Water Quality Monitoring in the Lake Carmi Watershed
2016

Phosphorus and turbidity levels in the tributaries of Lake Carmi in Franklin, VT

A view of Lake Carmi's north beach during a late summer cyanobacteria bloom (2015).

Franklin Watershed Committee

By

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Introduction

For several decades, Lake Carmi has experienced a multitude of water quality issues as a result of high phosphorus concentrations including cyanobacteria blooms (commonly referred to as blue-green algae), reduced water clarity, and persistent aquatic plant growth (Lake Carmi Phosphorus TMDL, 2008). The Vermont Department of Environmental Conservation (DEC) lists Lake Carmi as impaired by phosphorus due to concentrations exceeding the 2014 Vermont Water Quality Standards. Lake Carmi is one of two lakes in Vermont other than Lake Champlain that has a completed and approved Total Maximum Daily Load (TMDL) by the EPA. Lake Carmi has also been altered by invasive species (Eurasian watermilfoil, Japanese knotweed) and water level drawdowns (Lake Carmi Phosphorus TMDL, 2008). The Pike River and the entire Lake Carmi watershed were identified as a significant source of phosphorus loading into the Missisquoi Bay by the Critical Source Areas study (Stone Environmental, 2011).

The Franklin Watershed Committee (FWC) began conducting a water quality monitoring program focused on several tributaries flowing into Lake Carmi in 2008 as part of the LaRosa Partnership Program to evaluate water quality conditions and assess potential sources of water quality problems. The parameters of this study include total digested phosphorus (TP) and turbidity. When the program began in 2008, the FWC identified 10 sites around the lake near the mouths of several tributaries suitable for sampling. In 2016, FWC volunteers sampled at 17 individual sites on 14 different dates (March 30, April 12, April 27, May 25, June 8, June 15, June 29, July 18, July 27, August 10, August 24, September 7, September 21, and October 5). Due to low flow, several sites were not sampled at all sampling dates.

Lake Carmi Description

Lake Carmi is 1,402 acres in size and is by far the most significant water body in the town of Franklin, VT. The lake drains the upper watershed of the Pike River in Franklin and a small section of Berkshire in Franklin Country, Vermont. The lowest elevation in the watershed is 133 m (436 ft.) at the lake surface and the highest is 276 m (905 ft.) at the eastern edge of the watershed. The soils within the watershed are a poorly drained, finely textured sandy loam. Lake Carmi's long axis roughly strikes north to south and is approximately 3 miles long.

Land use in the 7,710 acre watershed is divided evenly between intensive agriculture (dairy farming, hay, corn, pasture) and forested or wetland area. Low-density residential areas are scattered throughout the watershed, with the exception for the lakeshore, which is intensively developed. Lake Carmi State Park extends from the south-center portion of the shoreline to the southern half of the eastern side of the lake and accounts for most the undeveloped shoreline.

Stream Flow

Stream flow measures the volume of water transported through a given cross-sectional area of a stream per unit time. Flow can be calculated by multiplying water velocity by the cross-sectional area of a stream. Stream flow is a crucial component of the water cycle responsible for transporting water, sediment, organic material, and other compounds from the land to greater waterbodies. Stream flows vary greatly throughout the year in response to predictable seasonal changes in temperature and precipitation, but other factors, including anomalous seasonal weather, rare storm events, and land use can also greatly affect stream flow. Stream flow significantly impacts water quality, the quality aquatic and riparian habitats, and the ability of humans to accurately monitor water quality. Streams with greater flow will typically carry more dissolved and suspended sediment and nutrients from surficial runoff, but will also dilute the concentrations of those pollutants.

Samples collected during low flow are best for measuring the significance of groundwater and point sources of sediment and phosphorus while high flows are best for measuring the impacts of non-point sources of these pollutants. During a 2015 study on phosphorus in various tributaries to the Missisquoi Bay (which included a review of all the available water quality data collected by the Franklin Watershed Committee between 2007 and 2014), Fritz Gerhardt found that most of the data collected by volunteers occurred during periods of low to moderate stream flows. This was an issue when identifying and assessing the overall water quality of the Lake Carmi watershed as high flows typically account for the majority of sediment and nutrient loads entering the watershed (Stone Environmental 2011, Environmental Protection Agency 2015).

