INVESTIGATING THE EXTENT OF EURASIAN WATERMILFOIL PRESENCE IN THE TURTLE FLAMBEAU FLOWAGE

Wisconsin Department of Natural Resources Surface Water Grants Program

Aquatic Invasive Species-Early Detection and Response

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1. EXECUTIVE SUMMARY

Eurasian watermilfoil (EWM; *Myriophyllum spicatum*) was first verified in the Turtle Flambeau Flowage (TFF) in the summer of 2023. During summer 2024, staff from the Mary Griggs Burke Center for Freshwater Innovation (Burke Center) at Northland College and the North Lakeland Discovery Center conducted point intercept aquatic plant surveys to document the extent of EWM presence within portions of the flowage and to provide updated data on the flowage's overall aquatic plant community. Additionally, the Burke Center monitored flowage water levels at four locations to assess how water level fluctuations vary across the flowage in relation to fluctuations measured at the Turtle Dam.

EWM was not detected beyond the designated Quiet Area of the flowage, where it was found in 2023. However, the invasive plant was found at several locations within this area that were not identified as having EWM in 2023. Therefore, our work suggests it may be spreading within the Quiet Area or it is more widespread in the TFF than initially thought. EWM did not occur frequently when compared to other species surveyed, though it was present at higher densities within smaller areas where dense mats occurred. A survey of the entire flowage is needed to understand whether EWM has spread beyond the Quiet Area.

Overall, the aquatic plant community in the portions of the Turtle Flambeau Flowage that were surveyed was highly diverse and of high quality. The high quality of the plant community could be threatened by EWM, particularly if the invasive plant spreads throughout the flowage.

Water level monitoring results demonstrated that water level change was relatively consistent across the flowage when influenced by either natural or anthropogenic effects. Environmental drivers of water level change such as rain events and dry periods had a smaller influence over the monitoring period compared to water level changes due to management at the Turtle Dam. Annual water level fluctuations at the Turtle Dam are less than five feet and most of the EWM is in depths greater than six feet, so current water level management at the dam may not be sufficient if considered as an alternative for EWM management.

Management of EWM is complex. Information campaigns, such as signage at boat launches, can be used to inform visitors to the flowage. Ultimately, eradication of EWM is unlikely; therefore, controlling the spread of the current populations should be a key management goal.

2. INTRODUCTION

The Turtle Flambeau Flowage (TFF; WBIC 2294900) is located in Iron County, Wisconsin (Figure 2.1). It is Wisconsin's seventh largest waterbody with an area of 12,942 acres (WDNR, 2024b). Created in 1926 with the construction of the Turtle Dam, the TFF is generally shallow given that most of it is flooded forest and wetland. The maximum depth of the TFF is 50 feet (WDNR, 2024b). The TFF is a well-known recreation area with a diverse fishery, five boat landings, and 66 remote campsites. Most of the land surrounding the TFF is state-owned with little development. The TFF has two primary inflows; the Turtle River in the northeast and the Flambeau River in the east (Figure 2.1). Discharge from the TFF is controlled by the Turtle Dam, located at the Flambeau River outlet along the western shoreline (Figure 2.1). The TFF ranks at the top 10% of the Wisconsin Department of Natural Resources (WDNR) aquatic invasive species (AIS) priority waterbodies (WDNR, 2024a).

The WDNR and the Iron County Land and Water Conservation department (ICLWCD) completed a point-intercept aquatic plant survey of the entirety of the TFF in 2019 (Zach Wilson, personal communication). The invasive aquatic plant species, Eurasian watermilfoil (EWM; *Myriophyllum spicatum*), was not detected during this survey. However, in late summer 2023, ICLWCD staff observed EWM in the flowage for the first time.

EWM is an invasive species native to Europe, Asia, and northern Africa (Eiswerth et al., 2020). EWM reproduces through both sexual and asexual (vegetative) reproduction (Smith & Barko, 1990). Vegetative reproduction occurs via autofragmentation, whereby EWM leaflets detach from the parent plant after flowering (Gustafson & Adams, 1973). These fragments can subsequently distribute throughout a waterbody and establish in additional areas. Fragmentation can also occur via mechanical disruption, such as from boat propellers and general recreational activity. The nature of EWM propagation by both kinds of fragmentation leads to challenges in managing its spread both within and between waterbodies. EWM can grow in dense mats at the water surface, which can impact recreational activities and block sunlight from reaching native vegetation, often leading to a monoculture of EWM.

The 2023 EWM detection in the TFF was near Bonies Mound, which is located near the inflow of the Flambeau River, in the voluntary "Quiet Area" of the TFF, where boats are recommended to travel at slow, no-wake speeds (Figure 2.1). The likelihood that EWM will spread to other areas of the TFF is high given the "downstream" nature of water movement in the flowage from east to west. Frequent boat traffic and shallow depths with high proportions of littoral zone also increase this likelihood.

The Mary Griggs Burke Center for Freshwater Innovation (Burke Center) was awarded an Early Detection and Response grant (grant AIRR30025) from the WDNR Surface Water Grant Program to conduct a detailed aquatic plant survey of portions of the TFF in 2024. The primary objectives of the research were to assess (1) the extent of EWM presence, (2) physical characteristics of locations with EWM (e.g., depth, substrate type), and (3) native plant diversity and abundance in various locations of the flowage.

In addition to surveying aquatic plant communities in 2024, the Burke Center monitored water levels at four locations across the TFF from May to October with funding support from the Natural Resources Foundation of Wisconsin. Understanding how water level fluctuates across the flowage during the open water period could inform discussions on the use of water level manipulation as a form of EWM management. The primary objectives of this water level work were to 1) characterize fluctuations at four locations across the TFF and 2) assess natural and anthropogenic effects on water level.

The following report summarizes results from the 2024 aquatic plant survey and water level monitoring work.

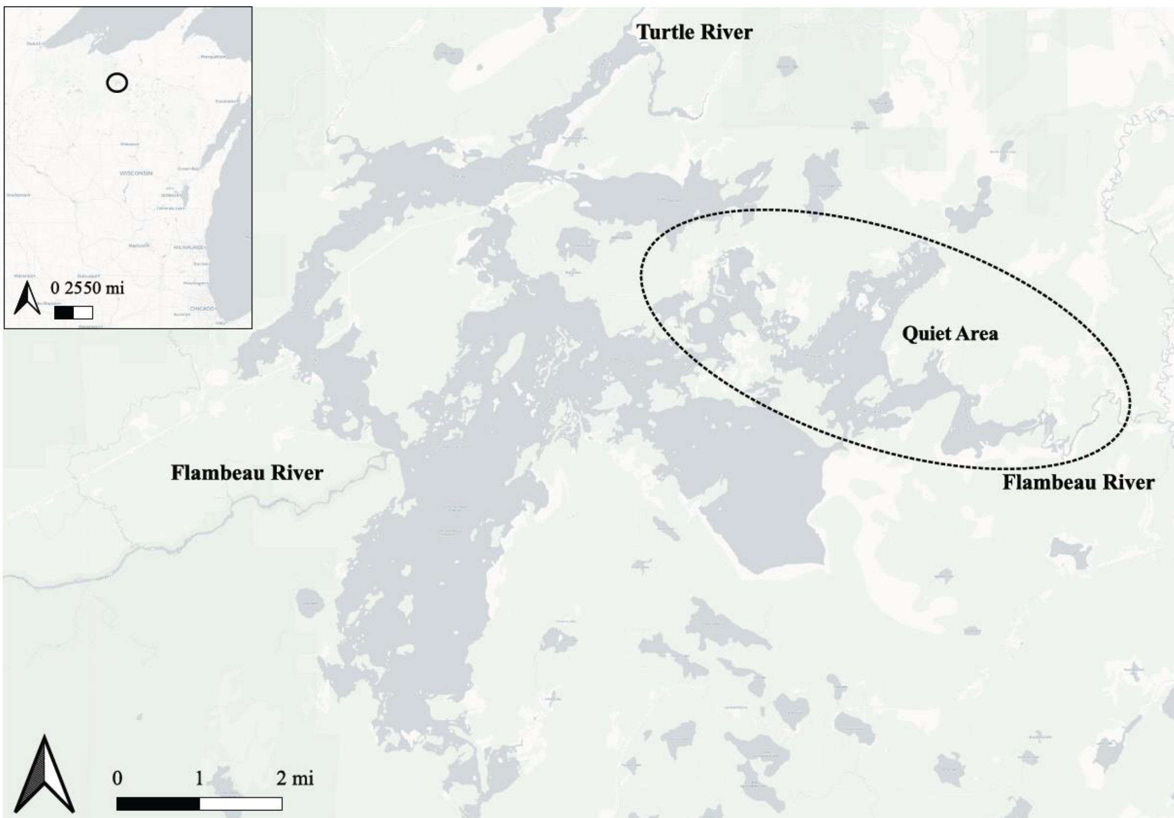

Figure 2.1. The Turtle Flambeau Flowage and designated Quiet Area (CartoDB., n. d).

