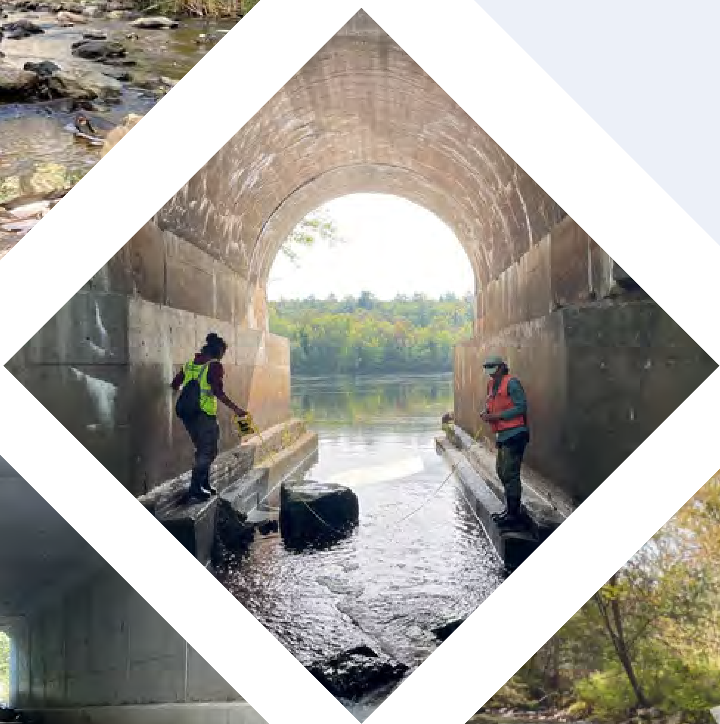
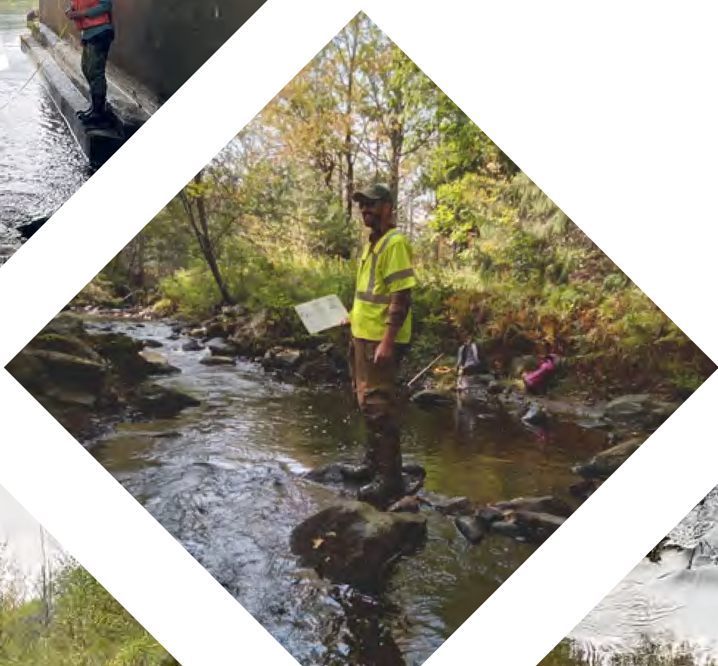
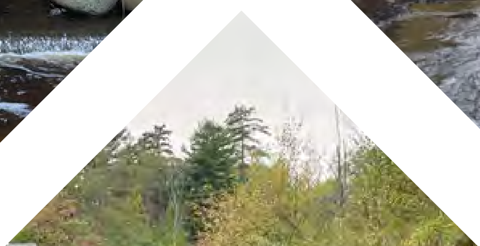
PENJAJAWOC STREAM CORRIDOR SURVEY

BANGOR, MAINE
MARCH, 2024







PENJAJAWOC
Stream Corridor Survey

Prepared by SEE in cooperation with the City of Bangor, the Maine Department of Environmental Protection, and Ecological Instincts.

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Acknowledgments

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1. Stream Corridor Survey Overview

In September 2023 a group of environmental professionals led by Stillwater Environmental Engineering and Ecological Instincts conducted a Stream Corridor Survey (SCS) of Penjajawoc Stream and its two main tributaries, Meadow Brook and Cemetery Brook (**Figure 1**). Before conducting the survey, the main stem of Penjajawoc Stream and the two tributaries were divided into segments (reaches) based on topography, similarity of physical characteristics, and habitat types. Further divisions (sub-reaches) were created in the field based on physical attributes and anthropogenic influences. The survey was divided into four areas (1-4); and a total of 21 stream reaches, 1 reach in the Cemetery Brook tributary (CB), five reaches in the Meadow Brook tributary (MB 1, MB 2A MB 2B, MB 2C, and MB 2D), and 15 reaches in the main body of Penjajawoc Stream (**Figure 1**) and attached in **Appendix A1: Map of Penjajawoc Stream and Tributary Survey Areas**.

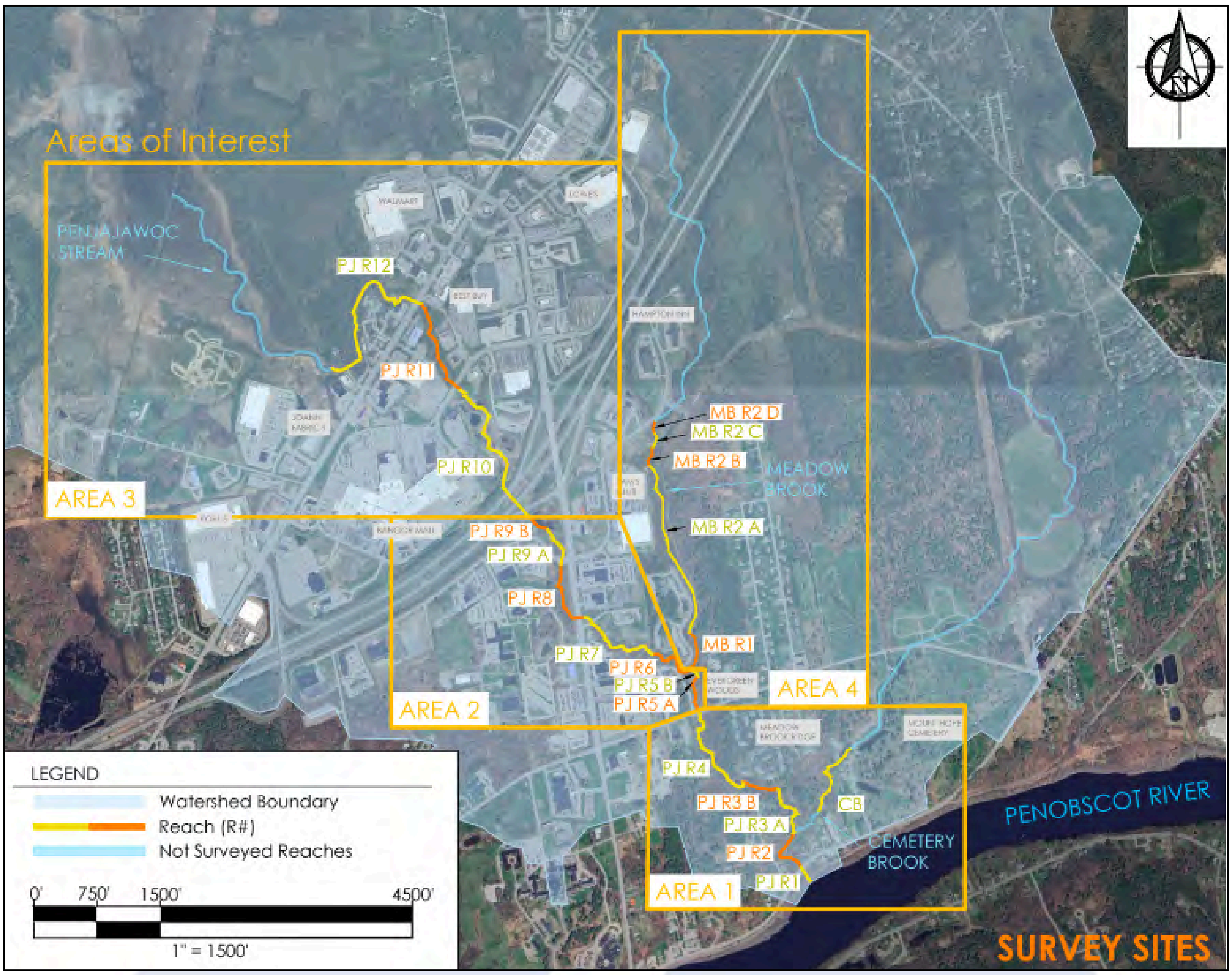

Figure 1: Map of the 2023 Penjajawoc Stream Corridor Survey Areas and Reaches

Area 1 includes the section of Penjajawoc Stream starting from the Penobscot River outflow east of Meadowbrook Road and ending on the north side of the Mt. Hope Avenue intersection with the Evergreen Woods access road. Area 1 also includes the entirety of the Cemetery Brook tributary. Area 1 is comprised of five reaches (PJ 1, PJ 2, PJ 3, PJ 4, and CB 1), one railroad crossing, two road crossings, and 15 stormwater outfalls. A detailed map of Area 1 is included in **Appendix A2: Map of Area 1**.

Area 2 includes the section of Penjajawoc Stream starting from the northern side of the Mt. Hope Ave. intersection with the Evergreen Woods access road and ending on the western side of the Hogan Road intersection with Exit 187 of the I-95 interchange. Area 2 is comprised of seven reaches (PJ 5A, PJ 5B, PJ 6, PJ 7, PJ 8, PJ 9A, and PJ 9B), four road crossings, the confluence of Meadow Brook, and 18 stormwater outfalls. A detailed map of Area 2 is included in **Appendix A3: Map of Area 2**.

Area 3 includes the section of Penjajawoc Stream starting from the western edge of the Hogan Road intersection with Exit 187 and ending on the northern side of 710 Stillwater Avenue. Area 3 is comprised of three stream reaches (PJ 10, PJ 11, and PJ 12), five road crossings, and 18 stormwater outfalls. Upstream of PJ 12 the stream is an open marsh that was not included in the survey. A detailed map of Area 3 is included in **Appendix A4: Map of Area 3**.

Area 4 includes the Meadow Brook tributary starting from the confluence with Penjajawoc Stream and ending on the eastern side of 47 Haskell Road. Area 4 is comprised of five reaches (MB 1, MB 2A, MB 2B, MB 2C, and MB 2D) and includes no significant crossings and 17 stormwater outfalls. Due to staffing and budgetary constraints, the remaining reaches of the Meadowbrook tributary upstream (north) of Haskell Road were not surveyed. This portion of the tributary is located in a more undeveloped portion of the watershed and likely has fewer anthropogenic impacts. Future surveys of this portion of Meadow Brook may be needed to complete a comprehensive review of the entire Penjajawoc Stream watershed. A detailed map of Area 4 is in **Appendix A5: Map of Area 4**.

The SCS collects visual observations and provides general information about the overall stream habitat. The purpose is to identify the habitat conditions in each stream reach, educate and encourage stewardship among landowners and watershed residents, and provide context for future management recommendations. Within the SCS, two assessments are conducted: a Rapid Habitat Assessment (RHA) and a Rapid Geomorphic Assessment (RGA). The RHA primarily focuses on collecting data on stream habitats and water quality, while the RGA assesses the shape and stability of the stream (Maine Department of Environmental Protection (MDEP), 2009). An overview of the Penjajawoc Watershed land use and geology provides a broader context of stream conditions (refer to Section 3).

