LAROSA ENVIRONMENTAL LABORATORY PARTNERSHIP

Ottauquechee River Group

Five Year Comprehensive Summary of Results

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**This report offers a comprehensive five year summary of results regarding water quality and nutrient levels in the Ottauquechee Watershed. The report encompasses the summer of 2010, the summer of 2013, the summer of 2014, and the summer of 2015. Data from 2011 is also included in this report, although the data set failed to achieve standards of statistical validity as Tropical Storm Irene restricted citizen volunteers' ability to perform water sampling protocol. The Ottauquechee River Group did not sample during the 2012 season. State and/or federal standards are depicted on figures as a horizontal black bar.*

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Overview:

The Ottauquechee River Group's (ORG) water quality monitoring program (WQMP) has been made possible through partnership with the LaRosa Environmental Laboratory of the Vermont Department of Environmental Conservation, as well as a dedicated team of citizen volunteers. The program has been run by volunteer coordinator and Southeastern Vermont River Engineer Todd Menees and assisted annually by an unpaid, part-time Vermont DEC intern, who typically divides their hours between the Ottauquechee River Group, the Southeastern Vermont Watershed Alliance (SeVWA), the Black River Action Team (BRAT), and tasks assigned by Marie Levesque Caduto.

There were 10 sites chosen to be sampled in 2010 and 15 sites from 2011 through 2015, each to be sampled once every two weeks for the duration of each summer. The annual goal for each site was seven sampling dates; with a minimum of five to hold statistical validity (2011 did not reach that goal). Each site was tested for five parameters including total phosphorus (TP), total nitrogen (TN), chloride (Cl-), turbidity (TURB), and E. coli bacteria, with the exception of 2010 when total nitrogen was not tested and 2011 when total phosphorus was not tested. The sample sites are depicted in two watershed maps located on *page 4*.

Ottauquechee River Watershed:

The Ottauquechee River runs approximately 38 miles in length and encompasses roughly 223 square miles of drainage area. The headwaters of the Ottauquechee are located in the Green Mountain Range in Killington, Vermont. From there the river travels through east-central Vermont before drainage into the main stem Connecticut River in North Hartland, Vermont. There are a number of major tributaries to the river, including the North Branch Ottauquechee, Broad Brook, Pinney Hollow Brook, Barnard Brook, and Kedron Brook.

The Ottauquechee River has many important recreational functions including but not limited to boating, kayaking, swimming, and fishing for both coldwater and warmwater species (warmwater fishery limited to the North Hartland Dam to the confluence with the Connecticut River). The watershed holds populations of both native and stocked trout (Rainbows, Browns, and Brook Trout).

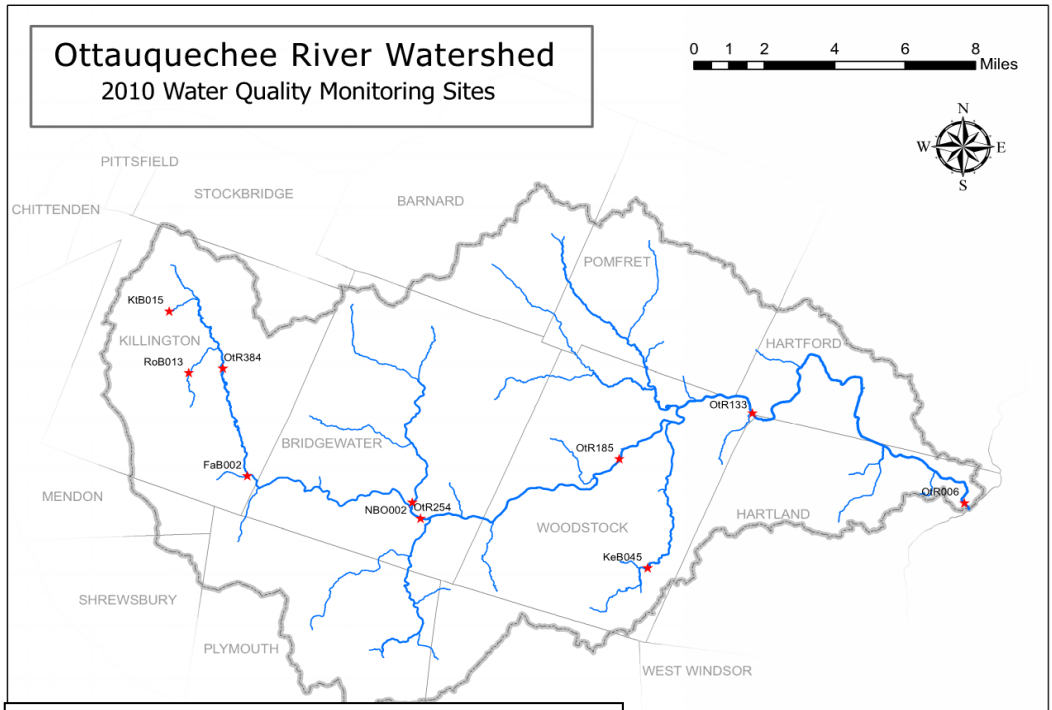
In addition to its many recreational uses and aquatic organism habitat, the Ottauquechee River Watershed is also home to many other important wildlife species, including Osprey, Common Loon, American Bittern, American Black Duck, Pied Billed Grebe, Blue Winged Teal, and American Bald Eagle.

Acronyms

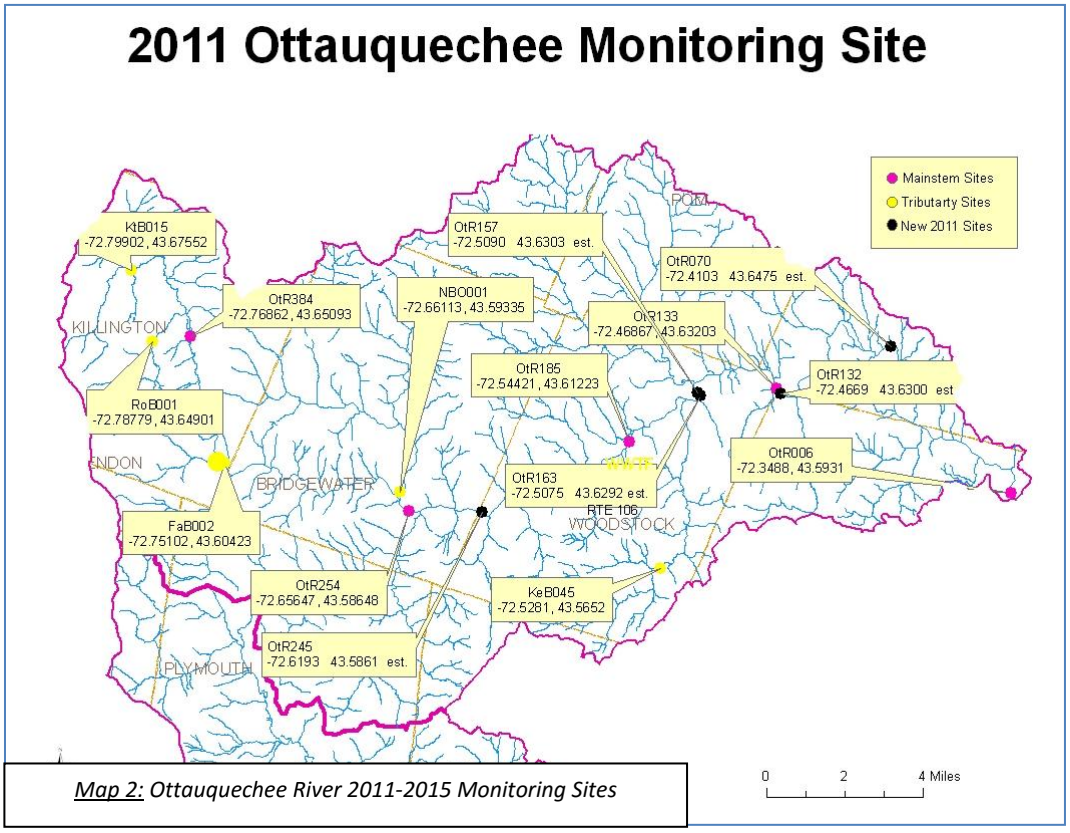
ORG	Ottauquechee River Group
WQMP	Water Quality Monitoring Program
WQM	Water Quality Monitoring
VT DEC	State of Vermont Department of Environmental Conservation
TP	Total Phosphorus
TN	Total Nitrogen
TURB	Turbidity
CL-	Chloride
NTU	Nephelometric Turbidity Units
WWTF	Waste Water Treatment Facility
RPD	Relative Percent Difference

SECTION 1 - SITE ID's, COORDINATES & WATERSHED MAPS:

Site Name	Site Number	Longitude	Latitude
Hartland covered bridge swim area	OtR006	-72.3488 W	43.5931 N
Below Quechee WWTF	OtR070	-72.4108 W	43.6477 N
Below Taftsville WWTF	OtR132	-72.4669 W	43.6299 N
Above Taftsville Dam	OtR133	-72.46867 W	43.63203 N
Below Woodstock WWTF	OtR157	-72.5090 W	43.6303 N
Above Woodstock WWTF	OtR163	-72.5075 W	43.6292 N
Behind Woodstock Union High School	OtR185	-72.54421 W	43.61223 N
Below Bridgewater WWTF	OtR245	-72.6184 W	43.5858 N
Route 100A bridge	OtR254	-72.65647 W	43.58648 N
Rabeck Road bridge	OtR384	-72.76862 W	43.65093 N
Falls Brook/Ottauquechee confluence	FaB002	-72.75102 W	43.60423 N
Kedron Brook below WWTF	KeB045	-72.5281 W	43.5652 N
Kent Pond outlet	KtB015	-72.79902 W	43.67552 N
North Branch/Ottauquechee confluence	NBO001	-72.66113 W	43.59335 N
Roaring Brook/Mountain View Road crossing	RoB010	-72.78779 W	43.64901 N



Map 1: *Ottauquechee River 2010 Monitoring Sites*



Map 2: *Ottauquechee River 2011-2015 Monitoring Sites*

SECTION 2: LITERATURE REVIEW

PHOSPHORUS:

Phosphorus is a naturally occurring nutrient, stemming from sources such as animal waste and phosphorus laden bedrock, to human induced sources such as laundry, cleaning and industrial effluent and agricultural/fertilizer runoff. Excess phosphorus in surface waters can lead to accelerated eutrophication (Brian Oram). *Eutrophication* refers to the natural aging process of a body of water, stemming from increased nutrient concentrations within the water body, leading to plant growth. As plants die at a faster rate than they can decompose, the dead plant matter, in tandem with sediment build-up, fill in the bed of the water body, causing the river, lake or bay to become shallower. This is a process that typically takes thousands of years (Brian Oram).

Cultural eutrophication is the unnatural acceleration of this process due to human activity, leading to increased phosphorus and nitrogen concentrations and increased sedimentation. This leads to the aging of waterways/water bodies at a much faster rate than the geological processes can create new ones (Brian Oram). Cultural eutrophication can often lead to extensive algal blooms, accompanied by a fishy smell and very low dissolved oxygen. If this is the case, water testing for phosphorus will lead to low readings due to the fact that the phosphorus is already in the algae (Brian Oram).

High concentrations of phosphorus can lead to severely detrimental affects upon a waterway. Excess phosphorus can cause accelerated algae and plant growth which can choke out the waterway and use excessive amounts of oxygen in the absence of photosynthesis and as plants die and are consumed by aerobic bacteria. Low levels of dissolved oxygen (DO) can lead to the death of fish and other aquatic organisms (Brian Oram).

CHLORIDE:

Chloride is a salt resulting from the combination of a gas chlorine with a metal. Small amounts of chlorides are essential for normal cell function in aquatic organisms and plants; however fish and aquatic communities cannot survive in high levels of chloride (Kentucky Water Watch). There are many potential contributing sources to excess chlorides in surface waters, including but not limited to agricultural runoff, rocks containing chlorides, industrial wastewater discharge, oil well wastes, waste water treatment facility discharge and, most commonly, road salting to prevent vehicle accidents (Kentucky Water Watch).

High chloride concentrations in aquatic communities can cause disruption of osmoregulation in aquatic organisms leading to impaired survival, growth, and/or reproduction. However, there are several factors which can influence the degree of detriment caused by excess chloride, including dissolved oxygen concentrations, water temperature, exposure time, and the presence/absence of other contaminants (Government of British Columbia - Environmental Protection Division).

CHLORIDE CONCENTRATIONS ABOVE THESE LEVELS CAN BE TOXIC		
SPECIES	SHORT-TERM EXPOSURE	LONG-TERM EXPOSURE
Snail	2,540 mg/L (PPM)	400 mg/L (PPM)
Fathead Minnow	6,570 mg/L (PPM)	430 mg/L (PPM)
Rainbow Trout	6,740 mg/L (PPM)	900 mg/L (PPM)
Channel Catfish	8,000 mg/L (PPM)	800 mg/L (PPM)
Carp	8,390 mg/L (PPM)	850 mg/L (PPM)

NITROGEN:

Much like phosphorus, nitrogen is essential for plant life, however an overabundance can cause a number of serious adverse health and ecological impacts. Although nitrogen is abundant naturally in the environment, it is also introduced to surface waters through sewage discharge and fertilizer runoff. Waste water treatment facilities (WWTF) can also contribute to nitrogen concentrations in surface waters if that facility does not specifically remove nitrogen. Some nitrates enter surface waters directly from the atmosphere, which carries nitrogen-containing compounds from automobiles and other similar sources of fossil fuel combustion (U.S. Geological Survey).

Excessive nitrogen concentrations can lead to over stimulated algae and aquatic plant growth. This excessive growth can clog water intakes, use up excessive dissolved oxygen (DO), and block light to deeper waters. *Eutrophication* can occur as a result which can lead to aquatic organism death and can even "kill" a lake or pond by depriving it of light and oxygen (U.S. Geological Survey).

TURBIDITY:

Turbidity is a measure a relative clarity of a liquid. It is an optical characteristic of water and is an expression of the amount of light that is scattered by material in the water when a light is shined through the water sample. It is usually expressed in Nephelometric Turbidity Units (NTU). "The higher the intensity of scattered light, the higher the turbidity. Material that causes water to be turbid include clay, silt, finely divided inorganic and organic matter, algae, soluble colored organic compounds, and plankton and other microscopic organisms" (U.S. Geological Survey).

During low flow (base flow) events, turbidity is usually relatively low. However during or immediately following a rain event, turbidity will be measurably higher due to the fact that particles from the surrounding land are washed into the waterway. Furthermore, during heavy precipitation or high flow events, erosive force within the stream increases, causing sediments from the stream bank to be more easily washed into the stream, in turn increasing turbidity (U.S. Geological Survey).

High turbidity readings can influence light penetration and productivity, recreational values, and aquatic organism habitat. In rivers and streams in can lead to sedimentation which fills is fish habitat and spawning areas. Particles can provide attachment places for other pollutants, notably metals and bacteria. For this reason, turbidity can be used as one of many means to gage surface water quality (U.S. Geological Survey).

E. COLI:

E. coli is a form of coliform bacteria, which is a large assemblage of various species of bacteria linked together because of ease of culturing as a single group. It is comprised of both fecal bacteria found in the intestines of warm-blooded animals, and non-fecal coliform bacteria. *E. coli* is one of the more common forms of coliform bacteria, and its presence in high concentrations may indicate a raw sewage discharge (New Hampshire Department of Environmental Services). The acceptable concentrations of *E. coli* bacteria present in surface waters is calculated by a risk analysis based upon statistics to protect human health. Acceptable volumes are also based upon the intended usage of the water resource (i.e. human consumption, swimming, boating, fishing, etc.). Typical sources of *E. coli* bacteria include waste water treatment facilities, failing septic systems, domestic and wild animal waste, and stormwater runoff (New Hampshire Department of Environmental Services).

SECTION 3: SUMMARY OF 2010 RESULTS

SECTION 3.1: 2010 TOTAL PHOSPHORUS DATA

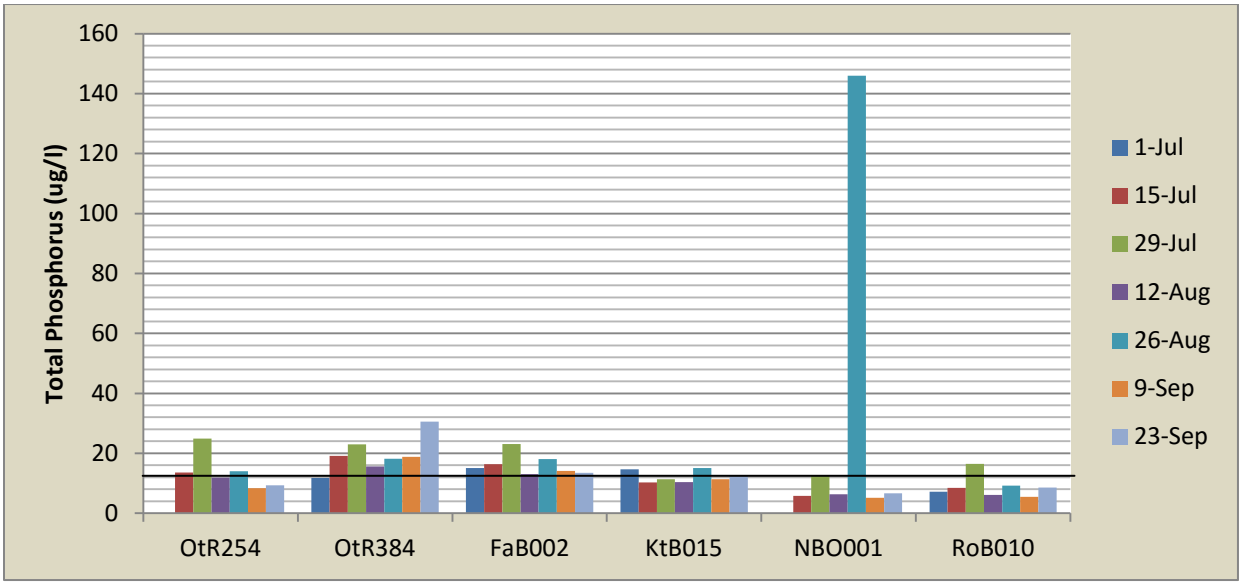


Figure 3a: 2010 Total Phosphorus Data (above Bridgewater WWTF)

As depicted in *Figure 3a & Figure 3b*, a large percentage of data points exceeded Vermont state standards (12 ug/L) with regards to phosphorus levels. A total of 77.6% of data points exceeded these standards. Consistently high phosphorus levels are exhibited at sites OtR133, KeB045, and OtR384 with tremendous spikes present at NBO001 and KeB045. Low and consistent trends are indicated at sites KtB015 and RoB010 on Roaring Brook in Killington, while higher trends are exhibited around Woodstock.

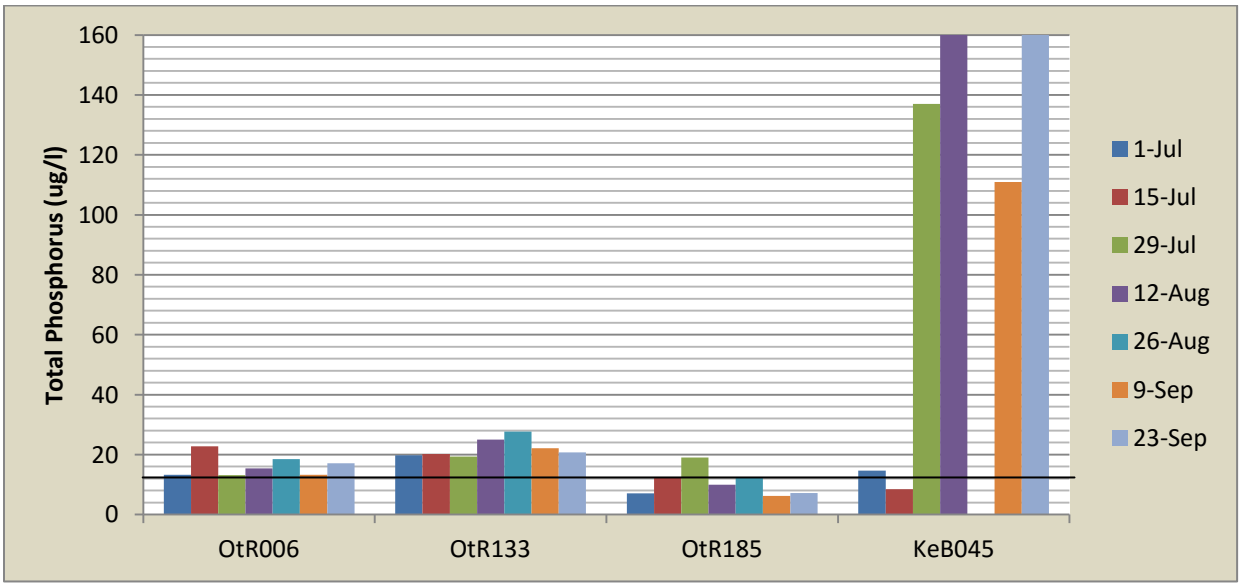


Figure 3b: 2010 Total Phosphorus Data (below Bridgewater WWTF)

SECTION 3.2: 2010 TURBIDITY DATA

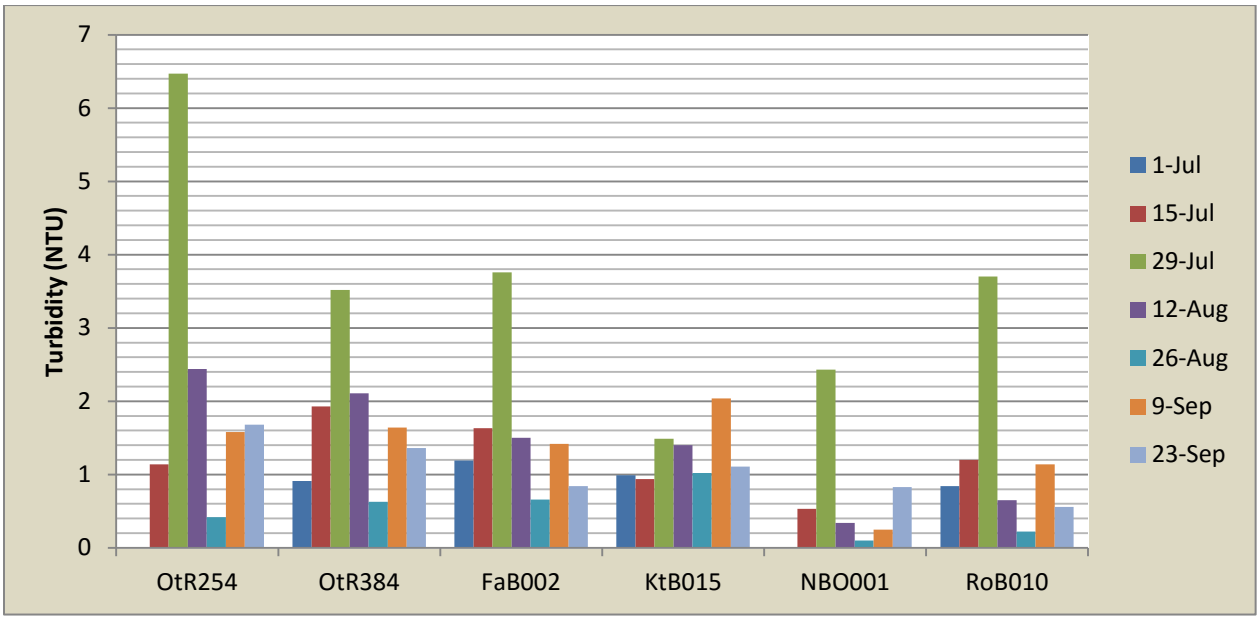


Figure 3c: 2010 Turbidity Data (above Bridgewater WWTF)

As indicated in *Figure 3c & Figure 3d,* turbidity levels in 2010 were well within compliance of the current State of Vermont standards. Current standards state that a river or stream should not exceed 10 NTU; while the highest level exhibited (OtR254 on July 29, 2010) is still well shy of 7 NTU. A significant spike in turbidity is observable at nearly all sites upstream of the Bridgewater WWTF on July 29. No significant increasing or declining trends are observable at any sites throughout the 2011 monitoring season.

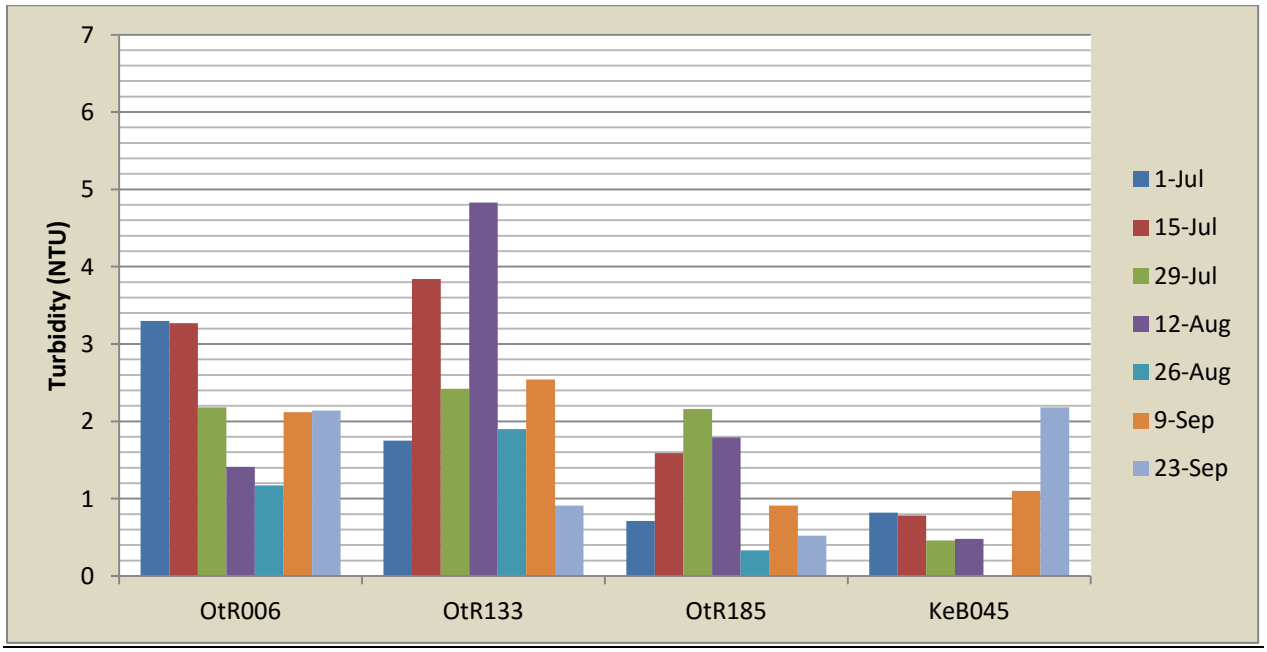


Figure 3d: 2010 Turbidity Data (below Bridgewater WWTF)

SECTION 3.3: 2010 CHLORIDE DATA

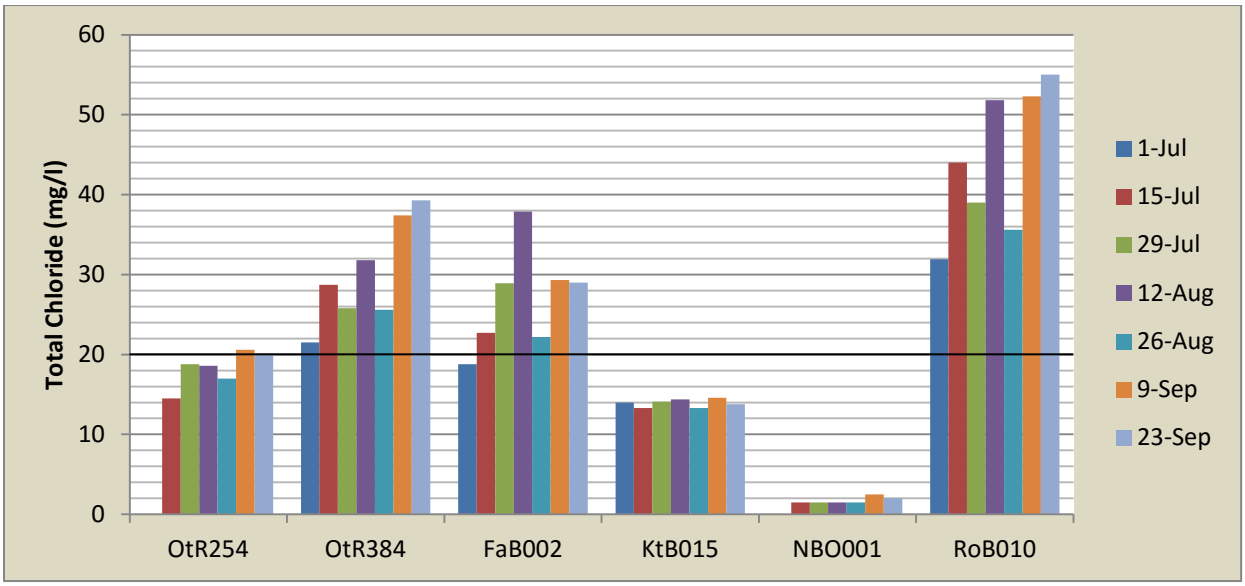


Figure 3e: 2010 Total Chloride Data (above Bridgewater WWTF)

Chloride concentrations during the 2011 monitoring season were consistently high at site RoB010 on Roaring Brook in Killington and consistently low at site NBO001 on the North Branch of the Ottauquechee River in Bridgewater. The next highest levels of trend variation occurred in the Ottauquechee River (site FaB002) below the confluence of Falls Brook in Killington and in the Ottauquechee River (site OtR384) in Killington. Nearly all sampling sites showed a generally increasing trend in Chloride levels as the summer progressed.

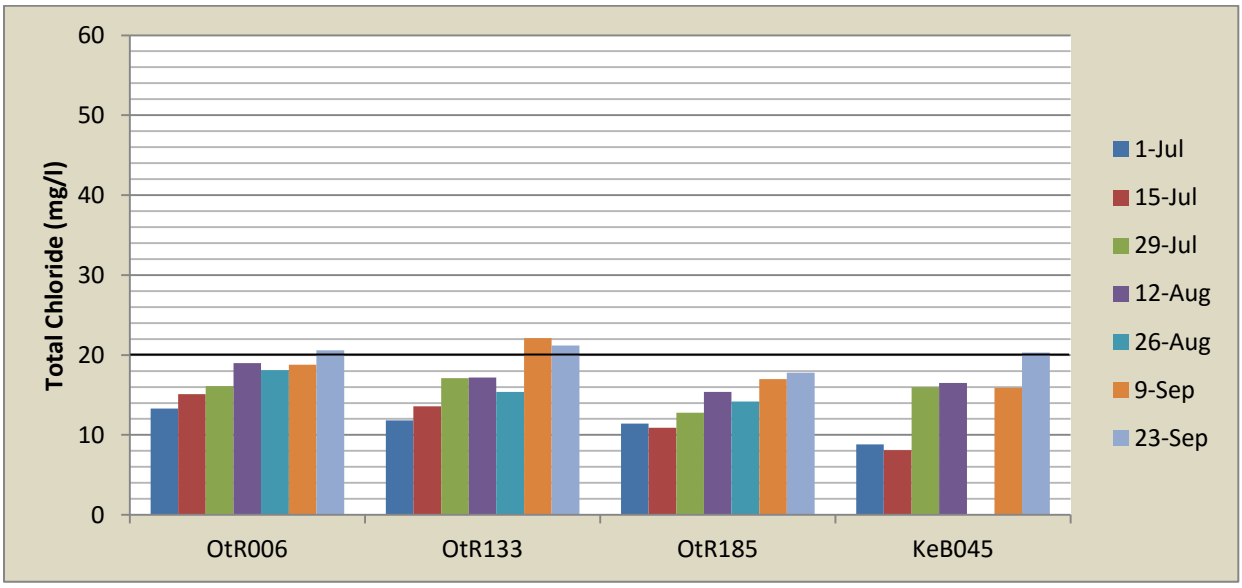


Figure 3f: 2010 Total Chloride Data (below Bridgewater WWTF)

SECTION 3.4: 2010 *E. COLI* DATA

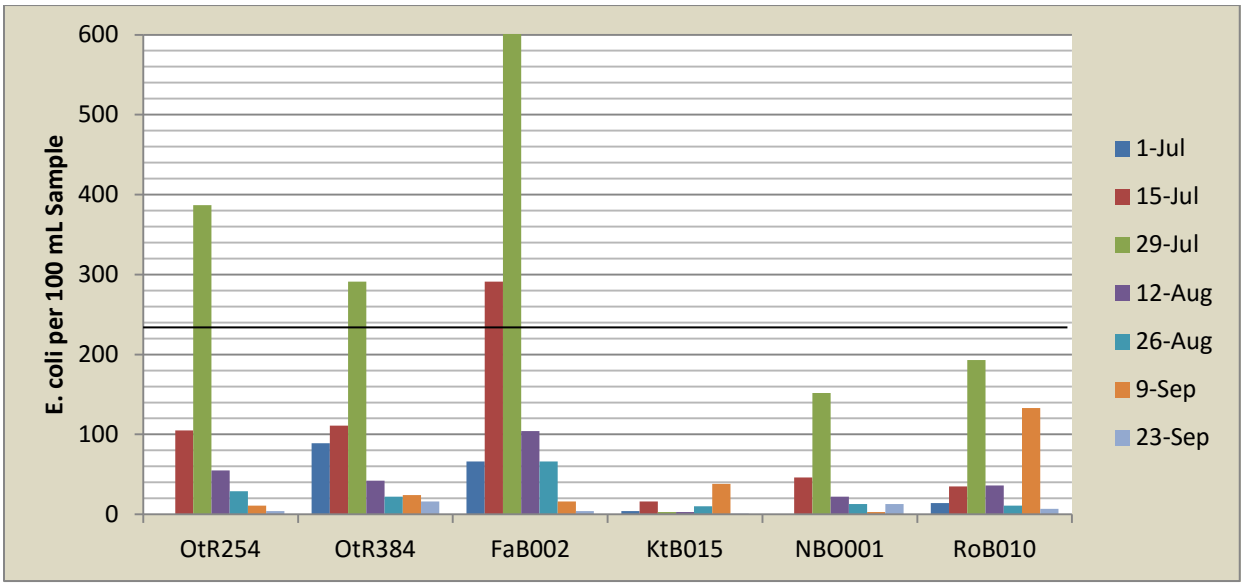


Figure 3g: 2010 E. coli Data (above Bridgewater WWTF)

About 37% of *E. coli* bacteria samples collected during the 2011 season had exceeded State or Federal limits for swimming suitability. Results indicate that *E. coli* bacteria levels varied the most in Kedron Brook (site KeB045) in South Woodstock and varied the least in Kent Pond Brook (site KtB015) in Killington. The Kedron Brook *E. coli* results exceeded State or Federal limits in 67% of the sampling events. The Kent Pond samples were the only sampling site without any results exceeding State or Federal *E. coli* limits. The next highest levels of *E. coli* trend variation occurred in the Ottauquechee River (site OtR254) in Bridgewater and in the Ottauquechee River (site OtR133) in Woodstock (less than half of the samples at both sites exceeded State or Federal standards). Only one site in Hartland (site OtR006) showed a declining *E. coli* trend for the sampling period with 57% of data points exceeding State and Federal standards for the first 4 sampling events and the last 3 sampling events were below State and Federal *E. coli* standards.