3. METHODS

POINT INTERCEPT SURVEY METHODS

The WDNR point intercept (PI) aquatic plant survey method (Hauxwell et al., 2010) was used to conduct one coarse-scale and eight fine-scale surveys on portions of the TFF during summer and early fall 2024. Sampling was conducted by staff from the Burke Center and the North Lakeland Discovery Center.

The coarse-scale survey was conducted in the designated "Quiet Area" of the TFF, with the objectives of documenting EWM presence and comparing aquatic plant communities in this part of the flowage to previous survey work completed in 2019. A total of 182 of the previous survey points in the Quiet Area were selected for re-surveying (Figure 3.1). Points were spaced in a grid 190 meters from each other due to the large size of the TFF. The coarse-scale survey was completed between July 16 and July 18, 2024 (Table 3.1).

In addition to the coarse survey, six 100-acre areas of the TFF were intensively surveyed to increase the (1) likelihood of detecting EWM if it was present and (2) robustness of the assessment of aquatic plant richness and abundance. Each fine-scale, or "sub-PI", survey area consisted of approximately 100 points that were spaced at 58-meter intervals (Figure 3.1). Three of the fine scale surveys were located where EWM was detected in 2023 (Yellow, Red, Blue; Figure 3.1) and the other three were located near the inflow of the Turtle River, which has had no EWM reported to date (Purple, Orange, and Green; Figure 3.1). Survey areas near the Turtle River inflow served as controls to compare the aquatic plant communities between known EWM and non-EWM areas.

To capture seasonal variation in the TFF's aquatic plant communities, two of the Quiet Area sub-PI surveys were re-surveyed in September of 2024 (Yellow and Blue; Table 3.1).

Table 3.1. Point intercept surveys conducted on the Turtle Flambeau Flowage in 2024.

Survey Dates			
Region	*Point Intercept Survey Area*	*Summer 2024*	*Fall 2024*
Quiet Area	Coarse	July 16-18	
	Yellow	July 16-17	Sept 24
	Red	July 16	
	Blue	July 17-18	Sept 24-25
Turtle Inflow	Purple	July 24	
	Orange	July 24	
	Green	July 24	

Sampling Procedure Summary

A grid of Global Positioning System (GPS) points for each survey area was generated by Burke Center staff (Figure 3.1). Partner contacts from the WDNR and the ICLWCD were consulted during grid generation to ensure consistency with WDNR procedures and past survey efforts. GPS points were loaded onto a boat-mounted sonar/GPS unit (Lowrance, Syosset, NY) and field staff navigated to each point via boat. At each point, aquatic plant communities were sampled using a double-sided rake (Figure 3.2). The rake was dropped to the bottom, turned three times and pulled to the surface. Once in the boat, any vegetation present were identified to species and the relative density of the individual species and total plant density were recorded as rake fullness (Figure 3.2). In addition to species data, water depth, sediment type, and sample site location were measured and recorded at each point. Plants were identified to species using "Through the Looking Glass: A Field Guide to Aquatic Plants" Ed. 2 by Susan Borman, Robert Korth and Jo Temte (2014) and "Aquatic Plants of the Upper Midwest" by Paul M. Skawinski (2011). Field staff were trained at the annual WDNR aquatic plant identification training at the Kemp Natural Resources Station in Woodruff, Wisconsin. Voucher specimens were kept for each species not previously collected during the 2019 survey.

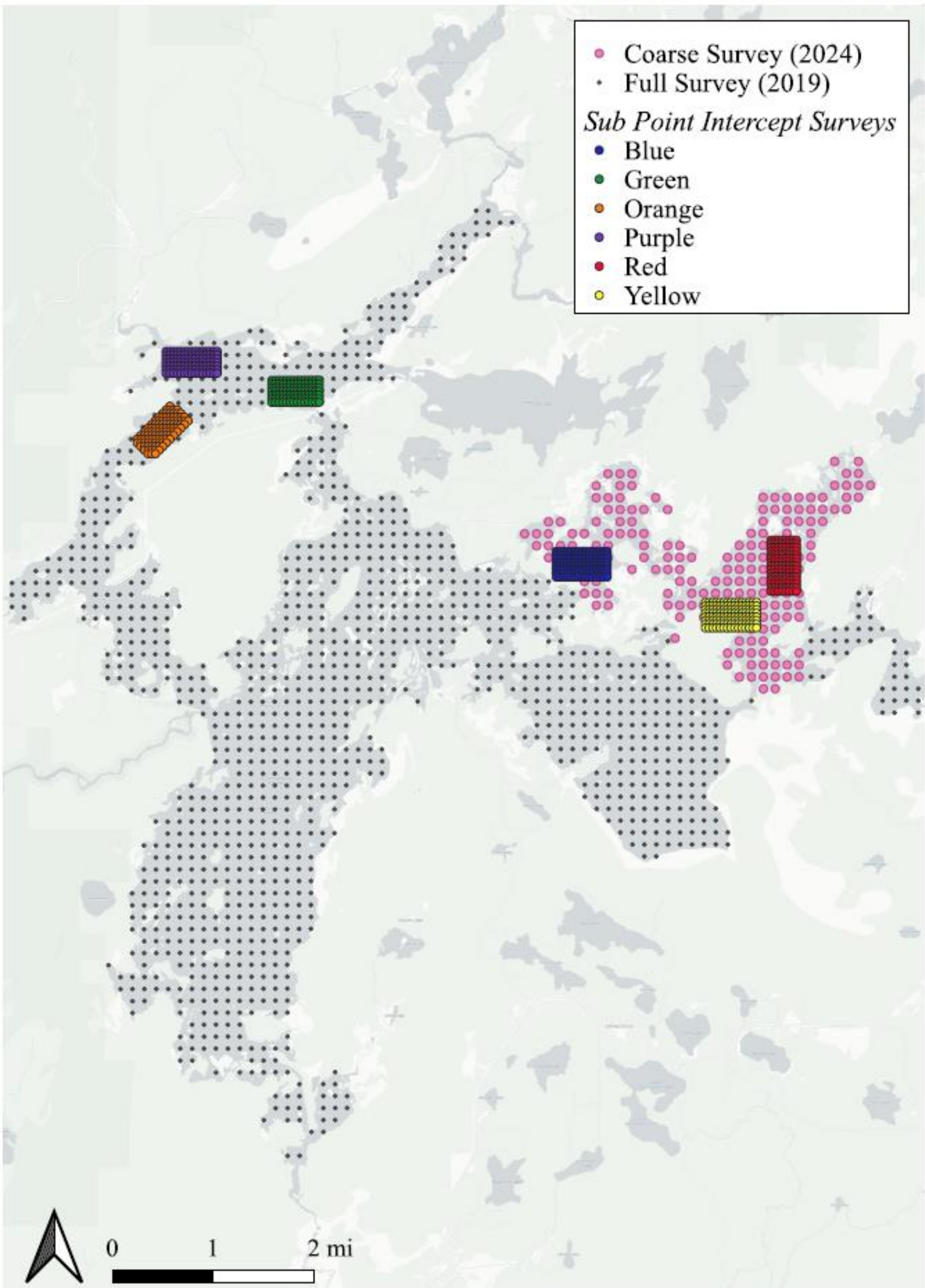

Figure 3.1. All point intercept survey areas on the Turtle Flambeau Flowage in 2019 and 2024 (CartoDB., n. d).