During 2016, only two of the fourteen sampling dates occurred during a high flow event (March 30 and April 12) and no samples were taken during medium flow conditions. Because stream flow measurements on individual tributaries in the Lake Carmi watershed currently does not exist, flow regiments (low, medium, high) were derived from the USGS station 04294300 along the Pike River in East Franklin.

Phosphorus and Turbidity

Total digested phosphorus (TP) samples were collected at each site to determine nutrient levels and compare to Vermont's 2014 Water Quality Standards (WQS). Turbidity samples were taken at the mouths of major tributaries to Lake Carmi to determine water clarity and identify the amount of suspended material (e.g. sediment, organic compounds, algae) in the streams. These water quality standards for nutrients (phosphorus and nitrogen) were designed to protect aquatic life from the harmful effects of eutrophication, or the excessive enrichment of nutrients in a water body. Phosphorus limits for "Medium High Gradient" streams during base low flow conditions is 15 ug/l. The following table and two figures only represent phosphorus concentrations and turbidity during low flow base conditions as that is when the Vermont WQSs apply. Note that the annual comparisons of mean phosphorus included below use data from samples taken during both low, moderate, and high flows.

Table 1: Mean values for total phosphorus and turbidity at all 17 FWC sampling sites during low flow conditions in 2016.

FWC Site #	Location	TP (ug/l)	Turbidity (NTU)
LC1	Sandy Bay Brook 1	116	12.7
LC3	Dicky's Brook at Middle Rd	26.7	
LC4	Dicky's Brook at Rainville Field	42.0	
LC5	Dicky's Brook near mouth	33.6	4.83
LC6	Dewing Brook near mouth	51.6	2.74
LC7	Marsh Brook at Towle Neighborhood Rd North	27.3	
LC8	Marsh Brook at Towle Neighborhood Rd South	144	
LC9	Marsh Brook at State Park Rd	95.0	
LC10	Marsh Brook near mouth	46.8	3.47
LC11	Alder Run at Middle Rd	46.1	
LC12	Kane’s Brook near mouth	60.4	6.15
LC14	Little Pond Rd Culvert	481	
LC16	Westcott Brook near mouth	42.6	15.2
LC17	Hammond Brook near mouth	42.2	2.04
LC20	Wagner Tile Drain	330	
LC21	Sandy Bay Brook 2	78.6	
LC22	Sandy Bay Brook 3	102	