2. Methods

The SCS was conducted following the procedures from the *Stream Survey Manual, A Citizen's Guide* by the MDEP for wadeable streams (MDEP, 2009). The guide provided a step-by-step visual observations survey and macroinvertebrate evaluation. Visual observations evaluated the physical and biological characteristics. The macroinvertebrate evaluation involves the selection of leaves, sticks, or rocks throughout a reach to inspect for the presence of various macroinvertebrates. SEE did a supplemental data collection of a single conductivity reading for each reach. Surveyors followed MDEP field sampling collection methods and used hand-held YSI Field Meters that were calibrated on the day of the survey (MDEP, 2019). These field conductivity readings were supplemented with sample collection and lab analyses for chloride at each of the conductivity locations. This was completed in an attempt to create a correlation between field conductivity readings and baseline chloride levels in the various stream reaches. The chloride readings will be assessed in the chloride analysis of the updated Penjajawoc Stream's Watershed Based Management Plan.

The SCS was conducted by a group with varying degrees of experience with stream corridor surveys, stream geomorphology, and stream restoration projects. The collected data is not fully comprehensive and should be evaluated as somewhat subjective, especially given that different teams of individuals completed surveys of different reaches throughout the watershed. This should be understood before any relevant conclusions or comparisons of reaches are made using these data. Wherever possible, subjective results were reviewed with multiple members of the SCS team. In addition, prior to the commencement of the SCS, the entire team, led by Jen Jesperson of Ecological Instincts, performed a full assessment of a small portion of reach PJ 5 to standardize methods across all of the various teams. The results of this portion of the SCS were compared and discussed prior to the commencement of the formal SCS.

Survey data, GPS locations, field notes, and images were collected by SEE staff using the Fulcrum mobile data collection application. Spreadsheets were used to organize and analyze the data. Field results are presented in five detailed tables included in **Appendix B: RHA Tables, Appendix C: RGA Tables,** and one overall summary table (**Table 2**), found in **Section 6: Summary of Findings**. Analysis and scoring followed the methodologies outlined in the 2009 *Draft of the Recommended Steps for Scoring and Writing Stream Corridor Survey Reports* (Varricchione, 2009). The overall condition for each reach was ranked from very good to very poor (**Figure 2**).

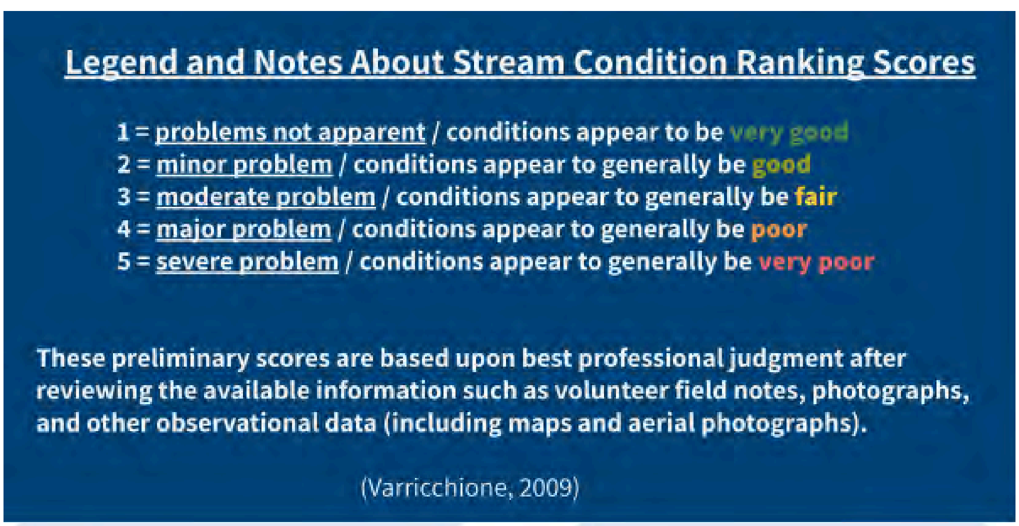

Figure 2. Legend for Reach Scores used for the Penjajawoc Stream Corridor Survey.

3. Land Use and Geologic Overview

Over the past 100 years, land use has changed considerably in the City of Bangor. In the 1940's a majority of the Penjajawoc watershed land use was for woodlots and open fields (FBE, 2015). Today, much of the land use has shifted to commercial uses and associated impervious cover, specifically in the middle sub-watershed (FBE, 2015)(MDEP, 2023). The entire watershed has approximately 11% impervious cover but ~45% of that total is concentrated in the middle sub-watershed, the largest portion of the Penjajawoc Stream watershed (MDEP, 2023). The Meadow Brook tributary and sub-watershed have ~25% of the total impervious cover. The Mt. Hope sub-watershed encompasses the entirety of Cemetery Brook and accounts for ~8% of the Penjajawoc watershed's total impervious cover (MDEP, 2023) (**Appendix D: Reference Maps** for impervious cover in the Penjajawoc Stream watershed).

Impervious Cover (IC) prevents water from absorbing into the ground. IC are surfaces that water flows over and creates run-off. For Example, paved surfaces.

Penjajawoc Stream and its tributaries are surrounded by silty-clay soils known as the Presumpscot Formation, a marine clay left behind when the last glacier retreated between 10,000 and 12,000 years ago [from the late-glacial sea floor (MGS, 2021)]. The stream beds are composed of stream alluvium, composed of sand, gravel, silt, and organic sediment (MGS, 2021). Between the Meadow Brook tributary and the Penjajawoc Stream, the main geologic feature is till, with a sandy to silty structure (MGS, 2021). Areas of development in naturally low places of elevation have been filled in with artificial till, these places include major Penjajawoc Stream crossings such as Interstate 95, Mt. Hope Avenue, Route 2, and Stillwater Avenue (MGS, 2021).

4. Rapid Habitat Assessment Results

4.1. Riparian Vegetation and Water Temperature

Riparian vegetation provides shade to the stream, reduces daily temperature fluctuation, and maintains cooler average water temperatures (MDEP, 2009). Wide stream channels and little to no riparian canopy reduce stream shading. As water temperature increases, dissolved oxygen (DO) retention decreases (Allan and Castillo, 2007). Cold water organisms require higher levels of DO to survive. A detailed table describing Riparian Vegetation and Water Temperature by reach is provided in **Appendix B1: Riparian Vegetation and In-Stream Temperature Conditions**. Reach shade cover is rated using a percentage scale, with available choices ranging from 0% to 100%, in 25% increments.

In general, reaches with a width of 25 feet or more would inherently have limited shade cover potential (50% cover or less)(Varricchione, 2009). However, the widest channel width surveyed was 17 feet (PJ 3A). For Penjajawoc Stream and tributaries, 12 out of the 21 surveyed reaches exhibited stream shade cover ranging from 0% to 25%. Among those 12 reaches, five (PJ 1, PJ 3A, PJ 3B, PJ 4, and PJ 5A) had channel widths exceeding 15 feet. Three reaches were noted as having 50% stream shade cover (CB, PJ 5B, and PJ 11), and three with 75% stream shade cover (PJ 6, PJ 8, MB 1). The remaining three reaches (MB 2A, MB 2B, and MB 2D), located in the Meadow Brook Tributary, had the highest rating of any of the reaches surveyed at 100% stream shade cover. This is likely due to a combination of a much more narrow stream channel than the majority of other reaches in the Penjajawoc Stream Watershed in addition to the primarily heavily forested riparian zone of the Meadow Brook Tributary.

Example of stream shade cover in Reach MB 2A.

Example of no stream shade cover in Reach PJ 10.

The riparian zone cover varied significantly across the reaches ranging from very good to very poor conditions. Two reaches in the Meadow Brook Tributary were noted to be in very good condition with the least amount of apparent riparian alterations (MB 2B and MB 2D). Impervious surfaces and garbage along the stream were found in a majority of the reaches (impervious surfaces: CB, PJ 1, PJ 2, PJ 5A, PJ 6, PJ 8, PJ 9A, PJ 11, PJ 12, MB 1, and MB 2A; garbage: PJ 2, PJ 3A, PJ 3B, PJ 5A, PJ 5B, PJ 6, PJ 7, PJ 9A, PJ 9B, PJ 10, PJ 11, MB 1, and MB 2A). Degraded plant cover was observed in five of the surveyed reaches (PJ 1, PJ 2, PJ 3A, PJ 3B, and MB 2A), and eroded banks were identified in a total of five reaches (PJ 4, PJ 8, PJ 12, MB 1, and MB 2A). This would indicate that a significant portion of the riparian zones throughout the watershed have been altered by anthropogenic factors.

Three reaches (CB, PJ 9B, and PJ 12) exhibited water temperatures of 16°C or higher, typically indicative of "fair" in-stream habitat conditions (Varricchione, 2009). Water temperatures recorded from the rest of the reaches were indicative of "good" habitat conditions (10°C - 15°C). Limited temperature readings were collected in the Meadow Brook Tributary reaches due to time constraints caused by the difficulty in navigating the tributary, but the two readings that were collected (MB 1 & MB 2A) were 12°C and 13°C, respectively, which would also indicate "good" habitat conditions.

4.2. Stream Bottom

Stream bottom structure influences aquatic organisms' ability to survive in a stream. Embeddedness is when particles such as silt, clay, mud, and sand, fill spaces between bigger substrates, such as gravel, cobble, boulders, and woody debris (MDEP, 2009). Embeddedness reduces habitat space used by aquatic organisms such as macroinvertebrates, algae, aquatic plants, and fish who rely on these spaces for spawning, attachment sites, and habitat (MDEP, 2009). When not embedded, woody debris provides shelter and can create pools (MDEP, 2009). (A detailed table of stream bottom conditions is provided in **Appendix B2: Stream Bottom, Streambank, and Channel Characteristics**)

Example of mostly embedded stream bottom in Reach 3B.

Observed embeddedness levels in the surveyed Penjajawoc Stream and tributary reaches varied significantly from "not embedded" to "completely embedded." Two reaches, MB 2B and MB 2D, were noted as "not embedded" (0% of substrate embedded). This observation correlates with the less impacted state of this portion of the Meadow Brook Tributary. Five reaches showed "somewhat embedded" conditions (5-25% of substrate embedded) (PJ 1, PJ 2, PJ 4, PJ 9A, PJ 11, and PJ 2C). Six reaches were classified as "halfway embedded" (50% of substrate embedded) (CB, PJ 5B, PJ 6, PJ 7, PJ 8, and MB 1). Finally, four reaches were categorized as "mostly embedded" (75% of substrate embedded) (PJ 3A, PJ 3B, PJ 5A, and PJ 12) and two reaches exhibited "complete embeddedness" (100% of substrate embedded) (PJ 10 and MB 2A). Again, this seems to correlate relatively closely with the general condition of each reach. Six reaches displayed equally mixed substrates with 50% embeddedness (CB, PJ 5B, PJ 6, PJ 7, PJ 8, and MB 1). Three reaches predominantly featured silt/clay/mud as their substrate (PJ 3B, PJ 10, and MB 2A), which correlates with a higher embeddedness. **Table 1** below describes the class size of substrates (MDEP, 2009).