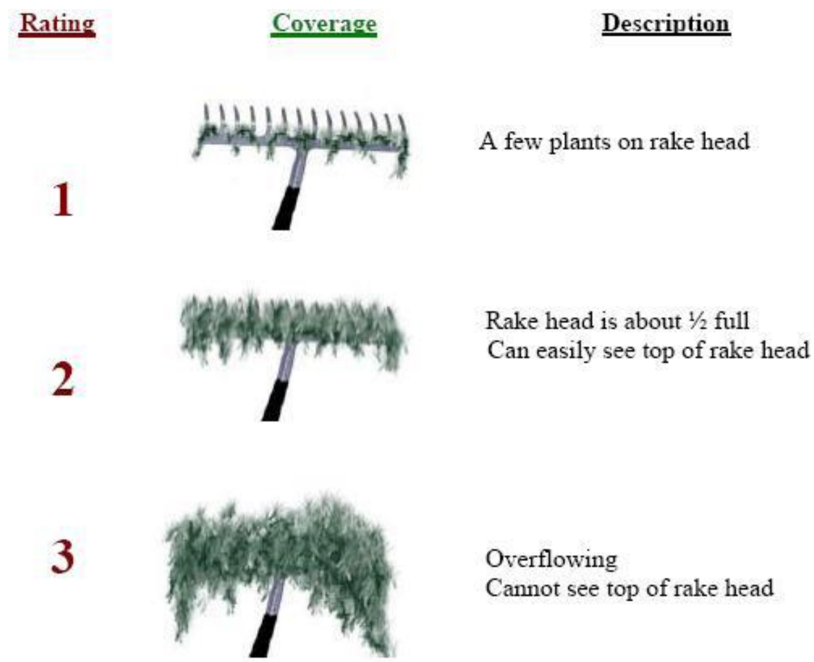

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Figure 3.2. Rake fullness rating scale and coverage estimates used in the 2024 TFF aquatic plant surveys (Hlake.org).

POINT INTERCEPT SURVEY DATA ANALYSIS

All data collected were entered into the standard spreadsheet developed by WDNR for PI surveys. The spreadsheet automatically calculates a range of metrics that are descriptive of the overall aquatic plant community and allows for comparisons of plant community data between waterbodies and within waterbodies over time. The metrics calculated include: Species richness, Simpson's Diversity Index, Coefficients of Conservatism and Floristic Quality Index. To compare the 2019 and 2024 surveys performed in the Quiet Area, only points that were surveyed in both years were used (i.e. points accessible by boat both years).

WATER LEVEL METHODS

Continuous water level data were recorded at four points across the TFF from May 14 to October 2, 2024. Water level logger locations were chosen to represent the TFF outflow (Sportsman's Landing, located near the Turtle Dam), the Flambeau River inflow (Murray's Landing), the Turtle River Inflow (North Popko Circle West), and an approximate middle point (Springstead Landing; Figure 3.3).

Non-vented pressure transducers (Onset HOBO U20-04 and U20L-04 models; Bourne, MA) were suspended within perforated, 2-inch PVC conduit secured to a fence or sign post driven into the lakebed at each site. The loggers were programmed to collect data at fifteen-minute intervals. Non-vented pressure transducers measure total pressure;

therefore, when suspended in water, they measure the total water and air pressure above their location. Thus, they require a separate barometric pressure dataset (collected in air outside of the water) to generate water level data. For this purpose, two additional non-vented pressure transducers were installed outside of the water at the Sportsman's Landing and Murray's Landing locations. A series of reference points and reference marks were used at each site to establish water level elevations. Primary reference points were typically a ¾-inch or one-inch rebar driven into the lakebed next to the water level logger. The primary reference point was given an arbitrary elevation of 10.00 feet, and it was used to collect field measurements of water level to calibrate the pressure transducer data and convert it to a water level elevation or stage using HOBOware software (Onset, Bourne, MA). Water level data were not adjusted to sea level elevation.

Turtle Flambeau Flowage pool heights measured at the Turtle Dam (Xcel Energy, unpublished data) were compared to water level data from the four loggers to evaluate spatial trends in water level fluctuations across the TFF. To compare the datasets, all data were adjusted to show change in elevation in feet from the lowest elevation within each dataset.

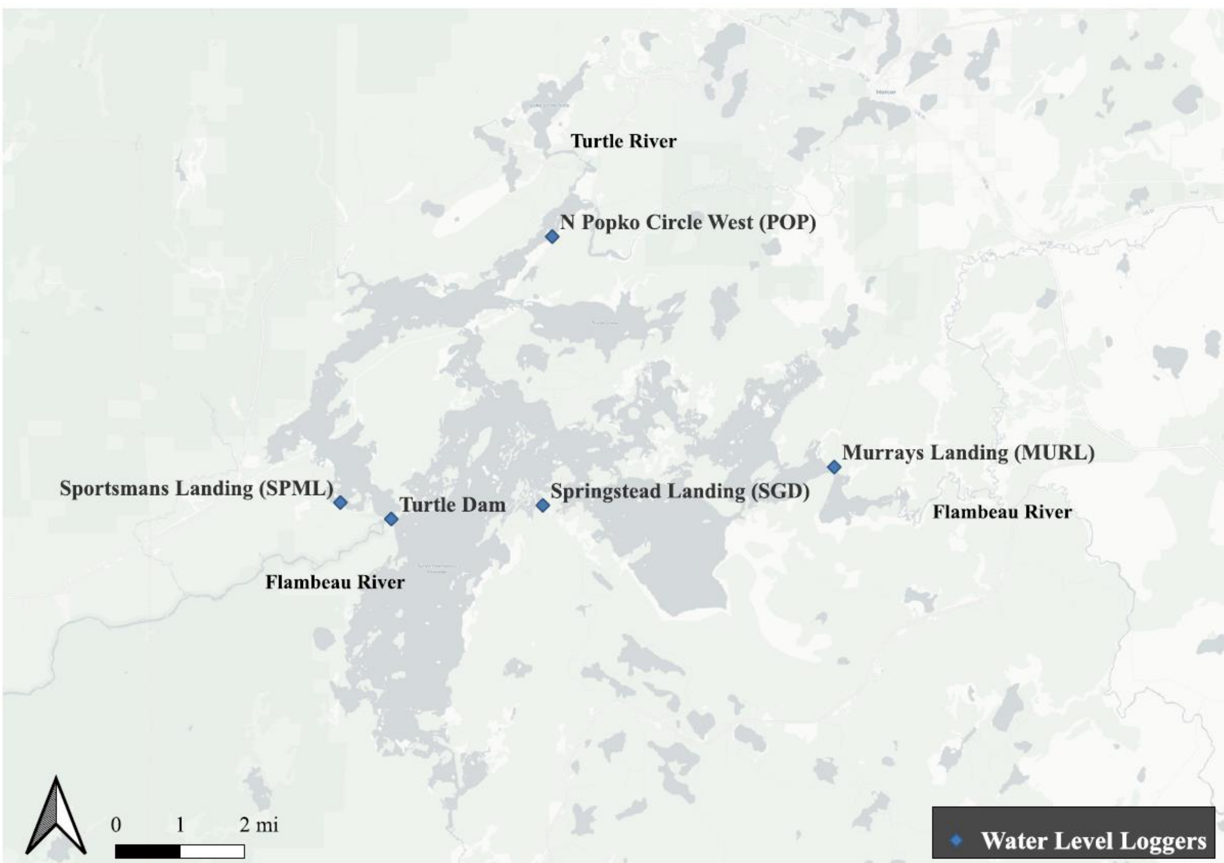

Figure 3.3. Burke Center water level logger locations and the Turtle Dam (CartoDB., n. d.)

4. RESULTS AND DISCUSSION

EURASIAN WATERMILFOIL

During the coarse survey, 167 of the 182 points on the sampling grid were accessible by boat. EWM was observed at four of the 167 sites sampled (2%; Figure 4.1). There were also three visual sightings of EWM recorded during the coarse survey that were not sampled with the rake. Of all species detected during the coarse survey, EWM was one of the least frequently encountered, occurring only 1% of the time on the sampling rake. The average rake fullness of EWM was 1.3. EWM was found at depths from six to eight feet when detected via rake, but was observed visually at depths from two to four feet.

