Lake Iroquois Association

# Tributary Water Quality Monitoring

# 2019

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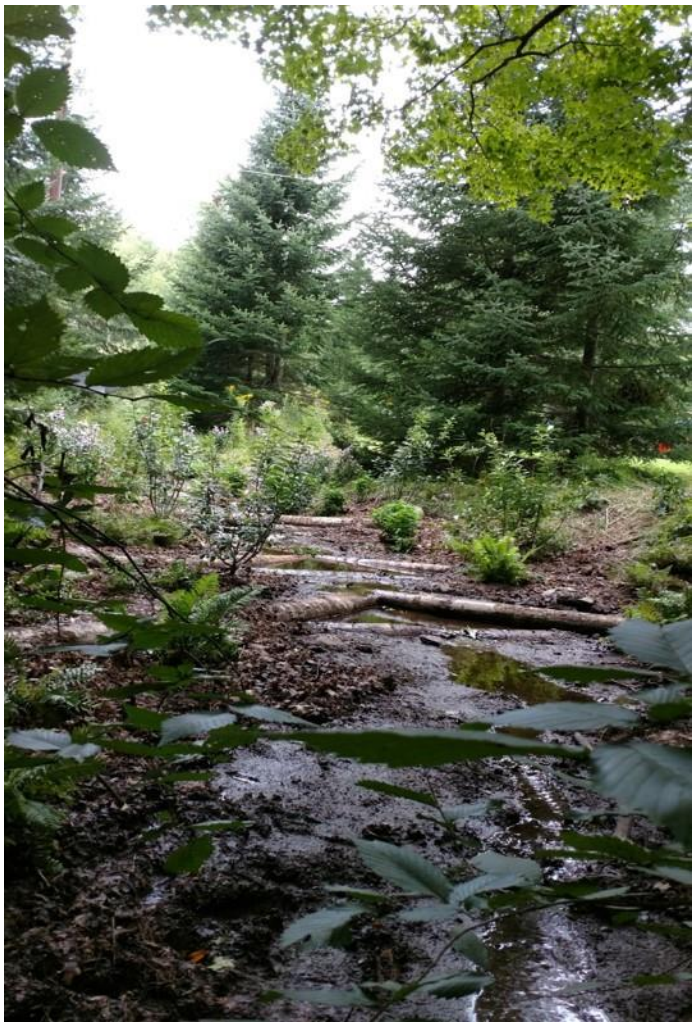
Vermont Department of Environmental Conservation
Watershed Management Division
LaRosa Volunteer Water Quality Monitoring Analytical Services Partnerships Montpelier, VT
**Ecosystem Restoration Program - Culvert & Stream Restoration Project - Pine Shore Rd, Hinesburg, VT**

**2017**



**2018**

**2019**

**Photograph taken mid-morning On November 1st, 2019 following a major storm**

**The restoration work is performing as designed with no major washouts or developing erosion features - and the stream is rediscovering its channel!**

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# Acknowledgements

**Template**

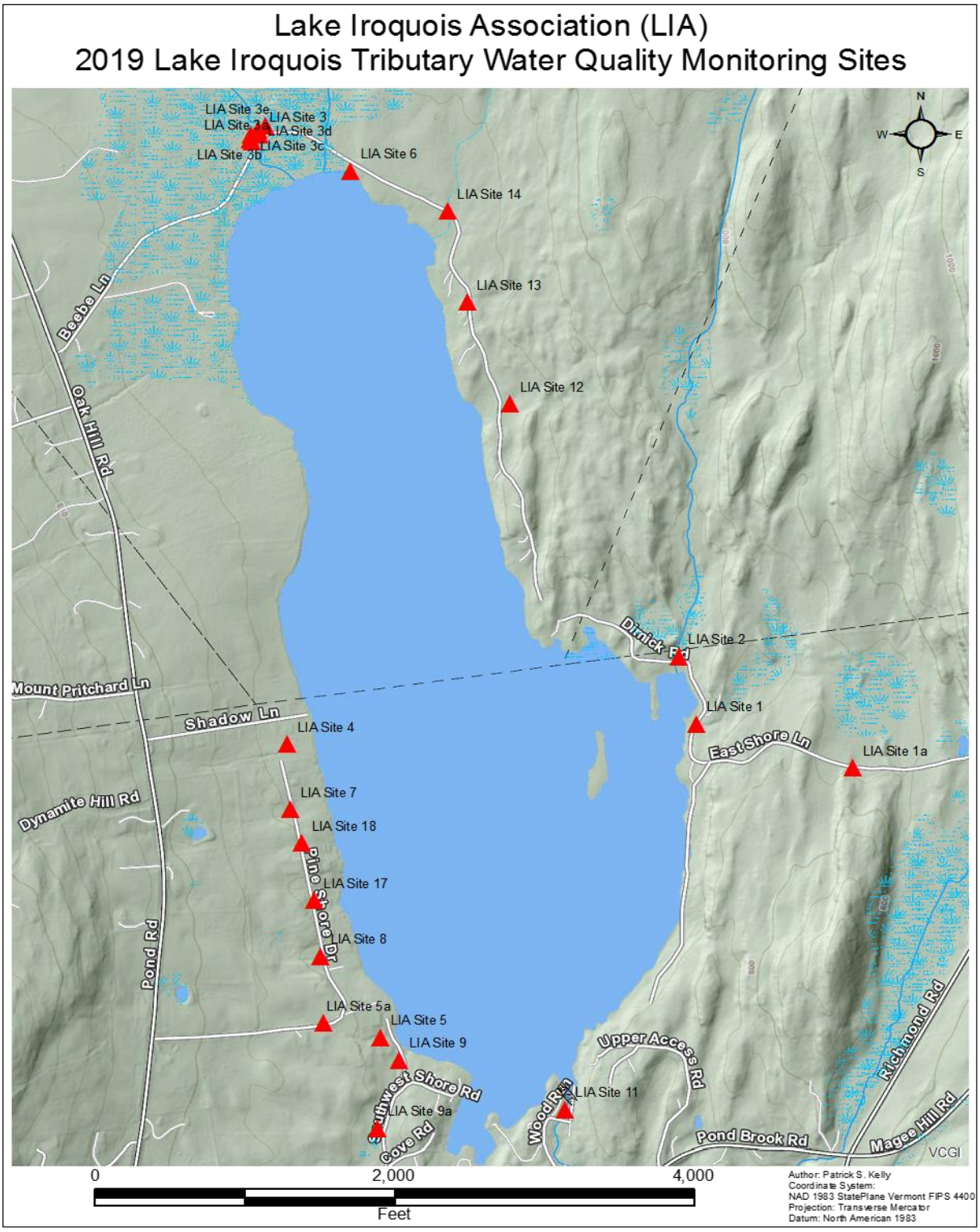
This document is one of five templates or guidance documents generated by the VT Department of Environmental Conservation (VT DEC) to support watershed groups engaged in ambient water quality monitoring under the LaRosa Partnership Program. These templates provide examples of data reduction and visualization, 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.

