Northeast Aquatic Research
Alejandro Reyes, CLM
www.northeastaquaticresearch.net
July 13th, 2022

To: Lake Hayward Property Owner's Association
RE: 2021 Lake Hayward Water Quality Monitoring Summary Report

Contents

Introduction

Twice per month from May to October, volunteer monitors conducted water quality monitoring of Lake Hayward. The primary monitoring location (Station 1) was located at the site of deepest water in the lake. Water clarity, water temperature, and dissolved oxygen was collected at this station. Water samples were also collected once a month for laboratory analysis of principal plant growth nutrients, phosphorus and nitrogen (specifically total phosphorus, total nitrogen, ammonia-nitrogen, and nitrate-nitrogen). These water samples were collected at 1m, 6m, 9m, and 11m. Only the 1m sample was analyzed for nitrate-nitrogen, while only the 11m sample was analyzed for total iron.

A second station, located in shallower water at the southeastern end of the lake, was visited to measure water clarity, water temperature, and dissolved oxygen. In 2021, this shallow northern station was moved to deeper water where the maximum depth was 6 meters.

Recommendations for 2022

- Continue monitoring in-lake conditions using volunteer efforts.
- Obtain quotes for both algaecide treatments and nutrient inactivation treatments (preferably lanthanum-based products) from reputable applicators.
  - The algaecide treatments should be explored for the July to August timeframe when clarity and cyanobacteria cell counts are the worst.
- Follow up on high-nutrient inlets identified in 2021 with continued monitoring, adding E. coli sampling during baseflow conditions.
  - Provide data to the health department, which has the authority to inspect individual septic systems and require compliance.
- Investigate the use of filter media such as Eutrosorb® and biochar to absorb a portion of the phosphorus and nitrogen entering from select streams.

Results

Water Clarity

- Seasonal trends in water clarity from 2019, 2020, and 2021 are shown in Figure 1.
- Water clarity has shown a regular decline from good values of 5-6 meters in May to poor values of 2-3 meters after August 1st in both 2020 and 2021.
- The 2019 water clarity was, in most cases, better than 2020 and 2021, with water clarity better than 3.5 meters for the whole season and very good clarity of 5.5 meters in August.
- Water clarity tended to improve in October in 2020 and 2021.

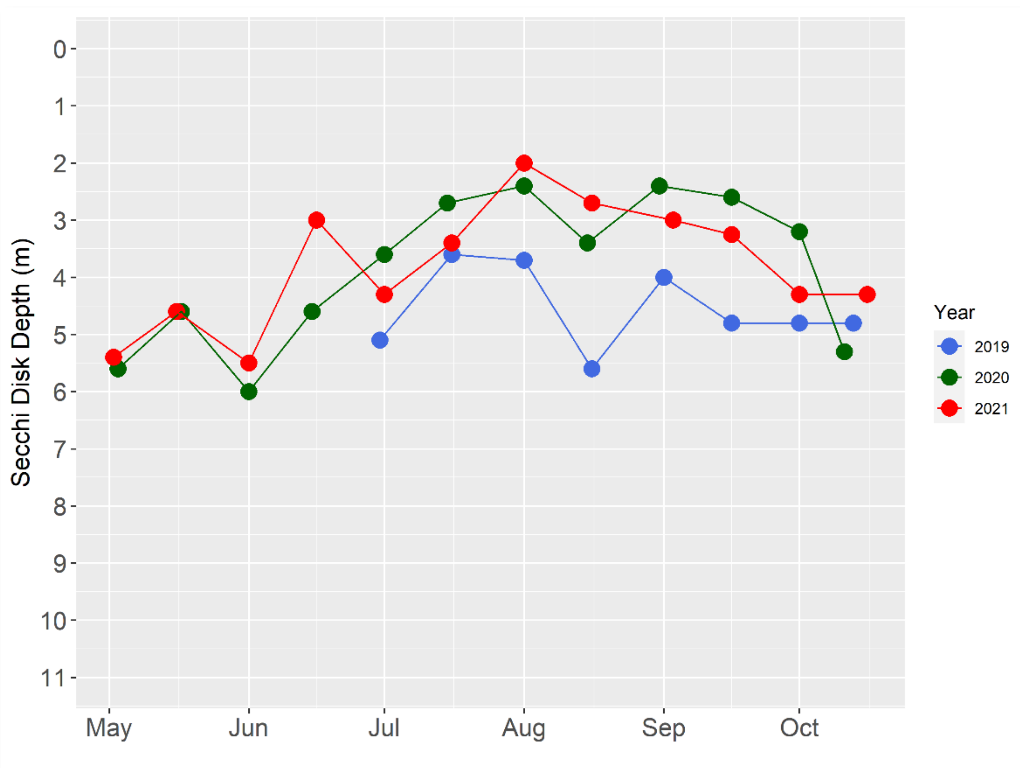

Figure 1. Lake Hayward 2019, 2020, and 2021 water clarity measured at the deep station.

Surface Water Temperature

- Surface and bottom water temperatures from Lake Hayward during 2021 are shown in Figure 2. Comparisons to previous years are shown in Figure 3. Water temperature profiles for 2021 are shown in Figure 4.
- Surface water temperature increased from 16°C on May 1 to the maximum for the year of 26.2 °C on July 1st. Surface temperatures were suppressed in July and early August due to almost constant rainfall during that period.
- Temperatures were relatively consistent from 2019 to 2021, with the largest differences documented at the beginning of July and the beginning of August (Figure 3).
    - Lower temperatures during July and August are likely due to increased rainfall in these months.
- Stratification began prior to the May 3rd sampling and persisted through October 1st.

