Lake Iroquois Association

Tributary Water Quality Monitoring

2018

Ecosystem Restoration Program - Culvert & Stream Restoration Project - Pine Shore Road, Hinesburg, VT

-Photos by Shannon Kelly

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Acknowledgements

Template

This document is one of five templates or guidance documents generated by the VT Department of Environmental Conservation (VT DEC) to support watershed groups engaged in ambient water quality monitoring under the LaRosa Partnership Program. These templates provide examples of data reduction and visualization, as well as statistical analysis, that enable more effective communication of the data – to constituents of Partnership groups; to local, state and federal partners in project implementation; and to the VT Agency of Natural Resources for meeting a variety of needs (e.g., listing / delisting of waters, basin planning, prioritization of resources to groups for project implementation). This template has been prepared by South Mountain Research & Consulting of Bristol, VT, under contract to VTDEC.

This template relies on water quality data from the Lewis Creek watershed, where sampling is carried out by a network of trained volunteers operating under the Addison County River Watch Collaborative (fiscal agent, Lewis Creek Association), with logistical and technical support provided by the VTDEC Monitoring, Assessment and Planning Program, the Addison County Regional Planning Commission and South Mountain Research & Consulting. Analytical services are provided by the Vermont Agricultural & Environmental Laboratory (http://agriculture.vermont.gov/vael) in Burlington, VT, through an analytical services partnership grant.

LaRosa Partnership

Since 2003, this monitoring effort and others are made possible through grants provided by the LaRosa Partnership Program (LPP). The Program funding has permitted non-profit organizations with implementation of recurring and non-recurring water quality projects critical to characterizing the many watersheds throughout the state of Vermont. The Lake Iroquois Association (LIA) is grateful for the continued support this grant provides.

Volunteer Support

The Lake Iroquois Association would also like to express its gratitude to Grace Washburn, who graciously volunteered her time over the summer months in support of LIA's tributary monitoring project. Her time was invaluable and allowed the Project Lead to focus energy and effort on other project proposals important for improving the state of Lake Iroquois. Grace's status as a full time Lake resident made her assistance even more meaningful and noteworthy.

Executive Summary

Sampling Approach

From May to October 2018, a total of 180 individual water quality samples were collected at 24 sites (16 tributaries leading to Lake Iroquois and 8 sites along Patrick Brook, Patrick Brook Canal, and a single tributary to Patrick Brook on Partridge Hill Road (hereafter referred to as the Patrick Brook sites). The LaRosa grant submittal proposed to collect 288 individual water quality samples but was not fully realized due to the dry season and lack of flow at some sites during the sampling season. Collection periodicity averaged every 10-14 days for a total of 12 site visits. Method of collection at each site was a grab sample taken from the centroid of the stream in the middle of the water column. Grab sampling is a straightforward technique that involves a single sample collected immediately at a specific time. With the exception of the digested phosphorous samples, each sample collection bottle was rinsed three times with native water before final sample collection. Samples were delivered to the Vermont Agriculture and Environmental Laboratory (VAEL) currently located in the Hills Building at the University of Vermont. The Lake Iroquois Association performed basic data analysis of the results including average and standard deviation. This report summarizes these data in the sections below and concludes with a discussion of future action in Section 5.

It is also important to note the tributaries to Lake Iroquois and the Patrick Brook sites are classified as B(2) "Medium High Gradient" (MHG) streams, and form the basis of the established water quality standards for each constituent. Class B(2) streams are to be managed to achieve and maintain good biological integrity.

Chlorides

Lab results showed no exceedances of water quality standards for chloride levels (230 mg/L) at any of the 24 sites **(Table 6).**

Site 7 along Pine Shore Road observed the highest average chloride level observed for the Lake Iroquois tributaries at (52.9 mg/L). This site is consistently higher than any of the other Lake Iroquois tributaries. **Site 2** on the eastern side of the Lake observed the lowest average chloride value at 2 mg/L.

Site 24 on Patrick Brook Canal (just above its confluence with the LaPlatte River) observed the highest average chloride levels of all the Patrick Brook sites and of all sites overall at 58.2 mg/L. **Site 11** just below the Lake Iroquois dam showed the lowest average chloride levels of the Patrick Brook sites at 14.9 mg/L.

Note: Site 11 is technically considered part of the Lake Iroquois 'tributaries' but for the purpose of this discussion is considered a legitimate part of Patrick Brook.

Phosphorous

***-Of 178 phosphorous samples collected across ALL sites, 75% (134) exceeded the water quality standard of 15 µg/L for phosphorous (*Table 7).**

-Of 90 Lake Iroquois tributary water quality samples collected, 62% (56) exceeded the water quality standards.

-Of 88 samples collected from the Patrick Brook sites, 92% (81) exceeded the state standards for phosphorous.

Of the **Lake Iroquois tributaries**, **Site 3** (Beebe Lane) observed the highest average phosphorous level for 2018 at (62.8 µg/L). **Site 12** observed the second highest average phosphorous level at 52 µg/L. **Site 9** observed the lowest average phosphorous level for 2018 at 12.4 µg/L.

Of the **Patrick Brook sites**, **Site 24** observed the highest average phosphorous level for 2018 was observed at 72.7 µg/L. **Site 17** (above the bridge on Pond Brook Road) observed the lowest average phosphorous level for 2018 at 18.5 µg/L.

It is also worth noting that although Site 5 (Old Pump Road) was dry most of the year, the average phosphorous levels were significantly lower than in all previous years. Sampling data in 2019 may provide a better understanding of the effectiveness of the Pine Shore Ecosystem Restoration Project, however, the 2018 data suggest improvements made in 2017 are already having a positive impact on water quality. Visually, sedimentation was largely absent during periods of flow and should continue to decrease as vegetation becomes well established upstream within the channel, and the rock-lined channel installed running parallel to the road decreases sediment transport.

Total Suspended Solids (TSS)

Samples for Total Suspended Solids (TSS) were collected only from the Patrick Brook sites with the exception of Site 11 just below the Lake Iroquois dam. ***No exceedances were observed due to the fact no water quality standard exists for Total Suspended Solids in B(2) "Medium High Gradient" (MHG) streams.*** Results are presented in **Table 9.**

Site 19 (tributary to Patrick Brook just off Partridge Hill Road) observed the highest average Total Suspended Solids at 18.8 mg/L. **Site 20** (above the bridge on Mechanicsville Road in Hinesburg) observed the lowest average Total Suspended Solids at 3.44 mg/L.

1.0 Introduction

This is the sixth season of the Lake Iroquois Association (LIA) tributary monitoring initiative that began in 2011 and is supported by the LaRosa Volunteer Water Quality Monitoring Analytical Services Partnership (LaRosa Partnership Program). The Lake Iroquois Association, a Section 501(c)(3) environmental conservation organization focused on the water quality of Lake Iroquois in Vermont, manages the initiative. Design of the LaRosa project, including preparation of the initial proposal, handling of pre-log packets, sample bottle requests, field sampling, and delivery of samples to the laboratory was handled by a LIA Board member and a summer volunteer during the 2018 season.