Of the six sub-PI surveys, only the Yellow area contained EWM, which includes the area where EWM was detected in 2023 (Figure 4.1). In the July survey of the Yellow sub-PI, EWM was present at 11 of the 107 sampled sites (10%). There were also 16 visual sightings of EWM. EWM was encountered 9% of the time on the sampling rake during the July Yellow sub-PI. The average rake fullness of EWM was 1.4. At the 11 sites where EWM was encountered via rake, depths ranged from seven to eight feet. Of the visual sightings of EWM, 11 were at depths from six to eight feet, while the remaining five were at two to three feet. During the September survey of the Yellow sub-PI, EWM was present at 11 of the 94 sites visited (12%; Figure 4.2). There were nine visual sightings of EWM during the September survey, a decrease of seven from July. EWM was more frequently encountered in September, occurring 28% of the time on the sampling rake. The average rake fullness of EWM in September was 1.1. EWM was found at depths from four to six feet when sampled via rake in September. Visual sightings of EWM during the September survey occurred at depths from three to six feet.

In 2023, EWM was observed near Bonies Mound (Figure 4.1). In 2024, EWM was primarily clustered in an area south of Bonies Mound, however, it was also observed in three locations west of Bonies Mound (Figure 4.1). This indicates that either EWM is spreading or it is more widespread in the TFF than initially thought. Although EWM has yet to be detected outside of the Quiet Area, a survey of the entire TFF is needed to identify other areas where EWM may be present.

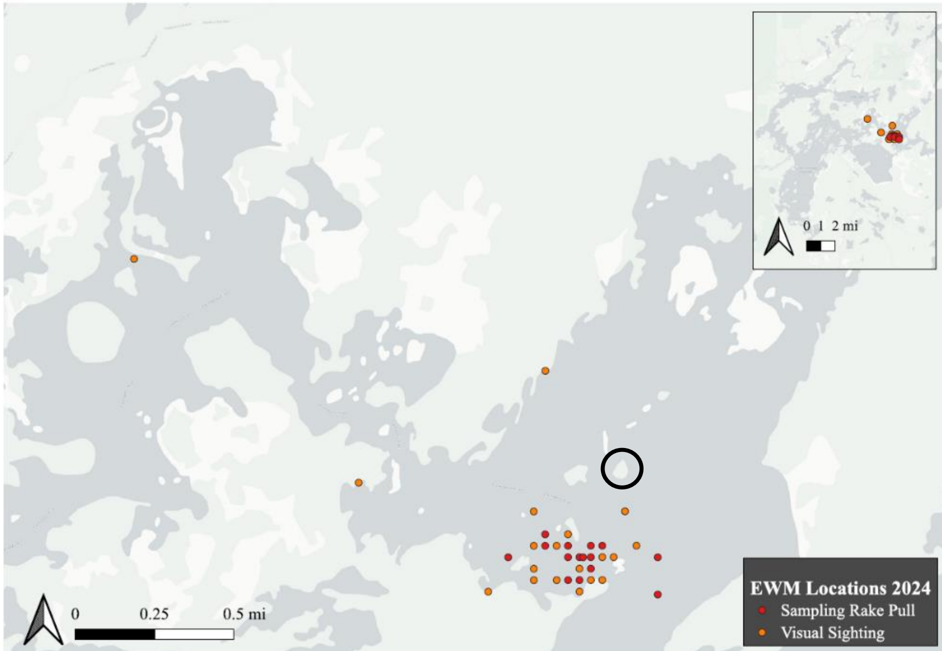

Figure 4.1. Locations where EWM was observed during the Coarse PI and Yellow sub-PI in July 2024. Red points indicate locations where EWM was noted via sampling rake pull. Orange points indicate where EWM was noted by visual sighting. The black circle designates Bonies Mound (CartoDB., n. d).

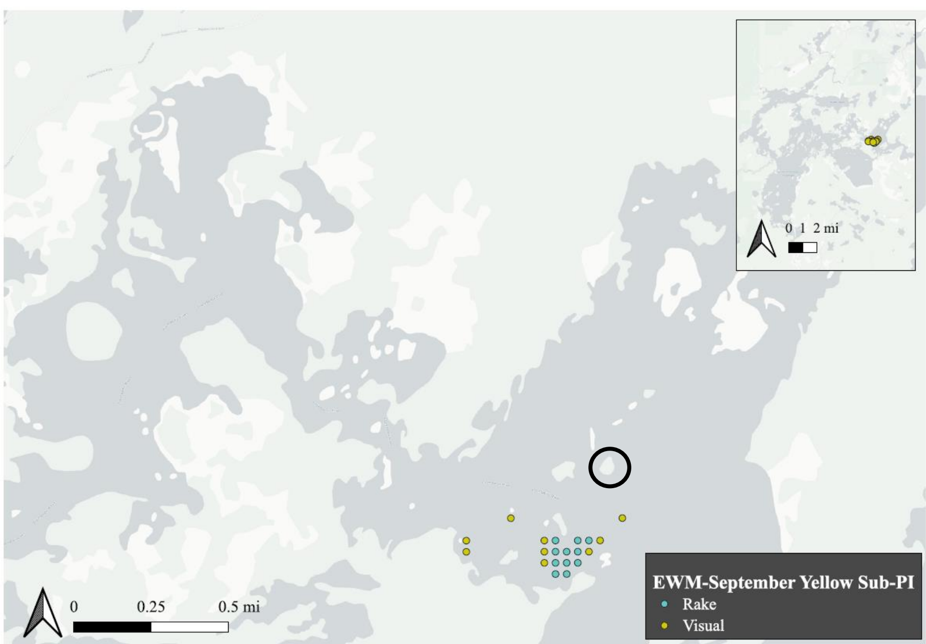

Figure 4.2. Locations where EWM was observed during the Yellow sub-PI in September 2024. Blue points indicate locations where EWM was noted via sampling rake pull. Yellow points indicate where EWM was noted by visual sighting. The black circle designates Bonies Mound (CartoDB., n. d).

AQUATIC PLANT COMMUNITY ASSESSMENT

Multiple metrics were used to evaluate the aquatic plant community of the TFF. Species richness, which is a measure of the number of species present, provides a simple assessment of the aquatic plant diversity of a waterbody (Chao and Chiu, 2016). Simpson's Diversity Index is a more nuanced measurement that considers both species richness and species abundance (i.e., the number of individuals of a given species; Hauxwell et al., 2010). The index ranges between 0 and 1, with indices near 0 indicating very low diversity and values near 1 representing high diversity (Hauxwell et al., 2010).

The WDNR spreadsheet also calculated Coefficients of Conservatism (C) and the Floristic Quality Index (FQI). A C-value is assigned to each plant species in an ecoregion or state. C-values range from 0-10, with lower scores assigned to species more likely to occur in degraded habitats and higher scores assigned to more sensitive species that tend to occur in undisturbed areas (Matthews et al., 2014). The mean C for a surveyed community of plants is included in the calculations of the FQI. The FQI assesses the quality of the full plant community, with higher FQI scores indicating higher quality plant communities more representative of undisturbed conditions (Nichols, 1999).

COARSE POINT INTERCEPT SURVEY: 2019-2024

Survey points sampled in both 2019 and 2024 were used to compare the two survey years. In 2019, 126 points surveyed were comparable to those surveyed in 2024. In 2019, 51 points of 126 had vegetation present (40%). The maximum water depth where plants grew in 2019 was seven feet. In 2024, 70 of the 126 comparable sites had vegetation present (56%). The maximum depth of plant growth was eight feet in 2024. The total sites with vegetation was higher in 2024 than 2019 and the maximum water depth of those plants was approximately one foot deeper.

Species Richness and Simpson's Diversity Index

The Quiet Area of the Turtle Flambeau Flowage has a highly diverse aquatic plant community. In 2019, species richness was 54, including both rake and visual detection methods. In 2024, species richness (rake and visual observations), within the Quiet Area survey was 48. When examining the 126 points that were comparable between the 2019 and 2024 surveys, Simpson's Diversity Index was very high in both time periods (0.96 in 2019 and 0.94 in 2024). The median species richness of northern lakes and flowages in Wisconsin is 23.5 (Nichols, 1999), so the Quiet Area of the TFF has a highly diverse assemblage of aquatic plants. When comparing the individual species found across both surveys, 31 species were found in both 2019 and 2024. In 2024, 9 species were identified that were not present in the 2019 survey, one of which was EWM. Additionally, 22 species were reported in 2019 that were not detected in 2024. The most common species in the 2019 survey was *Najas flexilis* (slender naiad), which was found at 33% of sampling points with vegetation. In 2024, the frequency of occurrence for *Najas flexilis* was only 4%. The most common species observed in 2024 was *Elodea canadensis* (common waterweed) which was found at approximately 53% of sampling points with vegetation. In 2019, the frequency of occurrence for *Elodea canadensis* was 18%.

