Salamanders in one of the jabs (Figure 13). Upon discovery, CWD staff released the salamanders back into the stream.

*Figure 13: Late larval state Northern Two Tailed salamander found by CWD from jab sample at Summer St reach, July 19, 2019.*

It is reasonable that Lex Brook and Summer Street both received water quality scores in the “Fair” range given that their habitat scores were both in the “Suboptimal” category (117 and

115, respectively). However, the habitat score for Lex Brook was perhaps not reflective enough of the differences in the level of development in the two catchments, which could have contributed to the relatively lower water quality score at Lex Brook (21.3) compared to Summer Street (34.4).

*Table 3: Summary of 2019 macroinvertebrate identification results and water quality scores*

| Site | **SB@Viles** | | **Harrington Property** | | **Lex Brook** | | **Summer Street** | |
|---|---|---|---|---|---|---|---|---|
| Date | 29-Jul-19 | | 22-Jul-19 | | 15-Jul-19 | | 15-Jul-19 | |
| Type | # Individuals | | # Individuals | | # Individuals | | # Individuals | |
| Class I | | | | | | | | |
| Water Penny Larvae | 5 | Rare | 1 | Rare | 6 | Rare | 0 | |
| Hellgrammites | 0 | | 0 | | 0 | | 0 | |
| Mayfly nymphs | 14 | Common | 12 | Common | 0 | | 1 | Rare |
| Gilled Snails | 0 | | 2 | Rare | 0 | | 2 | Rare |
| Riffle Beetle Adult | 10 | Common | 1 | Rare | 0 | | 0 | |
| Stonefly Nymphs | 20 | Common | 0 | | 0 | | 0 | |
| Non-Net Spinning Caddisfly Larvae | 2 | Rare | 45 | Common | 0 | | 7 | Rare |
| Class II | | | | | | | | |
| Beetle Larvae | 14 | Common | 64 | Common | 0 | | 1 | Rare |
| Clams | 0 | | 1 | Rare | 0 | | 0 | |
| Cranefly Larvae | 13 | Common | 0 | | 9 | Rare | 7 | Rare |
| Crayfish | 2 | Rare | 4 | Rare | 0 | | 0 | |
| Scuds | 67 | Common | 40 | Common | 7 | Rare | 1 | Rare |
| Sowbugs | 0 | | 7 | Rare | 2 | | 1 | Rare |
| Fishfly Larvae | 0 | | 0 | | 0 | | 0 | |
| Alderfly Larvae | 0 | | 0 | | 0 | | 0 | |
| Net Spinning Caddisfly Larvae | 36 | Common | 108 | Dominant | 32 | Common | 178 | Dominant |
| Class III | | | | | | | | |
| Aquatic Worms | 8 | Rare | 7 | Rare | 0 | | 5 | Rare |
| Blackfly Larvae | 10 | Common | 0 | | 19 | Common | 0 | |
| Leeches | 0 | | 0 | | 0 | | 4 | Rare |
| Midge Larvae | 0 | | 9 | Rare | 29 | Common | 1 | Rare |
| Snails | 0 | | 1 | Rare | 34 | Common | 0 | |
| **Total # of Individuals** | **201** | | **302** | | **138** | | **208** | |
| **Water Quality Score** | **48.7** | | **51.8** | | **21.3** | | **34.4** | |
| **Water Quality Category** | **Good (>40)** | | **Good (>40)** | | **Fair (20-40)** | | **Fair (20-40)** | |

At the SB @ Viles reach, 201 individual specimens of macroinvertebrates were collected (Table 3). This was fewer than at the Summer Street site where 208 specimens were found, but the distribution of macroinvertebrates gave the SB @ Viles reach a much higher water quality score (Table 3). The SB @ Viles water quality score totaled 48.7, placing it above the 40-point minimum to be considered in the “good” water quality category. The reason this site scored so well with a similar number of macroinvertebrates was because of the quantity of Class I types found. There were 5 different types identified, and three types (mayfly larvae, riffle beetles, and stonefly larvae) were abundant enough to be considered "common" (Table 3). Class I macroinvertebrates also contributed the largest number of points towards the water quality score for this site. In addition, there were 5 different types of Class II macroinvertebrates found, the most abundant being scuds (Table 3). Only two Class III macroinvertebrate types were found at this site (Table 3). SB @ Viles also scored the highest for habitat quality of the four sites (158). The types and abundance of macroinvertebrates collected here seem to support the high habitat score.

