BEAR LAKE – LAKE BOARD

REGULAR MEETING

Thursday, January 13, 2022

6:00 P.M.

N. MUSKEGON CITY HALL

I. ***Call to Order*:**

II. ***Pledge of Allegiance to the Flag*:**

III. ***Roll Call*:**

IV. **Approval of Agenda**

V. ***Minutes*:**

a. New Assistant to BLLB – Marlene

b. Review/Approve Draft Minutes for 12/9/'21 Mtging

VI. **Budget/Expenditures: (C. Howell)**

a. New Invoices – Review/Approval

b. Year End Summary/Amendments for 2022

VII. ***Reports/Updates*:**

RLS – Dr. Jones/Mike Solomon

a. 2021 Annual Bear Lake Update/Trends/Summary

b. Proper Lawn Care for Lake Health – Post on Website?

VIII. **Communications: None**

IX. ***Old Business*:**

a. 2022 RLS/BLLB Contract Review

b. EGLE Written Feedback – Post on Website?

c. Michigan State Univ. Inland Lake Intro. Course - Posted

d. Workshop - By-Laws/Secretary Job Description/Duties

e. Workshop - Open Meetings Act, January 31, 2022

f. Workshop - Bear Lake Improvement Plan

g. Website Development/Resident Communications (P. Pek)

h. City of North Muskegon Memo for Record

i. BLPA President/Leader - Posted

***X. New Business*:**

a. 2022 PLM/EGLE Treatment Permit

b. Resident Survey Option -- GVSU

XI. *Public Comments*

XII. *Next Meeting*:

a. *February 10, 2022 at 6 p.m. N*. Muskegon City Hall

XIII. *Adjourn*

BEAR LAKE LAKE BOARD MINUTES
REGULAR MEETING
WEDNESDAY, DECEMBER 09, 2021, 6:00 PM
N. MUSKEGON CITY HALL

I. Call to Order

The meeting was called to order by Chair, Darrell Van Fossan, at 6:02 PM

II. Guest Speakers

A. Al Steinman, GVSU AWRI Director

- Dr. Steinman gave a presentation with a PowerPoint titled "Bear Lake Restoration Overview", which will be posted electronically.
- His studies have shown that Bear Lake does not have an issue with low oxygen due to it being a shallow lake and constantly turning over from waves, with that, aeration would not be effective.
- His studies have shown high phosphorus level at the bottom of the lake, but if oxygen levels stay good, it will not be released.
- The main issue is high oxygen levels from external load.
- He discussed that in 1994 the Muskegon Lake "Area of Concern" was expanded to include Bear Lake, which allowed for them to apply for funding, and led to the cleanup and dredging of the celery flats, which had a super high level of phosphorus.
- He said we have already started to see the improvements from the celery field cleanup project, but need to wait for the wetlands to restore, as things were hampered by the recent high water levels, and the shoreline vegetation was not able to grow and act as a filter, and there was significant backflow from Muskegon Lake and Lake Michigan which didn't allow the filtering and expelling of phosphorus.
- Dr. Steinman addressed a common thought that fertilizing lawns is bad for the lake. He said that if the lawn is healthy with good root structure, they retain nitrogen, but yards that are in bad shape and have runoff, could pose issues.
- He indicated that PLM is a good company for herbicide and algaecide treatments.
- Van Fossan asked about oil. Dr. Steinman stated that his studies did not measure or look into anything with the oil in sediment, but Kathy may have some info on this.
- A resident asked about Septic Systems and if they are harmful for the lake. Dr. Steinman stated that as long as they are well maintained and of proper size, they don't pose any issues, but ones that are in bad shape can. He brought up Silver Lake as an example, as there are many small and old septic systems and new residents built much larger homes with more people and kept the old system, which the leech into Silver Lake.

- Pek asked what we could do to improve our lake. Steinman indicated that Shoreline buffers are always beneficial.
- A resident asked about a filtration system for Bear Creek flowing into Bear Lake. Steinman said the work from the celery cleanup, including planting natural buffers and marshes. We need to wait for it to grow, and need to wait for water to go down, and may need to do some more planting. Moore brought up that charcoal filters could be put on storm-drain type of water going, but not on natural water ways where fish need to be able to swim up and downstream.
- A resident asked about aeration and if we should wait to do any major projects. Dr. Steinman advocated for patience. He said to let the $7M project work its course, and that we are already seeing some initial improvements and will continue to see more. Steinman brough up that the main reason for the EGLE denial was petroleum, and we still haven't been able to pinpoint the source of the petroleum.

B. Kathy Evans, WMSRDC Environmental Planning
- Her message is that there are a lot of partners to work with. She said having a 319 watershed management plan, which is already in place for the entire Muskegon Lake Watershed, is a huge plus. This makes it much easier to get grants for projects like buffers and filters.
- One project her office did with the Delta institute was a nutrient filtering wetlands just below Twin Lake.
- She feels we can do more low impact development with buffer and filters. Tree planting, etc.
- A resident asked a question about a new drain system that was built for an old subdivision in Laketon Township that drains into Bear Lake. Kathy mentioned one of the projects they did was review ordinances of townships and how they could require buffers and filters. Moore said the townships sends plans to her office for review, and said most of the powers come through zoning restrictions and that Laketon Township is one of the better ones. The resident brought up concerns about the soil in that area being contaminated with petroleum.
- A resident brought up the work Kathy helped with eliminating the phragmites, and how those are no longer a problem on our lake. He also brought up if we should consider Milfoil similar to phragmites. Kathy said this is typically through lake associations to selectively treat. She said the watershed usually stops once you get inside the lake.
- Kathy brought up the project to cap Fenner's Ditch, and working on Zephyr oil refinery site and projects to improve water flowing from there into Muskegon and Bear Lake watersheds.
- Kathy is retiring, but will be looking to possibly do some volunteering in the future.

III. Pledge of Allegiance

IV. Roll Call

Present: Darrell Van Fossan, Brenda Moore, Craig Howell, Paul Pek
Absent: Doug Brown
Also present: Alan Steinman, Kathy Evans, Jennifer Jones, Mike Solomon

V. Approval of Agenda (on recording)

A. Van Fossan discussed getting approval for this month's agenda.
B. Moore made the motion to approve the agenda as written. Howell supported the motion. The motion carried by unanimous voice vote.

VI. Minutes

A. Pek will act as temporary recording secretary/minute taker again this month.
B. Moore made a motion to approve the minutes of November 10, 2021 meeting as corrected. Howell supported the motion. Motion carried by unanimous voice vote. The minutes will be placed on file.

VII. Budget/Expenditures (Howell)

- No new updates.

VIII. Reports/Updates (RLS – Mike Solomon)

A. Status – 2022 RLS/BLLB Contract
   - Van Fossan just received a revised counter-offer contract, copy attached. Action item: Get Darrell Comments Feedback by 20th of December, current contract ends January 14.

B. Status – Feedback from EGLE meeting with RLS/BLLB
   - Brenda, Darrell, Mike Solomon took part in the meeting.
   - EGLE kept reiterating issues of potential petroleum impact to fish and wildlife, and work should be done in watershed, but the lake board doesn't have authority for watershed projects, only those in the lake.
   - Mike Solomon called a friend who is in petroleum cleanup. Bill Dooley, and participated in Fenner's ditch. He recommended aeration and dredging, but it needs to be tied back to orphan wells. Will be pursuing this a little further. He did say they would like more bottom sediment data.
   - Still talking with PLM with using Phosloc in Fenner's Ditch, which could greatly help the problems in that area and be relatively low cost.
   - Van Fossan brought up EGLE said that you shouldn't rely solely on one item for improvement, and keep several things in the toolbox
   - Moore indicated that EGLE questioned why we were pursuing aeration when there are not issues with low oxygen levels. They also brought up natural shoreline, bioengineering.
   - Moore also indicated EGLE gave much better details in some letters, which will be shared on website

- Moore brought up that the head of Water Resources out of Lansing that was at the at EGLE meeting, she said the law said if there could be and adverse impact on any aquatic resources, they are supposed to say no. Moore asked about threshold levels, but they don't really consider any level for a threshold.
- Moore indicated that someone said that our sediment samples for petroleum were not properly taken. Maybe that had an impact.

C. Status – 2021 Annual Bear Lake Update/Trends/Summary
- Jennifer Jones Will be giving an update in January
- Jennifer will be going back over the original study and potential solutions

IX. Communications From Laketon Township

- Copy of communication for Township because they received several complaints from residents about the next assessment and whether they must pay it, given the aeration project. Van Fossan reiterated that residents do have to pay their assessments.
- Van Fossan said NM City and Laketon can forward complaints to him to respond to
- Moore discussed that NM and Laketon are in this with us, and they should have staff that should be able to answer basic questions.
- Pek brought up that we don't know what we're going to do in respect to a future assessment. There are several scenarios 1) We may legally have to refund what's leftover, and that's something we need input from our attorney on, and would have to start from scratch with a new assessment,2) Could put a pause on any new assessment until we spend down the balance, 3) Have could have a substantially lower assessment, so residents are still aware this exists, maybe $50-$100 per year vs. current $500, but explain this could go up at the next assessment if funds are depleted.

X. Old Business

A. 2022 Treatment Protocol (Van Fossan)
- Van Fossan indicated the main focus was to streamline things so we can react faster to issues
- Discussion took place around how Van Fossan should not take all the work on his shoulder, and should also involve the other lakefront owners on the lake board. Van Fossan indicated that was added that Pek and Howell will be involved as fellow lakefront owners
- Pek brought up that the wording on the surveys should be changed from 5 aquatic surveys, to "up-to" 5, so we are not required to do surveys if they are not needed.
- Discussion that Van Fossan would have allowance to treat up to the budgeted amount, and anything further would require the board to increase the budget.
- Moore moved to approve with as amended (removing the year and add up-to in front of the 5 surveys). A roll call vote took place: Moore-Yes, Howell-Yes, Pek-Yes, Van Fossan-Yes.

B. Recording Secretary (Howell)
   - Marlene will start for us next month. City of NM employee that they will allow us to have limited use for minutes.
   - Some discussion took place that the minutes will be covered by NM, and that other assistance would be charged. Moore recommended an Memo of Agreement so we have that documented and how much it will cost per hour.
   - Moore motion to approve the job description (conditional upon memo of agreement with the city) Howell seconded. Motion carried by unanimous voice vote.

C. BLPA President/Leader (Van Fossan)
   - Van Fossan brought up that the BLPA still exists and Van Fossan is still on record as the President, and is looking for someone else to volunteer and take over as President.
   - Pek indicated that the only indication of this association was the nice booklet that he received. He has never seen anything about meetings, etc. He recommended to Van Fossan to put a post out on the area "Bear Lake Property Owners" Facebook page, and he may find someone interested.

D. Website/Communications (Pek)
   - Pek has started development on the new bllb.org website with an estimated completion in January. Not sure yet if we will use NM's Documents on Demand site, or host documents directly on the website.
   - Pek has created, but not published a "Bear Lake Lake Board" Facebook Government Organization page. This page will be used as one mode of communication to post things like Meetings, when the website is updated, etc.
   - Pek plans on reaching out to start gathering contact information from Riparians through various methods. Facebook posts, word of mouth, and getting with each municipality for the information they have.
   - Howell and Pek discussed the texting utility that NM uses and offered to us. The plan is to use that selectively for things like spray dates.

XI. New Business

- No New Business

XII. Workshop

A. Open Meetings Act Training/Bylaw Finalization
   - Van Fossan shared Meeting Notice update on the workshop scheduled for January 31
   - Van Fossan discussed we need to have a working session as next step on the bylaws, and then discuss with the attorney. May have time available after the Open meetings act to discuss some of this with the attorney.

B. Improvement Development Plan – EGLE Feedback
   - Van Fossan discussed a working session to discuss a plan for the lake. Dr. Jones mentioned they will be making some recommendations at their January update.

XIII. Next Meeting

A. January 13, 2022 at 6:00 PM at North Muskegon City Hall
B. Final review and approval of RLS/BLLB Contract – Action to get comments to Darrell by December 20.
C. RLS Year End Summary/Lake Improvement Recommendations
D. 2022 Budget Revisions – preliminary year end, and new budget

XIV. Public Comments

A. Dave Shields: Going forward, are we looking at other Lake Mgt Companies, maybe we should take to look around at what others have to offer. We may get some fresh ideas. Van Fossan indicated that we don't have the time to make a change and is recommending we stay with RLS. Pek did add there is a clause in the contact that either party can back out of the contract with 7-day notice.

XV. Board Comments

A. Moore brought up that we're making a lot of progress, but we are a little overloaded with topics
B. Moore stated we should be careful on switching to a new lake management company. She's been involved with several that only look at using chemicals. Just adding chemicals is not the answer. She said the law is very specific of what is necessary. Pek asked what law she was referring to, she brought up getting approval to spray and that it's all tied to a law. Van Fossan indicated that he is open to objective bidding
C. Discussion took place about what is needed for the future. Do we need to start over with a professional engineer and feasibility study, or is it a one-time thing? Dr. Jones indicated that it's only needed if you change the scope, otherwise you can just amend the plan.
D. Moore discussed that if you change, you must start from ground zero. Unless someone is completely incompetent, you should stick with same firm. She said it's majority rules, but may be opening up a can of worms. More wanted to go on record that she was not present at the meeting where RLS was picked as the lake management firm.
E. Pek brought up that we need to have KPIs (key performance indicators) and review RLS to insure they are doing a good job, just like a school board reviews the superintendent. He doesn't see that right now. What is success? Moore agreed that an evaluation is great.
F. Pek brought up the aeration project, and his stance being against it. He indicated that the board supported this, and so did RLS as one of the solutions. This would be a negative on any review.

G. Moore indicated that RLS and our Board are attempting to regain credibility and are in regroup mode. Van Fossan indicated that better communication is needed.

XVI. Adjourn

A. Moore made a motion to adjourn, which was seconded by Howel. Motion caried by unanimous voice vote.
B. Meeting adjourned at 8:10 PM.

Submitted:
Paul Pek

Approved by the Bear Lake Lake Board on: _____

Signed: _____

PLM Lake & Land Management Corp.
Great Lakes Region
PO Box 438
Howard City, MI 49329
www.plmcorp.net
616-891-1294

INVOICE

DATE	ACCOUNT
9/2/2021	Bear Lake

Invoice to:

Bear Lake Lake Board
C/O Laketon Township
Supervisor, Kim Arter
2735 West Giles Rd.
North Muskegon, MI 49445

If you have questions about this invoice or would like to find out about our expanded service offerings, please call call us at: 616-891-1294

INVOICE #	TERMS	MGR CODE	P.O.#	Customer Number
3003797	Net 30	JC		MI00560

Date Treated	Description	Quantity	Price	Time Treat...	Amount
9/2/2021	Algae Treatment of Lake using SeClear	4.5	124.85	08:30	561.83

If you have any questions, please contact accountspayablema@plmcorp.net

BALANCE	$561.83

·TO INSURE PROPER CREDIT PLEASE DETACH BELOW AND RETURN WITH PAYMENT·

DUE DATE	INVOICE #	AMOUNT DUE	ACCOUNT	Customer Number
10/2/2021	3003797	$561.83	Bear Lake	MI00560

If you would like to pay by credit or debit card (Visa or Mastercard) please call 616-891-1294, there will be a 4% fee.
There will be a $25.00 fee charged for NSF checks.
If you would like to pay your invoice online, please visit www.plmcorp.net/payinvoiceonline

AMOUNT ENCLOSED $_____

Please Remit Payment To: PLM Lake & Land Management - PO Box 438 Howard City, MI 49329

ACCREDITED BUSINESS BBB.