Coefficient of Conservatism and Floristic Quality Index

In 2019, the mean coefficient of conservatism (C) was 6.9, while in 2024 it was 7.1. In both years, mean C was above the regional median for northern lakes and flowages in Wisconsin (Nichols, 1999), indicating the Quiet Area of the TFF has many aquatic plant species that are sensitive to disturbance (Nichols, 1999). The Floristic quality index (FQI) in 2019 was 46.4 and 40.0 in 2024. The FQI in both years is well above the regional median of 28.3 for northern lakes and flowages in Wisconsin (Nichols, 1999), further indicating that the aquatic plant community in the Quiet Area of the TFF is high quality and representative of undisturbed conditions.

SUB POINT INTERCEPT SURVEYS

A total of 634 sites were visited over all six of the sub-PI surveys completed in July 2024. The proportion of sites with vegetation present varied between each sub-PI area, ranging from 4%-51%. The majority (70%) of sites with vegetation were found within the three sub-PI surveys located in the Quiet Area. The maximum depth of plant observation also varied between sub-PI areas, ranging from seven to ten feet.

The Yellow and Blue sub-PI areas were re-surveyed in September 2024. The proportion of vegetation present in the Yellow sub-PI decreased from 51% to 24% between July and September. The proportion of vegetation present in the Blue sub-PI decreased from 38% to 30% between July and September. The maximum depth of plant growth was reduced from eight to six feet in the Yellow and from nine to six feet in the Blue sub-PI.

Species Richness and Simpson's Diversity Index

Total species richness (rake and visual detections) varied between sub-PI survey areas, ranging from 12 to 31 (Figure 4.3). Sub-PIs located in the Quiet Area had higher overall species richness with and without including visual observations. Simpson's Diversity Index ranged from 0.86 to 0.92 (Figure 4.4). The results indicate that the makeup of the aquatic plant community varies across surveyed areas of the TFF depending on the type of substrate and available littoral area. However, the consistently high Simpson's Diversity Index numbers indicate that even in areas where fewer species of plants are present, the diversity of the plants present remains high.

In September, total species richness of the Yellow sub-PI was 17, a reduction of 14 species from July. Total species richness of the Blue sub-PI in September was 29, an increase of two species since the summer survey. From July to September, Simpson's diversity index changed from 0.89 to 0.84 in the Yellow sub-PI and from 0.92 to 0.88 in the Blue.

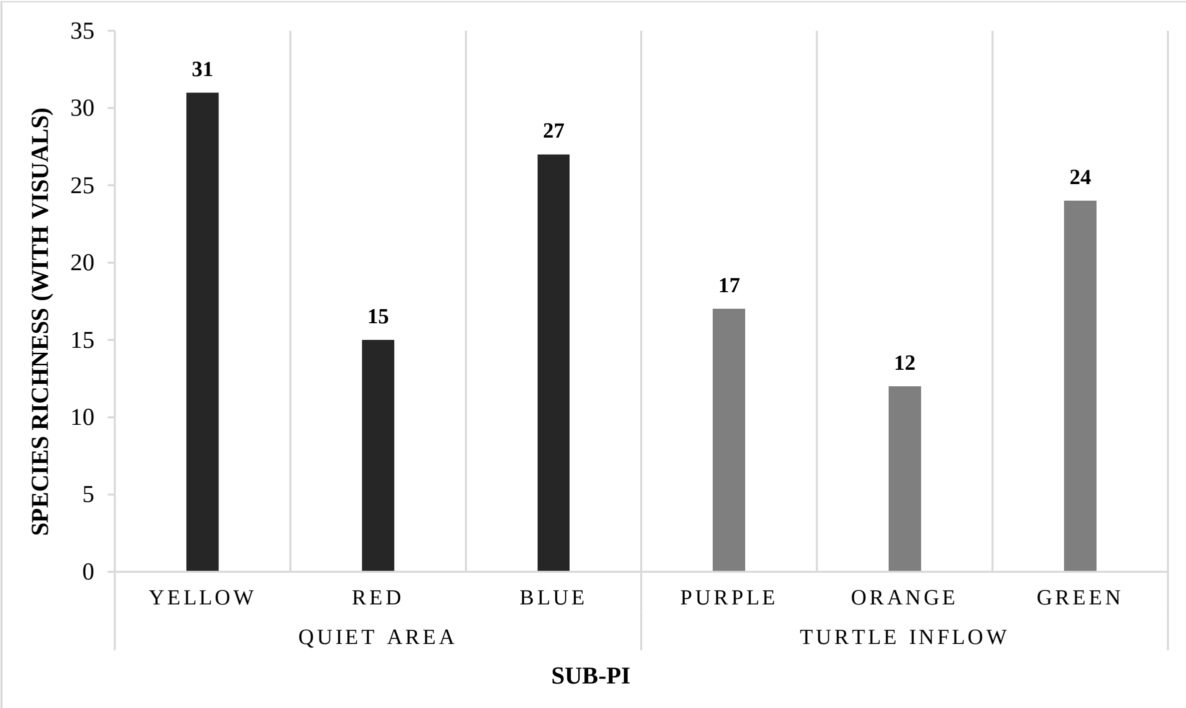

Figure 4.3. Total species richness of the six sub-PI surveys.

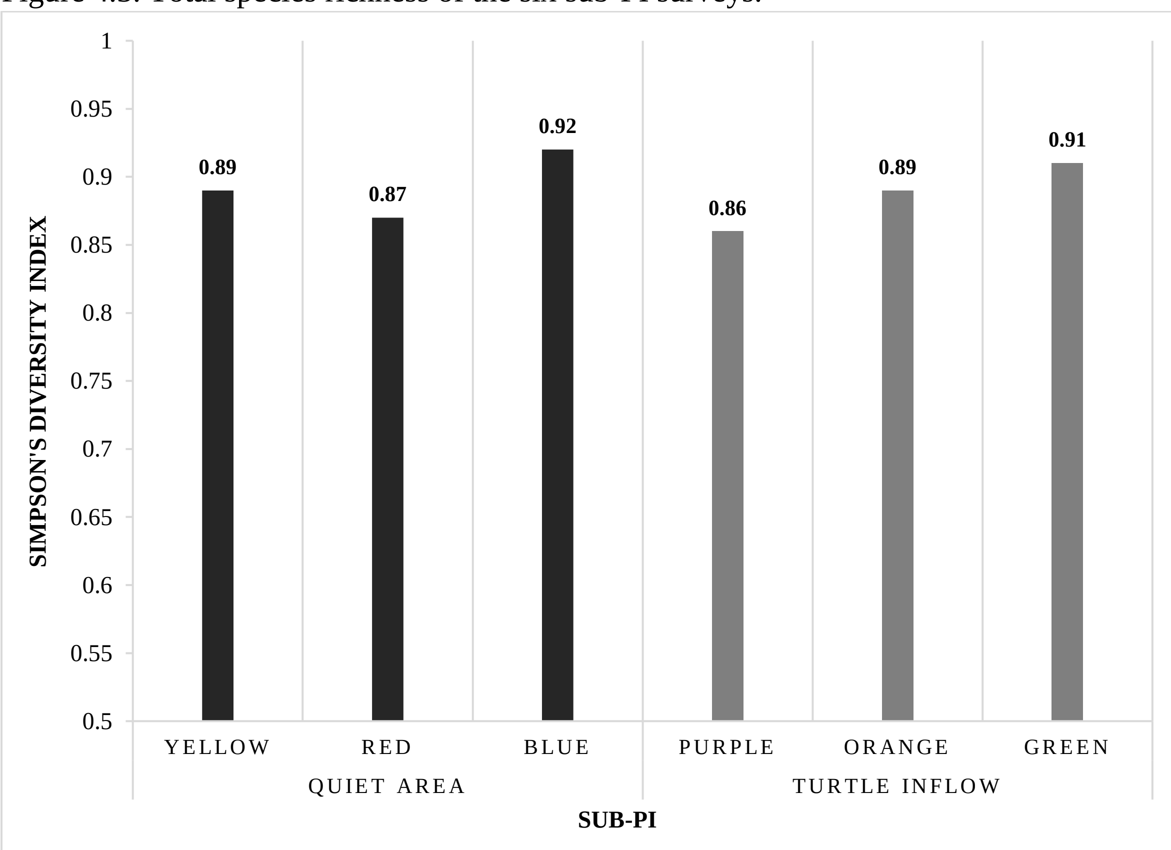

Figure 4.4. Simpson’s Diversity Index of the six sub-PI surveys.