Table 1: Classification of Substrate Size

Size Class	Millimeters	Inches	Approximate Relative Size
Bedrock	>2048	>80	Bigger than a car
Boulder	>256	>10.1	Bigger than a basketball
Cobble	64-256	2.5-10.1	Tennis ball to basketball
Gravel	2-64	0.08-2.5	Peppercorn to tennis ball
Sand	0.06-2.00	0.002-0.08	Salt to peppercorn
Silt	<0.06	<0.002	Finer than salt

The quantity of woody debris found in each reach ranged from none to plentiful. One reach had no woody debris (PJ 5A). Thirteen reaches had few woody debris (CB, PJ 1, PJ 2, PJ 3A, PJ 3B, PJ 4, PJ 8, PJ

9B, PJ 10, PJ 12, MB 2B, MB 2C, and MB 2D). Three had many woody debris (PJ 6, PJ 9A, and PJ 11), and three had plentiful woody debris (PJ 5B, MB 1, and MB 2A).

4.3. Stream Bank/Channel Characteristics

A stream characterized by diverse habitat types offers enhanced support for aquatic life (MDEP, 2009). Having a variety of flow rates and water depths creates habitat diversity for aquatic organisms. Bank shape plays a critical role in determining erosion susceptibility and also affects aquatic organism habitat, with steeply sloping banks being the most vulnerable to erosion (MDEP, 2009), with less aquatic organism habitat. Conversely, vertical or undercut banks exhibit reduced erosion susceptibility in comparison to steeply sloping banks, while also providing shelter for aquatic organisms, however severely undercut banks are at risk of collapse (MDEP, 2009). Gradually sloping banks are the least susceptible to erosion, but sustain little to no aquatic organism habitat. A detailed table of Stream Bank and Channel Characteristics is depicted in **Appendix B2: Stream Bottom, Streambank, and Channel Characteristics**.

Stream channel features like pools, riffles, runs, cascades, rapids, and dead water provide the necessary habitat variation needed for many aquatic organisms such as varying flow velocities, water depths, and substrates. Eighteen of the reaches included pool, riffle, and run features (CB, PJ 1, PJ 2, PJ 3A, PJ 3B, PJ 4, PJ 5A, PJ 5B, PJ 6, PJ 7, PJ 8, PJ 9A, PJ 11, PJ 12, MB 1, MB 2B, MB 2C, and MB 2D). Four reaches contained cascade features (CB, PJ 1, PJ 3A, and PJ 4) and two reaches contained deadwater features (MB 2A and MB 2C).

Example of riffles in reach PJ 11.

Example of constructed riffles in reach PJ 10.

The bank shape in each reach ranged from gradual to undercut. Seven reaches had vertical or undercut banks (PJ 4, PJ 5A, PJ 5B, PJ 7, PJ 9A, MB 1, and MB 2A). Seven reaches had steeply sloping banks (CB, PJ 1, PJ 3A, PJ 6, PJ 8, PJ 11, and PJ 12). Six reaches were less susceptible to erosion due to gradual banks (PJ 2, PJ 3B, PJ 10, MB 2B, MB 2C, and MB 2D). Reach PJ 9B is a beaver impoundment and no bank shape data was recorded.

4.4. Water Quality

Water quality was evaluated through various indicators including water color and odor, presence of algae, wildlife, amphibians, fish, macroinvertebrates, and specific conductance (SpCond). Water odor and color serve as indicators of potential pollution (MDEP, 2009). The presence of abundant organisms in and around the water are indicators of good water quality (MDEP, 2009). Different types of macroinvertebrates are more sensitive to pollution than others and are often used as an indicator of water quality (MDEP, 2009). SpCond readings were also collected in each reach to determine if conductivity levels in the stream exceeded chronic thresholds for aquatic life populations. Detailed water quality information for Penjajawoc Stream is provided in **Appendix B3: Water Quality Issues**.

Water appearance and odor are both physical indicators of pollution. Penjajawoc Stream generally had no odor other than a sulfur (rotten egg) smell in the Cemetery Brook tributary and a sewage smell in reach PJ 8, which may be caused by vented sanitary sewer covers in the adjacent area, but should likely be investigated further. Water appearance varied between reaches, and in some cases variation in appearance was documented within a single reach. Five reaches appeared to have a light brown color (CB, PJ 2, PJ 3A, PJ 4, and MB 1). One reach had an orange appearance (PJ 8), and one had an oily sheen (PJ 3A). Six reaches had a foamy appearance (PJ 1, PJ 2, PJ 3A, PJ 3B, PJ 4, and PJ 6). This may be due to natural organic foam or from upstream anthropogenic impacts but should be evaluated in the future. In 11 of the reaches the water appeared dark brown (PJ 5A, PJ 5B, PJ 6, PJ 7, PJ 8, PJ 9A, PJ 9B, PJ 10, PJ 11, and PJ 12), which is fairly typical of the waterways in the region, which generally contain naturally occurring high organic acid levels.

Example of wildlife presence from Reach PJ 4.

Algae is naturally occuring in streams but excess algae is an indicator of nutrient pollution from high levels of nitrogen and phosphorus (MDEP, 2010). High levels of nutrients cause pollution and algal growth that depletes dissolved oxygen levels in the water (MDEP, 2010). The survey assesses how much algae is seen in the stream. Algal coating over stones or twigs occurs in every reach, 15 reaches have brownish algal coating (CB, PJ 1, PJ 2, PJ 3A, PJ 3B, PJ 4, PJ 5A, PJ 5B, PJ 6, PJ 7, PJ 8, PJ 9, PJ

10, and PJ 12), 12 reaches have greenish algal coating (PJ 1, PJ 2, PJ 3A, PJ 5A, PJ 5B, PJ 7, PJ 10, MB 1, MB 2A, MB 2B, MB 2C, and MB 2D). Eight reaches have a heavy coating of algae (PJ 1, PJ 2, PJ 3A, PJ 3B, PJ 7, PJ 9B, PJ 10, and MB 1), while 10 reaches have a light coating of algae (CB, PJ 4, PJ 5A, PJ 5B, PJ 9A, 11, PJ 12, MB 1, MB 2A, MB 2B, MB 2C, and MB 2D). 16 reaches had no filamentous algae, four reaches had plentiful brownish filamentous algae (PJ 1, PJ 2, PJ 3A, and PJ 3B), and three reaches had green filamentous algae, two plentiful (PJ 1 and PJ 2) and one occasional (PJ 12). 19 reaches had no detached mats of algae, two had brownish and greenish algae clumps (PJ 3A and PJ 3B).

Wildlife such as amphibians, mammals, birds, and waterfowl were present in 17 reaches (CB, PJ 2, PJ 3A, PJ 3B, PJ 4, PJ 5A, PJ 5B, PJ 6, PJ 7, PJ 8, PJ 9A, PJ 9B, PJ 10, PJ 12, MB 1, and MB 2A). Fish were observed in 14 reaches (CB, PJ 3A, PJ 3B, PJ 4, PJ 5A, PJ 5B, PJ 6, PJ 7, PJ 10, PJ 12, MB 1, MB 2A, MB 2B, and MB 2D). Eight reaches had fish one to two inches long (CB, PJ 3B, PJ 4, PJ 5A, PJ 5B, PJ 6, PJ 7, PJ 10, and PJ 12). Eight reaches had fish 3-6 inches long (CB, PJ 3A, PJ 5A, PJ 12, MB 1, MB 2A, MB 2B, and MB 2D). Two reaches had fish seven or more inches (PJ 5A and PJ 12). Macroinvertebrates were observed in 15 reaches. 11 of these reaches had macroinvertebrates considered very intolerant of pollution (CB, PJ 1, PJ 2, PJ 4, PJ 5A, PJ 5B, PJ 6, PJ 7, PJ 8, PJ 9A, PJ 10, PJ 11, PJ 12, and MB 1) such as water penny larva, caddisfly larva, and right-handed snails. Four reaches had macroinvertebrates that are moderately intolerant of pollution (PJ 2, PJ 5A, PJ 10, and PJ 12) such as dragonfly and damselfly nymphs (Purdue, 2019).

Examples of macroinvertebrates collected during the survey. Left (PJ 5A) and right (PJ PJ 7).

Field readings of specific conductance (SpCond) were measured in each reach except for three Meadow Brook reaches (MB 2B, MB 2C, and MB 2D). Chloride samples were also collected and will be assessed in the updated Penjajawoc Stream Watershed Based Management Plan. For undeveloped stream watersheds in Maine, SpCond levels fluctuate around 30 to 50 µS/cm, however, disturbed streams tend to be much higher (MDEP, 2010). All surveyed reaches had SpCond levels above 300 µS/cm. Each reach's SpCond reading was compared to the chronic conductivity level, 854 µS/cm (Whiting, 2010). Reaches with SpCond above the chronic conductivity level, indicate that the conductivity level is harmful to aquatic life over an indefinite amount of time (USGS). One reach in Penjajawoc Stream was above the chronic conductivity level (PJ 4), as well as two reaches in Meadow Brook (MB 1 and MB 2A). One reach, PJ 12, was only 18 µS/cm below the chronic conductivity level.

4.5. Potential Pollution Sources

Potential sources of pollution along the stream were noted during the survey. These included significant crossings, stormwater outfalls, and man-made impacts such as litter, impervious surfaces in the riparian zone, and alterations to the stream banks. Stormwater discharges are a form of nonpoint source pollution, potentially carrying contaminants such as oil, trash, chlorides, sediment, metals, toxins, nutrients, and sewage (MDEP, 2010). This survey did not include sources of pollution that could not be seen from within the stream during the assessment. For detailed information on Potential Pollution Sources see **Appendix B4: Potential Pollution Sources**.

Outfalls are the point where the stormwater discharges from a pipe, ditch or other conveyance to the waters of the state.

There are 73 stormwater outfalls discharging to the stream and there is at least one in most reaches of the stream. Three reaches had no outfalls (PJ 3A, PJ 5B, and MB 2B), six had one to two outfalls (PJ 1, PJ 2, PJ 3B, PJ 9A, MB 1, and MB 2C), and six reaches had three to four outfalls (CB, PJ 4, PJ 5A, PJ 6, PJ 8, and PJ 9B). The reaches with the most outfalls ranged from five to nine outfalls per reach (PJ 7, PJ 10, PJ 11, PJ 12, MB 2A, and MB 2D). Based on conversations with MDEP staff, two outfalls that had a history of high conductivity were sampled during the survey for SpCond. Both of these outfalls had high specific conductivity readings during the survey (2640 µS/cm, notable condition 1 in Reach PJ 4) (4215 µS/cm, notable condition six in Reach PJ 10).

Examples of stormwater outfalls: Reach PJ 4 (left) and Reach PJ 10 (right).

A significant crossing is a structure that passes across the stream. In the Penjajawoc Stream watershed, a majority of significant crossings are roads. Three crossings were documented in reach PJ 10, two crossings were documented in reach PJ 1, and one crossing was documented in each of seven reaches along Penjajawoc Stream (PJ 4, PJ 6, PJ 7, PJ 8, PJ 9A, PJ 11, and PJ 12).

Impervious cover and garbage in the stream are discussed in this section and the potential pollution section due to their impact on riparian vegetation, and their role as potential sources of pollution. Impervious cover was documented within 25 yards of the stream in 11 reaches (CB, PJ 1, PJ 2, PJ 5A, PJ 6, PJ7, PJ 9A, PJ 10, PJ 11, PJ 12, and MB 1) and seven reaches had garbage scattered within the stream (CB, PJ 2, PJ 3A, PJ 3B, PJ 5B, PJ 7, and PJ 11).