Great Lakes Region (A)

BLLB TREASURERS REPORT Ending December 31,2012

C. Howell

Proposed Bear Lake Management Improvement Item	*2021 Budget*	*First Quarter Ending 3/31/21*	*Second Quarter Ending 6/30/21*	*Third Quarter Ending 9/30/21*	*Fourth Quarter Ending 12/31/21*	*Year to Date Actual*	*2021 Budget*	*2022 Budget*
Herbicides for removal of invasives - May 24th, Permit Fees[1] $1,500	$9,000	$1,500	$11,899	$10,731.65	$561.83	$24,130.65	$9,000	$3,000
Professional Limnologist Services (limnologist surveys, all lake sampling, meetings, workshops reports, contractor oversight, education)[2]	$22,000	$5,500	$5,500.00	$5,500.00	$5,500.00	$16,500	$22,000	$50,000
Attorney Fees	$1,000	$0				$0	$1,000	$ 1,000.00
Assessment Appeals	$0	$0				$0	$0	$0
Lake-Wide Aeration System/Bioaugmentation	$124,056	$0				$0	$124,056	$95,922
Consumer Energy/Electricity	$9,600	$0				$0	$9,600	$9,600
Consumer Energy Installation/Boring Company Installation	$30,000	$0				$0	$30,000	$0
Audit, Bond, Insurance	$2,311	$0				$0	$2,311	$2,000
Mailings, Publications, start up loan, admin fees/costs and Miscellaneous	$1,000	$122.50				$122.50	$1,000	$1,000
Subtotal	**$198,967**	**$7,123**	**$17,399.00**	**$16,232**	**$6,061.83**	**$46,254**	**$198,967**	**$ 162,522.00**
Contingency (10% 2021 & 2022)	**$19,897**						**$19,897**	**$16,252**
TOTAL ANNUAL ESTIMATED COST PER YEAR	**$ 218,863.70**						**$ 218,863.70**	**$ 178,774.00**

Total Budgeted Expense 2021/2022 = $397,937.70

December 31,2021

23% of Annual Budget Spent YTD 2021

Total Revenue: $66.123

Total Expenses: $46,254

Balance/Cash Available $358,814.12

An Audit in 2022 is Planned

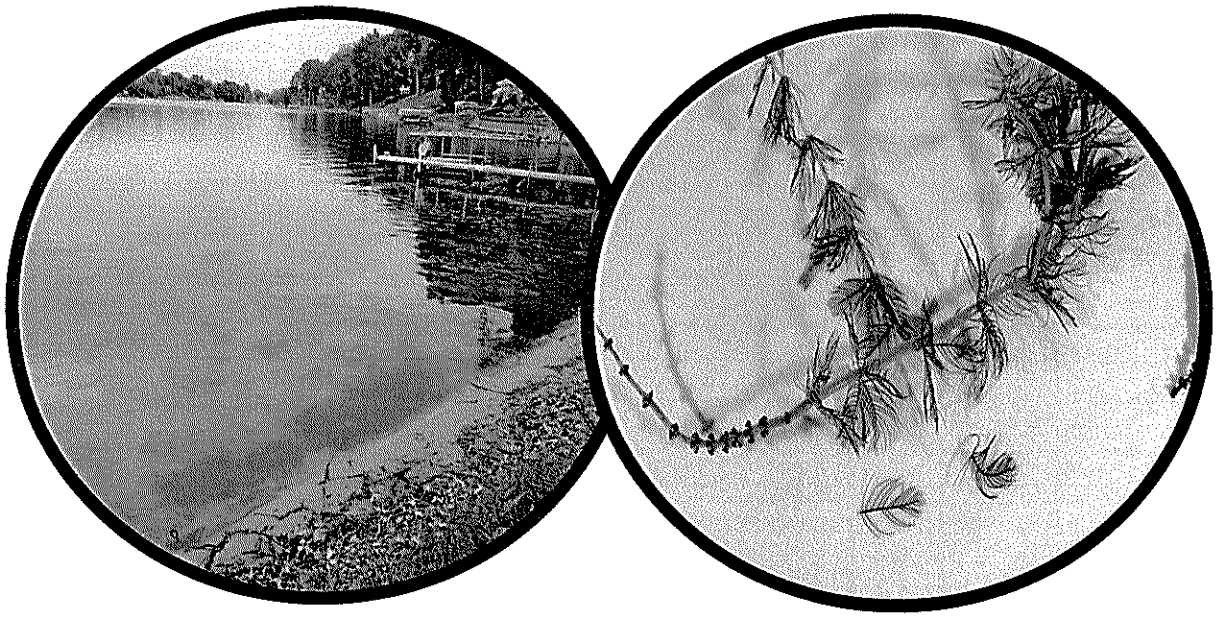
12/30/2022 End of 5 Year Initial Improvement Plan

Cash Balance 12/31/21 $358,814.12

$358,814.12

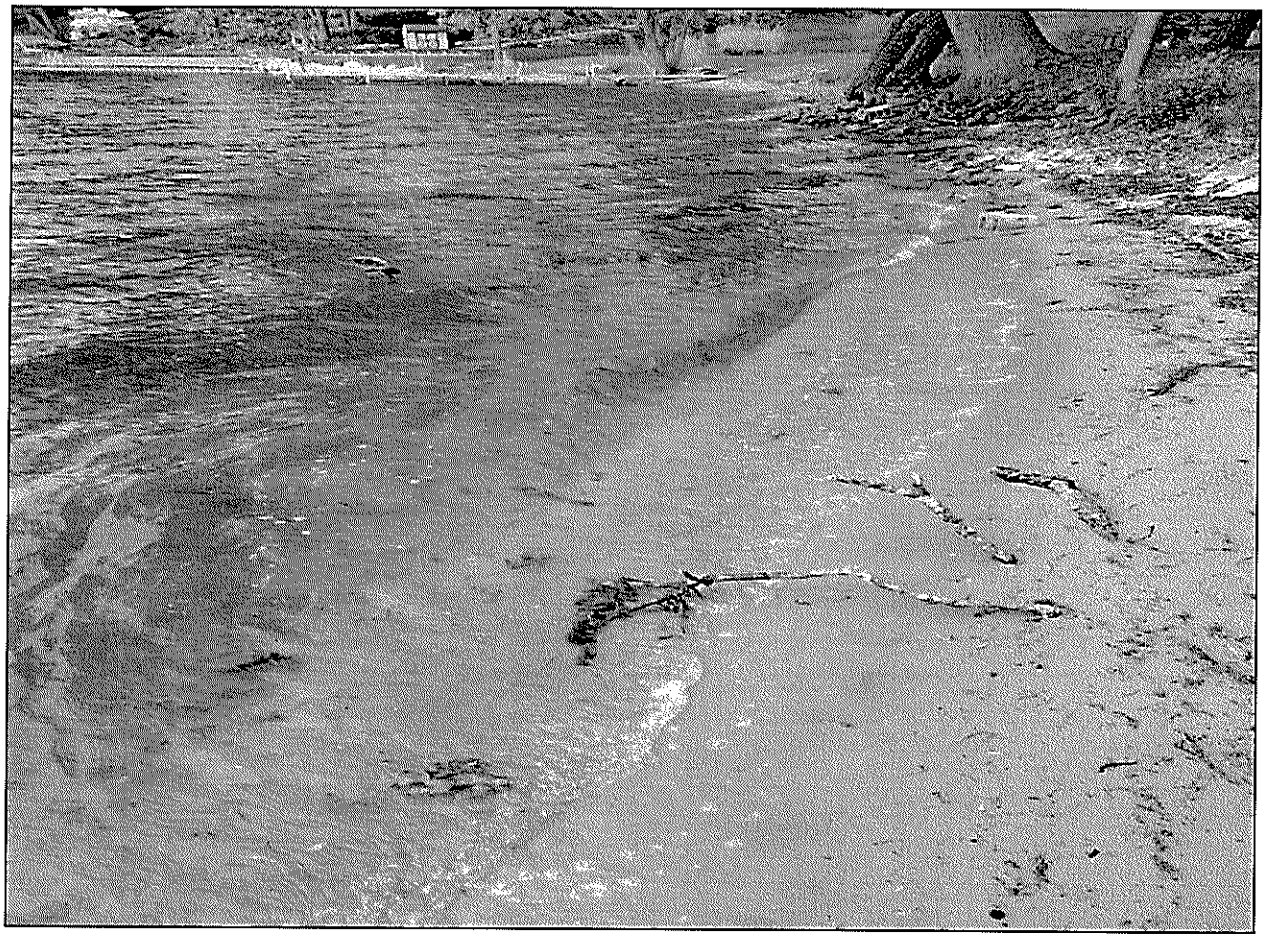
Restorative Lake Sciences™

Bear Lake 2021 Aquatic Vegetation, Water Quality, and 2022 Management Recommendations Annual Report



January, 2022

Bear Lake 2021 Aquatic Vegetation, Water Quality, and 2022 Management Recommendations Annual Report



18406 Spring Lake Road
Spring Lake, Michigan 49456
Website: http://www.restorativelakesciences.com

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Section 1

Bear Lake 2021 Aquatic Vegetation, Water Quality, and 2022 Management Recommendations Annual Report

Executive Summary

The overall condition of Bear Lake relative to invasive species management has been improving over the years due to rigorous aquatic vegetation surveys and selective spot-treatments to control invasive aquatic plant species such as hybrid Eurasian Watermilfoil (EWM), and Curly-leaf Pondweed. Previous infestations of the invasive emergent Phragmites have also been well controlled with rigorous treatments with less than 0.1 acres of active growth present in 2021. The quantity of EWM varies within and among seasons due to the ecology of the seed bank which can experience substantial germination at any time or can remain dormant for long periods. In 2021, there were two periods of EWM growth with one present in early May and another in early July. While it is most desirable to treat EWM with systemic herbicides for root control, it may be practical to treat it with contact herbicides when there are other nuisance natives present such as Thin-leaf Pondweed which occurred in 2021. The new systemic herbicide ProcellaCOR® has been used to effectively treat EWM and RLS will plan to use it more on Bear Lake EWM in the future. Due to the preservation efforts by RLS scientists, the native aquatic plant community of Bear Lake has increased by 7 species since the 2017 feasibility study! The lake had 14 submersed, 5 floating-leaved, and 4 emergent aquatic plant species in 2021 for a total of 23 species which is quite diverse!

Since 2017, RLS has collected multiple water quality parameters from Bear Lake and the inlets (Fenner's Ditch and Bear Creek) which include water temperature, dissolved oxygen, pH, conductivity, total suspended and dissolved solids, turbidity, total phosphorus and total nitrogen. Secchi transparency and chlorophyll-a and algal community were also measured and collected in the deep basins. RLS analyzed the collected data to date and generated mean trend graphs for key parameters in this report and will continue to update those trends each year.

After discussions with the Michigan Department of Environment, Great Lakes, and Energy (EGLE) in recent months, RLS offers many improvement recommendations for the 2022 season and beyond relative to nutrient reduction, blue-green algal reduction, continued management of invasive aquatic plant species, watershed management, and the education of Bear Lake riparians. These are offered in the last section of this report.

Section 2

Bear Lake Water Quality Data (2017-2021)

Water Quality Parameters Measured

There are hundreds of water quality parameters one can measure on an inland lake, but several are the most critical indicators of lake health, and these have been consistently measured in Bear Lake by RLS scientists since 2017. These parameters include water temperature (measured in °C), dissolved oxygen (measured in mg/L), pH (measured in standard units-SU), specific conductivity (measured in micro-Siemens per centimeter-µS/cm), total dissolved solids (mg/L), turbidity (NTU's), Secchi transparency (feet), total phosphorus, and total Kjeldahl nitrogen (both in mg/L), chlorophyll-*a* (in µg/L), and algal species composition. Such water quality parameters have been measured in the two deepest basins of Bear Lake in spring and summer. In 2021, the deep basins were sampled on May 5, 2021 and July 16, 2021. Water quality measurements for physical parameters were recorded in 0.5 meter depth increments.

All chemical water samples were collected at the specified depths (one each at the top, middle, and bottom depths of the deep basin sampling site or for very shallow sites at mid-depth) using a 4-liter VanDorn horizontal water sampler with weighted messenger (Wildco® brand). Water quality physical parameters (such as water temperature, dissolved oxygen, conductivity, and pH) were measured with a calibrated Eureka Manta 2® multi-probe meter at top, middle, and bottom depths of the deep basin sampling sites in 0.5-meter increments. Total phosphorus was titrated and analyzed in the laboratory according to method SM 4500-P E. Ortho-phosphorus was titrated and analyzed in the laboratory according to method SM 4500-P E. Total suspended solids were analyzed for each sample using SM 2540 D-97. All of the aforementioned chemical parameters were analyzed at NELAC-certified Trace Analytical Laboratories in Muskegon, Michigan.

Chlorophyll-*a* was analyzed using method SM 10200H by Trace Analytical Laboratories in Muskegon, Michigan. Prior to analysis of the samples as described above, water samples were placed in clean, unpreserved polyethylene bottles for ortho-phosphorus and total suspended solids and placed in H_2SO_4-preserved, clean, polyethylene bottles for total phosphorus analysis. Chlorophyll-*a* samples were placed in glass brown, amber 1-liter bottles with magnesium carbonate as a preservative and analyzed within days after collection.

All water samples were maintained on ice in a large cooler prior to being placed into the laboratory fridge. Samples used for microscopic analysis of algal community composition were preserved with magnesium carbonate and counted with a Sedgewick Rafter® Counting Cell under high power objective on a bright-field Zeiss® compound microscope. Multiple 1 micro-liter (µL) aliquots were used to determine the relative abundance of algal genera in the samples.

Additional water quality measurements were also collected from the two main inlets—Fenner's Ditch and the Bear Creek wetland at the northeast region of the lake (Figure 2).

Table 1 below demonstrates how lakes are classified based on key parameters. Bear Lake would be considered eutrophic (productive) since it does contain ample phosphorus, nitrogen, and aquatic vegetation and excessive blue-green algae growth. General water quality classification criteria are defined in Table 1. 2021 water quality data for Bear Lake are shown below in Tables 2-7. Tables 8-9 display the means and standard deviations for spring and summer lake basin parameters with time.

Figure 1. Deep Basin Water Quality Sampling Locations (n=2) in Bear Lake.

Figure 2. Inlet Water Quality Sampling Locations (n=2) in Bear Lake.

Table 1. Lake trophic classification (MDNR).

Lake Trophic Status	*Total Phosphorus ($\mu g\ L^{-1}$)*	*Chlorophyll-a ($\mu g\ L^{-1}$)*	*Secchi Transparency (feet)*
Oligotrophic	< 10.0	< 2.2	> 15.0
Mesotrophic	10.0 – 20.0	2.2 – 6.0	7.5 – 15.0
Eutrophic	> 20.0	> 6.0	< 7.5

Bear Lake Deep Basin Water Quality Data Tables:

Table 2. Bear Lake water quality parameter data collected over deep basin #1 on May 5, 2021.

Depth (m)	*Water Temp °C*	*DO mg L^{-1}*	*pH S.U.*	*Cond. µS cm^{-1}*	*Turb. NTU*	*TDS mg L^{-1}*	*TSS mg L^{-1}*	*TP mg L^{-1}*	*SRP mg L^{-1}*	*TKN mg L^{-1}*	*Chl-a µg L^{-1}*
0	14.2	10.6	8.5	403	7.0	258	<10	0.020	<0.010	0.6	11.0
0.5	14.1	10.4	8.4	403	--	258	--	--	--	--	
1.0	14.1	10.4	8.4	403	--	258	--	--	--	--	
1.5	14.1	10.4	8.4	403	--	258	--	--	--	--	
2.0	14.1	10.4	8.4	403	--	258	--	--	--	--	
2.5	14.0	10.4	8.4	403	--	258	--	--	--	--	
3.0	14.0	10.4	8.4	403	--	258	--	--	--	--	
3.5	13.9	10.4	8.4	403	7.0	258	--	--	--	--	
4.0	13.9	10.4	8.4	403	--	258	--	--	--	--	
4.5	13.9	10.4	8.4	403	--	258	<10	0.057	<0.010	<0.5	
5.0	13.9	10.4	8.4	403	--	258	--	--	--	--	
5.5	13.8	10.4	8.4	403	--	258	--	--	--	--	
6.0	13.7	10.4	8.4	403	--	258	--	--	--	--	
6.5	13.4	9.9	8.2	405	--	258	--	--	--	--	
7.0	13.3	9.4	8.1	408	--	260	--	--	--	--	
7.5	13.3	8.8	8.0	408	--	261	--	--	--	--	
8.0	13.3	8.0	8.0	409	--	261	--	--	--	--	
8.5	13.2	4.0	8.0	483	8.0	262	<10	0.038	<0.010	0.6	

Table 3. Bear Lake water quality parameter data collected over deep basin #2 on May 5, 2021.

