Water Quality and Invasive Species Assessment Report (TAR) 2022

Joe Musante
Water Resources Program
Environmental Department
Indian Township Tribal Government

Indian Township Tribal Government
PO Box 301, Princeton ME, 04668

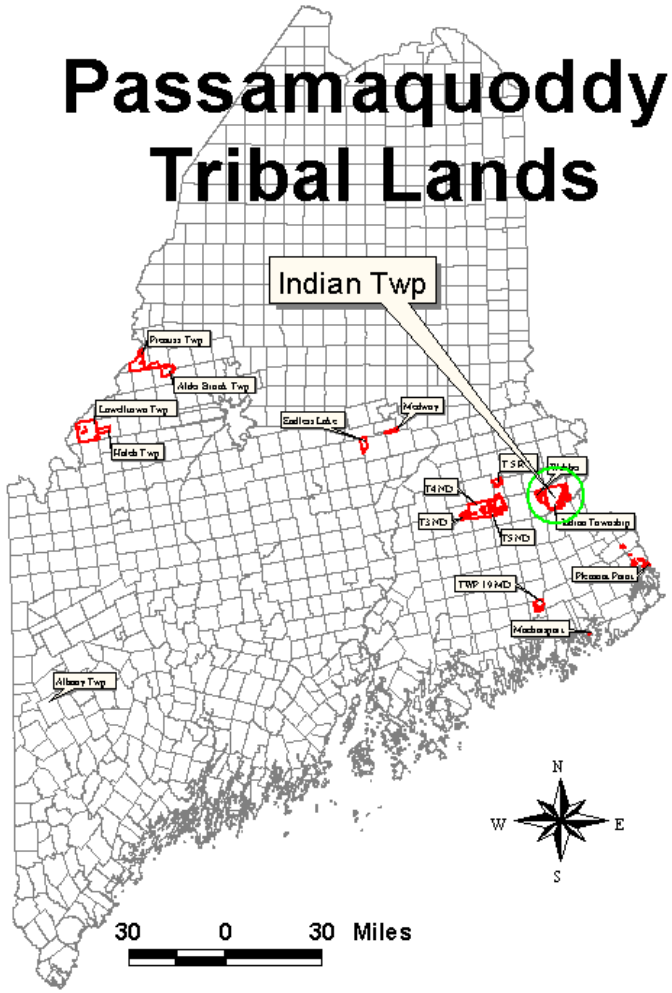


Figure 1: Location of Indian Township, Maine.

Introduction

Background

The Passamaquoddy Tribe at Indian Township began its Water Resources Planning and Inventory Program in April 1993 with funding from a Multi-Media grant from the U.S. Environmental Protection Agency (US EPA), and a Bureau of Indian Affairs (BIA) Water Resources contract. The US EPA requires a Quality Assurance Project Plan (QAPP) as a prerequisite for funding of monitoring programs. The QAPP details the program's procedures for field work, transportation, data use, laboratory and field protocols, and safety. For data to be useful, procedures must be consistent and reliable. The QAPP is submitted to, reviewed, and approved by the US EPA for each year of monitoring.

Indian Township has a wealth of water resources. Bordering the southern edge of the Reservation is part of a long series of reservoirs controlled by Woodland Pulp LLC as part of the St. Croix River drainage. The Reservation waters include Big Lake, Long Lake, Lewey Lake, Grand Falls Flowage and its tributary Tomah Stream. These water bodies make up a significant section of the 647 mi^2 West Branch of the St. Croix River basin. Reservoir water levels are controlled and used for power generation, mill effluent dilution, fisheries, and flood control. Indian Township's lake levels are controlled at the Grand Falls Dam in Woodland. In addition to Tribal land inside Indian Township, the Passamaquoddy Tribe has in Trust over 115,000 acres distributed over 7 counties in the State of Maine.

Purpose

The Indian Township Water Quality Monitoring Program was undertaken to compile baseline data for reservation water bodies. Water quality is the biological, chemical, and physical composition of the water in its natural state, taking into account any human inputs and alterations. In order to protect water quality in the future, one must have an idea of the current water quality, the sources of pollution currently entering the system, and the trends of the system. Determining trophic state and water quality trends are nearly impossible without data to back up those determinations. A reliable, long term monitoring program can help identify problems before the degradation of water quality is irreversible. To further complicate the water quality issue, watersheds cross municipal, state, tribal and national boundaries. Reliable data can also provide the necessary scientific backing to elicit the political will to address pollution sources.

General Program Summary

We restarted the Water Quality Sampling Program in 2008 with sampling the original four Township lakes: Big Lake, Long Lake, Lewey Lake, and Grand Falls Flowage. The 2009 season built on this foundation by continuing sampling of the Township lakes, as well as adding in monthly sampling of 13 other lakes and ponds, most of which had been regularly sampled in the past. The 2010 Water Quality Sampling Season continued on our 2009 season with sampling of the same 17 lakes and ponds. In 2011 we continued to build on 2010 by adding in 4 more lakes: East and West Musquash Lake, Pleasant Lake, and West Grand Lake. We also added in sampling of a small pond known locally as Bassett Pond, which is evidently fishless, in the summer of 2013.

All those additions combined with slowly eroding budgets and of course inflation, have caught up to us. We were forced to cut back sampling to reduce costs and man hours. Bassett Pond, while interesting and unique, was given the axe for now. It would be best focused on with a special project. Shaw and Mill Privilege were also cut after just one visit in 2017, as the access is poor and causes damage to equipment. The three ponds in the Jackman area were also cut for now, as they require the most resources to get to for data gained. In 2021 sampling was scaled back to once a month instead of twice. Staffing limits and the emergence of variable-leaved water milfoil as a serious aquatic invasive issue in Big Lake has the Department reorganizing priorities. Starting in August of 2022 we again scaled down our water quality sampling regiment to prioritize invasive milfoil surveys: down from 16 lakes once a month to 6 lakes once a month. Big, Long, Lewey, Grand Falls, Side Pistol, and Killman were sampled May – September. The remaining lakes listed below only sampled May – July.

An updated look at our sampling lakes are as follows: **Big Lake**, **Long Lake**, **Lewey Lake**, and **Grand Falls Flowage** (the original four lakes to be sampled) **Junior Lake**, **Pocumcus Lake**, **Scraggly Lake**, **Sysladobsis Lake, West Grand Lake** (5 major lakes upstream of the Township lakes), **Pleasant Lake** (large tributary to Scraggly Lake), **Upper Chain Lake**, **Middle Chain Lake** (2 tributaries to Sysladobsis Lake), **East and West Musquash Lakes** (eventually drain into Big Lake) **Side Pistol Lake** (drains into the Passadumkeag River, and eventually the Penobscot River), and **Killman Pond** (drains into Upper Chain Lake). If looked at the watershed level, fifteen of our lakes and ponds sampled are part of the St. Croix River watershed, while only one remains (Side Pistol) included of the extensive Penobscot River watershed.

A full sampling regiment of parameters in 2022 includes the following: **Dissolved Oxygen** (DO), **Temperature**, **pH**, **Conductivity**, **Transparency** (Secchi depth), **Chlorophyll-a** (Chla), **Total Phosphorus** (TP), **Alkalinity**, and **True Color** analysis. Each one of those parameters will be explained in greater detail later on in the report.

Monthly Program Summary

May Our weather station on the reservation recorded about 2.4" of rain, compared to about 3.6" for May 2021, 3.4" for 2020, 4.90" for 2019, 2.20" for 2018, 4.75" for 2017, 2.75" for 2016. The season started a bit dry, nothing like 2020. 2" of the rains came in the second half of May.

Things are basically back to normal regarding Covid affecting operations. We started out collecting our first samples on May 16th as planned to avoid mud season road closures that typically last until May 15th. A full QAPP rewrite was completed and approved in May 2021, no adjustments to the QAPP for the 2022 season. Our 2020 16' boat was serviced in May and is running great, truck was serviced Oct 2021 and is running great. Ryan Gabriel returns for another season as our field assistant. Our yearly retraining with Lake Stewards of Maine was in September. **(Sampling Events: 16/16: 100%)**

June Our weather station on the reservation recorded about 2" of rain for June 2022. For comparison, we had 2" of rain for 2021, 2.75" for 2020, 7.3" for 2019, 5.0" for 2018, 1.9" for 2017, and 2.80" for 2016. Nothing out of the ordinary for June 2022. **(Sampling Events: 16/16: 100%)**

July Our weather station on the reservation recorded 4.3" for July 2022, a good-sized total for July. Compare this to about 5.8" for July 2021, 1.75" for 2020, 3.8" for 2019, 1.5" for 2018, 1.4" of rain in 2017, 3.8" of rain for July 2016. No issues to report for July. **(Sampling Events: 16/16: 100%)**

August Our weather station on the reservation had technical issues and was not able to record precipitation amounts for August 2022. We had 1.8" for August 2021, 2.6" 2020, 4.2" for 2019, 4.5" for 2018, only 1.0" of rain for August 2017, about 3.25" of rain for 2016. Starting August 1st the department made the decision to drop some sampling lakes for more time to survey invasive variable-leaved watermilfoil. HETL had some TP equipment issues causing the 6 samples to be tested 1-2 days past holding time. **(Sampling Events: 16/16: 100%)**

September Our weather station on the reservation had technical issues and did not record rain amounts in September 2022. In comparison 6.7" of rain fell in September 2021, 1.3" in 2020, 4.2" in 2019, 2.4" in 2018, 1.4" in 2017, 2.0" of rain for September 2016. September temperatures have been very mild this year. HETL again had TP equipment issues causing samples to be tested 8 days past holding time. The last sample of the season was taken on September 22nd at Killman Pond. **(Sampling Events: 16/16: 100%)**

Parameter Summary

In order to further measure our sampling success, the following shows each parameter sampled and its associated success rate (measured by valid samples taken/possible samples taken) not including quality control duplicate samples. These numbers incorporate the change from 16 lakes per month to 6 for August and September.

- **Dissolved Oxygen/Temperature Profiles:** 60/60 (100%) 2022 continued with changed implemented in 2021, with a less intensive survey schedule, moving from twice a month to once a month. We replace the ProDO probe tip every Spring and that's normally the only maintenance required. This meter has shown to be extremely accurate in DO and Temp readings and having a 40m cable allows us to take readings to the bottom of even the deepest lakes in the area.

- **Chlorophyll-a:** *60/60 (100%) Some samples were tested past the 28 day frozen holding time due to lab equipment issues and have been flagged. We've been assured by other water quality experts that the data is still viable. Again this year there were no large outliers to deal with, all the readings were within the general expected range from past experience. Chl-a readings ranged from a low of 1.0 ppb (the reporting limit) on many lakes at least once, to a high of 4.0ppb (Grand Falls Flowage).

- **Transparency/Secchi:** 60/60 (100%) No secchi readings were missed in 2022. The secchi disk didn't hit bottom at all this season. We had some slightly low water situations in the reservation lakes this summer but nothing like 2020. We'll see how the color data compares to past years soon enough. Secchi depth ranged from 3.20m (Killman Pond) in the shallowest to 11.00m (West Grand) at the deepest.

- **Total Phosphorus: ***60/60 (100%) No additional Total Phosphorus samples were missed in 2022 per se, but many of August and September's samples were flagged due to being tested past the 28 day holding time. HETL had equipment issues causing the delays. To help with any hold time issues we made sure to get all of our sampling activities done and mailed as quickly as possible to maximize the extra holding time on their end. Our TP range for 2022 was a low of 2ppb (West Grand) with a high of 14ppb (Grand Falls Flowage).

- **pH:** 60/60 (100%) No major issues to report. The refillable probe continues to be reliable. We emptied and flushed the old fluid at the start of the season, replacing it with fresh solution. Our pH low for the season was 6.56 (Upper Chain) and a high of 7.20 (Pocumcus Lake).

- **Alkalinity:** 60/60 (100%) No additional samples were lost. No problems to report. Our low alkalinity reading for the season was 5.0 mg/l of CaCO3 (Upper Chain, Middle Chain, and East Musquash) with a high of 8.5 mg/l of CaCO3 (Pocumcus,

Long, and Grand Falls Flowage). These readings are very stable from year to year, usually trending up slightly as the summer goes on.

- **Conductivity:** 60/60 (100%) Our conductivity meter has always been very reliable, and due to the short season, we did not pursue a backup unit at this time. We lost no additional samples in 2022. Our low conductivity reading was 18.2 UMHOS/cm (West Musquash Lake) with a high of 26.0 UMHOS/cm (Grand Falls Flowage).