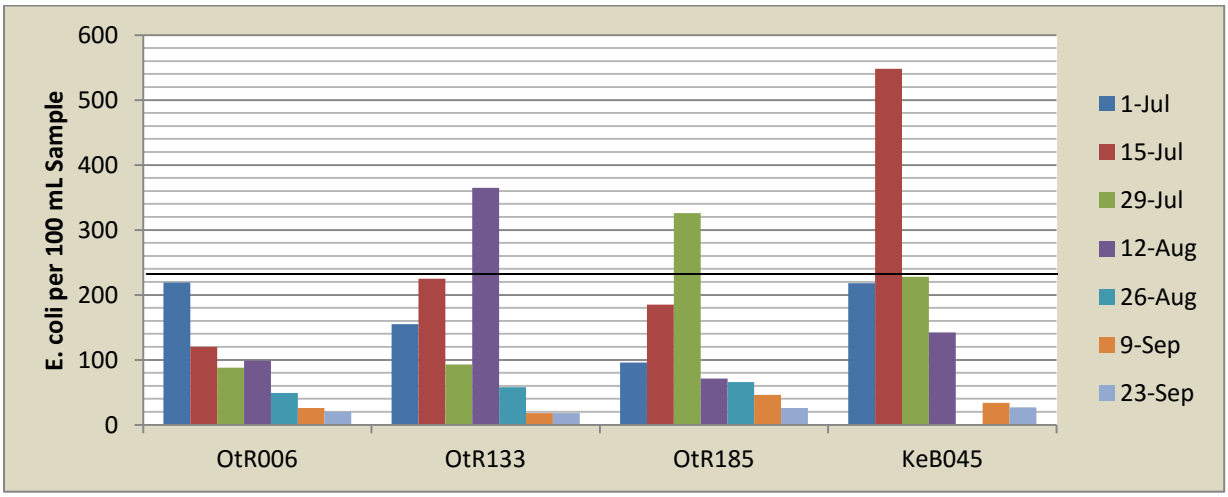


Figure 3h: 2010 E. coli Data (below Bridgewater WWTF)

SECTION 4: SUMARRY OF 2013 RESULTS

SECTION 4.1: 2013 TOTAL PHOSPHORUS DATA

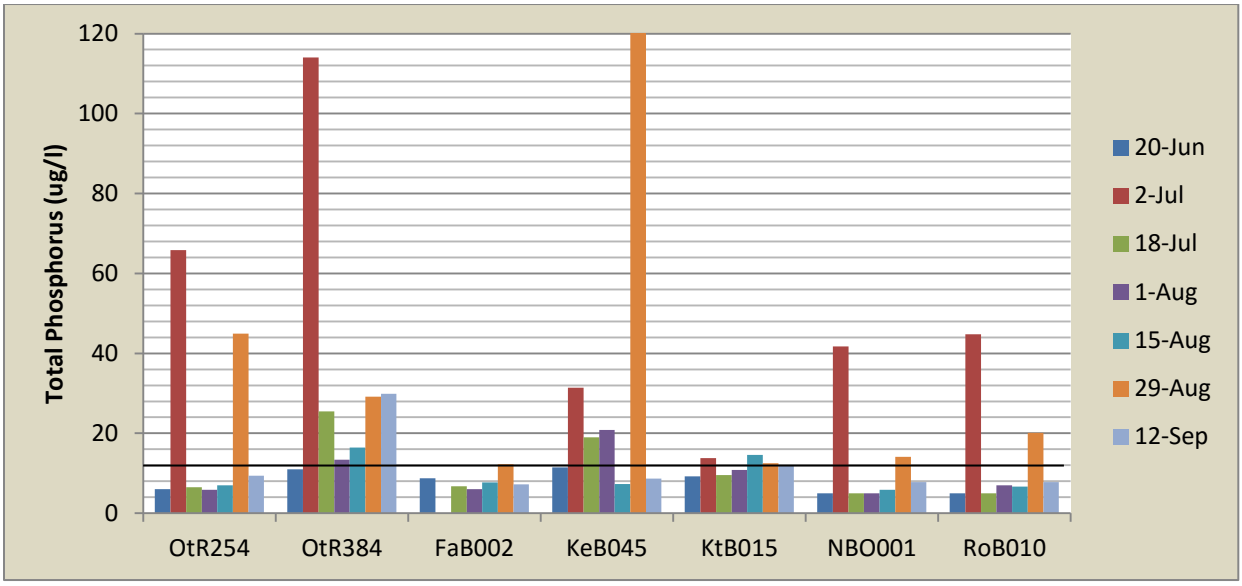


Figure 4a: 2013 Total Phosphorus Data (above Bridgewater WWTF)

As indicated in *figures 4a & 4b*, a significant percentage of data points exceeded Vermont state standards regarding phosphorus levels in 2013 at 45%. Site to site variation in phosphorus levels stayed fairly uniform; however multiple sampling dates stand out as huge spikes, including July 2nd and August 29th. Sites FaB002 near the confluence of Falls Brook and KtB015 near the Kent Pond outlet exhibit no significant spikes and FaB002 did not exceed state phosphorus level standards at any point throughout the course of the sampling season. No notable trends seem to exist by with respect to phosphorus levels in 2013.

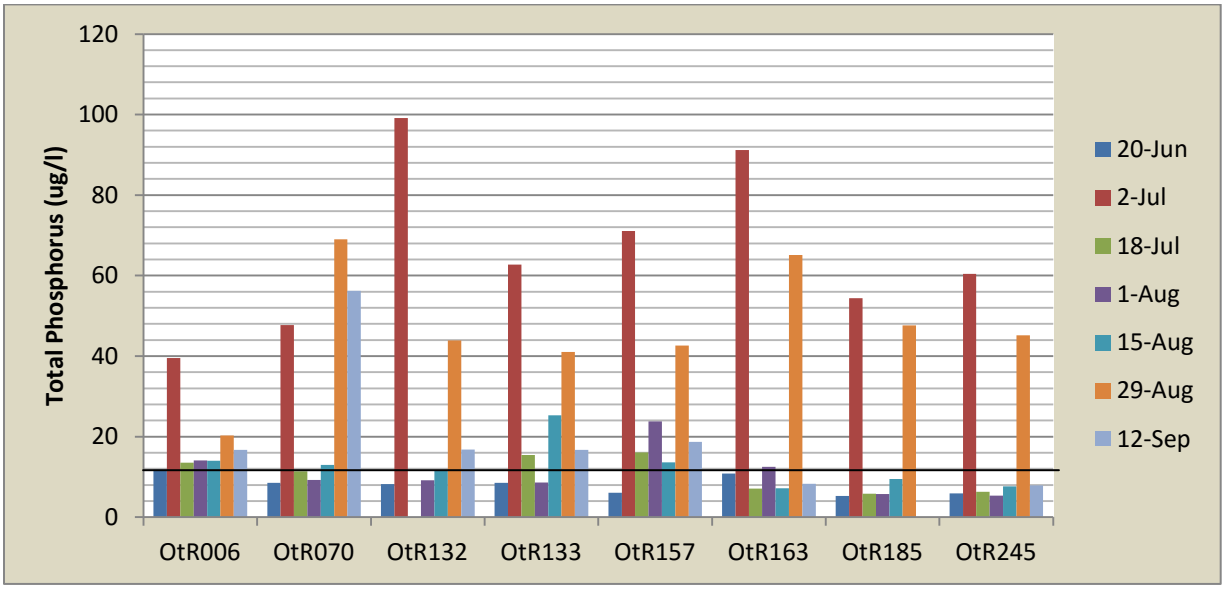


Figure 4b: 2013 Total Phosphorus Data (below Bridgewater WWTF)

SECTION 4.2: 2013 TURBIDITY DATA

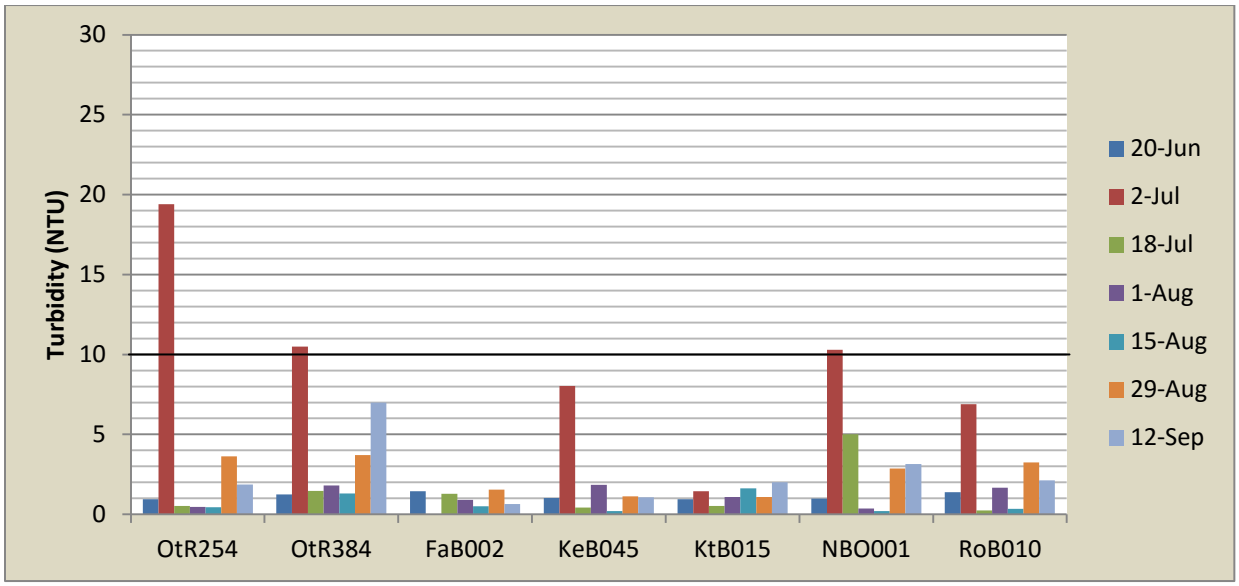


Figure 4c: 2013 Turbidity Data (above Bridgewater WWTF)

Figures 4c & 4d indicate that turbidity levels in 2013 were well within compliance of state standards by and large. July 2nd exceeded standards at almost every site and OtR070, OtR132, and OtR185 exceeded standards on August 29th. Excluding those dates, everything was in compliance. FaB002 and KtB015 exhibited extremely low and stable turbidity levels. No significant trends with regards to turbidity levels are apparent throughout the 2013 sampling season.

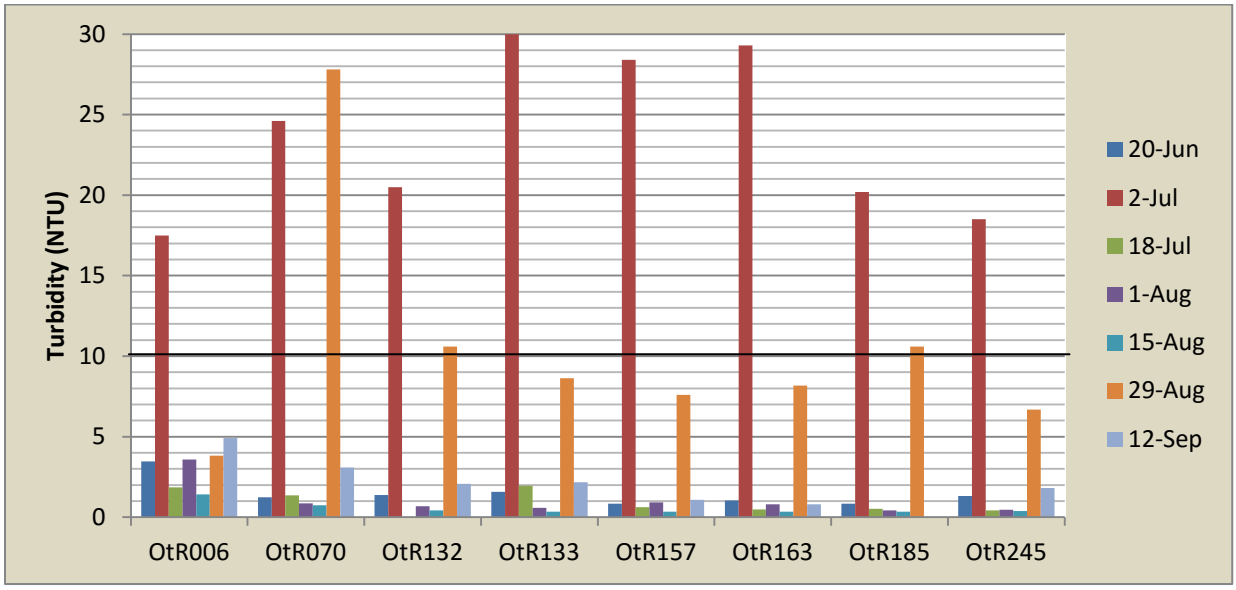


Figure 4d: 2013 Turbidity Data (below Bridgewater WWTF)

SECTION 4.3: 2013 CHLORIDE DATA

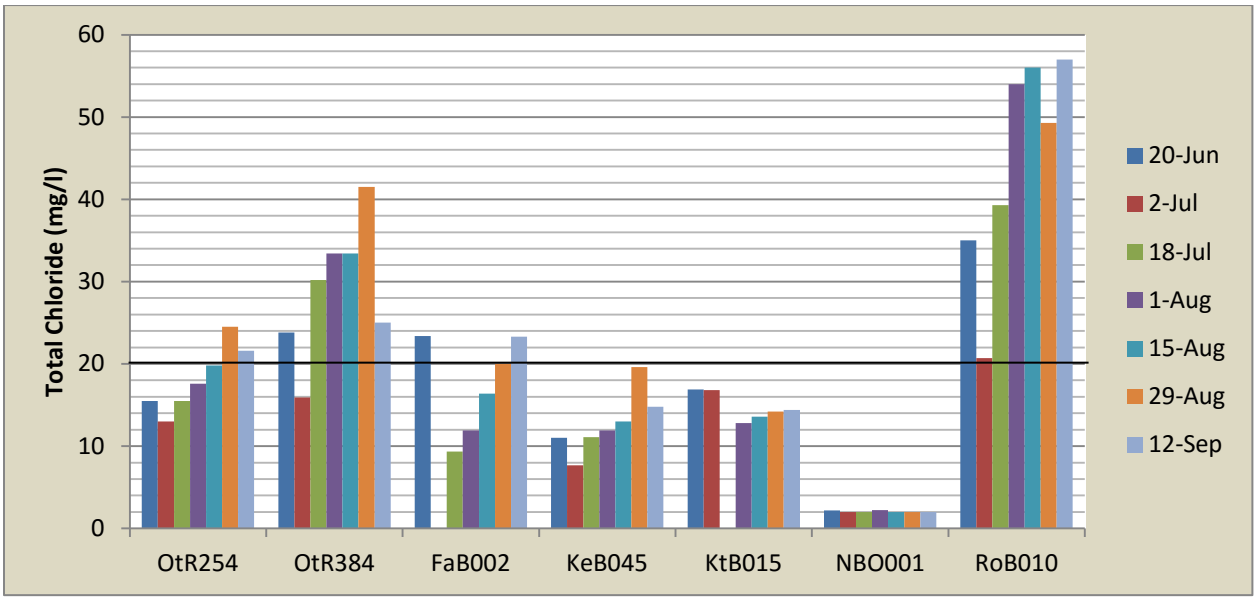


Figure 4e: 2013 Total Chloride Data (above Bridgewater WWTF)

Consistently high concentrations of chloride were found throughout the course of the 2013 sampling season at sites RoB010 on Roaring Brook near Killington and OtR384. By far the lowest and most stable concentrations were found at site NBO001. KtB015 also exhibited relatively stable concentrations. With the exception of these two sites, chloride concentrations showed a significantly increasing trend throughout the monitoring season, with RoB010 showing that trend most strongly. Chloride concentrations were somewhat lower generally below the waste water treatment facility in Bridgewater.

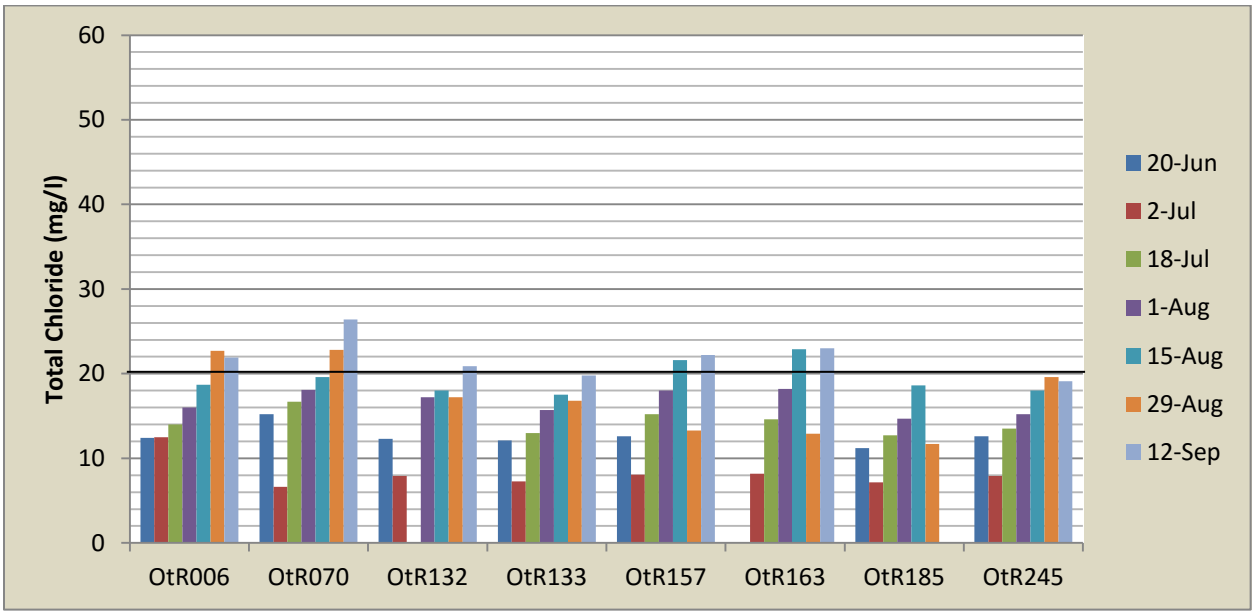


Figure 4f: 2013 Total Chloride Data (below Bridgewater WWTF)

SECTION 4.4: 2013 *E. COLI* DATA

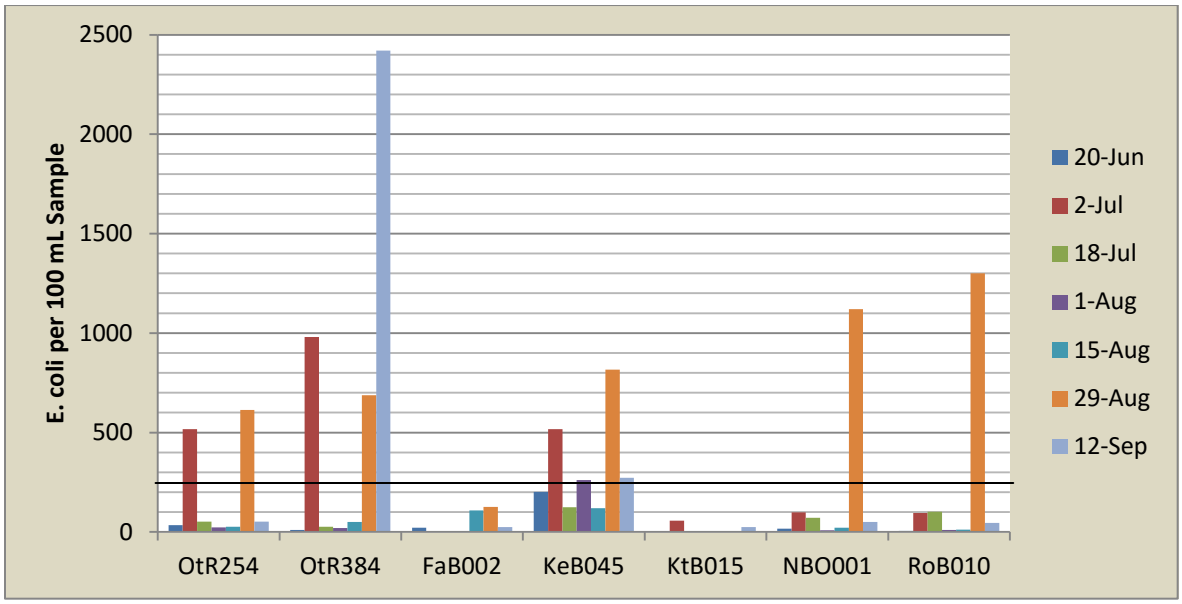


Figure 4g: 2013 E. coli Data (above Bridgewater WWTF)

E. coli concentrations throughout the 2013 monitoring season were generally considered suitable for swimming under state and federal standards, with the exception of August 29th and July 2nd. Only roughly 26% of *E. coli* samples collected exceeded standards. A few very significant spikes are observable on September 12th at several sites. Sites FaB002 and KtB015 remained very stable and suitable for swimming throughout the duration of the 2013 monitoring season. No significant increasing or declining trends are observable.

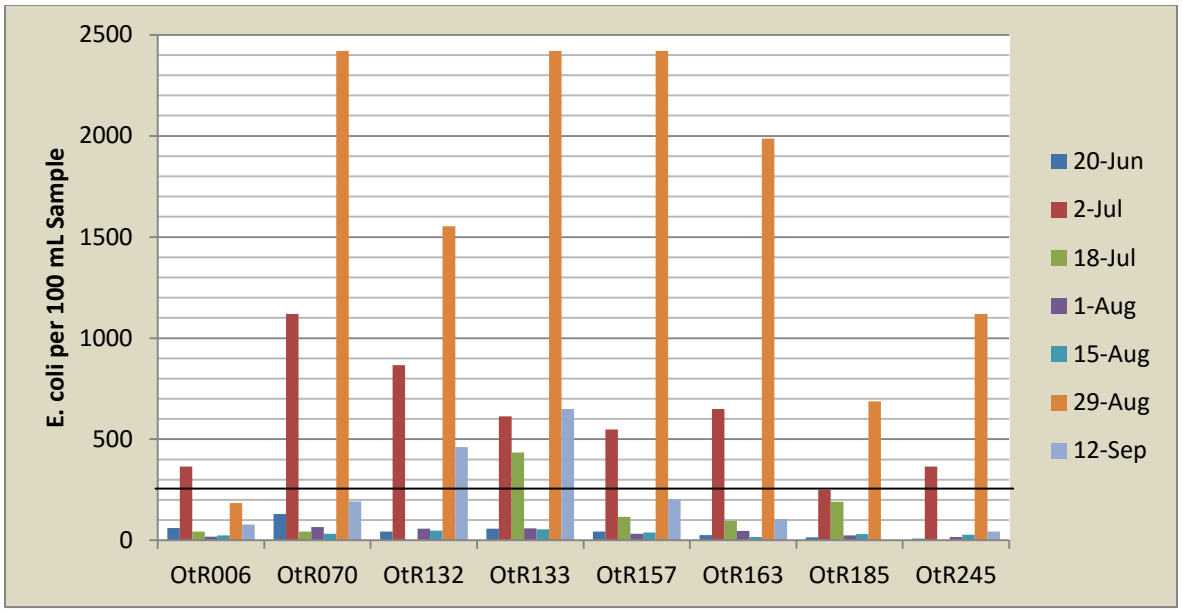


Figure 4h: 2013 E. coli Data (below Bridgewater WWTF)

SECTION 4.5: 2013 TOTAL NITROGEN DATA

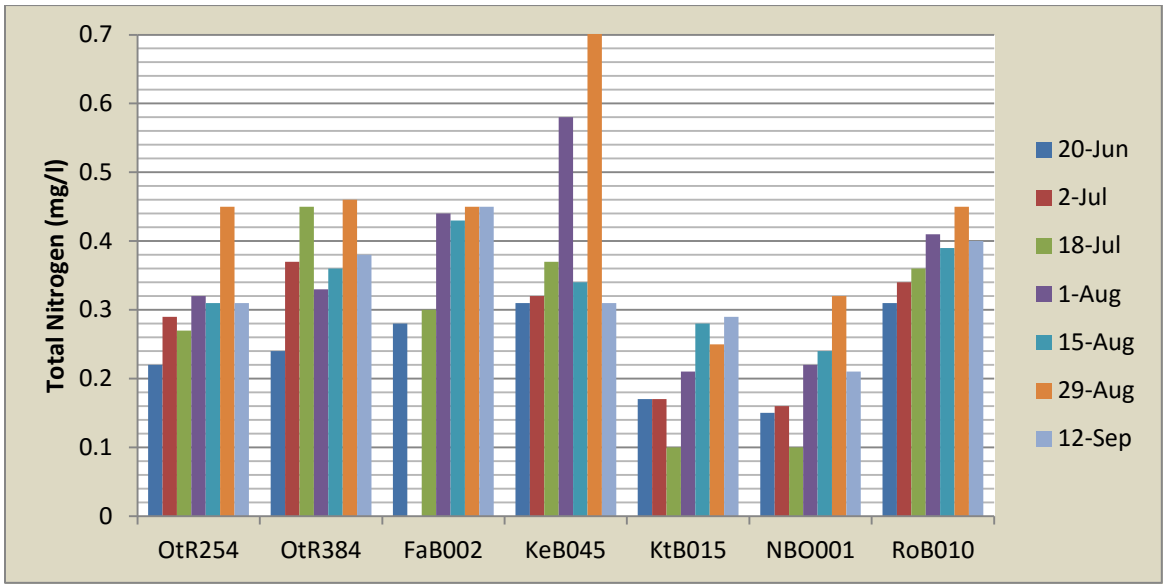


Figure 4i: 2013 Total Nitrogen Data (above Bridgewater WWTF)

Total Nitrogen concentrations during the 2013 season were in compliance with state standards across the board. None of the data points throughout the season exceeded those standards. Nearly all of the sites exhibited an increasing trend in nitrogen concentrations during the course of the summer. Sites KtB015 and NBO001 stand out as having the lowest nitrogen concentrations though they do trend upward as the season progressed. A significant spike in nitrogen can be observed on August 29th at several sites.

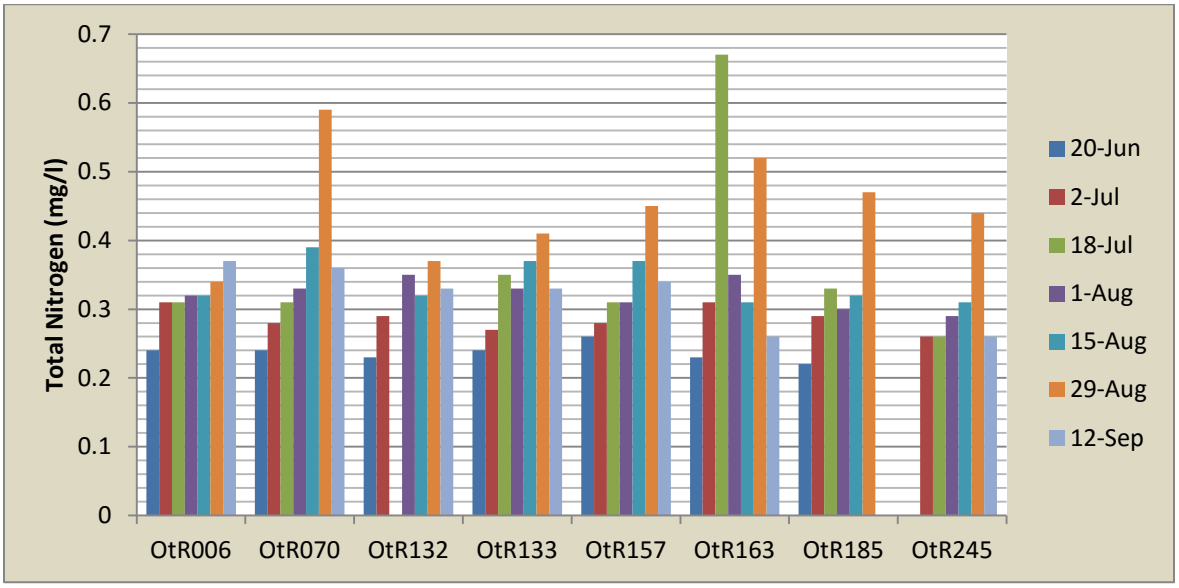


Figure 4j: 2013 Total Nitrogen Data (below Bridgewater WWTF)

SECTION 5: SUMMARY OF 2014 RESULTS

SECTION 5.1: 2014 TOTAL PHOSPHORUS DATA

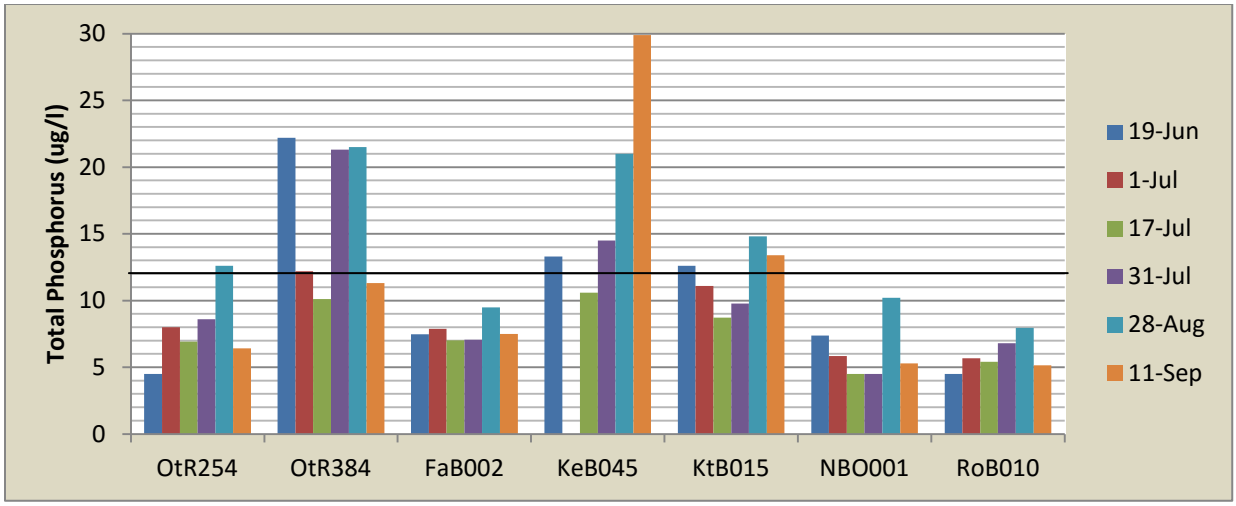


Figure 5a: 2014 Total Phosphorus Data (above Bridgewater WWTF)

Total phosphorus levels in 2014 achieved the greatest rate of compliance the program has seen to date, with only roughly 30% of data points exceeding state standards, down from about 78% during the summer of 2010. Phosphorus concentrations were generally slightly higher below the Bridgewater waste water treatment facility, and also had a much greater rate of significant spikes. Sites OtR245, FaB002, NBO001, and RoB010 had notably low phosphorus concentrations and each of those four sites remained in compliance throughout the entire monitoring season. Notably high concentrations can be observed at sites OtR384 (Rabeck Road Bridge), OtR006 (Hartland Covered Bridge), and KeB045 (Kedron Brook). No noticeable increasing or descending trends are observable during the course of the 2014 monitoring season.