Present usage of the Lake, its persistently high water level, shoreline erosion, runoff from development and roads, outdated septic systems and other factors are suspected of accelerating the productivity and increasing nutrient concentrations within the Lake. Increasing nutrient loads in the Lake have impaired the water quality and public uses of Lake Iroquois and contribute to elevated nutrient levels in Lake Champlain. The Lake has a significant invasion of Eurasian water milfoil (Myriophyllum spicatum). In the fall of 2010, 2011, 2017 and 2018, blooms of blue-green algae (Cyanobacteria) occurred in the Lake. Assuming no change in current regulations, it is anticipated that changes in the watershed such as new development and increased motor boat usage in the Lake will continue unabated due to anticipated, population growth in proximity of the Lake, particularly Hinesburg and Williston.

The Lake Iroquois Association additionally elected to sample eight locations on Patrick Brook. Patrick Brook had not been sampled for water quality since 2008, and discussions with the Vermont Department of Environmental Conservation (VT DEC) led to agreement this would be a worthy undertaking in order to inform future objective outlined in the Winooski Tactical Basin Plan. At the request of VT DEC, nearly all sites selected were ones previously sampled under the Department's Biomonitoring and Aquatic Studies (BASS) program.

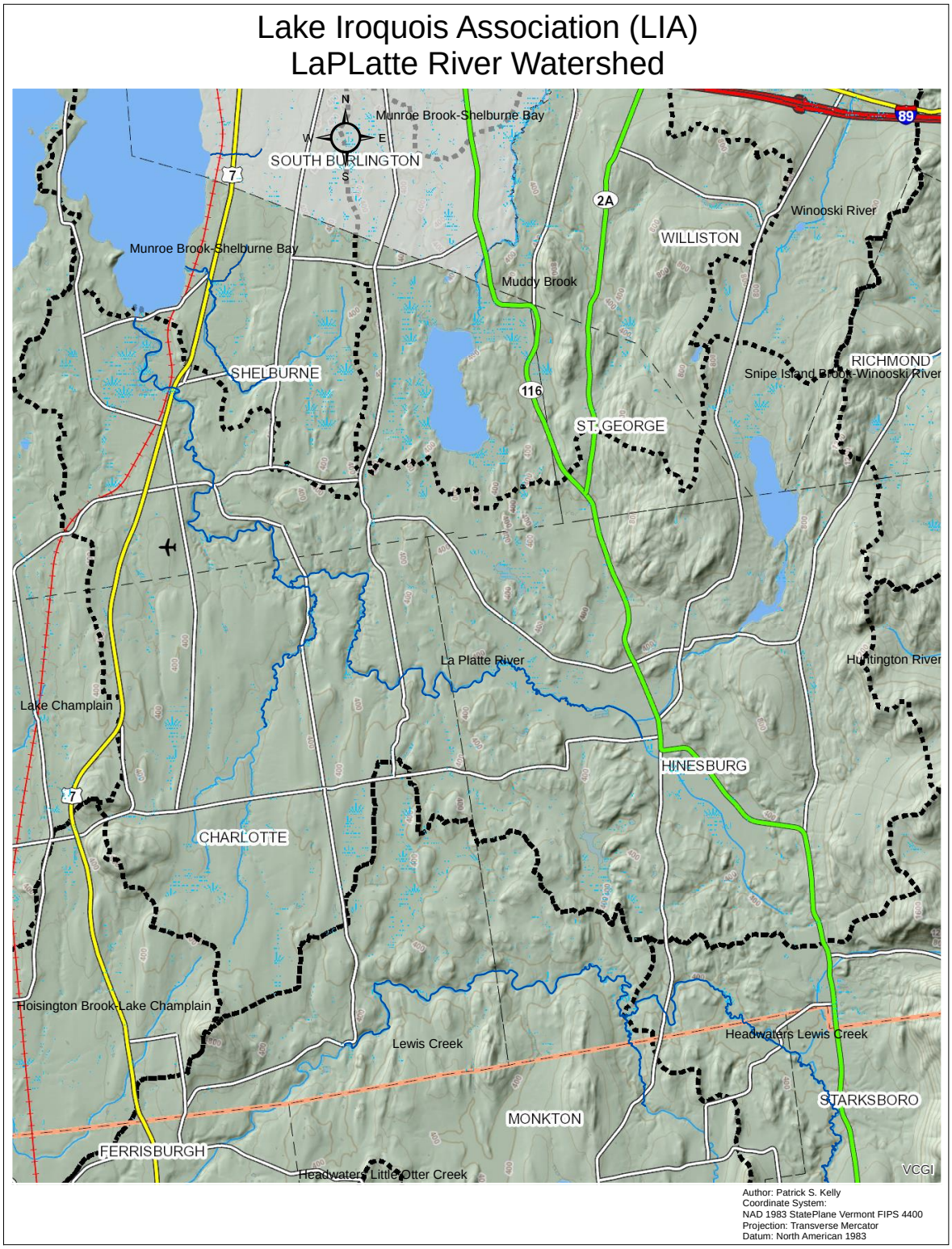
2.0 Background

2.1 Description of Watershed

Lake Iroquois, known formerly as Hinesburg Pond and hereafter referred to as 'the Lake', is a 229-acre eutrophic kettle pond bordered by the towns of Hinesburg, Williston, and Richmond. The town of St. George also lies within the Lake's watershed. The Lake is situated in a valley bracketed by Dow and Magee Hills to the east and Mount Prichard on the west. The Lake lies about 15 miles from Vermont's principal urban area of Burlington and is

the largest body of water in the LaPlatte River watershed, which drains to the greater Lake Champlain watershed (**Figure 1**).

Figure 1. LaPlatte River Watershed



The Lake was formed following the receding of the last ice coverage in Vermont about 15,000 years ago. Over the years, the Lake has naturally become more eutrophic, and has