- **Color:** 60/60 (100%) We didn't lose any true color readings for 2022. Our lowest true color reading was 5 PCU (Side Pistol Lake), with a high reading of 72 PCU (Upper Chain). These two lakes are consistently on opposite ends of the color range for our sampling sites.

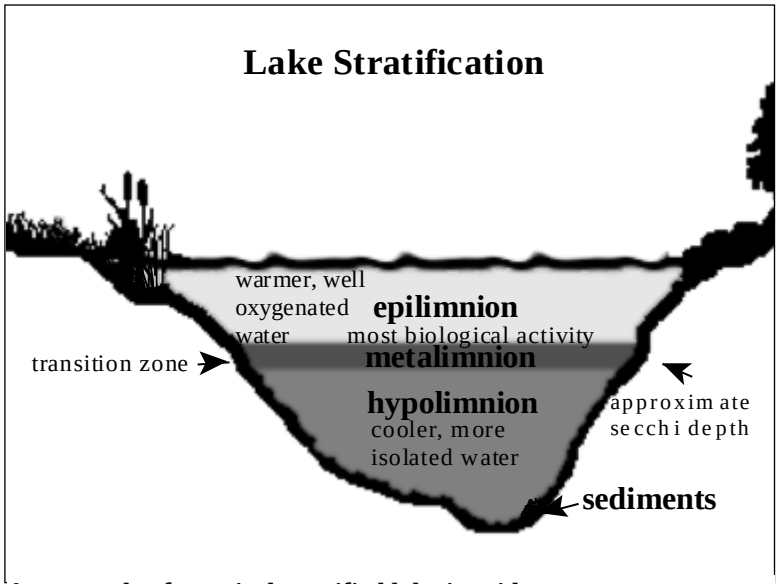
General Information

Stratification

Holdren et al (2001) defines stratification as a process in which several horizontal water layers of different density form in some lakes. These layers are classified as follows:

Epilimnion – the well-mixed and uniformly warm surface waters
Hypolimnion – the uniformly unmixed bottom waters
Metaliminion - zone of rapidly changing temperature and density separating the epilimnion and the hypolimnion

The lake is stratified when warm water, the epilimnion, floats on the significantly colder water, the hypolimnion. The metalimnion is formed in the region where the temperature gradient decreases markedly. This separation also allows little mixing of the upper layer with the bottom waters. After stratification, the hypolimnion has a finite quantity of oxygen until fall turnover.



An example of a typical stratified lake in midsummer.
Hill, R., Williams, S. 2008 Maine Lakes Report

Dissolved Oxygen

Dissolved Oxygen (D.O.) is the measure of the amount of oxygen dissolved in the water. All living organisms, except for certain types of bacteria, need oxygen to survive. Organisms living in the water have the ability to use the oxygen dissolved in the water to breathe. Too little oxygen severely reduces the diversity and population of aquatic communities. Therefore the amount of D.O.in the water is very important to aquatic life. Low oxygen can directly kill or stress organisms such that they will not be able to successfully reproduce or grow. Water with less than 1 part per million (ppm) of oxygen is considered anoxic (no oxygen present); less than 5 ppm of oxygen is generally considered so stressful that most coldwater fish will avoid these areas. Anoxic conditions can also promote TP release from sediments (VLMP, 2008 Maine Lakes Report).

Chlorophyll is what makes plants green, Snappy the Quill Pig loves his green veggies.

Chlorophyll-a

A pigment found in algae and other plants used to estimate biological productivity of lake ecosystems. By measuring the concentration of Chl-a in lake water, the algae population can be estimated. Chl-a is measured in parts per billion (ppb). Chlorophyll-a samples are generally obtained from an integrated water column sample because the greatest concentration of algal growth typically occurs from the surface of the lake to the bottom of the epilimnion or the top of the thermocline (VLMP, 2008 Maine Lakes Report).

Transparency

A measure of water clarity; the distance one can see down into the water column. Factors that affect transparency include algal growth, zooplankton, natural watercolor, and suspended silt particles. Because algae are the most abundant particles in most lakes, transparency indirectly measures algal growth. Transparency values vary widely in Maine lakes. Unless a lake is highly colored or turbid from suspended sediment, transparency readings of 2 meters or less generally indicates a severe algal bloom (VLMP, 2008 Maine Lakes Report).

Two summer youth workers learning how to take secchi readings.

First pair of loon chicks spotted in July 2020 on Scraggly Lake!

Total Phosphorous

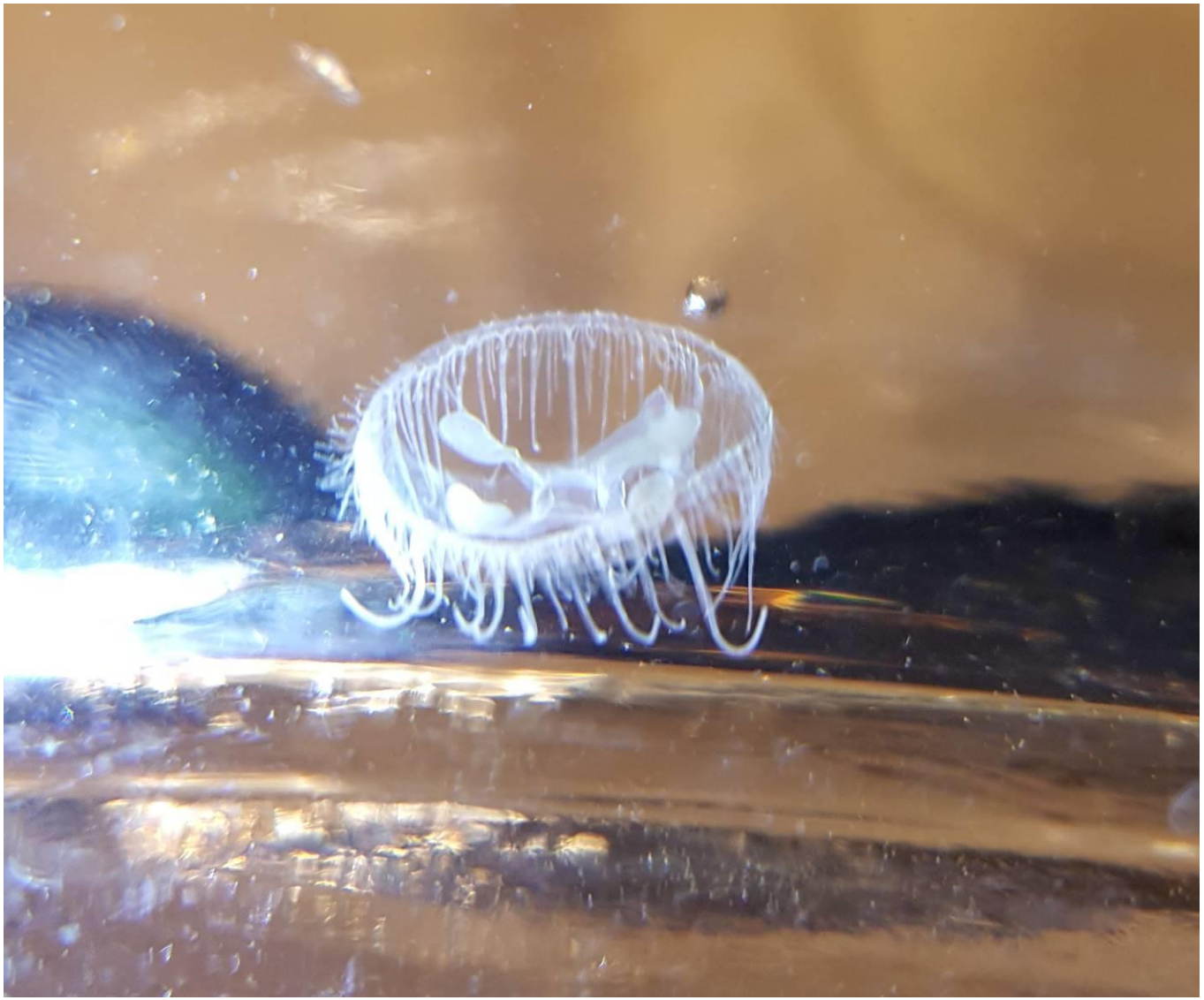
A measure of all forms of phosphorus (organic and inorganic) in the water. Phosphorus is one of the major nutrients needed for plant growth. Because its natural occurrence in lakes is very small, phosphorus "limits" the growth of algae in lake ecosystems. Small increases in phosphorus in lake water can cause substantial increases in algal growth.

Phosphorus is measured in parts per billion (ppb). Phosphorus concentrations may be based on samples taken from the surface of the lake or from discrete samples taken at specific depths, or from an integrated water column (epilimnetic core) sample (VLMP, 2008 Maine Lakes Report).

.

pH

A measure of the relative acid-base status of lake water, pH helps determine which plant and animal species can live in the lake, and it governs biochemical processes that take place. The pH scale ranges from 0-14, with 7 being neutral. Water is increasingly acidic below 7, and increasingly alkaline above 7. A one unit change in pH represents a tenfold change in acidity or alkalinity. The pH scale is the inverse log of the hydrogen ion concentration (VLMP, 2008 Maine Lakes Report).



A rare find! Fresh water jellyfish in Mill Privilege Pond, 2015.

Jack Downing taking an integrated Core sample on Side Pistol Lake, May 2016.

Alkalinity

A measure of the capacity of water to neutralize acids, or buffer against changes in pH, alkalinity is also referred to as "buffering capacity." It is a measure primarily of naturally available bicarbonate, carbonate, and hydroxide ions in the water. Alkalinity is measured in milligrams per liter (mg/l) (VLMP, 2008 Maine Lakes Report).

Specific Conductance

A measure of the ability of water to carry an electrical current, conductivity is directly related to the level of dissolved ions in the water. Conductivity levels will generally increase if there is an increase in the concentration of pollutants in the water. Conductivity is measured in micro-siemens per centimeter (µS/cm) or micro-mhos per centimeter (or µmhos/cm) (VLMP, 2008 Maine Lakes Report).

Our remote floating lake 'lab' hard at work. Testing around the West Branch of the St Croix every summer.

Color

The concentration of natural, dissolved, humic acids in lake water, organic "Humic" acids leach from vegetation in the lake watershed. Color is measured in Standard Platinum Units (SPU). Lakes with color levels greater than 25 SPU are considered to be colored. This can cause transparency to be reduced, and phosphorus levels to be elevated. The water in highly colored lakes often has the appearance of tea. When lakes are highly colored, the best indicator of algal growth is chlorophyll-a (VLMP, 2008 Maine Lakes Report).

Getting Martin Dana out of the office and into the boat for once.

Methods

Site Selection

Lakes on or near tribal lands to be included in the monitoring program were selected according to accessibility by road. Bathymetric maps were obtained from the Maine Department of Inland Fisheries and Wildlife for the following water bodies: **Junior Lake, Killman Pond, Middle Chain Lake, Pocumcus Lake, Scraggly Lake, Side Pistol Lake, Sysladobsis Lake, Upper Chain Lake**, **Pleasant Lake, West Musquash Lake, East Musquash Lake, and West Grand Lake.** These were all incorporated into the monitoring program along with the 4 lakes on Indian Township: **Big Lake, Long Lake, Lewey Lake, Grand Falls Flowage**. See Table 1 for summary of water bodies sampled each season.

Joe Musante and Ryan Gabriel taking samples on Lewey Lake, July 2019.