4.6. Rapid Habitat Assessment (RHA) Summary of Findings

Each reach received a score for every RHA category (scores can be found in **Figure 2,** in the Summary of Findings). The scores are based on a one to five scale, where five is the worst and one is the best. Overall, Reaches PJ 10 and MB 2A scored higher than other reaches and displayed generally poor conditions. These reaches are the longest reaches and are located near a lot of commercial development. Reach PJ 10 scored a five in potential pollution problems, a four for stream structure and water quality categories, and a three for the two remaining RHA categories. Reach MB 2A scored a four for four out of the five RHA categories and a three for the riparian zone and temperature category.

In contrast, two Meadow Brook reaches (MB 2B and MB 2D) scored the lowest compared to the other reaches, and displayed generally good conditions. The reaches had identical scores due to their observational similarities. They scored a one for riparian and temperature characteristics, a two for streambank and channel structure and potential pollution problem, and a three for stream bottom and water quality characteristics.

The remaining reaches displayed generally fair characteristics. These reaches tended to have worse RHA characteristics than MB 2B and MB 2D and better characteristics than PJ 10 and MB 2A.

5. Rapid Geomorphic Assessment Results

The second significant portion of the stream survey was the Rapid Geomorphic Assessment (RGA). The RGA evaluates the channel stability conditions and the stage of channel evolution in each reach. The RGA identifies areas exhibiting aggradation (deposition of sediment), degradation (removal of sediment), widening, and planimetric form (stream pattern changes) adjustments. This identifies areas that are receiving large volumes of sediment from stormwater or bank erosion, areas that have been altered by man-made activities, and areas that are potential candidates for restoration. Aggradation, degradation, widening, and planimetric form adjustment are each indicated by features listed in the MDEP Stream Corridor Survey Manual. The MDEP's RGA scoring system is based on the number of

Example of degradation in Reach MB 2A.

features present within each reach rather than how severe these features are (Field, 2023). The RGA assessment calculates a stability index to assess stream reach stability (MDEP, 2009). Reach stability is categorized into three geomorphic conditions: in regime, in transition or stressed, and in adjustment. For detailed RGA results information see Appendix C: RGA Tables.

5.1. In Adjustment (most impacted)

In adjustment conditions are classified by reaches that exhibit multiple aggradation, degradation, widening, and planimetric form characteristics. In adjustment can indicate reaches that are changing due to anthropogenic influences or natural events (Field, 2023). Eight of the surveyed reaches are characterized as in adjustment (CB, PJ 2, PJ 3A, PJ 5B, PJ 11, PJ 12, MB 1, and MB 2A). Reach 2A in the Meadow Brook Tributary (MB 2A) had the worst channel stability conditions with seven out of nine aggradation characteristics, four out of seven for degradation and planimetric form characteristics, and seven out of eight widening characteristics. Four reaches had seven out of the nine aggradation characteristics (PJ 2, PJ 3A, PJ 12, and MB 2A). Two reaches had four of seven degradation characteristics (MB 1 and MB 2A). Three reaches had six of the eight widening characteristics (PJ 3A, MB 1, and MB 2A). One reach had five out of seven planimetric form characteristics (PJ 11).

Example of degradation. Image taken within Reach MB 2B.

A "J" shaped tree is an example of widening. Image taken within Reach MB 1.

5.2. In Transition (medium impact)

In transition or stressed conditions are classified by the reaches that exhibit some aggradation, degradation, widening, and planimetric form characteristics. In transition or stressed can indicate which reaches are changing due to anthropogenic influences or natural events (Field, 2023). Six reaches are characterized as "In Transition" (PJ 1, PJ 3B, PJ 4, PJ 6, PJ 7, and PJ 8). One reach had five out of seven degradation characteristics (PJ 7). One reach had six out of eight widening characteristics (PJ 6). One reach had two of the seven planimetric form characteristics (PJ 4).

5.3. In Regime (least impacted)

In regime is the most favorable stream channel condition, and is classified by the reaches that exhibit few aggradation, degradation, widening, and planimetric form characteristics. In regime reaches indicates dynamic equilibrium while maintaining a variety of healthy habitats for aquatic life (MDEP, 2009). Six stream reaches were In regime, three in the Meadow Brook tributary (MB 2B, MB 2C, and MB 2D) and three in the Penjajawoc Stream (PJ 5A, PJ 9A, and PJ 10).

5.4. RGA Summary of Findings

Reaches in adjustment are located near the confluences of Cemetery Brook (CB, PJ 2, and PJ 3A) and Meadow Brook (PJ 5B, MB 1, and MB 2A) and the most upstream reaches of the main stem of Penjajawoc Stream (PJ 11 and PJ 12). The in adjustment, in transition, and in regime reaches were scattered throughout the length of the Penjajawoc Stream as seen in **Figure 3,** below. A more detailed examination of these results is included in Section 6 below.

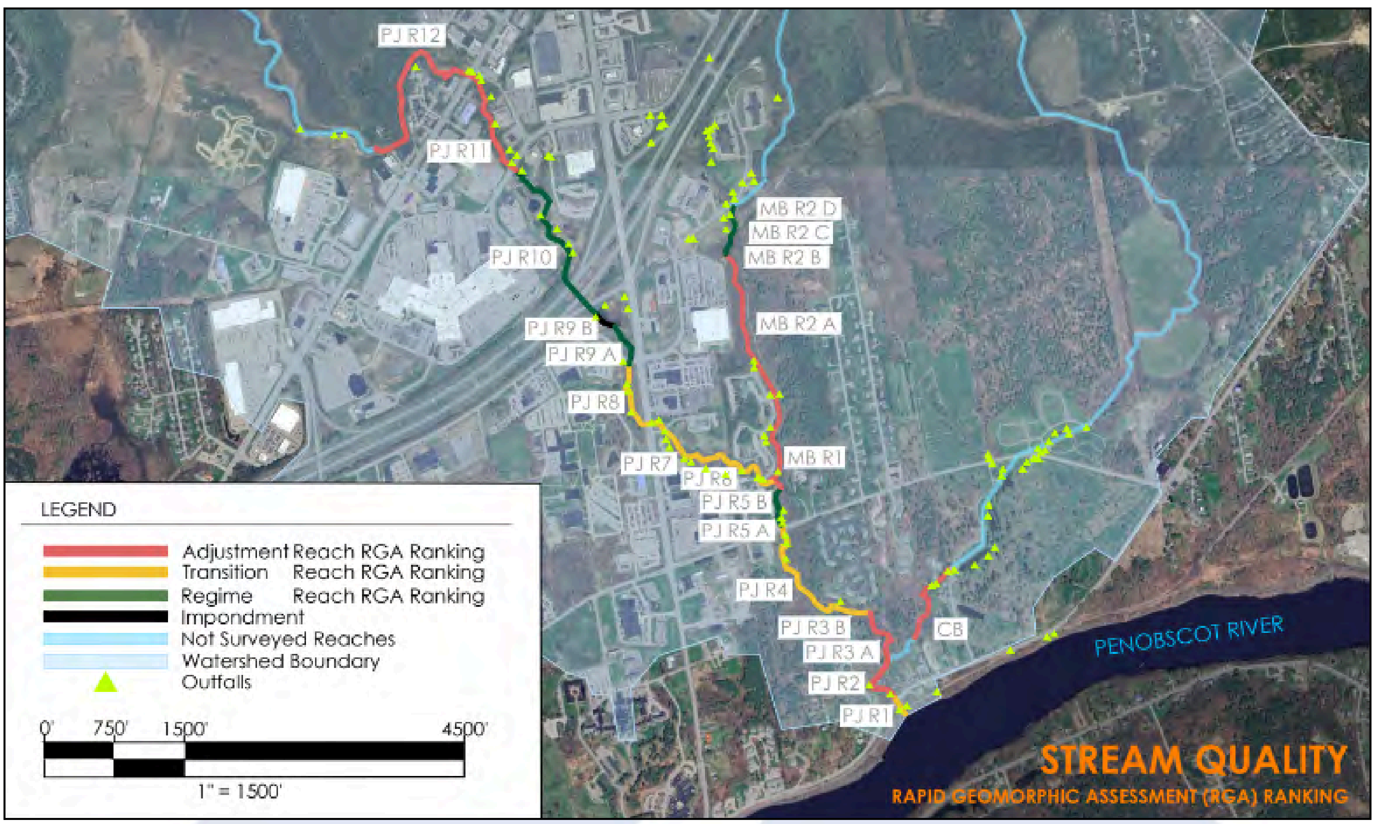

Figure 3: Rapid Geomorphic Assessment Ranking Map

6. Summary of Findings & Next Steps

Using the Maine DEP scoring criteria (Varricchione, 2009)(**Figure 2**) and best professional judgment, a score was assigned to compare the overall condition of each reach of Penjajawoc Stream and its tributaries based on the conditions described above from the RHA (Section 4) and RGA (Section 5) Sections. The overall condition score for each reach is an average of RHA and RGA scores seen in Table 2 and more details in Appendix B and C. The scoring allows for comparison between reaches to determine which reaches would be the best to target restoration efforts.

The overall condition varied throughout the Penjajawoc Stream and its tributaries. Sixteen reaches achieved scores indicative of being in Fair Condition, ranging from Good-Fair to Poor-Fair. Only two of the reaches, MB 2B and MB 2D, achieved scores indicating Good Condition, while reaches MB 2A, PJ 8, and PJ 11 achieved scores indicative of Poor Condition (**Figure 4** and **Table 2**). These ratings on both Good and Poor appear to closely correlate with adjacent land use practices and stormwater outfall locations. Reaches MB 2B and 2D are located in areas that appear to have had reduced impacts (relative to other reaches in the watershed) from development. Reach MB 2A (rated as Poor condition) is located downstream of a significant stormwater channel that appears to have a large effect on Meadow Brook as evidenced by the change from Good to Poor condition downstream of this conveyance. Further investigation of this area and inputs to the channel are certainly needed. These impacts from the drainage channel are not as evident after Meadow Brook's confluence with Penjajawoc Stream, due to the size of the stream in this area, which likely masks the indicators noted further upstream. Reach PJ 8 (rated as Poor condition) is located between Sylvan Road and Hogan Road, receives stormwater discharges from commercial and institutional sources, and is also located downstream of the I-95 corridor. PJ 11 (also rated as Poor condition) is located between Stillwater Avenue and Bangor Mall Blvd and also receives stormwater discharges from many commercially developed lots. A common characteristic for both of these reaches is the adjacency to major roadways and large areas of impervious parking lots and rooftops. In contrast, PJ 9A, located directly upstream of PJ 8 and rated as Fair condition, is a much shorter, wooded reach, with reduced exposure to stormwater discharges from the roadways and large impervious surfaces.

A surprising outcome of the SCS, was the identification of a larger macroinvertebrate community, both in Penjajawoc Stream and its tributaries than was originally anticipated. As described earlier in this report, many species, including caddisfly nymphs, damselfly nymphs, and right-handed snails were found in plentiful numbers in many stream reaches. Given this, a more thorough macroinvertebrate study of the stream and its tributaries may be warranted in the future.

Following a review of the compiled scores from the 2023 Stream Corridor Survey, we determined that the overall condition of the stream is fair (**Figure 4** and **Table 2**). Penjajawoc Stream is impaired due to the high amount of development and impervious cover within its watershed (MDEP, 2023). This impervious cover along with the 73 stormwater outfalls discharging into the Penjajawoc and its tributaries are major contributors to the "Fair" ranking.