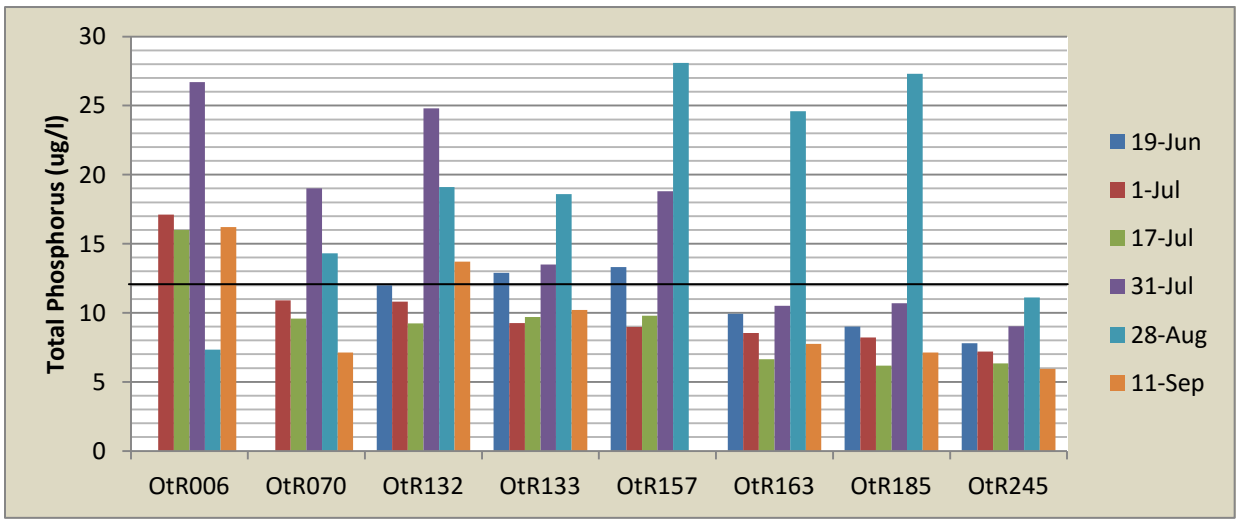


Figure 5b: 2014 Total Phosphorus Data (below Bridgewater WWTF)

SECTION 5.2: 2014 TURBIDITY DATA

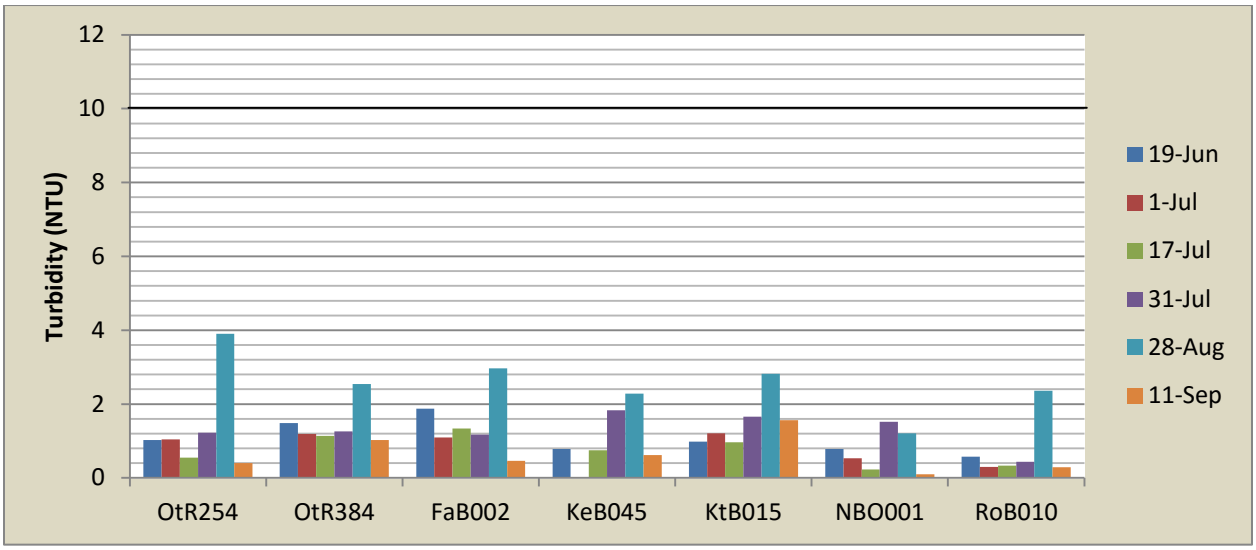


Figure 5c: 2014 Turbidity Data (above Bridgewater WWTF)

Turbidity in 2014 was generally well within compliance of state standards, as only a mere 4% of data points exceeded those standards. All of the spikes in turbidity that exceeded state standards are located below the waste water treatment facility in Bridgewater, and overall turbidity levels are generally higher below the WWTF. The lowest turbidity levels can be found at sites NBO001 and RoB010, though all of the sites above the Bridgewater WWTF exhibit notably low levels of turbidity. The highest turbidity levels appear to be located at site OtR006 at the Hartland covered bridge swim area.

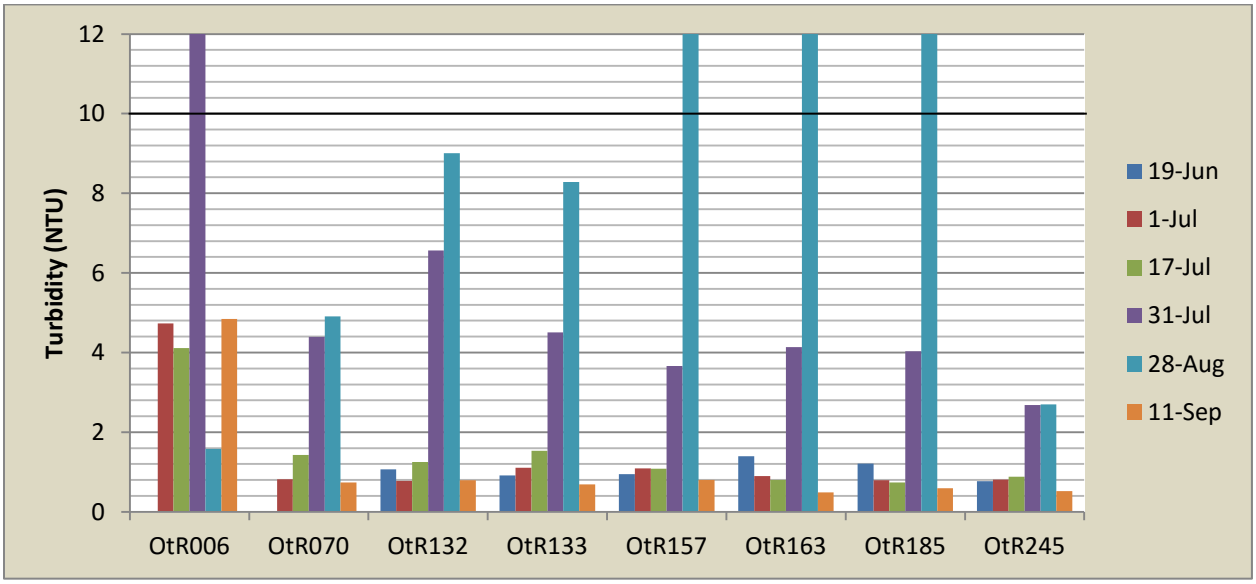


Figure 5d: 2014 Turbidity Data (below Bridgewater WWTF)

SECTION 5.3: 2014 CHLORIDE DATA

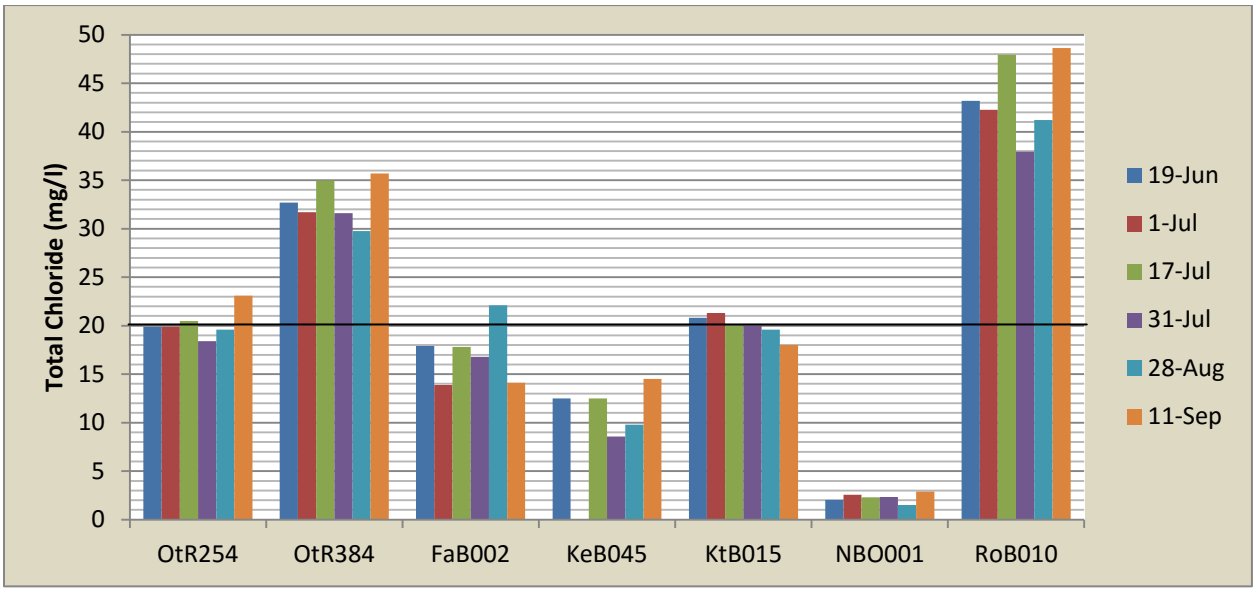


Figure 5e: 2014 Total Chloride Data (above Bridgewater WWTF)

Chloride concentrations in the Ottauquechee River Watershed in 2014 were generally significantly higher above the waste water treatment facility in Bridgewater, specifically at site RoB010 which had higher chloride concentrations than any other site during each of the 2014 sampling dates. This is likely a result of heavy road salting to accommodate safe vehicle travel to the Killington Ski Resort. Site OtR384 (Rabeck Road Bridge) also exhibits notably high chloride concentrations. Site NBO001 on the North Branch Ottauquechee River had by far the lowest and most consistent levels of chloride. Unlike 2010 and 2013 which both exhibited increasing trends in chloride concentrations throughout the summer, no significant trends are present in that respect during the summer of 2014.

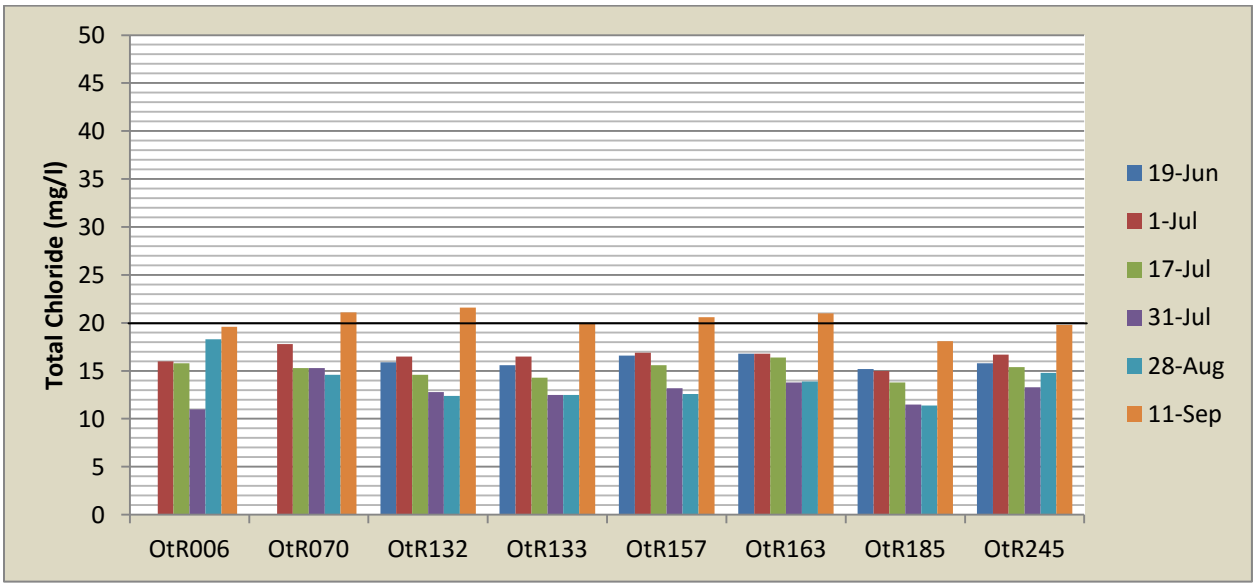


Figure 5f: 2014 Total Chloride Data (below Bridgewater WWTF)

SECTION 5.4: 2014 *E. COLI* DATA

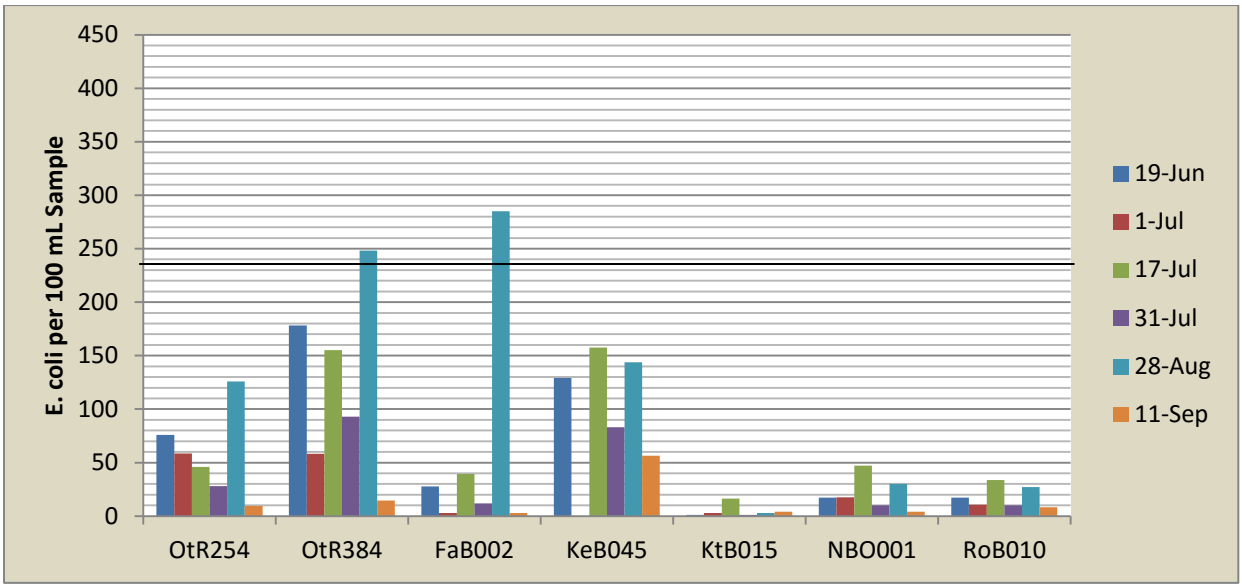


Figure 5g: 2014 E. coli Data (above Bridgewater WWTF)

E. coli bacteria concentrations in the Ottauquechee River Watershed in 2014 were generally in compliance with state and federal standards as only 8% of data points exceeded the 235 per 100 mL sample limit. A significant spike in *E. coli* bacteria is observable on August 28th. Generally high bacteria counts are present at sites OtR384 and OtR163 while KtB015, NBO001, and RoB010 exhibit notably low bacteria counts. No significant increasing and descending trends are observable throughout the course of the sampling season, though bacteria counts are generally higher below the Bridgewater waste water treatment facility.

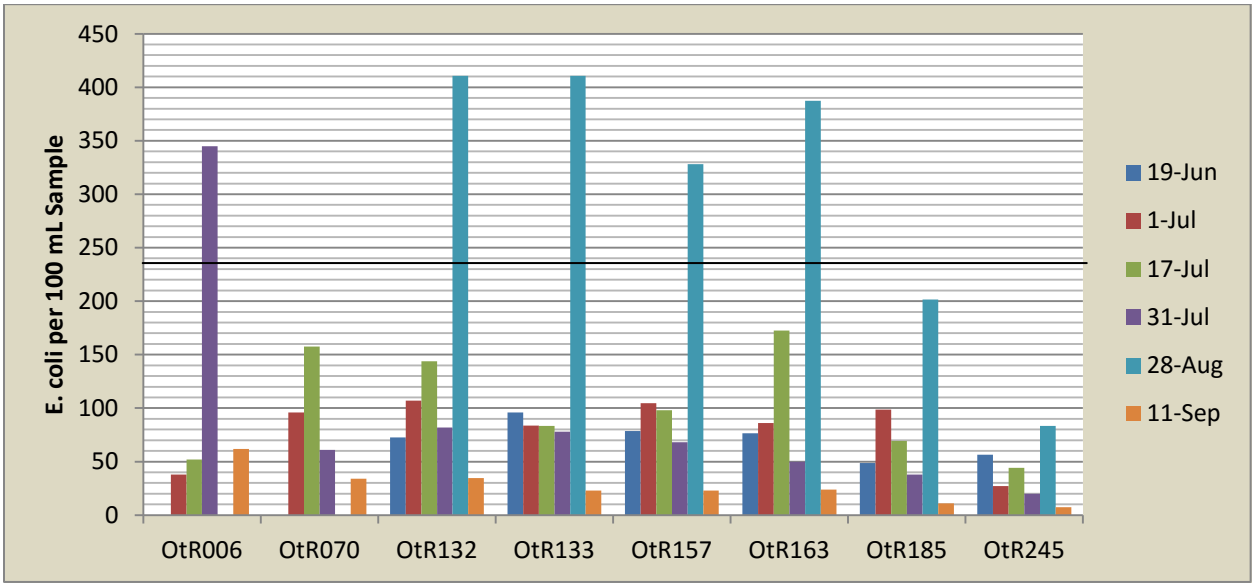


Figure 5h: 2014 E. coli Data (below Bridgewater WWTF)

SECTION 5.5: 2014 TOTAL NITROGEN DATA

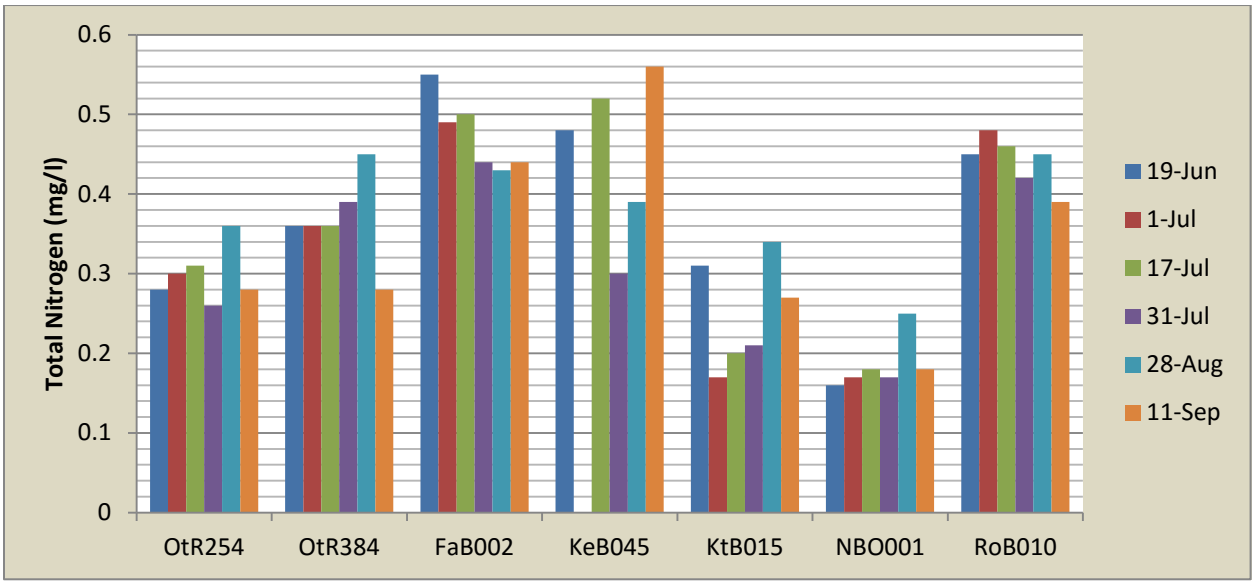


Figure 5i: 2014 Total Nitrogen Data (above Bridgewater WWTF)

All of the total nitrogen data points in the Ottauquechee River Watershed in 2014 were in compliance with state standards. Sites RoB010, FaB002, and KeB045 stand out as generally having the highest TN concentrations, while NBO001 is shown to have the lowest concentrations. No significant increasing or descending trends are evident throughout the course of the sampling season.

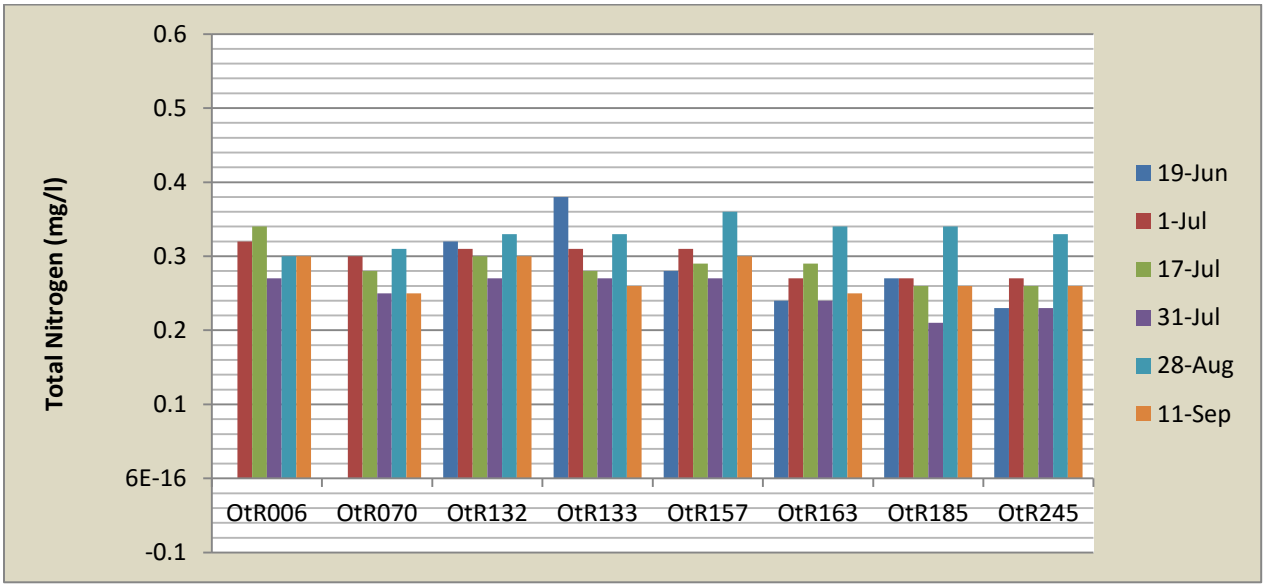


Figure 5j: 2014 Total Nitrogen Data (below Bridgewater WWTF)

SECTION 6: SUMMARY OF 2015 RESULTS

SECTION 6.1: 2015 TOTAL PHOSPHORUS DATA

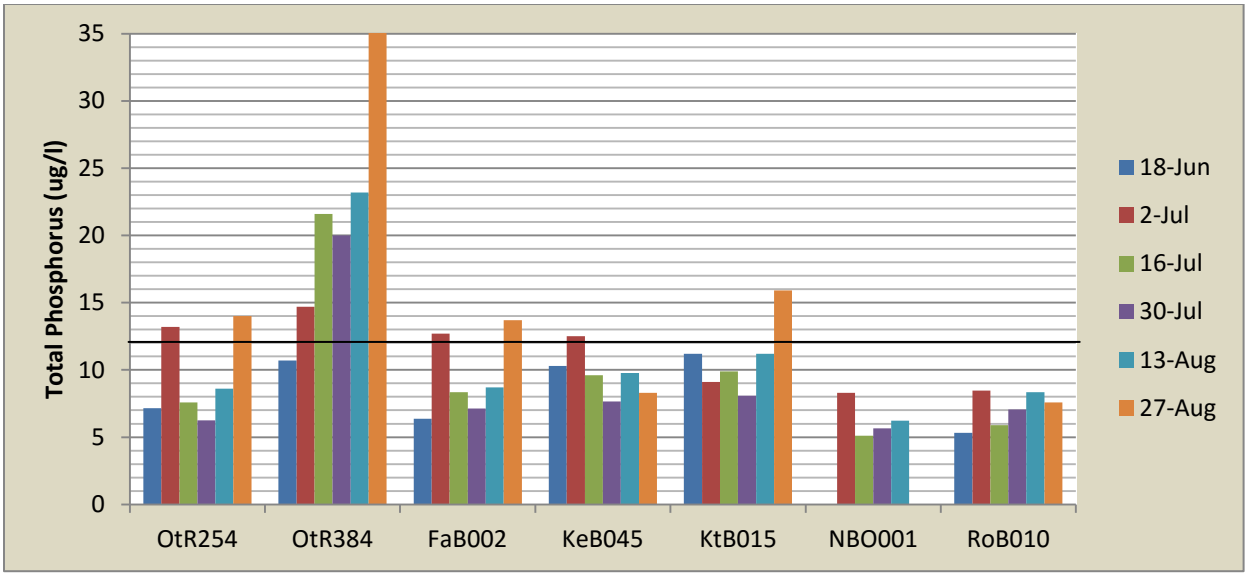


Figure 6a: 2015 Total Phosphorus Data (above Bridgewater WWTF)

Roughly 40% of total phosphorus data points collected in 2015 exceeded state standards (12 ug/l). The highest phosphorus concentrations can be found at site OtR384, as well as site OtR006, which exceeded standards during each sampling event carried out in 2015. The lowest total phosphorus concentrations can be found at sites NBO001 and RoB010. With the exception of site OtR384, which shows a very distinct increasing trend throughout the course of the sampling season, no significant increasing or declining trends seem to exist.

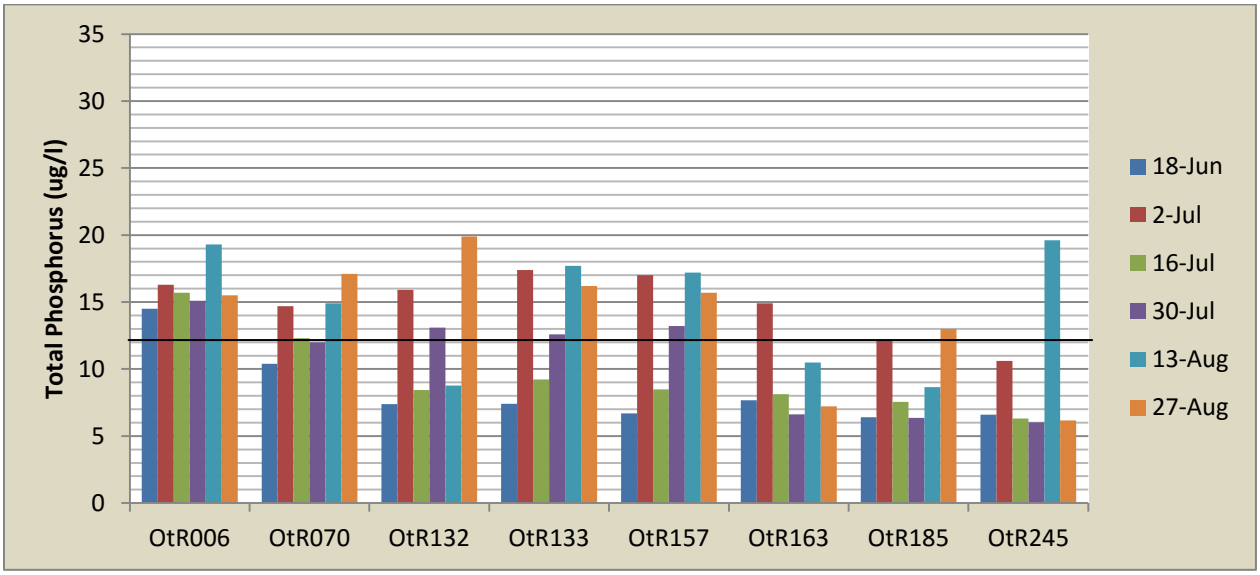


Figure 6b: 2015 Total Phosphorus Data (below Bridgewater WWTF)

SECTION 6.2: 2015 TURBIDITY DATA

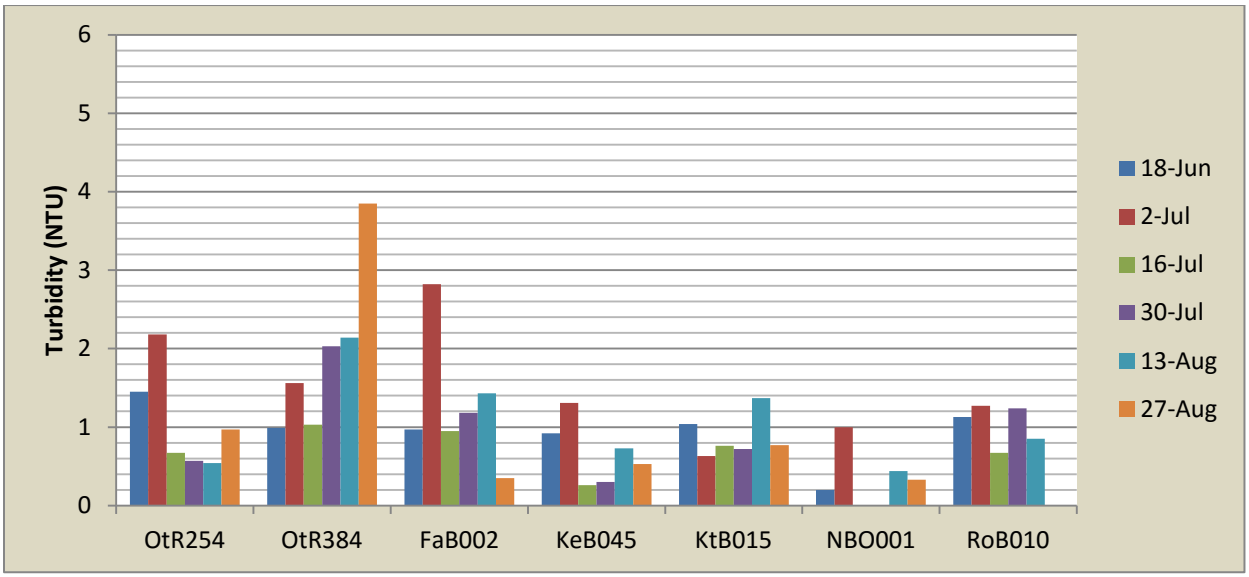


Figure 6c: 2015 Turbidity Data (above Bridgewater WWTF)

All of the 2015 turbidity data points are in compliance with current Vermont state standards (10 NTU). The most turbid site is shown to be OtR006 at the Hartland covered bridge swimming area, and the sites below the waste water treatment facility in Bridgewater are generally more turbid than those located above the facility. The least turbid sites include NBO001, RoB010, and KeB045.

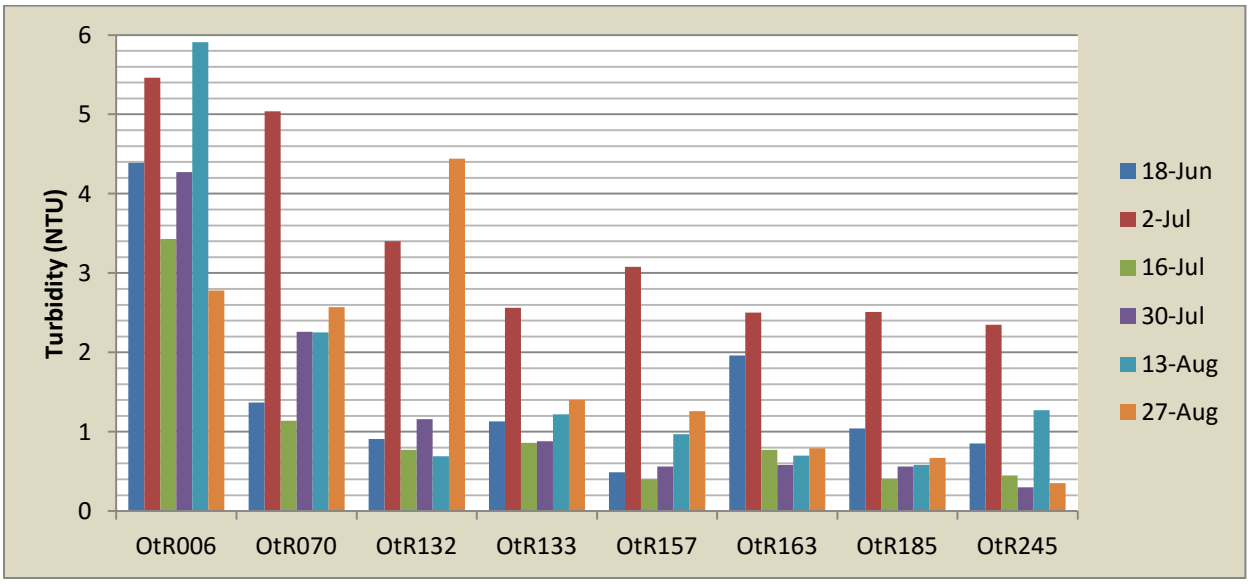


Figure 6d: 2015 Turbidity Data (below Bridgewater WWTF)

SECTION 6.3: 2015 CHLORIDE DATA

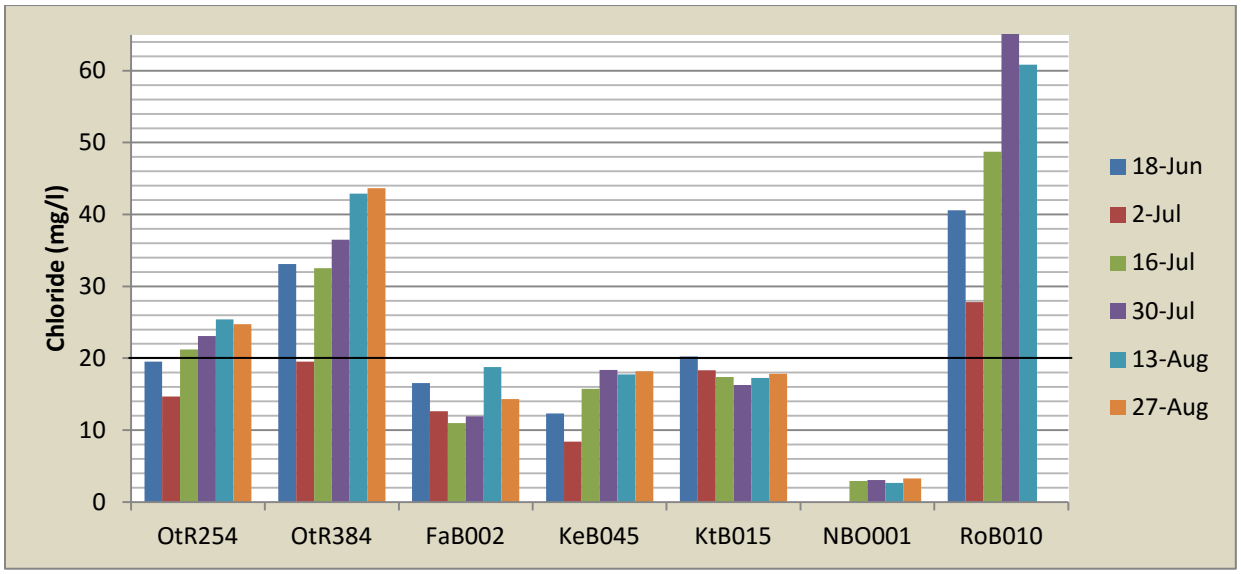


Figure 6e: 2015 Chloride Data (above Bridgewater WWTF)

A total of 38.9% of chloride data points collected in 2015 exceeded state standards (20 mg/l). The highest concentrations of chloride by far are located at sites OtR384 and RoB010. Nearly all of the sampling sites exhibit a generally increasing trend as the season progresses, excluding only sites FaB002, KtB015, and NBO001. Site NBO001 also possesses by far the lowest and most stable chloride concentrations. Chloride levels below the waste water treatment facility in Bridgewater exhibit much more consistent trends than those located above the facility.