Coefficient of Conservatism and Floristic Quality Index

Mean C was relatively similar between each sub-PI, ranging from 6.1 (Red) to 6.9 (Blue and Orange; Figure 4.5). Only the Red sub-PI had a mean C value below the regional median for northern lakes and flowages in Wisconsin of 6.1 (Nichols, 1999). The relatively high mean C values for the sub-PIs reflect the coarse PI data in that the TFF has many sensitive species, indicating undisturbed conditions. The FQI values ranged from 18.3 (Red) to 32.2 (Blue; Figure 4.6). The sub-PIs with the highest FQI values were Blue (32.2), Green (29.0), and Yellow (28.7). Half of the sub-PI FQI's were above regional median FQI for northern lakes and flowages in Wisconsin (Nichols, 1999). While the FQI values from the sub-PIs are generally lower than the coarse PI survey, they still indicate high quality aquatic plant communities representative of undisturbed conditions. The variation in FQI also demonstrates that the makeup of the aquatic plant community varies across the TFF depending on the type of substrate and available littoral area.

In the sub-PIs sampled in both July and September, both mean C and FQI decreased between the two time points. Mean C decreased from 6.6 to 5.9 from July to September for the Yellow sub-PI and from 6.9 to 6.6 in the Blue sub-PI. FQI for the Yellow sub-PI survey changed from 28.7 to 15.5, whereas Blue changed from 32.2 to 29.3. The reductions in mean C and FQI between July and September are reflective of the seasonal changes in the aquatic plant community and the senescence of plants as summer progresses to fall.

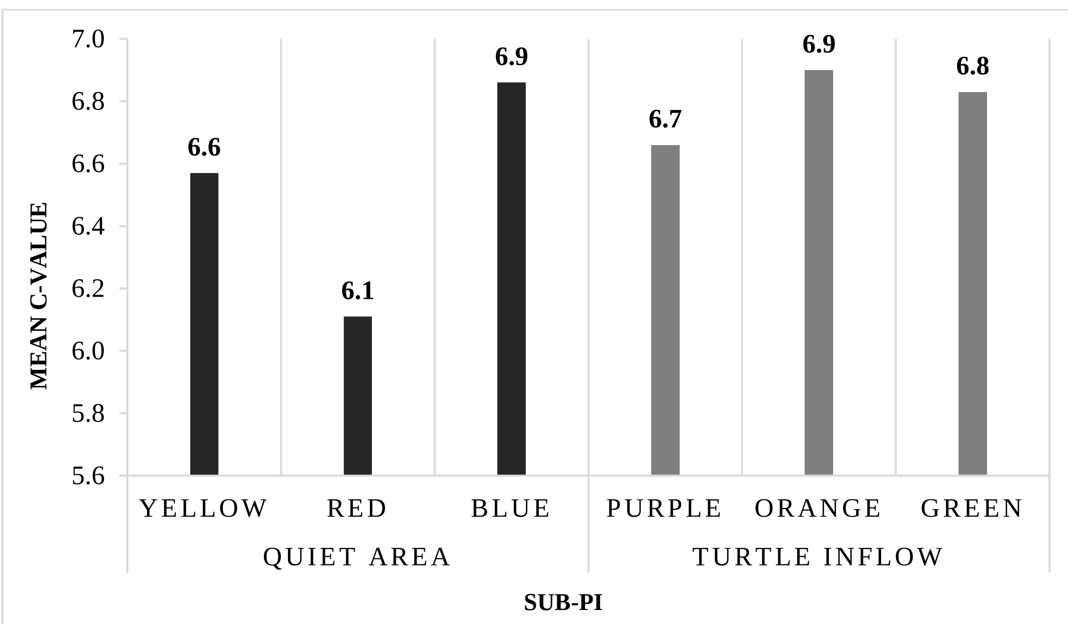

Figure 4.5. Mean Coefficient of Conservatism for the six sub-PI's.

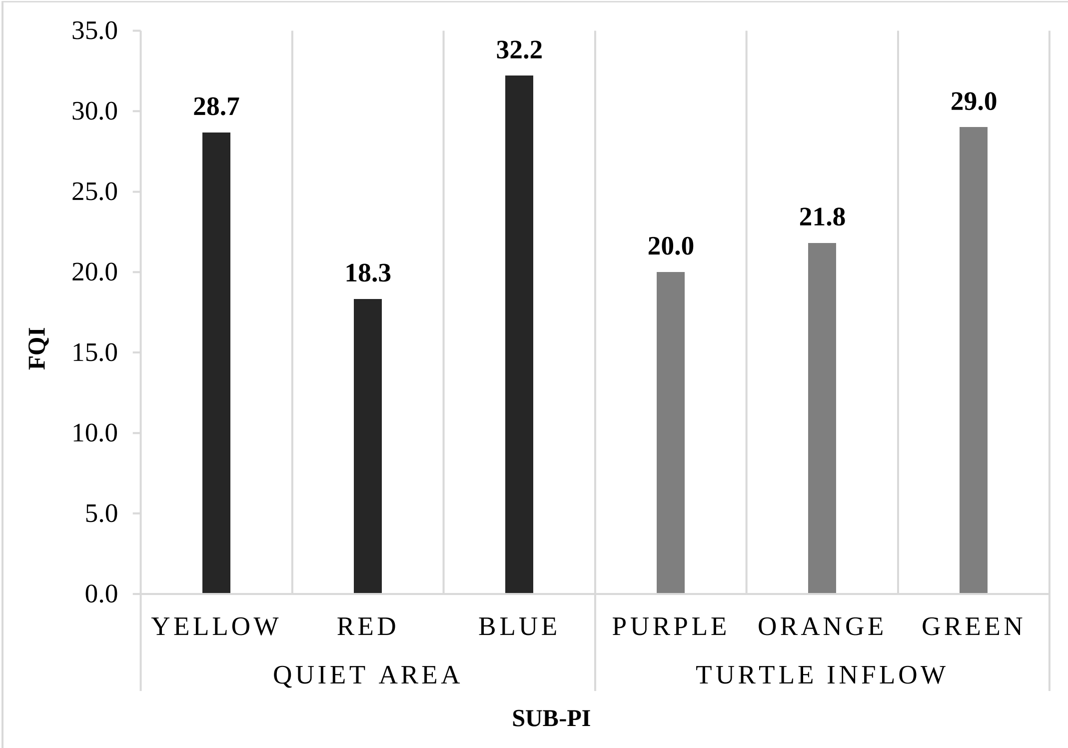

Figure 4.6. Floristic Quality Index of the six sub-PI's.

Water Level Monitoring

Water levels increased steadily in the TFF from logger deployment on May 14 to early June as the flowage filled to a relatively consistent elevation that was maintained until mid-July, when a steady decline in water level began and continued through the remainder of the record (Figure 4.7). The spring increase and late-summer-to-fall decline in water levels reflect the annual management of water levels at the Turtle Dam.

Variation in water level was relatively low (generally < 0.1 ft) between sites, indicating that water levels remained similar across the flowage (Figure 4.7). The loggers at the majority of sites (Sportsman's, Springstead, and Murray's) all tracked quite closely with water level at the dam, indicating that the response of water level change in the flowage is consistent with adjustments to dam discharge. The water levels at the Popko site were around 0.1 ft lower than the pond elevation measured at the Turtle Dam and the other three water level loggers, particularly during the high-water level period in June and July (Figure 4.7). It is unclear why the Popko location would have slightly lower water levels than the other locations but regardless, the difference was very small (~0.1 ft) and likely not significant with respect to water level management and the aquatic plant community.