**Figure 1. Lake Iroquois tributary sampling locations**



# Executive Summary

From May to October 2019, a total of 254 individual water quality samples, including Duplicates and Blanks, were collected at 24 sites (tributaries leading to Lake Iroquois). 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) located in Randolph, 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 important to note the tributaries to Lake Iroquois 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.

**Phosphorous**

Please refer to Figure 1 for Site locations. Figure 2 and Table 1 below summarize the 2019 sampling results.

**Summary highlights:**

- *Across **ALL** **sites**, 103 out of 254 samples (41%) exceeded the water quality standard of 15 µg/L for phosphorous*
- ***Highest Individual & Average Values**: **Site 9*** (below old Pump Road) at *76 µg/L*
- ***Highest number of individual exceedances: Sites 3, 3b, and 3c** (Beebe Lane)*
- ***Highest number of exceedances by date: Sites 3c, 3, and 3b** (Beebe Lane)*
- ***Highest average results: Sites 9** (below Old Pump Road), **3c, 3d, 12, 3b, 3a, and 3** (Beebe Lane)*
- ***Highest Multiple-year average: Site 3** (below Beebe Lane) at 41.3 µg/L*
- ***Highest Seasonal Averages**: **between late July-late September***
- ***Highest number of individual exceedances**: Late July & August*
- ***Lowest Average 2019 Value**: **Site 7** (off Pine Shore Road) at 7 µg/L*
- ***Lowest Multiple-year Average** (two or more seasons): **Site 11** at 15.2 µg/L*