Figure 4: Penjajawoc Stream and Tributaries Condition Ranking Map

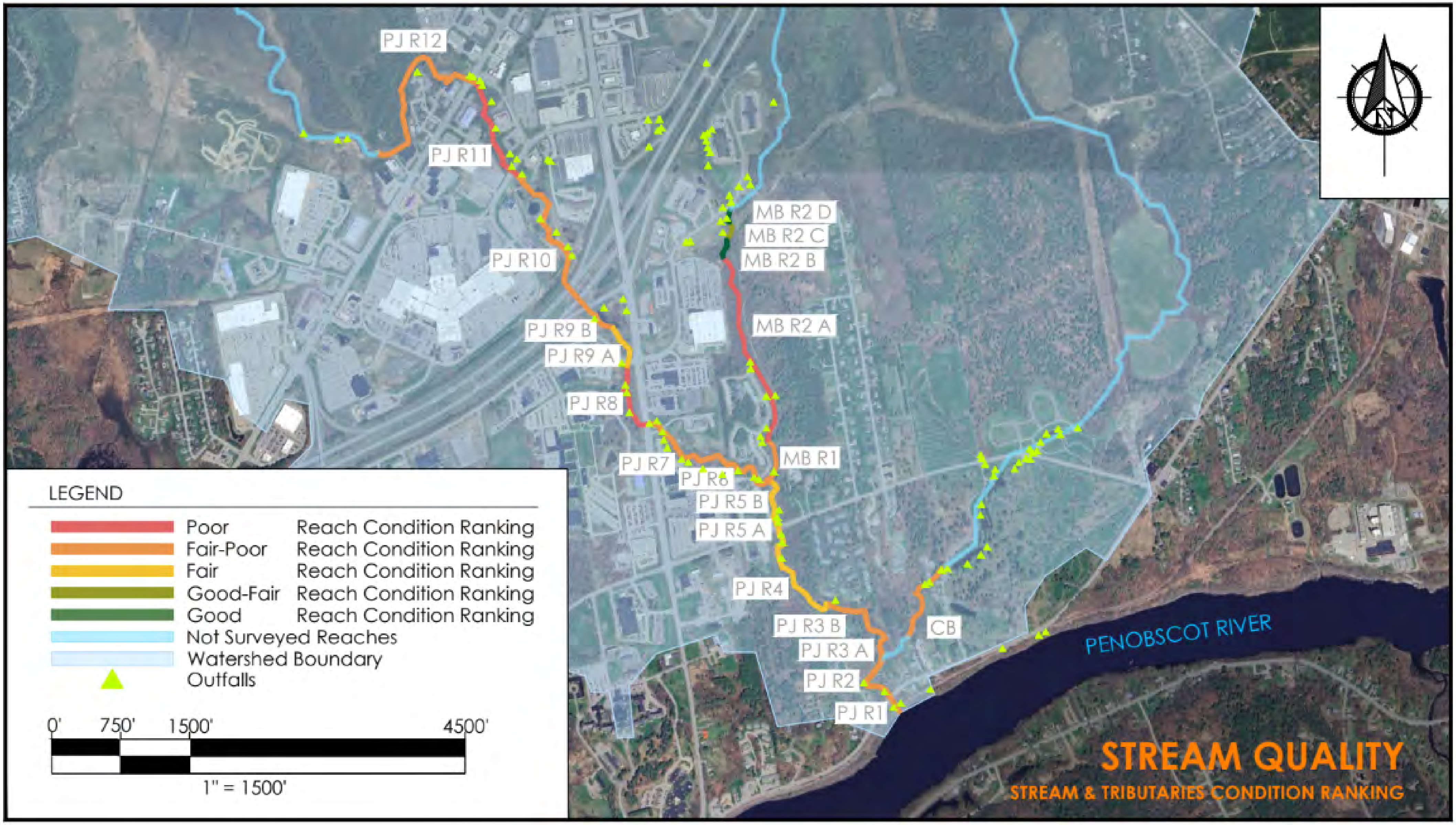

Table 2: Penjajawoc Stream and Tributaries Condition Ranking

Reach ID	Riparian/ Temp	Stream Bottom	Stream-bank/ Channel Structure	Water Quality	Potential Pollution Problem	RGA	Overall Condition	Condition Ranking
CB	3	3	2	3	4	4	3.17	Fair - Poor
PJ 1	3	3	3	4	4	3	3.33	Fair - Poor
PJ 2	3	3	3	3	4	4	3.33	Fair - Poor
PJ 3A	4	4	2	2	3	4	3.17	Fair - Poor
PJ 3B	4	4	2	3	3	3	3.17	Fair - Poor
PJ 4	3	3	2	3	4	3	3.00	Fair
PJ 5A	3	4	3	2	3	2	2.83	Fair
PJ 5B	3	3	3	2	2	5	3.00	Fair
PJ 6	3	3	3	3	4	3	3.17	Fair - Poor
PJ 7	3	3	3	3	5	3	3.33	Fair - Poor
PJ 8	3	3	3	4	5	3	3.50	Poor
PJ 9A	3	3	3	3	4	2	3.00	Fair
PJ 9B	4	N/A	N/A	3	3	N/A	3.33	Fair - Poor
PJ 10	4	4	3	3	5	1	3.33	Fair - Poor
PJ 11	3	3	3	3	5	4	3.50	Poor
PJ 12	4	4	2	2	4	4	3.33	Fair - Poor
MB 1	3	3	3	4	3	4	3.33	Fair - Poor
MB 2A	3	4	4	4	4	5	4.00	Poor
MB 2B	1	3	2	3	2	1	2.00	Good
MB 2C	3	3	3	3	3	1	2.67	Good - Fair
MB 2D	1	3	2	3	2	1	2.00	Good

A major factor influencing water quality in Penjajawoc Stream is chloride usage from the use of road salt in the watershed. Every reach sampled had SpCond above 300 μS/cm and three reaches were above the chronic SpCond level of 854 μS/cm. Given that SpCond can be used as a proxy measurement for chloride, the elevated SpCond levels measured during the SCS as well as during the City's continuous monitoring efforts from 2016-2023 indicate that chloride is a consistent and persistent stressor, likely contributing to the Penjajawoc's aquatic life impairment (MDEP, 2020).

The City is currently in the process of developing an updated Watershed-Based Management Plan (WBMP) for the Penjajawoc Stream. This plan will provide recommendations for addressing the water quality issues documented during this survey. The next steps for updating the WBMP include a watershed chloride assessment, an updated impervious cover GIS layer, a stressor analysis, and an assessment of the Stormwater Best Management Practices currently in use in the watershed. These assessments along with the SCS and a public process with local experts and stakeholders will allow the City to develop strategies for improving water quality and habitat in the stream over the next decade.

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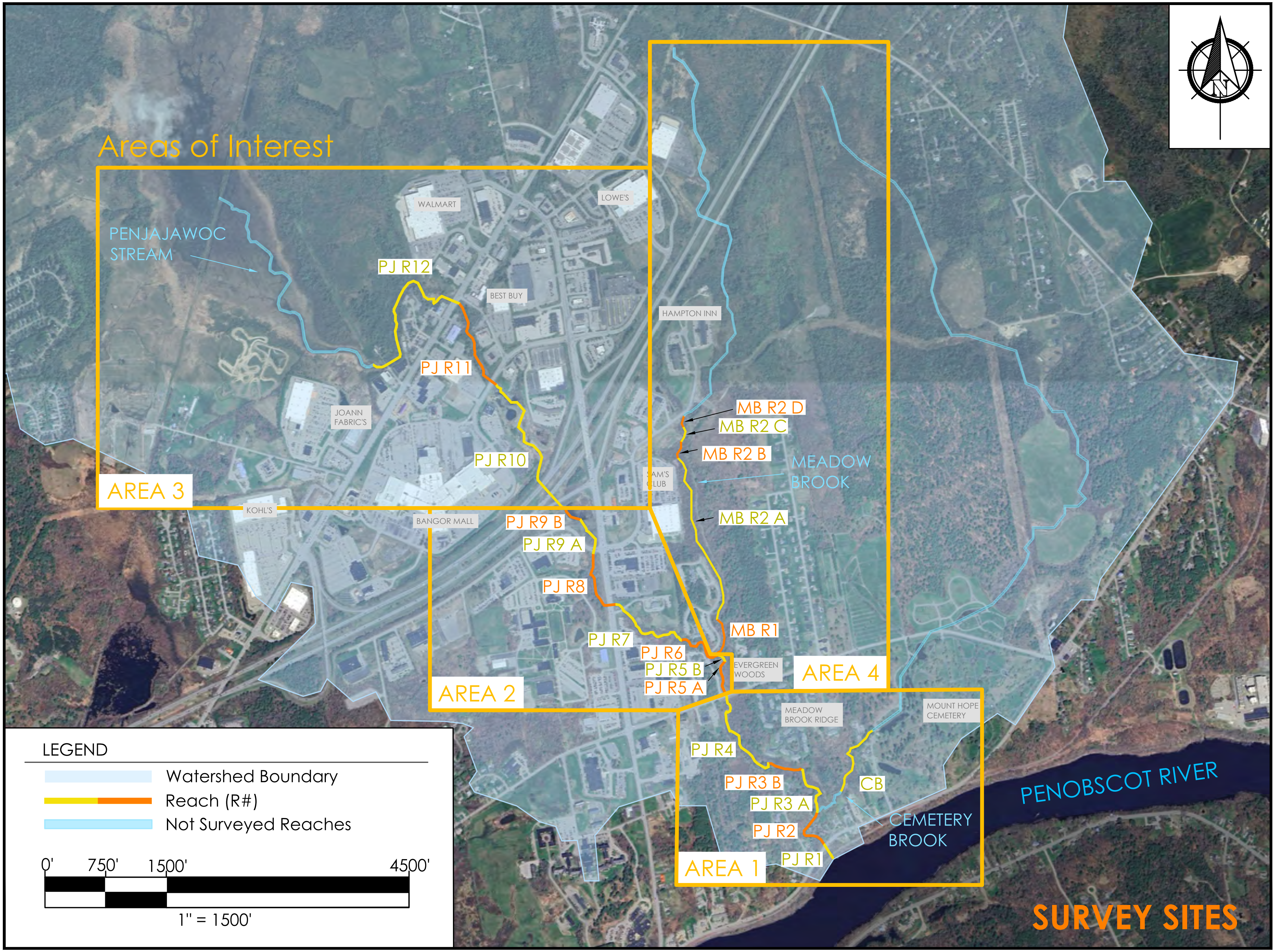
Appendices