Precipitation events and periods of drier weather affected water levels consistently across the flowage (Figures 4.8 and 4.9); however, variations in water level due to weather patterns were small (less than one foot) compared to water level changes caused by management at the Turtle Dam (Figures 4.7 and 4.8). Between 2015 and 2024, pond elevation at the Turtle Dam varied between 3.1 ft and 4.8 ft from maximum to minimum elevation each year (Xcel Energy, unpublished data; Figure 4.10). However, most of the EWM observed in the 2024 PI surveys was found at depths greater than six feet. Annual fluctuations in water level at the Turtle Dam are currently less than five feet from maximum to minimum, so current amounts of drawdown may not be enough to influence EWM given the depths it is currently found most frequently.

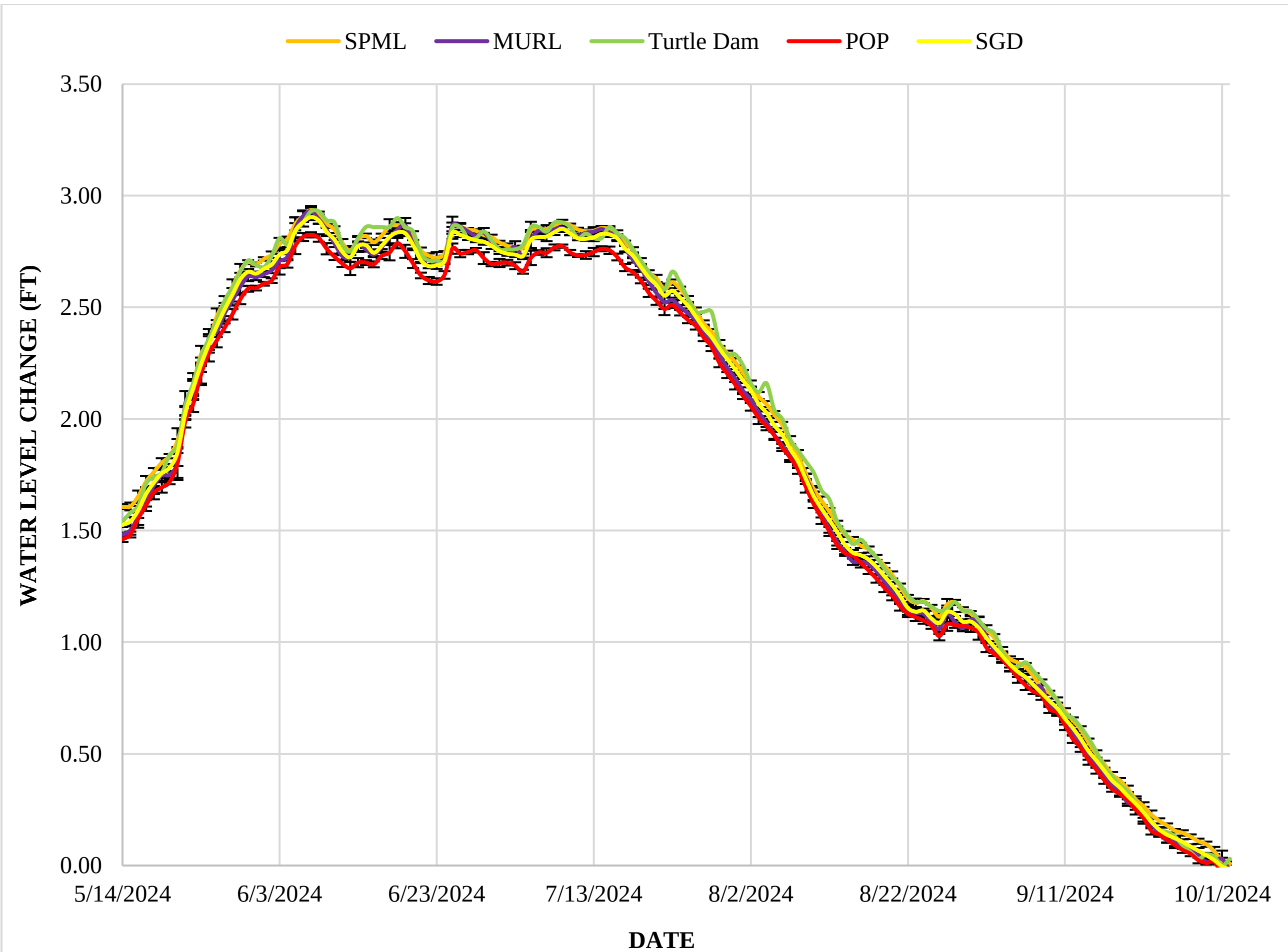

Figure 4.7. Daily averages (+/- standard deviation) of water level change from May 14 to October 2, 2024 in the Turtle Flambeau Flowage (Xcel Energy, unpublished data). The orange line represents Sportsman's Landing (SPML), purple Murray's Landing (MURL), green is the Turtle Dam, red is North Popko Circle West (POP), and yellow is Springstead Landing (SGD).

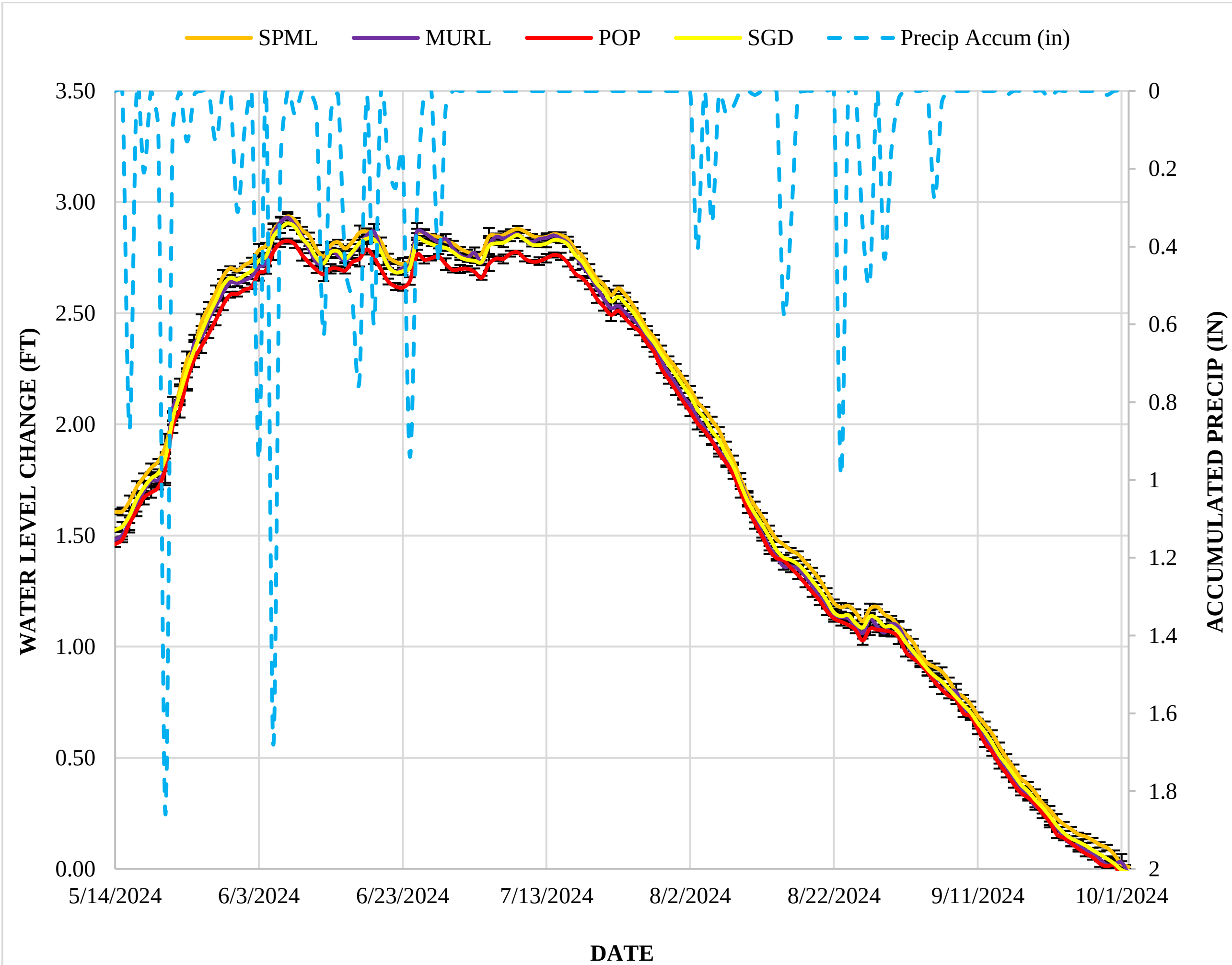

Figure 4.8. Daily averages (+/- standard deviation) of water level change in the Turtle Flambeau Flowage from May 14 through October 2, 2024 and accumulated daily precipitation (dashed blue line) (Weather Underground station KWIMERCE3, 2024). The orange line represents Sportsman's Landing (SPML), purple Murray's Landing (MURL), red is North Popko Circle West (POP), and yellow is Springstead Landing (SGD).