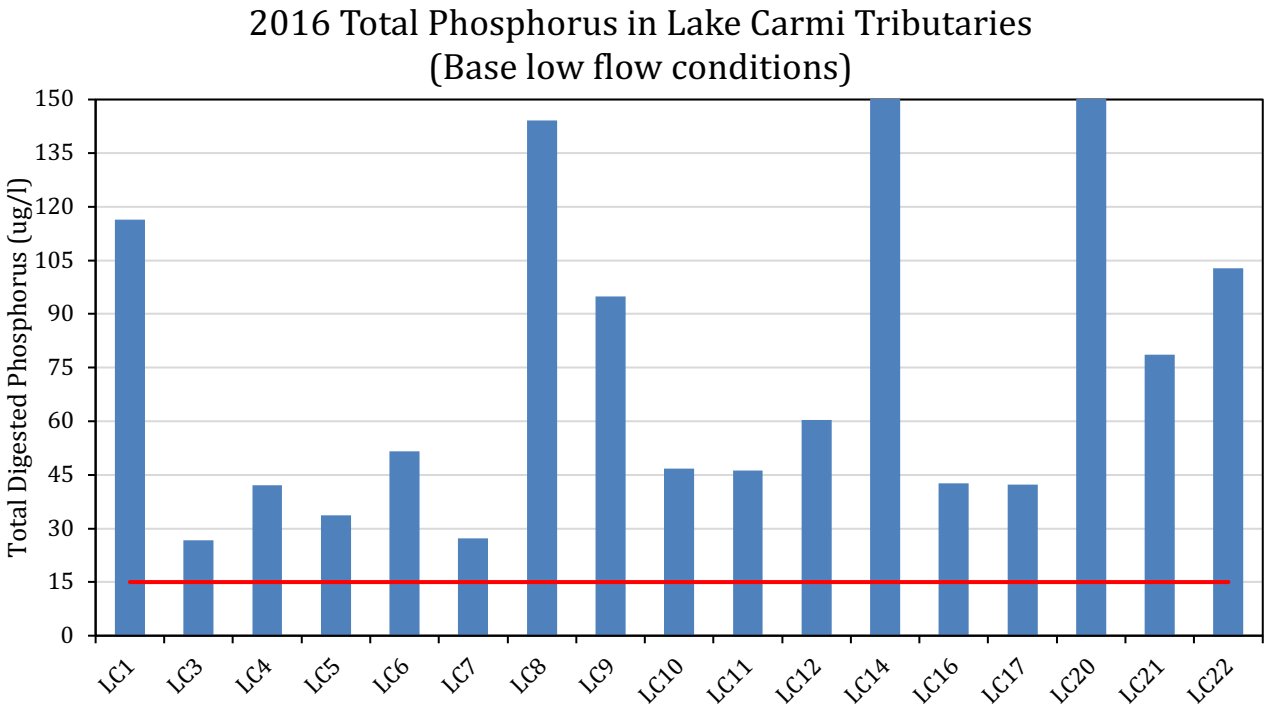

Figure 1: Mean total digested phosphorus at each FWC water quality monitoring site in 2016 under base low flow conditions. The solid red line shows the Vermont standard for phosphorus in Class B, medium, high-gradient streams (15 ug/l). Note that the phosphorus levels for LC14 (481 ug/l) and LC20 (330 ug/l) both exceed the upper bounds of the graph to allow for greater detail.

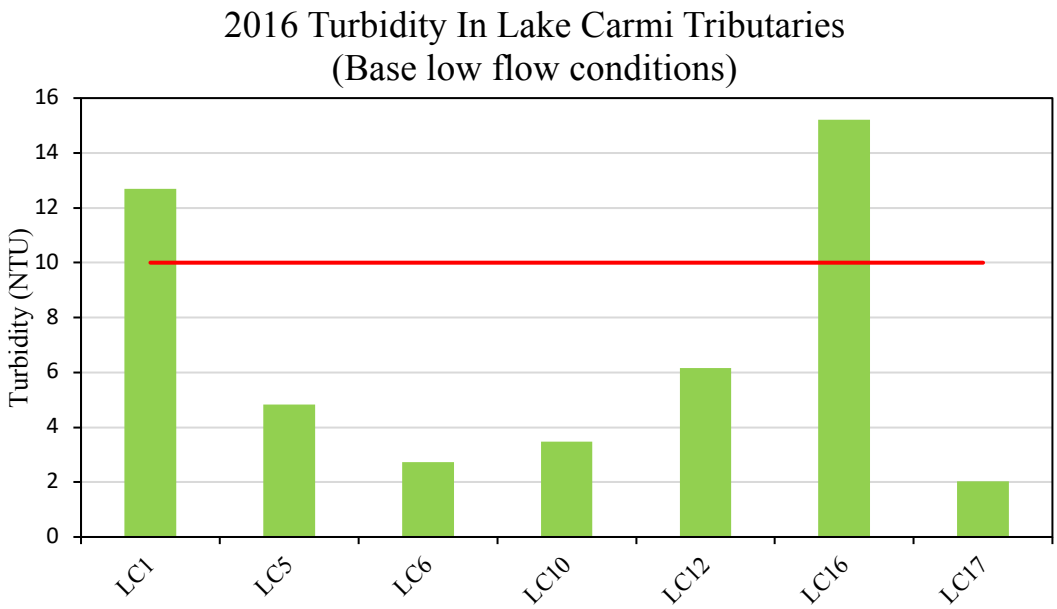

Figure 2: Mean turbidity levels near the mouth of Lake Carmi tributaries in 2016 during base low flow conditions. Note the solid red line showing the Vermont water quality standard (VWQS) for turbidity in Class B streams at 10 NTU. Mean turbidity values exceed the VWQSat LC1 (Sandy Bay Brook) and LC 16 (Westcott Brook).

