DRAFT

Paw Paw tree located on the banks of the Branch & Derby Drain.

Autosampler installed on Green Drain, site A2

Tree over Branch & Derby Drain

2020 Summary of Water Quality Results Branch & Derby Intercounty Drain

December 15, 2020

Prepared For:

Paw Paw Lake Improvement Board

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Summary:

This document is intended to concisely summarize recent Branch & Derby Intercounty water quality monitoring efforts. The complete database of water quality results and supporting documents is maintained by Spicer Group.

SUMMARY OF 2017 – 2020 RESULTS
BRANCH & DERBY INTERCOUNTY DRAIN
BERRIEN COUNTY, MI
DECEMBER 17, 2020

SAMPLING PLAN

The Branch & Derby Intercounty Drain's watershed is located north and east of Paw Paw Lake and extends into Van Buren County. The land within the watershed is agricultural, residential, and forestland. Three autosamplers were installed in the drain in 2017, 2018, and 2019. In the year 2020, samplers were installed in the Branch & Derby Drain and its tributaries.

Figure 1- Autosampler, suction line, bubbler line, installed in the Branch & Derby Drain.

Autosamplers are a type of equipment that can be programmed to automatically start collecting water samples during certain conditions in the stream, river, or drain that is being monitored. The autosamplers utilized for the Branch & Derby Drain have 24 water sample bottles in their bases.

Figure 2- 24-Bottle carousel in base of automated sampler.

Autosamplers were programmed to start sampling once water levels started to rise due to rainfall and runoff. This type of wet weather sampling allows for a better understanding of the effects of the Branch & Derby Intercounty Drain on Paw Paw Lake.

SAMPLE SITE LOCATIONS

2017 – 2019 Sample Sites:

- **A1** – Furthest site downstream, ~300 feet upstream of Branch & Derby Intercounty Drain outlet into Paw Paw Lake.
- **A2** – Located downstream of detention basin, immediately west of M-140 culvert.
- **A3** – Sample site furthest upstream and is located at inlet of M-140 detention basin.

2020 Sample Sites:

- **A1** – Furthest site downstream, ~300 feet upstream of Branch & Derby Intercounty Drain outlet into Paw Paw Lake.
- **A2** – Installed within Green Drain, downstream of Hagar Shore Road crossing of Green Drain, prior to confluence with the Branch & Derby
- **A3** – Upstream of Hagar Shore Road crossing of the Branch & Derby, prior to confluence of McConnell and Olcott Drain

Branch & Derby Intercounty Drain Sample Site Locations 2020

Berrien County, MI

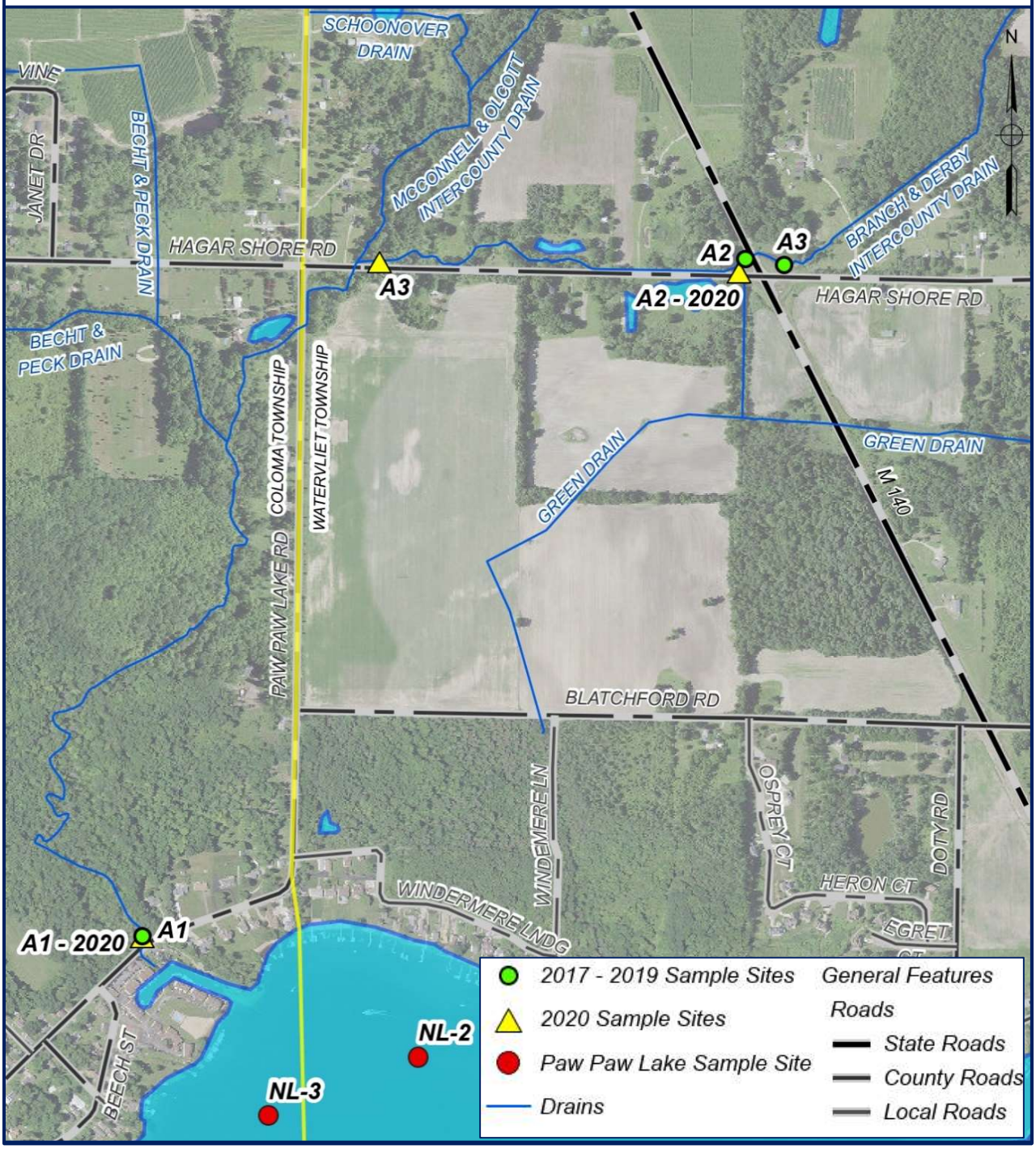

Figure 3- Branch & Derby Intercounty Drain sample site location map. Water quality data from Paw Paw Lake sample sites NL-2 and NL-3 were utilized as a metric to compare Branch & Derby Intercounty Drain water quality data.