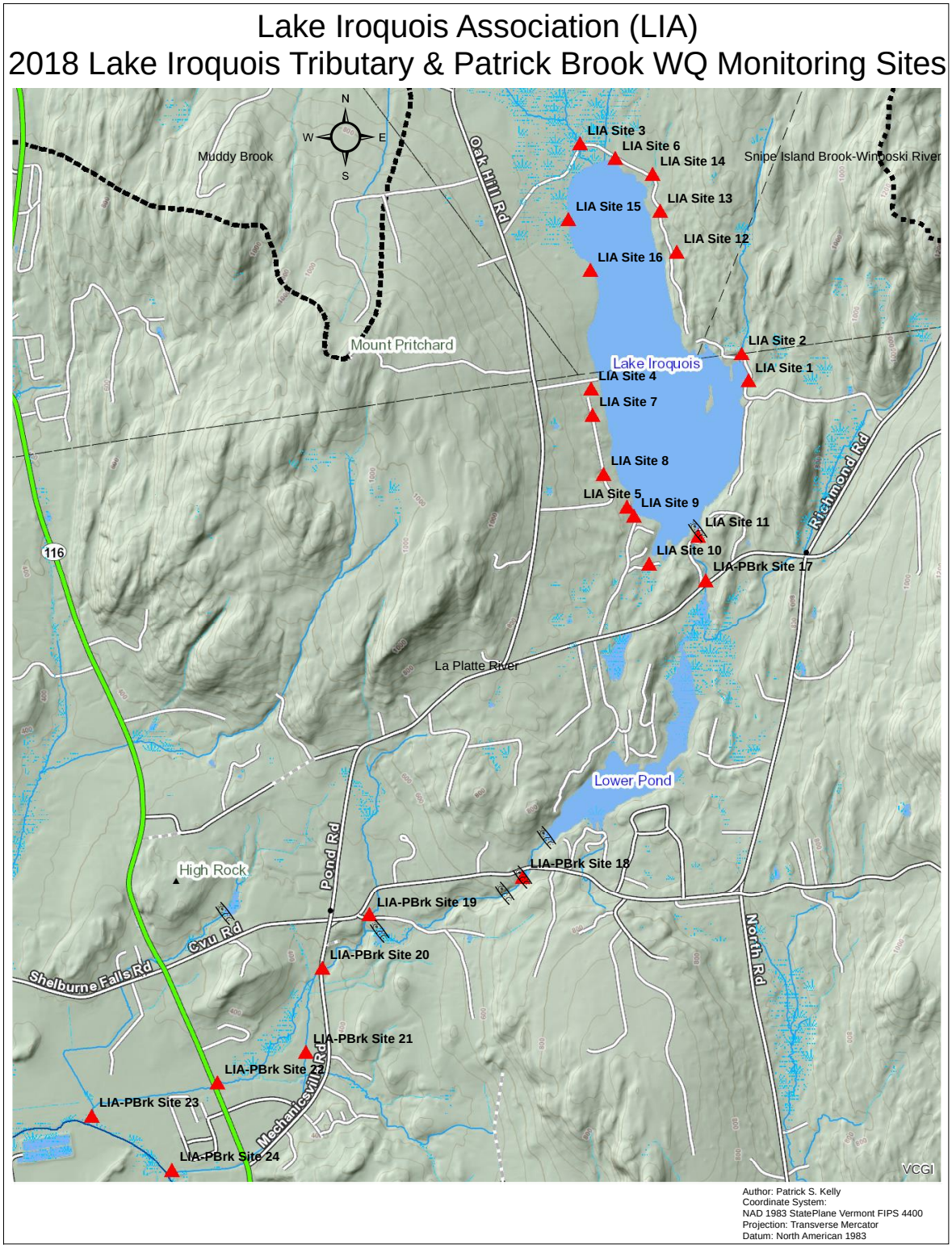
been the site of significant human development and use in the last 150 years. A dam constructed on the Lake's outlet in the mid-1800s led the spring-fed body of water to rise above the existing banks and was used to control the water supply to mills downstream in Hinesburg. These mills are no longer operational. Around the 1960s, the dam was intentionally cemented into its top position, retaining the pond at an artificially high level throughout the year. The outflow of the Lake is over the dam in the south end and forms Patrick Brook. It is interesting to note that historic U.S. Geological Survey and Town maps dating back to the 1800s show the stream formerly labeled as Pond Brook all the way to its confluence with the LaPlatte River. This outlet stream first flows into Sunset Lake (formerly known as Lower Pond) and eventually through the Town of Hinesburg, prior to draining into the LaPlatte River on its way to Lake Champlain.

Ninety-one camps and homes are located on the lake shore. In 1958, the four towns in the watershed formed the 150-acre Lake Iroquois Recreation District (LIRD), which operates a public beach and the 1.3-mile Lake Iroquois Walking Trail on the northeast end of the Lake. The Vermont Fish & Wildlife Department maintains a public fishing access at the northwest end of the Lake. Some conserved land exists at the north end. Much of the remaining lake shore has been developed, with many summer camps and year-round residences built close to the shoreline.

2.2 Description of Lake Iroquois Tributary and Patrick Brook Sampling Locations

Figure 2 below illustrates the location of each tributary sampling location around Lake Iroquois and sample sites on Patrick Brook. **Table 1** describes the sampling locations in detail.

Figure 2. Lake Iroquois tributary and Patrick Brook sampling locations



Lake Iroquois Tributaries

Site 1: This stream originates from Magee Hill. The stream crosses under Richmond Road (a paved, well-traveled public road running from Hinesburg to Richmond) and passes through culverts under East Shore Road and Dimick Road before entering the Lake on its east shore. Through historic observation, this is the largest tributary of Lake Iroquois and it is known to generally flow continuously through the season. The sampling location was approximately 10 meters from the Lake. The stream is contained in a mostly rocky-bottomed bed before entering the Lake.

Site 2: This stream enters a marshy area after passing beneath Dimick Road prior to entering the east side of the Lake. The sampling location resides above the culvert on Dimick Road and is approximately 30 meters above the stream entrance to the Lake. This stream is believed to drain a largely wooded area to the east of the Lake and does not appear to pass over or beneath any regularly used public or paved roads.

Site 3: This stream may be considered the inlet and a principle contributor to the Lake. This tributary drains a large, low-lying area on the north side of the Lake. This northern portion of the Lake contains a wetland and would be a larger marsh if not for the dam on the Lake's southern outlet, which artificially maintains an elevated water level above the Lake's natural pool. There are several smaller streams that converge upstream of the sampling site. The stream passes beneath Beebe Lane and drains sparsely developed areas in Williston north of the Lake. The watershed area extends north of South Road in Williston. The sampling location from 2011-2014 was below the culvert. The sampling conducted in 2017 was above the culvert. *The sample location was shifted in 2018 once again to just below the culvert at the request of Karen Bates, Watershed Coordinator for the Vermont Department of Environmental Conservation.*

Site 4: This stream originates on Mount Pritchard and descends in a line perpendicular to the Lake's western shore, ultimately crossing beneath Pond Road. The stream bed is partly man-made as a result of development, and runs parallel to Shadow Lane, a dirt road sloping perpendicular to the Lake shore. This Site is influenced by remediation work, including the construction of retention ponds, undertaken in 2012 and extending into summer and fall 2013.

Site 5: This is an intermittent Site on the Lake's west side whose stream bed had been impacted significantly by development. This stream crosses Pond Road via a culvert and similar to Site 4, drains an area descending directly to the west side of the Lake.

Site 6: This is an intermittent drainage area at the north end of the Lake leading from a wooded area through a culvert beneath Beebe Lane and discharging directly into the Lake.

Site 7: This tributary is located on the west side and conveys water across Pond Road. The stream is impacted by runoff from developed areas uphill and to the west of Pond Road. The stream passes beneath Pine Shore Road prior to entering the Lake.

Site 8: This stream is located on the west side of the Lake and passes beneath Pine Shore Road.

Site 9: A stream that drains an area on the southwest side of the Lake, flowing parallel to Southwest Shore Road and passing beneath Old Pump Road prior to discharge to the Lake.

Site 10: This stream drains an area southwest of the Lake which may include agricultural use at its headwaters. The stream enters a swampy area south of Pike Point Road prior to passing under a culvert at Pike Point Road and entering the Lake.

Site 11: This site is located below the outlet of the Lake. Samples are taken below the dam.

(NEW!) Site 12: This site is located on an east central portion of Beebe Lane draining the mountain slope running north and south on the eastern side of Lake Iroquois (south of Site 13). The sampling location will be above the culvert.

(NEW!) Site 13: This site is located on an east central portion of Beebe Lane draining the mountain slope running north and south on the eastern side of Lake Iroquois (south of Site 14). The sampling location will be above the culvert.