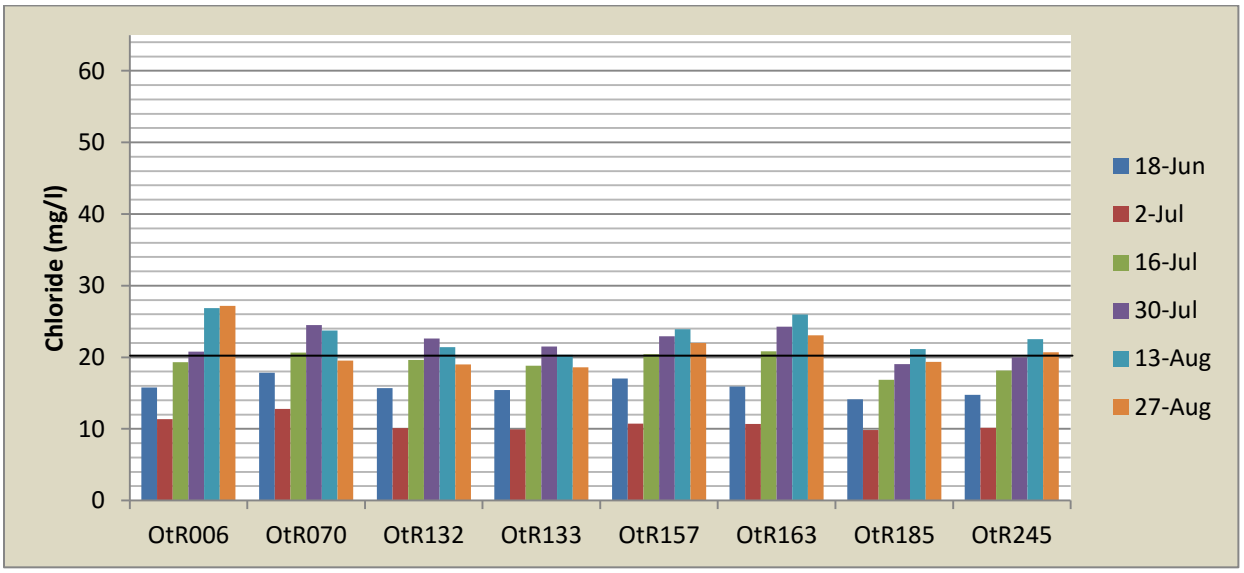


Figure 6f: 2015 Chloride Data (below Bridgewater WWTF)

SECTION 6.4: 2015 *E. COLI* DATA

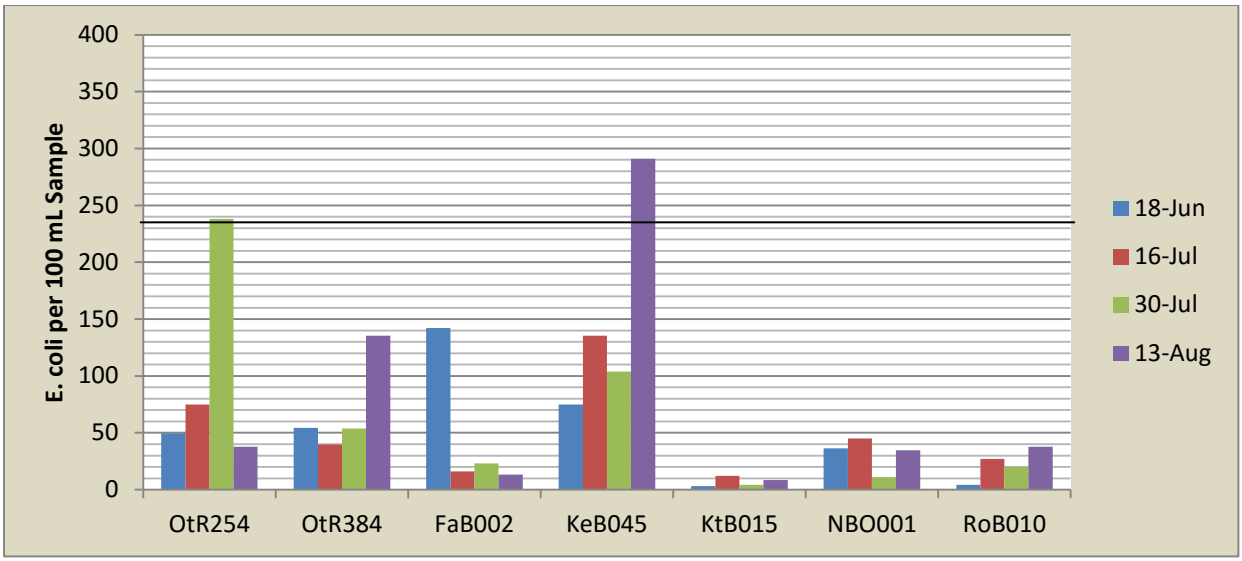


Figure 6g: 2015 E. coli Data (above Bridgewater WWTF)

The vast majority of *E. coli* bacteria data points collected during the 2015 monitoring season were well within compliance of state standards. Only 8% of data points exceeded those standards (235 *E. coli* per 100 mL sample). *E. coli* bacteria were generally found in higher concentrations below the waste water treatment facility in Bridgewater. Sites KtB015, NBO001, and RoB010 consistently show notably low concentrations of *E. coli* bacteria. No significant increasing or decreasing trends seem to exist throughout the course of the 2015 monitoring season.

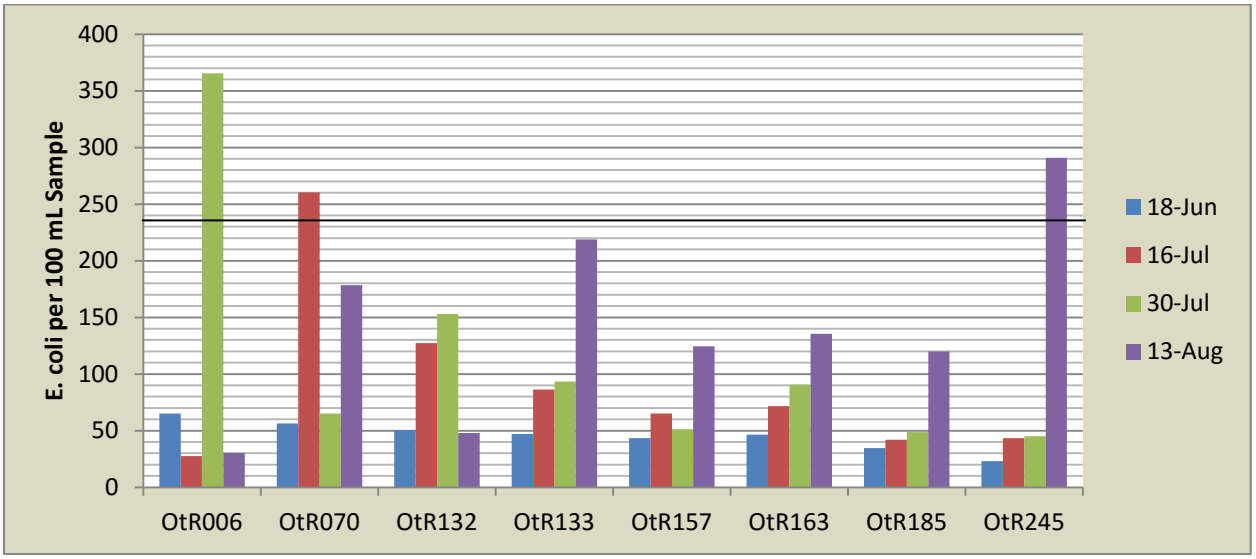


Figure 6h: 2015 E. coli Data (below Bridgewater WWTF)

SECTION 6.5: 2015 TOTAL NITROGEN DATA

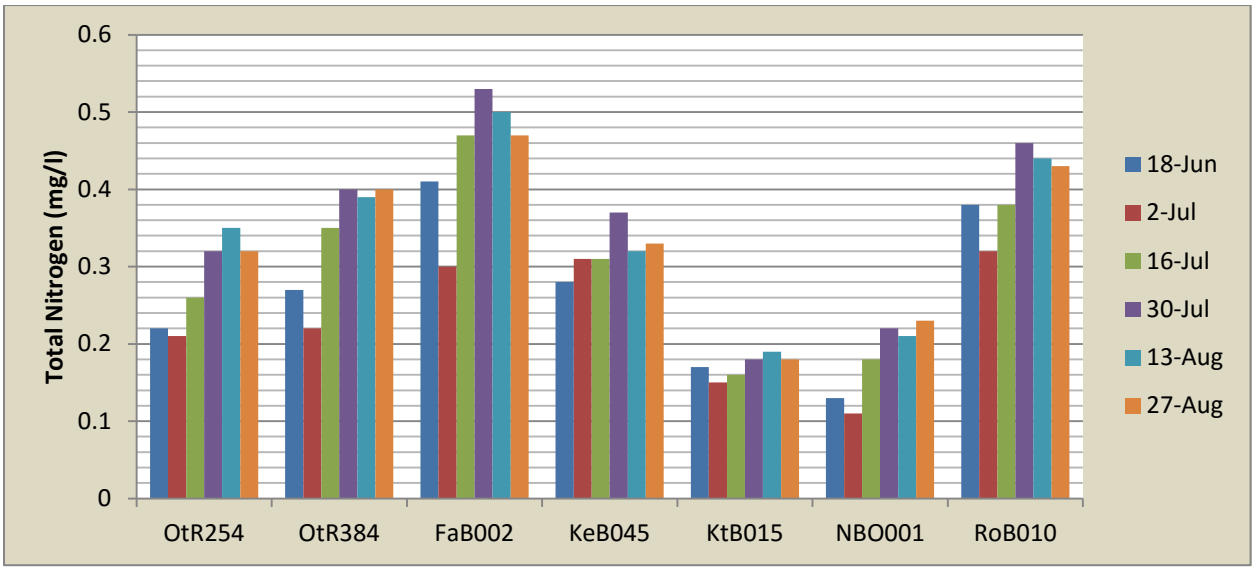


Figure 6i: 2015 Total Nitrogen Data (above Bridgewater WWTF)

All of the 2015 total nitrogen data points are well within compliance of state standards (5 mg/l). The highest concentrations of nitrogen can be found at sites FaB002 and RoB010 while the lowest concentrations are found at sites KtB015 and NBO001. Generally increasing trends in nitrogen concentrations can be found at nearly all sites throughout the 2015 monitoring season.

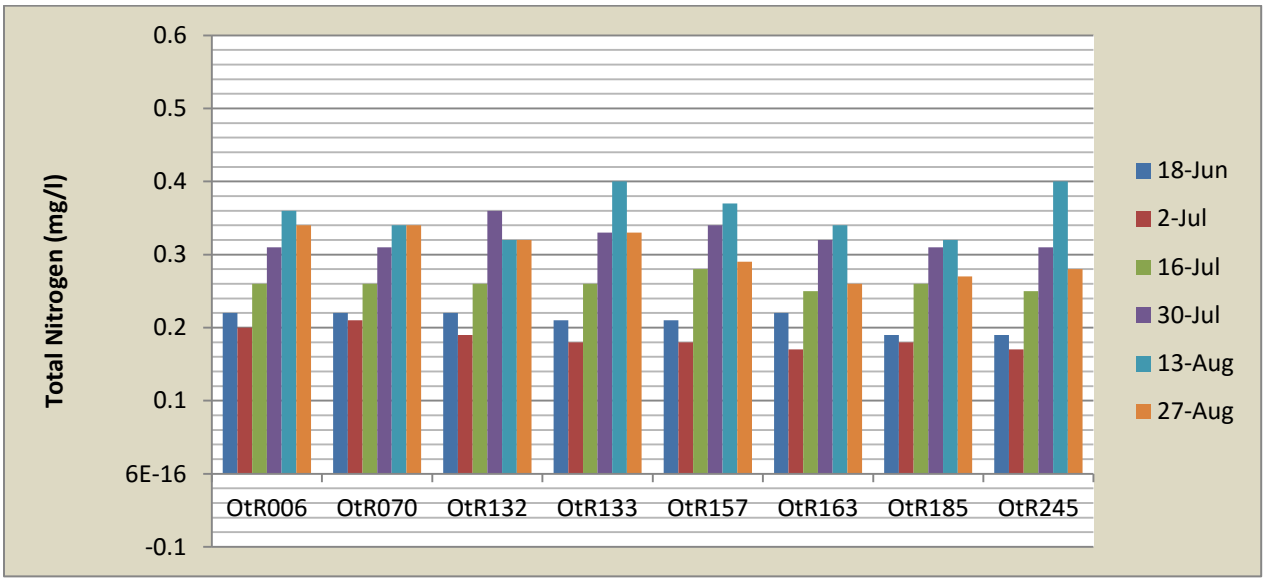


Figure 6j: 2015 Total Nitrogen Data (below Bridgewater WWTF)

SECTION 7: DATA COMPLETENESS

2010 – Number of sampling events & Data completeness								
I = Intended, A = Actual								
	Chloride		Phosphorus		E. coli.		Turbidity	
	I	A	I	A	I	A	I	A
FaB002	7	7	7	7	7	7	7	7
KeB045	7	6	7	6	7	6	7	6
KtB015	7	7	7	7	7	7	7	7
NBO001	7	6	7	6	7	6	7	6
OtR006	7	7	7	7	7	7	7	7
OtR133	7	7	7	7	7	7	7	7
OtR185	7	7	7	7	7	7	7	7
OtR254	7	6	7	6	7	6	7	6
OtR384	7	7	7	7	7	7	7	7
RoB010	7	7	7	7	7	7	7	7
Total	70	67	70	67	70	67	70	67
% complete	96%		96%		96%		96%	
Field Duplicates	7	7	7	7	7	7	7	7
Blanks	7	5	7	5	7	5	7	5

2011 - Number of sampling events & Data completeness								
I = Intended, A = Actual								
	Chloride		E. coli.		Turbidity		Nitrogen	
	I	A	I	A	I	A	I	A
OtR006	7	4	7	4	7	4	7	4
OtR070	7	4	7	4	7	4	7	4
OtR132	7	4	7	4	7	4	7	4
OtR133	7	4	7	4	7	4	7	4
OtR157	7	4	7	4	7	4	7	4
OtR163	7	4	7	4	7	4	7	4
OtR185	7	4	7	4	7	4	7	4
OtR245	7	4	7	4	7	4	7	4
OtR254	7	4	7	4	7	4	7	4
OtR384	7	4	7	4	7	4	7	4
FaB002	7	4	7	4	7	4	7	4
KeB045	7	4	7	4	7	4	7	4
KtB015	7	4	7	4	7	4	7	4
NBO001	7	4	7	4	7	4	7	4
RoB010	7	4	7	4	7	4	7	4
Total	105	60	105	60	105	60	105	60
% complete	57%		57%		57%		57%	
Field Duplicates	7	ND	7	ND	7	ND	7	ND
Blanks	7	ND	7	ND	7	ND	7	ND

2013 - Number of sampling events & Data completeness										
I = Intended, A = Actual										
	Chloride		Phosphorus		E. coli.		Turbidity		Nitrogen	
	I	A	I	A	I	A	I	A	I	A
OtR006	7	7	7	7	7	7	7	7	7	7
OtR070	7	7	7	7	7	7	7	7	7	7
OtR132	7	6	7	6	7	6	7	6	7	6
OtR133	7	7	7	7	7	7	7	7	7	7
OtR157	7	7	7	7	7	7	7	7	7	7
OtR163	7	6	7	7	7	7	7	7	7	7
OtR185	7	6	7	6	7	6	7	6	7	6
OtR245	7	7	7	7	7	7	7	6	7	6
OtR254	7	7	7	7	7	7	7	7	7	7
OtR384	7	7	7	7	7	7	7	7	7	7
FaB002	7	6	7	6	7	6	7	6	7	6
KeB045	7	7	7	7	7	7	7	7	7	7
KtB015	7	6	7	7	7	7	7	7	7	7
NBO001	7	7	7	7	7	7	7	7	7	7
RoB010	7	7	7	7	7	7	7	7	7	7
Total	105	100	105	102	105	102	105	102	105	101
% complete	95%		97%		97%		97%		96%	
Field Duplicates	7	ND	7	ND	7	ND	7	ND	7	ND
Blanks	7	ND	7	ND	7	ND	7	ND	7	ND

2014 - Number of sampling events & Data completeness										
I = Intended, A = Actual										
	Chloride		Phosphorus		E. coli.		Turbidity		Nitrogen	
	I	A	I	A	I	A	I	A	I	A
OtR006	7	5	7	5	7	4	7	5	7	5
OtR070	7	5	7	5	7	4	7	5	7	5
OtR132	7	6	7	6	7	6	7	6	7	6
OtR133	7	6	7	6	7	6	7	6	7	6
OtR157	7	6	7	5	7	6	7	6	7	6
OtR163	7	6	7	6	7	6	7	6	7	6
OtR185	7	6	7	6	7	6	7	6	7	6
OtR245	7	6	7	6	7	6	7	6	7	6
OtR254	7	6	7	6	7	6	7	6	7	6
OtR384	7	6	7	6	7	6	7	6	7	6
FaB002	7	6	7	6	7	6	7	6	7	6
KeB045	7	5	7	5	7	4	7	5	7	5
KtB015	7	6	7	6	7	6	7	6	7	6
NBO001	7	6	7	6	7	6	7	6	7	6
RoB010	7	6	7	6	7	6	7	6	7	6
Total	105	87	105	86	105	84	105	87	105	87
% complete	83%		82%		80%		83%		83%	
Field Duplicates	7	5	7	5	7	5	7	5	7	5
Blanks	7	5	7	5	7	4	7	5	7	5

2015 - Number of sampling events & Data completeness										
I = Intended, A = Actual										
	Chloride		Phosphorus		E. coli.		Turbidity		Nitrogen	
	I	A	I	A	I	A	I	A	I	A
OtR006	7	6	7	6	7	4	7	6	7	6
OtR070	7	6	7	6	7	4	7	6	7	6
OtR132	7	6	7	6	7	4	7	6	7	6
OtR133	7	6	7	6	7	4	7	6	7	6
OtR157	7	6	7	6	7	4	7	6	7	6
OtR163	7	6	7	6	7	4	7	6	7	6
OtR185	7	6	7	6	7	4	7	6	7	6
OtR245	7	6	7	6	7	4	7	6	7	6
OtR254	7	6	7	6	7	4	7	6	7	6
OtR384	7	6	7	6	7	4	7	6	7	6
FaB002	7	6	7	6	7	4	7	6	7	6
KeB045	7	6	7	6	7	4	7	6	7	6
KtB015	7	6	7	6	7	4	7	6	7	6
NBO001	7	6	7	6	7	4	7	6	7	6
RoB010	7	5	7	6	7	4	7	6	7	6
Total	105	89	105	90	105	60	105	90	105	90
% complete	84.8%		85.7%		57%		85.7%		85.7%	
Field Duplicates	7	5	7	5	7	3	7	5	7	5
Blanks	7	4	7	4	7	3	7	4	7	4

SECTION 8: QUALITY CONTROL DATA

**Data from the 2013 monitoring season was QC'd and reviewed prior to storage; however the data is no longer available and is not included in this report. Data from the 2011 monitoring season is not available and thus is not included in this report.*

SECTION 8.1: 2010 QUALITY CONTROL DATA

2010 Field Duplicate Data									
FD=Duplicate Value, A=Actual Value									
Date	Site ID	Cl-		TP		E. coli		TURB	
		FD	A	FD	A	FD	A	FD	A
7/01/10	KeB045	8.58	8.81	31.8	14.7	214	218	0.82	0.2
7/15/10	FaB002	22.4	22.7	17	16.4	276	291	1.26	1.63
7/29/10	OtR185	12.8	12.8	14.6	19	126	326	3.53	2.16
8/12/10	RoB010	50.8	51.8	6.55	6.06	37	36	2.01	0.65
8/26/10	OtR006	18.4	18.1	18.3	18.5	58	49	1.42	1.17
9/09/10	OtR133	22.3	22.1	23.2	22.1	18	18	2.45	2.54
9/23/10	KtB015	13.8	13.8	12.7	12.5	3	1	1.06	1.11

2010 Relative Percent Difference of Field Duplicates to Actual Sample Values					
		Parameter			
Date	Site ID	Cl-	TP	E. coli	TURB
7/01/10	KeB045	2.6%	***73.5%**	1.9%	***121.6%**
7/15/10	FaB002	1.3%	3.6%	5.3%	25.6%
7/29/10	OtR185	0%	26.2%	***88.5%**	***48.2%**
8/12/10	RoB010	1.9%	7.8%	2.7%	***102.3%**
8/26/10	OtR006	1.6%	1.1%	16.8%	***19.3%**
9/09/10	OtR133	0.9%	4.9%	0%	3.6%
9/23/10	KtB015	0%	1.6%	100%	4.6%
Average RPD		1.21%	16.95%	30.74%	46.44%

**Bolded values indicate that those values exceeded the precision standards listed in the QAPP*

SECTION 8.2: 2014 QUALITY CONTROL DATA

2014 Field Duplicate Data											
FD=Duplicate Value, A=Actual Value											
Date	Site ID	Cl-		E. coli		TN		TP		TURB	
		FD	A	FD	A	FD	A	FD	A	FD	A
7/01/14	FaB002	13.2	13.9	3.06	3.06	0.49	0.49	6.91	7.89	1.18	1.1
7/17/14	KeB045	12.4	12.5	209.82	157.56	0.51	0.52	12.6	10.6	0.58	0.75
7/31/14	OtR006	11.2	11	225	345	0.27	0.27	27.4	26.7	18.2	18.9
8/28/14	OtR384	29.13	29.76	248.09	248.09	0.42	0.45	22.6	21.5	2.81	2.54
9/11/14	OtR132	21.6	21.6	21.57	34.51	0.28	0.3	13.2	13.7	0.72	0.79

2014 Relative Percent Difference of Field Duplicates to Actual Sample Values						
		Parameter				
Date	Site ID	Cl-	E. coli	TN	TP	TURB
7/01/14	FaB002	***5.16%**	0%	0%	13.24%	7.01%
7/17/14	KeB045	0.8%	28.45%	1.94%	***17.24%**	***25.56%**
7/31/14	OtR006	1.8%	42.1%	0%	2.58%	3.77%
8/28/14	OtR384	2.14%	0%	6.89%	4.98%	10.09%
9/11/14	OtR132	0%	46%	6.89%	3.71%	9.27%
Average RPD		1.98%	23.31%	3.14%	8.35%	11.14%

**Bolded values indicate that those values exceeded the precision standards listed in the QAPP*

2014 Field Blank Data											
FB=Field Blank Value, A=Actual Value											
Date	Site ID	Cl-		E. coli		TN		TP		TURB	
		FB	A	FB	A	FB	A	FB	A	FB	A
6/19/14	OtR384	<2	32.7	<1	178.21	<0.1	0.36	5.29	22.2	<0.2	1.49
7/17/14	FaB002	<2	17.8	<1	39.29	<0.1	0.5	<5	7.01	<0.2	1.34
7/31/14	OtR157	<2	13.2	<1	68	<0.1	0.27	<5	18.8	<0.2	3.66
8/28/14	OtR070	<2	14.6	NT	NT	<0.1	0.31	<5	14.3	<0.2	4.91
9/11/14	OtR133	<2	20	<1	23.07	<0.1	0.26	<5	10.2	<0.2	0.69

SECTION 8.3: 2015 QUALITY CONTROL DATA

2015 Field Duplicate Data											
FD=Duplicate Value, A=Actual Value											
Date	Site ID	Cl-		E. coli		TN		TP		TURB	
		FD	A	FD	A	FD	A	FD	A	FD	A
6/18/15	N/A	NT	-	NT	-	NT	-	NT	-	NT	-
7/02/15	OtR132	10.22	10.12	NT	-	.19	.19	19.9	15.9	3.52	3.4
7/16/15	OtR157	20.14	20.43	49.54	65.04	.27	.28	7.87	8.48	.36	.4
7/30/15	OtR185	19.11	19.06	39.66	48.74	.32	.31	7.36	6.35	.67	.56
8/13/15	OtR254	24.9	25.4	45	37.86	.35	.35	11.3	8.6	.77	.54
8/27/14	FaB002	14.5	14.31	NT	-	.47	.47	5.71	13.7	.35	.35

2015 Relative Percent Difference of Field Duplicates to Actual Sample Values						
		Parameter				
Date	Site ID	Cl-	E. coli	TN	TP	TURB
7/02/15	OtR132	.98%	N/A	0%	22.34%	3.47%
7/16/15	OtR157	1.43%	27.07%	3.64%	7.47%	10.52%
7/30/15	OtR185	.26%	20.54%	3.22%	14.74%	***18.03%**
8/13/15	OtR254	1.98%	17.23%	0%	27.13%	***35.38%**
8/27/15	FaB002	1.32%	N/A	0%	***82.37%**	0%
Average RPD		1.19%	21.61%	1.37%	30.81%	13.48%

**Bolded values indicate that those values exceeded the precision standards for field duplicates listed in the QAPP*

2015 Field Blank Data											
FB=Field Blank Value, A=Actual Value											
Date	Site ID	Cl-		E. coli		TN		TP		TURB	
		FB	A	FB	A	FB	A	FB	A	FB	A
7/02/15	OtR133	<2	9.93	NT	NT	<0.1	.18	<5	17.4	<0.2	2.56
7/16/15	OtR163	21.19	20.82	69.68	71.73	.25	.25	7.68	8.12	.35	.77
7/30/15	OtR245	<2	20	<1	45	<0.1	.31	<5	6.03	.56	.3
8/13/15	OtR384	<2	42.92	<1	135.37	<0.1	.39	<5	23.2	<0.2	2.14