WATER QUALITY PARAMETERS MONITORED

The following water quality parameters were monitored in the drain(s):

- ***Total Suspended Solids (TSS):*** Quantifies the number of **solid particles** transported by the watercourse. TSS concentrations provide insight on erosion and pollutant loads within the watershed. As concentrations of TSS increase, a wide range of other pollutants may increase in mobilization and concentration (for example, phosphorus).

- ***Total Phosphorus (TP) and Soluble Reactive Phosphorus (SRP):*** Total phosphorus and soluble reactive phosphorus are variant forms of phosphorus, the limiting nutrient that **contributes to algal blooms**. In the form of SRP, phosphorus is readily available for plant and algae uptake. TP is typically bound to soils and other organic substances; it is not 100% available for vegetation and algal uptake.

Figure 4- Sample site A3 during the August 2020 sample event.

- ***Nitrate (NO_3^-):*** Nitrate is also a nutrient used by plants for growth. There is usually an excess of this compound in Michigan waterways compared to phosphorus. For that reason, **algal blooms are generally not a result of increased nitrate levels**; however, that does not mean it cannot happen.

- ***Ammonia (NH_3):*** Ammonia may be produced from nitrate through a series of natural chemical reactions. Typically, ammonia concentration is impacted by low dissolved oxygen in a watercourse, over fertilization of land in a watershed, animal waste, and leaky septic systems. **Ammonia (at elevated concentrations) is toxic to many forms of aquatic life**. Understanding its fluctuations is crucial to protecting water quality.

- ***Water Level:*** Water level fluctuations are influenced by rainfall events. However, the farthest downstream site could be affected by backwater from Paw Paw Lake, meaning it likely would not see as large a change in level as the other two monitoring sites.

- ***Rainfall:*** Rainfall impacts the water level and results in runoff that may carry fertilizers, sediment, and other pollutants.

SAMPLING RESULTS

TOTAL SUSPENDED SOLIDS

Total suspended solids are small particles that consist of organic material, clay, and other **particulate matter suspended in the water** and are measured in milligrams per liter (mg/L). Oftentimes, TSS carries other types of contaminants including nutrients, metals, and hydrocarbons (which is more common in urban areas). While TSS occurs naturally in some waterways, an excessive increase in TSS can lead to a decrease in visibility and an increase in other undesired contaminants previously mentioned, in addition to smothering fish eggs and other aquatic wildlife. Therefore, **low concentrations of TSS are desired**.

The State of Michigan has a **"narrative standard" for TSS; meaning, the water should not have unnatural physical characteristics** (MDEQ Rule 50, Part 4 of Act 451). Typically, water with TSS concentrations at >20 mg/L is clear, 40 – 80 mg/L is cloudy, and >150 mg/L appears dirty.

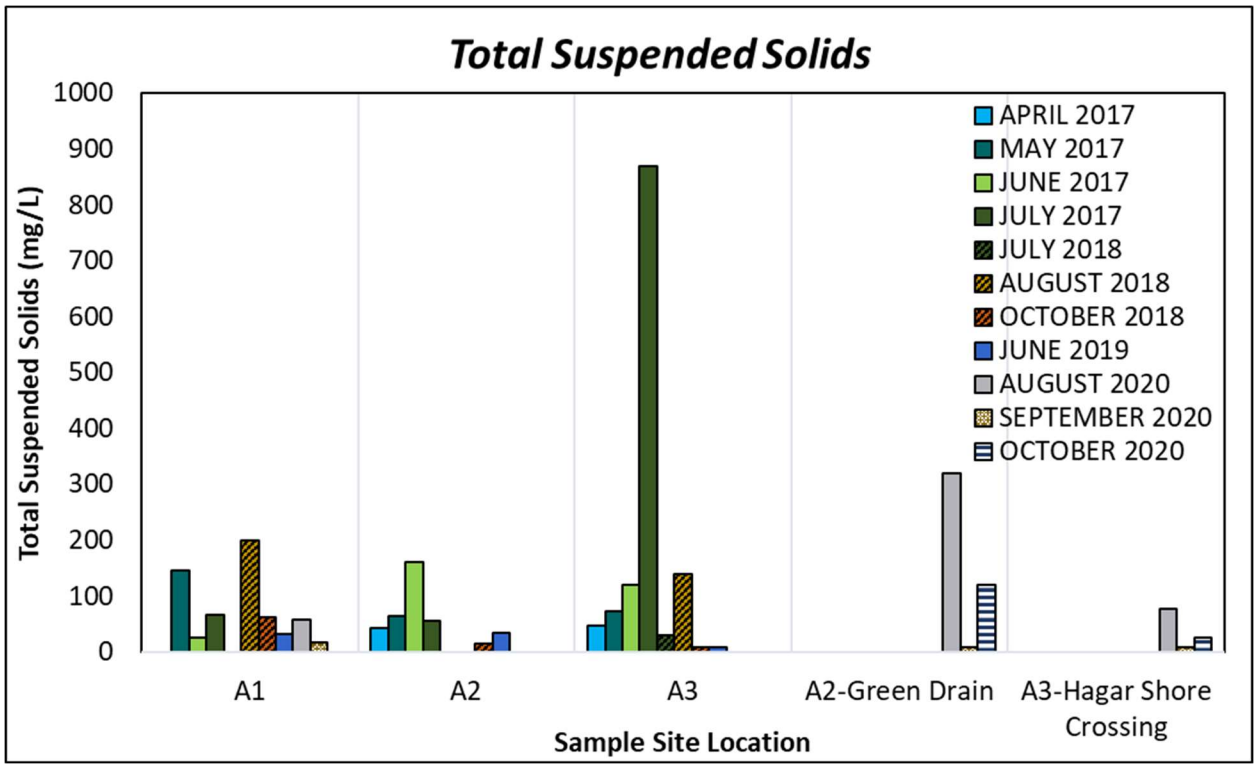

Figure 5- Total suspended solids results 2017 -2020.