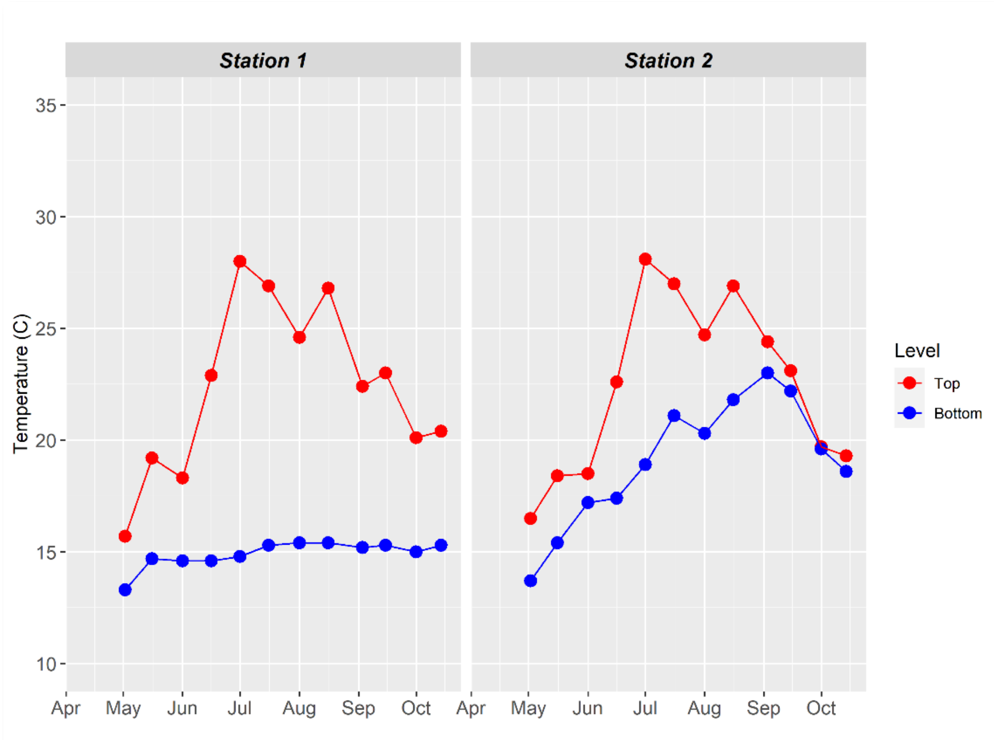

Figure 2. Lake Hayward surface and bottom water temperatures, Station 1 is 11 meters deep, and Station 2 is 6 meters deep.

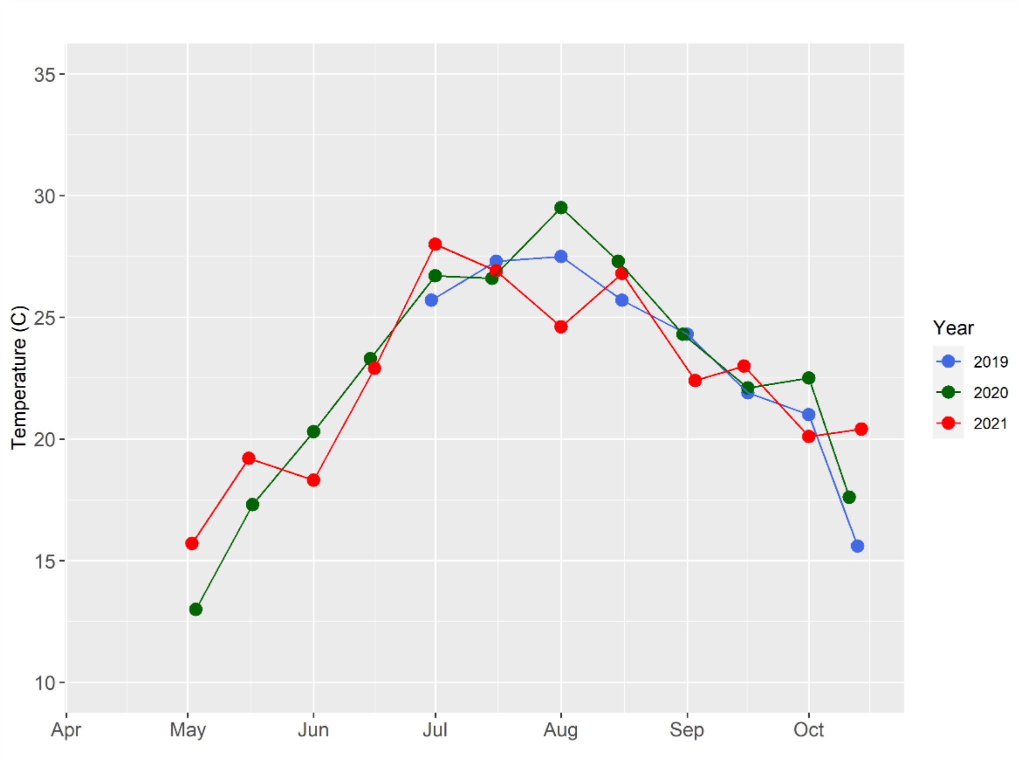

Figure 3. Lake Hayward surface water temperatures from 2019 to 2021.

Lake Stratification

- Data on water temperature profiles and lake stratification is shown in Figures 4 & 5 and Table 1.
- Stratification most likely began shortly before the June 16th sampling. Temperature started to decline with depth as early as the May 16th sampling.
- Stratification was present for the entirety of the season, still evident during the October 14th sampling date.
- Thermocline depth declined as the season progressed, as was the case in 2019 and 2020.