The water quality score for the Harrington Property site was the highest of all sites, slightly above SB @ Viles (48.7) at 49.2 (Table 3). Like SB @ Viles, specimens from all three classes of macroinvertebrates were collected from the reach at the Harrington Property. The water quality scores were overall very similar between the two sites. This was not surprising given that the Harrington Property reach lies within a subcatchment of the SB @ Viles catchment and the land use within the two catchments is similar (Figure 9 - Figure 11). Although the habitat assessment score of 148 placed the reach in the Suboptimal category for macroinvertebrates, it was only two points shy of Optimal. Further, the protected land surrounding the reach may also have contributed to the high water quality score. One of the major differences between the Harrington Property reach and the SB @ Viles reach was that the Class II net-spinning caddisfly larvae was found to be dominant at Harrington property, rather than just common at SB @ Viles (Table 3). Another difference was that there were three types of Class III macroinvertebrates found at the site, rather than just 2 at SB @ Viles (Table 3).

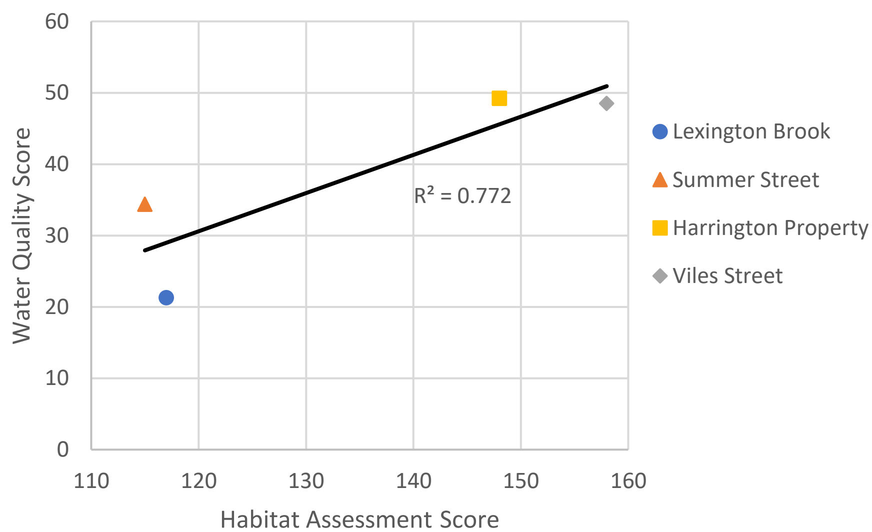


*Figure 14: Comparison of 2019 habitat assessment and water quality scores*

In 2019, higher habitat scores correlated with higher water quality scores (Figure 14). For the four sites monitored by CWD in 2019, albeit a small sample size, the R-squared value for a simple linear regression between habitat score and water quality score was 0.772. This shows a moderately strong positive correlation, suggesting that sites with higher habitat scores higher also tend to have better water quality as measured by macroinvertebrate abundance and diversity. Other explanations for differences in water quality scores could include differences in the physical and chemical water quality between sites. This relationship is not explored in this report, but ample information on chemical and physical parameters measured by CWD at Lex Brook, SB @ Viles, and Summer Street through the SWQMP can be found online at the following website:

https://www.cambridgema.gov/Water/watershedmanagementdivision/sourcewaterprotectionprogram/sourcewaterqualitymonitoringprogram/datamanagement/reportsandresearch

## Common Macroinvertebrates

This section discusses the macroinvertebrates commonly identified by CWD in 2019. For the following macroinvertebrates, CWD identified one or more individuals in at least three of the four sampling reaches. Unless otherwise cited, the source of information presented in this section is Voshell's 2002 resource, *A Guide to Common Freshwater Invertebrates of North America*.