Total Suspended Solids (mg/L)											
SAMPLE SITE	*APR 2017*	*MAY 2017*	*JUN 2017*	*JUL 2017*	*JUL 2018*	*AUG 2018*	*OCT 2018*	*JUN 2019*	*AUG 2020*	*SEP 2020*	*OCT 2020*
A1		145	25	66	-	200	61	32	58	17	-
A2	43	65	160	56	-	-	15	33	-	-	-
A3	48	74	120	870	30	140	8.4	8.5	-	-	-
A2-Green Drain	-	-	-	-	-	-	-	-	320	8.3	120
A3-Hagar Shore Crossing	-	-	-	-	-	-	-	-	77	9.1	25

Figure 6- Total suspended solids results 2017 - 2020.

Overall, water samples collected and analyzed for TSS in 2020 showed similar concentrations of TSS compared to previous years. More sample events would be necessary in order to make definite correlations as to why TSS increases or decreases from year to year or event to event. TSS concentrations in the Branch & Derby Drain tend to be significantly higher in concentration than TSS measured in Paw Paw Lake (sites NL-2 and NL-3 were used as data reference points for Paw Paw Lake). The lake has TSS concentrations near 0 mg/L. According to the State of Michigan's narrative standard, samples collected within the drain were mostly clear to cloudy in appearance. The August sample event had the highest measurements of TSS on average out of the three 2020 sample events.

TOTAL PHOSPHORUS

Phosphorus is an element that is a major component in all lifeforms. Phosphorus can also be found in inorganic forms like in rocks. Therefore, as the name says, total phosphorus is the measurement of how much of all types of phosphorus (both organic and inorganic) are within the water and is measured in milligrams per liter (mg/L). **Low TP concentrations that provide a balanced environment for aquatic wildlife are desired**. If there is too much phosphorus within the water, **it can lead to excess algal and plant growth**. Excess algal growth can lead to reduced dissolved oxygen, reduced clarity, unpleasant odors/discolored water, and many more undesirable water quality issues.

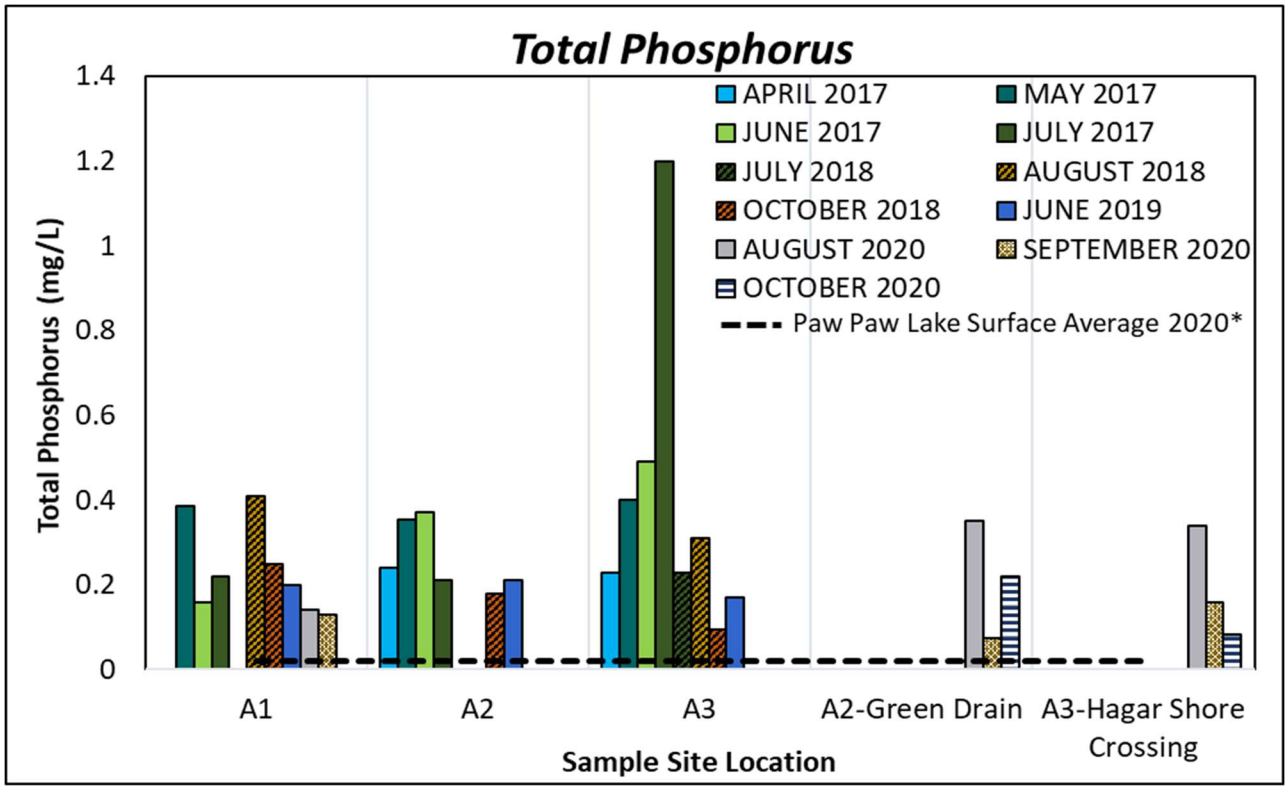

Figure 7- Total phosphorus results 2017 - 2020.
**2020 Paw Paw Lake surface data comes from total phosphorus measurements collected at sites NL-2 and NL-3.*

Total Phosphorus (mg/L)											
SAMPLE SITE	*APR 2017*	*MAY 2017*	*JUN 2017*	*JUL 2017*	*JUL 2018*	*AUG 2018*	*OCT 2018*	*JUN 2019*	*AUG 2020*	*SEP 2020*	*OCT 2020*
A1	-	0.39	0.2	0.2	-	0.4	0.3	0.2	0.1	0.1	-
A2	0.2	0.36	0.4	0.2	-	-	0.2	0.2	-	-	-
A3	0.2	0.40	0.5	1.2	0.2	0.3	0.1	0.2	-	-	-
A2-Green Drain	-	-	-	-	-	-	-	-	0.4	0.1	0.2
A3-Hagar Shore Crossing	-	-	-	-	-	-	-	-	0.3	0.2	0.1

Figure 8- Total phosphorus results 2017 - 2020.