Table 1. Waterbodies included in ITTG Monitoring Program

Waterbodies Sampled in the ITTG Water Quality Program by Year													
93-'99	00-'02	2002	03-'04	2005	06-'07	2008	09-'10	11-'12	13-'16	2017	18-'19	2020	21-'22
Big	Big	Big	Big	Big (2)	No	Big	Big	Big	Big	Big	Big	*Big	Big
Long	Long	Long	Long	Long	sampling	Long	Long	Long	Long	Long	Long	*Long	Long
Lewey	Lewey	Lewey	Lewey	Lewey	done	Lewey	Lewey	Lewey	Lewey	Lewey	Lewey	*Lewey	Lewey
Grand Falls	Grand Falls	Grand Falls	Grand Falls	Grand Falls(2)	these	Grand Falls	Grand Falls	Grand Falls	Grand Falls	Grand Falls	Grand Falls	*Grand Falls	Grand Falls
			Tomah Str.	Tomah Str	two	Tomah Str	Tomah Str						
	*Side Pistol	Side Pistol	Side Pistol	Side Pistol	years.		Side Pistol	Side Pistol	Side Pistol	Side Pistol	Side Pistol	*Side Pistol	Side Pistol
	*Upper Chain	Upper Chain	Upper Chain	Upper Chain		*Upper Chain	Upper Chain	Upper Chain	Upper Chain	Upper Chain	Upper Chain	*Upper Chain	Upper Chain
		Duncan	Duncan	Duncan		*Duncan	Duncan	*Duncan	*Duncan				
		Junior	Junior	Junior			Junior	Junior	Junior	Junior	Junior	*Junior	Junior
		Killman	Killman	Killman		*Killman	Killman	Killman	Killman	Killman	Killman	*Killman	Killman
		Mill Privilege	Mill Privilege	Mill Privilege			Mill Privilege	Mill Privilege	Mill Privilege	*Mill Privilege			
		Pocumcus	Pocumcus	Pocumcus			Pocumcus	Pocumcus	Pocumcus	Pocumcus	Pocumcus	*Pocumcus	Pocumcus
		Scraggly	Scraggly	Scraggly			Scraggly	Scraggly	Scraggly	Scraggly	Scraggly	*Scraggly	Scraggly
		Shaw	Shaw	Shaw			Shaw	Shaw	Shaw	*Shaw			
		Sysladobsis	Sysladobsis	Sysladobsis			Sysladobsis	Sysladobsis	Sysladobsis	Sysladobsis	Sysladobsis		Sysladobsis
				Mary Petuche		*Mary Petuche	Mary Petuche	*Mary Petuche	*Mary Petuche				
						*Hall	Hall	*Hall	*Hall				
				East Grand			Middle Chain	Middle Chain	Middle Chain	Middle Chain	Middle Chain	*Middle Chain	Middle Chain
								West Grand	West Grand	West Grand	West Grand	*West Grand	West Grand
								Pleasant	Pleasant	Pleasant	Pleasant	*Pleasant	Pleasant
								E. Musquash	E. Musquash	E. Musquash	E. Musquash	*E. Musquash	E. Musquash
								W. Musquash	W. Musquash	W. Musquash	W. Musquash	*W. Musquash	W. Musquash
*Only sampled once or twice this year									Bassett				

Sample Collection and Field Measurements

Samples were collected and *in situ* measurements were taken according to procedures outlined in *Maine Department of Environmental Protection's 1993 Standard Field Methods for Lake Water Quality Monitoring by Judy Potvin and Linda Bacon.* These methods have been updated throughout the years, but that document was the start of our program!

Laboratory Analysis

Alkalinity samples are typically titrated within 48 hours of collection by staff in the office, some however are tested later, but well within the 14 day holding time. True color samples are processed by staff in the office within 48 hours of collection. Chl *a* samples are filtered within 24 hours using a hand held filter apparatus. The filter is then stored in the freezer waiting to be sent to the Health and Environmental Testing Lab (HETL) in Augusta to be processed. TP samples are immediately placed in the fridge. Within the appropriate time period (generally 1-2 weeks) Chl a and TP samples are mailed to HETL for analysis. The holding time for Chl-a and TP samples to be processed by the lab (assuming the Chl-a has been filtered and frozen) is 28 days.

Statistical Analysis

The formulas for calculating the Carlson Trophic State Index values for Secchi disk, chlorophyll *a*, and total phosphorus are presented below. Also presented is a table that lists the trophic state values and the corresponding measurements of the three parameters. Ranges of trophic state index values are often grouped into trophic state classifications. The range between 40 and 50 is usually associated with mesotrophy (moderate productivity). Index values greater than 50 are associated with eutrophy (high productivity). Values less than 40 are associated with oligotrophy (low productivity).

Maine DEP Lake Assessment Criteria for Calculating Valid TSIs

1. Samples are to be taken from open water.
2. Five months of data are necessary; one reading per month is acceptable, but 2 readings per month are preferred.
3. Sampling period is May through November.
4. It is not permissible to be missing any 2 consecutive months of data.
5. The mean used in the equations shall be calculated as the mean of the monthly means in order that all months be equally weighted in the calculation.
6. Integrated cores should be taken to a depth equal to that of the late summer epilimnion or to the 2.0 mg/l D.O. level, whichever is less.
7. Secchi Transparency readings must not have hit the lake bottom.

Formulas

All lakes: TSIc = 70 log (mean Chlorophyll a in ppb + 0.71)

Lakes having color less than or equal to 25 Standard Platinum Units:

TSIp = 70 log (0.33 mean total phosphorus in ppb + 0.7)

TSIsd = 70 log [(105 / mean Secchi transparency^2) + 0.7]

Note: Secchi transparency in meters

TSI Table

TSI	Chlorophyll a (ppb)	Secchi Transparency (m)	Total Phosphorus (ppb)
0	0.3	18.7	0.9
10	0.7	12.3	2.1
20	1.2	9.2	3.1
30	2.0	7.3	6.0
40	3.0	5.9	9.2
50	4.5	4.8	13.6
60	6.5	4.0	19.7
70	9.3	3.4	28.2
80	13.2	2.8	40
90	18.6	2.4	56.4
100	26.1	2.0	79.2

Note: Avoid making comparisons using raw data for the various parameters; the criteria assure that the TSIs are representative of the water quality for the open water season of May through November.

Results: Reservation Waters

Big Lake, Washington County, Maine

Table 2, Big Lake

2022 Big Lake			Site: BIG2				
Date	Chl-a(µg/L)	TP(µg/L)	Secchi(m)	Alka(mg/l CaCO3)	pH	Cond(UMHOS/CM)	Color (PCU)
05/16/22	1.0	6	5.35	7.5	6.83	23.6	32
06/14/22	2.0	11	5.15	8.0	6.93	24.0	32
07/18/22	2.0	10	5.30	8.0	7.13	24.6	23
08/15/22	2.0	10	5.00	8.0	7.13	25.0	21
09/19/22	2.0	9	5.05	8.0	7.12	24.6	19
Year Mean:	**1.8**	**9**	**5.17**	**7.9**	**7.03**	**24.4**	**25**
Maximum:	**2.0**	**11**	**5.35**	**8.0**	**7.13**	**25.0**	**32**
Minimum:	**1.0**	**6**	**5.00**	**7.5**	**6.83**	**23.6**	**19**
Stand Dev:	**0.45**	**1.92**	**0.15**	**0.22**	**0.14**	**0.55**	**6.19**
TSI:	**28**	**40**	**47**				
September TP tested 8 days past 28 day holding time.							
***CHLA Only valid TSI due to mean color >25**							

Table 2 shows Chl-*a*, TP, Secchi, Alkalinity, pH, Conductivity, and True Color mean, max, min, standard deviations, and TSI values for Big Lake for May – September 2022. Big Lake is about 10,300 acres, with a max depth of 70 feet (21m) and is part of the St. Croix River watershed. Our sample site is in a shallower basin of 30 feet (9m). Sampling has been done on this lake since 1993.

Long Lake, Washington County, Maine

Table 3, Long Lake

2022 Long Lake			Site: LNG2				
Date	Chl-a(µg/L)	TP(µg/L)	Secchi(m)	Alka(mg/l CaCO3)	pH	Cond(UMHOS/CM)	Color (PCU)
05/16/22	1.0	7	4.80	7.0	6.78	23.5	37
06/14/22	4.0	9	4.50	8.0	6.98	24.0	36
07/18/22	4.0	9	4.60	8.0	7.19	24.9	25
08/15/22	4.0	13	5.25	8.0	7.11	24.6	21
09/19/22	3.0	9	4.50	8.5	7.12	24.5	18
Year Mean:	**3.2**	**9**	**4.73**	**7.9**	**7.04**	**24.3**	**27**
Maximum:	**4.0**	**13**	**5.25**	**8.5**	**7.19**	**24.9**	**37**
Minimum:	**1.0**	**7**	**4.50**	**7.0**	**6.78**	**23.5**	**18**
Stand Dev:	**1.30**	**2.19**	**0.32**	**0.55**	**0.16**	**0.55**	**8.68**
TSI:	**41**	**41**	**51**				
September TP tested 8 days past 28 day holding time.							
***CHLA Only valid TSI due to mean color >25**							

Table 3 shows Chl-*a*, TP, Secchi, Alkalinity, pH, Conductivity, and True Color; mean, max, min, and standard deviations for Long Lake for May – September 2022. Long Lake is about 595 acres, and is part of the St. Croix River watershed. It has been sampled since 1993. It also should be noted in Long Lake that from June to late August the hypoliminion becomes anoxic. This results in an increase of anaerobic bacteria and production of hydrogen sulfide. Water collected from the hypolimnion typically has a rotten egg odor when anoxic. Numerous seasonal and year-round residences and camps occur on its western and southern shores.

Lewey Lake, Washington County, Maine

Table 4, Lewey Lake

2022 Lewey Lake			Site: LWY1				
Date	Chl-a(µg/L)	TP(µg/L)	Secchi(m)	Alka(mg/l CaCO3)	pH	Cond(UMHOS/CM)	Color (PCU)
05/16/22	1.0	7	4.60	7.5	6.84	23.8	37
06/14/22	3.0	12	4.15	8.0	6.82	24.6	39
07/18/22	4.0	11	4.45	8.0	7.07	24.6	26
08/15/22	3.0	12	5.20	8.0	7.13	24.7	24
09/19/22	2.0	9	4.55	7.5	7.08	24.5	17
Year Mean:	**2.6**	**10**	**4.59**	**7.8**	**6.99**	**24.4**	**29**
Maximum:	**4.0**	**12**	**5.20**	**8.0**	**7.13**	**24.7**	**39**
Minimum:	**1.0**	**7**	**4.15**	**7.5**	**6.82**	**23.8**	**17**
Stand Dev:	**1.14**	**2.17**	**0.38**	**0.27**	**0.15**	**0.36**	**9.24**
TSI:	**36**	**43**	**53**				
September TP tested 8 days past 28 day holding time.							
***CHLA Only valid TSI due to mean color >25**							

Table 4 shows Chl-*a*, TP, Secchi, Alkalinity, pH, Conductivity, and True Color; mean, max, min, and standard deviations values for Lewey Lake for May – September 2022. Lewey Lake is about 447 acres, and is part of the St. Croix River watershed. It has been sampled since 1993. It is very populated along its eastern and southern shores, Indian Township and Princeton respectively.

Grand Falls Flowage, Washington County, Maine

Table 5, Grand Falls Flowage

2022 Grand Falls Flowage			Site: GFF1				
Date	Chl-a(µg/L)	TP(µg/L)	Secchi(m)	Alka(mg/l CaCO3)	pH	Cond(UMHOS/CM)	Color (PCU)
05/16/22	2.0	8	4.20	7.0	6.77	24.3	43
06/14/22	5.0	12	3.60	8.5	6.90	25.2	39
07/18/22	4.0	13	3.85	8.0	7.01	25.2	40
08/15/22	4.0	14	4.25	8.0	7.09	26.0	31
09/19/22	3.0	9	4.85	8.0	7.05	24.8	23
Year Mean:	**3.6**	**11**	**4.15**	**7.9**	**6.96**	**25.1**	**35**
Maximum:	**5.0**	**14**	**4.85**	**8.5**	**7.09**	**26.0**	**43**
Minimum:	**2.0**	**8**	**3.60**	**7.0**	**6.77**	**24.3**	**23**
Stand Dev:	**1.14**	**2.59**	**0.47**	**0.55**	**0.13**	**0.62**	**8.14**
TSI:	**44**	**45**	**58**				
September TP tested 8 days past 28 day holding time.							
***CHLA Only valid TSI due to mean color >25**							

Table 5 shows Chl-*a*, TP, Secchi, Alkalinity, pH, Conductivity, and True Color; mean, max, min, and standard deviations values for Grand Falls Flowage for May – September 2022. Grand Falls Flowage expands to 6,691 acres of mostly shallow coves due to the impoundment of the dam. Not far below the dam does this watershed finally meet the St. Croix River. Maximum depth is listed at 29 feet (9 m), but our sampling site is located at 20 feet (6m). There are numerous seasonal and year-round residences along its shores, primarily to the south.