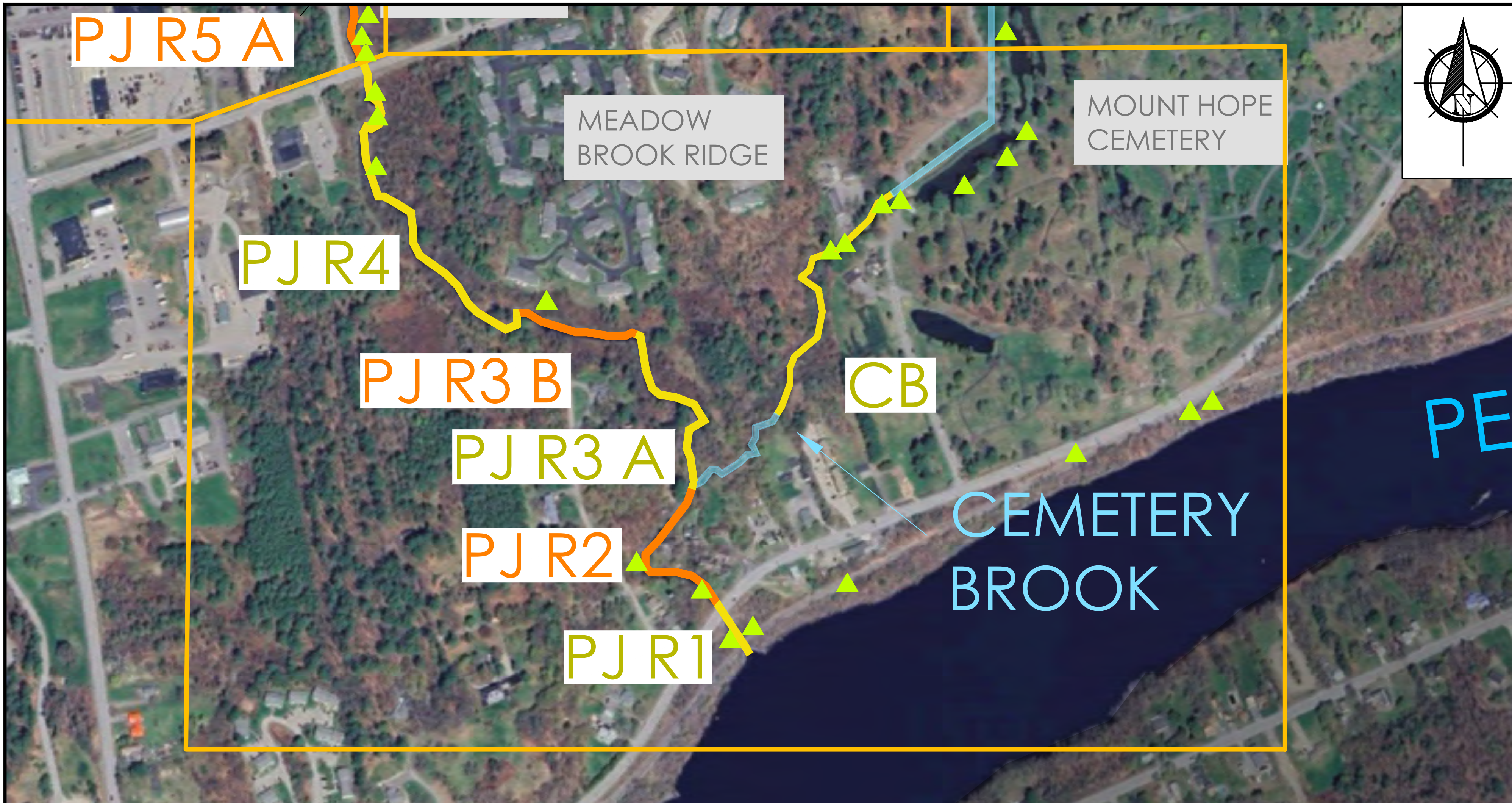
APPENDIX A: SURVEY MAP

APPENDIX A1: Map of Penjajawoc Stream and Tributary Survey Areas



Areas of Interest
PENJAJAWOC STREAM
WALMART
LOWE'S
BEST BUY
HAMPTON INN
JOANN FABRIC'S
SAM'S CLUB
KOHL'S
BANGOR MALL
EVERGREEN WOODS
MEADOW BROOK RIDGE
MOUNT HOPE CEMETERY
AREA 1
AREA 2
AREA 3
AREA 4
PJ R12
PJ R11
PJ R10
PJ R9 B
PJ R9 A
PJ R8
PJ R7
PJ R6
PJ R5 B
PJ R5 A
PJ R4
PJ R3 B
PJ R3 A
PJ R2
PJ R1
MB R2 D
MB R2 C
MB R2 B
MB R2 A
MB R1
MEADOW BROOK
CB
CEMETERY BROOK
PENOBSCOT RIVER
LEGEND
Watershed Boundary
Reach (R#)
Not Surveyed Reaches
0'
750'
1500'
4500'
1" = 1500'
SURVEY SITES

APPENDIX A2: Map of Survey Area 1 of the Penjajawoc Stream and Tributaries



LEGEND

- Reach (R#)
- Not Surveyed Reaches
- Outfalls

0' 250' 500' 1500'

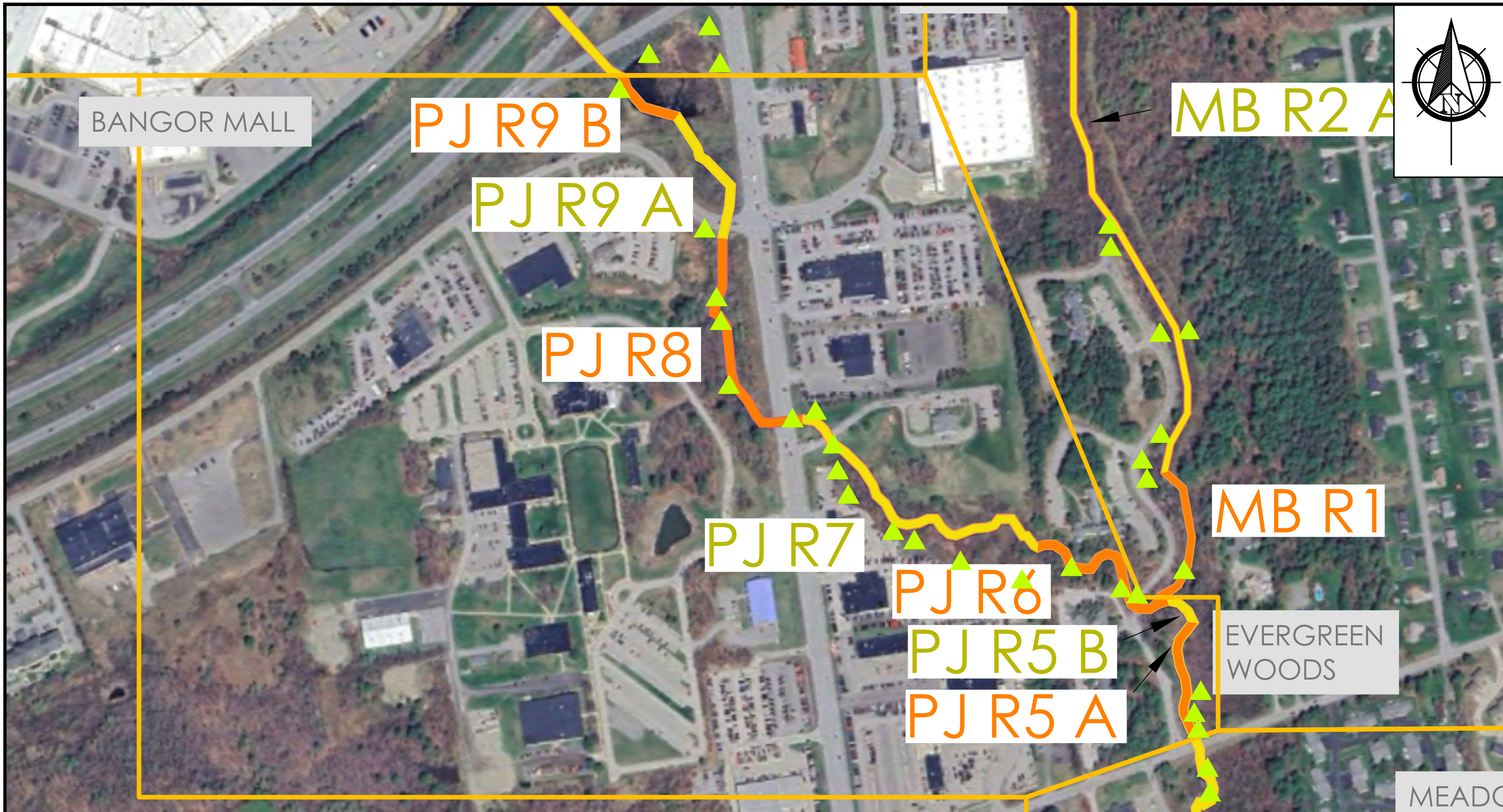
1" = 500'

REACH DESCRIPTION

AREA 1

Reach	Description (Downstream to Upstream)	Sig. Crossing
PJ R1	Penobscot River to Above US Rt. 2	Railroad; US Rt. 2
PJ R2	Above US Rt. 2 to Confluence of Cemetery Brook	N/A
PJ R3	Confluence of Cemetery Brook to SW Corner of Meadowbrook Ridge (Development)	N/A
PJ R4	SW Corner of Meadowbrook Ridge to Above Mt. Hope Ave.	Mt. Hope Ave.
CB R2	Wetland area to Cemetery access road	N/A

APPENDIX A3: Map of Survey Area 2 of the Penjajawoc Stream and Tributaries



AREA 2

LEGEND

Reach (R#)

Outfalls

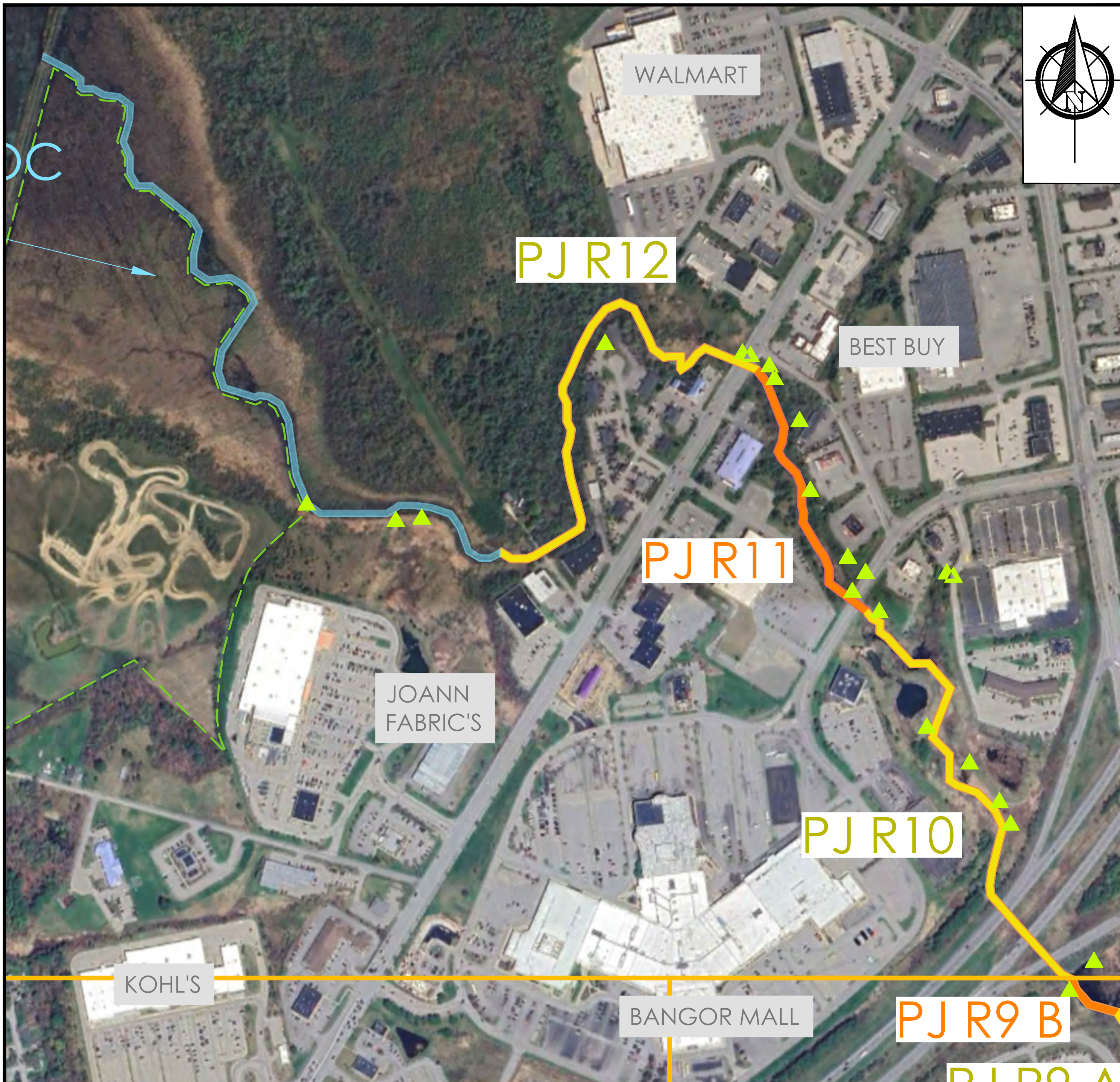
0' 250' 500' 1500'

1" = 500'

REACH DESCRIPTION

Reach	Description (Downstream to Upstream)	Sig. Crossing
PJ R5	Above Mt. Hope Ave. to Confluence of Meadow Brook	N/A
PJ R6	Confluence of Meadow Brook to Edge of Evergreen Woods (opens up to less forested)	Evergreen Woods access road
PJ R7	Edge of Evergreen Woods to below Hogan Road	BFCU access road
PJ R8	Below Hogan Road to below Sylvan Road	Hogan Rd.
PJ R9	Below Sylvan Road to below I-95 Interchange	Sylvan Rd.