SECTION 9: USGS FLOW GAGE DATA

**2010 USGS flow gage data is not available.*

SECTION 9.1: 2011 USGS FLOW GAGE DATA – NORTH HARTLAND GAGING STATION

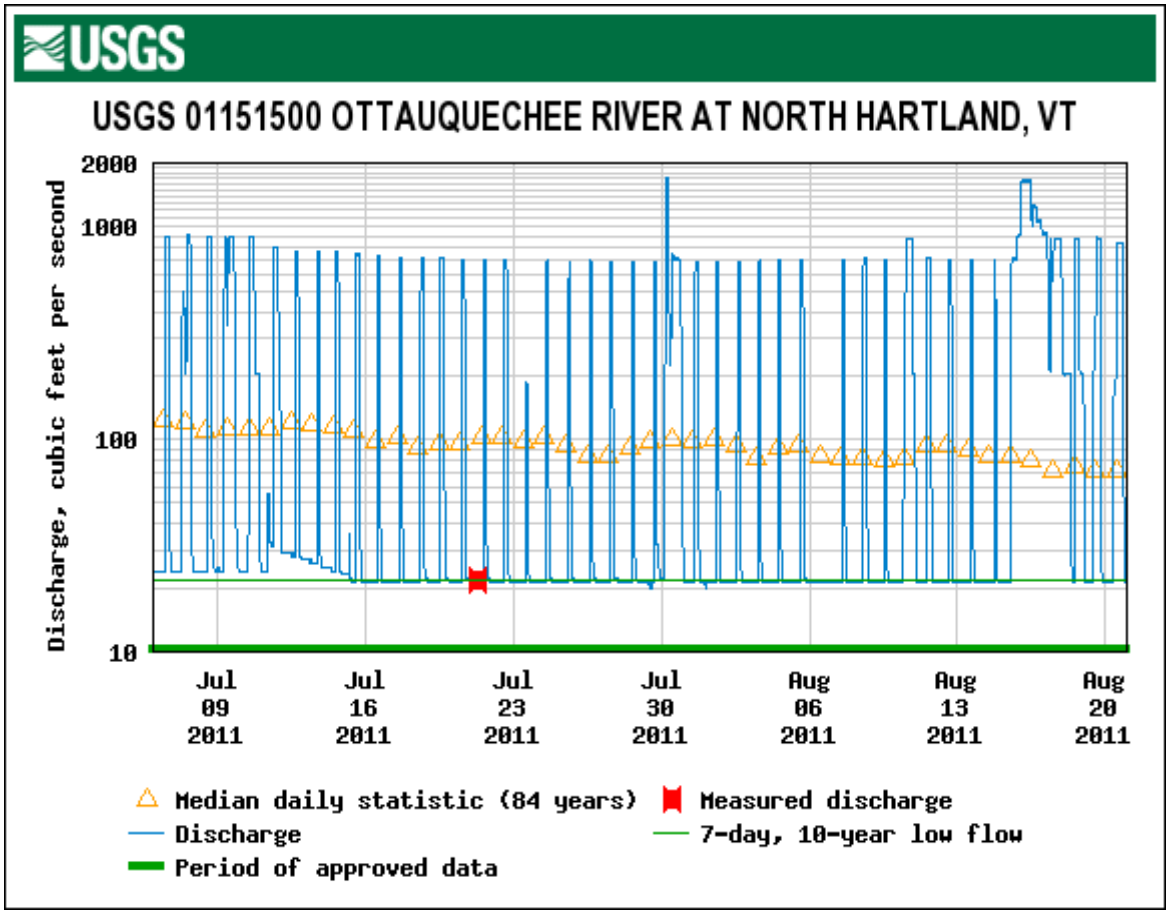


Figure 9a: USGS Flow Gage Data - North Hartland - July 7 - August 20, 2011

SECTION 9.2: 2013 USGS FLOW GAGE DATA – WEST BRIDGEWATER GAGING STATION

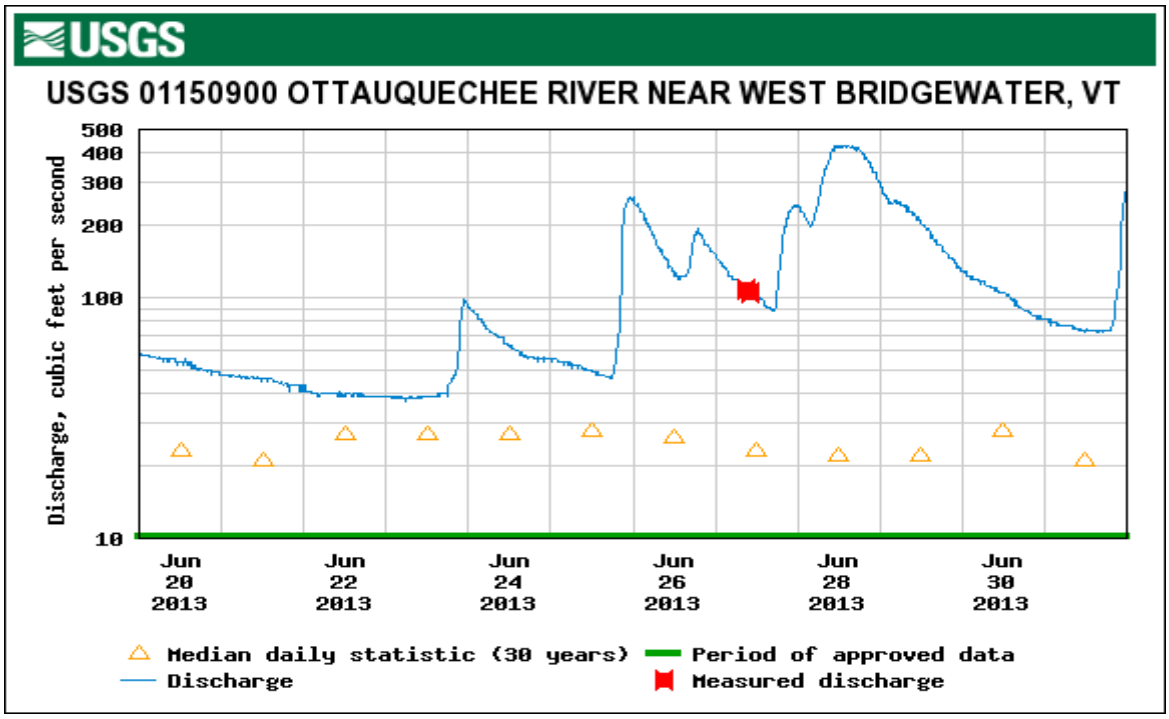


Figure 9b: USGS Flow Gage Data - West Bridgewater - June 20 - June 30, 2013

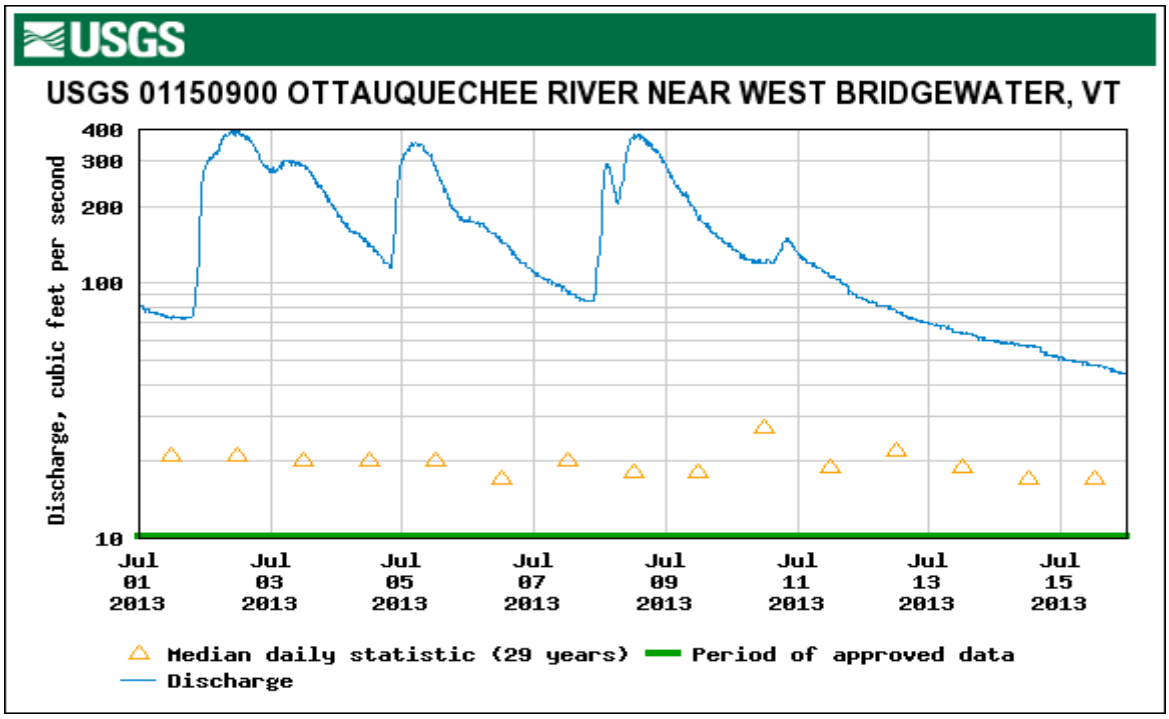


Figure 9c: USGS Flow Gage Data - West Bridgewater - July 1 - July 15, 2013

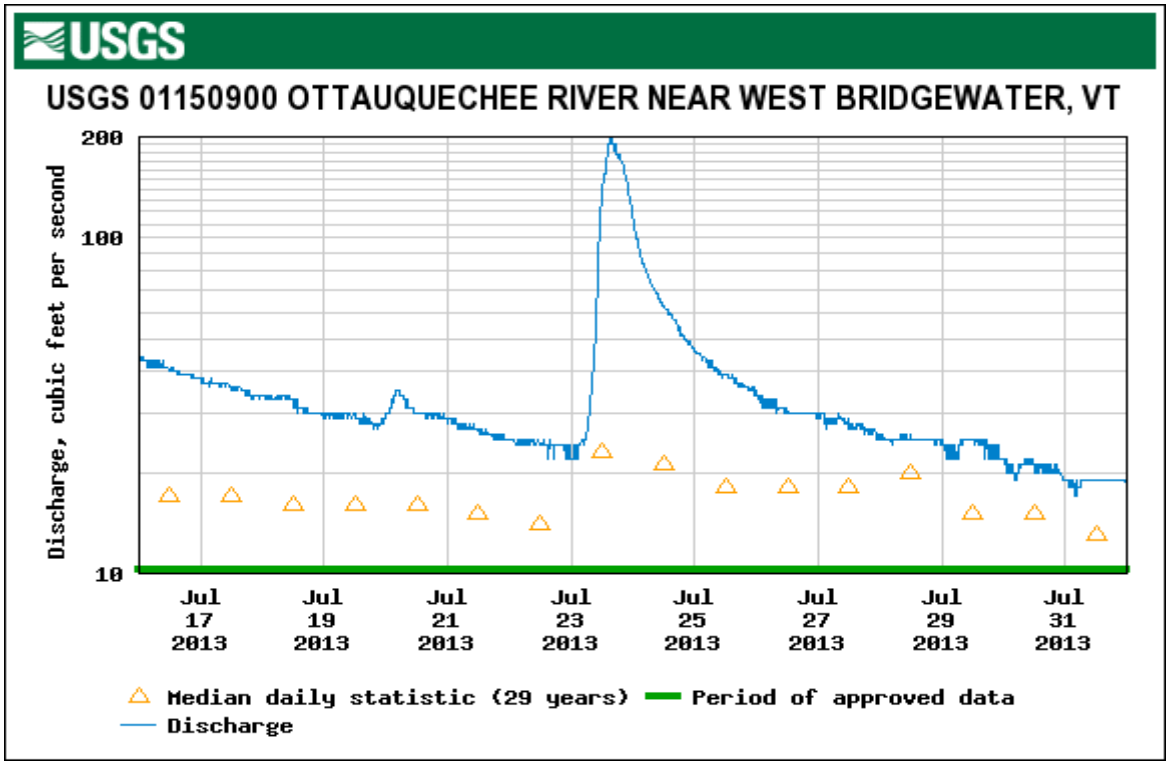


Figure 9d: USGS Flow Gage Data - West Bridgewater - July 16 - July 31, 2013

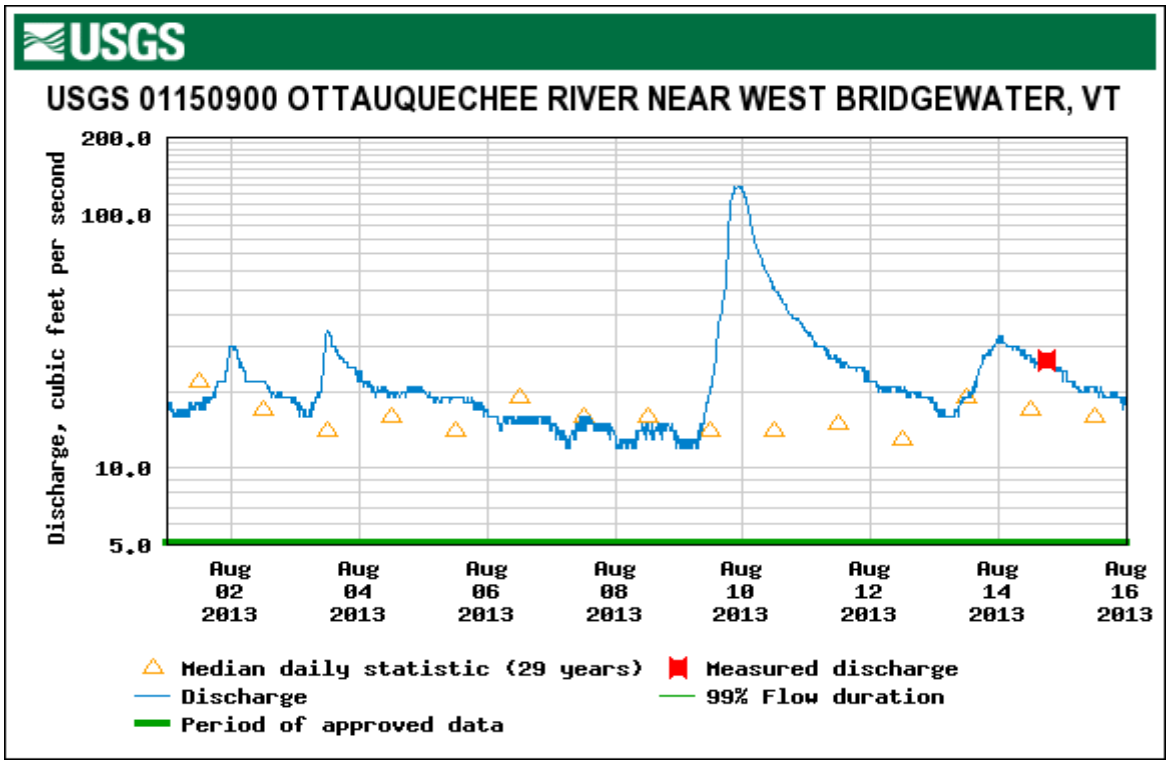


Figure 9e: USGS Flow Gage Data - West Bridgewater - August 1 - August 15, 2013

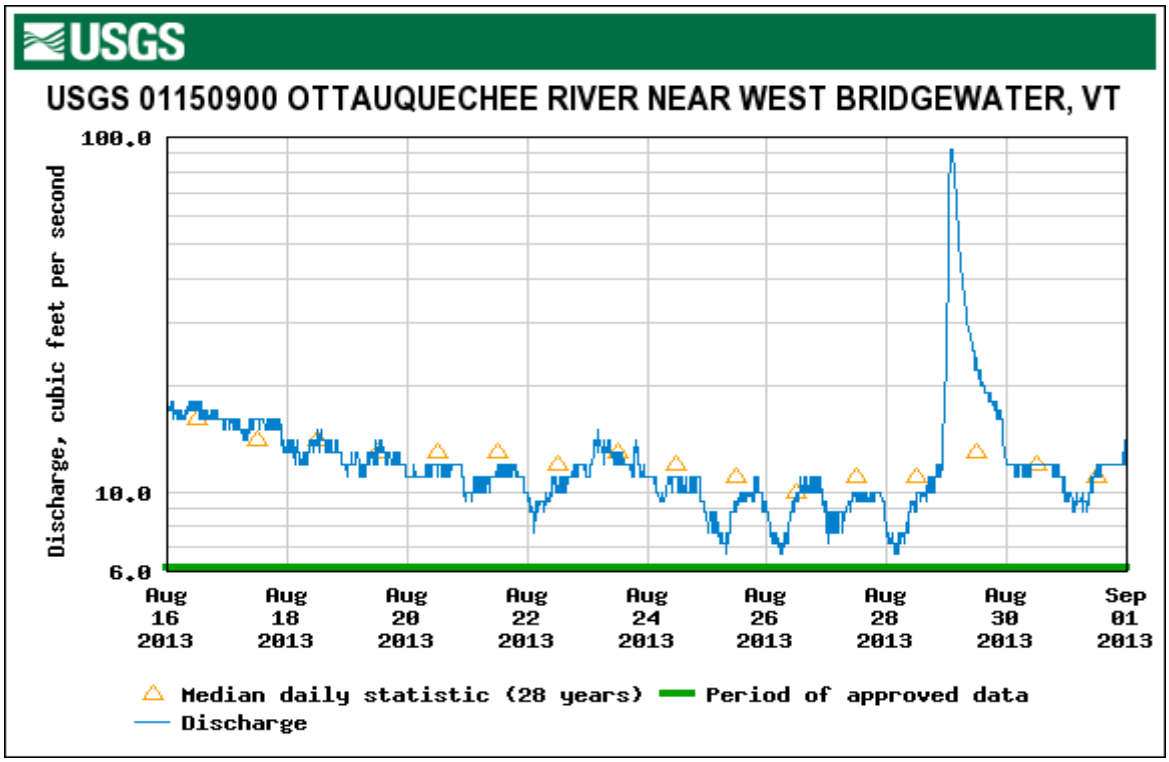


Figure 9f: USGS Flow Gage Data - West Bridgewater - August 16 - August 31, 2013

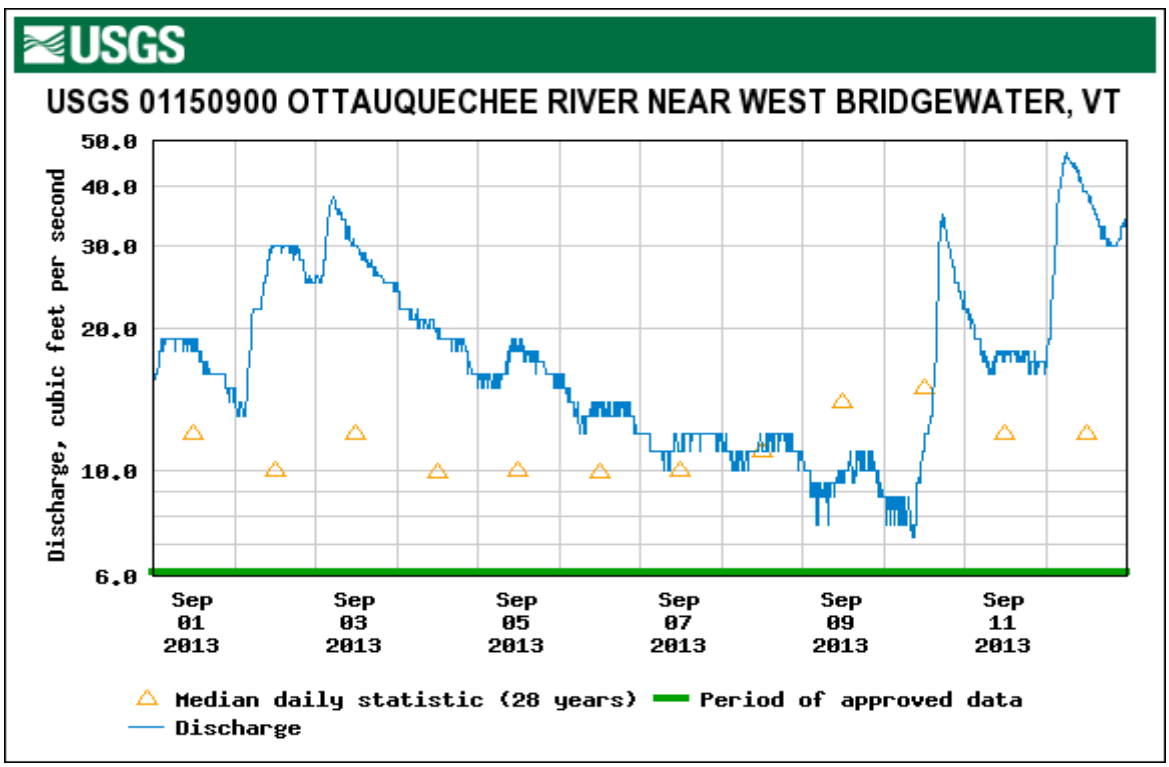


Figure 9g: USGS Flow Gage Data - West Bridgewater - September 1 - September 12, 2013

SECTION 9.3: 2013 USGS FLOW GAGE DATA – NORTH HARTLAND GAGING STATION

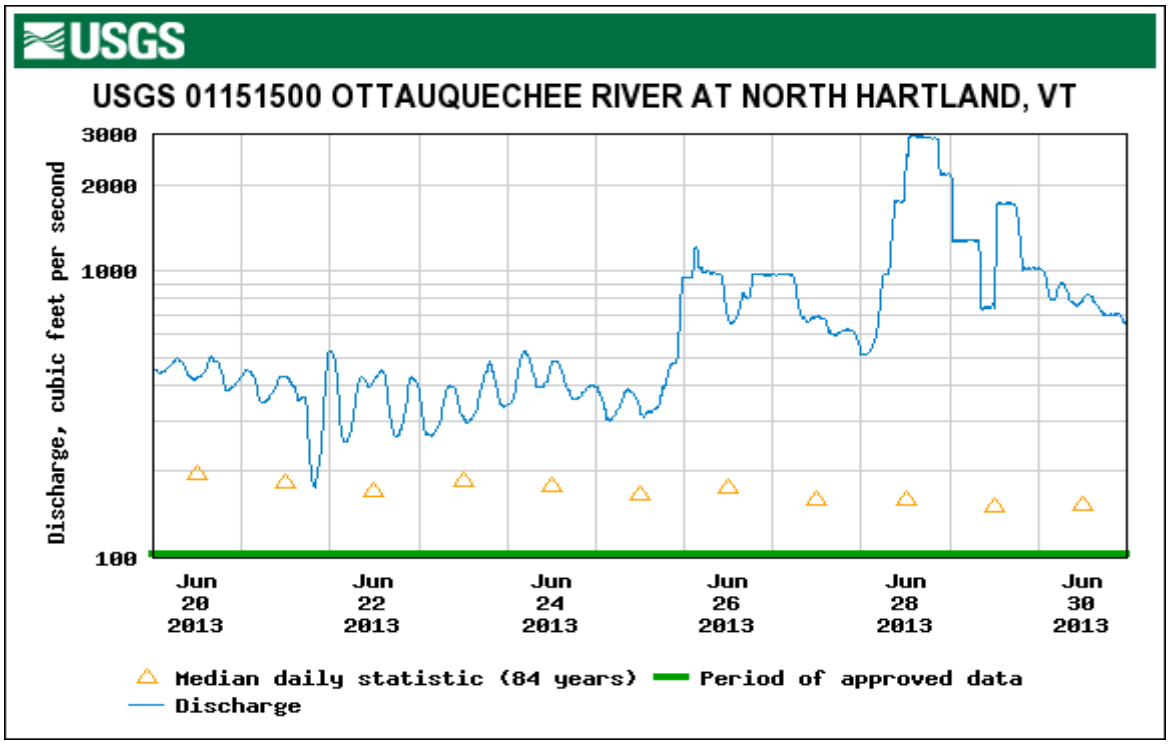


Figure 9h: USGS Flow Gage Data - North Hartland - June 20 - June 30, 2013

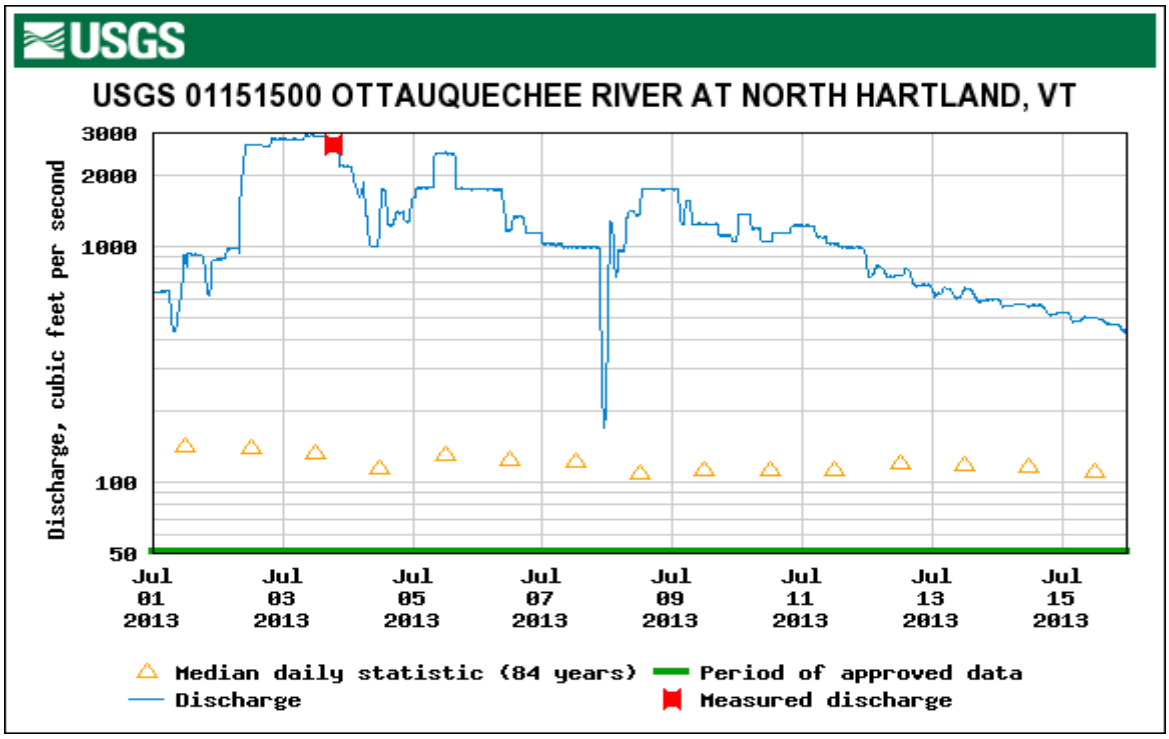


Figure 9i: USGS Flow Gage Data - North Hartland - July 1 - July 15, 2013

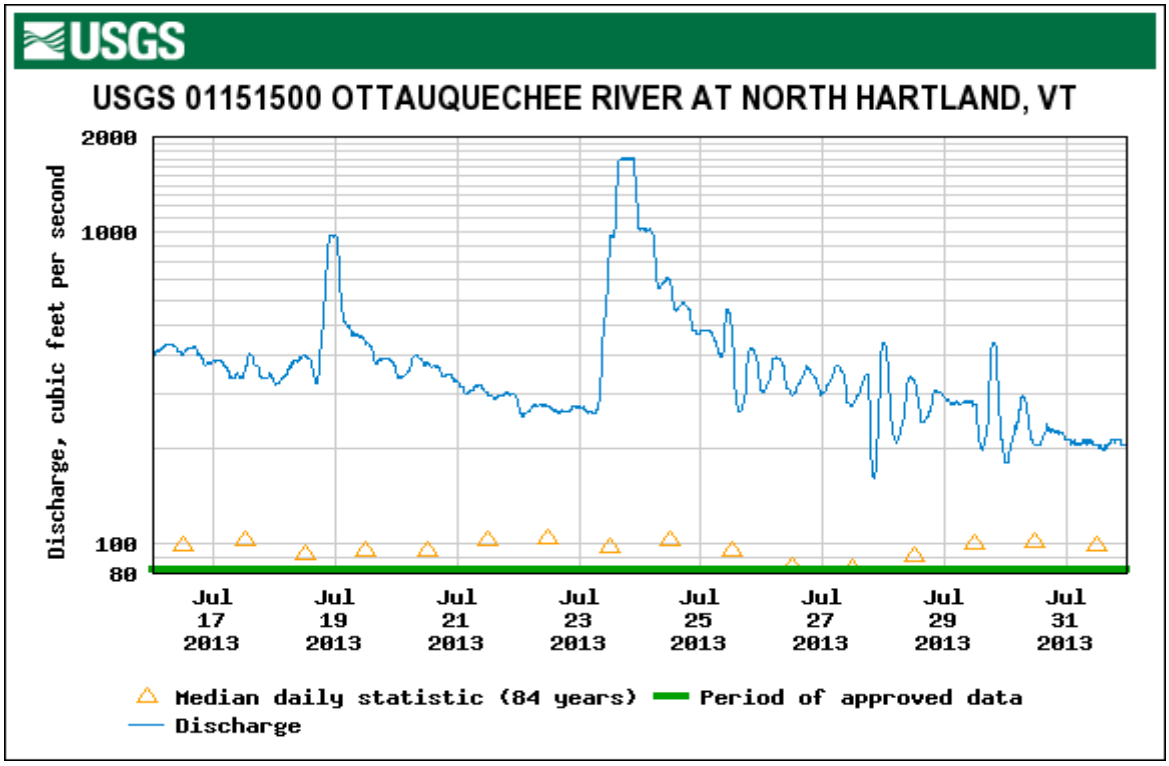


Figure 9j: USGS Flow Gage Data - North Hartland - July 16 - July 31, 2013

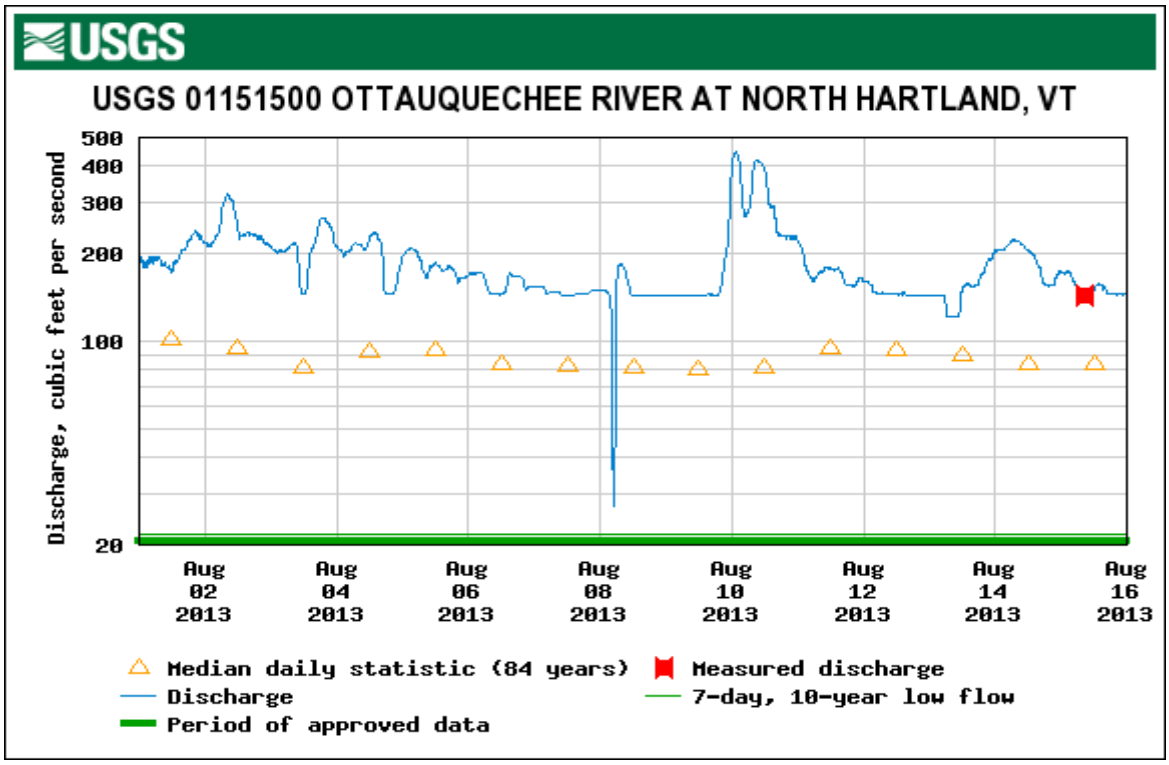


Figure 9k: USGS Flow Gage Data - North Hartland - August 1 - August 15, 2013

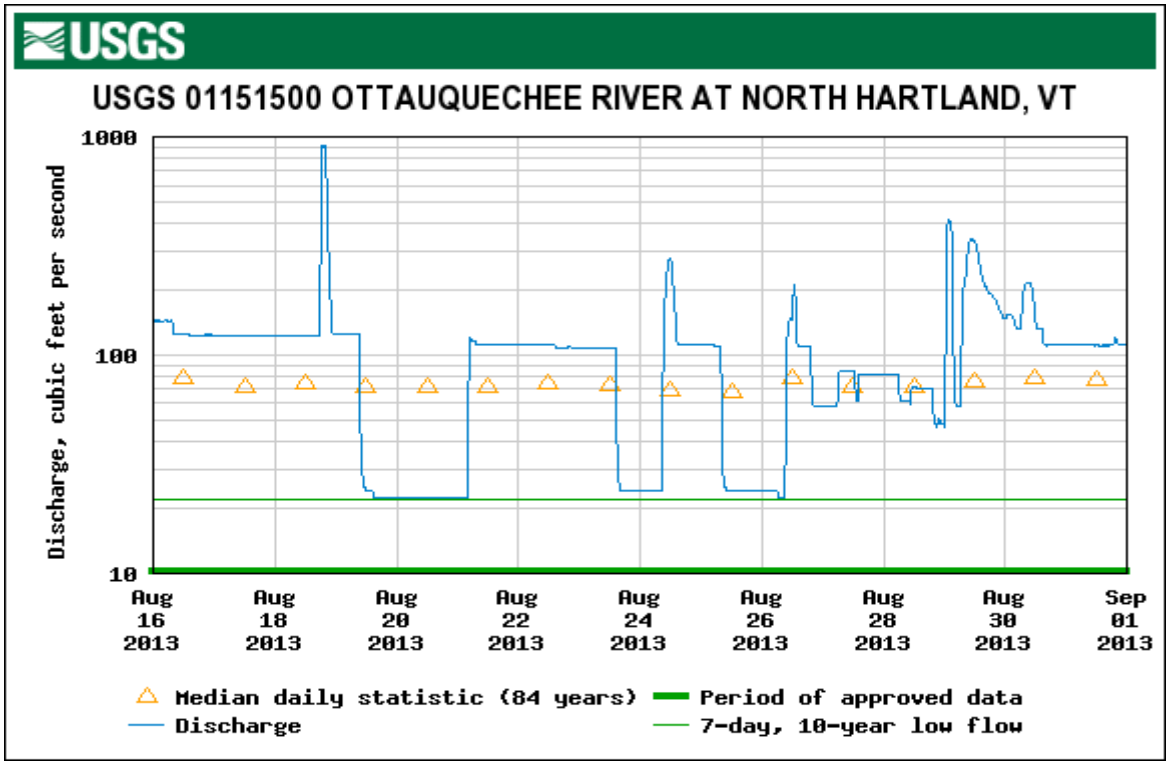


Figure 9l: USGS Flow Gage Data - North Hartland - August 16 - August 31, 2013

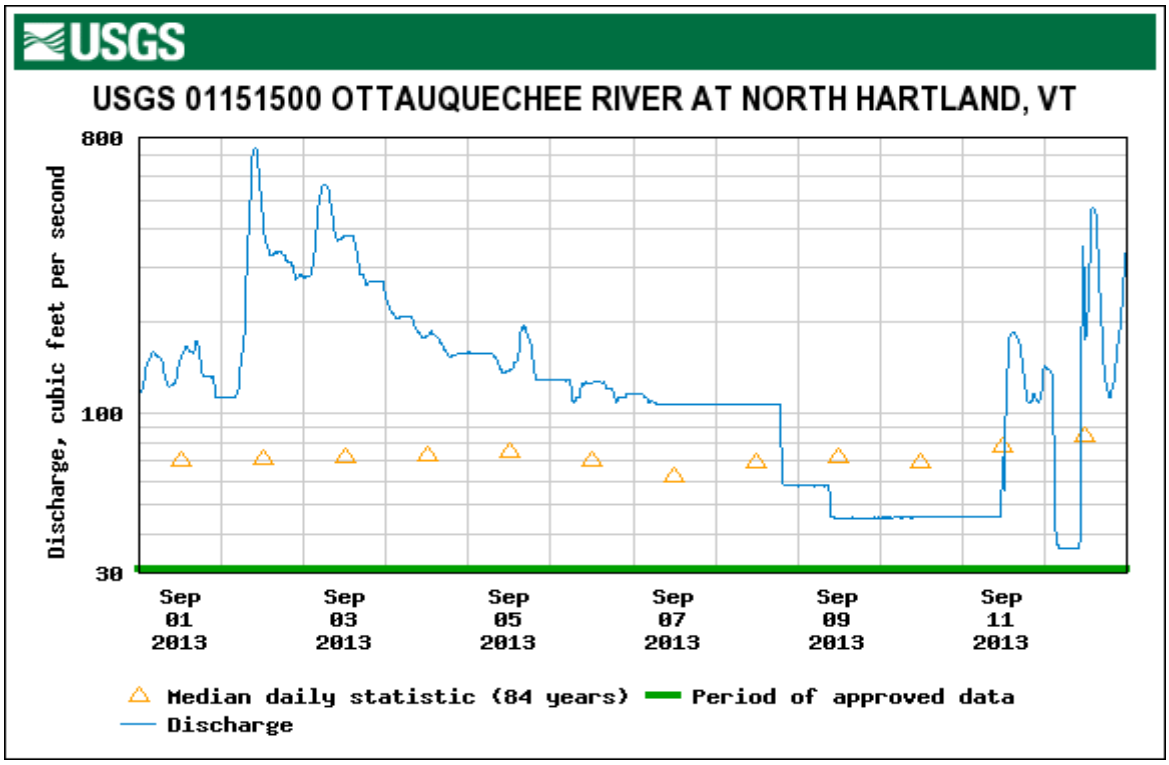


Figure 9m: USGS Flow Gage Data - North Hartland - September 1 - September 12, 2013