(NEW!) Site 14: This site is located on an east central portion of Beebe Lane draining the mountain slope running north and south on the eastern side of Lake Iroquois (south of Site 6). The sampling location will be above the culvert.

(NEW!) Site 15: This site is located on a single tributary just above the confluence with the Lake, and just below the confluence of two tributaries; one tributary leads from Oak Hill Road and another paralleling the Vermont Fish and Wildlife Boat Launch off Beebe Lane.

Note: This site demonstrated poor flow and only one sample was collected at the beginning of the season. This site will not be included in the 2019 sampling season.

(NEW!) Site 16: This site is located on a tributary that drains a portion of the Lake's western slope below Oak Hill Road (south of Site 15). The Site is sampled just above the confluence with the Lake.

Note: This site demonstrated poor flow and only two samples was collected at the beginning of the season. This site will not be included in the 2019 sampling season.

Patrick Brook

(NEW!) LIA-PBrk Site 17: This site sits below a clustered residential development interspersed with forested area near Lake Iroquois. The sampling site is located above and adjacent to Pond Road.

(NEW!) LIA-PBrk Site 18: This sampling site is adjacent to Iroquois Manufacturing and below mostly forested area leading from Lower Pond Dam with some dense higher residential development to the northeast side. The sampling location is just below the old Dam off Richmond Road.

(NEW!) LIA-PBrk Site 19: This site is located on Partridge Hill Road below a mostly forested area of light residential density with some influence from multiple roads in its upper reach. The sampling location is just above the culvert on the north side of the road.

(NEW!) LIA-PBrk Site 20: This sampling location is above the bridge off Mechanicsville Road. The site drains the section of forested area between Partridge Hill Road and the start of Hinesburg's urban footprint. The sampling location is above the culvert on the east side of the Road.

(NEW!) LIA-PBrk Site 21: This site is located below open residential area prior to entry into the area of commercial development on Commerce Street. The sampling location is above the confluence with an unnamed tributary passing beneath Mechanicsville Road and Patrick Brook's split with Patrick Brook Canal.

(NEW!) LIA-PBrk Site 22: This site drains much of Hinesburg's urban development prior to entering a straight, channelized run to its confluence with the LaPlatte River. The sampling location is just above Route 116 in Hinesburg.

(NEW!) LIA-PBrk Site 23 (Patrick Brook): This site drains much of the urban, channelized portion of Patrick Brook just above and adjacent to its confluence with the LaPlatte River. The area is surrounded by agricultural fields and related activity.

(NEW!) LIA-PBrk Site 24 (Patrick Brook Canal): This site drains much of the urban, channelized portion of Patrick Brook Canal just above and adjacent to its confluence with the LaPlatte River. The area is surrounded by agricultural fields to the north and is below the former Saputo cheese factory to the east.

Table 1. Physical Habitat & Surrounding Features

Site #	Habitat/Surrounding Features
1	Forested; crosses major local road on east side.
2	Forested; should be the cleanest tributary.
3	Former agricultural area; developed with houses and roads.
4	Developed area on west; road improvements to be monitored.
5	Developed area on west; road improvements to be monitored.
6	Developed area on northeast; forested area to be monitored.
7	Developed area on west; road improvements to be monitored.
8	Developed area on west; road improvements to be monitored.
9	Developed area on west; road improvements to be monitored.
10	Agricultural area; crosses Pond Brook Rd. and camp area in south.
11	Lake outlet; developed area at south end
12	Undeveloped area on the eastern slopes of Lake Iroquois
13	Undeveloped area on the eastern slopes of Lake Iroquois
14	Undeveloped area on the eastern slopes of Lake Iroquois
15	Largely undeveloped area on the northwestern slopes of Lake Iroquois
16	Undeveloped area on the northwestern slopes of Lake Iroquois
LIA-PBrk Site 17	Clustered residential development interspersed with forested area above site
LIA-PBrk Site 18	Adjacent to Iroquois Manufacturing; below mostly forested area leading from Lower Pond Dam with some dense higher residential development to the northeast side
LIA-PBrk Site 19	Mostly forested area below light residential density with some influence from multiple roads in upper reach
LIA-PBrk Site 20	Mostly forested area
LIA-PBrk Site 21	Open residential area above commercial development
LIA-PBrk Site 22	Open area within wetlands heavily influenced by commercial development and impervious surfaces
LIA-PBrk Site 23	Open field below urban developed area of Hinesburg
LIA-PBrk Site 24	Open field below urban developed area of Hinesburg

Table 2. Locational Data

Site #	DD.mmmmm North	DD.mmmmm West
1	44.369204	-73.077965
2	44.370476	-73.078435
3	44.380389	-73.089219
4	44.368760	-73.088387
5	44.363178	-73.085965
7	44.379700	-73.086900
8	44.367512	-73.088308
9	44.364721	-73.087516
10	44.362749	-73.085478
11	44.361827	-73.081231
12	44.375277	-73.082777
13	44.377222	-73.083888
14	44.378950	-73.084400
15	44.376788	-73.089969
16	44.374394	-73.088496
LIA-PBrk Site 17	44.35973	-73.08067
LIA-PBrk Site 18	44.34556	-73.09268
LIA-PBrk Site 19	44.34368	-73.102843
LIA-PBrk Site 20	44.34115	-73.10594
LIA-PBrk Site 21	44.33715	-73.107
LIA-PBrk Site 22	44.33566	-73.11286
LIA-PBrk Site 23	44.334052	-73.12117
LIA-PBrk Site 24	44.331497	-73.115803

2.3 Discharge Measurement

No U.S. Geological Survey or other type discharge gaging stations exist within Lake Iroquois' immediate watershed or along the length of Patrick Brook. Table 3 outlines each qualitative discharge flow level and category.

Table 3. Qualitative Flow Level and Category

Qualitative Discharge		
Sites 1-24		
Date	**Flow Level**	**Category**
6-May	High	Freshet
14-May	Moderate	Base
31-May	Moderate	Base
11-Jun	Moderate	Base
27-Jun	High	Freshet
14-Jul	Low	Base
25-Jul	Low	Base
20-Aug	Low	Base
2-Sep	Low	Base
17-Sep	Low	Base
1-Oct	Low	Base
11-Oct	Low	Freshet

2.4 History of Water Quality Monitoring

Lake Monitoring

Since the late 1970s, samples of phosphorus and chlorophyll, in addition to Secchi disk measurements for clarity have been taken as part of the Vermont Lay Monitoring Program (LMP).

Lake Iroquois Tributaries

In 2010, a LIA watershed survey identified as many as 21 tributaries flowing into Lake Iroquois. Many of these tributaries flow intermittently during the period of the year when the Lake is not frozen. A number of these tributaries formed artificially as a result of development around the Lake, including the construction of homes, roads, and parking areas. Five tributary sites were originally monitored beginning in 2011 and five others added in 2012, continuing through 2014. The purpose was to provide general water quality data on water flowing into the Lake and determine the effectiveness of remediation projects being

undertaken on the western shore. Tributary monitoring was suspended for two seasons in 2015 and 2016 while the LIA continued its work planning and assessing run-off mediation projects on the Lake's west shore. Sampling was resumed during the 2017 season. Sampling was suspended at Site 6 during the 2017 due to reports of inconsistent flow. In 2018, LIA decided to expand efforts to additional locations not previously sampled in order to determine if any of the other tributaries were contributing nutrients to the Lake. Sampling was also renewed at Site 6. The decision was based on the fact that even ephemeral flow contributes inputs to the Lake, and still contributes to the overall character of inputs to the Lake. In addition, LIA consulted with the Vermont Department of Conservation on an initiative to include eight additional sites on Patrick Brook, Patrick Brook Canal, and a single tributary to Patrick Brook. All sites are described in Section 2.2 and shown in Figure 2.