***Figure 2. Average phosphorus levels per Site for 2019***

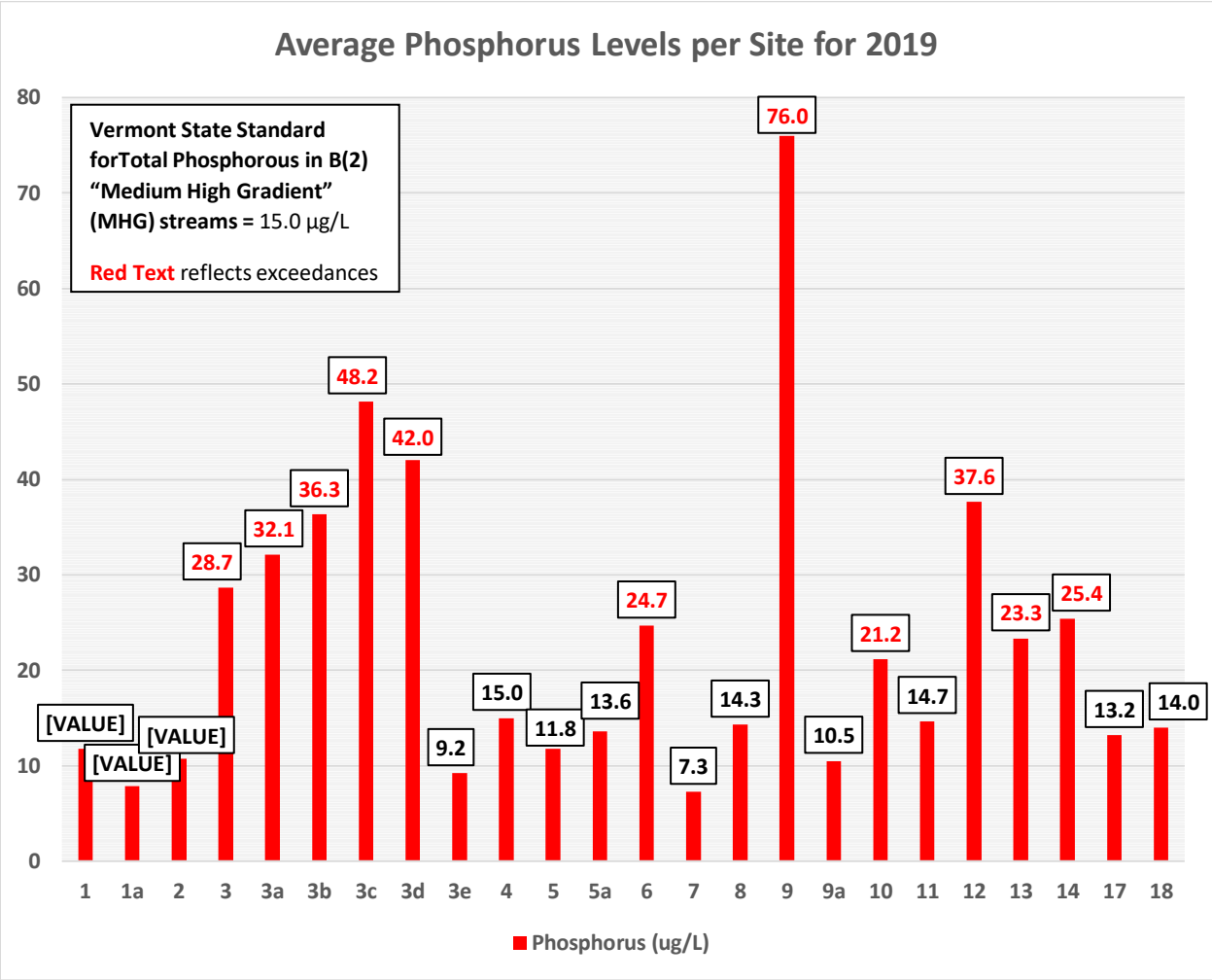


**Table 2. Mean Total Phosphorus (µg/L) in Lake Iroquois Tributaries**

| LAKE IROQUOIS TRIBUTARIES | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Sites** | **2011** | **2012** | **2013** | **2014** | **2017** | **2018** | **2019** | **Multi-Year Avg** |
| **1** | 18.7 | 22.9 | 15.8 | 14.7 | 15.0 | 17.67 | 11.8 | **16.7** |
| **1a** | - | - | - | - | - | - | 7.8 | - |
| **2** | 20.2 | 17.2 | 13.1 | 14 | 12 | 19.84 | 10.8 | **15.3** |
| **3** | 70.7 | 44.2 | 41.7 | 20.6 | 20.6 | 62.84 | 28.7 | **41.3** |
| **3a** | - | - | - | - | - | - | **32.1** | - |
| **3b** | - | - | - | - | - | - | **36.3** | - |
| **3c** | - | - | - | - | - | - | **48.2** | - |
| **3d** | - | - | - | - | - | - | **42.0** | - |
| **3e** | - | - | - | - | - | - | 9.2 | - |
| **4** | 46.8 | 12.1 | 15.2 | 11.5 | 19.3 | 29.9 | 15.0 | **21.4** |
| **5** | 34.3 | 19.9 | 30.4 | 25.4 | 73.1 | 15.1 | 11.8 | **30.0** |
| **5a** | - | - | - | - | - | - | 13.6 | - |
| **6** | - | 25.4 | 23.5 | 13.6 | - | 19.9 | 36.3 | **23.7** |
| **7** | - | 12.9 | 11.6 | 15.2 | 8.68 | 15.9 | 48.2 | **18.7** |
| **8** | - | 19.1 | 24.3 | 29.8 | 21.1 | 20.9 | 42 | **26.2** |
| **9** | - | 23.7 | 15.5 | 13.3 | 33 | 12.4 | 9.2 | **17.9** |
| **9a** | | | | | | | 10.5 | - |
| **10** | - | 44.1 | 25.1 | 56 | 25.15 | 29.5 | 21.2 | **33.5** |
| **11** | 21* | 18* | 17* | 14.3 | 15.7 | 16.0 | 14.7 | *15.2 |
| **12** | - | - | - | - | - | 52.0 | **37.6** | **32.8** |
| **13** | - | - | - | - | - | 50.8 | 23.3 | **37.8** |
| **14** | - | - | - | - | - | 51.3 | **25.4** | **29.3** |
| **17** | - | - | - | - | - | - | 13.2 | - |
| **18** | - | - | - | - | - | - | 14.0 | - |
| *** LMP in-lake readings / *Average reflects stream samples only / Red text denotes exceedance** | | | | | | | | |

# 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 during the 2019 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 late summer and early fall of 2010, 2011, 2017, 2018, and 2019, 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.