SECTION 9.4: 2014 USGS FLOW GAGE DATA – WEST BRIDGEWATER GAGING STATION

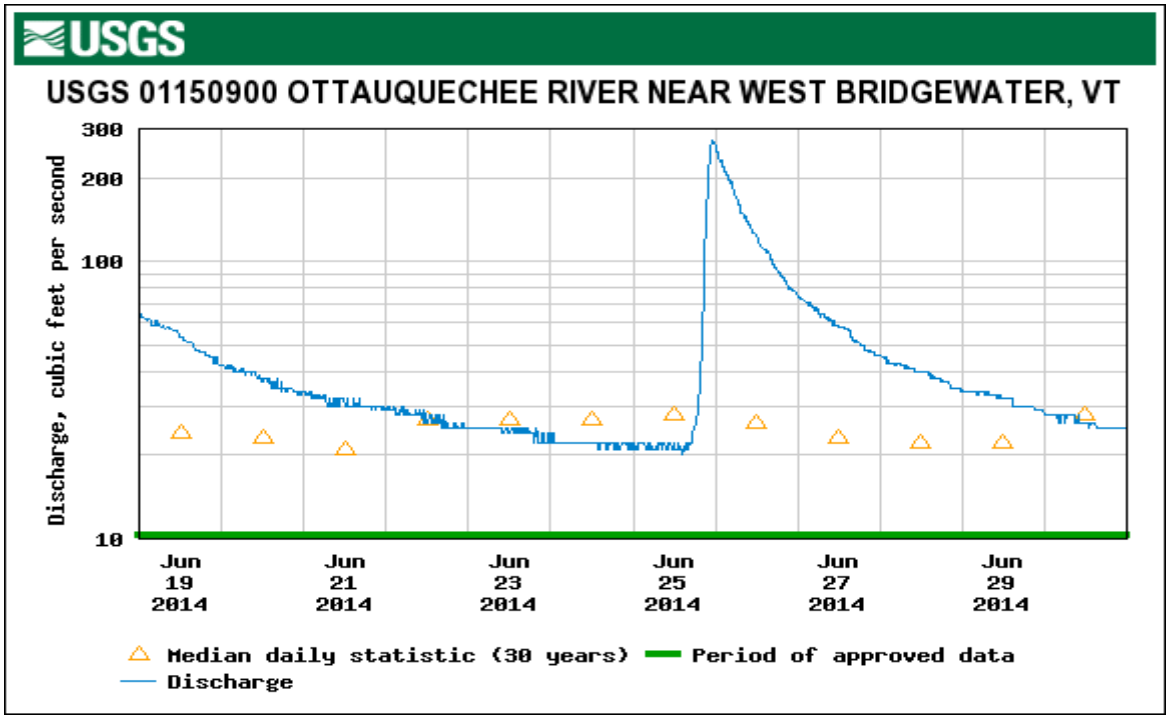


Figure 9n: USGS Flow Gage Data - West Bridgewater - June 19 - June 30, 2014

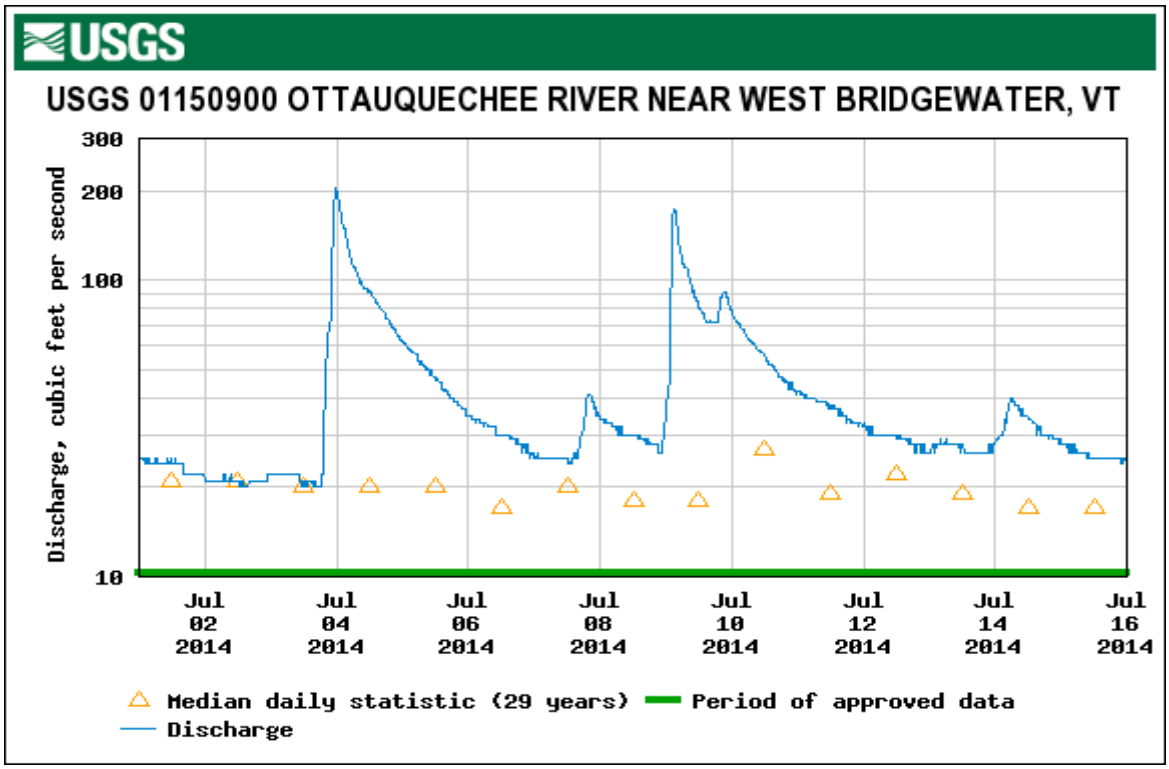


Figure 9o: USGS Flow Gage Data - West Bridgewater - July 1 - July 15, 2014

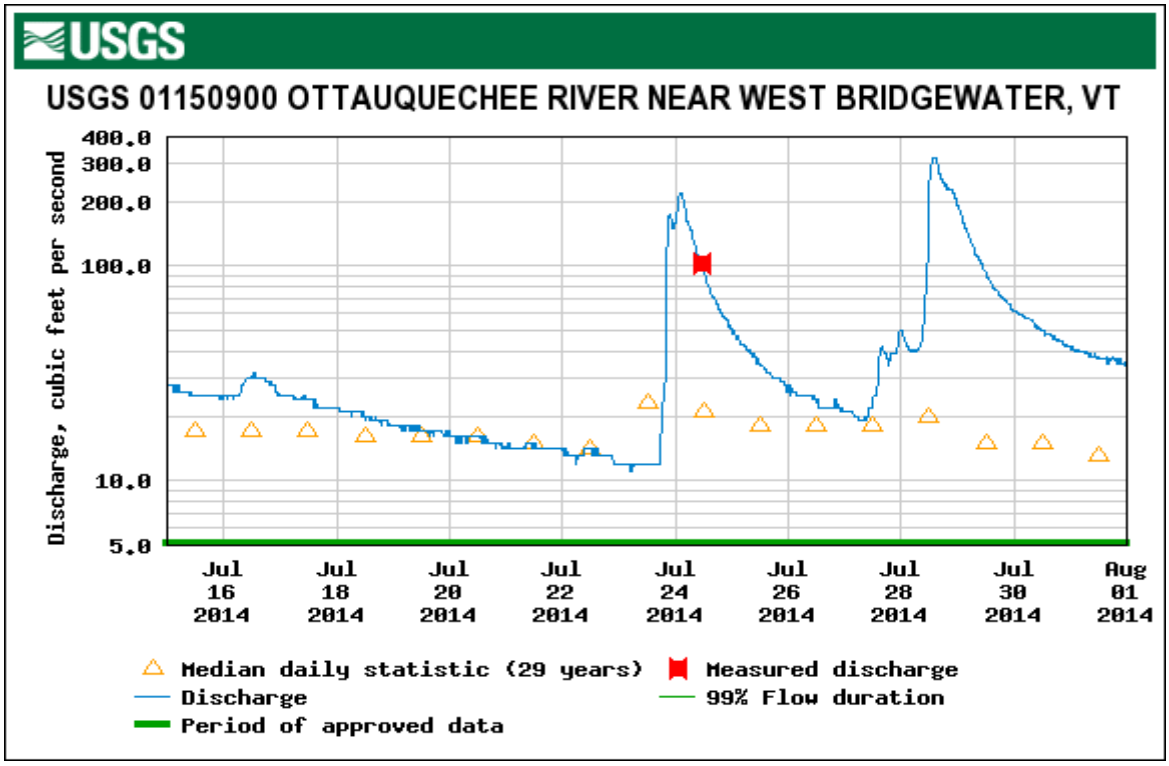


Figure 9p: USGS Flow Gage Data - West Bridgewater - July 16 - July 31, 2014

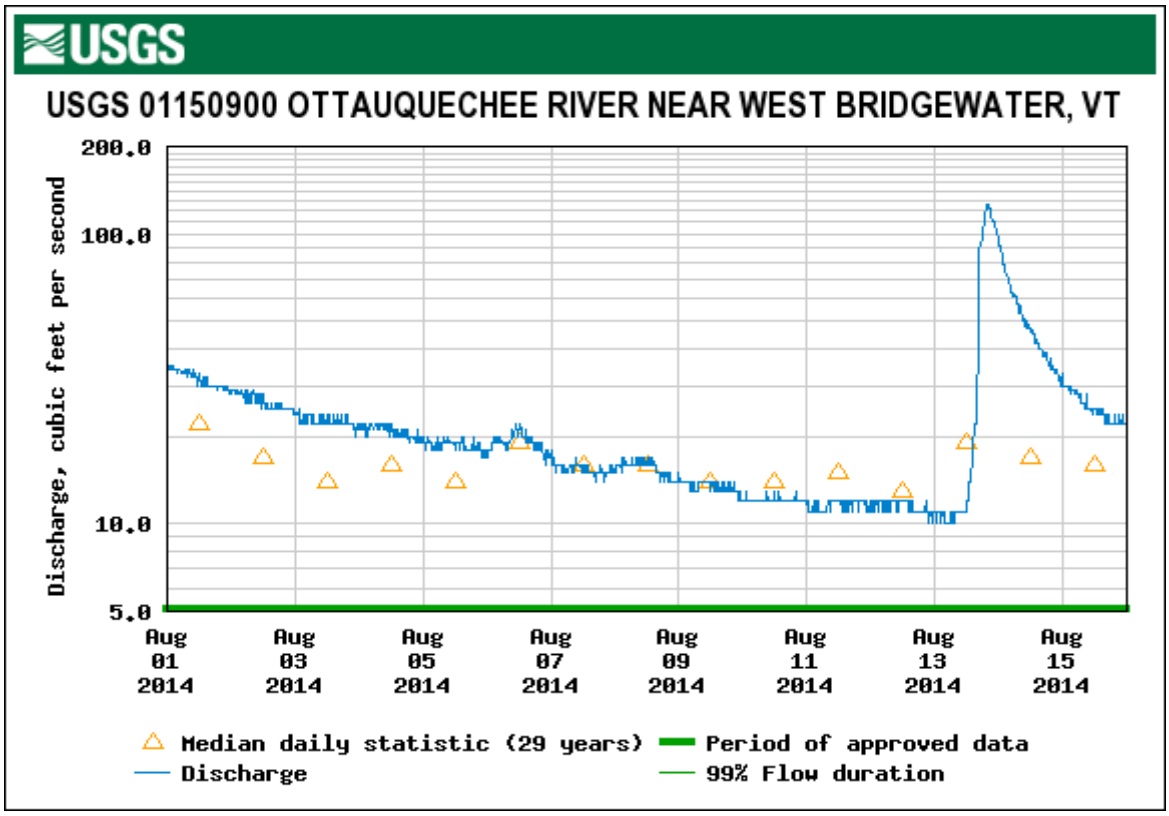


Figure 9q: USGS Flow Gage Data - West Bridgewater - August 1 - August 15, 2014

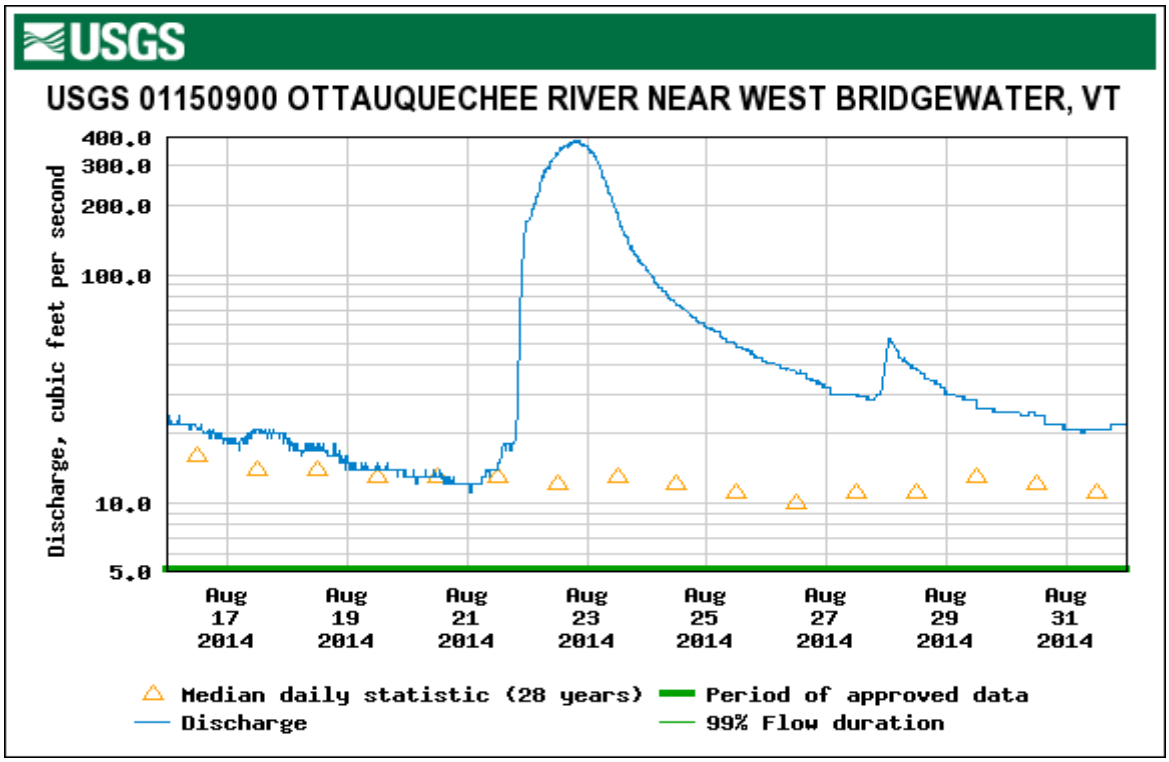


Figure 9r: USGS Flow Gage Data - West Bridgewater - August 16 - August 31, 2014

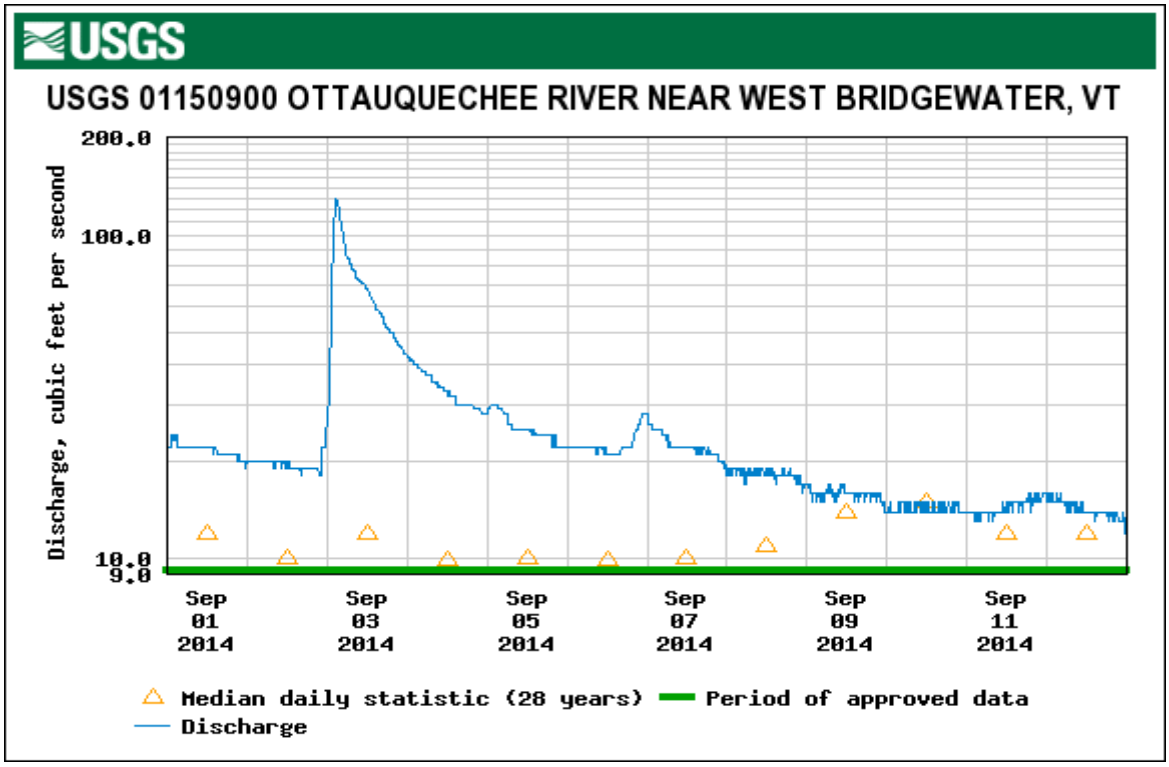


Figure 9s: USGS Flow Gage Data - West Bridgewater - September 1 - September 12, 2014

SECTION 9.5: 2014 USGS FLOW GAGE DATA – NORTH HARTLAND GAGING STATION

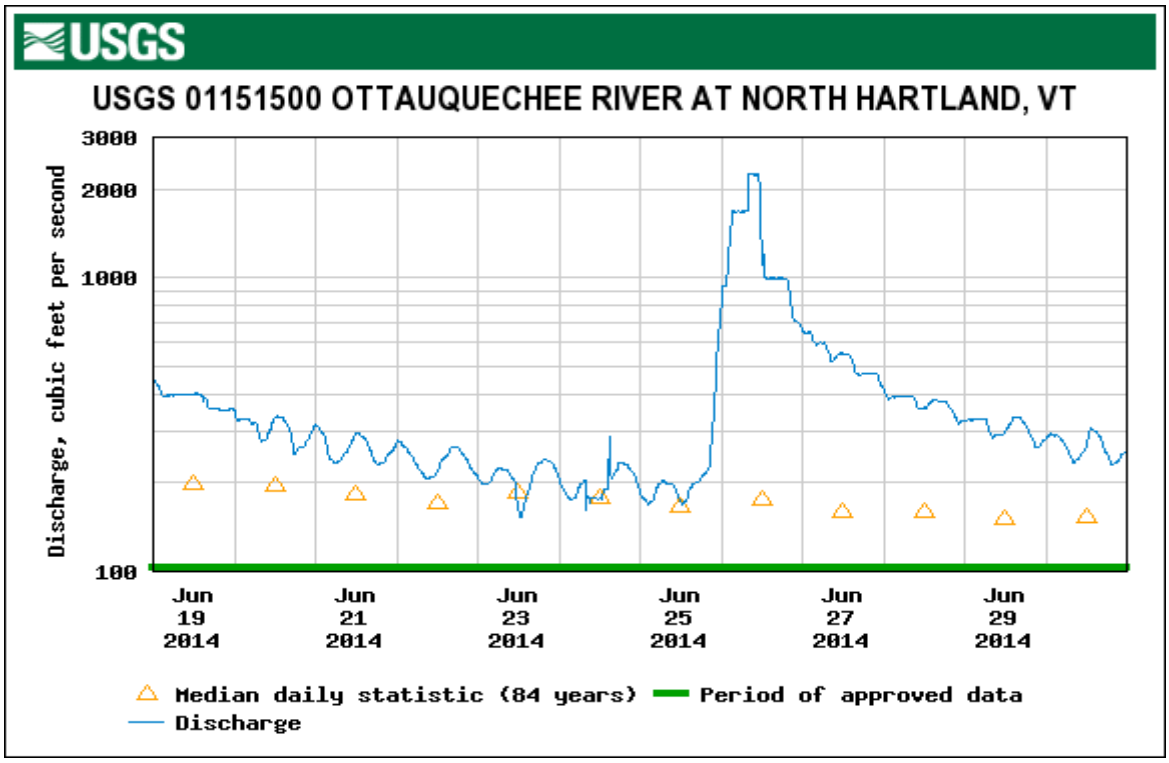


Figure 9t: USGS Flow Gage Data - North Hartland - June 19 - June 30, 2014

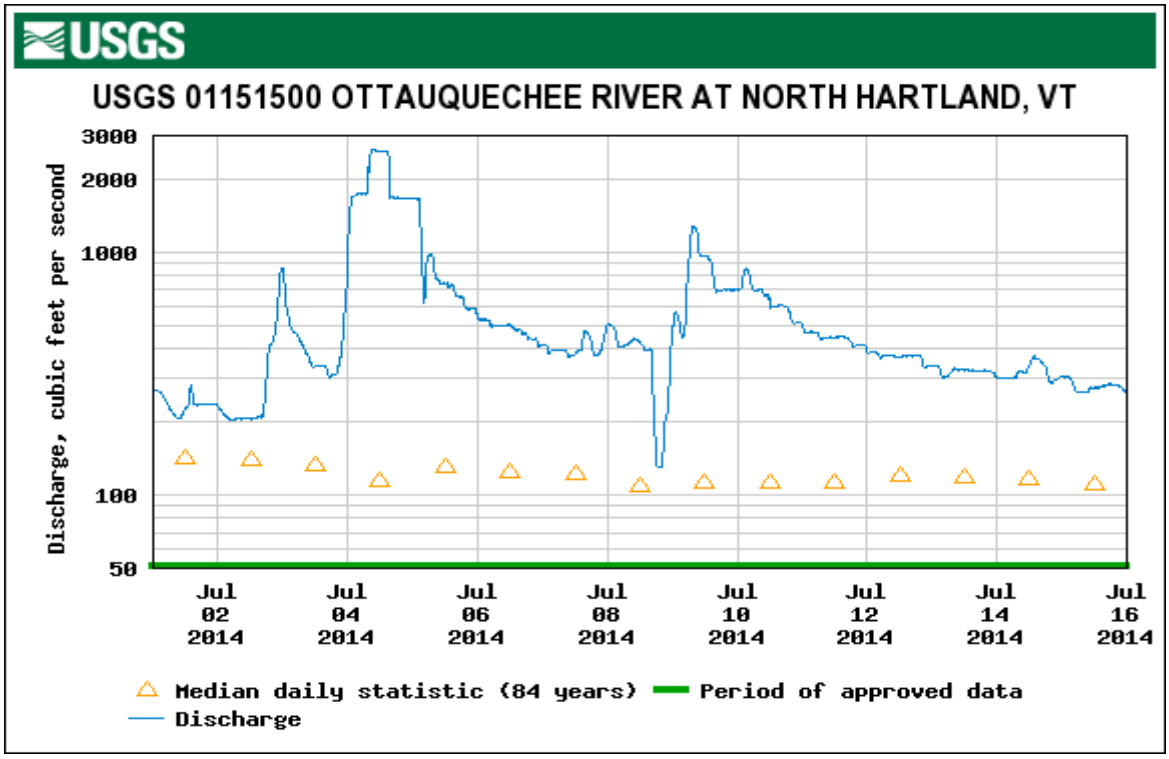


Figure 9u: USGS Flow Gage Data - North Hartland - July 1 - July 15, 2014

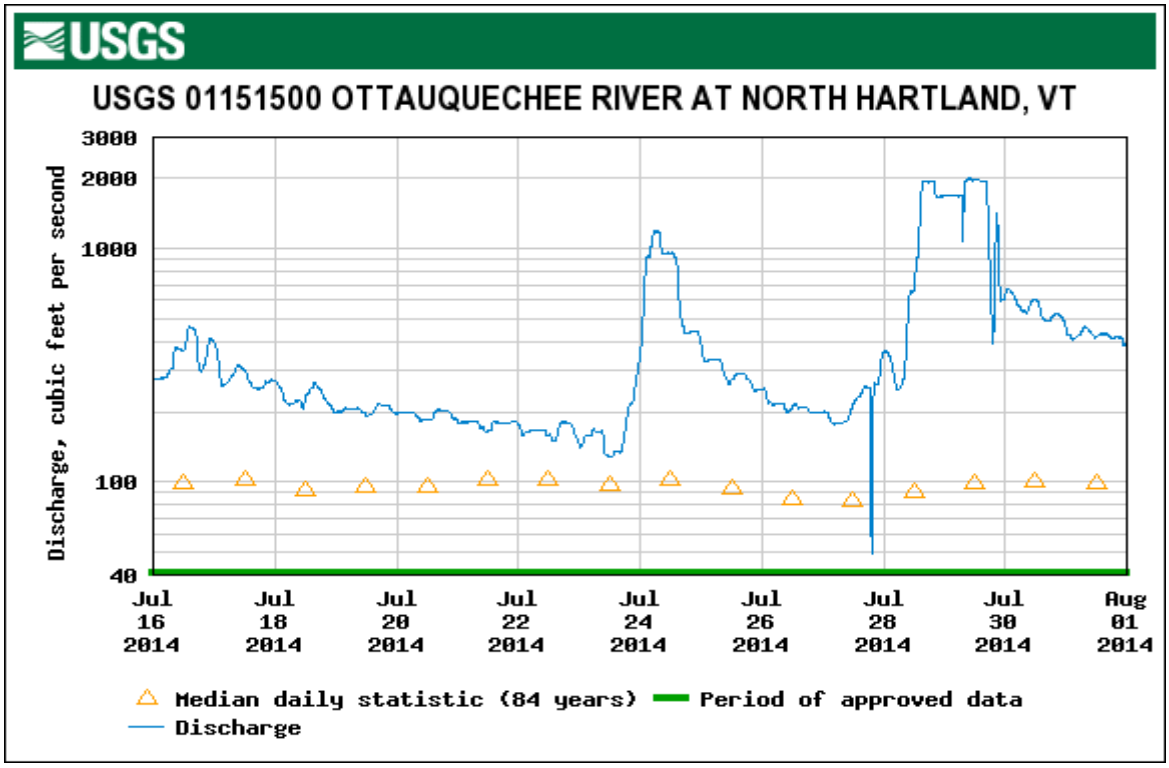


Figure 9v: USGS Flow Gage Data - North Hartland - July 16 - July 31, 2014

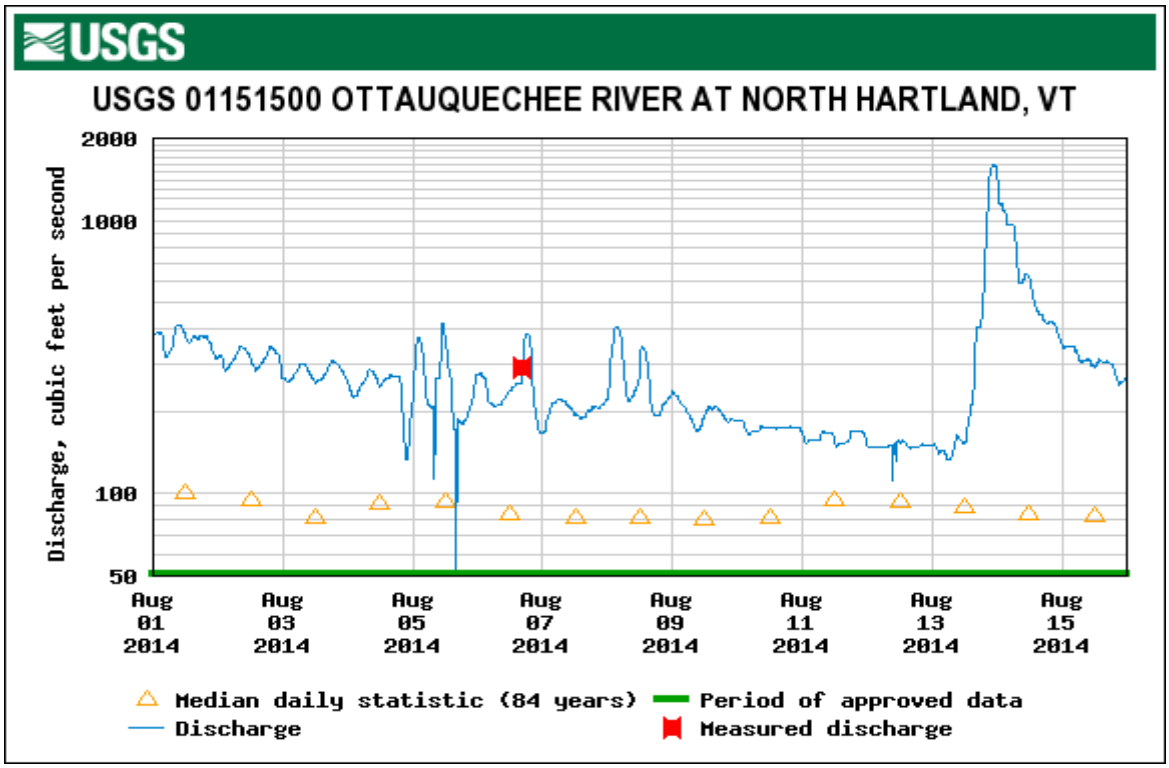


Figure 9w: USGS Flow Gage Data - North Hartland - August 1 - August 15, 2014

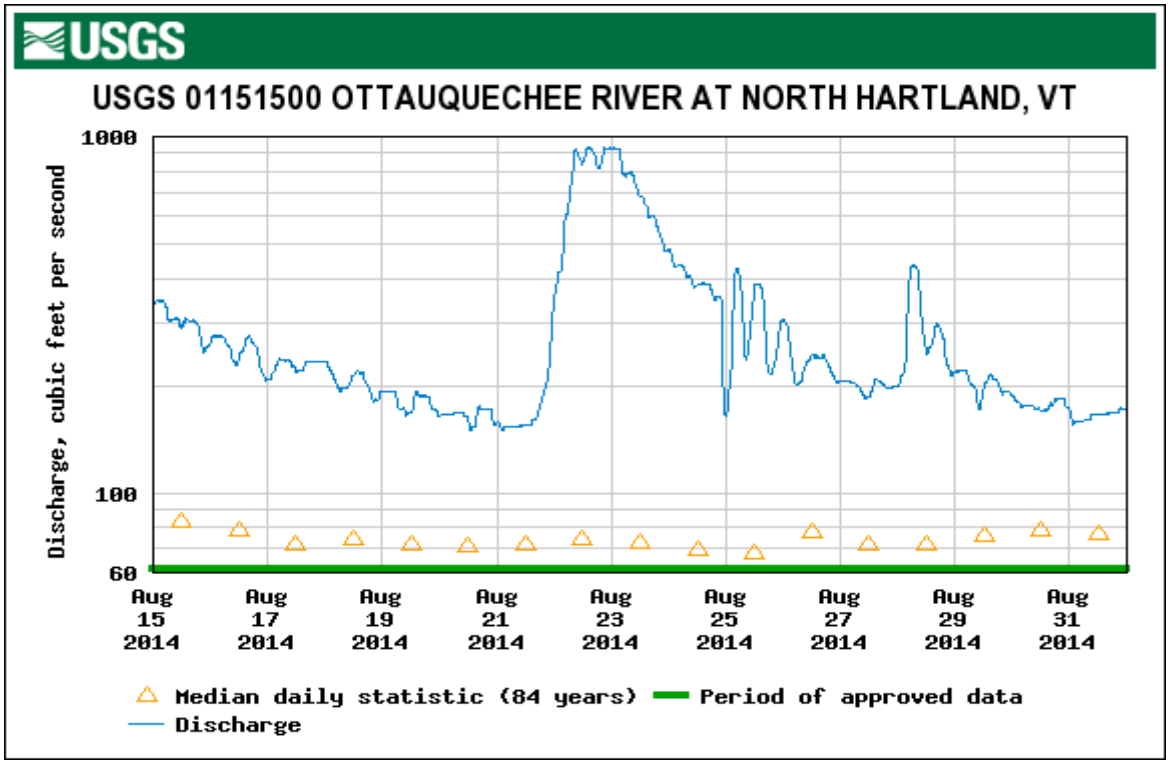


Figure 9x: USGS Flow Gage Data - North Hartland - August 15 - August 31, 2014

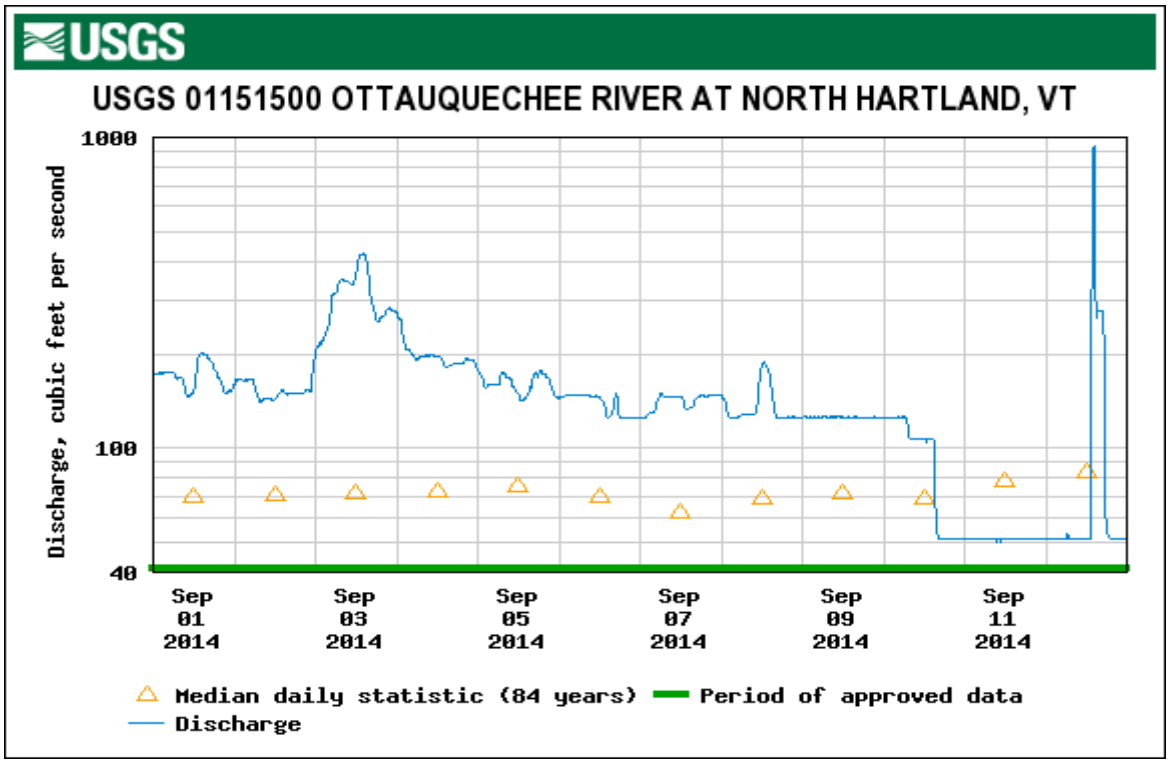


Figure 9y: USGS Flow Gage Data - North Hartland - September 1 - September 12, 2014