Water quality sampling was carried out by two volunteers operating under an EPA-approved Quality Assurance Project Plan during the period of May 6 through October 11, 2018. The Project Manager and a volunteer sampled each site having flow on average every 10-14 days. Analytical services are provided by the Vermont Agricultural & Environmental Laboratory in Burlington, VT. In earlier years, analytical services were provided by Endyne, Inc. (2000-2002). Lab tests were performed for chloride and total phosphorus at all stations. Samples for total suspended solids were added to all Patrick Brook sites except for Site 11 below the dam on Lake Iroquois.

3.0 Methods

Wadeable tributary samples were collected within the thalweg (lowest point of the stream) at the vertical midpoint of the water column. Each sample collection bottle was rinsed no less than three times with native water with the exception of the Total Phosphorous, which required no rinse. Samples were stored in a cooler and delivered to the lab within 24 hours following collection.

3.1 Quality Assurance

The Quality Assurance Project Plan (QAPP) was developed based on the "Generic QAPP" template provided by VT DEC. The Program relies wholly on volunteers and sampling in 2018 was handled by the Project Coordinator and a summer volunteer. Training for the Program included a spring training session in April 2018 at the VT DEC lab located at the University of Vermont. Table 4 outlines quality assurance measures for Chlorides, Total Phosphorus, and Total Suspended Solids (TSS).

Regular Data

October 11, 2018

Only one regular sample at Site 10 was rejected due to what appeared to be an abnormally high phosphorous value of 375 µg/L. No duplicate sample was scheduled for this location. However, it appears cross-contamination may have occurred with the sample collection tube or possible error with the in-stream sampling such as collection too close to the bottom of the stream bed. The Project Leader, Shannon Kelly, made the decision to reject this sample.

QAPP – Summary of steps need for data analysis

Duplicates

To assess the precision of results, the Mean Relative Percent Difference (RPD) between field duplicate samples should be calculated. The average RPD should be less than or equal to the Estimated Precision listed in Table 4. This simple measure is calculated as follows:

$RPD_{\text{field duplicate pair 1}}$ = absolute value ($sample_1$ - $sample_2$) / average ($sample_1$ and $sample_2$); and, the Mean RPD for "n" duplicate pair = average ($RPD_{\text{pair 1}}$ + $RPD_{\text{pair 2}}$ + ... + $RPD_{\text{pair n}}$)

Three dates below reflect unusual duplicate values flagged for further attention (See Table 4).

May 31, 2018

The value flagged showed a duplicate value for total phosphorous over five times the regular result. The Lake Iroquois Association concurs this value should be dismissed due to suspected cross-contamination of the sample.

June 27, 2018

The second set of duplicate total values for total phosphorous were collected in the midst of a stormwater event and a fast rise which may explain the disparity. The Lake Iroquois Association does not agree these results should be rejected.

September 2, 2018

The value flagged showed a duplicate value exceeding the total phosphorous precision limit of ≤ 30% for field duplicates versus the regular result. The Lake Iroquois Association concurs this value should be dismissed due to suspected cross-contamination of the sample.

Blanks

Average Blank Concentrations (**Table 5**) below reflect suspected lab contamination and field contamination:

May 14, 2018

Blank samples most likely experienced cross-contamination in the field.

June 11, 2018

Blank samples most likely experienced cross-contamination in the field.

September 17, 2018

Due likely to lab contamination – data was rejected from the results.

Table 4. Quality assurance measures for chlorides, total phosphorus, & Total Suspended Solids

Location	Date	Test	Dup Results	Regular result	Units	Precision for Field Duplicates	RPD Analysis
LIA003 (Site 3) DUPLICATE	5/6/2018	Chloride	15.9	16.2	mg/L	≤ 5%	1.869158879
LIA003 (Site 3) DUPLICATE	5/6/2018	Phosphorus - Digested	**16.1**	**17**	ug P/L	≤ 30%	5.438066465
LIA-PBrk Site 20 (Site 20) DUPLICATE	5/14/2018	Chloride	**21.7**	**21.5**	mg/L	≤ 5%	0.925925926
LIA003 (site 3) DUPLICATE	5/14/2018	Chloride	**17.8**	**17.7**	mg/L	≤ 5%	0.563380282
LIA003 (site 3) DUPLICATE	5/14/2018	Phosphorus - Digested	**16.4**	**17.3**	ug P/L	≤ 30%	5.341246291
LIA-PBrk Site 20 (Site 20) DUPLICATE	5/14/2018	Phosphorus - Digested	**26.7**	**22.5**	ug P/L	≤ 30%	17.07317073
LIA-PBrk Site 20 (Site 20) DUPLICATE	5/14/2018	Solids, Total Suspended	7	6	mg/l	≤ 15%	15.38461538
LIA-PBrk Site 20 (Site 20) DUPLICATE	5/31/2018	Chloride	**24.6**	**26.9**	mg/L	≤ 5%	8.932038835
LIA003 (Site 3) DUPLICATE	5/31/2018	Chloride	**20.5**	**19.8**	mg/L	≤ 5%	3.473945409
LIA003 (Site 3) DUPLICATE	5/31/2018	Phosphorus - Digested	**159**	**801**	ug P/L	≤ 30%	**133.75 Concur to reject - this may be due to cross contamination of the sample**
LIA-PBrk Site 20 (Site 20) DUPLICATE	5/31/2018	Phosphorus - Digested	**24.4**	**26.9**	ug P/L	≤ 30%	9.746588694
LIA001 (Site 1) DUPLICATE	6/11/2018	Chloride	8.55	8.59	mg/L	≤ 5%	0.466744457
LIA001 (Site 1) DUPLICATE	6/11/2018	Phosphorus - Digested	12.1	12.5	ug P/L	≤ 30%	3.25203252
LIA010 (Site 10) DUPLICATE	6/27/2018	Chloride	**24.1**	**23.7**	mg/L	≤ 5%	1.673640167
LIA009 (Site 9) DUPLICATE	6/27/2018	Chloride	**16.1**	**16.1**	mg/L	≤ 5%	0
LIA009 (Site 9) DUPLICATE	6/27/2018	Phosphorus - Digested	**31.1**	**15.3**	ug P/L	≤ 30%	**68.10344828 Collection took place during a stormwater event with a fast rise**
LIA010 (Site 10) DUPLICATE	6/27/2018	Phosphorus - Digested	**41.6**	**40.2**	ug P/L	≤ 30%	3.422982885
LIA003 (Site 3) DUPLICATE	9/2/2018	Chloride	6.19	6.06	mg/L	≤ 5%	2.12244898
LIA003 (Site 3) DUPLICATE	9/2/2018	Phosphorus - Digested	**93**	**60.1**	ug P/L	≤ 30%	**42.97844546 Collection took place during a stormwater event with a fast rise**
LIA005 (Site 5)-DUPLICATE	10/11/2018	Chloride	14.8	15.1	mg/L	≤ 5%	2.006688963
LIA005 (Site 5)-DUPLICATE	10/11/2018	Phosphorus - Digested	19.2	17.2	ug P/L	≤ 30%	10.98901099