### Class I

Macroinvertebrates in Class I are very sensitive to pollution and are typically only found in environments with good water quality.

#### Non-Net Spinning Caddisfly Larvae

Caddisflies are the largest order of insects (order Trichoptera) that are entirely aquatic as larvae and pupae. In North America, there are 21 different families and 1,400 distinct species of caddisfly. In their larval stage, they can be identified by their caterpillar-like long cylindrical bodies, three pairs of front legs, and hardened skin on their heads. These insects can produce a silk thread that some species use to spin "nets", which help them catch food to eat. Others, like the non-net spinning variety, use the silk to create "cases" which they build around themselves for protection (Figure 15). The non-net spinning caddisfly larvae is one of the more sensitive types of caddisfly. Finding these in a stream is a good indication that the water quality is favorable. In 2019, CWD found non-net spinning caddisfly larvae at the SB @ Viles, Harrington Property, and Summer St reaches (Table 3). While these organisms were classified as "rare" at SB @ Viles and Summer St, they were "common" at the Harrington Property reach (Table 3).

*Figure 15: Non-net spinning caddisfly larva*
Image by Jan Hamrsky via www.lifeinfreshwater.net

#### Water Penny Larvae

Water pennies are part of the order Coleoptera. In North America, only 6 different genera and 16 distinct species of water penny are present. The most common species is found only in the eastern side of the continent. They have a distinctive round, flat shape (Figure 16). They are referred to as clingers because they utilize their flexible plates to shape to whatever surface they are on. Water pennies prefer riffle-type habitats with moderate currents where they can latch onto rocks. Since they rely on being able to attach effectively to rocks to feed, they do not do well in habitats where rocks accumulate layers of algae, fungi, or inorganic sediment. Water quality must be good enough to facilitate latching to rocks, so they will not be found in eutrophic environments. Water penny larvae were present at SB @ Viles, Harrington Property, and Lex Brook in 2019 (Table 3). However, the water penny abundance was categorized as "rare" in all three cases (Table 3). Because water pennies are such effective clingers, it is possible that their numbers are under counted in the CWD BMI program; water penny larvae can be difficult to dislodge by kick sampling without the use of forceps.

*Figure 16: Water penny larva*
Image from The BMI Project via *https://sites.google.com/site/thebmiprojectthewaterpenny/*

## Mayfly Nymphs

In 2019, mayfly nymphs (larvae) were common at SB @ Viles and Harrington Property and rare at Summer Street. CWD staff did not find mayfly larvae at Lex Brook in 2019. Mayflies (Ephemeroptera) are an order of insects consisting of 21 families and 676 species in North America. While mayfly larvae live in streams and lakes, adult mayflies are purely terrestrial. Larvae have elongate bodies and three pairs of segmented legs extending from the thorax (Figure 17). Mayfly larvae also have gills along the sides of the abdomen and have two to three long, thin tails. Mayfly larvae thrive in a variety of habitats, the most of any order of aquatic insect. While many mayfly larvae prefer riffles and firm substrates, certain species have adapted to soft substrates in depositional zones. Given the diversity of habitats, mayfly larvae move using many different techniques ranging from swimming to climbing to burrowing while others specialize at clinging. Although mayfly larvae can thrive in myriad habitats, they are very sensitive to water quality and usually will not survive well in polluted waters.

*Figure 17: Mayfly larva*
Image by Jan Hamrsky via www.lifeinfreshwater.net

## Class II

Macroinvertebrates in Class II are moderately sensitive to pollution. They do well in most waters except for significantly polluted water bodies.

### Crane Fly Larvae

Crane flies are common throughout the continent of North America. There are 34 genera and 577 known species in this family (Tipulidae). They are the largest family of "true flies" by species count (order Diptera). The crane fly family is very diverse, with the tolerance levels for pollution ranging from somewhat sensitive to somewhat tolerant. Crane fly larvae are found in many different habitats, but among their favorites are leaf packs, woody debris, and stones. Crane fly larvae were common at SB @ Viles but rare at Lex Brook and Summer St in 2019 (Table 3). CWD did not find crane fly larvae at the Harrington Property reach in 2019. Figure 18 shows a crane fly larva collected at SB @ Viles in July of 2019.