SECTION 9.6: 2015 USGS FLOW GAGE DATA – WEST BRIDGEWATER GAGING STATION

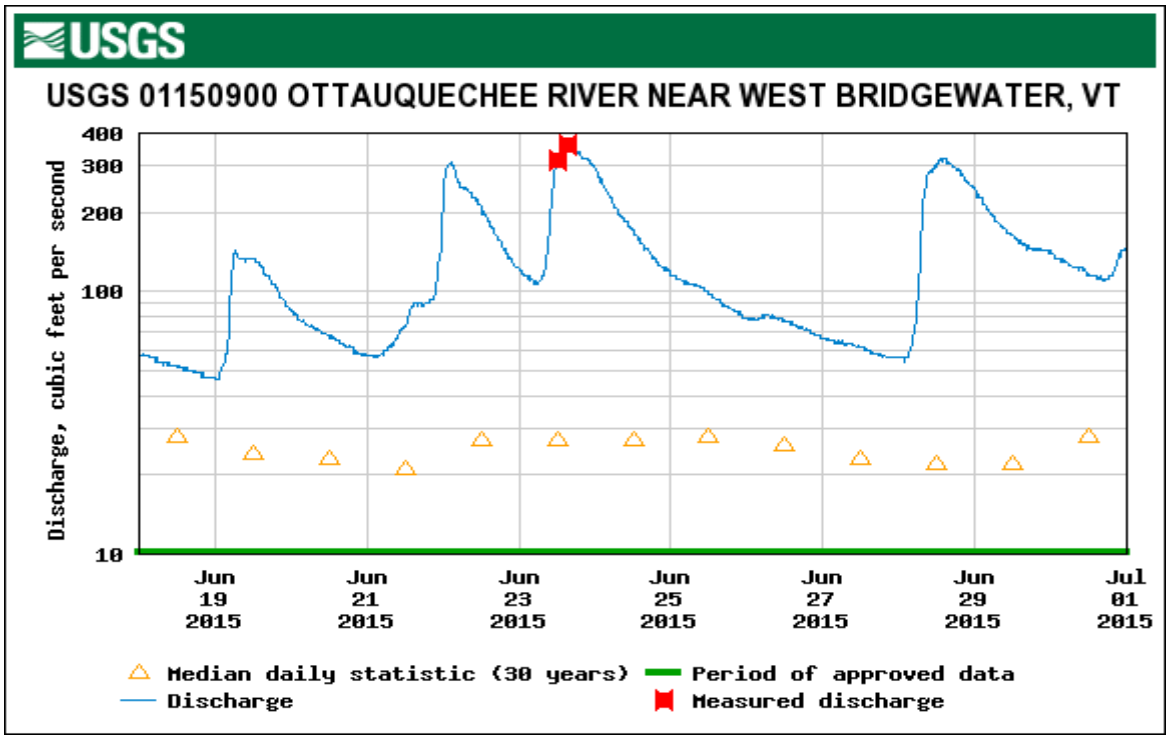


Figure 9z: USGS Flow Gage Data - West Bridgewater - June 18 - June 30, 2015

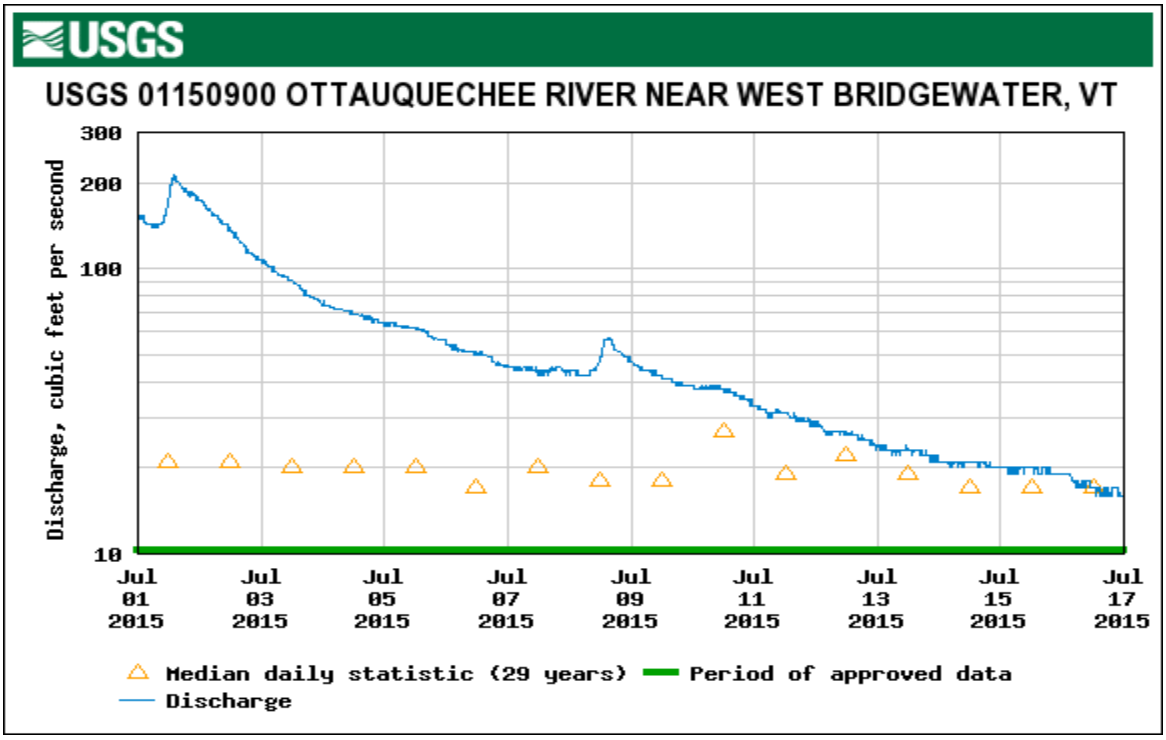


Figure 9aa: USGS Flow Gage Data - West Bridgewater - July 1 - July 16, 2015

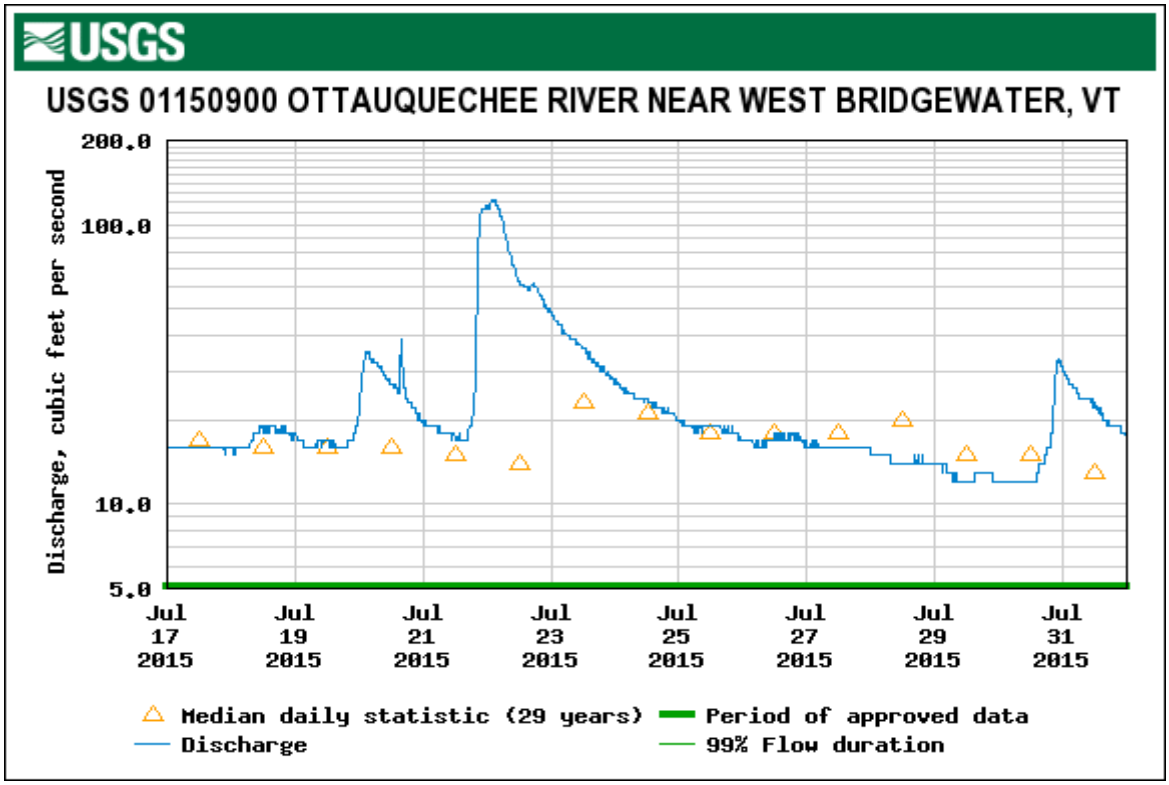


Figure 9bb: USGS Flow Gage Data - West Bridgewater - July 17 - July 31, 2015

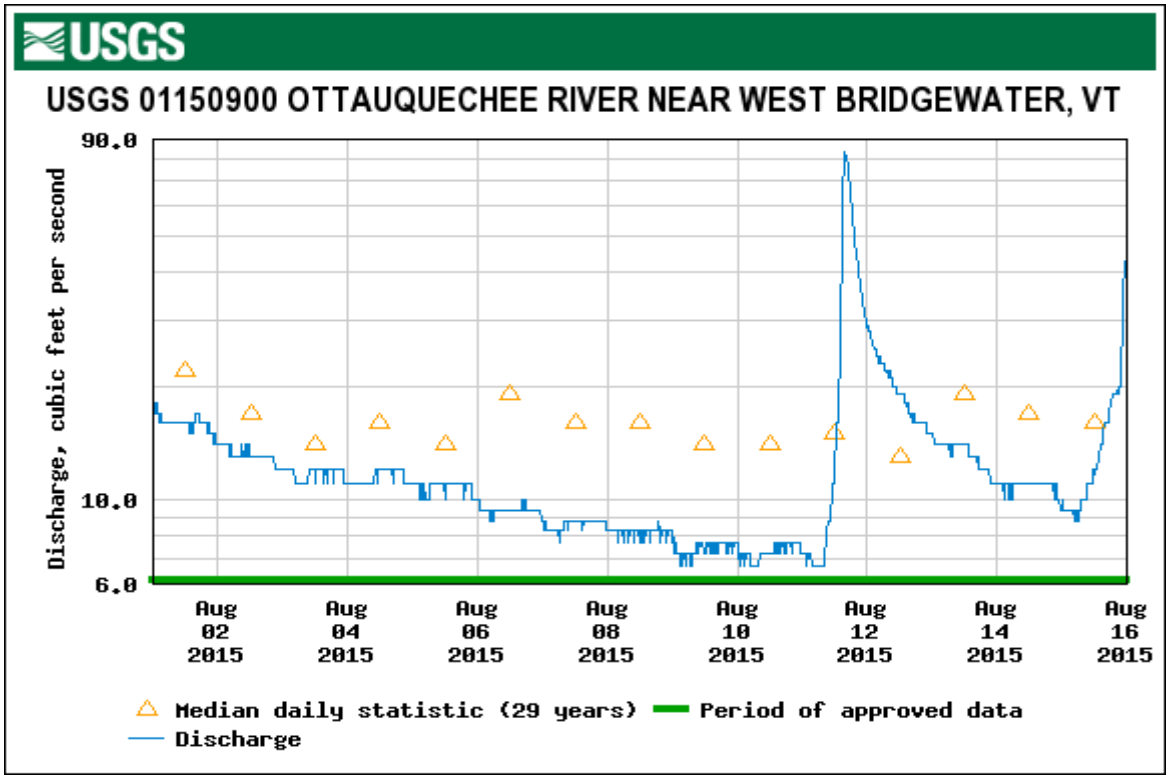


Figure 9cc: USGS Flow Gage Data - West Bridgewater - August 1 - August 15, 2015

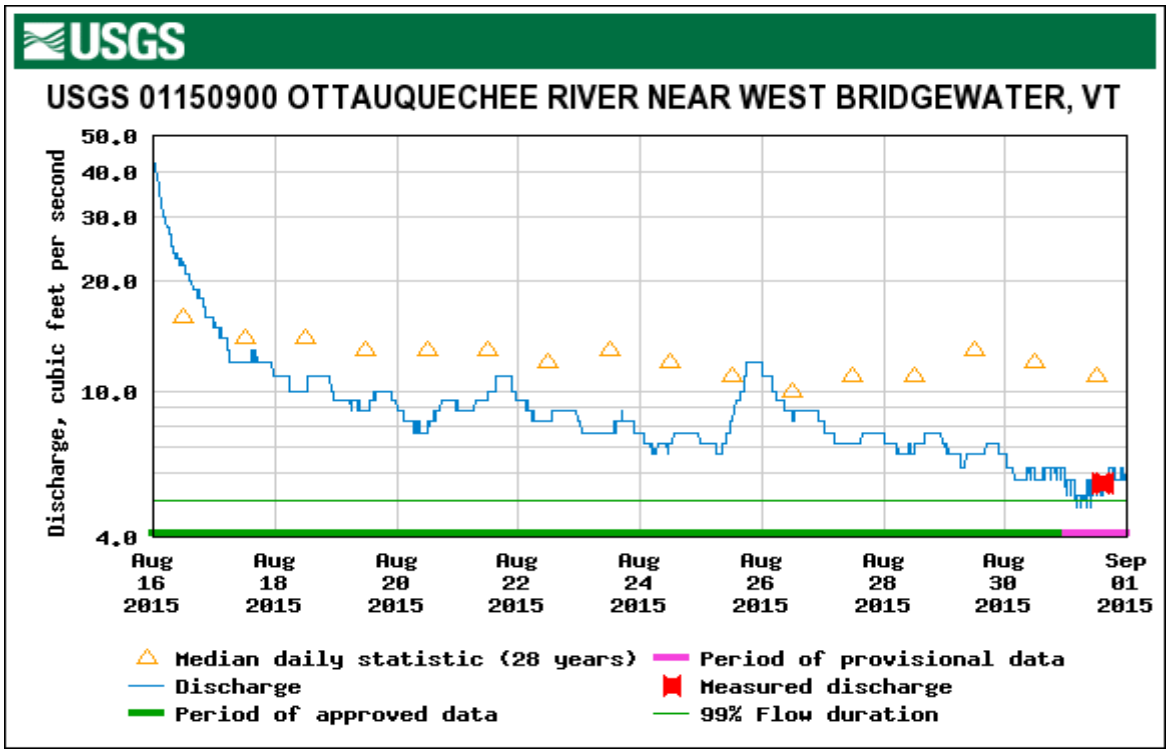


Figure 9dd: USGS Flow Gage Data - West Bridgewater - August 16 - August 31, 2015

SECTION 9.7: 2015 USGS FLOW GAGE DATA – NORTH HARTLAND GAGING STATION

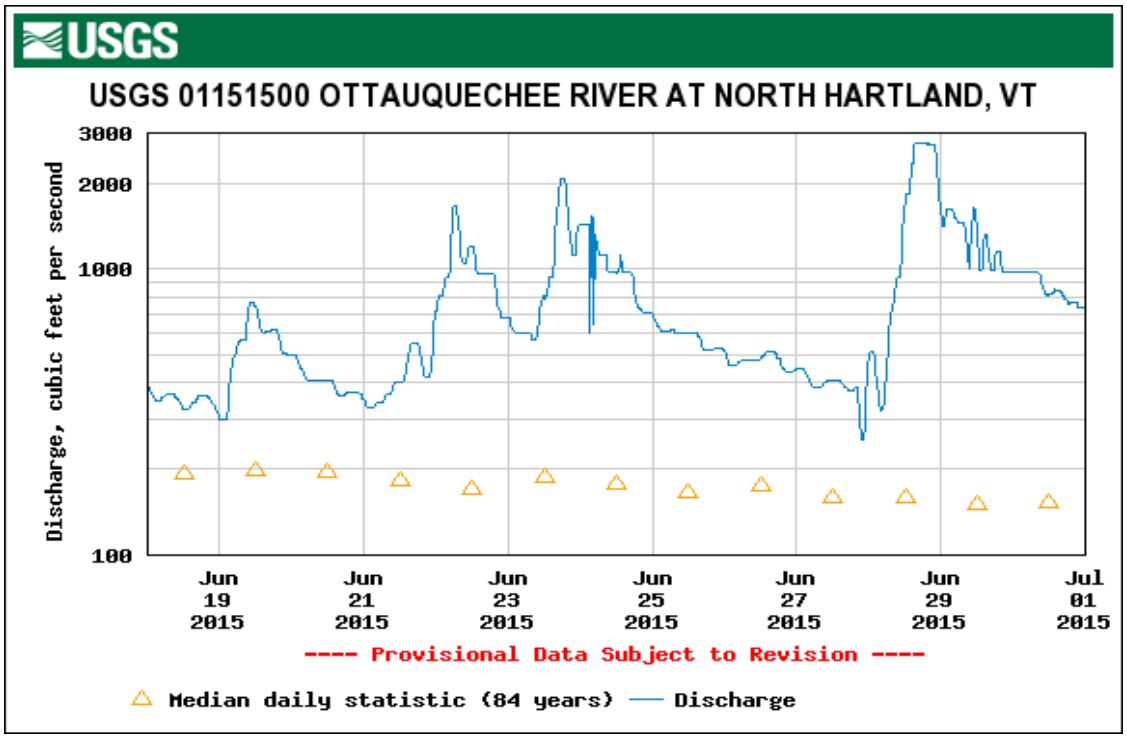


Figure 9ee: USGS Flow Gage Data - North Hartland - June 18 - June 30, 2015

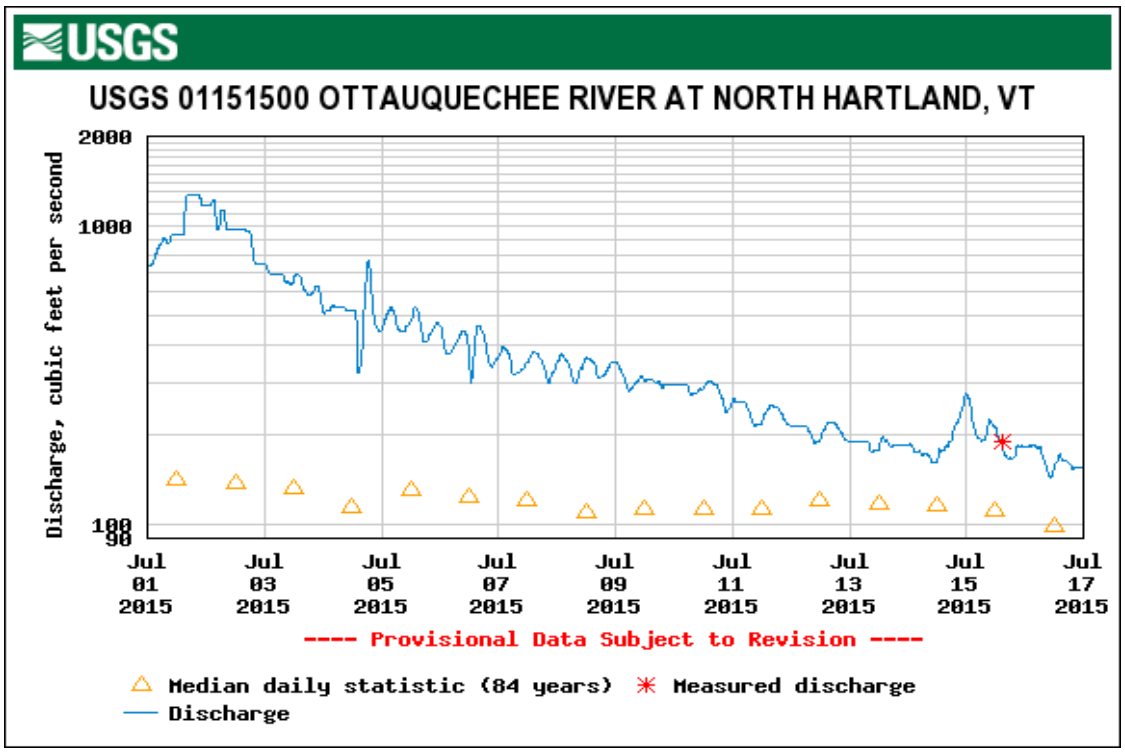


Figure 9ff: USGS Flow Gage Data - North Hartland - July 1 - July 16, 2015

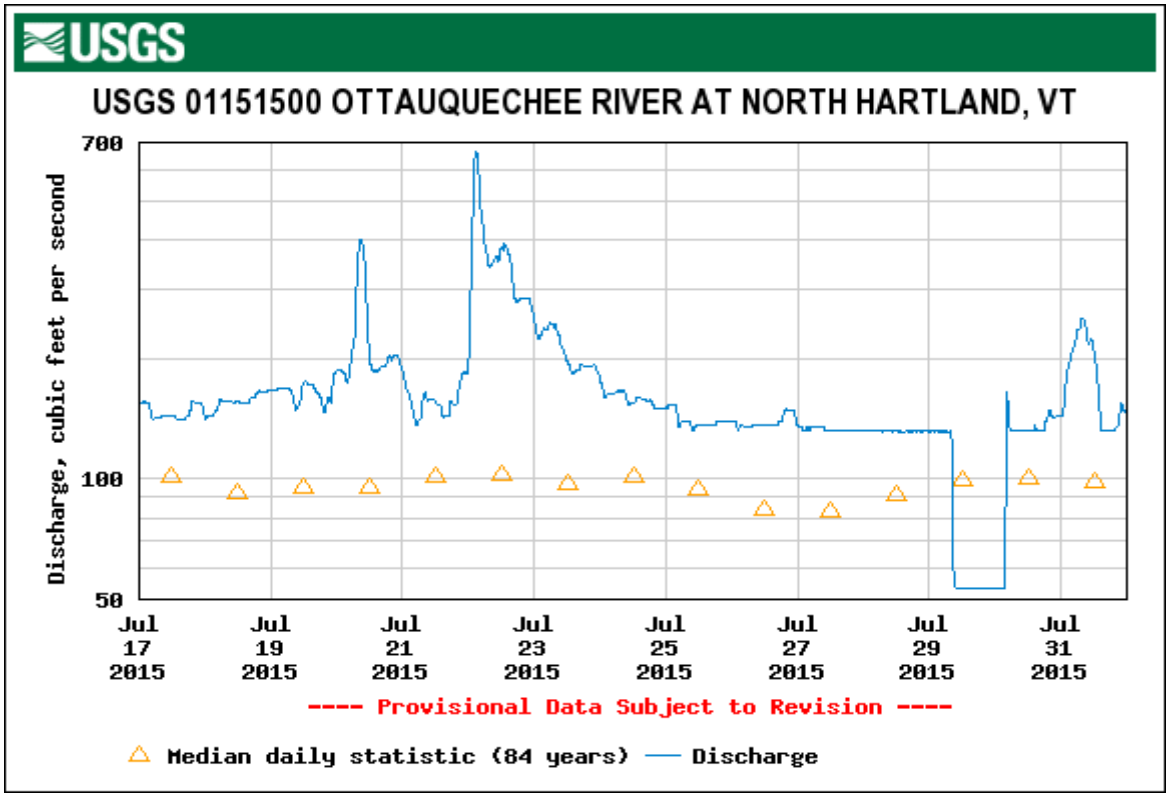


Figure 9gg: USGS Flow Gage Data - North Hartland - July 17 - July 31, 2015

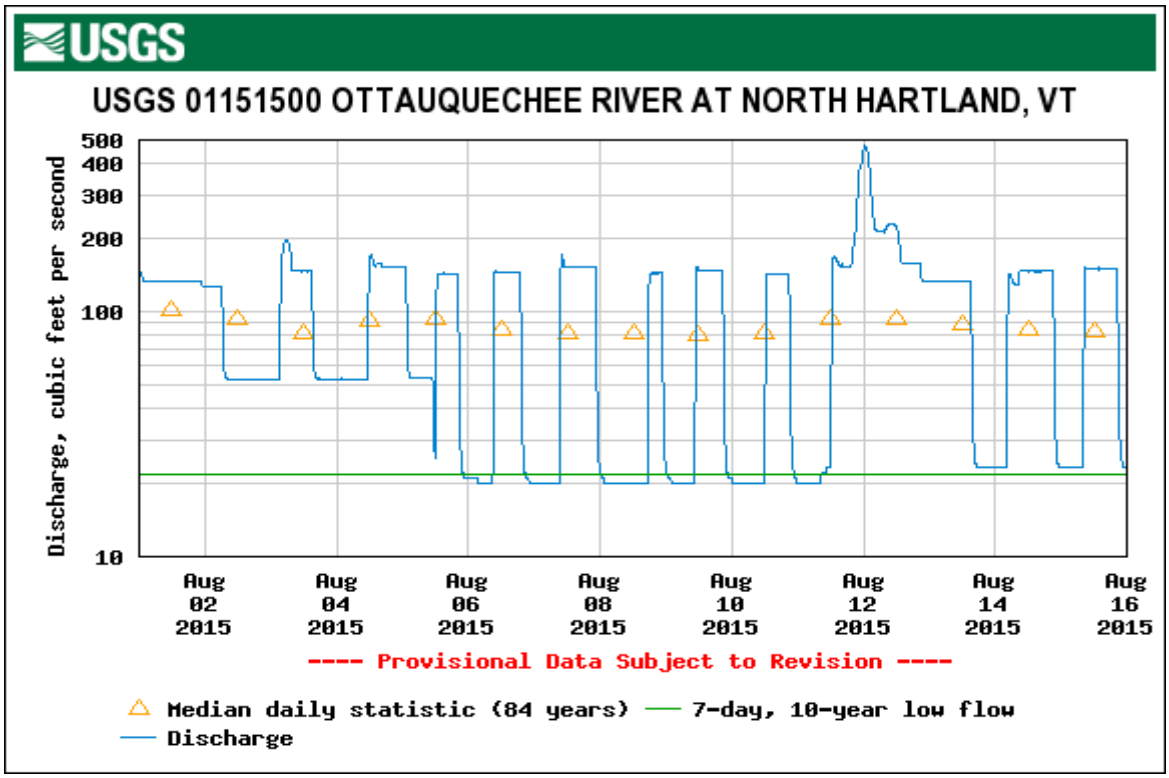


Figure 9hh: USGS Flow Gage Data - North Hartland - August 1 - August 15, 2015

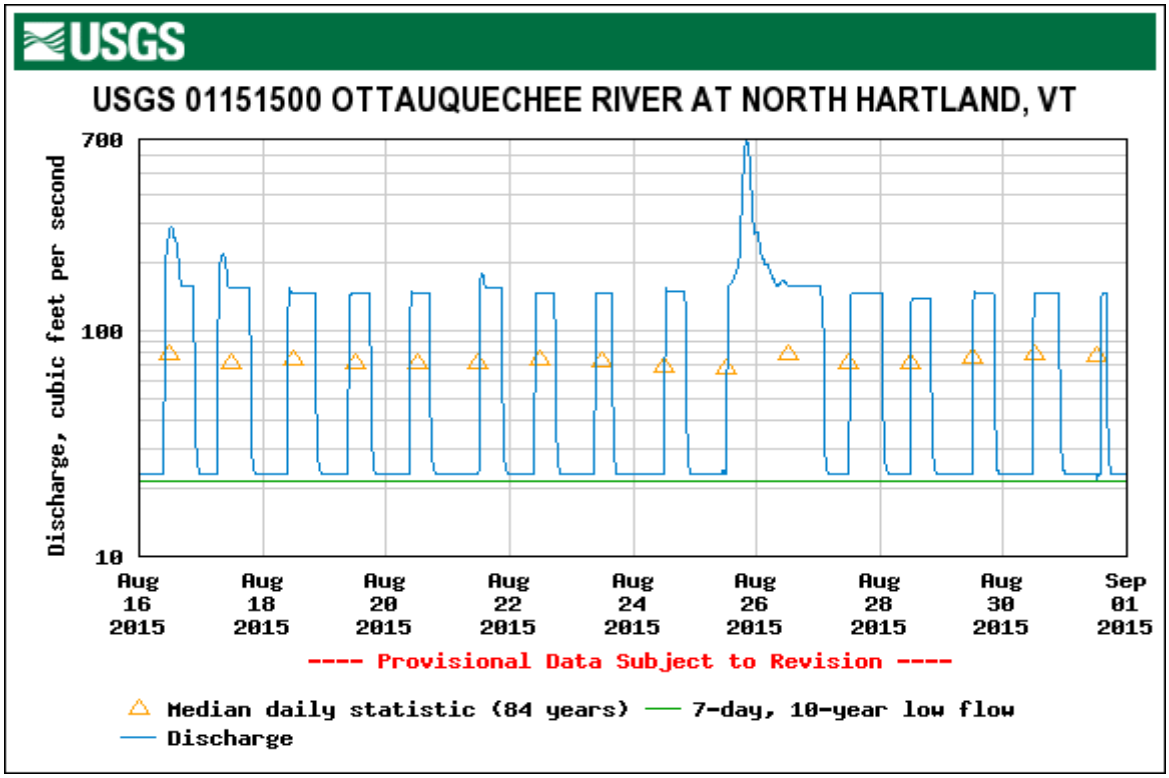


Figure 9ii: USGS Flow Gage Data - North Hartland - August 16 - August 31, 2015

SECTION 10: ANNUAL GEOMETRIC MEAN BY SITE

This section depicts the annual geometric mean for each parameter and site in order to identify potential long-term trends. Data from 2011 is included in this section as a reference, though it did not meet the minimum standards of statistical validity listed in the QAPP. Phosphorus was not monitored during the 2011 sampling season, and thus is not depicted in* ***figure 10a* *below.*

SECTION 10.1: TOTAL PHOSPHORUS - ANNUAL GEOMETRIC MEAN

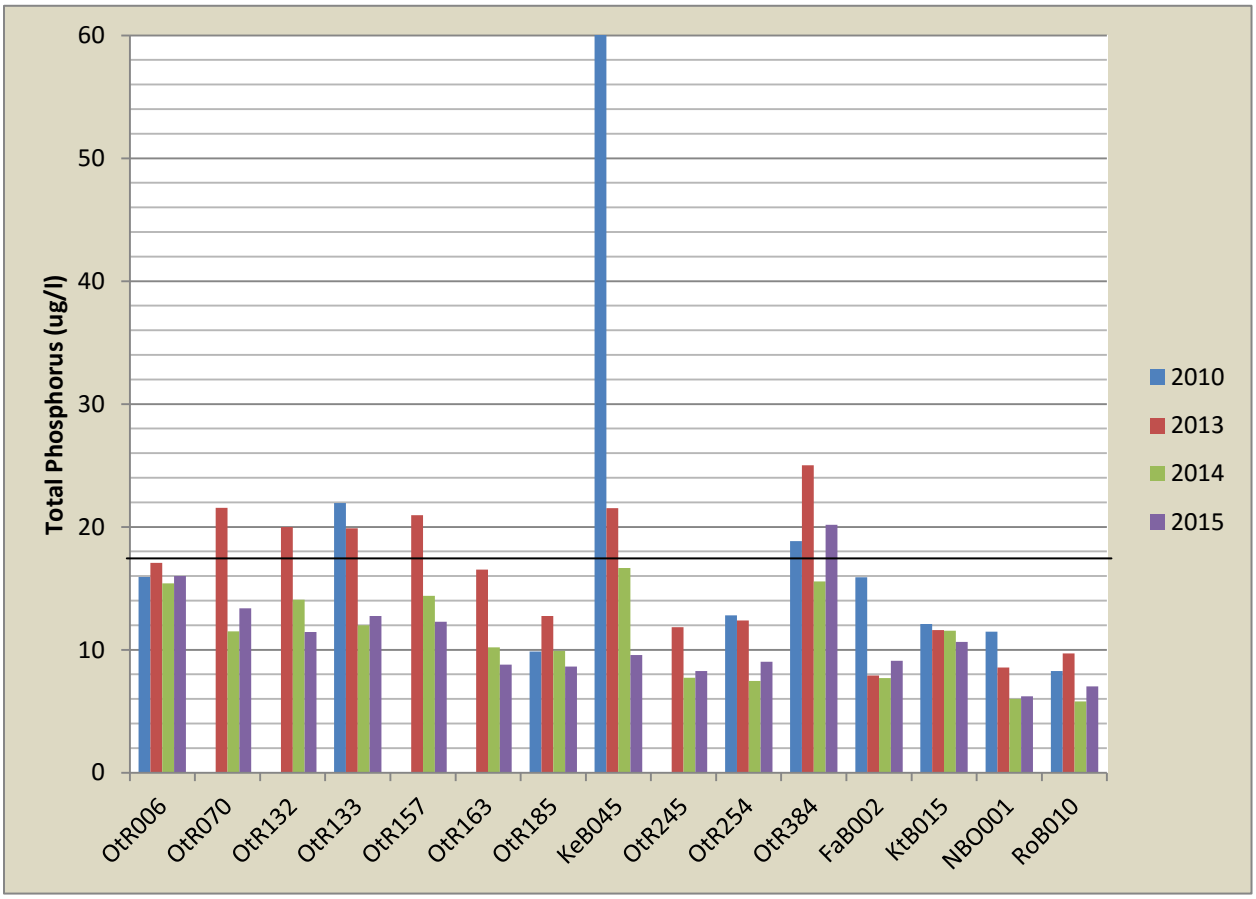


Figure 10a: Total Phosphorus Data - Annual Geometric Mean

A total of 34.5% of data points exceed state standards with respect to total phosphorus levels dating back to 2010. Sites which consistently exceed these standards include OtR006, OtR157, KeB045, and OtR384. Sites which are consistently in compliance with state standards include OtR185, OtR245, OtR254, KtB015, NBO001, and RoB010. A tremendous spike in phosphorus concentrations can be observed at site KeB045 in 2010. Though these concentrations significantly drop in following years, they still consistently exceed Vermont state standards. Sites OtR133, KeB045, and NBO001 each exhibit generally declining trends in phosphorus concentrations since 2010. With the exception of these sites, no significant increasing or declining trends in phosphorus concentrations are observable.