Results: Trust Lands

Junior Lake, Penobscot County, Maine

Table 6, Junior Lake

2022 Junior Lake			Site: JNR1				
Date	Chl-a(µg/L)	TP(µg/L)	Secchi(m)	Alka(mg/l CaCO3)	pH	Cond(UMHOS/CM)	Color (PCU)
05/20/22	2.0	5	7.65	7.0	6.92	24.2	19
06/15/22	2.0	5	7.75	8.0	7.02	23.6	16
08/01/22	1.0	7	8.65	8.0	6.85	23.9	17
Year Mean:	1.7	6	8.02	7.7	6.93	23.9	17
Maximum:	2.0	7	8.65	8.0	7.02	24.2	19
Minimum:	1.0	5	7.65	7.0	6.85	23.6	16
Stand Dev:	0.58	1.15	0.55	0.58	0.09	0.30	1.53
TSI:	No valid TSI values due to less than 5 months of data.						

Table 6 shows Chl-*a*, TP, Secchi, Alkalinity, pH, Conductivity, and True Color; mean, max, min, and standard deviations values for Junior Lake for May – July 2022. Junior Lake is a large lake in the St. Croix River watershed at approximately 3866 acres. Junior has seasonal camps primarily dotting the north and western shores, and its deepest spot is about 64 feet (19.5m). Up lake from Junior is Scraggly Lake, and down lake via Junior Stream is Junior Bay and West Grand Lake. Junior has been sampled most years since 2002.

Killman Pond, Hancock County, Maine

Table 7, Killman Pond

2022 Killman Pond			Site: KLL1				
Date	Chl-a(µg/L)	TP(µg/L)	Secchi(m)	Alka(mg/l CaCO3)	pH	Cond(UMHOS/CM)	Color (PCU)
05/31/22	2.0	10	4.40	7.0	6.83	22.2	24
06/23/22	2.0	8	3.70	6.5	6.97	21.8	20
07/20/22	2.0	8	4.25	7.0	7.05	23.3	18
08/16/22	2.0	9	4.05	7.0	7.02	23.8	17
09/21/22	3.0	9	3.20	7.0	6.84	24.1	15
Year Mean:	**2.2**	**9**	**3.92**	**6.9**	**6.94**	**23.0**	**19**
Maximum:	**3.0**	**10**	**4.40**	**7.0**	**7.05**	**24.1**	**24**
Minimum:	**2.0**	**8**	**3.20**	**6.5**	**6.83**	**21.8**	**15**
Stand Dev:	**0.45**	**0.84**	**0.48**	**0.22**	**0.10**	**1.00**	**3.42**
TSI:	**32**	**39**	**61**				
September TP tested 8 days past 28 day holding time.							

Table 7 shows Chl-*a*, TP, Secchi, Alkalinity, pH, Conductivity, and True Color; mean, max, min, and standard deviations values for Killman Pond for May – September 2022. Killman Pond is a small pond of about 17 acres flowing into Upper Chain Lake via a small stream. It is part of the St. Croix River watershed. There are no camps or structures along its shores, but it does have a maintained dirt road within 100 feet along its north shore, which undoubtedly adds runoff and sediments. The boat launch is only accessible to canoes and the like. This pond is strongly stratified most of the field season, and is about 23 feet (7m) at its deepest. This pond has been sampled most years since 2002.

Middle Chain Lake, Hancock County, Maine

Table 8, Middle Chain Lake

2022 Middle Chain Lake			Site: MCL1				
Date	Chl-a(µg/L)	TP(µg/L)	Secchi(m)	Alka(mg/l CaCO3)	pH	Cond(UMHOS/CM)	Color (PCU)
05/26/22	2.0	11	3.85	5.0	6.68	20.7	66
06/23/22	4.0	8	3.95	6.5	6.87	20.8	56
07/20/22	3.0	7	5.05	6.0	6.92	21.8	48
Year Mean:	**3.0**	**9**	**4.28**	**5.8**	**6.82**	**21.1**	**57**
Maximum:	**4.0**	**11**	**5.05**	**6.5**	**6.92**	**21.8**	**66**
Minimum:	**2.0**	**7**	**3.85**	**5.0**	**6.68**	**20.7**	**48**
Stand Dev:	**1.00**	**2.08**	**0.67**	**0.76**	**0.13**	**0.61**	**9.02**
TSI:	**No valid TSI values due to less than 5 months of data.**						

Table 8 shows Chl-*a*, TP, Secchi, Alkalinity, pH, Conductivity, and True Color; mean, max, min, and standard deviations values for Middle Chain Lake for May – July 2022. Middle Chain Lake is about 220 acres, and flows downstream into Lower Chain Lake, and eventually into the large lake of Sysladobsis. These are all part of the St. Croix River watershed. Middle Chain had one camp along its shores that burned down recently, and also did have a small wood mill on the northern shore in the past, with remnant saw dust piles. Maximum depth found was 20 feet (6m). The lake strongly stratifies in the summer, and also is very colored. A new boat launch was constructed recently, allowing easy boat access. Middle Chain has been sampled regularly since 2009.

Pocumcus Lake, Washington County, Maine

Table 9, Pocumcus Lake

2022 Pocumcus Lake			Site: POC1				
Date	Chl-a(µg/L)	TP(µg/L)	Secchi(m)	Alka(mg/l CaCO3)	pH	Cond(UMHOS/CM)	Color (PCU)
05/24/22	2.0	6	9.10	7.0	7.01	22.6	15
06/24/22	2.0	5	7.80	7.5	7.20	22.2	17
07/27/22	2.0	3	8.90	8.5	7.05	23.0	16
Year Mean:	**2.0**	**5**	**8.60**	**7.7**	**7.09**	**22.6**	**16**
Maximum:	**2.0**	**6**	**9.10**	**8.5**	**7.20**	**23.0**	**17**
Minimum:	**2.0**	**3**	**7.80**	**7.0**	**7.01**	**22.2**	**15**
Stand Dev:	**0.00**	**1.53**	**0.70**	**0.76**	**0.10**	**0.40**	**1.00**
TSI:	**No valid TSI values due to less than 5 months of data.**						

Table 9 shows Chl-*a*, TP, Secchi, Alkalinity, pH, Conductivity, and True Color; mean, max, min, and standard deviations values for Pocumcus Lake for May – July 2022. Pocumcus Lake is a large lake of 2200 acres in the St. Croix River watershed. Upstream is Sysladobsis Lake, and downstream is West Grand Lake. Numerous camps, including a campground, dot its shores, particularly the southern shore. The campground has a good boat launch where you can launch any reasonably sized motor boat, the launch is shallow however. Maximum depth of this lake is 44 feet (13.5m) and it does not strongly stratify every year. The lake is cool and clear. Pocumcus Lake has been sampled now since 2002.

Scraggly Lake, Penobscot County, Maine

Table 10, Scraggly Lake

2022 Scraggly Lake			Site: SCR1				
Date	Chl-a(µg/L)	TP(µg/L)	Secchi(m)	Alka(mg/l CaCO3)	pH	Cond(UMHOS/CM)	Color (PCU)
05/20/22	2.0	8	6.05	7.0	6.85	21.3	23
06/15/22	3.0	10	5.50	7.5	6.98	21.8	20
07/22/22	3.0	7	6.15	8.0	7.11	22.2	17
Year Mean:	**2.7**	**8**	**5.90**	**7.5**	**6.98**	**21.8**	**20**
Maximum:	**3.0**	**10**	**6.15**	**8.0**	**7.11**	**22.2**	**23**
Minimum:	**2.0**	**7**	**5.50**	**7.0**	**6.85**	**21.3**	**17**
Stand Dev:	**0.58**	**1.53**	**0.35**	**0.50**	**0.13**	**0.45**	**3.00**
TSI:	**No valid TSI values due to less than 5 months of data.**						

Table 10 shows Chl-*a*, TP, Secchi, Alkalinity, pH, Conductivity, and True Color; mean, max, min, and standard deviations values for Scraggly Lake for May – July 2022. Scraggly Lake is the furthest lake upstream to be affected by the impoundment by the dam at Sysladobsis Lake, all part of the St. Croix River watershed. Measuring up at 2758 acres, this lake is sizeable, with a channel running through the center of it at about 42 feet (13m) at its deepest. Shallow coves line the north, south, and eastern shores. There are a few seasonal camps along its shores, and has a small boat launch at Hasty Cove where small trailered boats can be launched. This lake stratifies each summer as well. We have sampled this lake since 2002.

Side Pistol Lake, Hancock County, Maine

Table 11, Side Pistol Lake

2022 Side Pistol Lake			Site: SPL1				
Date	Chl-a(µg/L)	TP(µg/L)	Secchi(m)	Alka(mg/l CaCO3)	pH	Cond(UMHOS/CM)	Color (PCU)
05/31/22	2.0	8	6.90	7.0	6.93	21.1	7
06/23/22	4.0	9	4.45	6.0	7.03	20.8	7
07/20/22	2.0	9	6.10	7.0	7.17	21.9	6
08/16/22	2.0	11	5.25	7.0	7.08	22.3	6
09/21/22	4.0	9	3.80	7.0	6.98	21.7	5
Year Mean:	**2.8**	**9**	**5.30**	**6.8**	**7.04**	**21.6**	**6**
Maximum:	**4.0**	**11**	**6.90**	**7.0**	**7.17**	**22.3**	**7**
Minimum:	**2.0**	**8**	**3.80**	**6.0**	**6.93**	**20.8**	**5**
Stand Dev:	**1.10**	**1.10**	**1.24**	**0.45**	**0.09**	**0.61**	**0.84**
TSI:	**38**	**40**	**45**				
July CHLA and TP tested past 28 day holding time.							

Table 11 shows Chl-*a*, TP, Secchi, Alkalinity, pH, Conductivity, and True Color; mean, max, min, and standard deviations values for Side Pistol Lake for May – September 2022. Side Pistol Lake is a small lake of 147 acres in a series of small lakes known as the Pistol's. Maximum depth of the lake is 26 feet (8m). There are only a few seasonal camps on this lake, as well as a small boat launch able to handle small trailered boats. This lake is mostly sand bottomed near the launch (NE corner), and is very clear, almost blue-green colored. This lake chain is the only lake sampled in the Springfield or Township area that isn't part of the St. Croix River watershed; it flows into the Passadumkeag River, and finally the Penobscot River. Side Pistol Lake has been sampled somewhat since 2000.

Sysladobsis Lake, Hancock County, Maine

Table 12, Sysladobsis Lake

2022 Sysladobsis Lake			Site: SYS1				
Date	Chl-a(µg/L)	TP(µg/L)	Secchi(m)	Alka(mg/l CaCO3)	pH	Cond(UMHOS/CM)	Color (PCU)
05/24/22	2.0	5	7.10	7.0	6.93	23.4	20
06/24/22	1.0	8	7.70	8.0	7.11	23.0	21
07/27/22	1.0	5	8.90	7.5	7.04	23.7	22
Year Mean:	**1.3**	**6**	**7.90**	**7.5**	**7.03**	**23.4**	**21**
Maximum:	**2.0**	**8**	**8.90**	**8.0**	**7.11**	**23.7**	**22**
Minimum:	**1.0**	**5**	**7.10**	**7.0**	**6.93**	**23.0**	**20**
Stand Dev:	**0.58**	**1.73**	**0.92**	**0.50**	**0.09**	**0.35**	**1.00**
TSI:	**No valid TSI values due to less than 5 months of data.**						

Table 12 shows Chl-*a*, TP, Secchi, Alkalinity, pH, Conductivity, and True Color; mean, max, min, and standard deviations values for Sysladobsis Lake for May – July 2022. Sysladobsis Lake is a large lake of 5376 acres in the St. Croix River watershed. Maximum lake depth found was 65 feet (20m). Numerous camps dot the shoreline and islands of this large lake. There is a small boat launch at the southern end, as well as a state run public launch on the northern end of the lake. This lake can get rough easily with just a little wind. Early morning sampling on the calmest of days is recommended. Sampling has occurred here since 2002.