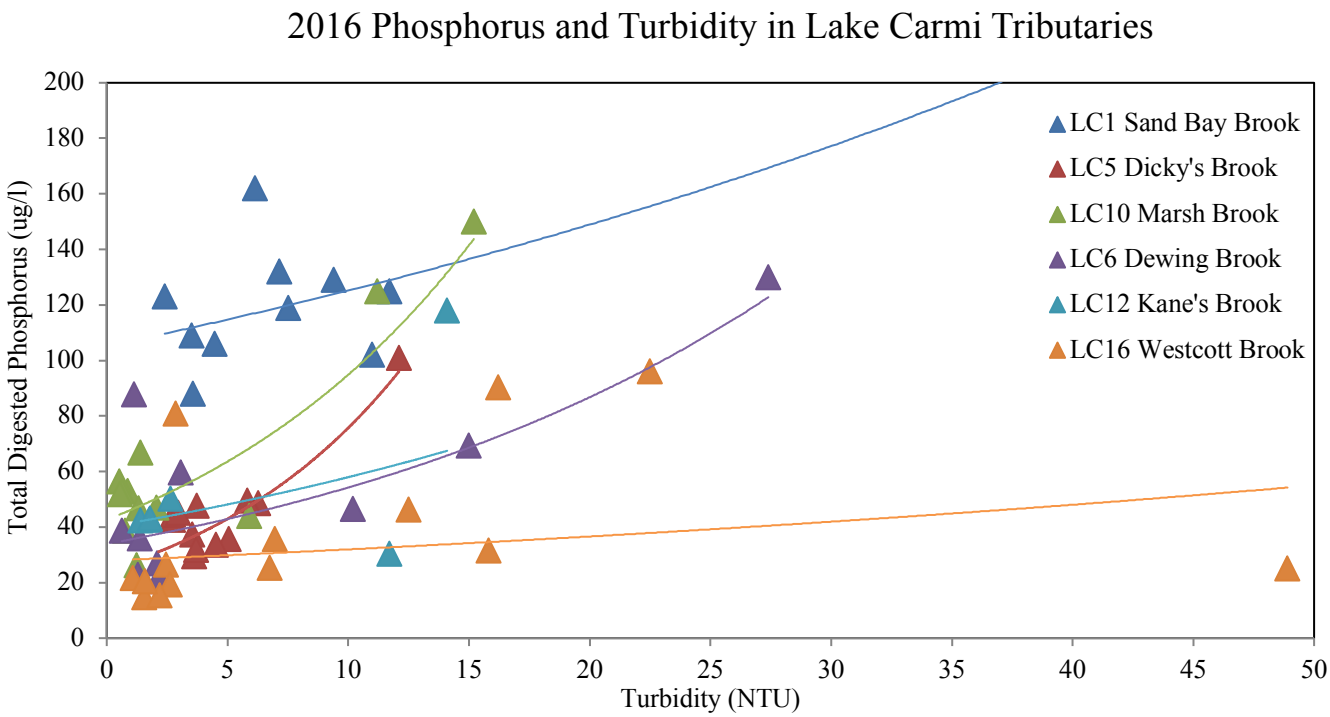

Figure 3: Mean total digested phosphorus concentrations in relation to turbidity values along six tributaries to Lake Carmi during 2016 including data from both high and low flows conditions. The single point of data not shown on this graph is from the Sandy Bay Brook (343 ug/l TDP, 67.2 NTU).

The above graph shows the relationship between turbidity and phosphorus in six of the main streams flowing into Lake Carmi during 2016. Generally, there is a positive correlation between turbidity values and phosphorus concentrations. The Sandy Bay Brook and Marsh Brook both had consistently high phosphorus and turbidity values when compared with the rest of the tributaries. Based on the other data collected, it is possible the very high turbidity value along the Westscott Brook seen in the bottom right portion of the graph is a result of sampling error.

Sandy Bay Brook

Water quality data collected by FWC volunteers indicates there are very high phosphorus concentrations at all three sites along the Sandy Bay Brook. Since 2012, mean phosphorus concentrations in the Sandy Bay Brook have decreased although the current concentration values still greatly exceed the Vermont Water Quality Standards. It should be noted that Sandy Bay Brook dries up during the summer. This allowed only 2 samples to be taken at LC21. The sampling site at the mouth was more consistently flowing, allowing sampling most dates.

In a study on nutrient levels in several tributaries of the Missisquoi Bay by Fritz Gerhardt, he concluded it is likely that much of this excessive phosphorus may be originating from a small farm near the upper part of the brook (Gerhardt, 2015).

Specifically, he notes that significant sources of phosphorus may originate from an old settling pond and possibly runoff from an area used to stack manure (Gerhardt, 2015).

Table 1: Summary of total digested phosphorus concentrations at three Sandy Bay Brook water quality monitoring sites in 2016 during all flow conditions, as base flow condition samples were limited in number.