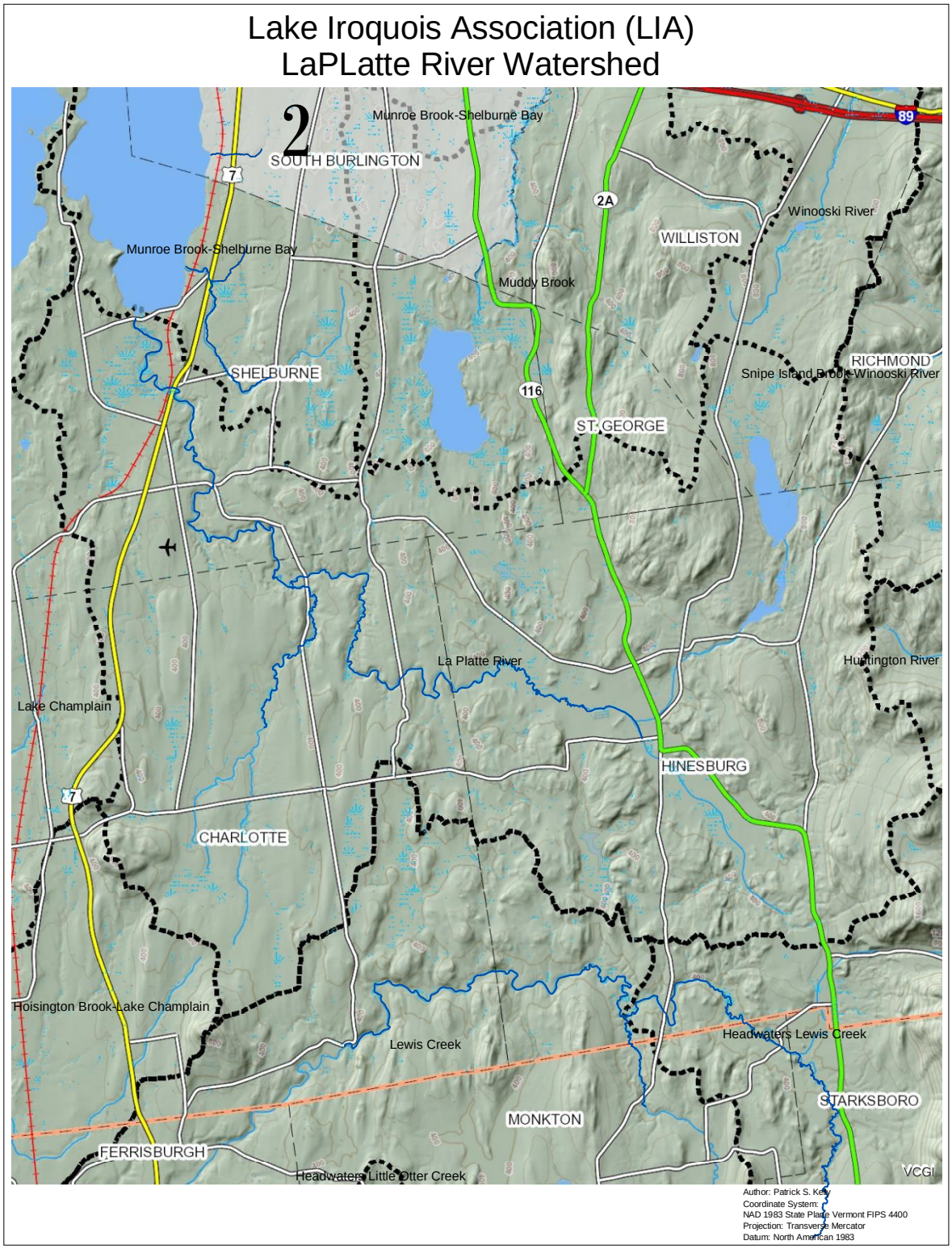
# 2.0 Background

## 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 3**).

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.

**Figure 3. LaPlatte River Watershed**




Approximately 91 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 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, however, sampling at this Site continued in 2018 and 2019. 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 2018 and 2019, 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.

Water quality sampling was carried out by a single volunteer operating under an EPA-approved Quality Assurance Project Plan during the period of May 13 through October 12, 2019. The Project Manager sampled each site having flow on average every 10-14 days. Analytical services are provided by the Vermont Agricultural & Environmental Laboratory in Randolph, Vermont. Lab tests were performed for total phosphorus at all stations.

Refer to **Figure 1** for the location of each tributary sampling location around Lake Iroquois. **Table 2** describes the sampling locations in detail.

## 2.3 Description of Lake Iroquois Tributary Sampling Locations

**Lake Iroquois Tributaries**

**Site 1:** PLEASE NOTE THIS CORRECTS THE PREVIOUS DESCRIPTION IDENTIFYING MAGEE HILL AS THE STREAM SOURCE OFF RICHMOND ROAD. This is a higher elevation stream originating from the mountain slope bordering Lake Iroquois along its eastern shore on Dimick Road. No known measurements exist to verify discharge but observation suggests this is one of the two largest tributaries of Lake Iroquois and is known to flow continuously through the season. The sampling location is approximately 10 meters from the Lake and is sampled above a culvert passing beneath Dimick Road. The stream is contained within a cobble bed prior to entering the Lake.

**Site 1a (NEW):** This stream passes through a culvert on East Shore Lane before joining with another unnamed tributary that eventually forms the Site 1 tributary. The sampling location is on the downstream side of the road culvert.
**Site 2:** This stream passes through a marshy area before and 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 but was shifted in 2018 back to below the culvert. This location will continue in 2019.

**Site 3a (NEW):** This sampling location is part of a dendritic pattern of flow north of the box culvert on Beebe Lane that converges with four other tributaries to form a single tributary and ultimately Site 3. This is the leftmost tributary when facing north located at the nine 'o'clock position.

**Site 3b (NEW):** This sampling location is part of a dendritic pattern of flow north of the box culvert Beebe Lane that converges with four other tributaries to form a single tributary and ultimately Site 3. This tributary is viewed when facing north at roughly a ten 'o'clock position.

**Site 3c (NEW):** This sampling location is part of a dendritic pattern of flow north of the box culvert Beebe Lane that converges with four other tributaries to form a single tributary and ultimately Site 3. This tributary is viewed when facing north roughly at an eleven 'o'clock position.

**Site 3d (NEW):** This sampling location is part of a dendritic pattern of flow north of the box culvert Beebe Lane that converges with four other tributaries to form a single tributary and ultimately Site 3. This tributary is viewed when facing north roughly at a twelve 'o'clock position.

**Site 3e (NEW):** This sampling location is part of a dendritic pattern of flow north of the box culvert Beebe Lane that converges with four other tributaries to form a single tributary and ultimately Site 3. This tributary is viewed when facing north roughly at the three 'o'clock position.

**Site 4:** This stream originates on Mount Pritchard, ultimately crossing beneath Pond Road, and descending in an easterly direction on the Lake's western shore. The stream bed is partly man-made as a result of development, and runs parallel on the south side of 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 impacted significantly by development originating from Pond Road and Pine Shore Road. This stream crosses Pond Road via a culvert and continues via overland flow and drainage ditches. A portion of the stream drains to a small detention pond which occasionally discharges in confluence with flow in the Pine Shore ditch line. The stream then passes through a series of Low Impact Development (LID) features constructed in 2012 before crossing a narrow road and picking up velocity downslope to its confluence with the Lake at the sample Site. Stream rehabilitation and road work on Pine Shore Road completed in Summer 2017 and Summer 2018 hope to realize improvements to water quality at this location.

**Site 5a (NEW):** This sampling site is located above the culvert at the bottom of Pine Shore Road, above the Low Impact Development (LID) feature implemented in 2012. This site will run intermittently with the rainy season and higher flows

with the purpose of measuring nutrient inputs prior to reaching the LID feature and stream rehabilitation work completed in 2017.

**Site 6:** This Site has extensive drainage at the north end of the Lake leading from a wooded area through a culvert beneath Beebe Lane and discharging directly into the Lake. The sample location is just above its confluence with 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. The sampling location is just above the culvert on the western side of Pine Shore Road.

**Site 8:** This stream is located on the west side of the Lake and passes beneath Pine Shore Road. The sample is collected just above the culvert on Pine Shore Road.

**Site 9:** This stream drains an area on the southwest side of the Lake, flowing parallel to Southwest Shore Road and Old Pump Road before passing beneath a culvert discharging to the Lake. The sample is collected just above the culvert on Old Pump Road.

**Site 9a (NEW):** This site is located on the tributary below Southwest Shore road and adjacent to Old Pump Road, just below the confluence of two tributaries. The sample is collected midstream below the confluence.