*Figure 18: Crane fly larva collected at SB @ Viles 7/29/2019*

### Scuds

Scuds ("side swimmers") are a type of crustacean (Figure 19). Most scud species (order Amphipoda) are marine, but about 150 species of freshwater scuds can be found in North America. They are most commonly found in the shallow of cool streams and can be very abundant where there are no fish. They have a distinctive way of moving, by pushing themselves along on their sides. Scuds are moderately sensitive to pollution, but some are especially sensitive to toxic heavy metals and pesticides. In 2019, CWD found scuds at all four BMI monitoring sites. Scud abundance was classified as common at SB @ Viles and Harrington Property and rare at Summer St and Lex Brook (Table 3).

*Figure 19: Scud*

Image from The BugLady at University of Wisconsin Milwaukee via https://uwm.edu/field-station/scuds/

## Net Spinning Caddisfly Larvae

Net spinning caddisfly larvae (order Trichoptera) use their silk to catch food and attach to solid substrates rather than to make cases. Net spinning caddisfly larvae (Figure 20) are usually less sensitive to pollution than the non-net spinning caddisfly larvae. Net spinning caddisfly larvae were among the most abundant types of macroinvertebrates at all four CWD sites in 2019. Net spinning caddisfly larvae were common at SB @ Viles and Lex Brook and were dominant at the Harrington Property and Summer Street sites (Table 3).

*Figure 20: Net spinning caddisfly larva*

Image from Macroinvertebrates.org via https://www.macroinvertebrates.org/taxa-characters/trichoptera-larva/hydropsychidae/cheumatopsyche/lateral/dc27

## Water Beetle Larvae

Water beetle larvae belong to the order Coleoptera, the most diverse order of insects. While most beetle species are terrestrial-only, there are approximately 20 families and 1,000 species of beetles in North America that spend at least part of their life in the water. Water beetle larvae usually have hardened skin, lack wing pads on the thorax, and usually do not have structures protruding from the sides of the abdomen (Figure 21). Most water beetle larvae prefer still water, although some species have adapted to riffle environments. Beetle larvae were common at SB @ Viles and Harrington Property but were rare at Summer Street (Table 3). There were no beetle larvae found in kick samples from Lex Brook in 2019.

*Figure 21: Riffle beetle larva*

Image from Macroinvertebrates.org via https://www.macroinvertebrates.org/taxa-characters/coleoptera-larva/elmidae/macronychus%20glabratus/dorsal

## Class III

Class III macroinvertebrates are the most tolerant of pollution and poor water quality. Large numbers of these organisms can be a sign of poor water quality.

## Midge Larvae

Midges are also "true flies" (order Diptera) and live throughout North America. Midge larvae occupy many different habitats, including both flowing and stagnant water. Midge larvae can thrive in degraded habitats as well as unimpacted areas. They can be found on vegetation, solid substrates, and fine sediments. Midge larvae look like small "C" shaped hooks (Figure 22). In

2019, midge larvae were common at Lex Brook but were only rare at Harrington Property and Summer St (Table 3). CWD did not find midge larvae at SB @ Viles in 2019.

*Figure 22: Midge larva*
Image from Macroinvertebrates.org via https://www.macroinvertebrates.org/taxa-characters/diptera-larva/chironomidae/tanytarsus/lateral

### Aquatic Earthworms

Like their terrestrial counter parts, aquatic earth worms have soft segmented bodies with no suckers or eye sockets (Figure 23). North America has 3,500 species of earthworms (class Oligochaeta) but only 170 of those are aquatic. The most common species of aquatic worms live in slow moving or stagnant water in silt and mud. Many aquatic earthworms are very tolerant of pollution and low dissolved oxygen. Aquatic earthworms were found at Harrington Property, SB @ Viles, and Summer St in 2019 but were rare at all three sites (Table 3). CWD did not find any aquatic earthworms at Lex Brook in 2019.

*Figure 23: Aquatic earthworm*
Image by Michael R. Clapp via https://www.nwnature.net/macros/worms.html

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