APPENDIX A4: Map of Survey Area 3 of the Penjajawoc Stream



LEGEND

- Reach (R#)
- Not Surveyed Reaches
- Outfalls
- Don't Access Parcel

0' 300' 600' 1800'

1" = 600'

AREA 3

REACH DESCRIPTION

Reach	Description (Downstream to Upstream)	Sig. Crossing
PJ R10	Below I-95 Interchange to below Bangor Mall Blvd.	I-95 (NB and SB lanes, NB off ramp)
PJ R11	Below Bangor Mall Blvd. to below Stillwater Ave.	Bangor Mall Blvd.
PJ R12	Below Stillwater Ave. to Confluence of small tributary from ditch system (behind Joann Fabric)	Stillwater Ave., Access Rd to 748 Stillwater Ave.
PJ R13	Small tributary from ditch system into Penjajwoc Marsh (to old Railroad Bed?)	N/A

APPENDIX A5: Map of Survey Area 4 of the Penjajawoc Stream and Tributaries

LEGEND

Reach (R#)
Not Surveyed Reaches
Outfalls

0' 300' 600' 1800'

1" = 600'

REACH DESCRIPTION

AREA 4

Reach	Description (Downstream to Upstream)	Sig. Crossing
MB R1	Confluence with Penjajawoc to bend east of Evergreen Woods	N/A
MB R2	Bend east of Evergreen Woods to Haskell Road	N/A

APPENDIX B: RHA Tables

APPENDIX B1: Riparian Vegetation and In-Stream Temperature Conditions

Area	Reach ID	Riparian Vegetation and In-Stream Temperature Conditions	Prelim. Score
1	CB	50% stream shade by vegetation; plenty of vegetative cover and shade; and riparian zone altered by lawn, structures, and pavement. Water temperature: 16.3 C.	3
1	PJ 1	25% stream shaded by vegetation; natural streamside cover degraded; foam or sheen on bank; and riparian zone altered by structures and pavement. Water temperature: 13.6 C.	3
1	PJ 2	25% stream shaded by vegetation; natural streamside plant cover degraded; foam or sheen on the bank; garbage and trash adjacent to the stream; and riparian zone altered by lawn, structures, and pavement. Water temperature: 14.6 C.	3
1	PJ 3A	25% stream shaded by vegetation; natural streamside plant cover degraded; foam or sheen on bank; garbage/trash in the stream; and mud/silt/sand entering the stream. Water temperature: 15.8 C.	4
1	PJ 3B	0% stream shaded by vegetation; bare soil; turbulence or foam; garbage/trash adjacent to the stream; natural streamside plant cover is degraded; mud/silt/sand entering the stream. Water temperature: 15.5 C.	4
1	PJ 4	25% stream shaded by vegetation; banks collapsed/eroded. Water temperature: 12.9 C.	3
2	PJ 5A	25% stream shaded by vegetation; riparian zone altered by lawn, structures, and pavement; garbage adjacent to the stream; 13.4 C.	3
2	PJ 5B	50% stream shaded by vegetation; garbage/trash adjacent and in the stream. Water temperature: 14.2 C.	3
2	PJ 6	75% stream shaded by vegetation; garbage and trash adjacent to the stream; and riparian zone altered by lawn, pavement, structures, and bare soils. Water temperature: 14.6 C.	3
2	PJ 7	25% stream shaded by vegetation; old culvert and garbage and trash adjacent and in the stream. Water temperature: 14.7 C.	3
2	PJ 8	75% stream shaded by vegetation; banks collapsed/eroded, geotextile fabric adjacent and ditches entering the stream; and bare soils in the riparian zone. Water temperature: 14.7 C.	3
2	PJ 9A	25% stream shaded by vegetation; old culvert and garbage/trash adjacent to the stream; and riparian zone altered by structures and pavement. Water temperature: 15 C.	3
2	PJ 9B	0% stream shaded by vegetation; garbage/trash adjacent to the stream. Water temperature: 16.7 C.	4

APPENDIX B1: Riparian Vegetation and In-Stream Temperature Conditions

Area	Reach ID	Riparian Vegetation and In-Stream Temperature Conditions	Prelim. Score
3	PJ 10	0% stream shaded by vegetation; garbage/trash adjacent to the stream; and mud/silt/sand entering the stream. Water temperature: 15.2 C.	4
3	PJ 11	50% stream shaded by vegetation; garbage/trash adjacent and in the stream; and riparian zone altered by sand, structures, and pavement. Water temperature: 15.7 C.	3
3	PJ 12	25% stream shaded by vegetation; banks collapsed/eroded; and riparian zone altered by lawn, pavement, and structures. Water temperature: 16.1 C.	4
4	MB 1	75% stream shaded by vegetation; banks collapsed/eroded; garbage/trash adjacent to the stream; and riparian zone altered by lawn, structures, and pavement. Water temperature: 12 C.	3
4	MB 2A	100% stream shaded by vegetation; natural streamside plant cover degraded; banks collapsed/eroded; geotextile adjacent to the stream; and riparian zone altered by lawn. Water temperature: 13 C.	3
4	MB 2B	100% stream shaded by vegetation.	1
4	MB 2C	25% stream shaded by vegetation; and meadow and powerline corridor.	3
4	MB 2D	100% stream shaded by vegetation.	1

APPENDIX B2: Stream Bottom, Streambank and Channel Characteristics

Reach ID	Stream Bottom Conditions	Bank and Channel Characteristics (Stream Structure)	Preliminary Score	
			Stream Bottom	Stream Structure
CB	Minor Substrate: Equally Mixed Substrates Embeddedness: Half 50% Large Woody Debris: Few	1 pool > 2 ft deep; cascades, pools, riffles, and runs; 100ft between pools; steeply sloping bank; 0-25% artificial bank alteration; and a wide and shallow channel shape.	3	2
PJ 1	Minor Substrate: Rubble Embeddedness: Somewhat (5-25%) Large Woody Debris: Few	Cascades, pools, riffles, and runs; 10 ft between pools; steeply sloping bank; 75% artificial bank alteration; wide and shallow channel; and the widest reach channel, 19 ft.	3	3
PJ 2	Minor Substrates: Cobble, Rubble, and Boulder Embeddedness: Somewhat (5-25%) Large Woody Debris: Few	Pools, riffles, and runs; 10ft between pools; gradual/ no slope bank; 0-25% artificial bank alteration; and a narrow and shallow channel.	3	3
PJ 3A	Minor Substrates: Sand; Cobble; Rubble Embeddedness: Mostly (75%) Large Woody Debris: Few	1 pool >2 ft deep; cascade, pool, riffle, and run; 15 ft between pools; steeply sloping bank; 0-25% artificial bank alteration; wide and shallow channel; and the second widest reach channel, 17ft.	4	2
PJ 3B	Minor Substrate: Silt/Clay/Mud Embeddedness: Mostly (75%) Large Woody Debris: Few	3 pools >2 ft deep; dominant run, pools, riffles, and runs; 30 ft between pools; gradual bank slope; 0-25% artificial bank alteration; and a wide and shallow channel.	4	2
PJ 4	Minor Substrate: Coarse Gravel Embeddedness: Somewhat (5-25%) Large Woody Debris: Few	2 pools >2 ft deep; cascades, pools, riffles, and runs; 100ft between pools; vertical/undercut banks; 0-25% artificial alterations; and a wide and shallow channel.	3	2
PJ 5A	Minor Substrates: Silt/Clay/Mud; Sand; Fine, Medium, and Coarse Gravel Embeddedness: Half 50% Large woody Debris: None	1 pool > 2 ft deep; pools, riffles, and runs; vertical/undercut banks; 0-25% artificial bank alterations; and a wide and shallow channel.	4	3

APPENDIX B2: Stream Bottom, Streambank and Channel Characteristics

Reach ID	Stream Bottom Conditions	Bank and Channel Characteristics (Stream Structure)	Preliminary Score	
			Stream Bottom	Stream Structure
PJ 5B	Minor Substrate: Equally Mixed Substrates Embeddedness: Half (50%) Large Woody Debris: Plentiful	Pools, riffles, and runs; 80 ft between pools; vertical/undercut banks; 0-25% artificial bank alterations; and a wide and shallow channel.	3	3
PJ 6	Minor Substrate: Equally Mixed Substrates Embeddedness: Half (50%) Large Woody Debris: Many	Pools, riffles, and runs; 100 ft between pools; steeply sloping bank; 0-25% artificial bank alteration; and a wide and shallow channel.	3	3
PJ 7	Minor Substrate: Equally Mixed Substrates Embeddedness: Half (50%) Large Woody Debris: None	Pools, riffles, and runs; 150 ft between pools; vertical/undercut banks; 0-25% artificial alteration; and wide and shallow channel.	3	3
PJ 8	Minor Substrate: Equally Mixed Substrates Embeddedness: Half (50%) Large Woody Debris: Few	Pools, riffles, and runs; 300 ft between pools; steeply sloping banks; 0-25% artificial bank alterations; and a wide and shallow channel.	3	3
PJ 9A	Minor Substrate: Coarse Gravel (Riprap channel) Embeddedness: Somewhat (5-25%) Large Woody Debris: Many	Pools, riffles, and runs; 100 ft between pools; vertical/undercut bank; 0-25% artificial bank alteration; and a wide and shallow channel.	3	3
PJ 9B	Beaver Impoundment Embeddedness: N/A Large Woody Debris: Few	Beaver impoundment, wide and deep.		
PJ 10	Minor Substrate: Silt/Clay/Mud Embeddedness: Completely (100%) Large Woody Debris: Few	Runs, pools; sections of constructed riffle; gradual/no slope bank; 0-25% artificial bank alterations; narrow and deep channel; and rapid channel due to dam.	4	3
PJ 11	Minor Substrate: Coarse Gravel Embeddedness: Somewhat (5-25%) Large Woody Debris: Many	Two pools > 2 ft deep; pools, riffles, runs; 50 ft between pools; steeply sloping bank; 0-25% artificial bank alterations; and a narrow and shallow channel.	3	3