**Site 10:** This stream drains an area southwest of the Lake that enters a swampy area south of Pike Point Road and is sampled below a culvert at Pike Point Road prior to entry into the Lake.

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

**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 is located above the culvert.

**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.

**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.
**(ELIMINATE)**

**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.

**(ELIMINATE) 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.
**Site 17 (NEW):** This site is located between Site 7 and Site 8 off Pine Shore Road. The sample will be collected below the culvert passing beneath the road.

**Site 18 (NEW):** This site is located off Pine Shore Road between Site 7 and Site 4. The sampling location is below the roadway culvert.

**Table 2. Physical Habitat & Surrounding Features**

| Site # | Habitat/Surrounding Features |
|---|---|
| 1 | Forested; crosses major local road on east side. |
| 1a | Forested; crosses East Shore Lane to the south on east side |
| 2 | Forested; should be the cleanest tributary. |
| 3 | Former agricultural area; developed with houses and roads. |
| 3a | Former agricultural area; developed with houses and roads. |
| 3b | Former agricultural area; developed with houses and roads. |
| 3c | Former agricultural area; developed with houses and roads. |
| 3d | Former agricultural area; developed with houses and roads. |
| 3e | Former agricultural area; developed with houses and roads. |
| 4 | Developed area on west; road improvements to be monitored. |
| 5 | Developed area on west; road and stream improvements to be monitored. |
| 5a | Developed area on west; road and stream 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 southwest side of lake. |
| 9a | Road and developed area on southwest side of lake |
| 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 |
| *(ELIMINATED) 15 | ~~Largely undeveloped area on the northwestern slopes of Lake Iroquois~~ *Flow not adequate |
| *(ELIMINATED) 16 | ~~Undeveloped area on the northwestern slopes of Lake Iroquois~~ *Flow not adequate |
| Site 17 | Tributary leading from forested area and passing beneath Pine Shore Road |
| Site 18 | Tributary leading from forested area and passing beneath Pine Shore Road residential development to the northeast side |

**Table 3. Locational Data**

| Site # | DD.mmmmm North | DD.mmmmm West |
|---|---|---|
| 1 | 44.369204 | -73.077965 |
| 1a | 44.368384 | -73.073952 |
| 2 | 44.370476 | -73.078435 |
| 3 | 44.380389 | -73.089219 |
| 3a | 44.380248 | -73.089421 |
| 3b | 44.380293 | -73.089477 |
| 3c | 44.380389 | -73.089434 |
| 3d | 44.380471 | -73.089253 |
| 3e | 44.380552 | -73.089073 |
| 4 | 44.368760 | -73.088387 |
| 5 | 44.368760 | -73.088387 |
| 5a | 44.363438 | -73.087416 |
| 6 | 44.363178 | -73.085965 |
| 7 | 44.379700 | -73.086900 |
| 8 | 44.367512 | -73.088308 |
| 9 | 44.364721 | -73.087516 |
| 9a | 44.361438 | -73.086012 |
| 10 | 44.362749 | -73.085478 |
| 11 | 44.360489 | -73.084446 |
| 12 | 44.375277 | -73.082777 |
| 13 | 44.377222 | -73.083888 |
| 14 | 44.377222 | -73.084166 |
| *(ELIMINATED) 15 | 44.378888 | -73.084166 |
| *(ELIMINATED) 16 | 44.374394 | -73.088496 |
| Site 17 | 44.366880 | -73.087999 |
| Site 18 | 44.369204 | -73.077965 |

# 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 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 4 below outlines each qualitative discharge flow level and category.

**Table 4. Qualitative Flow Level and Category**

| Qualitative Discharge | | |
|---|---|---|
| Sites 1-24 | | |
| **Date** | **Flow Level** | **Category** |
| 13-May | Moderate | Base |
| 28-May | High | Freshet |
| 10-Jun | Moderate | Base |
| 29-Jun | Moderate | Base |
| 12-Jul | Low | Base |
| 28-Jul | Low | Base |
| 4-Aug | Low | Base |
| 18-Aug | Low | Base |
| 30-Aug | Low | Base |
| 14-Sep | Low | Base |
| 30-Sep | Low | Base |
| 12-Oct | Low | Base |

## 3.2 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 2019 was handled entirely by the Project Coordinator. VT DEC staff hold a training session for the Program annually in the spring of each year at the Vermont Agriculture and Environmental Lab (VAEL) located in Randolph, Vermont. Table 4 outlines quality assurance measures for Total Phosphorus.

**Regular Data**

**May 13, 2019 and October 12, 2019**

Two regular samples at Site 001a and Site 5 were rejected due to RPD values for total phosphorous over the precision limit of ≤ 30% for field duplicates versus the regular results. 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 these samples.

### 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:

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

Two dates below reflect duplicate values flagged for further attention (See Table 5).

**May 13, 2019**

The value flagged showed a RPD value for total phosphorous over twice the precision limit of ≤ 30% for field duplicates versus the regular result at LIA 005 (Site 5). The Lake Iroquois Association concurs this value should be rejected due to suspected cross-contamination of the sample.

**October 12, 2019**

The value flagged showed a RPD value for total phosphorous twice the precision limit of ≤ 30% for field duplicates versus the regular result at LIA 001a (Site 001a). The Lake Iroquois Association concurs this value should be rejected due to suspected cross-contamination of the sample.