The data show that total phosphorus measurements in the Branch & Derby Drain during the 2020 monitoring period were similar to or lower than data collected in previous years. The August sample event had the highest measurements of total phosphorus of the three sample events of the year. Similar to TSS, TP is much higher in the drain compared to Paw Paw Lake. The surface average for sites NL-2 and NL-3, the sample sites in Paw Paw Lake closest to the outlet of the drain, was 0.019 mg/L for the year 2020. Lake surface average is depicted on the graph with a horizontal, dashed line on Figure 7.

SOLUBLE REACTIVE PHOSPHORUS

Also known as ortho-phosphate, soluble reactive phosphorus (SRP) is phosphorus in a form that is readily available for plant and algal uptake. This is a main constituent in fertilizers used for agricultural and residential purposes.

Soluble reactive phosphorus, or SRP, was not detected in 23 of the 29 samples collected in the timeframe between 2017 – 2020. All of the samples collected in 2020 were below the reporting limit of the analytical method used to measure SRP in water.

Soluble Reactive Phosphorus (mg/L)											
SAMPLE SITE	*APR 2017*	*MAY 2017*	*JUN 2017*	*JUL 2017*	*JUL 2018*	*AUG 2018*	*OCT 2018*	*JUN 2019*	*AUG 2020*	*SEP 2020*	*OCT 2020*
A1	-	U	U	U	-	U	U	0.19	U	U	-
A2	U	U	U	A - U, B - 0.15*	-	-	U	0.06	-	-	-
A3	U	U	0.07	0.13	U	U	U	0.09	-	-	-
A2-Green Drain	-	-	-	-	-	-	-	-	U	U	U
A3-Hagar Shore Crossing	-	-	-	-	-	-	-	-	U	U	U

*Figure 9- Soluble reactive phosphorus results 2017 - 2020. *Sample A was taken before the July 2017 storm event, and Sample B was taken after the storm event.*

NITRATE AND AMMONIA

Nitrogen may be found in many forms in the environment; nitrate (NO_3^-) and ammonia (NH_4^+) are two components that have been monitored on Paw Paw Lake and the Branch & Derby Intercounty Drain. Both components are important parts of the nitrogen cycle that happens naturally; however, too much nitrogen can cause the overgrowth of algae and aquatic plants, and too much nitrate may result in harmful effects to humans. Excess exposure to nitrate in drinking water may cause the restriction of oxygen transport in the bloodstream in infants and young livestock.

Figure 10- Branch & Derby Drain view from M-140 crossing looking downstream.

Nitrogen is used in agriculture to improve yield of a crop, and excess nitrogen may runoff through tile drainage or sheet flow. Other ways that nitrogen may be introduced to the environment include atmospheric deposition, fertilizers, sewage effluent, and the breakdown of organic materials.

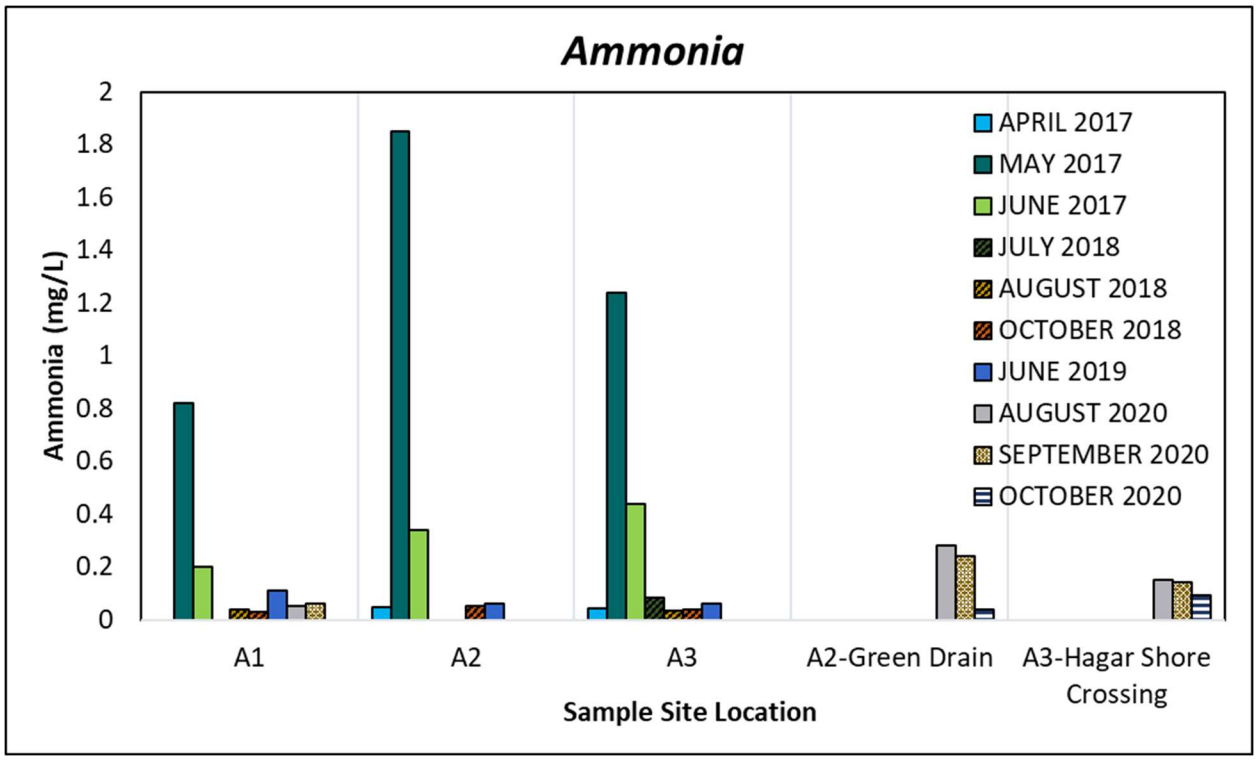

Figure 11- Ammonia results 2017 - 2020. Ammonia levels in Paw Paw Lake are typically below the reporting limit of the analytical test utilized to measure the amount of ammonia in water. Consequently, no Paw Paw Lake comparison data is shown on the graph, as the comparison data would essentially be 0 mg/L.