Upper Chain Lake, Hancock County, Maine

Table 13, Upper Chain Lake

2022 Upper Chain Lake			Site: UCL1				
Date	Chl-a(µg/L)	TP(µg/L)	Secchi(m)	Alka(mg/l CaCO3)	pH	Cond(UMHOS/CM)	Color (PCU)
05/26/22	3.0	9	3.90	5.0	6.56	19.9	72
06/23/22	3.0	11	4.10	5.5	6.65	19.8	65
07/20/22	3.0	9	4.55	6.0	6.79	20.5	57
Year Mean:	**3.0**	**10**	**4.18**	**5.5**	**6.67**	**20.1**	**65**
Maximum:	**3.0**	**11**	**4.55**	**6.0**	**6.79**	**20.5**	**72**
Minimum:	**3.0**	**9**	**3.90**	**5.0**	**6.56**	**19.8**	**57**
Stand Dev:	**0.00**	**1.15**	**0.33**	**0.50**	**0.12**	**0.38**	**7.51**
TSI:	**No valid TSI values due to less than 5 months of data.**						

Table 13 shows Chl-*a*, TP, Secchi, Alkalinity, pH, Conductivity, and True Color; mean, max, min, and standard deviations values for Upper Chain Lake for May – July 2022. Upper Chain Lake is about 717 acres with a maximum depth of 30 feet (9m). This lake eventually flows into Sysladobsis Lake, and thus is part of the St. Croix River watershed. There are only a few camps along the north, east, and southern shores. There is a public boat launch able to take small boat trailers at the northern end of the lake. Also here is a group of tribally run tenting campsites and a year-round residence. The lake strongly stratifies in the summer, and also is very colored. Sampling here has occurred since 2000 in some form.

West Grand Lake, Washington County, Maine

Table 14, West Grand Lake

2022 West Grand Lake			Site: WGL1				
Date	Chl-a(µg/L)	TP(µg/L)	Secchi(m)	Alka(mg/l CaCO3)	pH	Cond(UMHOS/CM)	Color (PCU)
05/24/22	2.0	4	10.30	7.5	7.03	22.2	8
06/24/22	1.0	5	9.60	7.0	7.17	21.3	8
07/27/22	1.0	2	11.00	7.5	7.14	22.0	10
Year Mean:	**1.3**	**4**	**10.30**	**7.3**	**7.11**	**21.8**	**9**
Maximum:	**2.0**	**5**	**11.00**	**7.5**	**7.17**	**22.2**	**10**
Minimum:	**1.0**	**2**	**9.60**	**7.0**	**7.03**	**21.3**	**8**
Stand Dev:	**0.58**	**1.53**	**0.70**	**0.29**	**0.07**	**0.47**	**1.15**
TSI:	**No valid TSI values due to less than 5 months of data.**						

Table 14 shows Chl-*a*, TP, Secchi, Alkalinity, pH, Conductivity, and True Color; mean, max, min, and standard deviations values for West Grand Lake for May – July 2022. West Grand Lake is a large lake, at about 14,340 acres with numerous islands. Most of the shoreline is forested with few camps, the only built up area is along the dam in the Southeastern corner. Our sampling location of about 110ft near a supposed 127ft hole that could not be located. West Grand is part of the West Branch of the St. Croix Watershed and is considered one of the more premier fishing and recreation lakes in the area.

Pleasant Lake, T6R1 Washington County, Maine

Table 15, Pleasant Lake

2022 Pleasant Lake			Site: PLS1				
Date	Chl-a(µg/L)	TP(µg/L)	Secchi(m)	Alka(mg/l CaCO3)	pH	Cond(UMHOS/CM)	Color (PCU)
05/20/22	2.0	5	7.10	7.0	6.93	22.5	17
06/15/22	2.0	5	8.00	7.5	7.01	21.5	15
07/22/22	3.0	5	8.30	8.0	7.07	22.2	14
Year Mean:	**2.3**	**5**	**7.80**	**7.5**	**7.00**	**22.1**	**15**
Maximum:	**3.0**	**5**	**8.30**	**8.0**	**7.07**	**22.5**	**17**
Minimum:	**2.0**	**5**	**7.10**	**7.0**	**6.93**	**21.5**	**14**
Stand Dev:	**0.58**	**0.00**	**0.62**	**0.50**	**0.07**	**0.51**	**1.53**
TSI:	**No valid TSI values due to less than 5 months of data.**						

Table 15 shows Chl-*a*, TP, Secchi, Alkalinity, pH, Conductivity, and True Color; mean, max, min, and standard deviations values for Pleasant Lake for May – July 2022. Pleasant Lake is a moderately sized lake at 1,574 acres, with a max depth of 92ft. Two campgrounds are located on this lake, a public one with boat launch on the Southern shore, as well as a private business with a few rentable cabins and sites on the North shore. There are few, if any, other camps along its shores. Pleasant Lake outlet flows out of the Southwest part of the lake into Scraggly Lake, making it part of the St. Croix Watershed.

East Musquash Lake, Washington County, Maine

Table 16, East Musquash Lake

2022 East Musquash Lake			Site: EMQ1				
Date	Chl-a(µg/L)	TP(µg/L)	Secchi(m)	Alka(mg/l CaCO3)	pH	Cond(UMHOS/CM)	Color (PCU)
05/19/22	1.0	6	5.40	5.0	6.74	21.9	31
06/16/22	3.0	5	5.35	5.5	6.85	22.1	27
07/21/22	3.0	5	6.25	6.0	6.99	22.7	24
Year Mean:	**2.3**	**5**	**5.67**	**5.5**	**6.86**	**22.2**	**27**
Maximum:	**3.0**	**6**	**6.25**	**6.0**	**6.99**	**22.7**	**31**
Minimum:	**1.0**	**5**	**5.35**	**5.0**	**6.74**	**21.9**	**24**
Stand Dev:	**1.15**	**0.58**	**0.51**	**0.50**	**0.13**	**0.42**	**3.51**
TSI:	**No valid TSI values due to less than 5 months of data.**						

Table 16 shows Chl-*a*, TP, Secchi, Alkalinity, pH, Conductivity, and True Color; mean, max, min, and standard deviations values for East Musquash Lake for May – July 2022. East Musquash, located right alongside of Rt 6, in Topsfield, is about 806 acres. Rt. 6 runs along most of the Southern shore of the lake with numerous camps and year round residences. There is also a public boat launch and rest area (with a restroom) here. The outlet is located on the southeastern corner of the lake and eventually flows into Big Lake, including it in the St. Croix Watershed.

West Musquash Lake, Washington County, Maine

Table 17, West Musquash Lake

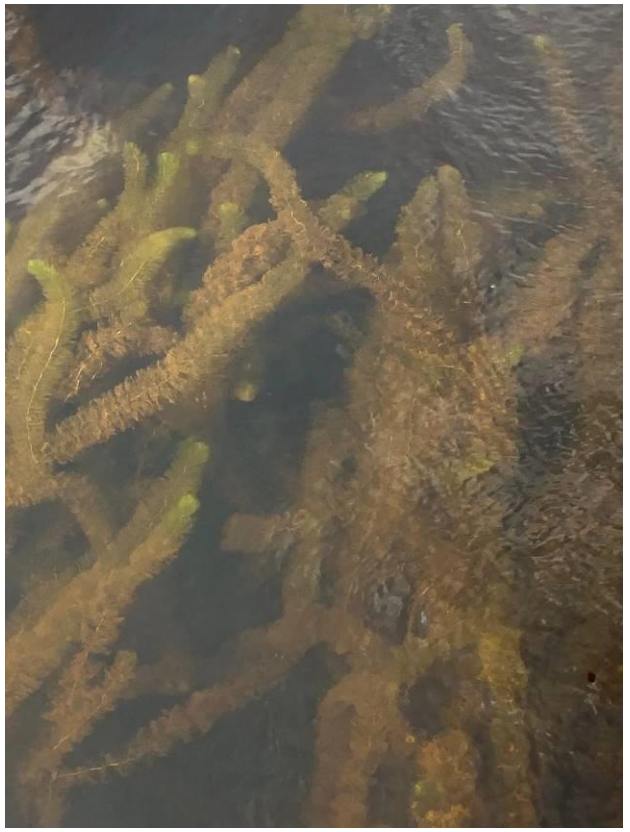
2022 West Musquash Lake			Site: WMQ1				
Date	Chl-a(µg/L)	TP(µg/L)	Secchi(m)	Alka(mg/l CaCO3)	pH	Cond(UMHOS/CM)	Color (PCU)
05/19/22	2.0	8	8.60	5.5	6.89	18.5	11
06/16/22	2.0	4	8.40	5.5	6.99	18.2	9
07/21/22	2.0	4	9.35	7.0	7.06	18.6	11
Year Mean:	**2.0**	**5**	**8.78**	**6.0**	**6.98**	**18.4**	**10**
Maximum:	**2.0**	**8**	**9.35**	**7.0**	**7.06**	**18.6**	**11**
Minimum:	**2.0**	**4**	**8.40**	**5.5**	**6.89**	**18.2**	**9**
Stand Dev:	**0.00**	**2.31**	**0.50**	**0.87**	**0.09**	**0.21**	**1.15**
TSI:	**No valid TSI values due to less than 5 months of data.**						

Table 17 shows Chl-*a*, TP, Secchi, Alkalinity, pH, Conductivity, and True Color; mean, max, min, and standard deviations values for West Musquash Lake for May – July 2022. This lake can be accessed off of the Pleasant Lake Road, south of Rt. 6. The shores of this lake are primarily undeveloped, except for a few camps on the Eastern shores. Numerous public boat access only campsites are available on the west end of the lake with great sand beaches. This lake has beautiful clear and cold water. The outlet is located on the eastern end of the lake and eventually flows into Big Lake, including it in the St. Croix Watershed.

Invasive Aquatic Species Program

Since its discovery in Clifford Bay, Big Lake in the fall of 2019, variable watermilfoil (VWM), *Myriophyllum heterophyllum*, has been a large piece of Environmental Department's focus. Being a new threat to the water resources of the Passamaquoddy Tribe, it's been a process to mold and adapt our current programs to face this new challenge, all while incorporating the limitations brought on by the Covid pandemic in 2020. Now that many of the covid limitations have lessened, we're able to focus more fully on building our invasive aquatic species program to **Locate**, **Remove**, and **Restore** resources affected by invasive aquatic species.

This threat of VWM to the Tribe's surface water resources cannot be understated. The window to try to get this infestation under control is short. The littoral habitat for VWM here is extensive since this is a dammed river system. Much of the flooded land is very shallow, soft bottomed and sheltered. These conditions describe entire coves of hundreds of acres. If VWM was thoroughly established in these areas, they would no longer be accessible to many Tribal and Non-Tribal traditions and uses.



To accomplish this long-term goal, the Tribe has been very fortunate to have numerous allies to assist in funding, setting up the program, and doing this important work. Environmental Protection Agency (EPA) 319 and 106 funding, as well as additional monies from the Bureau of Indian Affairs (BIA) have provided staff, development and equipment needed to start getting the work done. The Maine Department of Environmental Protection (MDEP) has also been heavily involved in the response to the VWM discovery, providing training and removal work to the Tribe and other local stakeholders through their invasive aquatic species program. Lake Stewards of Maine (LSM), a nonprofit organization, having worked with our water resources program for many years, has been an immense help in setting up the response with our program and the local communities. All these partners have worked together in assembling a defense against invasive aquatic species (IAS) threatening our local water resources.

Locate: Part A

Locating any aquatic invasive plant is a time-consuming endeavor. The more eyes on the lookout the more efficient the work. For these reasons we've divided this goal into two parts: *Education* and *Surveys*. These two parts are discussed below along with what we've done over the last year to address them.

Education is the building block of developing any program. We've broken down our education component into three different categories: build staff capacity, build local capacity, and build partnerships.

Staff Capacity

Building staff capacity is comprised of both funding to support staff time, as well as training opportunities to build skills. Without these dedicated funding agencies none of this work would be possible.

- Full time staff consists of a water resources biologist (WRB) and a field assistant. The staff split their time between water quality sampling and IAS.

- The water resources biologist completed the PADI introduction to open water scuba diving certification in spring 2022. This certification, coupled with a set of scuba dive gear, gives the department the ability to do deeper water surveys and removal activities.

- MDEP trained WRB in underwater removal techniques. MDEP also trained department and summer youth staff in shallow water removal and benthic barrier deployments that same day in July.

- Augmenting their work in 2022 was the tribal Summer Youth Program which trained and employed 8 young tribal members (16-25 years of age) and 2 supervisors in identifying and surveying for VWM. These extra survey crews really added in a large amount of manpower during the height of the summer season.

Local Capacity

Building up local capacity is an important piece to the long-term success of any invasive species project. Without the assistance and buy-in of local residents it would be just too difficult to monitor such a large area for species of concern. The more concerned and educated residents we have keeping an eye out the better.