**Table 5. Quality assurance measures for Total Phosphorus**

| RPD Analysis | | | | | | |
|---|---|---|---|---|---|---|
| **Site ID** | **Date** | **Test** | **Sample** | **Dup** | **RPD%** | **Precision for Field Duplicates (RPD)** |
| LIA003 (site 3) | 5/13/2019 | TP | 15 | 16 | 6.45161 | ≤30% |
| LIA005 (site 5) | 5/13/2019 | TP | 17 | 8 | 72 | ≤30% |
| LIA003 (Site 3) | 5/28/2019 | TP | 30 | 27 | 10.5263 | ≤30% |
| LIA011 (Site 11) | 6/10/2019 | TP | 12 | 14 | 15.3846 | ≤30% |
| LIA011 (Site 11) | 6/29/2019 | TP | 14 | 14 | 0 | ≤30% |
| LIA001 (Site 1) | 7/12/2019 | TP | 12 | 12 | 0 | ≤30% |
| LIA002 (Site 2) | 7/12/2019 | TP | 11 | 10 | 9.52381 | ≤30% |
| LIA001a (Site 1a) | 7/28/2019 | TP | 14 | 13 | 7.40741 | ≤30% |
| LIA002 (Site 2) | 7/28/2019 | TP | 19 | 18 | 5.40541 | ≤30% |
| LIA011 (Site 11) | 8/4/2019 | TP | 15 | 16 | 6.45161 | ≤30% |
| LIA010 (Site 10) | 8/18/2019 | TP | 16 | 16 | 0 | ≤30% |
| LIA011 (Site 11) | 8/18/2019 | TP | 15 | 16 | 6.45161 | ≤30% |
| LIA001a (Site 1a) | 8/30/2019 | TP | 8 | 8 | 0 | ≤30% |
| LIA011 (Site 11) | 8/30/2019 | TP | 17 | 17 | 0 | ≤30% |
| LIA001a (Site 1a) | 9/14/2019 | TP | 5 | 6 | 18.1818 | ≤30% |
| LIA011 (Site 11) | 9/14/2019 | TP | 12 | 13 | 8 | ≤30% |
| LIA001a (Site 1a) | 9/30/2019 | TP | 6 | 6 | 0 | ≤30% |
| LIA011 (Site 11) | 9/30/2019 | TP | 12 | 12 | 0 | ≤30% |
| LIA001a (Site 1a) | 10/12/2019 | TP | 7 | 13 | 60 | ≤30% |
| LIA011 (Site 11) | 10/12/2019 | TP | 13 | 13 | 0 | ≤30% |

**Blanks**

Concur to accept all noted (Table 6.)

**Table 6. Average Blank Concentration**

| Sample Number | Location | Date | Test | Symbol | BLANK Results | Regular Result | Units | Remark |
|---|---|---|---|---|---|---|---|---|
| 1900717-003 | LIA001a (Site 1a) BLANK | 7/28/2019 | Total Phosphorus | | 6 | 14 | ug P/L | |
| 1900930-003 | LIA001a (Site 1a) BLANK | 8/30/2019 | Total Phosphorus | < | 5 | 8 | ug P/L | |
| 1900929-003 | LIA001a (Site 1a) BLANK | 9/14/2019 | Total Phosphorus | < | 5 | 5 | ug P/L | |
| 1900931-002 | LIA001a (Site 1a) BLANK | 9/30/2019 | Total Phosphorus | < | 5 | 6 | ug P/L | |
| 1900932-002 | LIA001a (Site 1a) BLANK | 10/12/2019 | Total Phosphorus | | 7 | 8 | ug P/L | Concur as acceptable |
| 1900717-005 | LIA002 (Site 2) BLANK | 7/28/2019 | Total Phosphorus | | 7 | 14.9 | ug P/L | |
| 1900609-026 | LIA009a (Site 9a) BLANK | 7/12/2019 | Total Phosphorus | | 5 | 8 | ug P/L | |
| 1900755-019 | LIA010 (Site 10) BLANK | 8/4/2019 | Total Phosphorus | | 9 | 18 | ug P/L | Concur to accept; may be elevated due to a high blank issue thought to have been corrected, ignore. |
| 1900756-013 | LIA010 (Site 10) BLANK | 8/18/2019 | Total Phosphorus | | 8 | 16 | ug P/L | Concur to accept; may be elevated due to a high blank issue thought to have been corrected, ignore. |
| 1900498-025 | LIA011 (Site 11) BLANK | 6/10/2019 | Total Phosphorus | < | 5 | 12 | ug P/L | |
| 1900519-025 | LIA011 (Site 11) BLANK | 6/29/2019 | Total Phosphorus | < | 5 | 14 | ug P/L | |
| 1900609-021 | LIA011 (Site 11) BLANK | 7/12/2019 | Total Phosphorus | < | 5 | 12 | ug P/L | |
| 1900756-016 | LIA011 (Site 11) BLANK | 8/18/2019 | Total Phosphorus | | 8 | 15 | ug P/L | Concur to accept; may be elevated due to a high blank issue thought to have been corrected, ignore. |
| 1900930-022 | LIA011 (Site 11) BLANK | 8/30/2019 | Total Phosphorus | < | 5 | 17 | ug P/L | |
| 1900929-017 | LIA011 (Site 11) BLANK | 9/14/2019 | Total Phosphorus | < | 5 | 12 | ug P/L | |
| 1900931-021 | LIA011 (Site 11) BLANK | 9/30/2019 | Total Phosphorus | < | 5 | 12 | ug P/L | |
| 1900932-021 | LIA011 (Site 11) BLANK | 10/12/2019 | Total Phosphorus | | 7 | 13 | ug P/L | Concur as acceptable |
| 1900423-022 | LIA011 (Site 11)-BLANK | 5/13/2019 | Total Phosphorus | | 6 | 17 | ug P/L | |
| 1900123-022 | LIA011 (Site 11)-BLANK | 5/28/2019 | Total Phosphorus | | 5 | 23 | ug P/L | |
| 1900423-028 | LIA018 (Site 18)-BLANK | 5/13/2019 | Total Phosphorus | | 6 | 8 | ug P/L | |
| 1900123-028 | LIA018 (Site 18)-BLANK | 5/28/2019 | Total Phosphorus | < | 5 | 20 | ug P/L | |

**Table 7. 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** |

**(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 illustration of the mean measured concentrations (with standard deviation) of Total Phosphorus (TP) is 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 2019 are summarized in the Tables below.

## 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 8** and **Figure 4** reflect the average phosphorous levels and Standard Deviation for 2019.