SECTION 10.2: TURBIDITY – ANNUAL GEOMETRIC MEAN

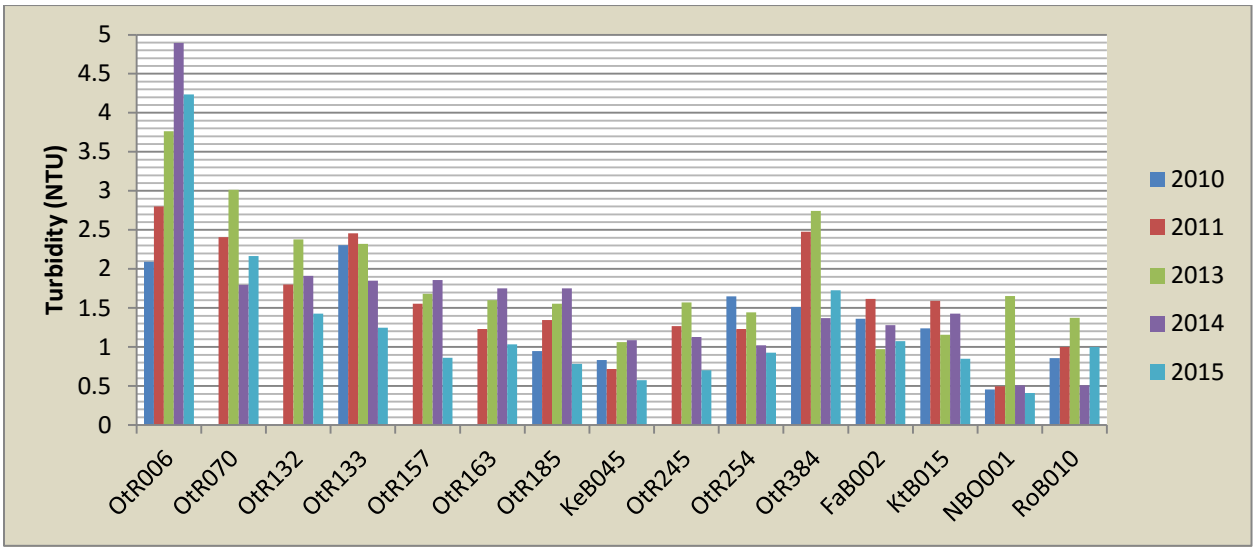


Figure 10b: Turbidity Data - Annual Geometric Mean

All of the turbidity data points dating back to 2010 are in compliance with current state standards (10 NTU). Sites OtR006 and OtR185 show generally increasing trends in turbidity, while no other significant trends are observable. Sites KeB045, NBO001, and RoB010 are shown to be the least turbid sites.

SECTION 10.3: TOTAL CHLORIDE – ANNUAL GEOMETRIC MEAN

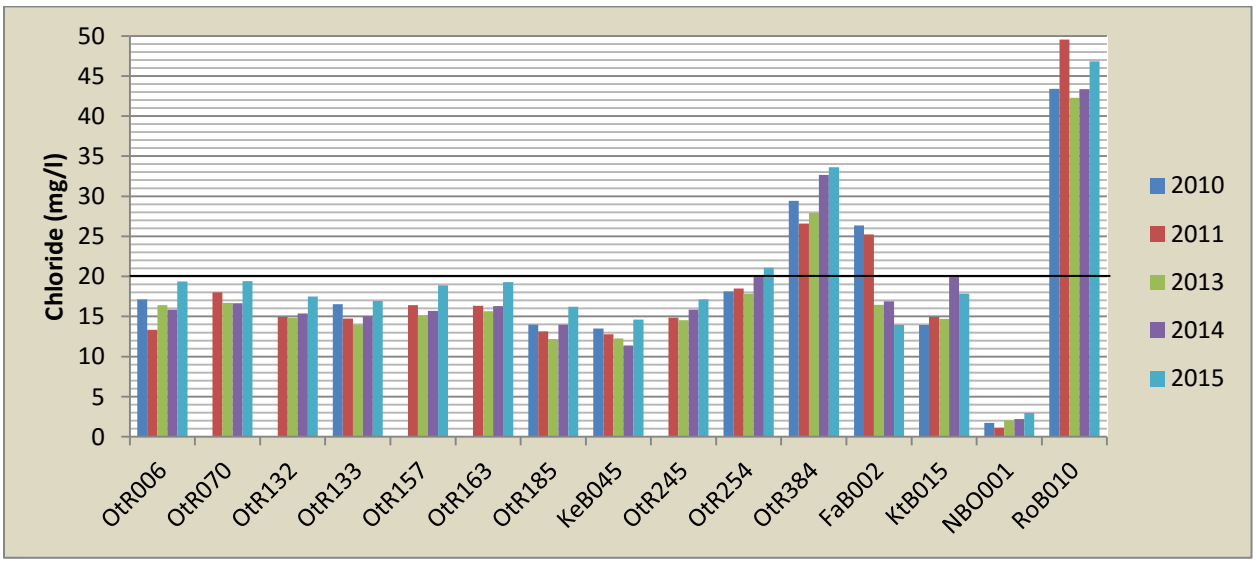


Figure 10c: Total Chloride Data - Annual Geometric Mean

Chloride concentrations since 2010 have generally remained within compliance of state standards, as only 18.5% of data points exceeded those standards. Sites OtR384 and RoB010 exhibit the highest chloride concentrations as they exceeded state standards every year. NBO001 possesses by far the lowest concentrations of chloride. No significant increasing or declining trends are observable at any sites.

SECTION 10.4: *E. COLI* – ANNUAL GEOMETRIC MEAN

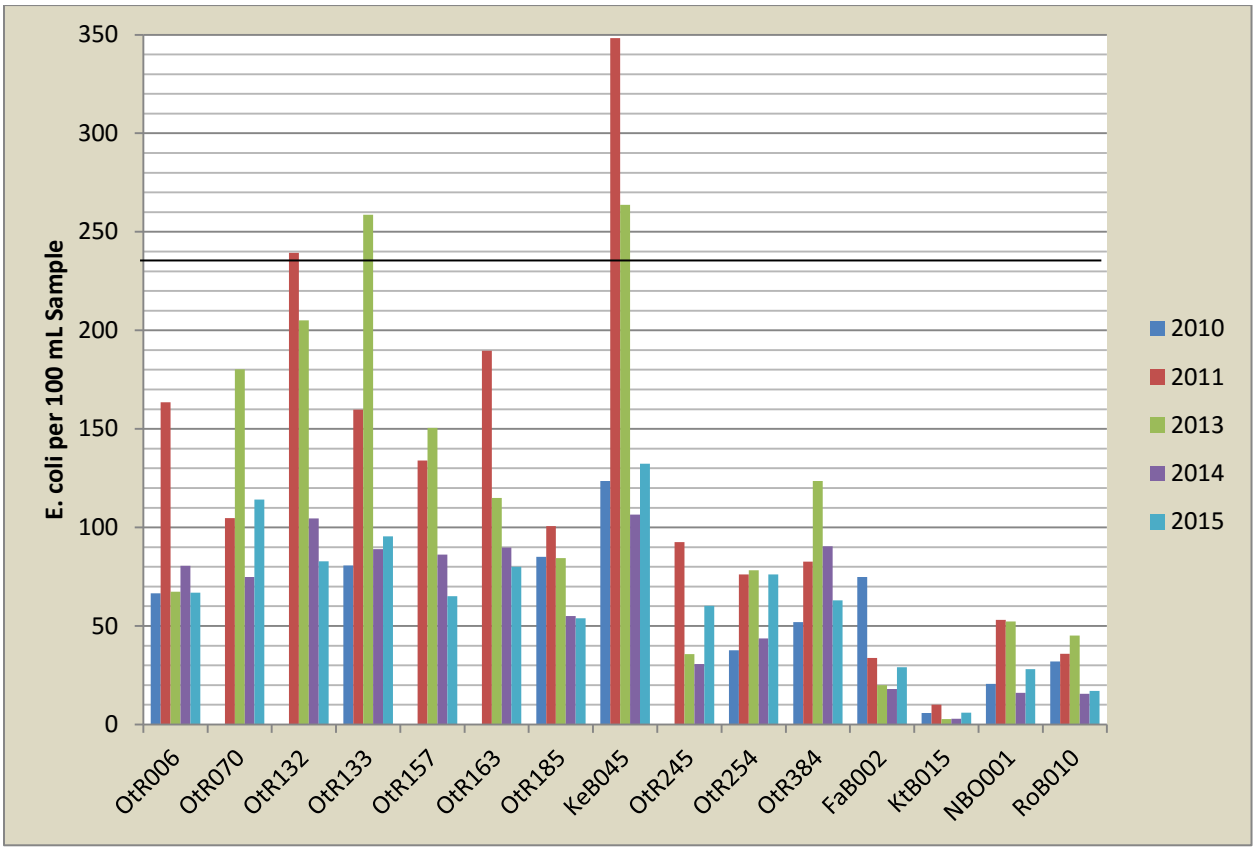


Figure 10d: E. coli - Annual Geometric Mean

Nearly all *E. coli* data points since 2010 are within compliance of state standards. Only 7% of data points exceed the 235 *E. coli* per 100mL sample standards. Site OtR132 exceeded standards in 2011, OtR133 exceeded in 2013, and KeB045 exceeded in both 2011 and 2013. *E. coli* concentrations since 2010 have generally been significantly higher below the waste water treatment facility located in Bridgewater, indicating that facility *may* be a contributor. Site KtB015 possesses by far the lowest concentrations of *E. coli* bacteria during each sampling season since 2010. No significant increasing or descending trends in *E. coli* bacteria concentrations seem to be present at any site.

SECTION 10.5: TOTAL NITROGEN – ANNUAL GEOMETRIC MEAN

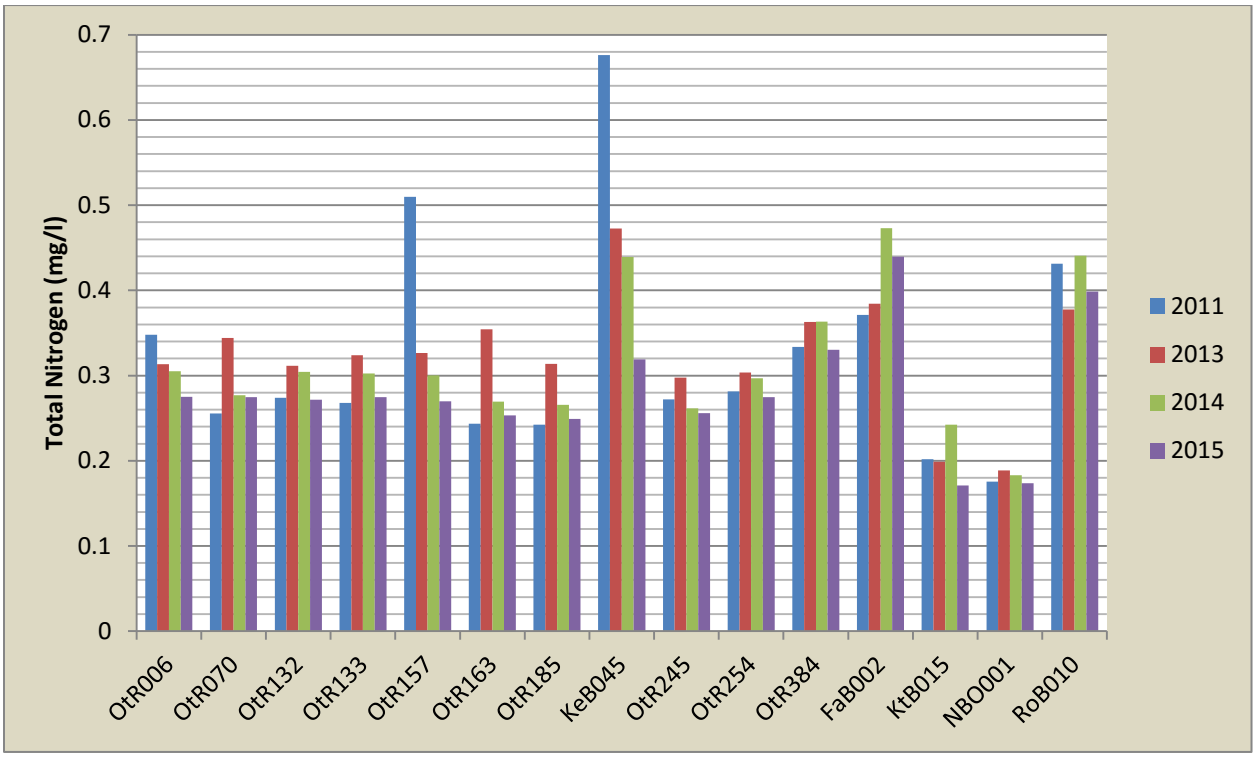


Figure 10e: Total Nitrogen - Annual Geometric Mean

All total nitrogen data points are well within compliance of state standards (5 mg/l). The highest TN concentrations are observable at sites KeB045, FaB002, and RoB010. The lowest total nitrogen concentrations can be found at sites KtB015 and NBO001. Total nitrogen concentrations appear to be generally consistent as no significant increasing or descending trends seem to be present.

Site ID	Parameter				
	TP	TN	Cl-	E. coli	TURB
OtR006	XXXX				
OtR070	XX				
OtR132	XX			X	
OtR133	XXX			X	
OtR157	XXX				
OtR163	X				
OtR185	X				
OtR245					
OtR254	XX		XX		
OtR384	XXXX		XXXXX		
FaB002	X		XX		
KeB045	XXX			XX	
KtB015					
NBO001					
RoB010			XXXXX		

**This table depicts the number of sampling seasons any particular site and parameter exceeded state standards (based upon geometric mean)*

SECTION 11: SUMMARY OF 2011 RESULTS

**The results included in this section should not be interpreted as statistically valid data. The minimum number of samples taken throughout the course of a season for a given parameter to hold statistical validity is 5. As the 2011 sampling season was interrupted by Tropical Storm Irene, ORG was only able to sample on four of the seven intended monitoring dates. Therefore this data is simply included as a reference.*

SECTION 11.1: 2011 TURBIDITY DATA

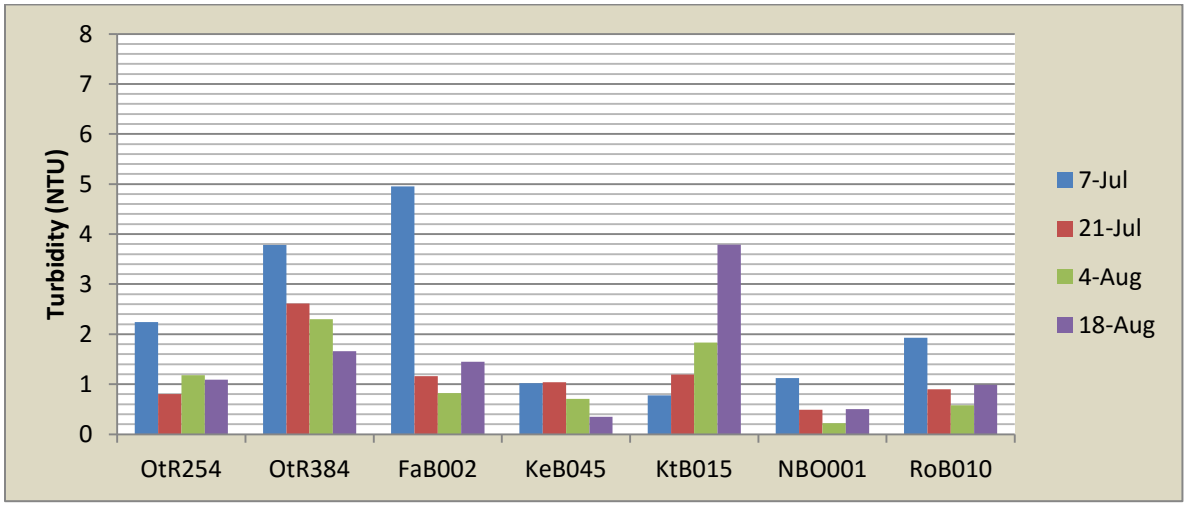


Figure 11a: 2011 Turbidity Data (above Bridgewater WWTF)

Each turbidity data point collected during the 2011 monitoring season fell well within current Vermont state standards (10 NTU). The site which appears to have been the least turbid during the 2011 season is NBO001. Conversely, sites OtR384 and OtR006 appear to have been the most turbid. Sites OtR006 and KtB015 show very distinct increasing trends in turbidity levels throughout the season and OtR384, despite being one of the more turbid site overall, exhibits a very distinct downward trend throughout the season. With those exceptions, no significant trends appear to take place throughout the monitoring season.

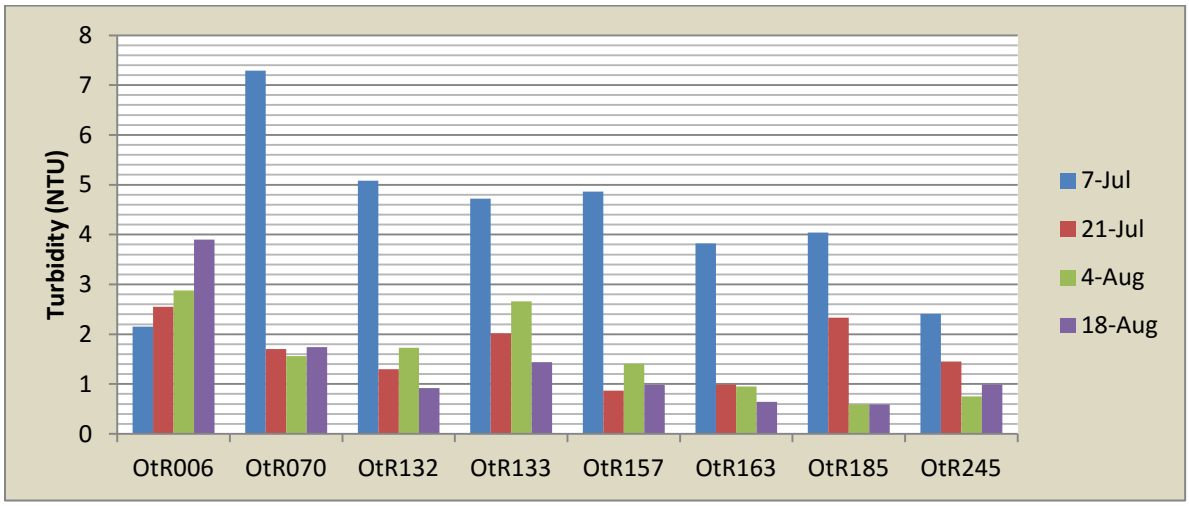


Figure 11b: 2011 Turbidity Data (below Bridgewater WWTF)

SECTION 11.2: 2011 CHLORIDE DATA

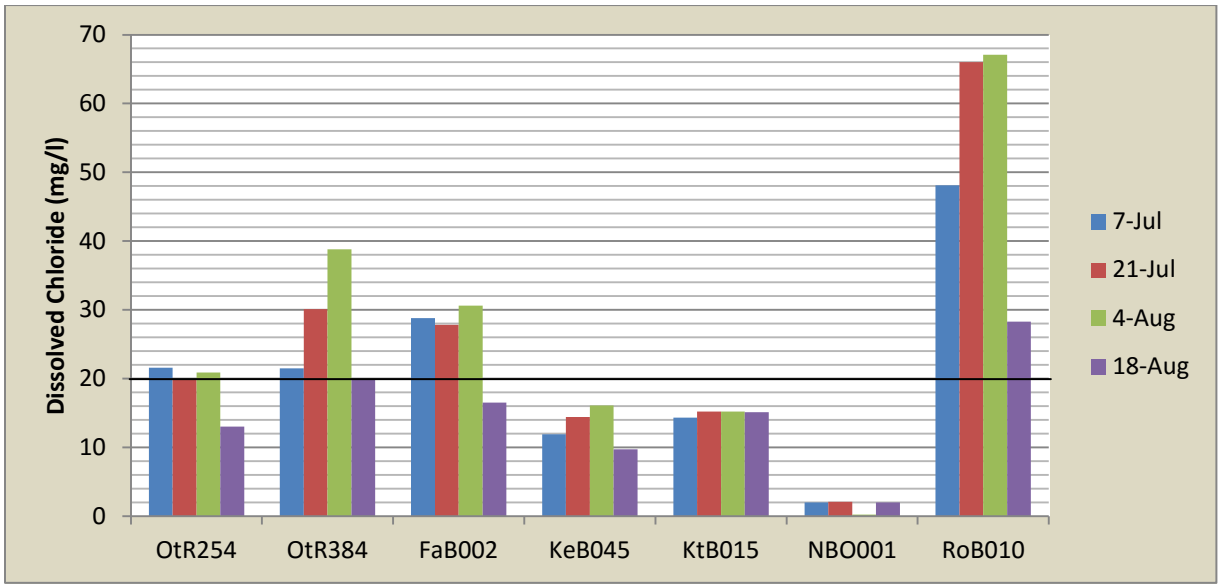


Figure 11c: 2011 Chloride Data (above Bridgewater WWTF)

The majority of chloride data points collected during the 2011 monitoring season were in compliance with current Vermont state standards (20 mg/L) as only roughly 31.6% of data points exceeded those standards. Site RoB010 on Roaring Brook in Killington exhibited by far the highest concentrations of chloride during the 2011 season, likely due to road salting to accommodate safe vehicle access to the Killington Ski Resort. By and large, chloride concentrations were significantly lower below the waste water treatment facility in Bridgewater. The lowest and most stable chloride concentrations in 2011 are shown to be at site NBO001 on the North Branch Ottauquechee River, by a significant margin.

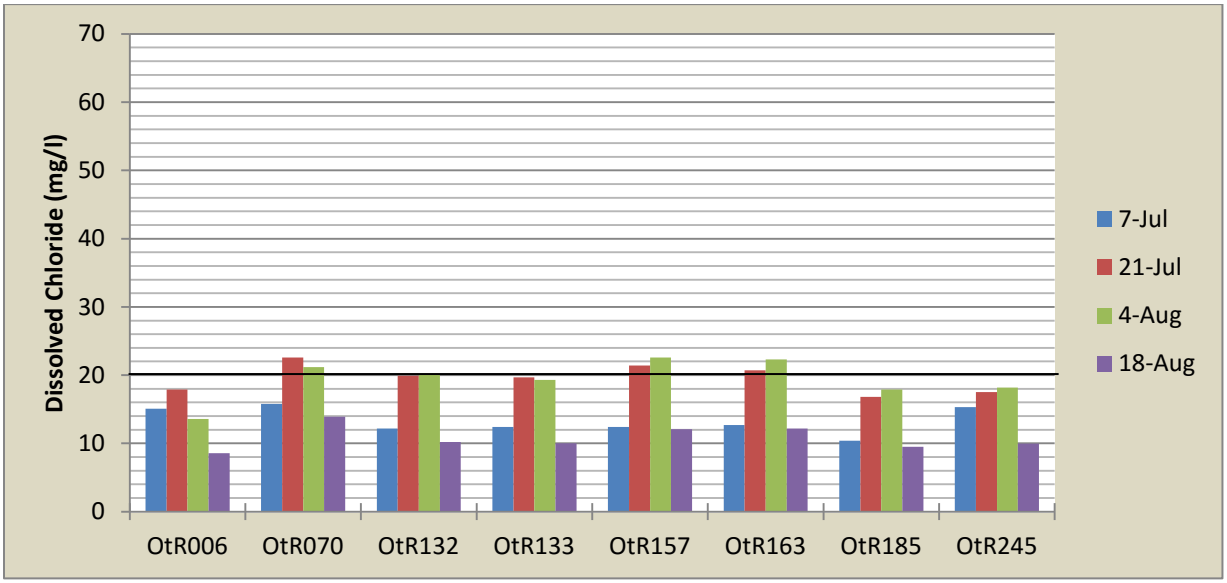


Figure 11d: 2011 Chloride Data (below Bridgewater WTFF)

SECTION 11.3: 2011 *E. COLI* DATA

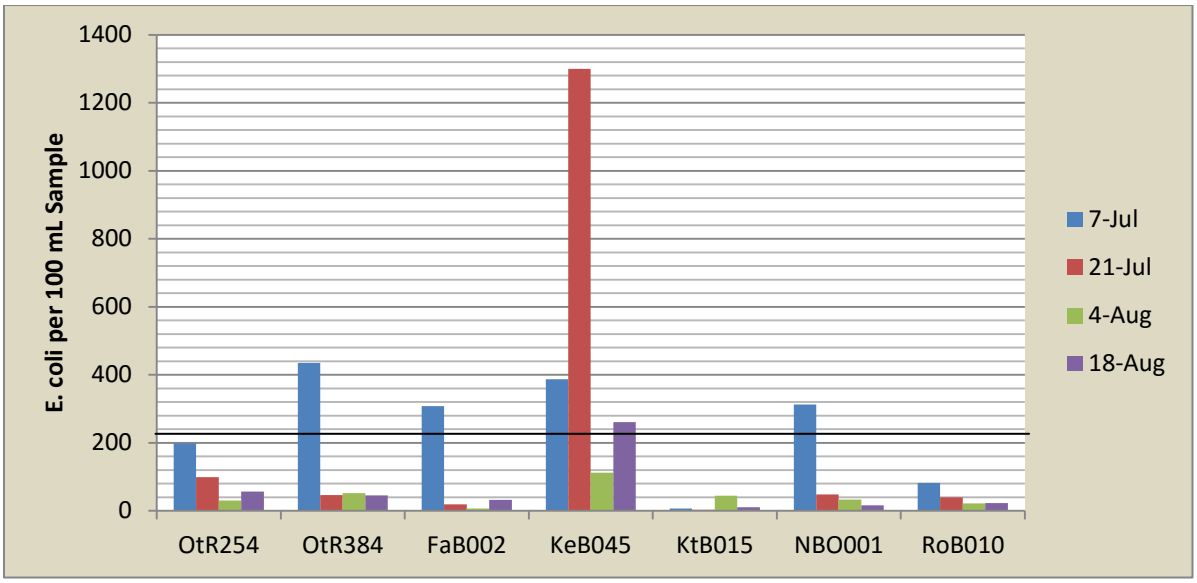


Figure 11e: 2011 E. coli Data (above Bridgewater WWTF)

The majority of *E. coli* data points collected during the 2011 monitoring season were in compliance with current Vermont state standards (235 per 100 mL sample) as only 20% of data points exceeded those standards. The highest *E. coli* concentrations during the 2011 monitoring season can be found at site KeB045 on Kedron Brook, as 3 of the 4 data points available at that site exceed state standards. The lowest *E. coli* concentrations can be found at site KtB015 (outlet of Kent Pond), followed by RoB010 on Roaring Brook and NBO001 on the North Branch Ottauquechee River. A significant spike is observable on July 7 at nearly all sites. No significant increasing or declining trends seem to be present throughout the season.

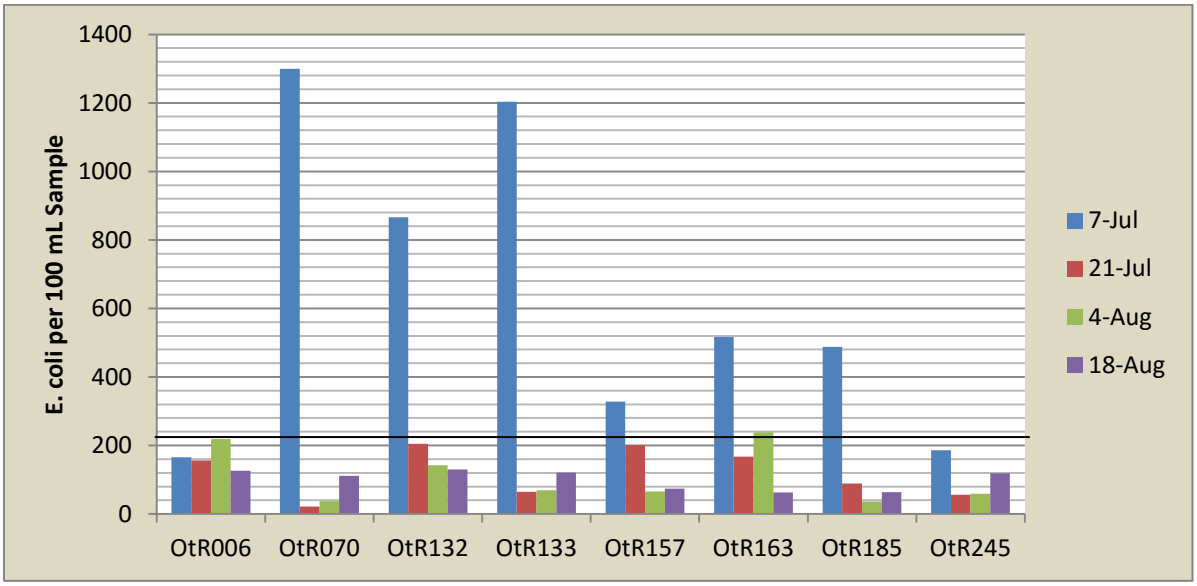


Figure 11f: 2011 E. coli Data (below Bridgewater WWTF)

SECTION 11.4: 2011 TOTAL NITROGEN DATA

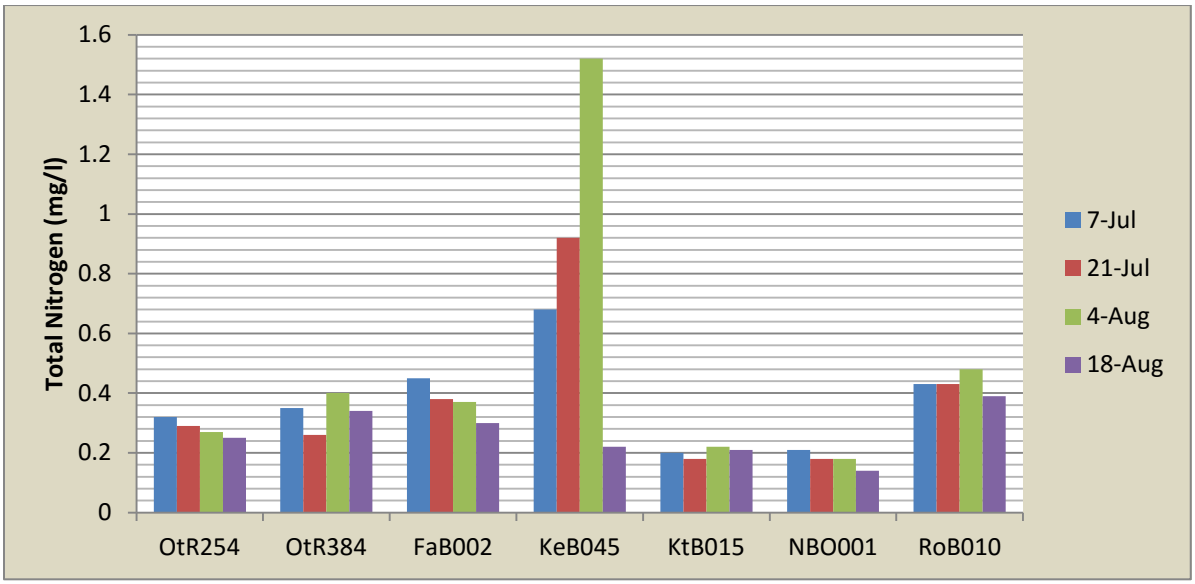


Figure 11g: 2011 E. coli Data (above Bridgewater WWTF)

All of the total nitrogen data points collected throughout the 2011 monitoring season were well within compliance of current Vermont state standards (5 mg/L). By far the highest concentrations of total nitrogen can be found at site KeB045 on Kedron Brook, while the lowest concentrations by a modest margin can be found at sites KtB015 at the outlet of Kent Pond and site NBO001 on the North Branch Ottauquechee River. Sites OtR070, OtR254, and FaB002 all exhibit distinct declining trends throughout the season. With those exceptions, no significant trends seem to be present.

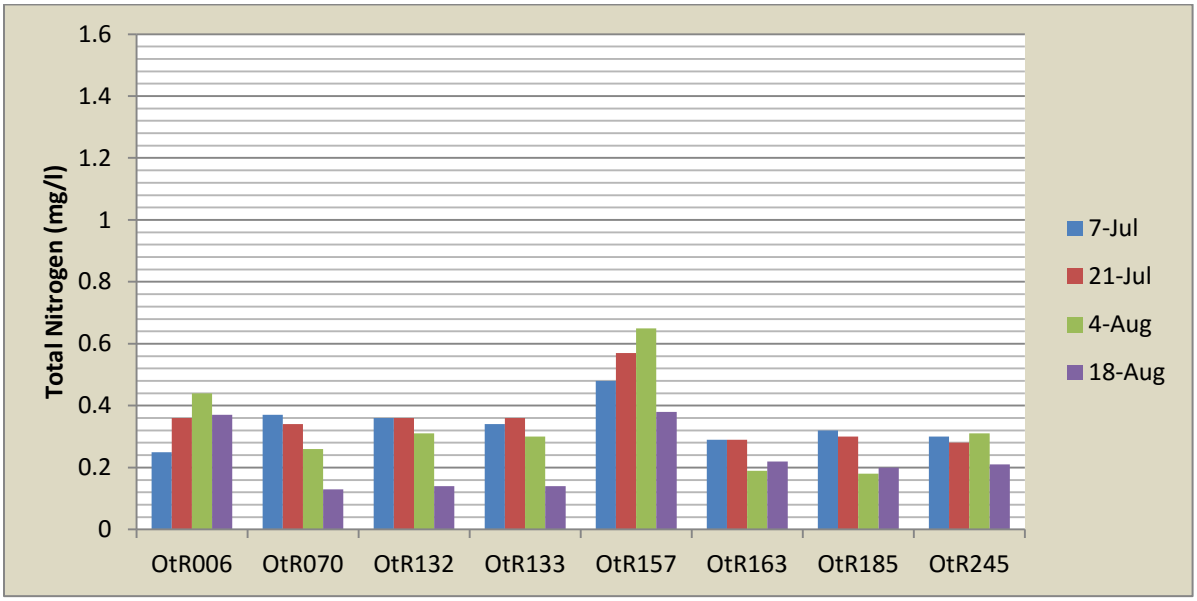


Figure 11h: 2011 E. coli Data (below Bridgewater WWTF)

SECTION 12: WORKS CITED

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