Ammonia (mg/L)											
SAMPLE SITE	*APR 2017*	*MAY 2017*	*JUN 2017*	*JUL 2017*	*JUL 2018*	*AUG 2018*	*OCT 2018*	*JUN 2019*	*AUG 2020*	*SEP 2020*	*OCT 2020*
A1	-	0.8	0.20	-	-	0	0	0.1	0.1	0.1	-
A2	0.048	1.9	0.34	-	-		0.1	0.1	-	-	-
A3	0.043	1.2	0.44	-	0.1	0	0	0.1	-	-	-
A2-Green Drain	-	-	-	-	-	-	-	-	0.3	0.2	0
A3-Hagar Shore Crossing	-	-	-	-	-	-	-	-	0.2	0.1	0.1

Figure 12- Ammonia results 2017 - 2020.

The **highest** ammonia concentrations were observed in **May of 2017** in the Branch & Derby Intercounty Drain. Monitoring results from **2018, 2019, and 2020 exhibited ammonia concentrations significantly lower than 2017 results**. This change may be attributed to the time of the year that samples were collected. More samples will need to be collected over time to fully understand why concentrations fluctuate. The data show that each site showed similar patterns in concentration fluctuation as time passed. This implies that ammonia concentrations are primarily influenced by the event itself and potentially the time of year – for example, the intensity of the rain event, the volume of water running off, or the atmospheric temperature.

During most sample events from 2017 – 2019, nitrate tends to increase in concentration the further downstream the sample site is. Again, more samples will need to be collected over time to solidify or refute this observation. **In 2018, the outlet of the drain had an average nitrate concentration of 0.37 mg/L**, where **Paw Paw Lake had an average concentration less than <0.023 mg/L** (which is at least **16 times lower** than the nitrate concentration in the drain).

The 2020 sample results are within the range of concentrations measured during the 2017 – 2020 monitoring period. The Green Drain (site A2 in 2020) did not have high concentrations of nitrate compared to other sample sites monitored. Two of the three times water samples were collected at the Green Drain, concentrations were below the reporting limit of the analytical method used to measure nitrate in water. Nitrate concentrations measured in the Branch & Derby Drain and the Green Drain were above that of Paw Paw Lake, as Paw Paw Lake's concentrations are below the reporting limit as well. Again, this means that the concentration of nitrate in the sample is too small for the test to be able to read it.

Figure 13- May 2017 Sample Event. Photo shows site A1.

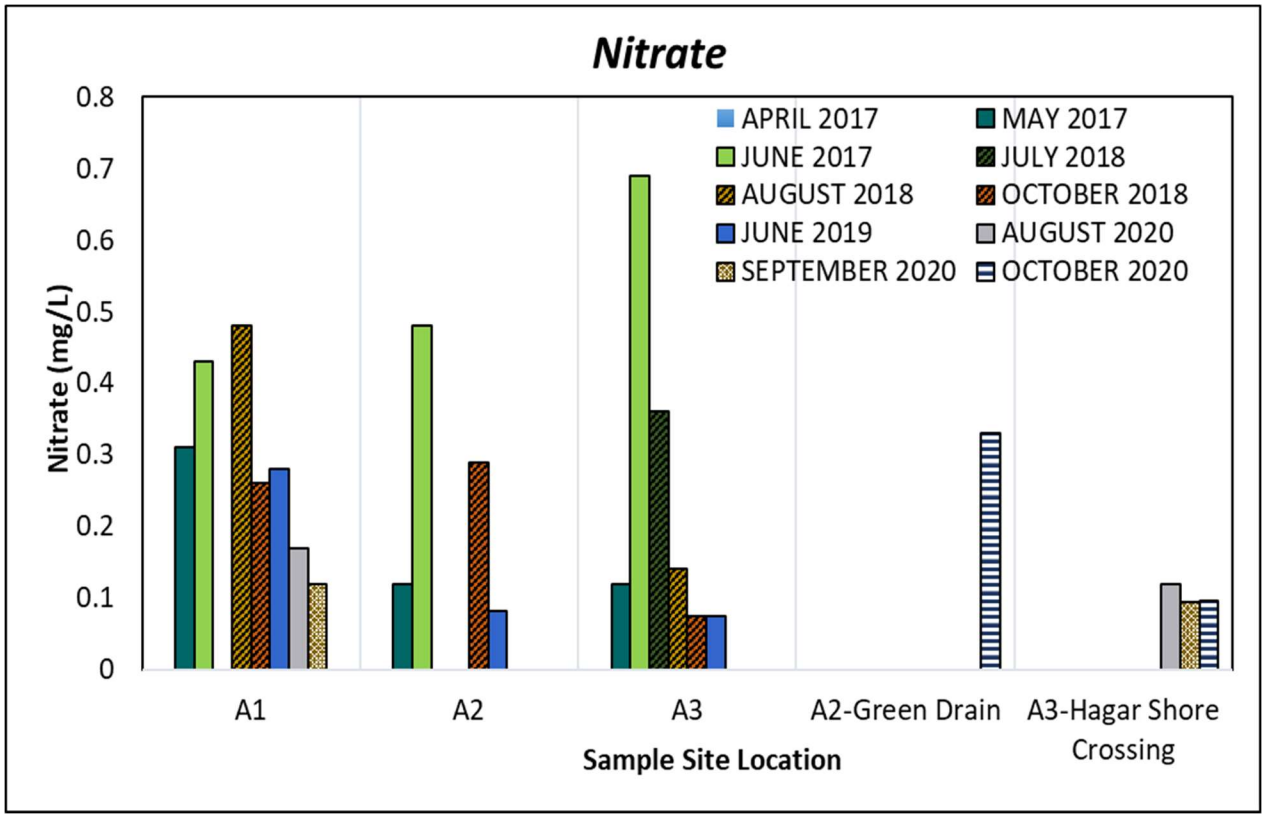

Figure 14- Nitrate results 2017 - 2020.