Depth (m)	*Water Temp °C*	*DO mg L^{-1}*	*pH S.U.*	*Cond. µS cm^{-1}*	*Turb. NTU*	*TDS mg L^{-1}*	*TSS mg L^{-1}*	*TP mg L^{-1}*	*SRP mg L^{-1}*	*TKN mg L^{-1}*	*Chl-a µg L^{-1}*
0	14.2	10.7	8.5	403	6.0	258	<10	0.023	<0.010	<0.5	1.07
0.5	14.1	10.6	8.5	403	--	257	--	--	--	--	
1.0	14.1	10.6	8.5	403	--	258	--	--	--	--	
1.5	14.1	10.6	8.4	403	--	258	--	--	--	--	
2.0	14.1	10.6	8.4	403	--	258	--	--	--	--	
2.5	14.1	10.6	8.4	403	6.0	258	<10	0.031	<0.010	0.7	
3.0	14.1	10.6	8.4	403	--	258	--	--	--	--	
3.5	14.1	10.6	8.5	403	--	258	--	--	--	--	
4.0	14.0	10.6	8.4	403	--	258	--	--	--	--	
4.5	14.0	10.6	8.4	403	7.0	258	<10	0.037	0.011	0.6	

Table 4. Bear Lake water quality parameter data collected over deep basin #1 on July 16, 2021.

Depth (m)	*Water Temp °C*	*DO mg L^{-1}*	*pH S.U.*	*Cond. µS cm^{-1}*	*Turb. NTU*	*TDS mg L^{-1}*	*TSS mg L^{-1}*	*TP mg L^{-1}*	*SRP mg L^{-1}*	*TKN mg L^{-1}*	*Chl-a µg L^{-1}*
0	24.1	8.7	8.4	409	5.0	262	<10	0.037	<0.010	0.7	0.267
0.5	24.2	8.7	8.4	409	--	262	--	--	--	--	
1.5	24.2	8.7	8.4	409	--	262	--	--	--	--	
2.0	24.2	8.7	8.4	409	--	262	--	--	--	--	
2.5	24.2	8.6	8.4	409	--	262	--	--	--	--	
3.0	24.2	8.6	8.4	409	--	262	--	--	--	--	
3.5	24.2	8.6	8.4	409	--	262	--	--	--	--	
4.0	24.1	8.6	8.3	408	--	261	--	--	--	--	
4.5	23.8	8.1	8.1	407	5.0	257	<10	0.046	<0.010	1.1	
5.0	23.3	7.1	7.9	399	--	254	--	--	--	--	
5.5	23.3	5.9	7.8	397	--	254	--	--	--	--	
6.0	23.2	5.6	7.8	397	--	255	--	--	--	--	
6.5	23.2	5.2	7.8	398	--	255	--	--	--	--	
7.0	23.2	4.9	7.8	398	--	255	--	--	--	--	
7.5	23.2	4.8	7.8	399	--	255	--	--	--	--	
8.0	23.2	4.7	7.8	399	--	255	--	--	--	--	
8.5	23.1	4.4	7.7	399	6.0	255	<10	0.050	<0.010	<0.5	

Table 5. Bear Lake water quality parameter data collected over deep basin #2 on July 16, 2021.

Depth (m)	Water Temp °C	DO mg L^{-1}	pH S.U.	Cond. µS cm^{-1}	Turb. NTU	TDS mg L^{-1}	TSS mg L^{-1}	TP mg L^{-1}	SRP mg L^{-1}	TKN mg L^{-1}	Chl-a µg L^{-1}
0	24.2	8.5	8.4	410	7.0	262	<10	0.034	<0.010	0.6	5.1
0.5	24.2	8.5	8.4	410	--	262	--	--	--	--	
1.0	24.2	8.4	8.4	410	--	262	--	--	--	--	
1.5	24.2	8.4	8.4	410	7.0	262	<10	0.036	<0.010	0.5	
2.0	24.2	8.4	8.4	410	--	262	--	--	--	--	
2.5	24.2	8.4	8.4	410	--	262	--	--	--	--	
3.0	24.2	8.3	8.3	411	--	263	--	--	--	--	
3.5	24.1	7.8	8.1	413	7.0	265	10	0.041	<0.010	0.6	

Table 6. Fenner's Ditch water quality parameter data collected in 2021.

Date	Water Temp (°C)	DO mg L^{-1}	pH (S.U.)	Cond µS cm^{-1}	TDS mg L^{-1}	TSS mg L^{-1}	TP mg L^{-1}	SRP mg L^{-1}	TKN mg L^{-1}
May 5, 2021	11.1	12.5	8.5	575	324	<10	0.012	<0.010	<0.5
July 16, 2021	16.6	9.5	8.0	478	306	<10	0.052	<0.010	0.5

Table 7. Bear Creek water quality parameter data collected in 2021.

Date	Water Temp (°C)	DO mg L^{-1}	pH (S.U.)	Cond µS cm^{-1}	TDS mg L^{-1}	TSS mg L^{-1}	TP mg L^{-1}	SRP mg L^{-1}	TKN mg L^{-1}
May 5, 2021	13.9	11.0	8.2	386	255	<10	0.030	<0.010	<0.5
July 16, 2021	21.0	9.7	8.4	384	254	<10	0.032	<0.010	<0.5

Table 8. Bear Lake deep basin spring water quality parameter means and standard deviations with time (2017-2021).

Parameter	*Spring 2017*	*Spring 2018*	*Spring 2019*	*Spring 2020*	*Spring 2021*
Dissolved Oxygen	4.9±2.7	5.2±3.6	11.0±0.2	6.5±3.2	10.0±1.4
pH	8.2±0.1	7.9±0.4	8.2±0.1	8.4±0.0	8.4±0.2
Specific Conductivity	329±5.7	370±7.7	314±35	376±57	407±15
Total Phosphorus	0.040±0.0	0.045±0.0	0.044±0.1	0.038±0.0	0.034±0.0
Ortho-Phosphorus	0.010±0.0	0.016±0.0	0.010±0.0	0.019±0.0	0.010±0.0
Total Kjeldahl Nitrogen	1.1±0.2	1.0±0.4	0.6±0.1	0.9±0.2	0.6±0.1
Chlorophyll-a	9.1±2.0	0.71±0.3	6.2±3.6	20.0±2.8	0.5±0.8
Secchi Transparency	4.0±0.1	3.8±0.4	5.6±0.3	1.4±0.1	5.2±0.4

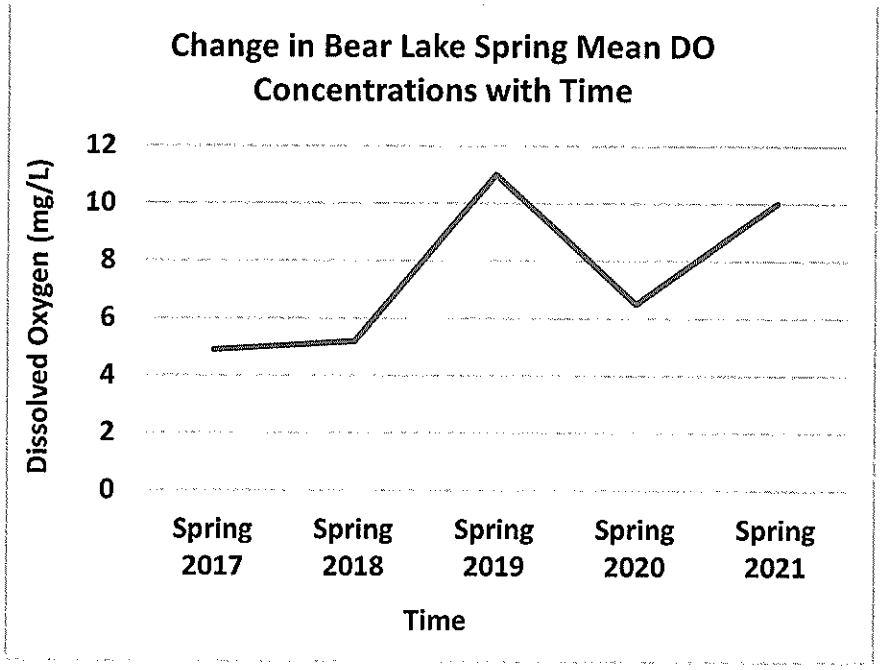
Table 9. Bear Lake deep basin summer water quality parameter means and standard deviations with time (2017-2021).

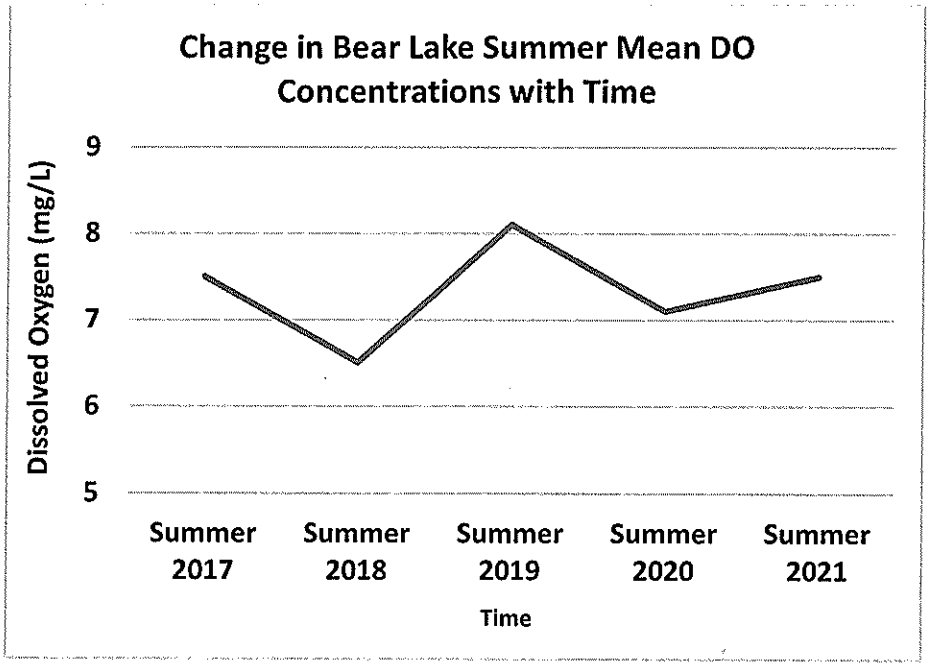
Parameter	*Summer 2017*	*Summer 2018*	*Summer 2019*	*Summer 2020*	*Summer 2021*
Dissolved Oxygen	7.5±1.9	6.5±2.8	8.1±2.3	7.1±0.3	7.5±1.6
pH	8.4±0.4	8.2±0.3	8.1±0.1	8.2±0.1	8.2±0.3
Specific Conductivity	365±4.1	366±4.0	411±79	726±223	406±5.5
Total Phosphorus	0.061±0.0	0.043±0.0	0.036±0.0	0.045±0.0	0.041±0.0
Ortho-Phosphorus	0.010±0.0	0.016±0.0	0.011±0.0	0.023±0.0	0.010±0.0
Total Kjeldahl Nitrogen	1.8±0.4	1.1±0.5	1.9±1.5	0.8±0.3	0.7±0.2
Chlorophyll-a	7.8±1.5	8.0±2.8	0.47±0.6	12.5±0.7	2.7±3.4
Secchi Transparency	2.3±0.4	3.3±0.6	2.6±0.2	4.0±0.7	4.5±0.2

Dissolved Oxygen

Dissolved oxygen is a measure of the amount of oxygen that exists in the water column. In general, dissolved oxygen levels should be greater than 5 mg L^{-1} to sustain a healthy warm-water fishery. Dissolved oxygen concentrations may decline if there is a high biochemical oxygen demand (BOD) where organismal consumption of oxygen is high due to respiration. Dissolved oxygen is generally higher in colder waters.

Dissolved oxygen was measured in milligrams per liter (mg L^{-1}) with the use of a calibrated Eureka Manta II® dissolved oxygen meter and multi-probe. During the summer months, dissolved oxygen at the surface is generally higher due to the exchange of oxygen from the atmosphere with the lake surface, whereas dissolved oxygen is lower at the lake bottom due to decreased contact with the atmosphere and increased biochemical oxygen demand (BOD) from microbial activity. Dissolved oxygen concentrations during the May 5, 2021 sampling event ranged from a high of 10.6 mg L^{-1} to a low of 4.0 mg L^{-1}. On the July 16, 2021 sampling date the dissolved oxygen concentration ranged from a high of 10.7 mg L^{-1} among the deep basins to a low of 4.4 mg L^{-1} which was observed at the bottom of the deepest basin. The dissolved oxygen concentrations in the inlets were higher than those in the lake. The graphs below demonstrate the changes in spring and summer mean dissolved oxygen with time. Although most of the shallows in Bear Lake retain adequate dissolved oxygen concentrations, the deep basins are often deficient which leads to release of phosphorus into the water column and exacerbates algal blooms.




Change in Bear Lake Summer Mean DO Concentrations with Time
Dissolved Oxygen (mg/L)
9
8
7
6
5
Summer 2017
Summer 2018
Summer 2019
Summer 2020
Summer 2021
Time

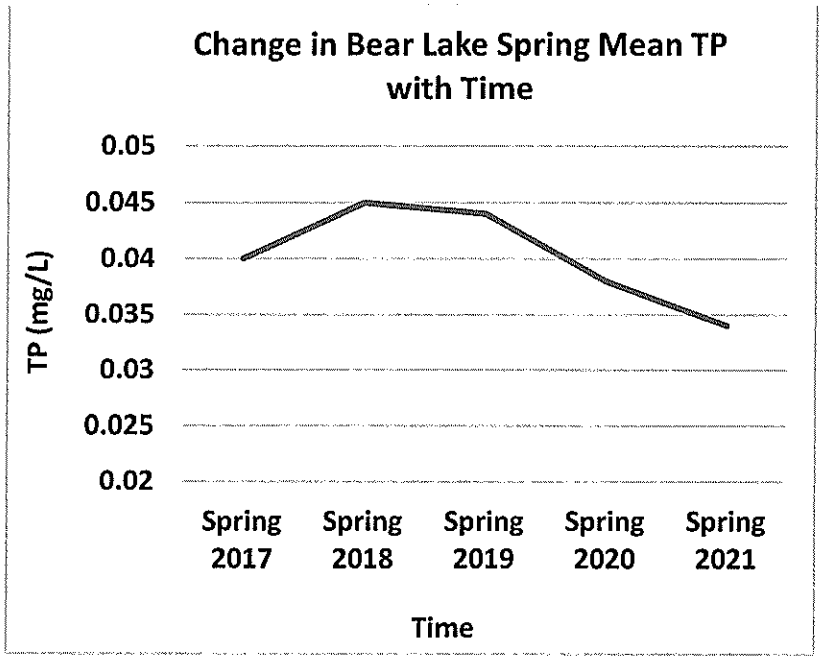
Water Temperature

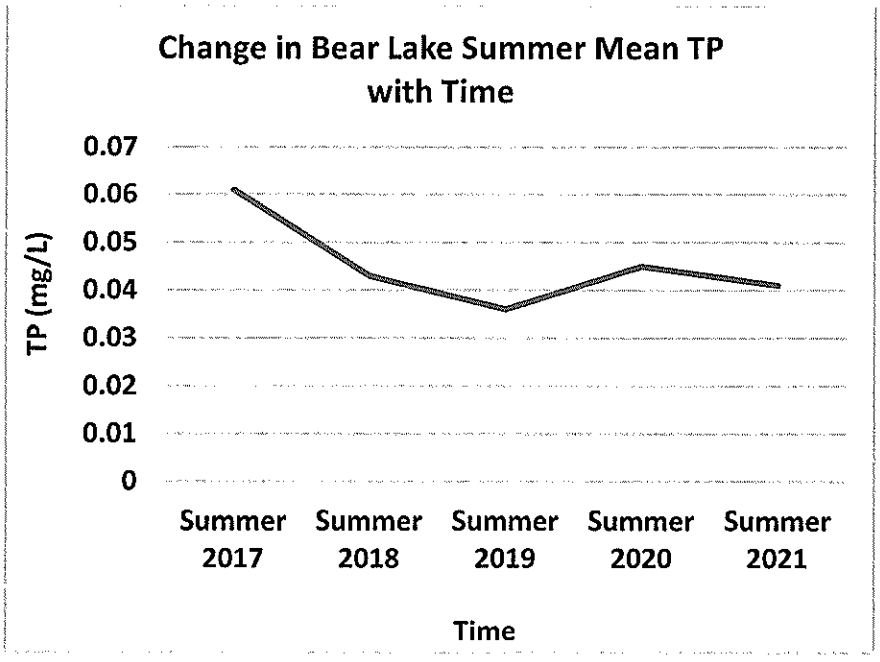
A lake's water temperature varies within and among seasons and is nearly uniform with depth under the winter ice cover because lake mixing is reduced when waters are not exposed to the wind. When the upper layers of water begin to warm in the spring after ice-off, the colder, dense layers remain at the bottom. This process results in a "thermocline" that acts as a transition layer between warmer and colder water layers. During the fall season, the upper layers begin to cool and become denser than the warmer layers, causing an inversion known as "fall turnover". In general, shallow lakes will not stratify and deeper lakes may experience single or multiple turnover cycles. Water temperature was measured in degrees Celsius (°C) with the use of a calibrated Eureka Manta II® thermometer electrode multi-probe. The May 5, 2021 water temperatures of Bear Lake demonstrated a weak thermocline with a temperature difference of 1.0°C in the deepest basin and 0.2°C in the shallower basin. During the July 16, 2021 sampling event, Bear Lake demonstrated a weak thermocline with a temperature difference of 1.0°C in the deepest basin and 0.1°C in the shallower basin. As the water temperatures get warmer throughout the season, the temperatures become less variable from the surface to the lake bottom. Water temperatures in the inlets were slightly lower than in the lake which is normal for flowing waters.