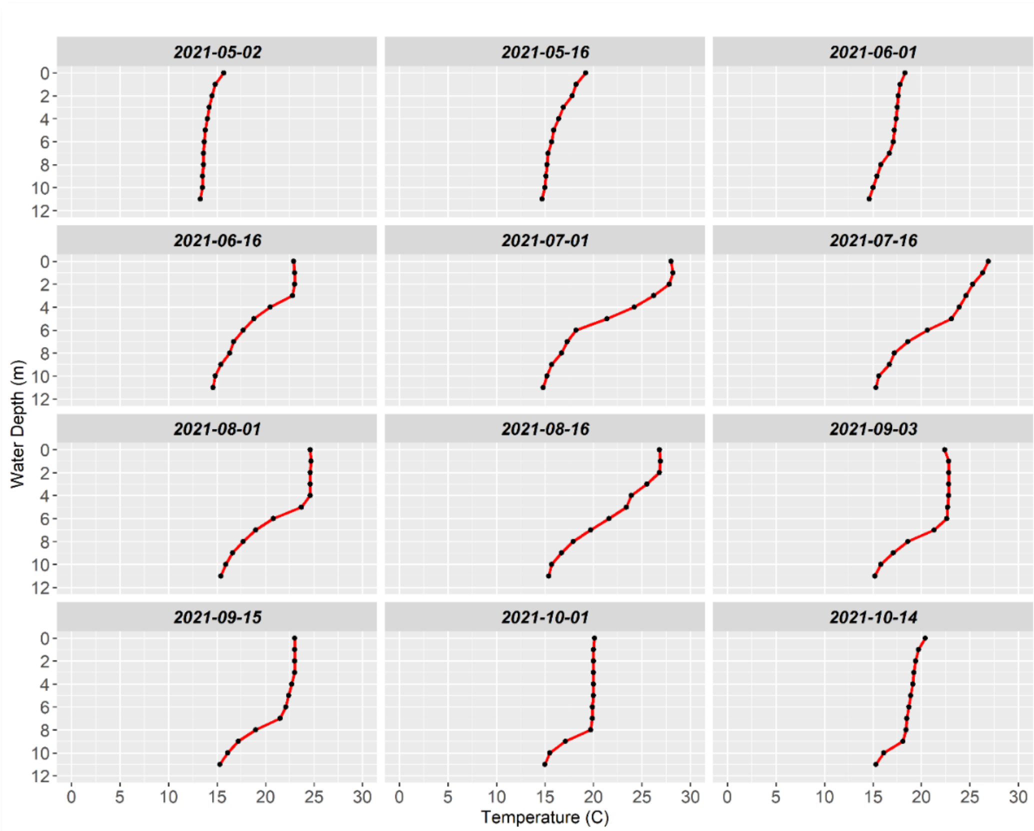

Figure 4. Lake Hayward temperature profiles from 2021 measured at the deep station.

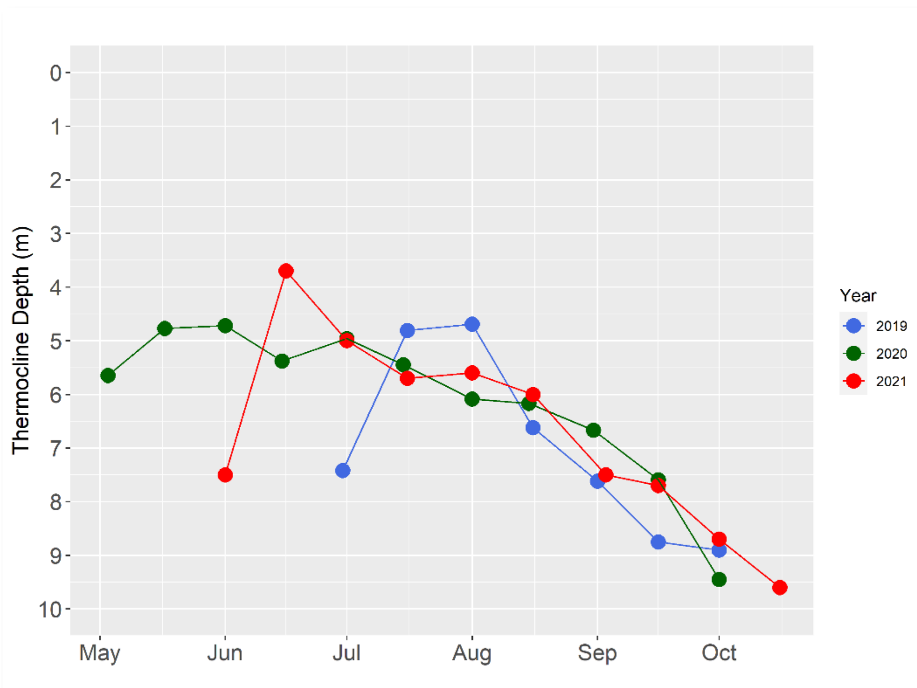

Figure 5. Lake Hayward 2021, 2020 and 2019 thermocline depth. The thermocline is defined as the zone of maximum thermal gradient, i.e., the largest difference between two temperature readings at depth.

Dissolved Oxygen

- Dissolved oxygen concentrations, the anoxic boundary, and the anoxic area are detailed in Figures 6-8 respectively.
- Dissolved oxygen concentrations on June 2nd and 16th were anoxic at the very bottom (11-meter depth), most likely due to the probe being slightly within the sediment on that date.
    - Sampling notes via the volunteers indicate that in May, the observed depth via depth sounder was between 35.8 and 35.0 ft just under 11 meters.
- Dissolved oxygen in the deep waters first started to deplete sometime in late May, and was anoxic by the June 16th sampling trip. The start date of anoxia is somewhere between the 1st and the 16th of June.
- Anoxia persisted from mid-June into the middle of October. Anoxic water was still present in October and was most likely still present into the end of the month.
- The depth of the anoxic boundary increased as the summer progressed, with the shallowest anoxic depths observed on July 15th and August 15th.
- The anoxic boundary in 2021 was shallower, earlier on in the season than in 2020.
    - Specifically anoxic boundary values in June and July of 2021 were recorded at shallower depths than the same depths in 2021.