FWC Site #	Location	# Dates Sampled	Median (ug/l)	Mean (ug/l)	Range (ug/l)
LC1	Sandy Bay Brook 1	11	123	140	88.1 - 342
LC21	Sandy Bay Brook 2	2	199	199	153 - 244
LC22	Sandy Bay Brook 3	8	118	119	72.3 - 179

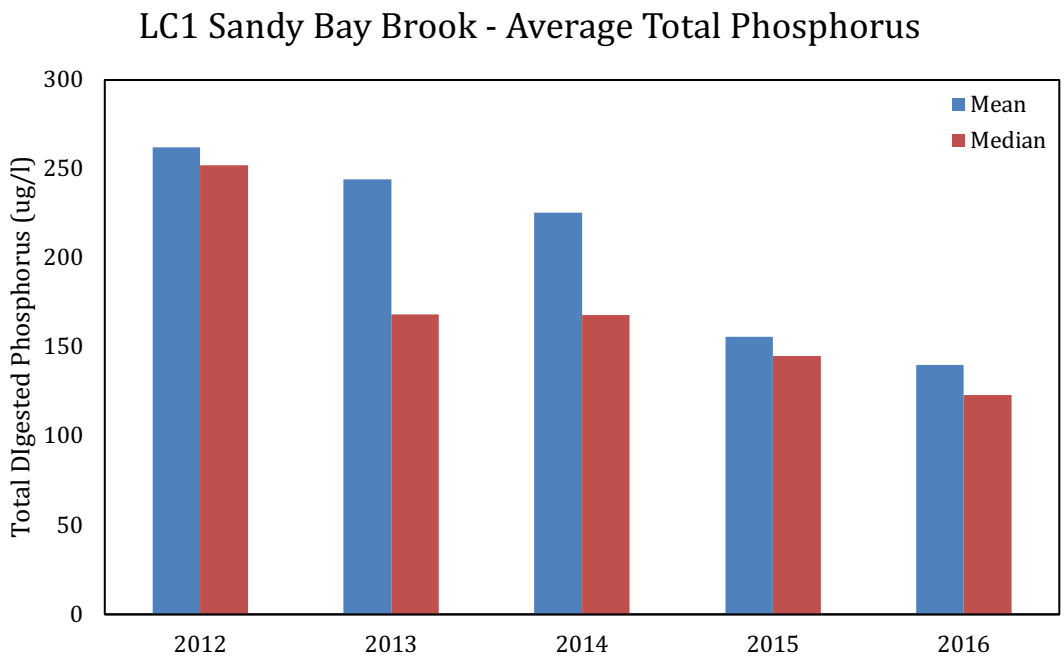

Figure 4: Mean and median total digested phosphorus concentrations at the water quality monitoring site closest to the mouth of the Sandy Bay Brook between 2012 and 2016 during all flow conditions.

Marsh Brook

Water quality data collected by FWC volunteers also identified major water quality issues in the Marsh Brook regarding phosphorus concentrations. The mean concentration of phosphorus at each site along the Marsh Brook greatly exceed Vermont Water Quality Standards although it should be noted that LC7 (Marsh Brook at Towle Neighborhood Rd South) was one of the least impaired sites in the

study. LC14 at the Little Pond Rd. Culvert was specifically noted for having mean phosphorus concentrations at base low flow conditions that exceed the Vermont Water Quality Standards by roughly 30 times (see Table 1). Since 2012, mean phosphorus concentrations have decreased at LC10 the lowermost site along the Marsh Brook (Figure 4). As seen in the phosphorus "profile" of Marsh Brook in Figure 5, the concentration of phosphorus significantly decreases moving towards the lower portion of the watershed near the mouth. The watershed below Towle Neighborhood road is predominately forested, which typically would contribute surface runoff with significantly less phosphorus and sediment.

Table 2: Summary of total digested phosphorus concentrations at six water quality monitoring sites along the Marsh Brook in 2016 during all flow conditions.

FWC Site #	Location	# Dates Sampled	Median (ug/l)	Mean (ug/l)	Range (ug/l)
LC7	Marsh Brook at Towle Neighborhood Rd North	6	27.7	27.3	14.7-38.1
LC8	Marsh Brook at Towle Neighborhood Rd South	11	119	144	71.4-257
LC9	Marsh Brook at State Park Rd	10	90.4	95.0	53-154
LC10	Marsh Brook near mouth	12	52.3	63.2	26.2-150
LC14	Little Pond Rd Culvert	9	232	536	148-1724
LC20	Marsh Brook Field Outlet	8	376	363	250-464