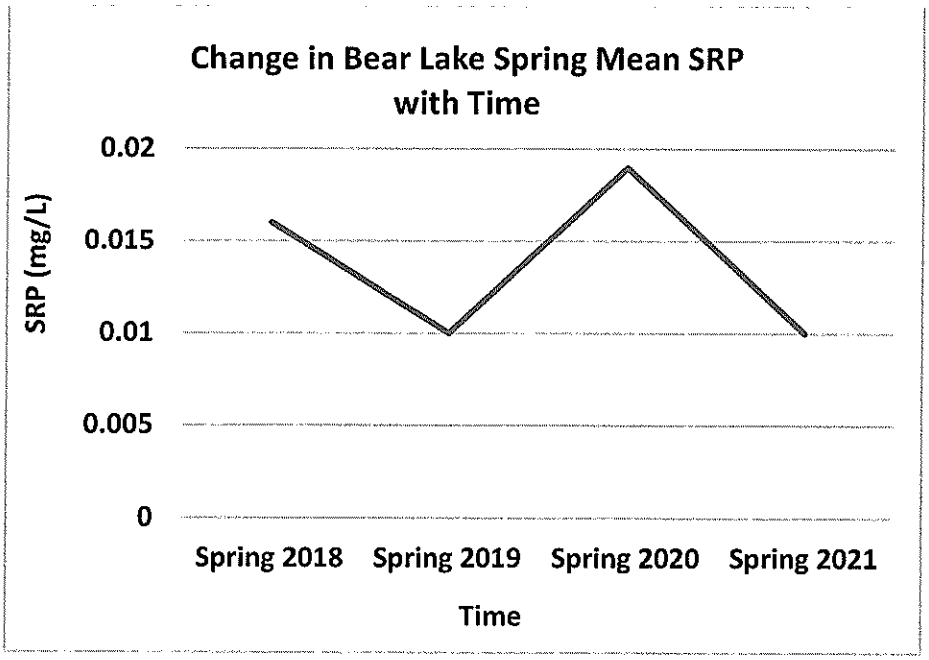
Total Phosphorus and Ortho-Phosphorus (SRP)

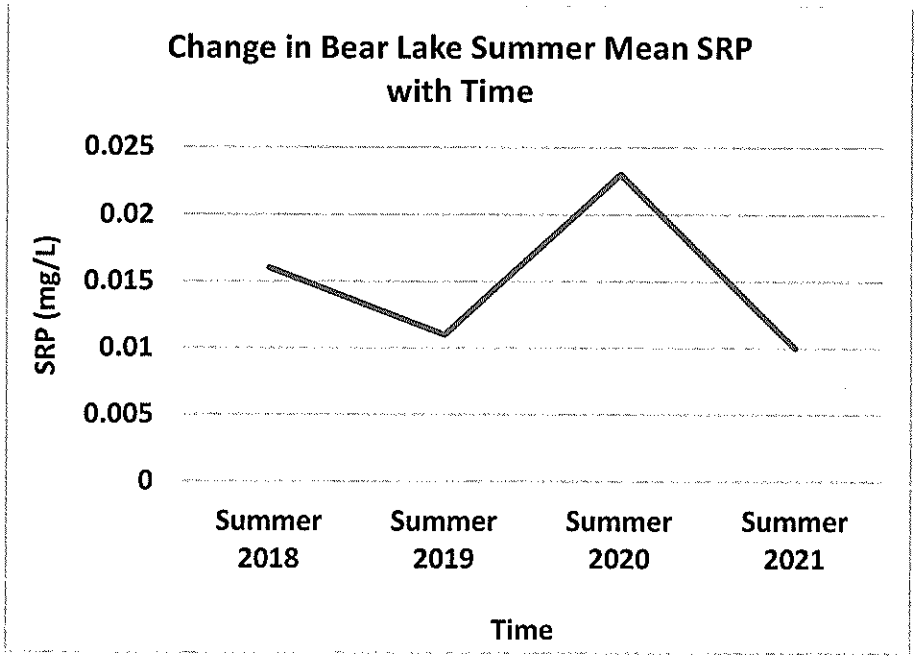
Total phosphorus (TP) is a measure of the amount of phosphorus (P) present in the water column. Phosphorus is the primary nutrient necessary for abundant algae and aquatic plant growth. TP concentrations are usually higher at increased depths due to higher release rates of P from lake sediments under low oxygen (anoxic) conditions. Phosphorus may also be released from sediments as pH increases. The TP levels in Bear Lake are moderate; however, the dissolved oxygen levels are low enough at the bottom to possibly cause release of phosphorus from the bottom. The TP concentrations on May 5, 2021 ranged from 0.020-0.057 mg L^{-1}, which is above the eutrophic threshold (≤ 0.025 mg L^{-1}). The TP concentrations on July 16, 2021 ranged from 0.034-0.050 mg L^{-1}. To determine the faction of bioavailable phosphorus in 2021, RLS measured ortho-phosphorus (also known as SRP) and those concentrations were all below detection at 0.010 mg L^{-1}. The TP from the inlets ranged from 0.012-0.052 mg L^{-1}. TP was measured in the laboratory with analytical method EPA 200.7 (Rev 4.4).

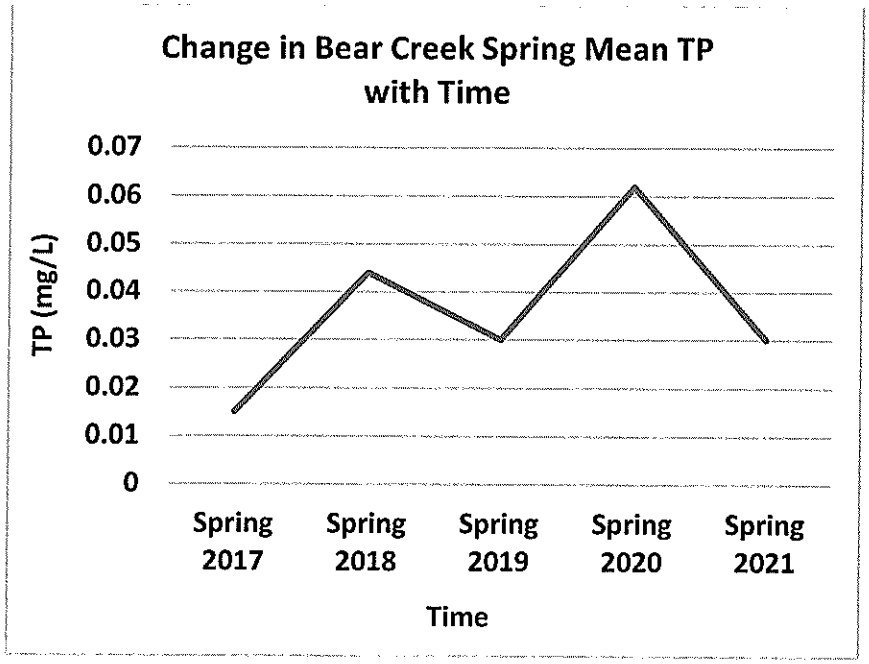
Ortho-phosphorus also known as soluble reactive phosphorus (SRP) is the faction of TP that is bioavailable to aquatic biota such as algae. The higher the SRP concentration, the more TP can be used by algae for growth. The SRP concentrations from the inlets were all <0.010 mg L^{-1} which is favorable. TP was measured in the laboratory with analytical method SM 4500-P (E-11). The trend graphs below demonstrate the changes in mean TP and SRP with time during spring and summer.

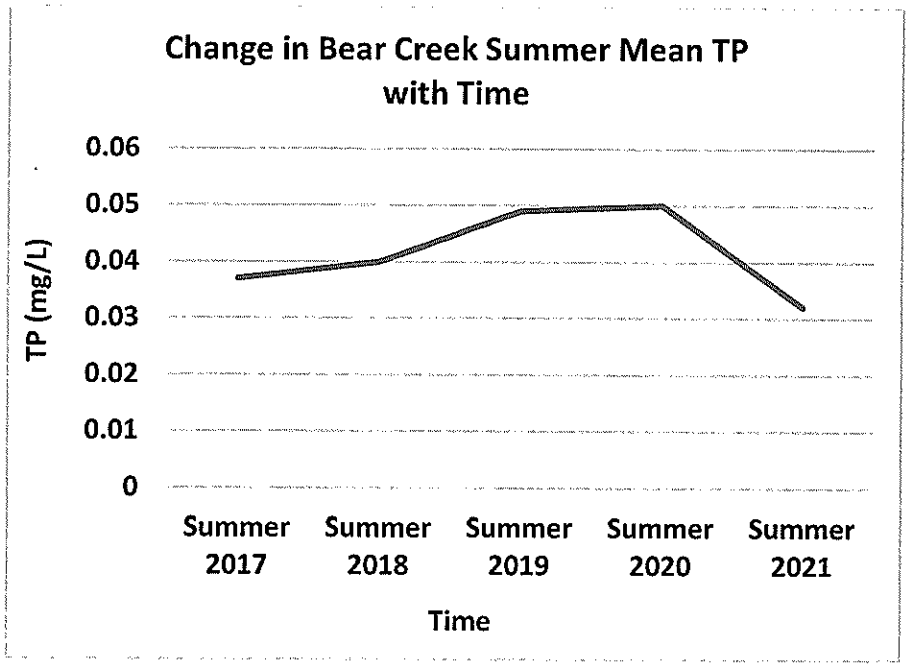

Change in Bear Lake Spring Mean TP with Time
0.05
0.045
0.04
0.035
0.03
0.025
0.02
TP (mg/L)
Spring 2017
Spring 2018
Spring 2019
Spring 2020
Spring 2021
Time

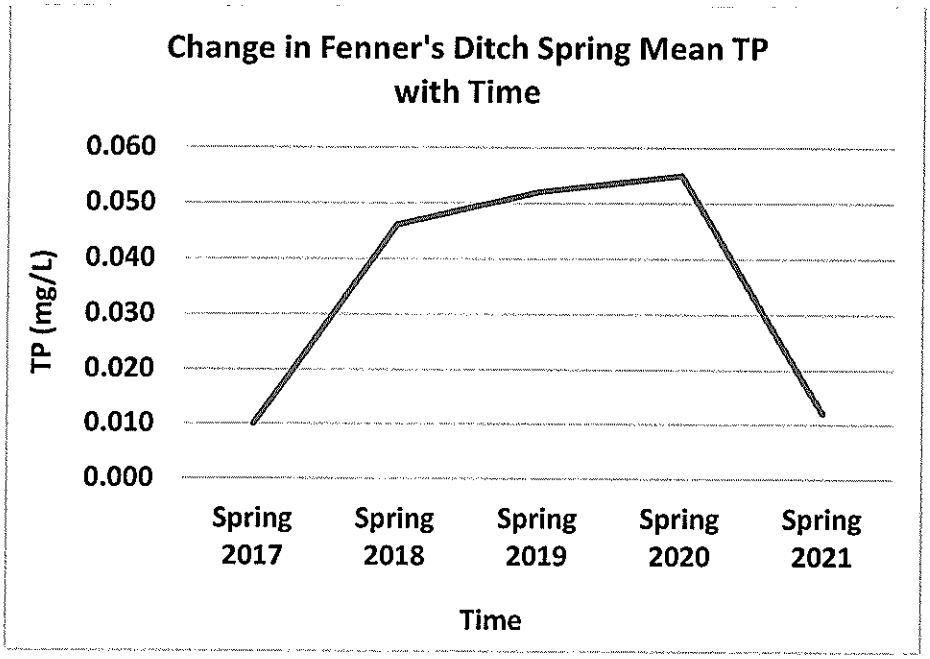

Change in Bear Lake Summer Mean TP with Time
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
TP (mg/L)
Summer 2017
Summer 2018
Summer 2019
Summer 2020
Summer 2021
Time

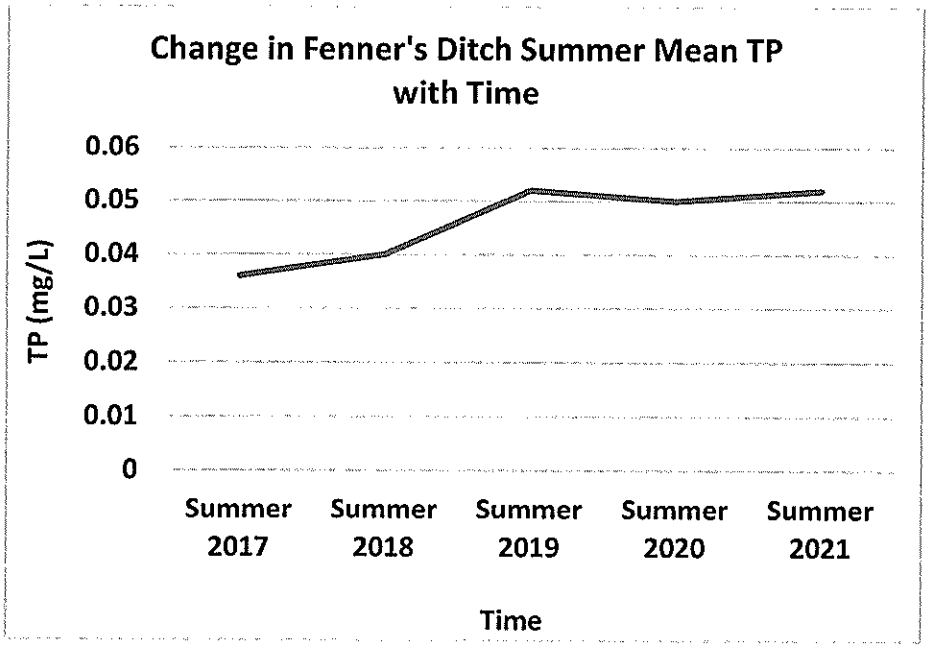

Change in Bear Lake Spring Mean SRP with Time
SRP (mg/L)
0.02
0.015
0.01
0.005
0
Spring 2018
Spring 2019
Spring 2020
Spring 2021
Time


Change in Bear Lake Summer Mean SRP with Time
SRP (mg/L)
0.025
0.02
0.015
0.01
0.005
0
Summer 2018
Summer 2019
Summer 2020
Summer 2021
Time


Change in Bear Creek Spring Mean TP with Time
TP (mg/L)
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
Spring 2017
Spring 2018
Spring 2019
Spring 2020
Spring 2021
Time