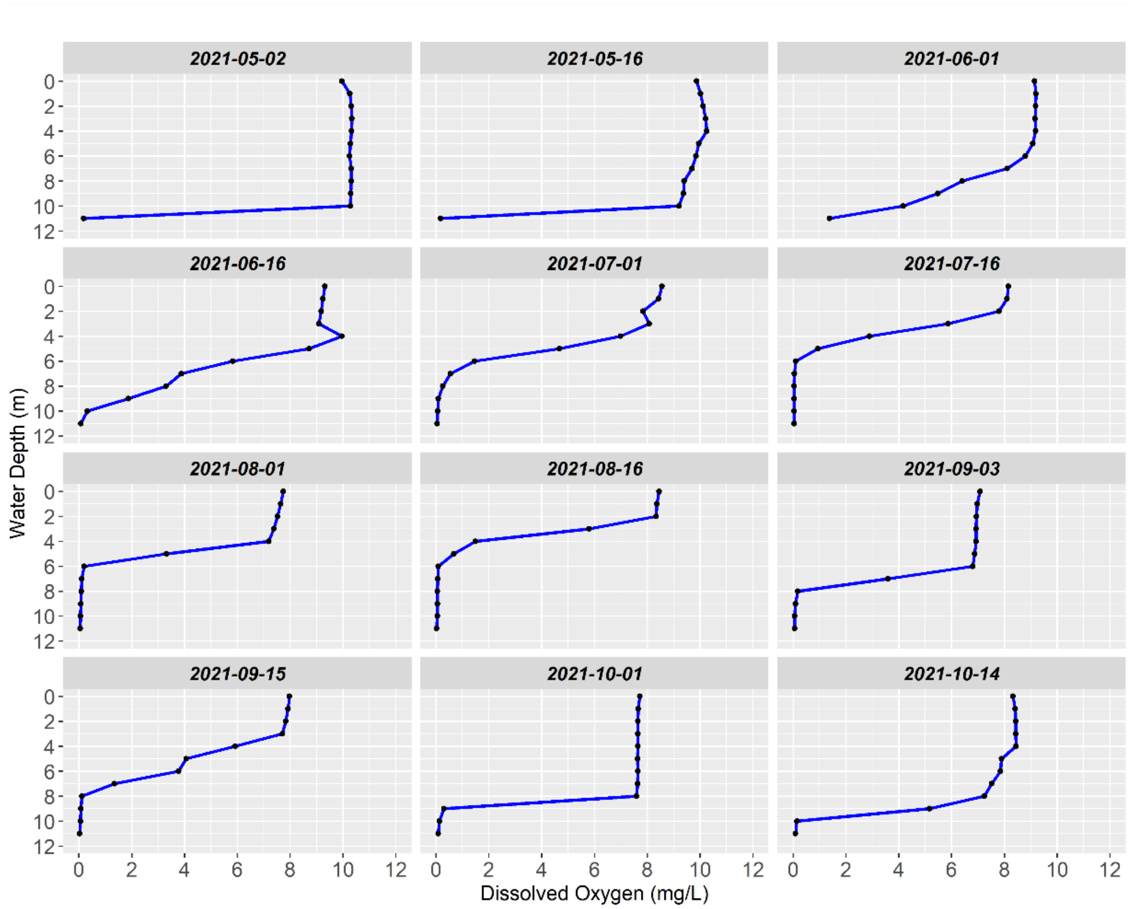

Figure 6. Lake Hayward 2021 Station 1 dissolved oxygen concentrations.

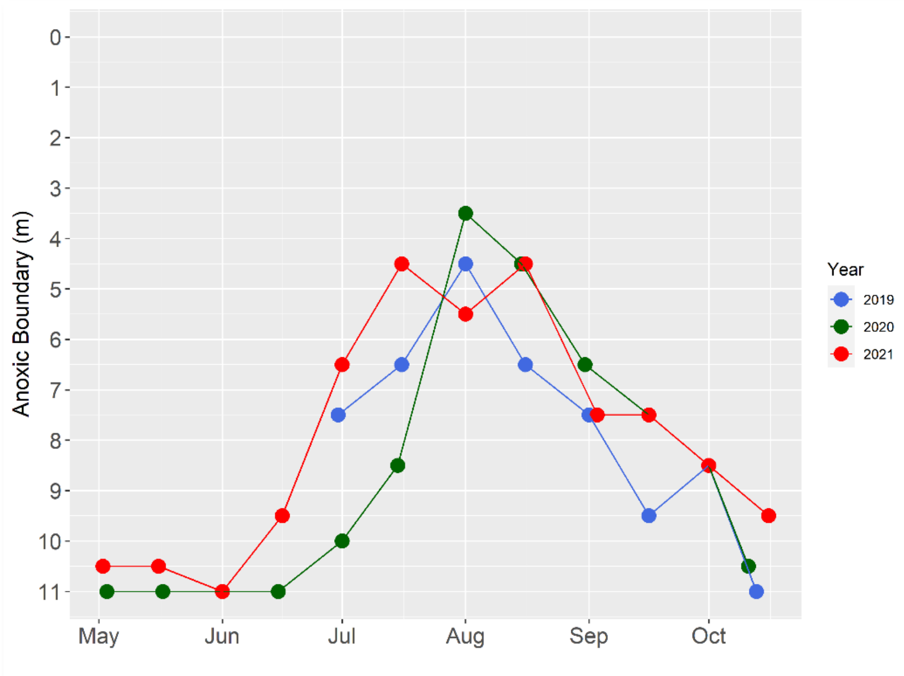

Figure 7. Lake Hayward 2019-2021 Station 1 anoxic boundary.