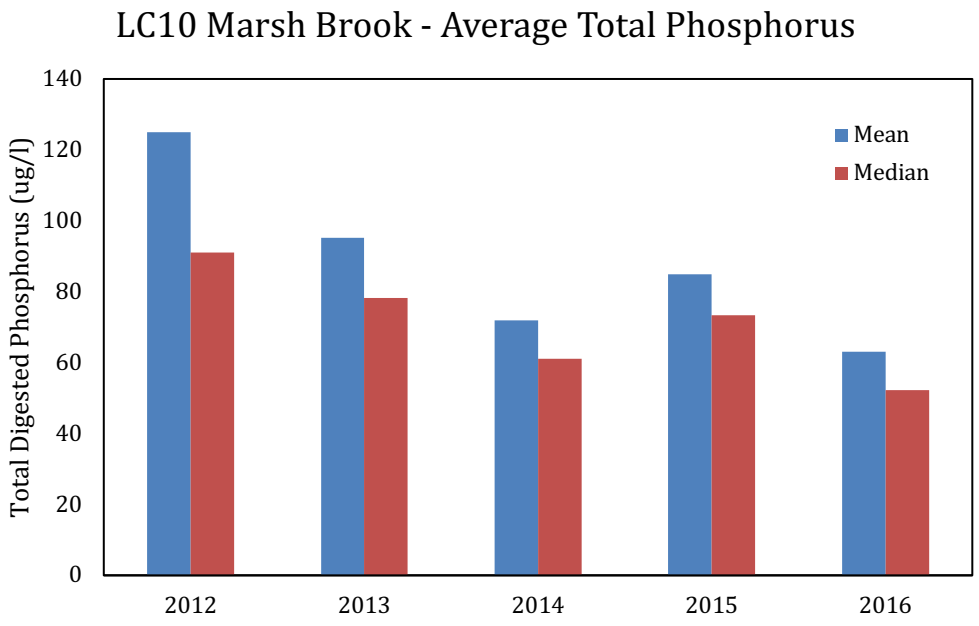

Figure 5: Mean and median total digested phosphorus concentrations at the water quality monitoring site nearest to the mouth of the Marsh Brook between 2012 and 2016 during all flow conditions.

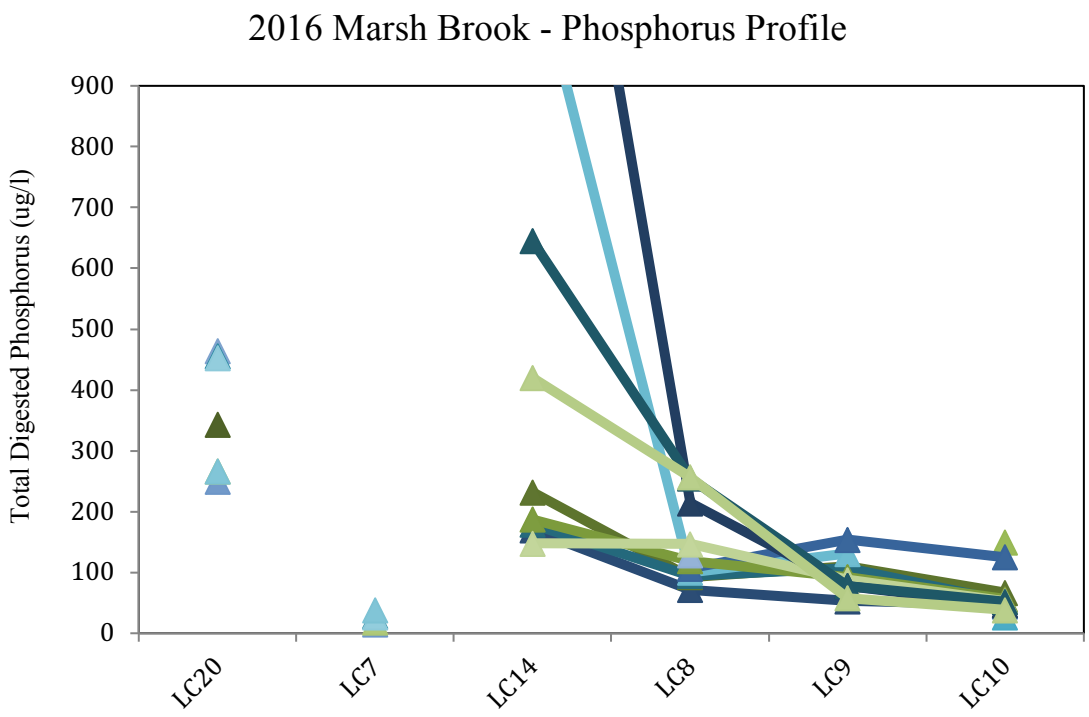

Figure 6: Total phosphorus profile of the Marsh Brook from the uppermost site (LC14) to the lowermost site (LC10) near the mouth.