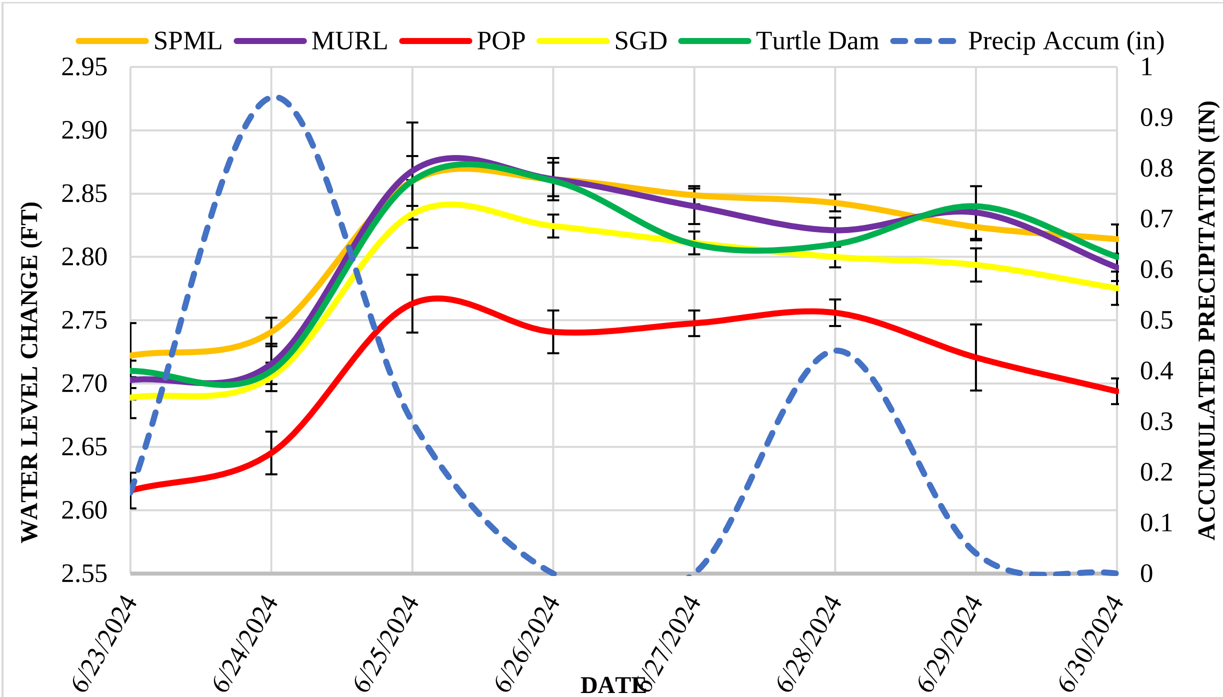

Figure 4.9. Daily water level fluctuations at deployed loggers and the Turtle Dam after a precipitation event on June 24, 2024 (Xcel Energy, unpublished data; Weather Underground station KWIMERCE3, 2024). The orange line represents Sportsman's Landing (SPML), purple Murray's Landing (MURL), red is North Popko Circle West (POP), yellow is Springstead Landing (SGD), and green is the Turtle Dam. The blue dashed line represents accumulated daily precipitation.

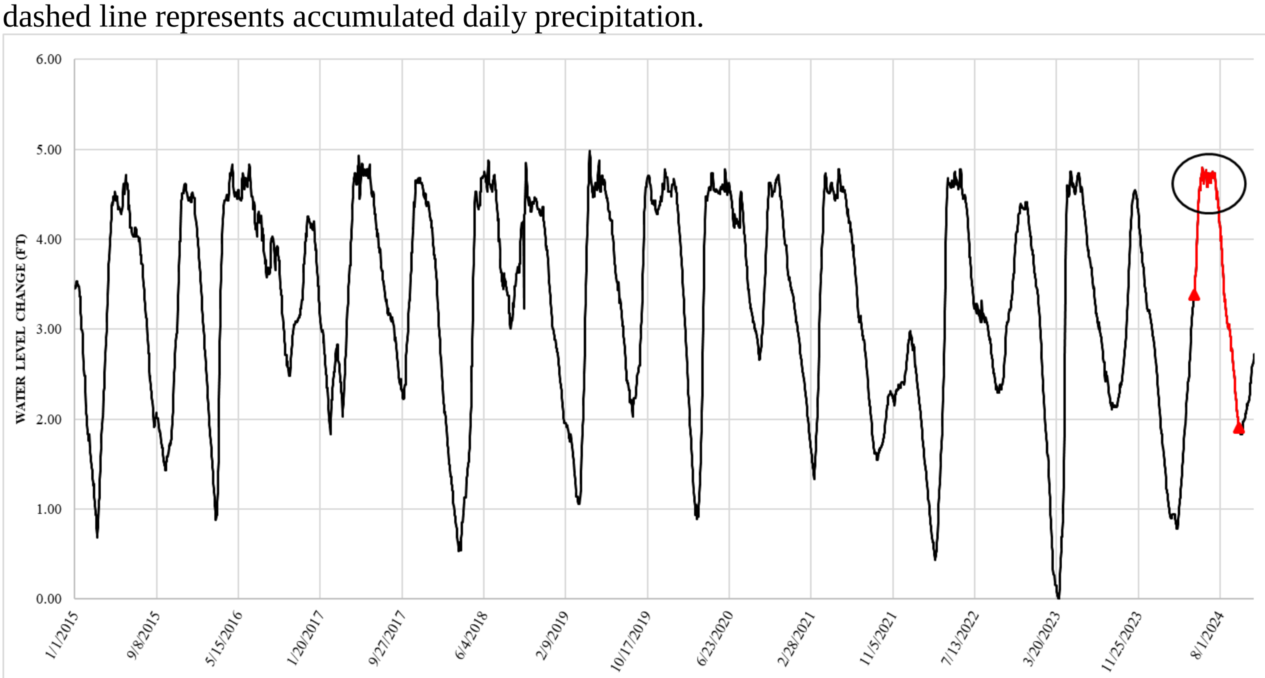

Figure 4.10. Water levels at the Turtle Dam from 2015-2024 (Xcel Energy, unpublished data) with 2024 time period where Burke Center loggers were deployed in red.

5. CONCLUSIONS

A coarse PI survey and eight sub-PI surveys conducted on the TFF during 2024 have clarified the extent of EWM presence within the Quiet Area of the flowage. EWM was primarily clustered in an area south of Bonies Mound, however, it was also observed in three locations west of Bonies Mound. The survey results indicate that EWM is spreading or is more widespread in the flowage than initially thought. Although EWM has yet to be detected outside of the Quiet Area, a survey of the entire TFF is needed to identify other areas where EWM may be present.

PI survey data metrics indicate that the overall aquatic plant community is highly diverse and of high quality in the areas of the TFF that were surveyed. This high diversity and quality may be threatened by EWM, particularly if the invasive plant spreads throughout the TFF. Dense patches of EWM have the potential to shade native plants and alter the community for years to decades.

Water level monitoring results demonstrated very little variation in water levels across the TFF and that environmental drivers of water level change had a smaller influence than water level changes due to management at the Turtle Dam. Annual water level fluctuations at the dam are less than five feet and most of the EWM is in depths greater than six feet, so current water level management at the dam may not be sufficient if considered as an alternative for EWM management.

Management of EWM is complex. Information campaigns, such as signage at boat launches, can be used to inform visitors to the flowage. Ultimately, eradication of EWM is unlikely; therefore, controlling the spread of the current populations will be a key management goal.

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