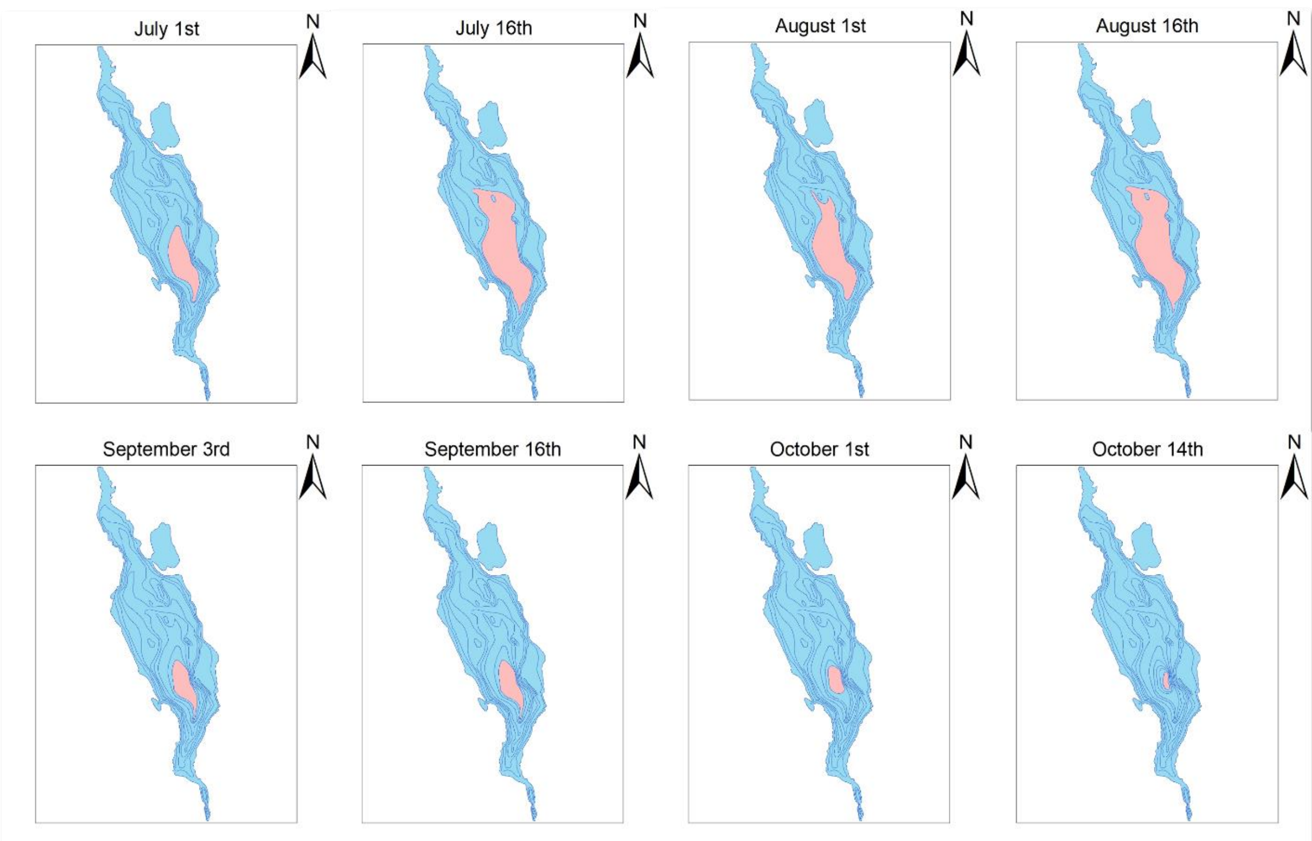

Figure 8. Lake Hayward 2021 estimated anoxic area. Red shaded area indicates the estimated sediment area which is in contact with <1 mg/l of oxygen.

Table 1. Thermocline depth and anoxic boundary in 2021 at both stations. NA values in the station 2 thermocline depth and anoxic boundary column indicate there was either no thermocline or anoxic conditions present.

Date	Thermocline Depth (m)		Anoxic Boundary (m)	
	Station 1	Station 2	Station 1	Station 2
2-May	*7.5*	*NA*	*10.5*	*NA*
16-May	*3.7*	*NA*	*10.5*	*NA*
1-Jun	*5*	*NA*	*11*	*NA*
16-Jun	*5.7*	*4.6*	*9.5*	*NA*
1-Jul	*5.6*	*4.8*	*6.5*	*NA*
16-Jul	*6*	*5.5*	*4.5*	*4.5*
1-Aug	*7.5*	*5.5*	*5.5*	*5.5*
16-Aug	*7.7*	*3.3*	*4.5*	*5.5*
3-Sep	*8.7*	*NA*	*7.5*	*NA*
15-Sep	*9.6*	*NA*	*7.5*	*NA*
1-Oct	*7.5*	*NA*	*8.5*	*NA*
14-Oct	*3.7*	*NA*	*9.5*	*NA*

Nutrients

- Nutrient concentrations from 2021 and comparisons to 2019 and 2020 data are shown in Table 2 and Figures 9-12.
- Surface total phosphorus decreased during the late spring and early summer, with a sharp increase during September.
    - Surface phosphorus concentrations were lower in 2021 than in past years for every month except for September and October.
- Bottom total phosphorus remained low until August, where there was a steady increase documented through October, with a high concentration of 164 µg/L.
    - Total iron was also highest during the October sampling.
- Surface total nitrogen decreased during the late spring and early summer, with a sharp increase during August and September.
- Bottom total nitrogen increased steadily as the season went along, with a high concentration of 1,856 µg/L.

Table 2. Nutrient Results from 2021 Sampling. TP = Total Phosphorus, TN = Total Nitrogen, NH_3 = Ammonia-Nitrogen, NOx = Nitrate-Nitrogen, Fe = Total Iron.

Depth	Date	NH_3 (µg/L)	NOx (µg/L)	TN (µg/L)	TP (µg/L)	Fe (µg/L)
1	5/1/2021	8	184	348	14	--
6		*5*	185	334	*9*	--
9		*6*	184	329	13	--
11		*7*	183	341	11	92
1	6/1/2021	13	77	263	13	--
6		17	78	259	12	--
9		58	132	342	14	--
11		163	117	406	15	240
1	7/1/2021	*6*	1.5	193	*8*	--
6		151	--	351	*9*	--
9		290	--	430	18	--
11		531	--	568	19	NA
1	8/1/2021	1.5	1.5	368	*10*	--
6		385	--	552	21	--
9		579	--	647	23	--
11		926	--	876	71	215
1	9/3/2021	135	48	322	24	--
6		158	--	361	23	--
9		956	1.5	865	36	--
11		1,524	1.5	1,497	106	12,230
1	101/2021	118	92	381	16	--
6		123	--	378	17	--
9		118	--	376	17	--
11		**2,410**	--	1,856	164	17,530