Dicky's Brook

Water quality data indicates that Dicky's Brook is in better condition than Sandy Bay Brook and Marsh Brook, although mean total phosphorus concentrations do exceed Vermont Water Quality Standards. Since 2012, mean total phosphorus concentrations in Dicky's Brook have been relatively stable.

FWC Site #	Location	# Dates Sampled	Median (ug/l)	Mean (ug/l)	Range (ug/l)
LC3	Dicky's Brook at Middle Rd	8	21.1	23.8	12.8-44.5
LC4	Dicky's Brook at Rainville Field	5	28.3	42.3	22.4-107
LC5	Dicky's Brook near mouth	13	42.6	43.6	20.6-101

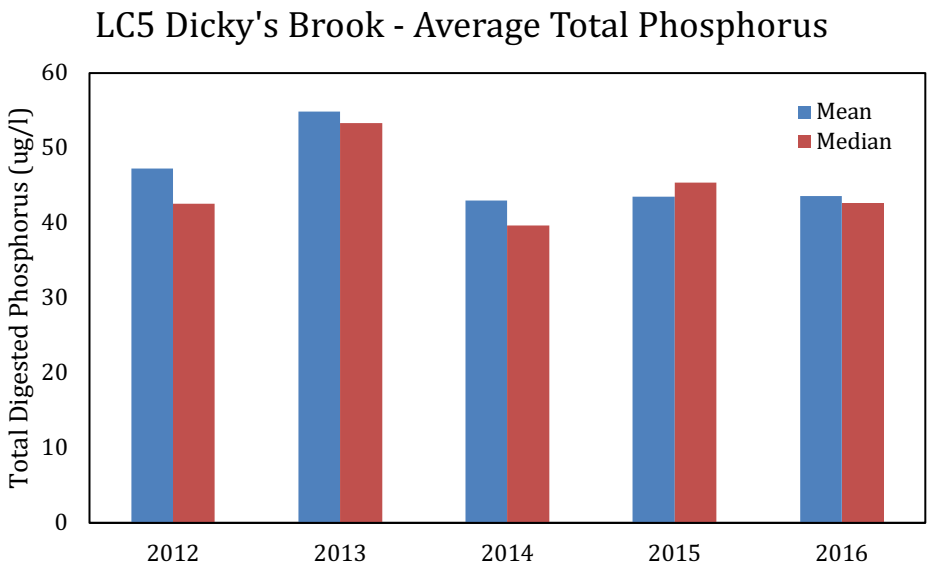

Figure 7: Mean and median total digested phosphorus concentrations at the lowermost water quality monitoring site along Dicky's Brook between 2012 and 2016 during all flow conditions.

Other Tributaries

FWC Site #	Location	# Dates Sampled	Median (ug/l)	Mean (ug/l)	Range (ug/l)
LC6	Dewing Brook near mouth	10	42.7	54.0	22-130
LC11	Alder Run at Middle Rd	10	30.2	29.4	9.97-61
LC12	Kanes Brook near mouth	6	43.0	54.5	30.5-118
LC16	Westcott Brook near mouth	8	26.0	35.8	19.4-90.4
LC17	Hammond Brook near mouth	6	28.2	43.9	14.8-96.1