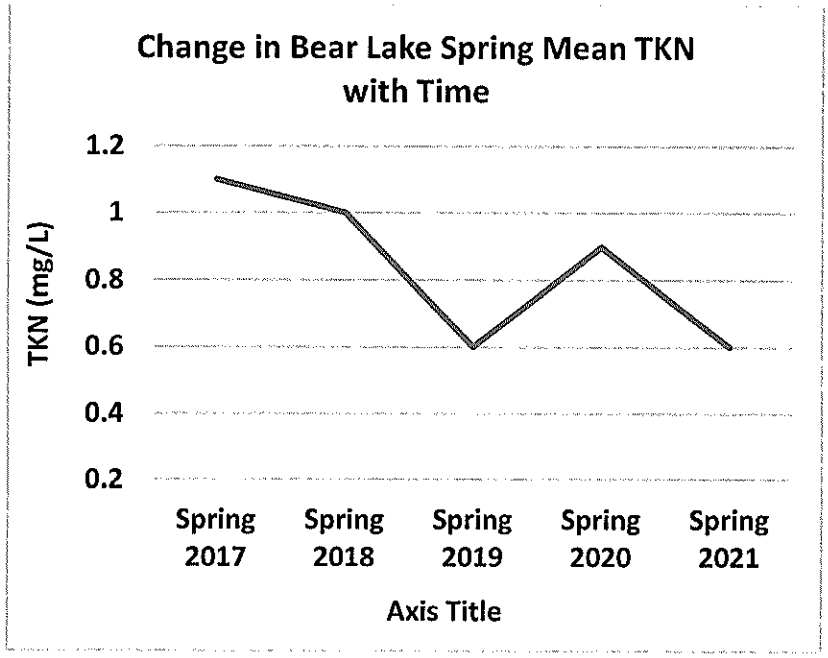

Change in Bear Creek Summer Mean TP with Time
TP (mg/L)
0.06
0.05
0.04
0.03
0.02
0.01
0
Summer 2017
Summer 2018
Summer 2019
Summer 2020
Summer 2021
Time

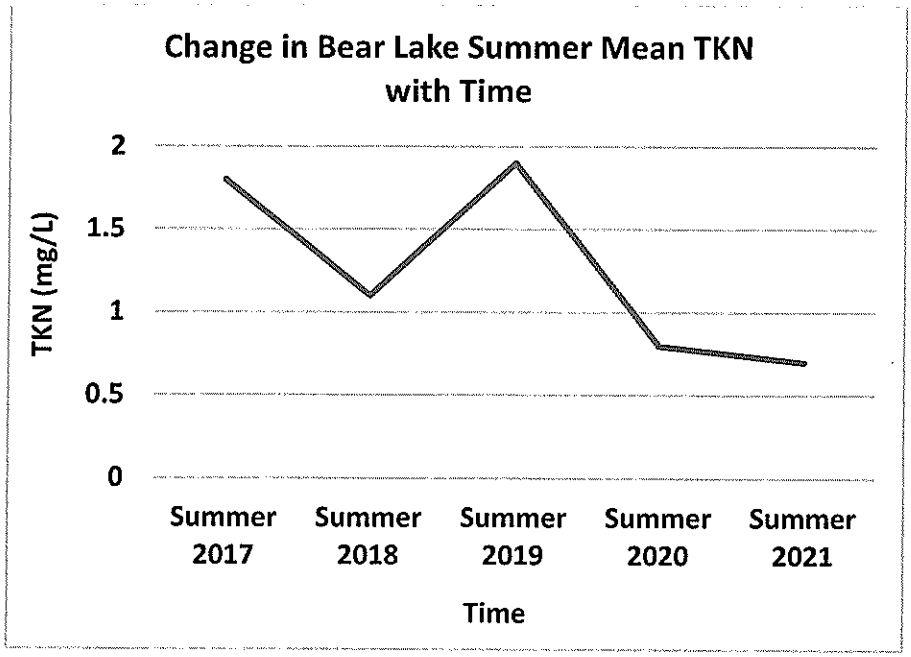

Change in Fenner's Ditch Spring Mean TP with Time
0.060
0.050
0.040
0.030
0.020
0.010
0.000
TP (mg/L)
Spring 2017
Spring 2018
Spring 2019
Spring 2020
Spring 2021
Time

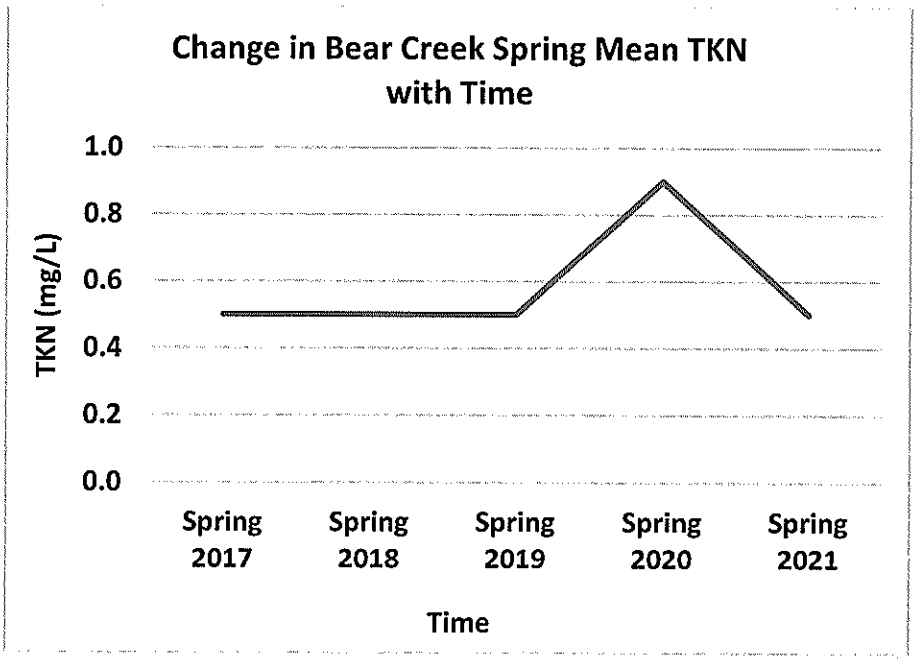

Change in Fenner's Ditch Summer Mean TP with Time
0.06
0.05
0.04
0.03
0.02
0.01
0
TP (mg/L)
Summer 2017
Summer 2018
Summer 2019
Summer 2020
Summer 2021
Time

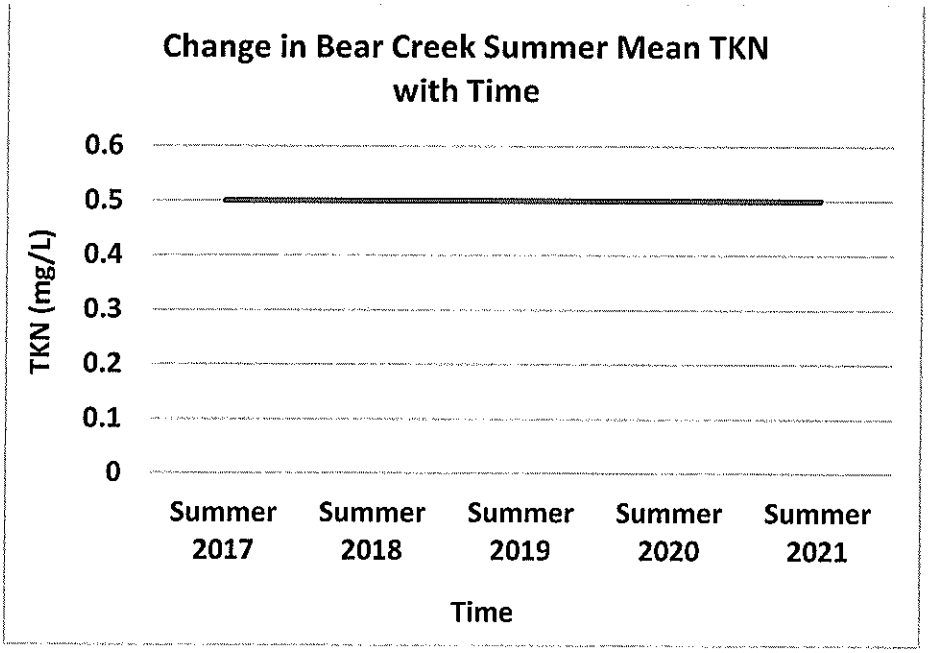
Total Kjeldahl Nitrogen

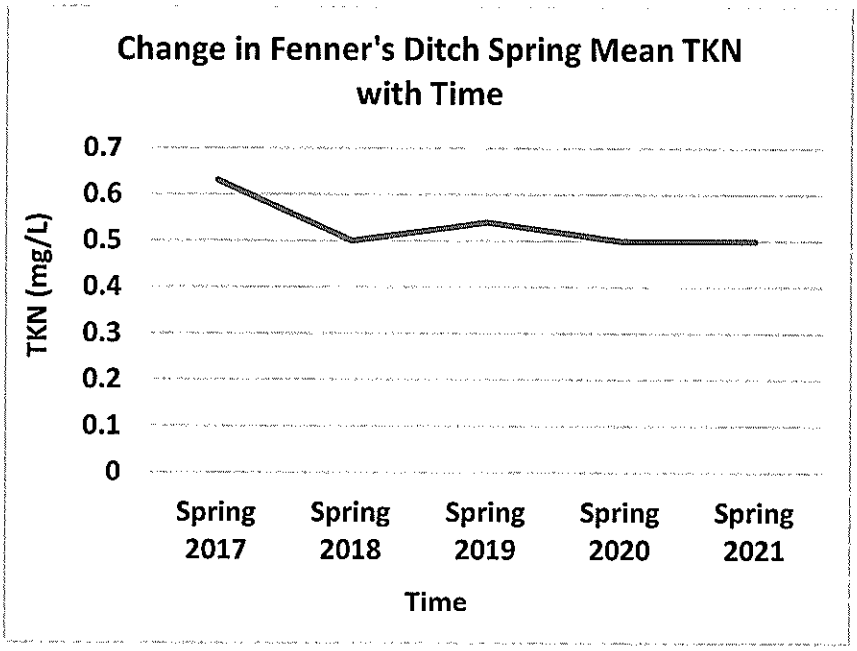
Total Kjeldahl Nitrogen (TKN) is the sum of nitrate (NO_3^-), nitrite (NO_2^-), ammonia (NH_4^+), and organic nitrogen forms in freshwater systems. Much nitrogen (amino acids and proteins) also comprises the bulk of living organisms in an aquatic ecosystem. Nitrogen originates from atmospheric inputs (i.e., burning of fossil fuels), wastewater sources from developed areas (i.e., runoff from fertilized lawns), agricultural lands, septic systems, and from waterfowl droppings. It also enters lakes through ground or surface drainage, drainage from marshes and wetlands, or from precipitation (Wetzel, 2001). In lakes with an abundance of nitrogen (N: P > 15), phosphorus may be the limiting nutrient for phytoplankton and aquatic macrophyte growth. Lakes with a mean TKN value of 0.66 mg L^{-1} may be classified as oligotrophic, those with a mean TKN value of 0.75 mg L^{-1} may be classified as mesotrophic, and those with a mean TKN value greater than 1.88 mg L^{-1} may be classified as eutrophic. The TKN concentrations in Bear Lake on May 5, 2021 ranged from <0.5-0.7 mg L^{-1}, which is moderate for an inland lake. The TKN concentrations in Bear Lake on July 16, 2021 ranged from <0.5-1.1 mg L^{-1}. The TKN of the inlets ranged were all around ≤0.5 mg L^{-1}, which is favorable. TKN was measured in the laboratory using Method EPA 351.2 (Rev 2.0). The trend graphs below demonstrate the change in mean TKN with time during spring and summer.

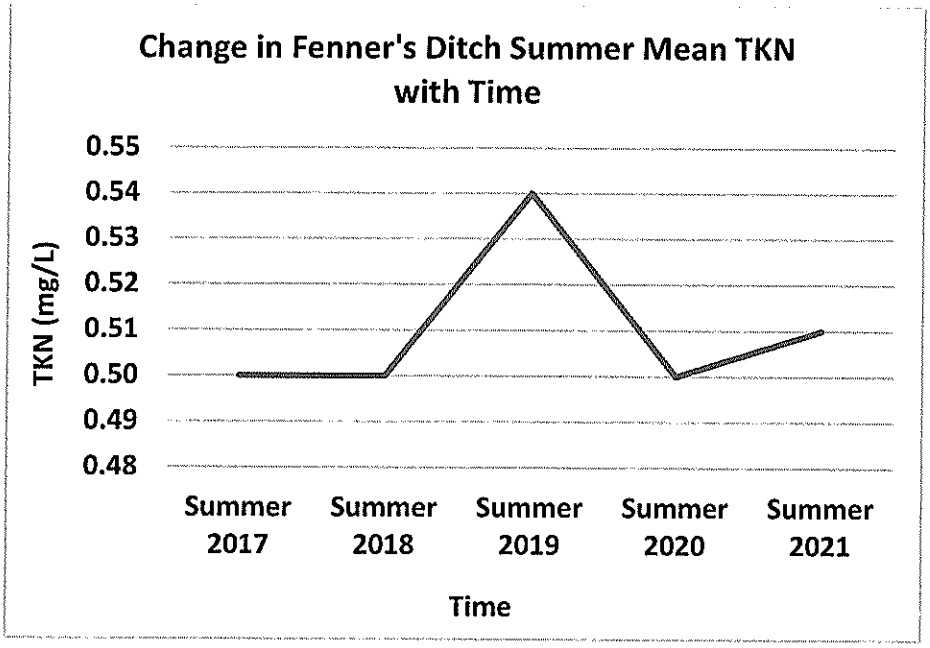



Change in Bear Lake Summer Mean TKN with Time
TKN (mg/L)
2
1.5
1
0.5
0
Summer 2017
Summer 2018
Summer 2019
Summer 2020
Summer 2021
Time


Change in Bear Creek Spring Mean TKN with Time
TKN (mg/L)
1.0
0.8
0.6
0.4
0.2
0.0
Spring 2017
Spring 2018
Spring 2019
Spring 2020
Spring 2021
Time


Change in Bear Creek Summer Mean TKN with Time
TKN (mg/L)
0.6
0.5
0.4
0.3
0.2
0.1
0
Summer 2017
Summer 2018
Summer 2019
Summer 2020
Summer 2021
Time


Change in Fenner's Ditch Spring Mean TKN with Time
TKN (mg/L)
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
Spring 2017
Spring 2018
Spring 2019
Spring 2020
Spring 2021
Time



Turbidity and Total Dissolved Solids

Turbidity is a measure of the loss of water transparency due to the presence of suspended particles. The turbidity of water increases as the number of total suspended particles increases. Turbidity may be caused by erosion inputs, phytoplankton blooms, storm water discharge, urban runoff, re-suspension of bottom sediments, and by large bottom-feeding fish such as carp in shallow areas. Particles suspended in the water column absorb heat from the sun and raise water temperatures. Since higher water temperatures generally hold less oxygen, shallow turbid waters are usually lower in dissolved oxygen. Turbidity was measured in Nephelometric Turbidity Units (NTU's) with the use of a calibrated Lutron® turbidimeter. The World Health Organization (WHO) requires that drinking water be less than 5 NTU's; however, recreational waters may be significantly higher than that.

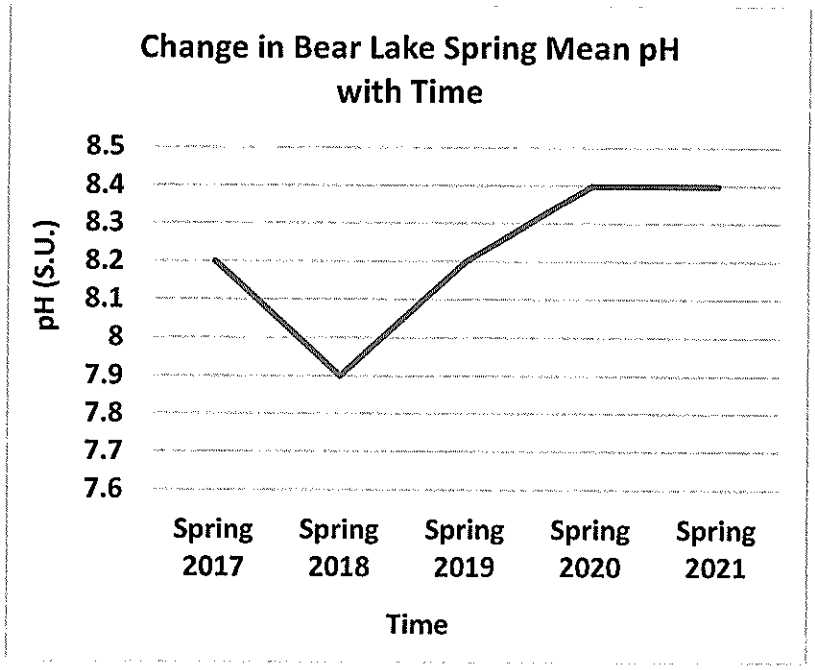
The turbidity of Bear Lake was moderate to high and ranged from 5.0-8.0 NTU's during the sampling events. Spring values would likely be higher due to increased watershed inputs from spring runoff and/or from increased algal blooms in the water column from resultant runoff contributions.