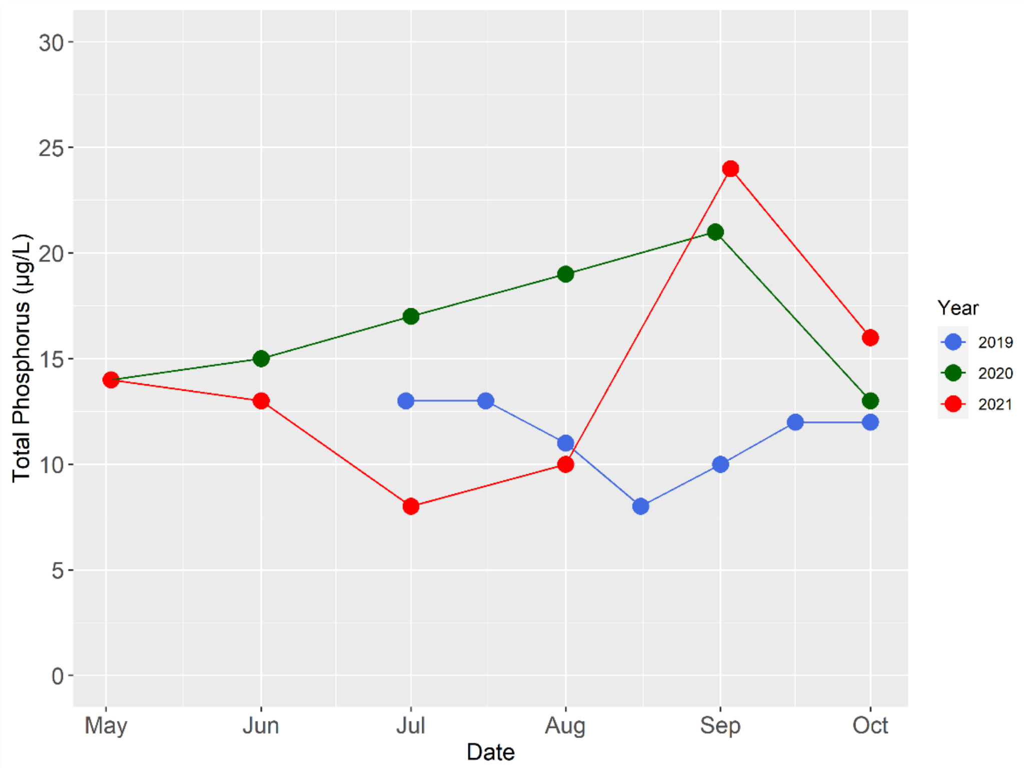

Figure 9. Lake Hayward 2019-2021 surface total phosphorus

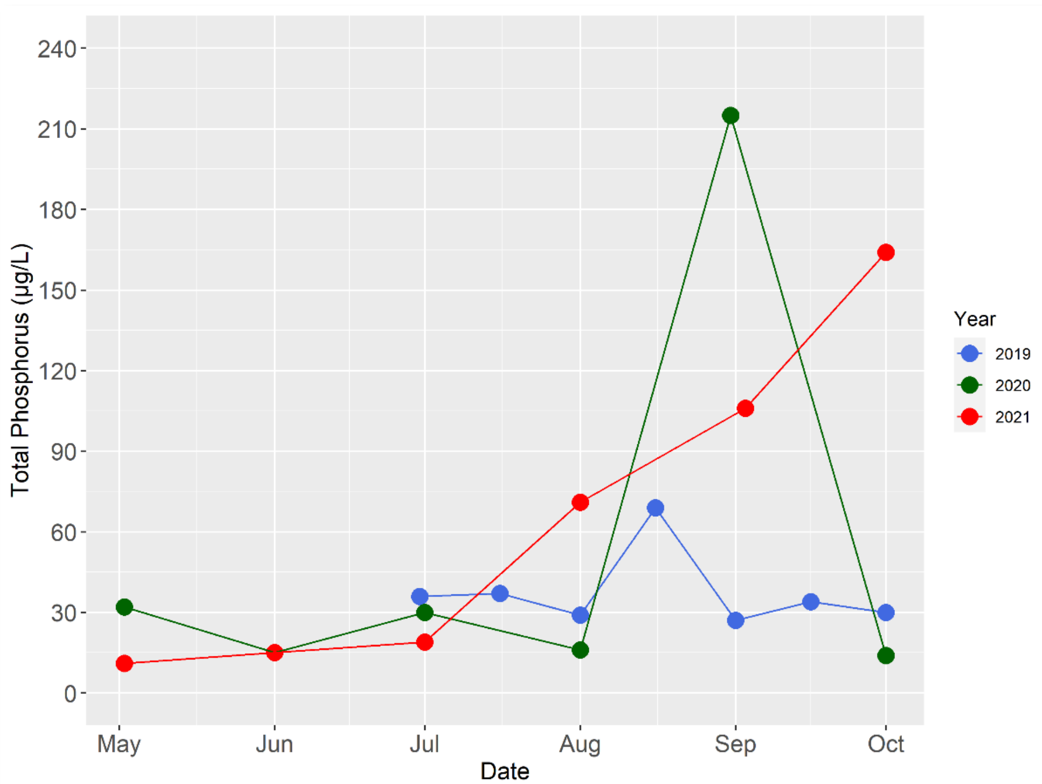

Figure 10. Lake Hayward 2019-2021 bottom total phosphorus

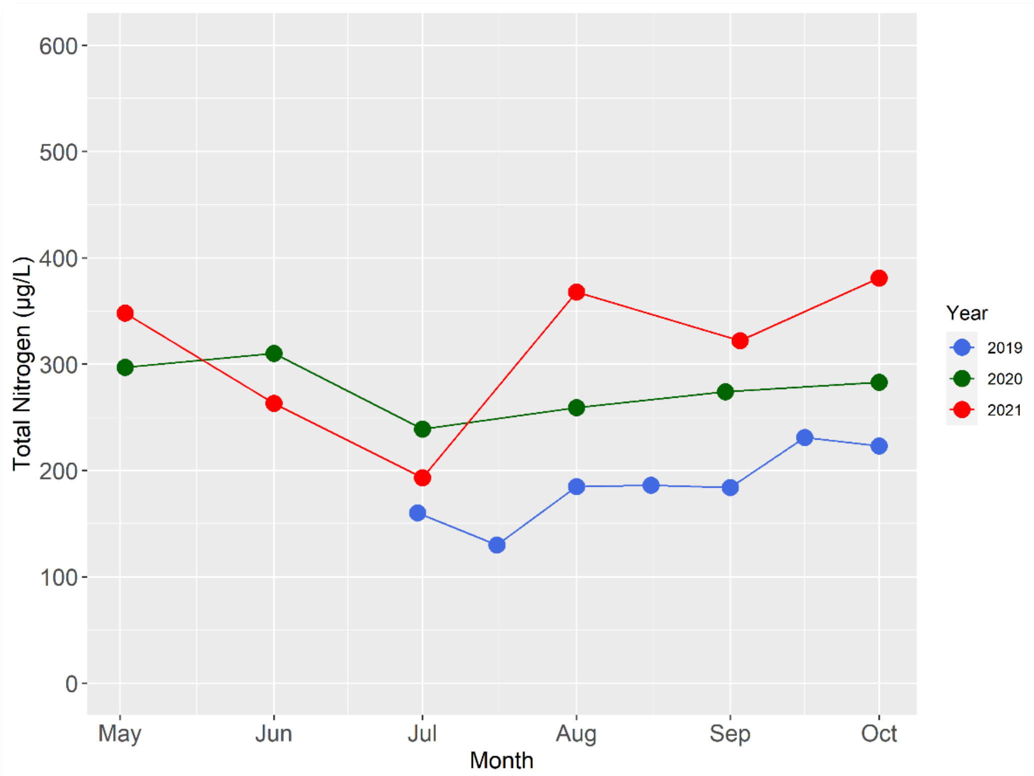

Figure 11. Lake Hayward 2019-2021 surface total nitrogen.

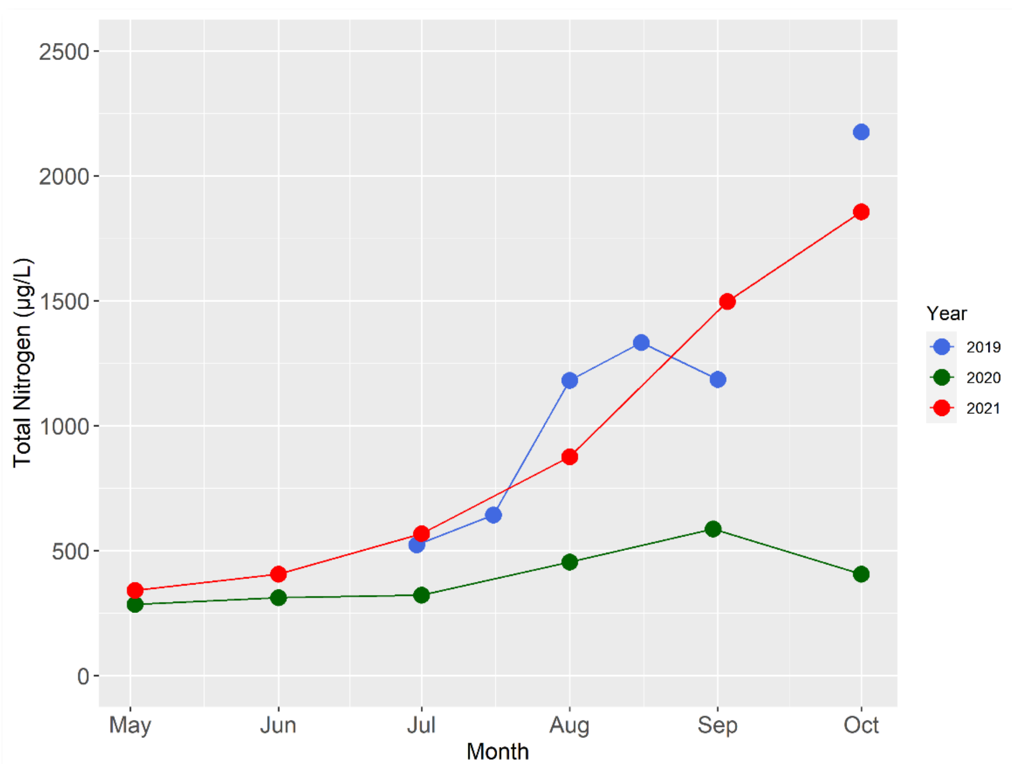

Figure 12. Lake Hayward 2019-2021 bottom total nitrogen.

Phytoplankton

- Phytoplankton during the 2021 season was dominated by blue-green algae starting in July and continuing into October.
- The single largest cell count was documented on August 1st, with 184,548 cells/mL. This coincided with the lowest water clarity value observed from 2019-2021.
- Green algae were present in all samples across the season.
- Three genera of cyanobacteria genera were present in 2021 samples (*Microcystis*, *Chroococcus*,and *Raphidiopsis*), with Microcystis having the highest single cell count among all samples.
- Cell counts for all phytoplankton were generally lower in 2021 than in 2020 and 2019.