Nitrate (mg/L)											
SAMPLE SITE	*APR 2017*	*MAY 2017*	*JUN 2017*	*JUL 2017*	*JUL 2018*	*AUG 2018*	*OCT 2018*	*JUN 2019*	*AUG 2020*	*SEP 2020*	*OCT 2020*
A1	-	0.31	0.4	-	-	0.5	0.3	0.3	0.2	0.1	-
A2	U	0.12	0.5	-	-	-	0.3	0.1	-	-	-
A3	U	0.12	0.7	-	0.4	0.1	0.1	0.1	-	-	-
A2-Green Drain	-	-	-	-	-	-	-	-	U	U	0.3
A3-Hagar Shore Crossing	-	-	-	-	-	-	-	-	0.1	0.1	0.1

Figure 15- Nitrate sample results 2017 - 2020.

ATMOSPHERIC TEMPERATURE AND WATER LEVEL – 2020

Water level at each of the three sites was monitored from **July to Mid-November 2020** on the Branch & Derby Intercounty Drain. Rainfall and air temperature data was obtained from the Southwest Michigan Regional Airport rain gauge. There are gaps in level data when the batteries that power the gauge died.

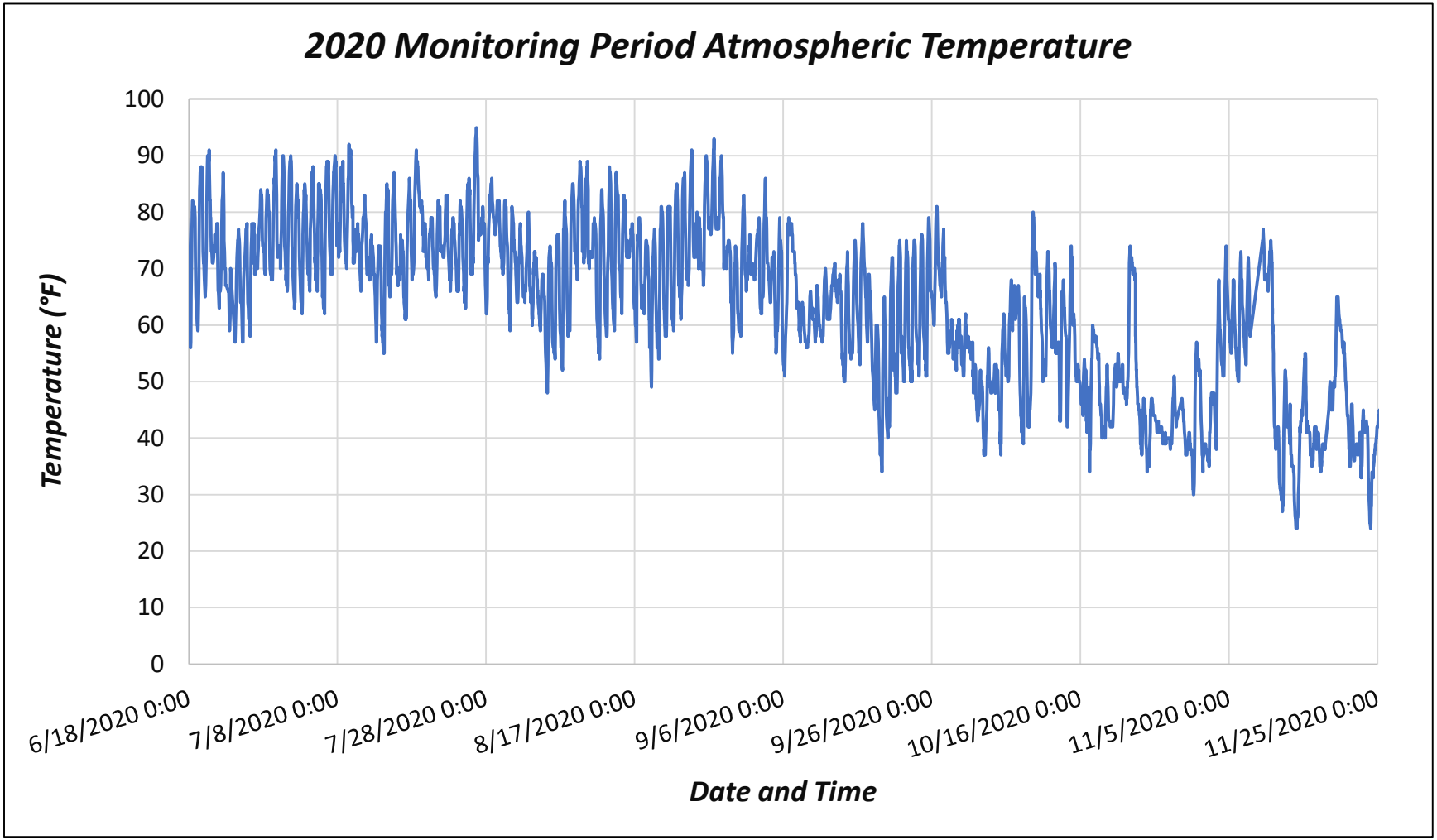

Figure 16- Temperature measured during the 2020 monitoring period.