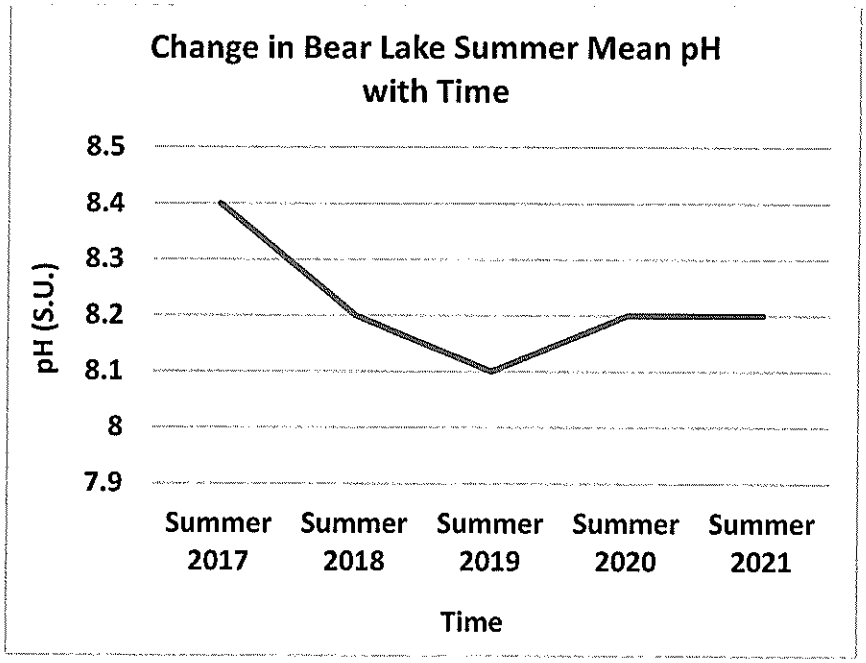
Total dissolved solids (TDS) is a measure of the amount of dissolved organic and inorganic particles in the water column. Particles dissolved in the water column absorb heat from the sun and raise the water temperature and increase conductivity. TDS was measured with the use of a calibrated Eureka Manta II® TDS probe in mg L^{-1}. Spring values are usually higher due to increased watershed inputs from spring runoff and/or increased planktonic algal communities. The TDS in Bear Lake ranged from 254-265 mg L^{-1} for the deep basins during the sampling events, which is moderately high for an inland lake.

The preferred range for TDS in surface waters is between 0-1,000 mg L^{-1} but the lower values are most favorable. The TDS in the inlets ranged from 254-324 mg L^{-1} which is only slightly higher than lake concentrations.

pH

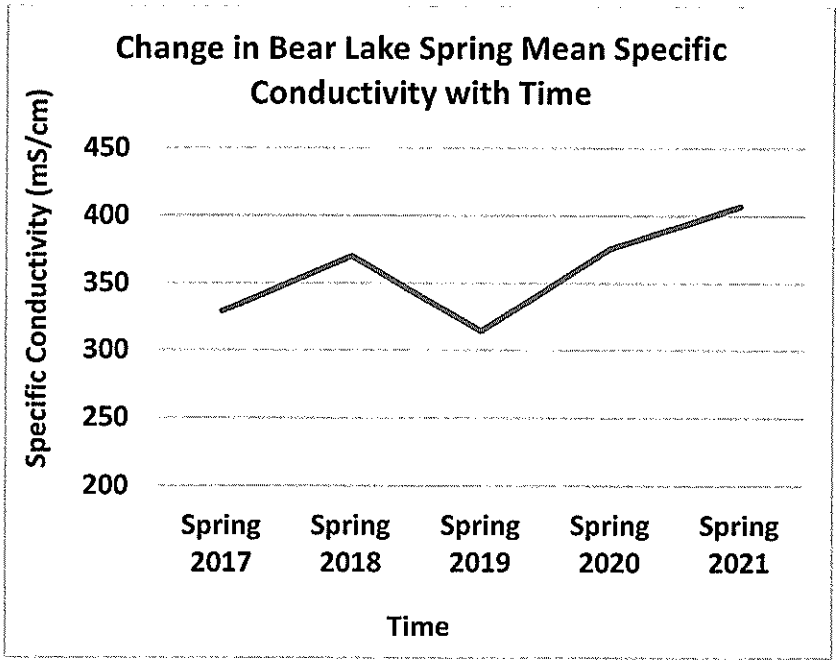
Most Michigan lakes have pH values that range from 6.5 to 9.5. Acidic lakes (pH < 7) are rare in Michigan and are most sensitive to inputs of acidic substances due to a low acid neutralizing capacity (ANC). pH was measured with a calibrated Eureka Manta II® pH probe. Bear Lake is considered "slightly basic" on the pH scale. The pH of Bear Lake and channel ranged from 7.7-8.5 S.U. during the sampling events which is ideal for an inland lake. Lower pH values were recorded at the lake bottom due to increased microbial activity and respiration which can result in a drop in pH relative to surface waters. All of these values are normal and favorable for aquatic environments. The pH values in the inlets ranged from 8.0-8.5 S.U. The trend graphs below demonstrate the changes in mean spring and summer pH.

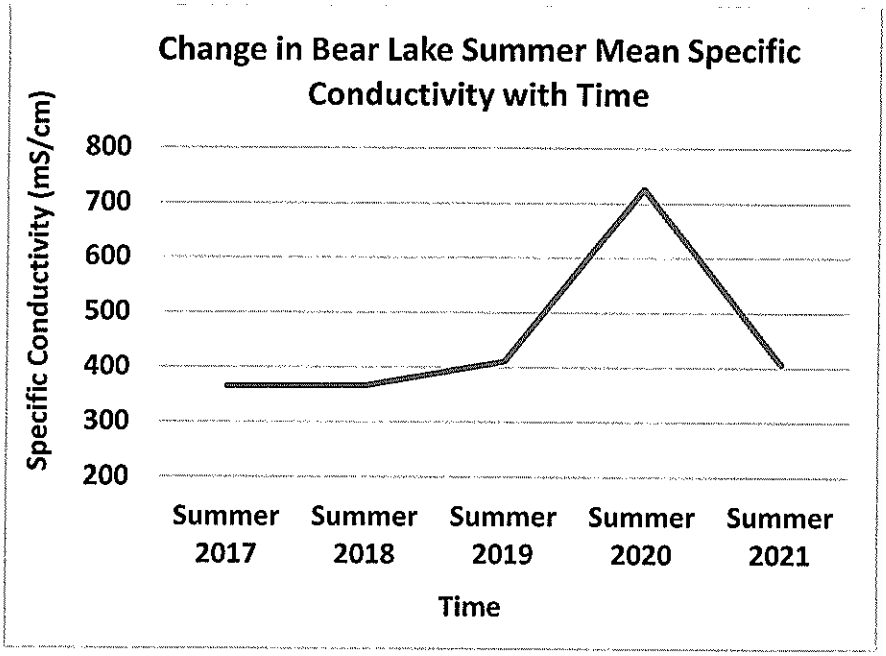



Change in Bear Lake Summer Mean pH with Time
8.5
8.4
8.3
8.2
8.1
8
7.9
pH (S.U.)
Summer 2017
Summer 2018
Summer 2019
Summer 2020
Summer 2021
Time

Conductivity

Conductivity is a measure of the amount of mineral ions present in the water, especially those of salts and other dissolved inorganic substances. Conductivity generally increases as the amount of dissolved minerals and salts in a lake increases, and also increases as water temperature increases. Conductivity was measured with a calibrated Eureka Manta II® probe. The conductivity in Bear Lake ranged from 403-483 µS/cm on May 5, 2021 and from 399-413 µS/cm on July 16, 2021. These values are moderate for an inland lake. Severe water quality impairments do not occur until values exceed 800 µS/cm and are toxic to aquatic life around 1,000 µS/cm. The conductivity values for the inlets were slightly higher and ranged from 384-575 µS/cm. The trend graphs below demonstrate the changes in mean spring and summer specific conductivity with time.




Change in Bear Lake Summer Mean Specific Conductivity with Time
Specific Conductivity (mS/cm)
800
700
600
500
400
300
200
Summer 2017
Summer 2018
Summer 2019
Summer 2020
Summer 2021
Time

Secchi Transparency

Secchi transparency is a measure of the clarity or transparency of lake water and is measured with the use of an 8-inch diameter standardized Secchi disk (Figure 3). Secchi disk transparency was measured by lowering the disk over the shaded side of the boat around noon and taking the mean of the measurements of disappearance and reappearance of the disk. Elevated Secchi transparency readings are usually correlated with increased aquatic plant and algae growth. Eutrophic systems generally have Secchi disk transparency measurements less than 7.5 feet due to turbidity caused by excessive planktonic algae growth. Further, elevated phytoplankton and turbidity, also are associated with decreased Secchi transparency. The Secchi transparency of Bear Lake ranged from 4.5-5.1 feet during the 2021 sampling events. This transparency is very poor and may be inadequate to allow abundant growth of aquatic plants in the majority of the littoral (shallow) zone of the lake. Overgrowth of algae may then occur since aquatic plants may not receive enough light for growth and the algae that are abundant in the water column can utilize the nutrients and low light conditions for growth. Secchi transparency is variable and depends on the amount of suspended particles in the water (often due to windy conditions of lake water mixing) and the amount of sunlight present at the time of measurement. The trend graphs below demonstrate the change in mean spring and summer Secchi transparency with time.

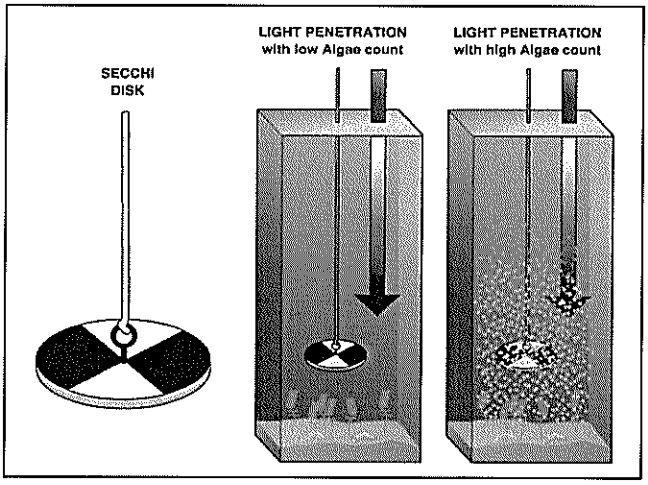
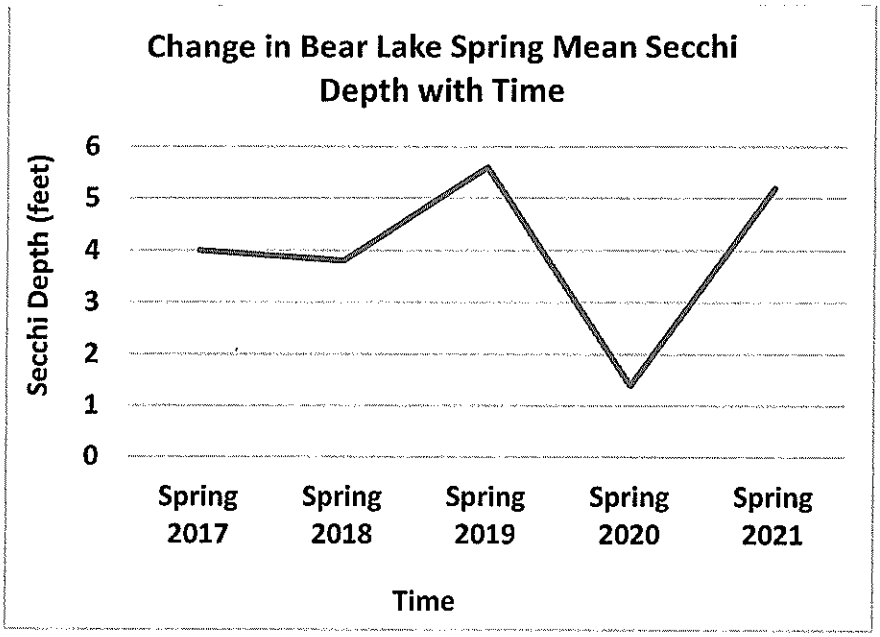
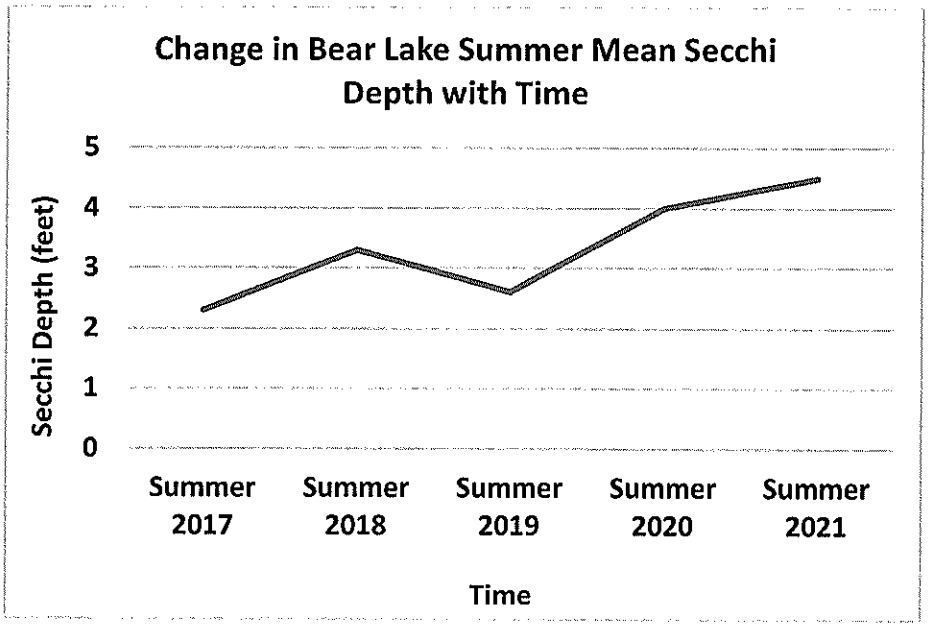


Figure 3. A Secchi disk.


Change in Bear Lake Spring Mean Secchi Depth with Time
Secchi Depth (feet)
6
5
4
3
2
1
0
Spring 2017
Spring 2018
Spring 2019
Spring 2020
Spring 2021
Time


Change in Bear Lake Summer Mean Secchi Depth with Time
Secchi Depth (feet)
5
4
3
2
1
0
Summer 2017
Summer 2018
Summer 2019
Summer 2020
Summer 2021
Time

Chlorophyll-*a* and Algal Species Composition

Chlorophyll-*a* is a measure of the amount of green plant pigment present in the water, often in the form of planktonic algae. High chlorophyll-*a* concentrations are indicative of nutrient-enriched lakes. Chlorophyll-*a* concentrations greater than 6 µg L^{-1} are found in eutrophic or nutrient-enriched aquatic systems, whereas chlorophyll-*a* concentrations less than 2.2 µg/L are found in nutrient-poor or oligotrophic lakes. The chlorophyll-*a* concentrations on May 5, 2021 ranged from 1.07-11.0µg L^{-1} and the chlorophyll-*a* concentrations on July 16, 2021 ranged from 0.267-5.1 µg L^{-1}. Figure 4 shows the conditions in Fenner's Ditch in 2021 where the algal community shifted from cyanobacteria to green filamentous algae. The trend graphs below demonstrate the changes in mean spring and summer chlorophyll-a with time.