APPENDIX B2: Stream Bottom, Streambank and Channel Characteristics

Reach ID	Stream Bottom Conditions	Bank and Channel Characteristics (Stream Structure)	Preliminary Score	
			Stream Bottom	Stream Structure
PJ 12	Minor Substrates: Silt/Clay/Mud; Sand; Fine, Medium, and Coarse Gravel; Cobble Embeddedness: Mostly (75%) Large Woody Debris: Few	Four pools > 2 ft deep; pools, riffle, runs; 100 ft between pools; steeply sloping bank; 0-25% artificial bank alterations; and a narrow and shallow channel.	4	2
MB 1	Minor Substrate: Equally Mixed Substrates Embeddedness: Half (50%) Large Woody Debris: Plentiful	Pools, riffles, runs; 75 ft between pools; vertical/undercut bank; 0-25% artificial bank alterations; and a narrow and shallow channel.	3	3
MB 2A	Dominant Substrate: Silt/Clay/Mud Embeddedness: Completely (100%) Large Woody Debris: Plentiful	Deadwater due to a stormwater pond; vertical/undercut banks; 0-25% artificial bank alteration; and a wide and shallow channel.	4	4
MB 2B	Minor Substrate: Cobble Embeddedness: Not embedded (0%) Large Woody Debris: Few	Pool, riffle, run; 50 ft between pools; gradual bank; 0-25% artificial bank alteration; and a wide and shallow channel.	3	2
MB 2C	Minor Substrate: Coarse Gravel Embeddedness: Somewhat (5-25%) Large Woody Debris: Few	Pool, riffle, run, deadwater; 50 ft between pools; gradual bank; 0-25% artificial bank alteration; and a narrow and shallow channel.	3	3
MB 2D	Minor Substrate: Cobble Embeddedness: Not embedded (0%) Large Woody Debris: Few	Pool, riffle, run; 50 ft between pools; gradual bank; 0-25% artificial alteration; and a wide and shallow channel.	3	2

APPENDIX B3: Water Quality Issues

Area	Reach ID	Water Quality Observations	Water Quality Prelim. Score
1	CB	Light brown color with a slight rotten egg odor; plentiful algae; mammals and reptiles; abundant small and medium fish; and caddisfly larvae and fly cases. Water is below the chronic level for SpCond.	3
1	PJ 1	Clear and foamy water appearance with no water odor; plentiful heavy coating and filamentous brownish-greenish algae; and water pennies. Water is below the chronic level for SpCond.	4
1	PJ 2	Clear and light brown foamy water appearance with no water odor; mud/silt/sand entering the stream; amphibians and mammals; plentiful heavy coating and filamentous brownish-greenish algae; and water penny, dragonfly, caddisfly present. Water is below the chronic level for SpCond.	3
1	PJ 3A	Clear and light brown foamy water appearance with no water odor; amphibians and mammals; medium-sized fish; occasional mats, plentiful filamentous and heavy coating of brownish-greenish algae; and plentiful insects, specifically caddisfly. Water is below the chronic level for SpCond.	2
1	PJ 3B	Clear, dark brown foamy water appearance with no water odor; mammals; small-sized fish; heavy coating of brownish algae; and plentiful insects, specifically caddisfly. Water is below the chronic level for SpCond.	3
1	PJ 4	Clear and light brown foamy water appearance, with no water odor; mammals; few small fish; beaver dams; light coating of brownish algae; and plentiful right snails, water strider, caddisfly nymphs, dragonfly nymphs. Water is above the chronic level for SpCond.	3
2	PJ 5A	Dark brown water appearance, with no water odor; mammals and songbirds; abundant large, medium, and small fish; light coating of brownish-greenish algae; and macroinvertebrates include gravel caddisfly case, right-handed snails, water penny, dragonfly nymph, snail case, caddis fly. Water is below the chronic level for SpCond.	2
2	PJ 5B	Dark brown water appearance, with no water odor; waterfowl; abundant large, medium, and small fish; light coating of brownish-greenish algae; and macroinvertebrates include right-handed snails, gravel caddisfly case, water penny, dragonfly nymph, snail case, caddisfly. Water is below the chronic level for SpCond.	2
2	PJ 6	Dark brown - foamy water appearance with no water odor; mammals; rare amount of small fish; occasional coating of brownish algae; and occasional insects and plentiful snails including right opening snails, dead dragonfly, water strider nymphs, caddisfly larvae. Water is below the chronic level for SpCond.	3
2	PJ 7	Dark brown water appearance, with no water odor; amphibians and mammals; heavy coating of brownish-greenish algae; rare amounts of small fish; and plentiful snails and insects like water striders, water penny, right-handed snails, caddis fly larvae. Water is below the chronic level for SpCond.	3

APPENDIX B3: Water Quality Issues

Area	Reach ID	Water Quality Observations	Water Quality Prelim. Score
2	PJ 8	Dark brown-orange water appearance with a slight sewage odor; amphibians; occasional brownish algae coating; and occasional insects like dead water pennies, caddisfly, and water strider larvae. Water is below the chronic level for SpCond.	4
2	PJ 9A	Dark brown water appearance with no water odor; mammals; occasional brownish-light coating of algae; and occasional insects like; water penny and caddisflies. Water is below the chronic level for SpCond.	3
2	PJ 9B	Dark brown water appearance with no water odor; mammals and waterfowl; plentiful heavy coating of brownish algae; and macroinvertebrates include water striders. Water is below the chronic level for SpCond.	3
3	PJ 10	Clear-dark brown water appearance with no water odor; waterfowl; plentiful heavy coating of brownish-greenish and some bright green algae; and macroinvertebrates include occasional caddisflies, riffle beetle, damselfly nymph. Water is below the chronic level for SpCond.	3
3	PJ 11	Clear-dark brown water appearance with no water odor; old beaver activity; plentiful light coating of algae; and macroinvertebrates include occasional damsel nymph and water penny. Water is below the chronic level for SpCond.	3
3	PJ 12	Clear-dark brown water appearance with no water odor; amphibians and waterfowl; occasional light coating of brownish algae, occasional greenish filamentous algae; and occasional insects and crayfish including water strider caddisfly cases, water penny larvae, dragonfly nymph. Water is below, but close to the chronic level for SpCond.	2
4	MB 1	Light brown water appearance with no water odor; mammals; abundant medium fish; plentiful heavy coating of greenish algae; and plentiful snails and insects including snails, prevalent caddisfly cases. Water is above the chronic level for SpCond.	4
4	MB 2A	Clear water appearance with no water odor; medium-sized fish; and plentiful coating of light greenish algae. Water is above the chronic level for SpCond.	4
4	MB 2B	Clear water appearance with no water odor; medium-sized fish; and plentiful coating of light greenish algae.	3
4	MB 2C	Clear water appearance with no water odor; medium-sized fish; and plentiful coating of light greenish algae.	3
4	MB 2D	Clear water appearance with no water odor; medium-sized fish; and plentiful coating of light greenish algae.	3

APPENDIX B4: Potential Pollution Sources

Area	Reach ID	Potentially Significant Sources of Pollution	Potential Pollution Prelim. Score
1	CB	Four outfalls; garbage and trash adjacent to the stream; unknown pipe adjacent from cemetery building; and lawn, structures and pavement close to stream.	4
1	PJ 1	Two outfalls; culvert barriers; structures and pavement close to stream; and significant crossings: railroad and US Rt.2.	4
1	PJ 2	Two outfalls; garbage/trash in the stream; mud/silt/sand entering the stream; unknown pipe on residential land; lawn, structures, and pavement close to stream; and minor crossing: wide walking bridge.	4
1	PJ 3A	No outfalls; garbage/trash in the stream, mud/silt/sand entering the stream.	3
1	PJ 3B	One outfall; garbage/trash in the stream; mud/silt/sand entering the stream.	3
1	PJ 4	Three outfalls, one with high conductivity; significant crossing: Mt. Hope Ave.	4
2	PJ 5A	Two outfalls; and lawn, structures, and pavement close to the stream.	3
2	PJ 5B	No outfalls; garbage/trash in the stream.	2
2	PJ 6	Three outfalls; lawn, pavement, and structures close to stream; and significant crossing: Evergreen Woods access road.	4
2	PJ 7	Seven outfalls; garbage/trash in the stream; significant crossing: 339 Hogan Rd.(Bangor Federal Credit Union).	5
2	PJ 8	Four outfalls; significant crossing: Hogan Rd.	5
2	PJ 9A	One outfall; structures and pavement close to the stream; and significant crossing: Sylvan Rd.	4
2	PJ 9B	One outfall.	3
3	PJ 10	Five outfalls; mud/silt/sand in or entering the stream; high conductivity reading from 56 Mall Blvd. (Wendy's) parking lot runoff; one detention pond; and significant crossing: I-95 (NB and SB lanes, NB off ramp).	5
3	PJ 11	Seven outfalls; garbage/trash in the stream; structures, and pavement close to the stream; significant crossing: Bangor Mall Blvd.	5
3	PJ 12	Six outfalls; lawn, pavement, structures close to the stream; and significant crossing: Stillwater Ave., Access Rd to 748 Stillwater Ave.	4
4	MB 1	One outfall; and lawn, structures, and pavement close to the stream.	3

APPENDIX B4: Potential Pollution Sources

Area	Reach ID	Potentially Significant Sources of Pollution	Potential Pollution Prelim. Score
4	MB 2A	Six outfalls; a carved channel from the NW changes the characteristics of the reach.	4
4	MB 2B	No outfalls.	2
4	MB 2C	One outfall; and a manmade meadow due to a powerline corridor.	3
4	MB 2D	Eight outfalls.	2

APPENDIX C: RGA Tables

APPENDIX C1: Geomorphic Position of Penjajawoc Stream & Tributaries

Area	Reach ID	Major Geomorphic Process	Stability Index	Geomorphic Position	Preliminary Score
1	CB	Aggradation	0.43	In Adjustment	4
1	PJ 1	Aggradation and Degradation	0.22	In Adjustment	3
1	PJ 2	Aggradation	0.43	In Adjustment	4
1	PJ 3A	Aggradation	0.48	In Adjustment	5
1	PJ 3B	Aggradation	0.21	In Transition or Stressed	3
1	PJ 4	Widening	0.37	In Transition or Stressed	4
2	PJ 5A	Widening	0.19	In Regime	3
2	PJ 5B	Widening	0.42	In Adjustment	4
2	PJ 6	Widening	0.37	In Transition or Stressed	4
2	PJ 7	Degradation	0.31	In Transition or Stressed	4
2	PJ 8	Widening	0.26	In Transition or Stressed	3
2	PJ 9A	Widening	0.17	In Regime	3
2	PJ 9B	(Impoundment due to beaver dam)	N/A	N/A	N/A
3	PJ 10	Aggradation	0.21	In Adjustment	3
3	PJ 11	Aggradation and Planimetric Form	0.41	In Adjustment	4
3	PJ 12	Aggradation	0.46	In Adjustment	5
4	MB 1	Widening	0.45	In Adjustment	5
4	MB 2A	Aggradation and Widening	0.7	In Adjustment	5
4	MB 2B	Degradation	0.04	In Regime	2
4	MB 2C	Aggradation	0.1	In Regime	2
4	MB 2D	Degradation	0.04	In Regime	2

APPENDIX D: REFERENCE MAPS

APPENDIX D: Impervious Cover in thePenjajawoc Stream Watershed (Source: MDEP, 2023)