### Lake Iroquois Tributaries

Of the **Lake Iroquois tributaries**, **Site 9** (off Old Pump Road) observed the highest average phosphorous level for 2019 at 76 µg/L. **Site 3c (above Beebe Lane)** observed the second highest average phosphorous level at 48 µg/L. **Site 7 (off Pine Shore Road)** observed the lowest average phosphorous level for 2019 at 7 µg/L.

The Beebe Lane Sites are most notable due to the fact this are of input to Lake Iroquois continues to carry the highest average phosphorous levels of all the Sites since 2011. The new sampling locations at Site 3a, 3b, 3c, 3d, and 3e, were among the highest average phosphorous levels at 32 µg/L, 36 µg/L, 48 µg/L, 42 µg/L, and 51.3 µg/L, respectively. Sites 12, 13, and 14 for a second year showed elevated phosphorous levels at 38 µg/L, 23 µg/L, and 25 µg/L, respectively. Higher numbers from these tributaries originating in undeveloped headwaters on the eastern side of the Lake are surprising. The results suggest legacy nutrients from anecdotal reports of hill farms that once existed above these Sites. There do not appear to be any erosion or sedimentation issues on the Lake Iroquois Recreation District's trail. Site 7 had the lowest average phosphorus levels in 2019 (7 µg/L), but Site 11 has the lowest average across multiple years (15.2 µg/L).

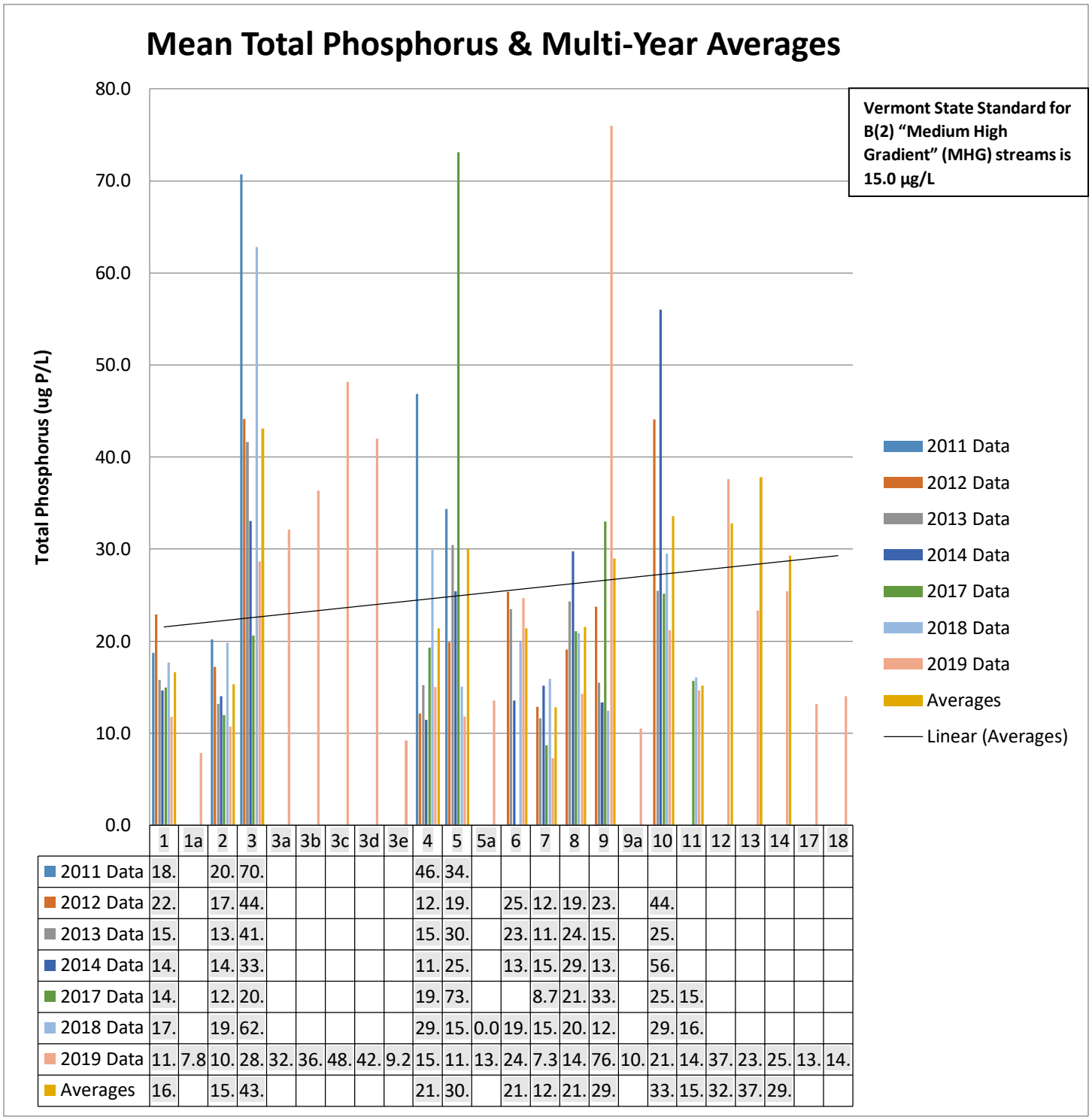
*It is also worth noting that although Site 5 (Old Pump Road) was dry most of the year, the average phosphorous levels were significantly lower than in all previous years. Sampling data in 2019 may provide a better understanding of the effectiveness of the Pine Shore Ecosystem Restoration Project, however, 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. 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.