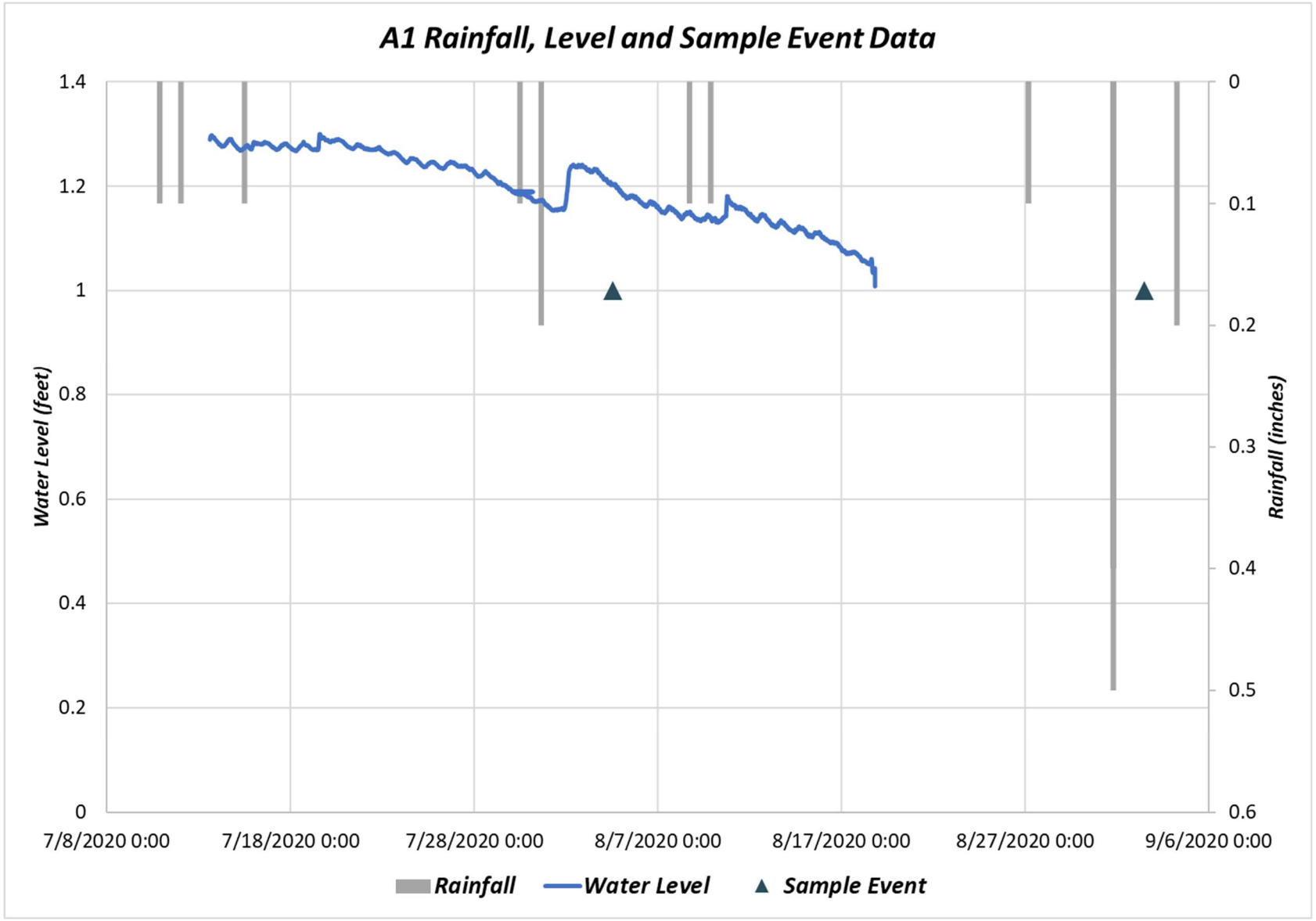

Figure 17- Sample site A1, which is located immediately upstream of the Paw Paw Lake Road crossing of the Branch & Derby Drain. Rainfall data comes from the Southwest Michigan Regional Airport Weather Station (KBEH).

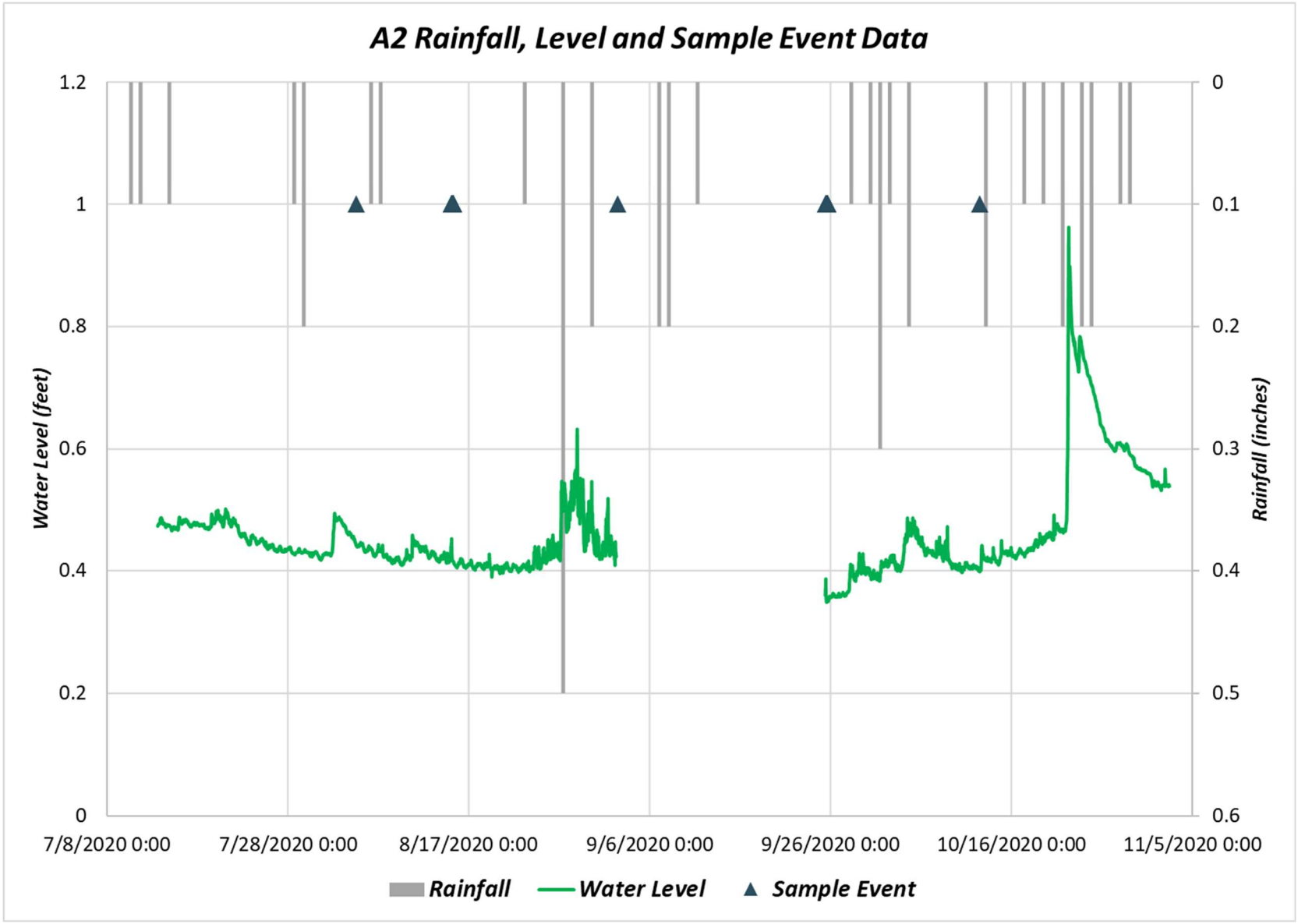

Figure 18- Sample site A2, located near the outlet of the Green Drain to the Branch & Derby Drain, water level data. Rainfall data comes from the Southwest Michigan Regional Airport Weather Station (KBEH).