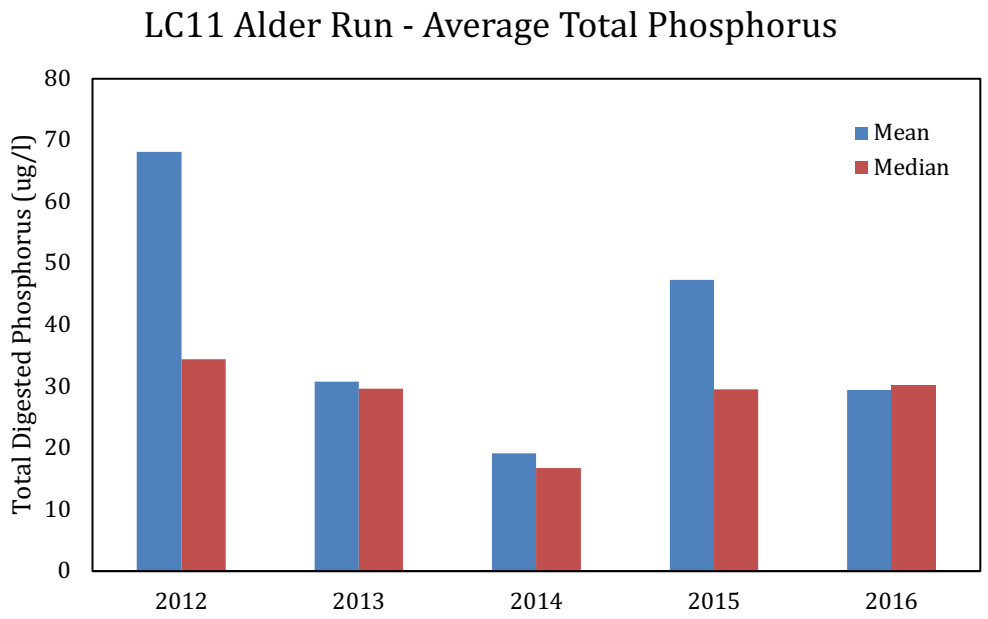

Figure 8: Mean and median total digested phosphorus concentrations at the water quality monitoring site along Alder Run between 2012 and 2016 during all flow conditions.

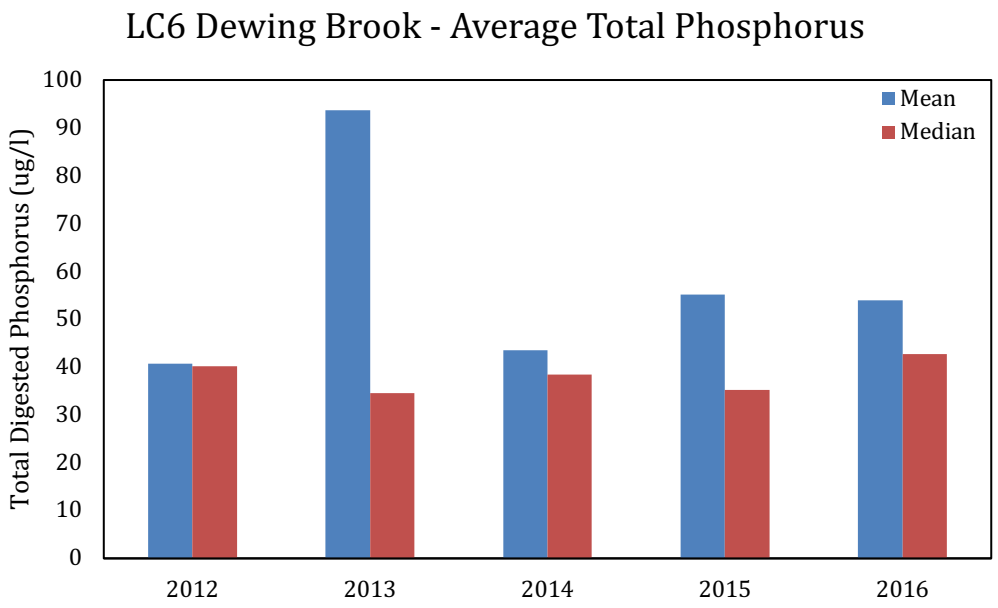

Figure 9: Mean and median total digested phosphorus concentrations at the lowermost water quality monitoring site along Alder Run between 2012 and 2016 during all flow conditions.

Conclusion

The goal of this report was to analyze water quality data collected by Franklin Watershed Committee volunteers in 2016 and assess the current state of water quality in Lake Carmi major tributaries in comparison to year's past. Similar to previous years, Sandy Bay Brook and Marsh Brook had the highest phosphorus concentrations and turbidity. Turbidity and phosphorus were related in many of the streams suggesting that channel erosion and land erosion were significant sources of phosphorus.

To better understand nutrient loads entering Lake Carmi the Franklin Watershed Committee will begin to take water samples specifically during high flow events in addition to maintaining the regular bi-weekly sampling process. In addition, the results from base flow events will be distinguished from the high flow events in the final report to allow for improved interpretation of data trends. As higher flows tend to dramatically increase phosphorus and turbidity values, a sampling season that inadvertently catches a few more storms during scheduled biweekly sampling, may not be able to show changes in values over the years.

References

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