## *Table 8. Average phosphorus levels & Standard Deviation for sampling year 2019*

Red Text Denotes Exceedance of the Vermont Total Phosphorous limits of 15 ug/L for B(2) Medium High Gradient streams

| Average of Results | Column Labels | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Row Labels | 13-May | 28-May | 10-Jun | 29-Jun | 12-Jul | 28-Jul | 4-Aug | 18-Aug | 30-Aug | 14-Sep | 30-Sep | 12-Oct | Grand Total | |
| **Total Phosphorus** | **10** | **19** | **14** | **13** | **16** | **31** | **31** | **32** | **69** | **36** | **50** | **16** | **24** | **Std Dev** |
| LIA001 (Site 1) | 8 | 13 | 10 | 11 | 12 | 17 | 15 | 12 | 14 | 12 | 9 | 8 | 12 | 2.8 |
| LIA001a (Site 1a) | 6 | 13 | 8 | 6 | 6 | 14 | 7 | 8 | 8 | 5 | 6 | | 8 | 2.9 |
| LIA002 (Site 2) | 6 | 13 | 9 | 9 | 11 | 19 | 12 | 11 | 13 | 9 | 9 | 8 | 11 | 3.3 |
| LIA003 (Site 3) | 15 | 30 | 24 | 24 | 24 | 28 | 36 | 36 | 54 | 36 | 20 | 17 | 29 | 10.7 |
| LIA003a (Site 3a) | 10 | 32 | 19 | 17 | 21 | 90 | | | | | 30 | 38 | 32 | 25.1 |
| LIA003b (Site 3b) | 19 | 31 | 44 | 26 | 25 | 66 | 37 | | | 16 | 63 | | 36 | 18.1 |
| LIA003c (Site 3c) | 16 | 28 | 26 | 18 | 16 | 32 | 96 | 34 | 160 | 90 | 42 | 20 | 48 | 44.4 |
| LIA003d (Site 3d) | 5 | 13 | 8 | 8 | | | | 106 | 158 | 47 | 18 | 15 | 42 | 54.1 |
| LIA003e (Site 3e) | 10 | 18 | 7 | 5 | | | | | | | | 6 | 9 | 5.3 |
| LIA004 (Site 4) | 10 | 23 | 14 | 11 | 10 | 18 | | | | | 16 | 18 | 15 | 4.6 |
| LIA005 (Site 5) | | 20 | 9 | 7 | | | | | | | | 6 | 11 | 6.5 |
| LIA005a (Site 5a) | 10 | 18 | 13 | 15 | 17 | | | | | | 12 | 10 | 14 | 3.2 |
| LIA006 (Site 6) | 8 | 17 | 16 | 24 | 44 | | | | | | | 39 | 25 | 14.1 |
| LIA007 (Site 7) | 9 | 10 | 5 | 5 | 5 | 8 | 7 | 6 | 13 | 7 | 6 | 6 | 7 | 2.4 |
| LIA008 (Site 8) | 12 | 16 | 12 | 12 | 14 | | | | | | 14 | 20 | 14 | 2.9 |
| LIA009 (Site 9) | 7 | 12 | 8 | 8 | 7 | 16 | 25 | 27 | 163 | 140 | 487 | 12 | 76 | 140.2 |
| LIA009a (Site 9a) | 7 | 12 | 8 | 7 | 8 | | 14 | 8 | | | | 20 | 11 | 4.6 |
| LIA010 (Site 10) | 10 | 18 | 12 | 12 | 15 | 18 | 18 | 16 | 94 | 22 | 11 | 8 | 21 | 23.3 |
| LIA011 (Site 11) | 17 | 23 | 12 | 14 | 12 | 14 | 15 | 15 | 17 | 12 | 12 | 13 | 15 | 3.2 |
| LIA012 (Site 12) | 8 | 15 | 12 | 19 | 34 | | 87 | 100 | | | | 26 | 38 | 35.6 |
| LIA013 (Site 13) | 16 | 27 | 27 | | | | | | | | | | 23 | 6.4 |
| LIA014 (Site 14) | 11 | 18 | 15 | 19 | | 64 | | | | | | | 25 | 21.8 |
| LIA017 (Site 17) | 12 | 17 | 10 | 15 | 12 | | | | | | | | 13 | 2.8 |
| LIA018 (Site 18) | 8 | 20 | | | | | | | | | | 14 | 14 | 6.0 |
| **Grand Total** | **10** | **19** | **14** | **13** | **16** | **31** | **31** | **32** | **69** | **36** | **50** | **16** | **24** | |




| | 1 | 1a | 2 | 3 | 3a | 3b | 3c | 3d | 3e | 4 | 5 | 5a | 6 | 7 | 8 | 9 | 9a | 10 | 11 | 12 | 13 | 14 | 17 | 18 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2011 Data | 18. | | 20. | 70. | | | | | | 46. | 34. | | | | | | | | | | | | | |
| 2012 Data | 22. | | 17. | 44. | | | | | | 12. | 19. | | 25. | 12. | 19. | 23. | | 44. | | | | | | |
| 2013 Data | 15. | | 13. | 41. | | | | | | 15. | 30. | | 23. | 11. | 24. | 15. | | 25. | | | | | | |
| 2014 Data | 14. | | 14. | 33. | | | | | | 11. | 25. | | 13. | 15. | 29. | 13. | | 56. | | | | | | |
| 2017 Data | 14. | | 12. | 20. | | | | | | 19. | 73. | | | 8.7 | 21. | 33. | | 25. | 15. | | | | | |
| 2018 Data | 17. | | 19. | 62. | | | | | | 29. | 15. | 0.0 | 19. | 15. | 20. | 12. | | 29. | 16. | | | | | |
| 2019 Data | 11. | 7.8 | 10. | 28. | 32. | 36. | 48. | 42. | 9.2 | 15. | 11. | 13. | 24. | 7.3 | 14. | 76. | 10. | 21. | 14. | 37. | 23. | 25. | 13. | 14. |
| Averages | 16. | | 15. | 43. | | | | | | 21. | 30. | | 21. | 12. | 21. | 29. | | 33. | 15. | 32. | 37. | 29. | | |

***Figure 4. Average phosphorus levels for the sampling year for each site (2011 to 2019)***

## 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 design grant in the fall of 2018 to rehabilitate Beebe Lane at the north end of the Lake. The next step is to pursue a grant or grants for implementation of the design. 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 2020, 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.

**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 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. A number of sampling locations continue to experience phosphorus levels that do not meet Vermont Water Quality Standards of 15 µg/L, including the eight new tributary sampling locations added in 2019.

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.