The most formal tool we have in place for building local capacity is to host a regular ‘on the water’ training. This training is used to introduce people to the program (and points of contact), what VWM looks like, and get them familiar with native plant species verses invasive aquatic plants. Taking them out on the water and showing them just what VWM looks like growing in the lake gives a good mental picture to recognize it later on. While we would love to have residents volunteering to do formal IAS surveys around the lakes, we recognize for most this is a big ask. Just having them recognize something as suspicious, (or likely VWM) while out on the lake is still very valuable. Many of our VWM populations found in GFF this year were reported by bass fisherman in the Spring.

- There were approximately 25 people who attended the Plant Paddle this year at Peter Dana Point. This was a mix of ENV staff, wildlife staff, tribal members, local non-tribal residents, and staff from the St Croix Watershed Commission from New Brunswick.

Impromptu discussions when the opportunity presented itself are also an important piece of building local capacity. VWM samples were kept on hand in the office to show to any and all that came in for whatever reason. I'm sure we annoyed many people visiting the office with our milfoil education attempts. Having live samples on hand to show people was especially helpful since many that were on the water could connect them to floating fragments they would see on the lake. The next step hopefully will be to go out in boats with them, individually or through future Plant Paddles to show them what they look like growing out of the sediment in the lake bottom. We feel like we've made a lot of progress as a staff and community in education and outreach.

- 10+ Office interactions with the community and another 5-10 interactions with landowners/boaters while on the water working.

A zoomed in section of the flower stalk of VWM. A fully definitive ID of VWM is impossible without seeing this, and most colonies that are young won't develop them. To get around this problem many samples get genetically tested by MDEP for new infestations.

We are involved with our partners in the Big Lake Milfoil Coalition in getting educational information out into local businesses to increase exposure. ENV staff have also been involved in virtual presentations and meetings with other regional stakeholders to increase awareness and build on relationships for the future.

- 1-2 Big Lake zoom calls with stakeholders and volunteers per month, per year.

Partnerships

Lakes and ponds are not a water resource for a singular entity, nor are they singular units on the landscape. Lakes, ponds, and streams are parts of huge, sprawling watersheds moving across the landscape to the ocean. Just as you need to manage these water resources as part of a larger watershed, the same holds true for communities intwined with that watershed. The Passamaquoddy Tribe is but one stakeholder in the west branch of the St Croix River watershed. For this reason, the Tribe has joined the Big Lake Milfoil Coalition, a

group of state and regional stakeholders working together to fight the VWM infestation of the Big Lake area. This coalition asks members to bring whatever resources they can contribute to the VWM battle.

To facilitate, organize, and invest stakeholders, LSM started regular Zoom calls to bring all those interested to the table. These meetings range from monthly to weekly, depending on the season. Attending and participating in these regular meetings has become an important part of developing the Tribe's IAS Program, as well as reinforcing partnerships with stakeholders, volunteers, and community members.

***Above*: MDEP IAS Program crew on Big Lake for some removal work with tribal staff.**

***Below*: Ross, a volunteer from LSM shows staff how to make viewing scopes out of pistol cases. Ross donated countless hours of his mapping and engineering expertise, while his wife Bunny did the same on the water.**

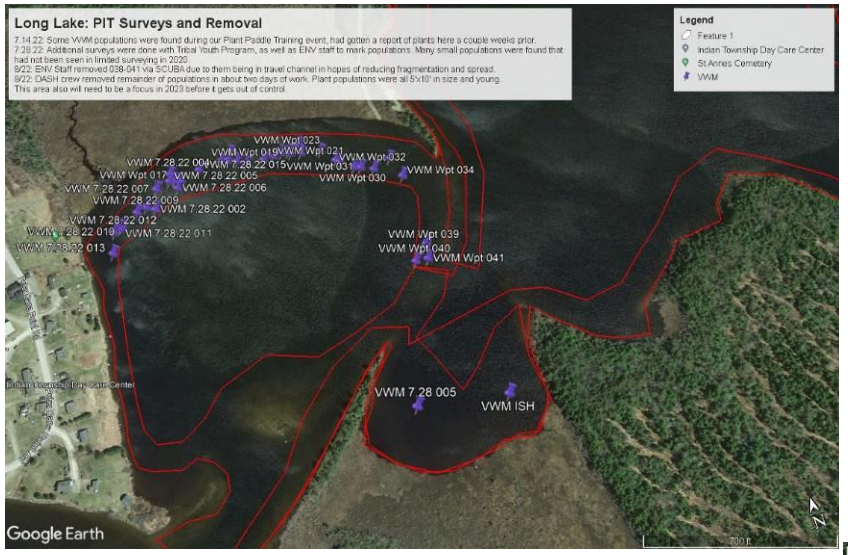
Locate: Part B

The second half of Locate is getting out on the water to conduct some form of a survey. These surveys are not all conducted the same way, but they are all after the same result: *is there an invasive aquatic plant here or not*? In our Quality Assurance Project Plan (QAPP) we've put specific guidelines on how surveys are conducted by department staff. These survey plans have specific goals in mind, based on limitations due to survey conditions, training, or equipment. While it would be beneficial for volunteers and community members to also follow these QAPP guidelines, we recognize there is still significant value to their eyes on the water looking for plants. Simply spotting something suspicious, grabbing a sample or taking down a location is an important piece of developing local capacity to fight invasive aquatic species.

Pre-removal Surveys

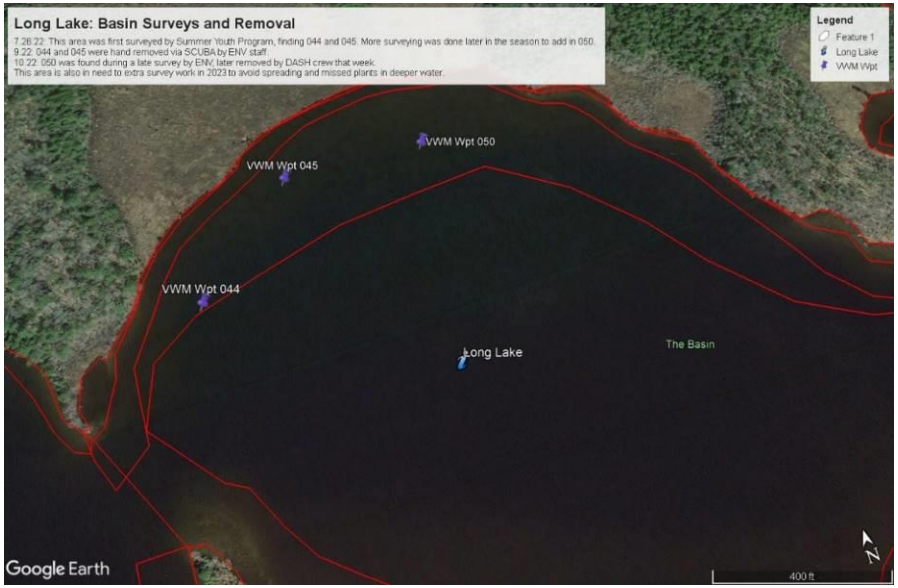
Most of the time and effort spent during the field season revolves around pre-removal surveys. Simply put, a pre-removal survey is time spent on, or in, the water looking for IAS. The major focus at this time is on VWM as we try to get initial surveys done of tribal reservation waters: Big, Long, Lewey, and Grand Falls Flowage (GFF).

A full level 3 survey of Long and Lewey Lakes was completed during the May - September 2022 field season. All areas of the shoreline and as much of the littoral zone that could be observed from a boat was surveyed by a combination of environmental department staff, summer youth program employees, volunteers from LSM's Invasive Plant Patrol Team, DLLT staff, and local volunteers. The littoral zone simply put are the areas on the bottom of the lake that are shallow enough to allow plant growth. By no means was every square foot of water viewed with 100% accuracy, but a very thorough initial survey was completed. Areas where the littoral zone extends to depths beyond what can be seen from the surface in good weather will need more work in the future. During sunny and calm weather we could usually see down to 5 or 6 feet of depth. We have observed VWM growing as deep as 10 feet. Techniques such as snorkeling, scuba, and sonar can be used to inspect these areas for IAS.

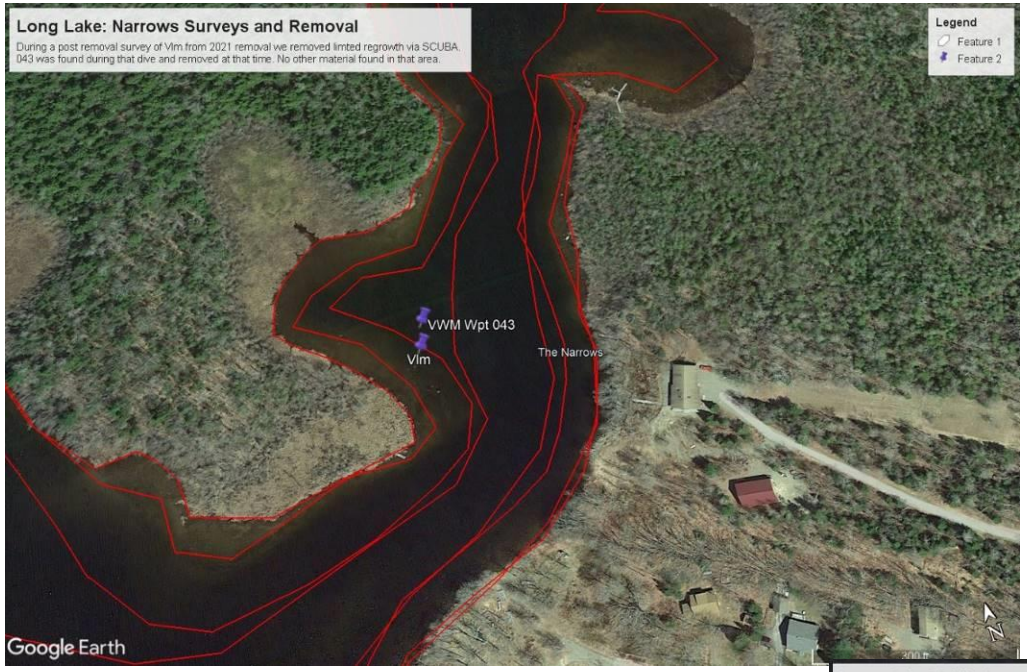


A large group of new populations were found at the start of Long Lake next to Peter Dana Point in 2022. Bass fishermen reported seeing patches in the Spring, which were later confirmed during our Plant Paddle in July. This area was lightly surveyed in 2020 and none of the populations to the north were found at that time.

There were four areas found in Long and Lewey that had established VWM growing. Long Lake had the largest group of populations right at the start of the lake coming from Big Lake (below Peter Dana Point), and another 2 groups of populations at the downstream end of the lake. Lewey Lake had a known population removed in 2021, with an adjacent one found during a post-removal survey. Another small population was found near the outlet of Lewey off a boat rental dock.

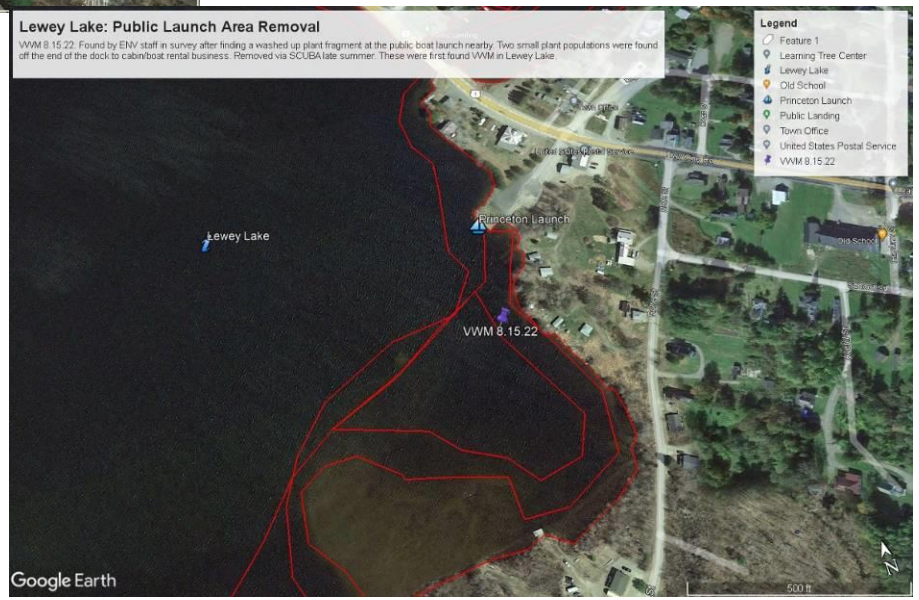


A trio of new small populations found in 2022 in the Basin of Long Lake. These were also removed by staff by hand pulling with scuba gear.