Table 5. Average Blank Concentration

Blanks						
Sample Number	Location	Date	Chloride (mg/L)	TP(ug P/L)	TSS (mg/L)	
181954-05	LIA-PBrk Site 17 (Site 17)- BLANK	9/17/2018	22.6	279.6	< 2	Note: These values were likely due to a bottle contamination from the lab. They can be thrown out of the dataset.
181792-06	LIA-PBrk Site 17 (Site17)-BLANK	9/2/2018	< 2	< 5	< 2	
181653-05	LIA-PBrk Site 17 (site 17) -BLANK	8/20/2018		< 5	< 2	
181419-06	LIA-PBrk Site 17 (Site 17) - Blank	7/25/2018	< 2	< 5	< 2	
181329-09	LIA-PBrk Site 17 (Site 17)-BLANK	7/14/2018	< 2	< 5	< 2	
181197-19	LIA-PBrk Site 17 (Site 17) BLANK	6/27/2018	< 2	< 5		
180995-12	LIA014 (Site 14) BLANK	6/11/2018	< 2	212		Note: Bottle contamination from the lab not likely the reason for these values (lab contamination happened in August and September).
180772-18	LIA-PBrk Site 17 (Site 17)-BLANK	5/14/2018	< 2	16.4	< 2	

Table 6. Laboratory Analysis Protocols for Water Samples

Parameter	Reporting Limit [A]	Accuracy[B] (% Recovery)	Estimated Precision for Field Duplicates [C] (RPD)	Laboratory Precision (RPD)	Analytical Method Reference[B]
Total and dissolved phosphorus	5 µg/l	85-115%	≤30%	15% [B]	*Standard Methods for the Examination of Water and Wastewater* (21st ed.) 4500-P H
Total Suspended Solids	1 mg/L	80-120%	≤15%	≤ 15%	*Standard Methods for the Examination of Water and Wastewater* (21st ed.) 2540D
Chlorides	230 mg/L	85%-115%	≤5%	≤15%	*Standard Methods for the Examination of Water and Wastewater* (21st ed.) 4500-N C

(A) - Reporting Limit is the minimum reported value (lowest standard in calibration curve or MDL x 3)
(B) - Section 5.0, Vermont Dept. of Conservation Laboratory QA Plan, 2008
(C) - Generated by the analysis of field duplicates

4.0 Results and Discussion

Graphic illustrations of the mean measured concentrations (with standard deviation) of Chloride, Total Phosphorus (TP), and Total Suspended Solids (TSS) are provided in Excel spreadsheets submitted with this report. Concentrations of the analytes for each sampling event are included in the Excel spreadsheets as well. The following observations for 2018 are summarized in the Tables below.

CHLORIDES

The Vermont Water Quality standards adopted a chloride chronic toxicity criterion of 230 mg/L (daily mean over four-day period), and 860 mg/L acute toxicity (one day mean) on October 30, 2014. Chloride becomes toxic to aquatic life once levels approach 230 mg/L.

All chloride levels observed were well below the Vermont Water Quality Standards with no exceedances in 2018 **(Table 7.)**.

Lake Iroquois Tributaries

Highest Average 2018 Value: Site 7 (52.9 mg/L)

Highest Multi-year average: Site 7 (50.7 mg/L)

Lowest Average 2018 Value: Site 2 (2 mg/L)

Lowest Multi-year average: Site 2 (2.87 mg/L)

Sample sites on the west and southern side of the Lake continue to be notably higher. These sample sites receive runoff from developed areas including Pond Road, Pine Shore Road, and Southwest Shore Road. Site 7 collects runoff from Pond Road in addition to the private roads above (Dynamite Hill) and below the road (Pine Shore Road). The 2018 and multiple-year average chloride levels for Site 2 are the lowest, suggesting a correlation with seasonal use of camps within that portion of the watershed.

Table 7. Mean Total Chlorides in Lake Iroquois Tributaries (mg/L)

Sites	2011	2012	2013	2014	2017	2018	Multi-Year Avg
1	8.0	13.0	12.0	-	13.28	13.18	11.89
2	< 2	< 2	< 2	-	3.43	2	2.87
3	12.5	22.0	17.5	-	20.01	8.93	16.2
4	20.0	25.50	23.0	36.81	17.79	33.72	26.1
5	16.0	21.0	17.0	24.33	14.68	19	18.7
6	-	< 2	< 2	14.40	-	2	5.1
7	-	55.0	43.0	59.33	43.43	52.9	50.73
8	-	27.5	23.0	28.91	22.49	26.2	25.6
9	-	16.0	13.0	15.63	13.73	16.52	14.97
10	-	21.0	20.0	-	27.81	25.95	23.69
11	-	-	-	-	14.80	14.87	14.84
12	-	-	-	-	-	2	-
13	-	-	-	-	-	2	-
14	-	-	-	-	-	2	-
15	-	-	-	-	-	12.4	-
16	-	-	-	-	-	22	-
PATRICK BROOK							
LIA-PBrk Site 17	-	-	-	-	-	15.03	-
LIA-PBrk Site 18	-	-	-	-	-	22.72	-
LIA-PBrk Site 19	-	-	-	-	-	41.05	-
LIA-PBrk Site 20	-	-	-	-	-	25.95	-
LIA-PBrk Site 21	-	-	-	-	-	27.07	-
LIA-PBrk Site 22	-	-	-	-	-	28.12	-
LIA-PBrk Site 23	-	-	-	-	-	33.72	-
LIA-PBrk Site 24	-	-	-	-	-	58.02	-

Patrick Brook sites

Highest Average 2018 Value: Site 24 (Patrick Brook Canal just above the confluence with the LaPlatte River) (58.02 mg/L)

Lowest Average 2018 Value: Site 17 (above the bridge on Pond Brook Road (15.03 mg/L)

Note: As referenced in the Executive Summary, Site 11, which samples Patrick Brook, technically has a lower average value.

PHOSPHORUS

The Total Phosphorus (TP) regulatory value for B(2) "Medium High Gradient" (MHG) streams is 15 µg/L under low, median monthly flow conditions. The nutrient criteria were derived to protect aquatic life from the detrimental effects of enrichment. **Table 7** and **Figure 3** below reflect the average phosphorous levels for 2018 and multiple year averages across all sampling years.

Lake Iroquois Tributaries

Highest Average 2018 Value: Site 3 (62.8 µg/L)

Highest Multi-year average: Site 3 (43.4 µg/L)

Lowest Average 2018 Value: Site 9 (12.4 µg/L)

Lowest Multi-year average: Site 7 (12.9 µg/L)

Beebe Lane is most notable due to the fact it continues to carry the highest average phosphorous levels of all the Sites since 2011. The new sampling locations at Site 12, 13, and 14 observed the second, third, and fourth highest average phosphorous levels at 52 µg/L, 50.8 µg/L and 51.3 µg/L, respectively. These are unexpected results and significant due to the fact the sampling took place above the developed residential areas. Higher numbers shown in tributaries leading from undeveloped areas on the eastern side of the Lake are surprising. One consideration as a potential contributing factor is that the samples were collected immediately below the Beebe Lane roadway and possibly captured nutrients carried by road sediment. Site 9 had the lowest average phosphorus levels in 2018 (12.4 µg/L), but Site 7 has the lowest average across multiple years (12.9 µg/L).