The algal genera were determined from composite water samples collected over the deep basins of Bear Lake in 2021 were analyzed with a compound bright field microscope. The genera present included the Chlorophyta (green algae): *Cladophora* sp., *Rhizoclonium* sp., Scenedesmus sp., *Mougeotia* sp., *Spirogyra* sp., *Chlorella* sp., *Haematococcus* sp., *Radiococcus* sp., *Pandorina* sp., and *Chloromonas* sp. The Cyanophyta (blue-green algae): *Microcystis* sp., and *Oscillatoria* sp., the Bascillariophyta (diatoms)*: Synedra* sp., *Navicula* sp., and *Cymbella* sp., and *Fragillaria* sp. The aforementioned species indicate a somewhat diverse algal flora and represent a good diversity of alga; however, the most dominant algae in the water samples were the blue-green algae *Microcystis aueroginosa* and *Oscillatoria rubsecens*, which are problematic for dense algal blooms that may form toxins and present a risk for public health and the overall health of the Bear Lake ecosystem.

Microcystis sp. colonies are a few micrometers in diameter and are evenly distributed throughout a gelatinous matrix. Younger colonies are spherical and older ones are more irregularly shaped. There are numerous gas vesicles, and the algae can thrive at the surface with minimal photo-degradation (breaking down) by the sun. When the sunlight is excessive, the algae can break down and release toxins and lower the dissolved oxygen in the water column. The algae are the only type known to fix nitrogen gas into ammonia for growth. *Microcystis* has also been shown to overwinter in lake sediments (Fallon et *al.*, 1981). In addition, it may thrive in a mucilage layer with sediment bacteria that can release phosphorus under anaerobic conditions (Brunberg, 1995). They assume a high volume in the water column (Reynolds, 1984) compared to diatoms and other single-celled green algae. The blue-green algae have been on the planet nearly 2.15 billion years and have assumed strong adaptation mechanisms for survival. In general, calm surface conditions will facilitate enhanced growth of this type of algae since downward transport is reduced. *Microcystis* may also be toxic to zooplankton such as *Daphnia* which was a zooplankton present in Bear Lake (along with *Bosmina* sp.) and in most lakes (Nizan et *al.*, 1986). Without adequate grazers to reduce algae, especially blue-greens, the blue-green population will continue to increase and create negative impacts to water bodies.

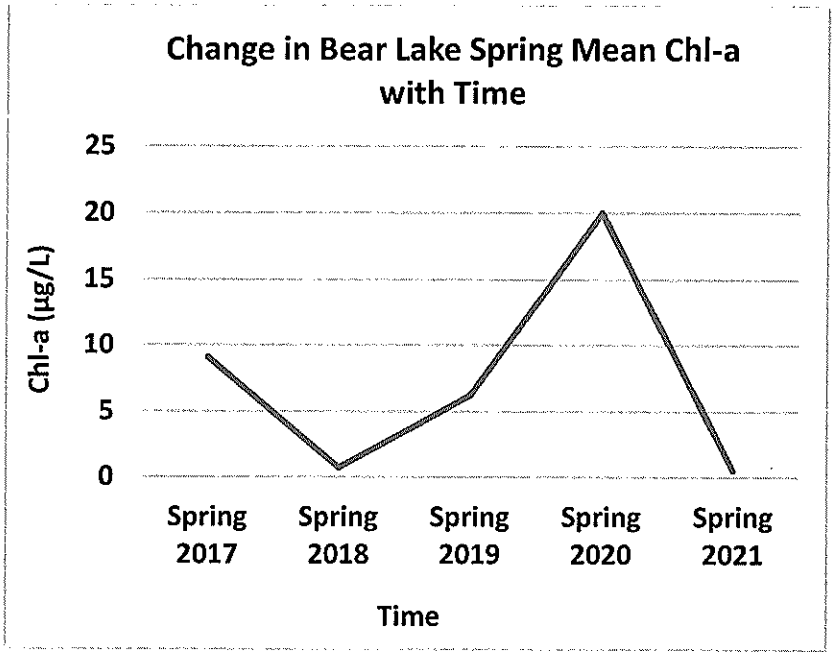
References:

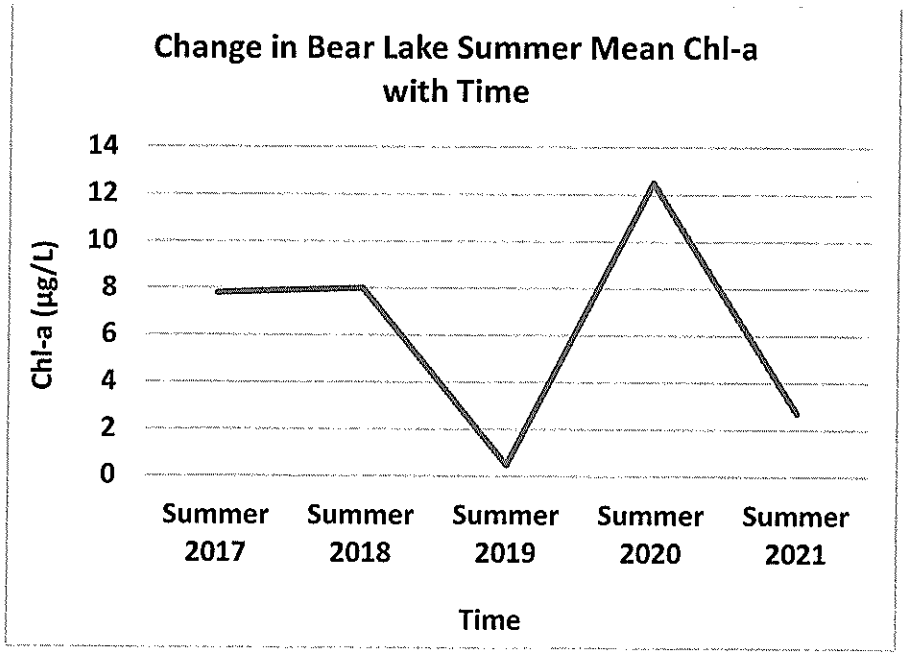
Brunberg, A.K. 2995. Microbial activity and phosphorus dynamics in eutrophic lake sediments enriched with *Microcystis* colonies. *Freshwater Biology* 33: 541-555.

Fallon, R.D., and T.D. Brock. 1981. Overwintering of *Microcystis* in Lake Mendota. *Freshwater Biology* 11:217-226.

Nizan, S., C. Dimentman, and M. Shilo. 1986. Acute toxic effects of the Cyanobacterium *Microcystis aeruginosa* on *Daphnia magna*. *Limnology and Oceanography* 31(3):497-502.

Reynolds, C.S. 1984. The Ecology of Freshwater Phytoplankton. Cambridge University Press, Cambridge, UK.




Change in Bear Lake Summer Mean Chl-a with Time
Chl-a (µg/L)
14
12
10
8
6
4
2
0
Summer 2017
Summer 2018
Summer 2019
Summer 2020
Summer 2021
Time

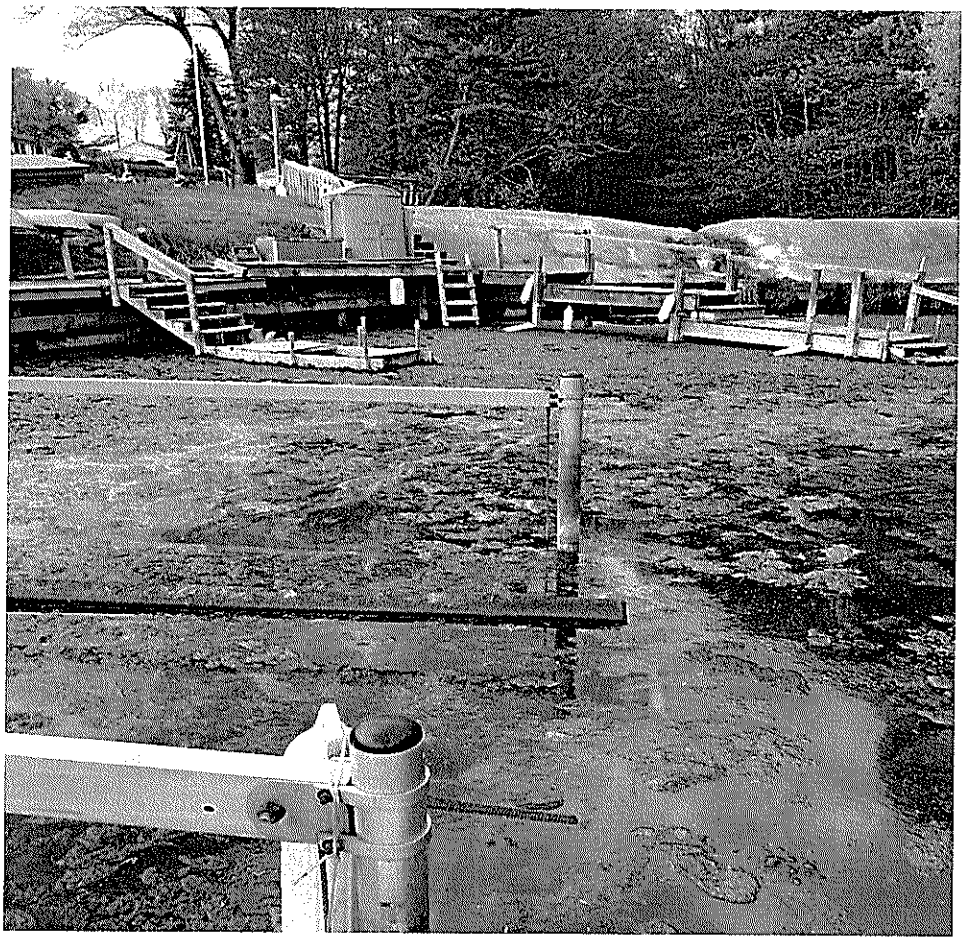


Figure 4. Dense green filamentous algae in Fenner's Ditch (June, 2021).

Section 3

Bear Lake Aquatic Vegetation Data (2021)

Status of Native Aquatic Vegetation in Bear Lake

The native aquatic vegetation present in Bear Lake is essential for the overall health of the lake and the support of the lake fishery. A point-intercept aquatic vegetation species inventory was conducted on Bear Lake on July 7, 2021 and utilized 476 sampling points. Additional whole-lake surveys to determine locations of invasive species were conducted on May 5, 2021, June 5, 2021, and August 20, 2021. An additional type of survey was a whole-lake benthic scan which generated an updated lake depth contour map and aquatic vegetation biovolume map.

The whole-lake aquatic plant survey using the GPS Point-Intercept survey method as in Figure 5 below determined that there were a total of 23 native aquatic plant species in the lake. These included 14 submersed species, 5 floating-leaved species, and 4 emergent species. This indicated a good biodiversity of aquatic vegetation in Bear Lake in 2021 and an increase in 7 native aquatic plant species since the 2017 feasibility study. The overall % cover of the lake by native aquatic plants is low relative to the lake size due to the great mean depth and thus these plants should be protected unless growing near swim areas at nuisance levels. A list of all current native aquatic plant species and their frequency is shown below in Table 10. Aquatic vegetation biovolume is displayed in Figure 6 below. The blue color represents a lack of aquatic vegetation whereas the green color represents low-growing aquatic vegetation. A red color represents aquatic plants that grow high into the water column such as milfoil or pondweeds. This figure demonstrates that a lot of area in the lake lacks aquatic vegetation.

The most dominant aquatic plant species on July 7, 2021 included: 1) Thin-leaf Pondweed which grows to the surface and has short, stringy leaves that accompany a small seed head. This plant can reach nuisance levels and require herbicide treatment.; 2) Wild Celery, which has long, green, ribbon-like leaves and a prominent tuber that generates stolons along the lake bottom. This plant produces a prominent coil when it has been fertilized later in the summer. It too may require treatment but often does not respond well to herbicides due to its thick cuticle; 3) White-stem Pondweed has long, bright green leaves and grows high into the water column. All of these species are favorable for the lake fishery and will help compete with the blue-green algae for nutrients in the lake water.

Figure 5. Aquatic vegetation sampling points for a whole-lake aquatic plant species inventory survey in Bear Lake (July 7, 2021).

Table 10. Bear Lake Native Aquatic Plant Species (July 7, 2021).

Native Aquatic Plant Species Name	*Aquatic Plant Common Name*	*Frequency (%)*	*Aquatic Plant Growth Habit*
Chara vulgaris	Muskgrass	13.8	Submersed, Rooted
Potamogeton pectinatus	Thin-leaf Pondweed	40.8	Submersed, Rooted
Potamogeton zosteriformis	Flat-stem Pondweed	5.0	Submersed, Rooted
Potamogeton robbinsii	Fern-leaf Pondweed	0.4	Submersed, Rooted
Potamogeton praelongus	White-stem Pondweed	25.0	Submersed, Rooted
Potamogeton richardsonii	Clasping-leaf Pondweed	6.3	Submersed, Rooted
Potamogeton amplifolius	Large-leaf Pondweed	0.4	Submersed, Rooted
Potamogeton natans	Floating-leaf Pondweed	0.4	Submersed, Rooted
Zosterella dubia	Water Stargrass	14.2	Submersed, Rooted
Vallisneria americana	Wild Celery	27.1	Submersed, Rooted
Elodea canadensis	Common Waterweed	2.1	Submersed, Rooted
Ceratophyllum demersum	Coontail	9.2	Submersed, Non-Rooted
Utricularia vulgaris	Bladderwort	2.0	Submersed, Non-Rooted
Najas minor	Brittle Naiad	0.4	Submersed, Rooted
Nymphaea odorata	Whitewater Lily	9.2	Floating-leaved, Rooted
Brasenia schreberi	Watershield	0.8	Floating-leaved, Rooted
Nuphar variegata	Yellow Waterlily	4.2	Floating-leaved, Rooted
Lemna minor	Duckweed	0.4	Floating-leaved, Non-Rooted
Wolffia sp.	Watermeal	0.4	Floating-leaved, Non-Rooted
Pontedaria cordata	Pickerelweed	1.7	Emergent
Typha latifolia	Cattails	10.4	Emergent
Scirpus acutus	Bulrushes	0.8	Emergent
Decodon verticillatus	Swamp Loosestrife	0.4	Emergent

Figure 6. Aquatic vegetation biovolume scan and map of Bear Lake on , July 16, 2021 (RLS). NOTE: The blue color represents no vegetation present; Red color represents tall, high-growing aquatic plants; Green color represents low-growing vegetation on the lake bottom such as Chara.

Status of Invasive (Exotic) Aquatic Plant Species

The amount of Eurasian Watermilfoil (Figure 7) and Curly-leaf Pondweed (Figure 8) present in Bear Lake varies each year and is dependent upon climatic conditions, especially runoff-associated nutrients and seed bank ecology. In 2021, the seed bank was very active in Bear Lake which resulted in increased nuisance milfoil as well as an abundance of native plants. The May 5, 2021 survey revealed that approximately 10.8 acres of dense milfoil were found throughout the entire lake and were treated by PLM on May 24, 2021 with a combination of the systemic herbicide ProcellaCOR® and the contact herbicide diquat for root-killing and sustained control. On June 18, 2021 a shoreline algae treatment was conducted by PLM due to the presence of dense green filamentous algae growing nearshore in many areas. On July 7, 2021, approximately 39 acres of Eurasian Watermilfoil were present and were treated on July 19, 2021 with the contact herbicide diquat since the milfoil was growing with Thin-leaf Pondweed which does not respond to systemic treatment. Finally, on September 1, 2021, an algal treatment for dense green filamentous algae was conducted on Fenner's Ditch by PLM due to thick mats in that region. Treatment maps for each of these invasive species are shown in the maps below (Figures 9-10). The invasive emergent Phragmites has been reduced to approximately 0.1 acres of active growth due to previous treatment efforts (Figure 11).