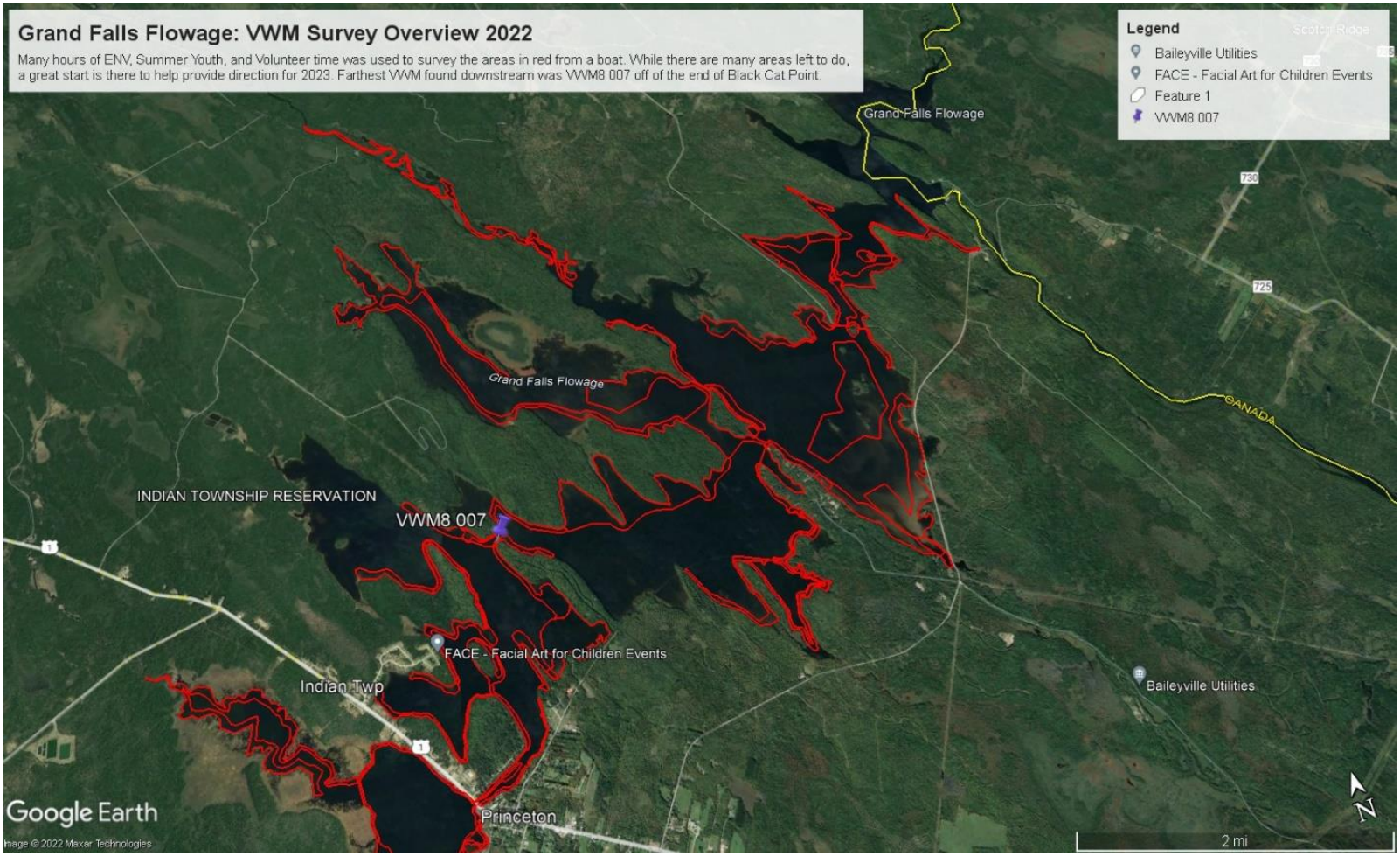


***Left*: One of these small patches was removed in 2021 by MDEP, the other was found during a post removal survey in 2022. The new patch, and 2021 regrowth was hand removed with scuba gear by staff.**

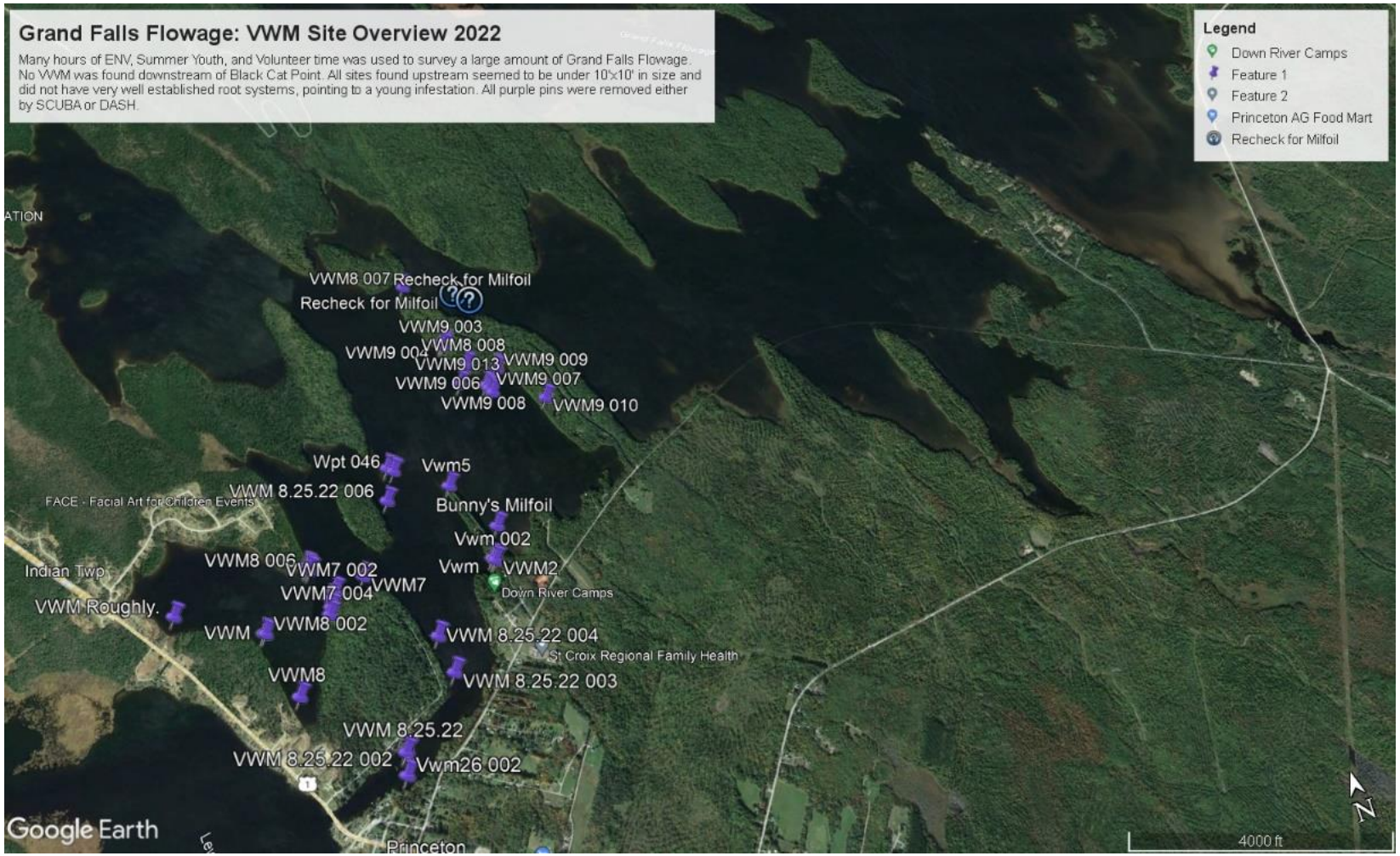
***Right*: For the first time we saw plant fragments washed up on the public boat launch. After some investigations we found a small patch off the end of a boat rental dock. Vacation rentals and guiding services are an important piece of the local economy. It was removed by staff via scuba.**



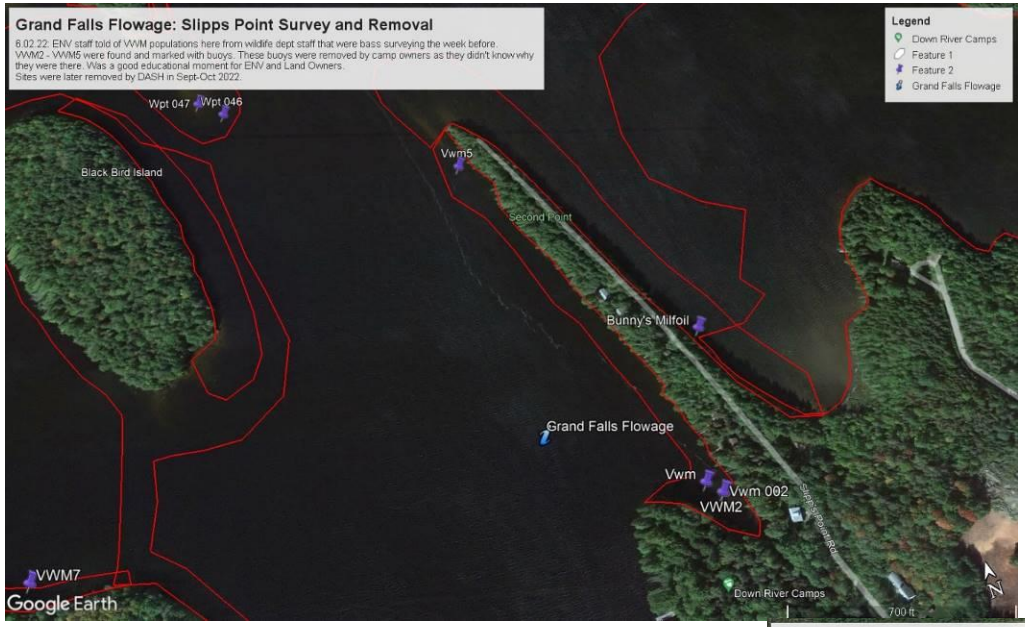
Quite a bit of surveying was also able to be done downstream into Grand Falls Flowage (GFF). Early season fisherman reports of VWM populations in GFF prompted immediate action and were confirmed as VWM. Pre-removal survey efforts were bolstered heavily with the addition of both LSM and local volunteers, as well as the Tribal Summer Youth Program.



A great start on the survey work planned for 2023. It's good we had the extra help as a very large percentage of GFF is littoral zone and very aquatic plant friendly. This is a dammed section of river and streams, these shallow, calm coves are perfect habitat for VWM.