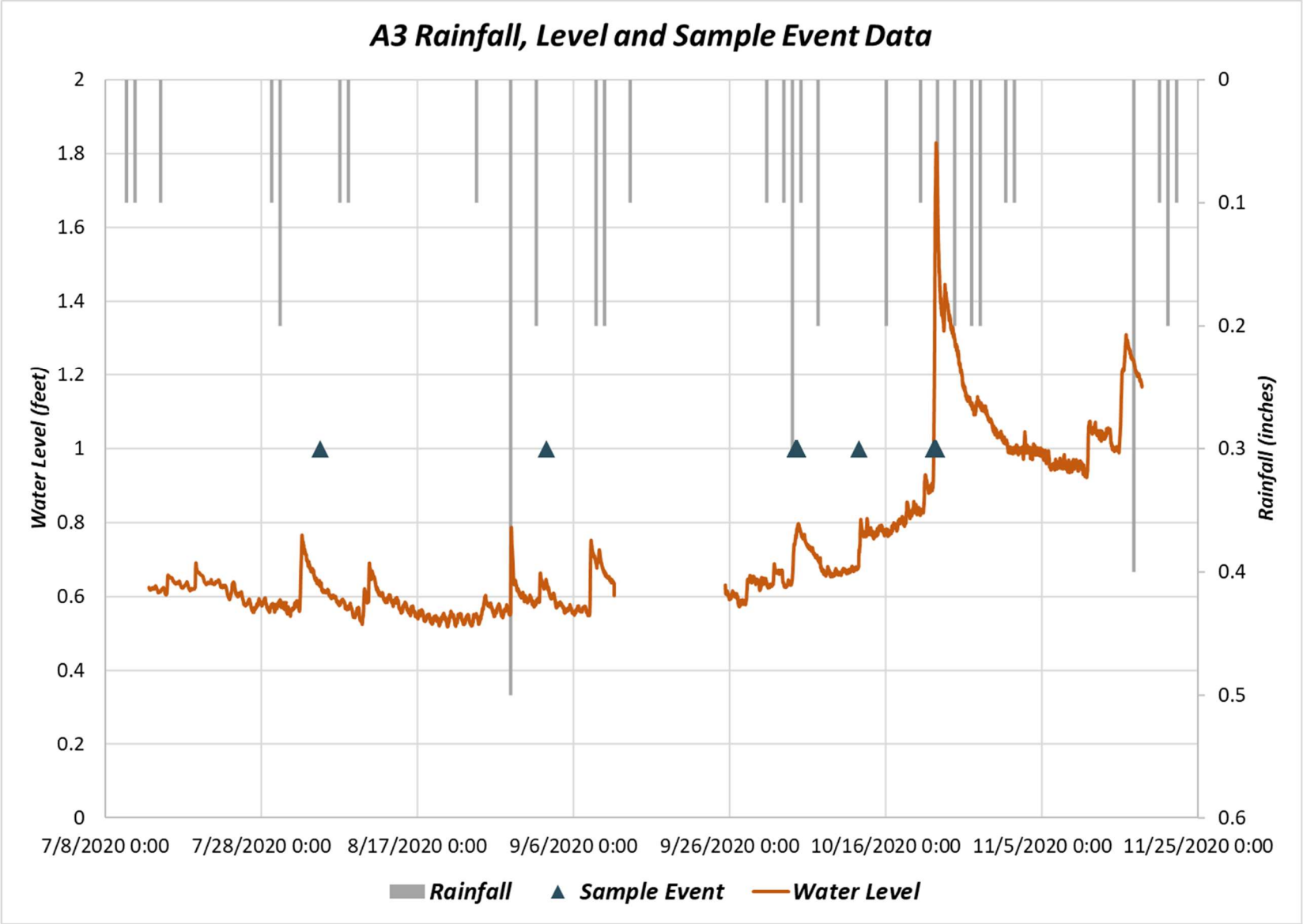

Figure 19- A3 water level, sample event, and rainfall data. A3 is located just upstream from the confluence of the Branch & Derby Intercounty Drain and the McConnell & Olcott Intercounty Drain Rainfall data comes from the Southwest Michigan Regional Airport weather station.

TAKEAWAY POINTS

- All parameters monitored in the Branch & Derby Intercounty Drain (total phosphorus, soluble reactive phosphorus, ammonia, nitrate, and total suspended solids) were at significantly higher concentrations in the drain compared to that of the concentrations in Paw Paw Lake (Sites NL-2 and NL-3 used as a comparison).

- Total suspended solids and ammonia concentrations appear to be strongly impacted by weather conditions – for example rainfall, runoff, and temperature. This is supported by the observation that each site monitored had similar patterns of behavior over time. For example, there were multiple instances where every site increased, decreased or stayed the same compared to the previous sample event, and increased or decreased at a similar magnitude at each site. While this may not always be true for every sample event, the data currently suggest this trend.

- Nitrate and total phosphorus data did not appear to follow any overarching trends as TSS and ammonia did. During the 2020 monitoring season, site A3 did have relatively consistent concentrations of nitrate in each of the three sampling events. Sites A1 and A2; however, had inconsistent concentrations.

- Sample Site A2 (Green Drain) had the highest concentration of total phosphorus on average for the year 2020. Historically (2017 – 2019), site A3 (upstream from the in-line basin adjacent to M-140) had the highest concentrations of total phosphorus. This site was not monitored in the 2020 season.

- As always, more datapoints lead to a more complete understanding of environmental conditions in a waterbody. The datapoints that were collected allow for insight on basic water quality conditions. However, for statistical analysis and drawing conclusions on major trends in the data, more datapoints are needed.

Figure 20- In-line detention basin adjacent to M-140.
Photo taken on October 7, 2019.