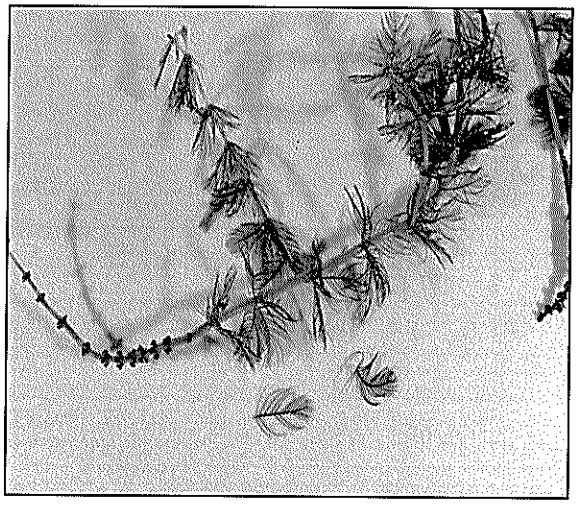


Figure 7. Eurasian Watermilfoil

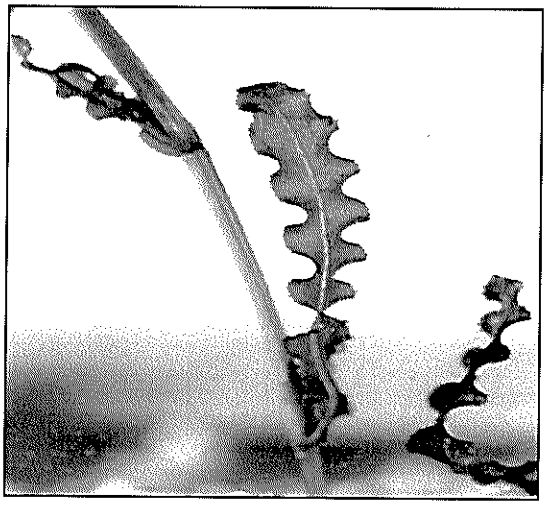


Figure 8. Curly-leaf Pondweed

Figure 9. Dense EWM in Bear Lake (May 5, 2021).

Figure 10. Dense EWM in Bear Lake (July 7, 2021).

Figure 11. Invasive emergent Phragmites and Curly-leaf Pondweed around the shoreline of Bear Lake (May 5, 2021).

Section 4

Management Recommendations for 2022

1. Aquatic Vegetation Surveys:

Continuous and regular aquatic vegetation surveys are needed in 2022 to determine the precise locations of Eurasian Watermilfoil (EWM) Curly-leaf Pondweed (CLP), or other problematic invasives in/or around Bear Lake. These surveys should include at least monthly visits to the lake as well as a whole lake inventory later in the season once all native aquatic plant species have germinated. RLS has been actively studying the change in native aquatic plant community structure since of the primary management objectives is to increase the native biodiversity to allow for competition against invasive species as well as with cyanobacteria for nutrients. RLS will also conduct a whole-lake benthic scan of the aquatic vegetation biovolume and sediment relative hardness during the 2022 season.

2. Aquatic Herbicide Treatments:

Due to the relative scarcity of native aquatic vegetation in Bear Lake relative to the lake surface area, the treatment of these species with aquatic herbicides is not recommended and re-colonization of the lake by these species is a major goal for the health of Bear Lake. The plan for 2022 includes he use of high doses of systemic aquatic herbicides (such as the new systemic herbicide ProcellaCOR® or triclopyr nearshore and 2, 4-D offshore) for the hybrid milfoil that may be present. If dense milfoil is present along with a nuisance native aquatic plant, then a contact herbicide such as diquat or diquat with ProcellaCOR® may be needed. Doses will be dependent upon the EGLE permit requirements as well as the size and density of the weed beds. If Curly-leaf is found at a nuisance level, it could be treated with the contact herbicide Aquathol-K® with great efficacy. If Starry Stonewort is found, then it may be treated with flumioxazin and hydrothol. As in previous years, RLS will be present to directly oversee the herbicide treatments to assure due diligence and precision with surveyed locations. On occasion, new treatment areas may be located during the actual treatment date and RLS will work with the applicator to assure these areas are added as long as they necessitate treatment. It is critical to remember that a major goal of the lake improvement program is to reduce the abundance of invasive species overall, and not necessarily focus on individual beaches.

3. Lake Water Quality Monitoring:

Water quality parameters will be monitored in Bear Lake for 2022 as in previous years. Fenner's Ditch and Bear Creek will also be sampled for the same water quality parameters as in previous years. These trends are important to follow as it allows for the determination of the efficacy of implemented upstream watershed improvements on lake health over time.

4. Fenner's Ditch Management:

Fenner's Ditch presents unique management challenges. The west side of the canal has very little vegetation with steep slopes towards the lakeshore. It is highly recommended that residents plant emergent plants down there to stabilize the shoreline and reduce erosion inputs and nutrient runoff into the canal. RLS recommends phosphorus-binding applications using PhosLock® which may require up to three applications at a cost of $1,100 per application. This should reduce the frequency of algal blooms in the canal throughout the season.

5. Bear Lake Sediment Petroleum:

RLS has been in discussions with the Geologic Unit of EGLE to determine possible mitigation strategies for petroleum deposits in Bear Lake sediments that were previously mapped by RLS based on sediment cores sampled using EPA methods. RLS will be looking into possible funding sources to assist with such efforts.

6. Bear Lake Watershed Management:

After recent discussions with EGLE, it is clear that they would like to see implemented more of the watershed recommendations originally offered by RLS in the lake improvement feasibility study. Those can be found in Section 7.3 but include specific methods for proper shoreline management Best Management Practices (BMP's), proper land use, implementation of nutrient reduction strategies to reduce land nutrient runoff and more.

7. Bear Lake Community Education:

Bear Lake riparians are encouraged to attend regular Bear Lake Board (BLLB) meetings that may held to discuss data trends and evaluate lake improvement progress. Once mitigation strategies are executed in future years, then there will be a need to incorporate different educational strategies into this lake restoration program. RLS recommends integration of an annual lake workshop where new data is presented to the public and new research information is disseminated. This should occur on the same date as a BLLB meeting with enhanced hours so more public can attend. Riparian BMP's and lake protection methods would be openly discussed with attendants. There would be handouts at the workshop with modernized lake maps, water quality graphs, and other updated lake information. Lastly, there would be water quality sampling demonstrations along with key Bear Lake biota present in the lake available for learning.

Professional Aquatic Consulting Services Contract
For Bear Lake, Muskegon County, Michigan
2022 (Renewable Annually Based on Performance)

The Bear Lake Lake Board, hereinafter called the "Board," and Restorative Lake Sciences, LLC, hereinafter called the "Consultant" agree to this contract made on this 14th day of January, 2022.

Part I - Professional Lake Management Consulting Components

The following items will be included in the professional consulting services for 2022:

1. Have a Consultant scientist in attendance at Board meetings that are conducted for purposes of improvements to Bear Lake or to present critical information to the Board. **Cost per meeting is to be $375 per staff x 1 staff present at N=12 BLLB meetings: $4,500. Note: If a meeting is cancelled, RLS will reduce the quarterly fee in the following quarter to reflect that cancellation and subsequent price reduction.**

2. Prepare any required herbicide, harvesting, and/or biological control contractor bid documents. Cost: **INCLUDED**

3. Prepare a professional aquatic management update to the BLLB to be distributed to riparians about Bear Lake improvements via email and/or the BLLB website and/or possibly with tax statements if allowed by the municipalities. Such material shall be published on a bi-annual basis on April 1st and Oct 1st 2022. **Cost: $0 for updates, and a fee of $1,500 for mailing and printing, to all riparians. if RLS performs the mailing and printing. Note: RLS would bill separate for mailed and printed updates.**

4. RLS will assist the BLLB with the development of an educational workshop to be held on the same day as a scheduled BLLB meeting. This workshop would have a budget of up to $1,500 to cover printing costs for educational brochures, materials, etc.

5 Technical assistance and dissemination of scientific information to the Board regarding the ecological status of Bear Lake or other factors (external or internal) that may affect the balance of the Bear Lake aquatic ecosystem. This information would also be provided to riparians via published updates and/or the BLLB website. The BLLB Chairman, or his designee, will be the sole communicator for riparian's requests. **Cost: INCLUDED**

modified accordingly. The cost would be $1,130 per basin for 2 basins at 2 sampling dates (spring and summer or summer and late fall) with two staff present. **Cost: $4,520.**

12. Preparation of a Bear Lake annual progress report (primarily updates on the current treatment program and proposed future plans will be presented at the December 2022 or January 2023 Board meeting - the reports will include all water quality data, aquatic vegetation survey results and maps, tables showing the biodiversity and relative abundance of native aquatic plants in the lake, and verification that contractor activities were successfully executed along with treatment dates and the amount of each product used. Since we have had many years of data collection, this data will be presented in trend graph format. This trend data would also be provided to riparians via published updates and/or riparian updates. RLS will share specific improvement areas as compared to the improvement Plan and any shortfalls. **Cost: $1,700.**

13. Assistance with any tax tribunals and other official duties that must be legally performed to keep the Board in compliance with the State of Michigan laws. **Cost: INCLUDED**

14. Consultant agrees to comply with all applicable laws, regulations, and ordinances, whether local, State, or Federal, with respect to the services to be performed pursuant to this contract; to comply with all applicable workers' compensation laws, State and Federal income tax laws, and State and Federal anti-discrimination laws, whether general or specific; and to hold the Board harmless by reason of any claims made against the Board or Consultant for violation of any such laws, regulations, or ordinances. By way of example only, in performing the services required under this contract, Consultant shall not discriminate against any person on the basis of race, color, religion, sex, national origin, age, disability, height, weight, marital status, or veteran status.

15. Consultant shall perform its services under this contract as skillfully and as expeditiously as is consistent with a high degree of care and diligence in accordance with the highest standards prevailing in the State of Michigan for professional consultants performing services of a similar nature.

16. Neither Consultant nor the Board shall assign, sublet, or transfer any rights or interest in this contract (or any obligations under this contract) without the written consent of the other. Unless specifically stated to the contrary in any written consent to an assignment, and unless agreed to by the other party to this contract, no assignment will release or discharge the assignor from any duty or responsibility under this contract.

17. All documents, including but not limited to drawings and specifications furnished by Consultant to the Board, shall be the property of the Board. All documents furnished to Consultant by the Board shall remain the property of Board. All documents covered by this paragraph shall be returned or provided to the Board upon termination of this contract.

Part II - Duration of Contract

the Board or from a breach of this contract by the Board. The indemnity required here shall not be limited by reason of the specification of any particular insurance coverage in this contract or any other agreement of the parties.

2. Consultant shall, at a minimum, purchase and maintain such insurance as will protect it and the Board from any and all claims which may arise out of or result from Consultant's operations under this contract, whether such operations be by itself or by anyone directly or indirectly employed by Consultant, or by anyone for whom Consultant may be liable. By way of example only, such claims may include:

   (a) Claims under workers' compensation, disability benefit, and other similar employee benefit acts which are applicable to the work to be performed under this contract;

   (b) Claims for damages because of bodily injury, occupational sickness or disease, or death of Consultant's employees under any applicable employer's liability law;

   (c) Claims for damages because of bodily injury or death of any person other than Consultant's employees;

   (d) Claims for damages insured by usual personal injury liability coverage which are sustained (i) by any person as a result of an offense directly or indirectly related to the employment of such person by Consultant or (ii) by any other person;

   (e) Claims for damages because of injury to or destruction of tangible property, including loss of use of that property; and

   (f) Claims for damages because of bodily injury or death of any person or property damage arising out of the ownership, maintenance, or use of any motor vehicle.

Part IV - Payments to Consultant

1. The total cost of consulting services for this contract on Bear Lake will be a total of $22,060. Payments are due on a quarterly basis for a total of $5,515 per quarter. The Consultant agrees that quarterly billings will be billed to the Board on a quarterly basis and sent directly to the Board Chairman.

2. For additional evaluation items requested by the Board, the Consultant will be paid at a billing rate of $85 per hour.

IN WITNESS WHEREOF, the Bear Lake Lake Board and Restorative Lake Sciences, LLC execute this agreement.

Consultant

By_____

Ronald A. Bultje <rbultje@dickinson-wright.com>
To Darrell and Suzanne Van Fossan, Jennifer L. Smith

FW: EXTERNAL: Subject: Lake Board By-Laws

2:26 PM

7 attachments

Thanks, Darrell. My intent would be to review the draft, compare it to other bylaws I've done for any missing items that should be addressed, and then revise/edit the entire document as necessary.

If your board meets monthly, I could have it done by the meeting after I'm authorized to do the review.

My estimate is that I could do this for less than $1000.

Let me know if you have other questions. Thanks.

Ronald A. Bultje Member
200 Ottawa Ave., N.W.
Suite 1000
Grand Rapids MI 49503
Phone 616-336-1007
Fax 844-670-6009
Email RBultje@dickinsonwright.com
Profile | V-Card

DICKINSON WRIGHT PLLC
ARIZONA CALIFORNIA FLORIDA ILLINOIS KENTUCKY MICHIGAN NEVADA
OHIO TENNESSEE TEXAS WASHINGTON D.C. TORONTO

From: Darrell and Suzanne Van Fossan <darrellsuzanne@comcast.net>
Sent: Tuesday, January 4, 2022 8:54 PM
To: Ronald A. Bultje <RBultje@dickinson-wright.com>
Subject: EXTERNAL: Subject: Lake Board By-Laws

Hi Ron,

I am sending you the attached rough draft of the BLLB by-laws for the purposes of providing me with the answers to my original e-mail questions. We modeled them after the existing Bear Lake Preservation Association (BLPA) by-laws, which may or may not apply to the Lake Board.

Look forward to hearing from you before my next BLLB meeting on Thursday, January 13

Bear Lake Social Survey Budget

The Bear Lake social survey will follow a three-wave mailing protocol, with each mailing sent at two-week intervals. The first contact will consist of an advanced notice letter informing the recipient of the study. The letter will contain a QR code link to a digital version of the survey. Next, a printed copy of the survey will be mailed in a questionnaire packet that includes a cover letter with instructions and a postage-paid envelope. Finally, a thank you/reminder postcard will be sent. It will thank householders who have responded to the study for doing so and remind those that have not returned their surveys to respond. A QR code link to the digital survey will again be included for convenience. In addition to materials and postage for survey mailings, the budget estimate below includes wages for one student worker to assist with assembling mailings and entering data from returned paper surveys into a digital database. For her time overseeing the survey mailings, analyzing the data, and preparing a report of results, one month of summer salary at a half-time equivalent is also requested for the supervising faculty member.

Item	Per Unit	Number	Subtotal	Description
Materials				
Letter head with logo	$ 0.11	600	$66.00	Advanced notice letter (contact 1), cover letter (contact 2) (CSP)
Questionnaire printing	$ 1.32	300	$396.00	Paper cover, booklet print, center staples (contact 2) (GV Copy Center)
Postcard printing	$ 0.20	300	$60.00	4x6" gloss white cardstock, (contact 3) (CSP)
#10 envelopes	$ 0.20	300	$60.00	Standard business with SSL logo (contact 1) (CSP)
6x9" booklet envelopes	$ 0.40	300	$120.00	For questionnaire packet (contact 2) (CSP)
#10 BRM envelopes	$ 0.20	300	$60.00	Business reply return envelopes (contact 2) (CSP)
Mailing Labels	$ 26.36	1	$26.36	Office Depot brand, 1 x 2 5/8" 3,000 count
Toner	$ 176.00	1	$176.00	HP 81A black LaserJet cartridge, Office Depot
Bulk mail postage	$ 0.16	600	$96.00	Letters (contact 1), postcards (contact 3)
Bulk mail postage	$ 0.80	300	$240.00	Questionnaire packets (contact 2)
Return postage	$ 0.51	200	$102.00	Business reply postage at first class rate
Materials Subtotal			**$1,402.36**	
Personnel				
Ugrad Wages	$ 14.47	120	$1,736.40	One student at $14.47 for 15 hours per week for 8 weeks (120 hours)
Ugrad Fringe	7.65%		$132.83	Student summer fringe
Faculty Summer Salary	$ 7,353.67	0.5	$3,676.84	One month faculty summer salary @ 50% FTE
Faculty Fringe	8.43%		$309.96	Faculty summer fringe
Personnel Subtotal			**$5,856.03**	
Indirect Costs	30%		**$2,148.48**	
Total			**$9,406.87**	