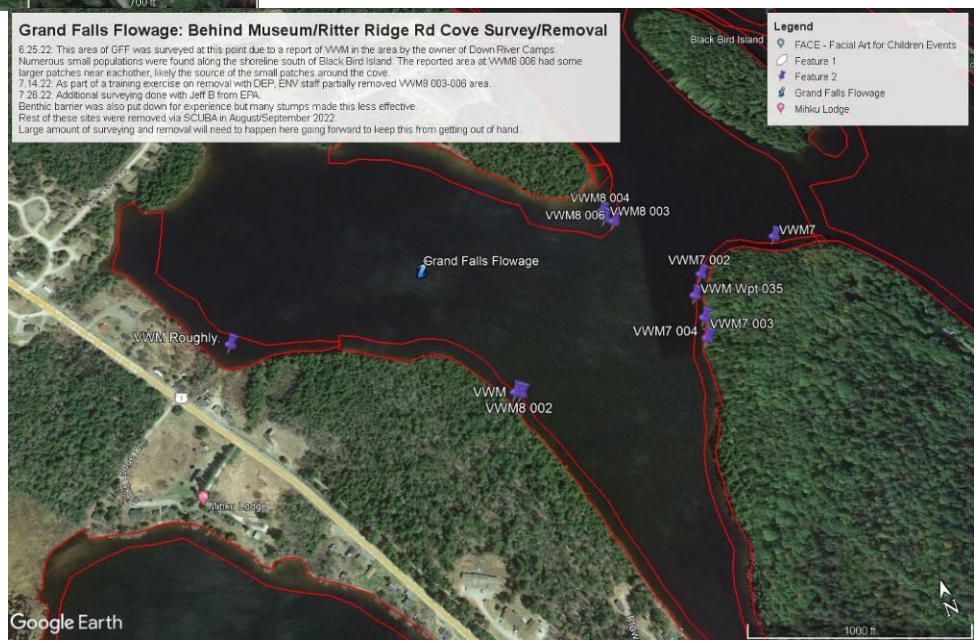


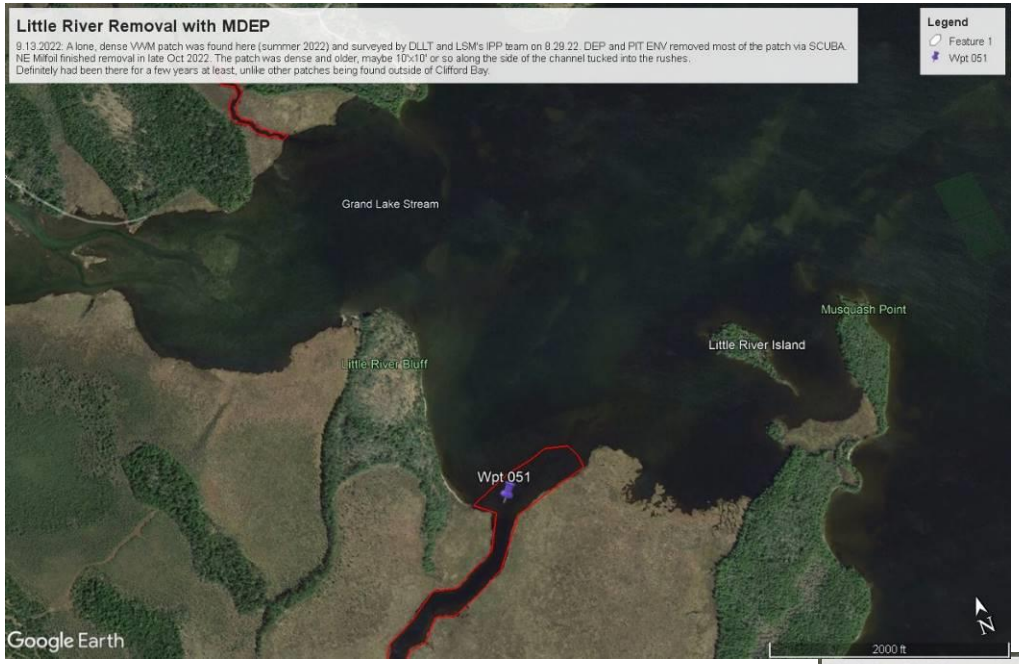
You can see how far downstream VWM has gotten established in GFF according to our survey results here so far. These were all removed in 2022 by staff and NEMilfoil. Much more work is planned for this area in 2023. All of these sites will need to be surveyed post removal, and the deeper areas surveyed via scuba.



***Above*: These VWM sites to the bottom right were the first reported sightings in GFF by our fisheries biologist doing Spring bass surveys. Removed by NEMilfoil.**

***Below*: A number of small VWM populations likely spawned from a larger, denser cluster at VWM8 004. These have all been removed by staff and NEMilfoil.**

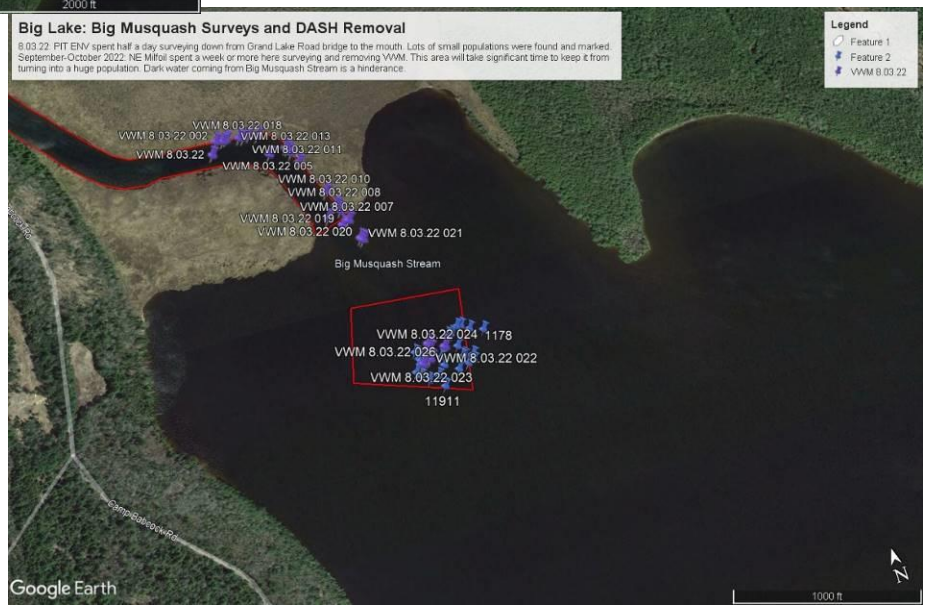




A new VWM population was discovered in Big Lake by DLLT staff and volunteers. Even though our focus in 2021 was Big Lake, there are constant bits of work to be done every year here, and the other lakes going forward.

***Below*: Big Musquash Stream was partially removed in fall of 2021, much more work was done there in 2022 with NE Milfoil doing the main lake survey and all removal work. Tribal staff surveyed the in-stream sections.**

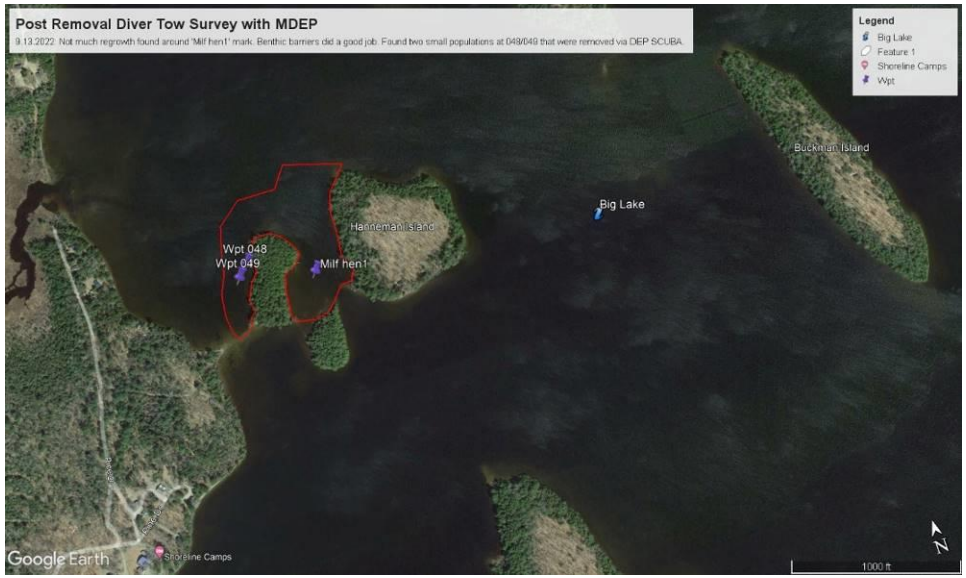
***Above*: Big Lake: Little River. Western end of the lake. New population surveyed by volunteers and DLLT. Removed by MDEP, Tribe and NEMilfoil 2022.**



***Above*: We had lots of help doing milfoil surveys this summer, some came from as far away as Massachusetts. Thanks Jeff.**

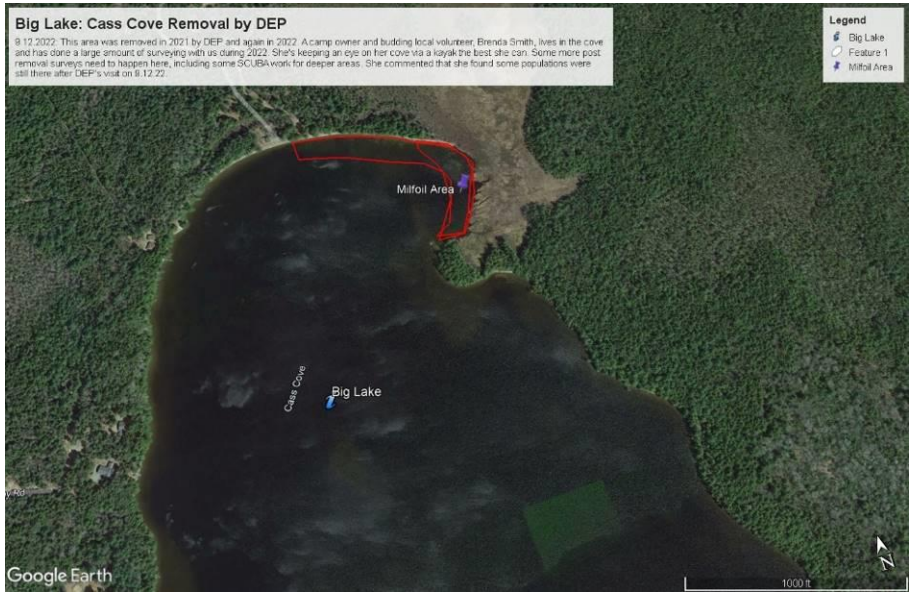
***Below*: Some more of our help this summer. LSM provided a summer intern, EJ and the Summer Youth Program added in some high school students. Here they are at MDEP's wading invasive removal training.**

Post-removal Surveys



After IAS populations are found, mapped, and marked they are then removed by trained personnel. In the years following those removal activities we will be surveying the sites for regrowth of IAS. Even with the most thorough removal activities there will usually be some level of regrowth, especially with larger, more established populations. This regrow usually occurs from small root fragments left in the substrate, or from small nearby plants that were missed due to size or water clarity. Any regrowth found is then removed. It is expected that within a handful of years of consistent post-removal surveying those removal efforts will be 100% effective, especially in younger, less established populations. Here are maps of post removal surveys conducted this year with MDEP in Big Lake.

***Above*: Hanneman Island is located in western Big Lake. MDEP did diver tows to clean up remnants of VWM from benthic barriers in 2021. Some small new populations found to the west: Wpt048/049.**



Right: Big lake: Cass Cove. Northern cove on Big Lake. This area was surveyed by volunteers and VWM pulled in 2021 by MDEP. Resurveyed and more material removed in 2022.

Remove

So far, the bulk of removal work has been done by a contracted DASH crew, NE Milfoil: (http://www.newenglandmilfoil.com/) contracted by our local partner DLLT through granted MDEP funding for new aquatic invasive species infestations. This contracted work by NEMilfoil has been going on for 4-10 weeks per summer since 2020.

Invasive removal implementation took place in a partnership with the MDEP and DLLT. Tribal environmental department staff were trained through MDEP for removal activities on 7/14/22. Using scuba hand removal and benthic barriers the Tribe was able to remove some of the smaller, isolated, or time sensitive populations in Long, Lewey, and Grand Falls Flowage. The bulk of new VWM populations found in Big, Long, Lewey, and Grand Falls Flowage were removed by the Diver Assisted Suction Harvest (DASH) crew contracted through DLLT/DEP. We are investigating our ability to create our own DASH boat and crew for the future. The following are some photos and maps of removal activities.

Restore

Restoration activities currently are not a priority. Most of the sites we've removed were very small and should be recolonized quickly by nearby native plants. If a site is heavily disturbed, we will want to look into recolonizing with local native plants. This is something that will need to be investigated for the future.

Literature Cited

Amnell, T., P. Anttila, A. Määttä, T. Ruoho-Airola and T. Salmi. 2002. Detecting Trends of Annual Values of Atmospheric Pollutants by the Mann-Kendall Test and Sen's Slope Estimates - The Excel Template Application MAKESENS, Finnish Meteorological Institute, Helsinki Finland

Bacon L. and J. Potvin. 1993 Standard Field Methods for Lake Water Quality Monitoring Maine Department of Environmental Protection, ME

Carlson, R.E., 1977. A Trophic State Index for Lakes. Limno. Oceangr. 22:361-368.

Holdren, C., W. Jones, and J. Taggart. 2001. Managing Lakes and Reservoirs. N. Am. Lake Manage. Soc. and Terrence Inst., in coop. With Off. Water Assess. Watershed Prot. Div. U.S. Environ. Prot. Agency, Madison, WI

Hill, R., Williams, S. 2008 Maine Lakes Report. Volunteer Lake Monitoring Program, US Environmental Protection Agency and Maine Department of Environmental Protection., ME