It is also worth noting that although Site 5 (Old Pump Road) was dry most of the year, the average phosphorous levels were significantly lower than in all previous years. Sampling data in 2019 may provide a better understanding of the effectiveness of the Pine Shore Ecosystem Restoration Project, however, the 2018 data suggest improvements made in 2017 are already having a positive impact on water quality. Visually, sedimentation was largely absent during periods of flow and should continue to decrease as vegetation becomes well established upstream within the channel, and the rock-lined channel installed running parallel to the road decreases sediment transport.

Based on higher numbers from disparate input locations across the Lake, these data suggest numerous potential sources of phosphorous including but not limited to 1) agricultural runoff (legacy and present day) 2) failing septic systems 3) sedimentation from roads and erosion features and 4) fertilizers from residential lawns. The trendline in **Figure 3** reflects a slight increase in average phosphorous levels since sampling began in 2011. These data

further underscore the importance of continuing to identify problem areas where Best Management Practices and riparian conservation measures should be implemented to further reduce nutrient loads.

Patrick Brook sites

Highest Average 2018 Value: Site 24 (Patrick Brook Canal just above the confluence with the LaPlatte River) (72.7 µg/L)

Lowest Average 2018 Value: Site 17 (above the bridge on Pond Brook Road (18.5 µg/L)

Note: As referenced in the Executive Summary, Site 11, which samples Patrick Brook, technically has a lower average value (15.03 µg/L) .

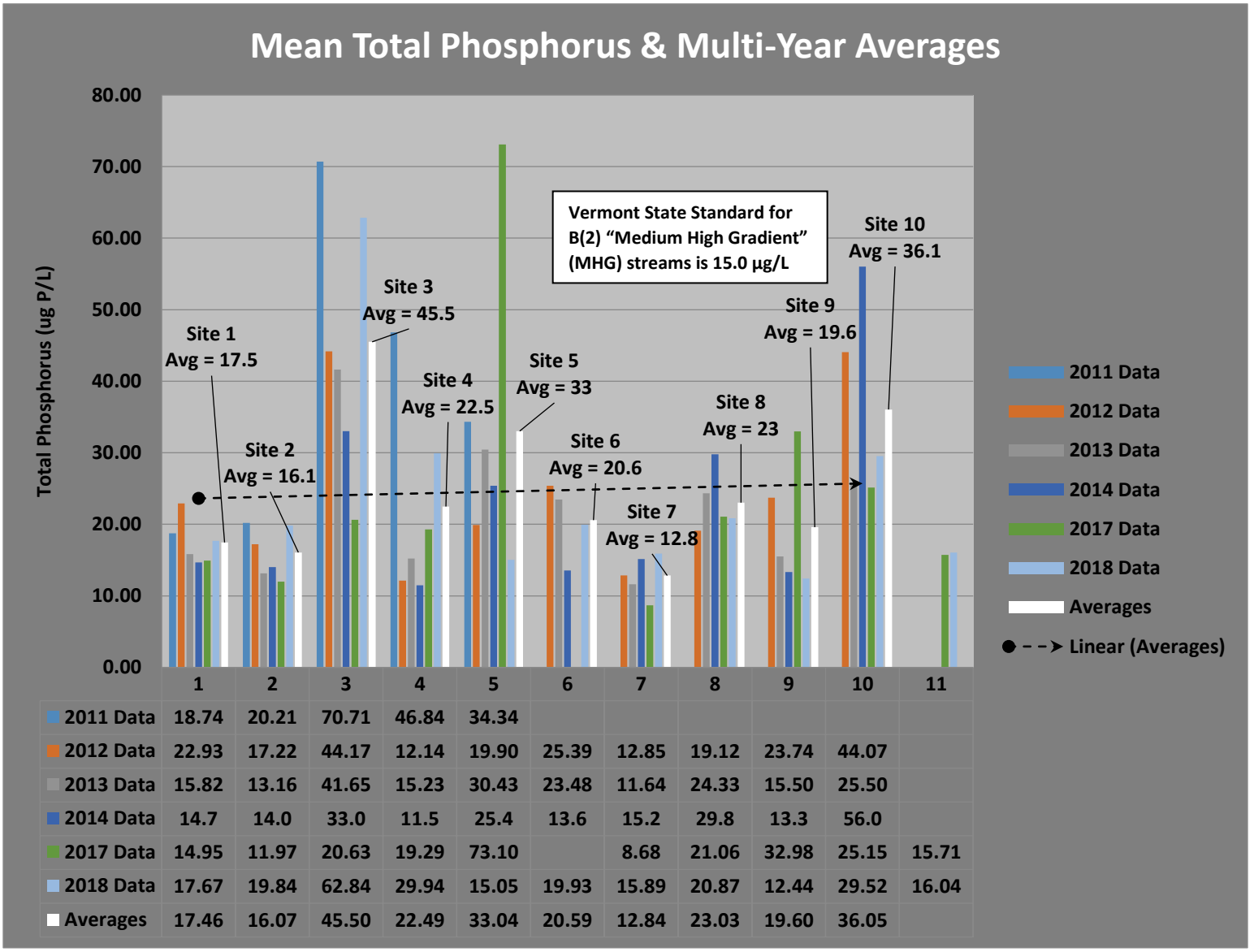
It is interesting to note that outside of Site 24 (Patrick Canal above its confluence with the LaPlatte), phosphorous levels reflected a degree of consistency at each site throughout the season and the data trend indicates an increase as sampling progressed downstream from Site 11 (located just below the dam on Lake Iroquois).

Table 7. Mean Total Phosphorus (µg/L) in Lake Iroquois Tributaries & Patrick Brook

LAKE IROQUOIS TRIBUTARIES							
Sites	**2011**	**2012**	**2013**	**2014**	**2017**	**2018**	**Multi-Year Avg**
1	18.7	22.9	15.8	14.7	15.0	17.67	**17.5**
2	20.2	17.2	13.1	14.0	12.0	19.84	**16.1**
3	70.7	44.2	41.7	20.6	20.6	62.84	**43.4**
4	46.8	12.1	15.2	11.5	19.3	29.94	**22.5**
5	34.3	19.9	30.4	25.4	73.1	15.05	**33.0**
6	-	25.4	23.5	13.6	-	19.93	**20.6**
7	-	12.9	11.6	15.2	8.68	15.89	12.9
8	-	19.1	24.3	29.8	21.1	20.87	**23.0**
9	-	23.7	15.5	13.3	33.0	12.44	**19.6**
10	-	44.1	25.1	56	25.15	29.52	**26.0**
11	21*	18*	17*	14.3	15.7	16.04	***15.3**
12	-	-	-	-	-	52.04	N/A
13	-	-	-	-	-	50.8	N/A
14	-	-	-	-	-	51.3	N/A
15	-	-	-	-	-	13.4	N/A
16	-	-	-	-	-	11.8	N/A
PATRICK BROOK							
LIA-PBrk Site 17	-	-	-	-	-	18.49	N/A

LIA-PBrk Site 18	-	-	-	-	-	21.52	N/A
LIA-PBrk Site 19	-	-	-	-	-	24.4	N/A
LIA-PBrk Site 20	-	-	-	-	-	22.93	N/A
LIA-PBrk Site 21	-	-	-	-	-	21.24	N/A
LIA-PBrk Site 22	-	-	-	-	-	28.6	N/A
LIA-PBrk Site 23	-	-	-	-	-	34.89	N/A
LIA-PBrk Site 24	-	-	-	-	-	72.68	N/A
*** LMP in-lake readings / *Average reflects stream samples only**							

Figure 3. Average phosphorus levels for the sampling year for each site (2011 to 2018)



	1	2	3	4	5	6	7	8	9	10	11
2011 Data	18.74	20.21	70.71	46.84	34.34						
2012 Data	22.93	17.22	44.17	12.14	19.90	25.39	12.85	19.12	23.74	44.07	
2013 Data	15.82	13.16	41.65	15.23	30.43	23.48	11.64	24.33	15.50	25.50	
2014 Data	14.7	14.0	33.0	11.5	25.4	13.6	15.2	29.8	13.3	56.0	
2017 Data	14.95	11.97	20.63	19.29	73.10		8.68	21.06	32.98	25.15	15.71
2018 Data	17.67	19.84	62.84	29.94	15.05	19.93	15.89	20.87	12.44	29.52	16.04
Averages	17.46	16.07	45.50	22.49	33.04	20.59	12.84	23.03	19.60	36.05	

NOTE: Averages reflect Sites 1 through 11 only; remaining Sites have only one year of sample data

TOTAL SUSPENDED SOLIDS

Highest Average 2018 Value: Site 19 (Tributary to Patrick Brook just off Partridge Hill Road) (18.8 mg/L)

Lowest Average 2018 Value: Site 20 (Above the bridge on Mechanicsville Road in Hinesburg (3.44 mg/L)

A total of 68 TSS samples were collected exclusively at the **Patrick Brook sites**. These results track with visual observations of water clarity. The lower number collected (68) compared to the number of phosphorous and chloride samples collected (88) reflects VT DEC's request to reduce the number of sampling periods from the original proposal due to higher LaRosa partnership participation and subsequent funding constraints. The second reason is attributed to lack of flow during drier months.

Table 9. (TSS) Total Suspended Solids (mg/L) in Patrick Brook

Site	2011	2012	2013	2014	2017	2018	Multi-Year Avg
LIA-PBrk Site 17	-	-	-	-	-	5.69	N/A
LIA-PBrk Site 18	-	-	-	-	-	4.22	N/A
LIA-PBrk Site 19	-	-	-	-	-	18.8	N/A
LIA-PBrk Site 20	-	-	-	-	-	3.44	N/A
LIA-PBrk Site 21	-	-	-	-	-	3.52	N/A
LIA-PBrk Site 22	-	-	-	-	-	6.02	N/A
LIA-PBrk Site 23	-	-	-	-	-	10.1	N/A
LIA-PBrk Site 24	-	-	-	-	-	7.33	N/A

5.0 Conclusion

Monitoring serves the following purposes: 1) maintain awareness of a watershed's baseline conditions 2) identify recurring pollutant sources 3) efficiently steer selection of projects leading to corrective action which improve the water quality in Lake Iroquois, the LaPlatte River, and Lake Champlain and 4) educate Lake residents and users about the effect of human actions on water quality and to assess the effects of remedial actions and better practices on water quality.

Proposals for Future Actions

Based on test results of prior years, the Lake Iroquois Association worked with the Lake Iroquois Recreation District (LIRD) to apply and gain approval for a Chittenden County Regional Planning Commission grant in the fall of 2018 to rehabilitate Beebe Lane at the north end of the Lake. The Site 3 data on Beebe Lane shows this tributary has the highest average phosphorous levels of any location. Notable problems include ponding of stormwater on the roadway and erosion and sedimentation, especially during and shortly after the winter season. The Lake Iroquois Association is hopeful this and other grants will allow corrective action in problem areas that serve to reduce erosion, sedimentation, and pollutants from entering the Lake. Other considerations are outlined below.

1. Continue organizational and cooperative outreach efforts that continue to educate and advocate for better property management practices along Lake shorelines and riparian buffer zones. This effort may serve to reduce phosphorus pollution coming from developed properties. Helping homeowners manage stormwater runoff from private roads would also aid in cleaning up the Lake.
2. Narrow the focus on monitoring tributary sites with the highest phosphorus levels. The objectives and goals are:
    a. Expand monitoring efforts on sites with the highest phosphorus levels to incorporate bracketing of the stream that leads to pinpointing pollutant source(s).
    b. Monitor the effectiveness of prior remediation actions through continued sampling.
    c. Continue to identify areas with evidence of erosion and sedimentation and seek project funding for remediation efforts.
3. Continue to strengthen working relationships and seek collaboration with the LaPlatte Watershed Partnership, Lewis Creek Association, and other watershed groups within the LaPlatte Watershed when and where possible.

4. Resume tributary monitoring in May 2019, including outflow monitoring with changes as suggested above.
5. Seek to diversify and expand funding resources.
6. Consider more sophisticated equipment and studies that support increased knowledge of the watershed. Examples include a full-time stream gage at the Lake outlet, a continuous water quality monitoring instrument, and sample discharge monitoring equipment.

Patrick Brook

Although not a central focus of the Lake Iroquois Association's monitoring efforts, the sampling conducted on Patrick Brook, one of its tributaries, and Patrick Brook Canal was important in terms of collecting additional data to gage current nutrient and suspended sediment levels. Patrick Brook and Patrick Brook Canal were and are culturally significant in shaping the Town of Hinesburg by virtue of the mills and ponds created in support of commerce and the Town's needs. Despite the important roles each stream has played, historic channelization has likely increased sedimentation over time. The growing popularity of Hinesburg as a place to live will likely lead to continued development pressure, challenging efforts to reduce nutrient and sediment levels. The information may provide Town planners and the Vermont Department of Environmental Conservation data to consider for future mitigation and development projects.

Lake Iroquois Tributaries

The Lake Iroquois Association Tributary Monitoring Program plans to continue sampling of inputs from the watershed into the Lake. Relative to concentrations of total phosphorus and chloride measured over the 20+ year period of the Lake Champlain Long Term Monitoring Program, the water quality results for the Lake Iroquois tributary monitoring are on par or are better than the average concentrations observed in the LaPlatte River. This is not surprising given the relatively small size of the Lake Iroquois watershed. Chloride levels at all sites are well within the Vermont Water Quality Standards, although notably they continue to be highest at the Site 7 tributary leading from Pond Road on the western shore. A number of sampling locations continue to experience phosphorus levels that do not meet Vermont Water Quality Standards of 15 µg/L, including the five new tributary sampling locations added for 2018.

The Lake Iroquois Association's monitoring efforts continue to be a critical part of its integrated approach to measuring the Lake's health. The Lake Iroquois Association will continue to rely on the tributary monitoring data to support pursuit of grants which address erosion mitigation and sediment control.