Table 3. Major phytoplankton groups observed in Lake Hayward open-water samples. Numbers represent cell counts (cells/mL)

Date	Cyanobacteria	Greens	Diatoms	Crysophytes	Euglenophytes
May 2nd, 2021	0	146	29	29	15
June 1st, 2021	5,248	641	87	0	0
August 1st, 2021	184,548	1,312	0	0	0
September 3rd, 2021	35,131	1,166	0	175	15
October 1st, 2021	0	875	0	0	15

Table 4. Cyanobacteria algae observed in Lake Hayward open-water samples. Numbers represent cell counts (cells/mL)

Date	*Microcystis*	*Chroococcus*	*Raphidiopsis*
May 2nd, 2021	0	0	0
June 1st, 2021	5,248	0	0
August 1st, 2021	184,548	0	0
September 3rd, 2021	0	1,603	24,781
October 1st, 2021	0	0	0

Stream Nutrient Concentrations

- During the 2021 Season, Lake Hayward volunteers collected nutrient samples from multiple streams and outfalls across the watershed. Collections were made on nine separate occasions.
- The highest concentrations of total phosphorus were documented at Hayward Inlet E6-RSWESD on 4/25/21, Hayward Inlet W2-HFLDUSDS on 8/22/22.
- The highest concentrations of total nitrogen were documented at the W2 Hayward inlet on multiple dates. These concentrations are anywhere from 8-10 times higher compared to in-lake nitrogen values.

Table 5. Volunteer stream nutrient concentrations 2021.

Date	Site	TP (µg/L)	TN (µg/L)
3/26/2021	Hayward Inlet W1	44	351
	Hayward Inlet E5	10	1,311
	Hayward Inlet E6	6	842
	Hayward Inlet W2-U	11	3,945
	Hayward Inlet W3	19	974
	Hayward Inlet W6	35	224
4/16/2021	Hayward Inlet W1	119	381
	Hayward Inlet E5	9	959
	Hayward Inlet E6	10	590
	Hayward Inlet W2-U	15	3,711
	Hayward Inlet W3	26	921
	Hayward Inlet W-6-U	16	230
4/25/2021	Hayward Inlet E6	138	654
	Hayward Inlet E6-RSWESD	843	1339
5/4/2021	Hayward Inlet W1	84	308
	Hayward Inlet E5	18	674
	Hayward Inlet E6	19	501
	Hayward Inlet W2	35	2951
	Hayward Inlet W3	43	863
	Hayward Inlet W6	17	117
5/29/2021	Hayward Inlet W1	203	270
	Hayward Inlet E5	31	624
	Hayward Inlet E6	16	583
	Hayward Inlet W6-USD	20	3002
	Hayward Inlet W3	40	1160
	Hayward Inlet W6-USD	90	415
6/14/2021	Hayward Inlet E5	96	1390
	Hayward Inlet E6	164	1069
	Hayward Inlet W1	192	471
	Hayward Inlet W2	183	2525
	Hayward Inlet W3	140	1164
	Hayward Inlet W6	251	1017
7/3/2021	Hayward Inlet W1	74	300
	Hayward Inlet W2-USD	20	3,069
	Hayward Inlet W3	42	928
	Hayward Inlet E5	18	636
	Hayward Inlet E6	10	588
7/9/2021	Hayward Inlet W1	183	397
	Hayward Inlet E5	76	857
	Hayward Inlet E6	37	624
	Hayward Inlet W2-USD	365	1,409
	Hayward Inlet W3	150	1,376
	Hayward Inlet W6	66	450
8/22/2021	Hayward Inlet W1	229	519
	Hayward Inlet W1-Lookout	203	438
	Hayward Inlet W2-USD	356	2,927
	Hayward Inlet W2-HFLDUSDS	645	1,131
	Hayward Inlet W2-HFLD31	268	3,882
	Hayward Inlet W3	198	2089
	Hayward Inlet E5	69	1,035
	Hayward Inlet E6	39	948

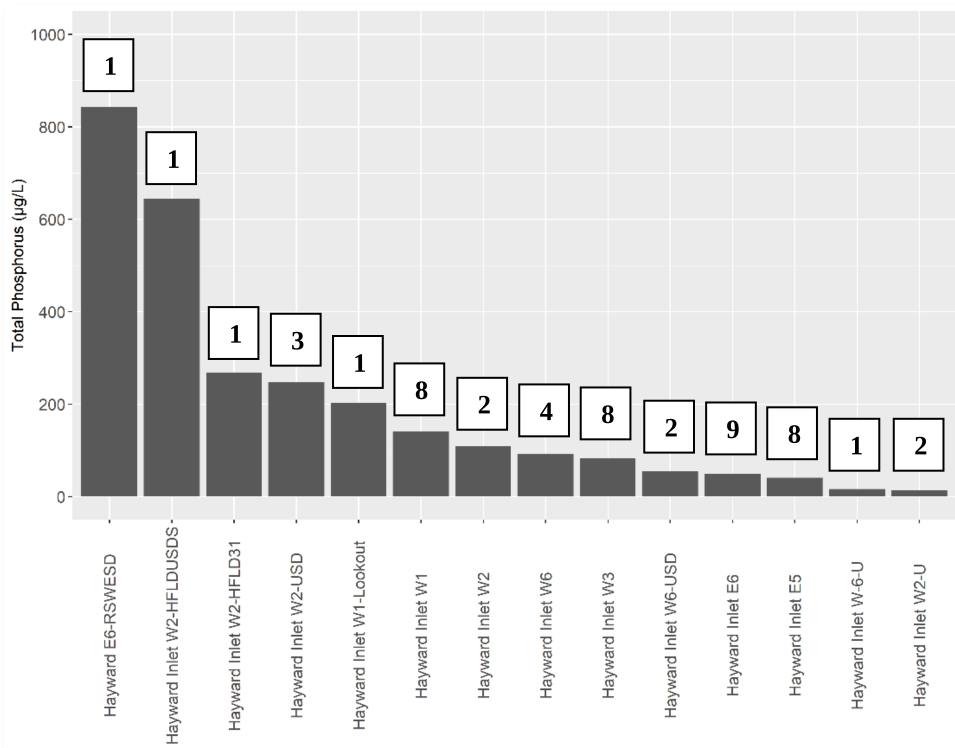

Figure 13. Mean total phosphorus values from Lake Hayward inlets. Numbers indicate number of individual samples per site.

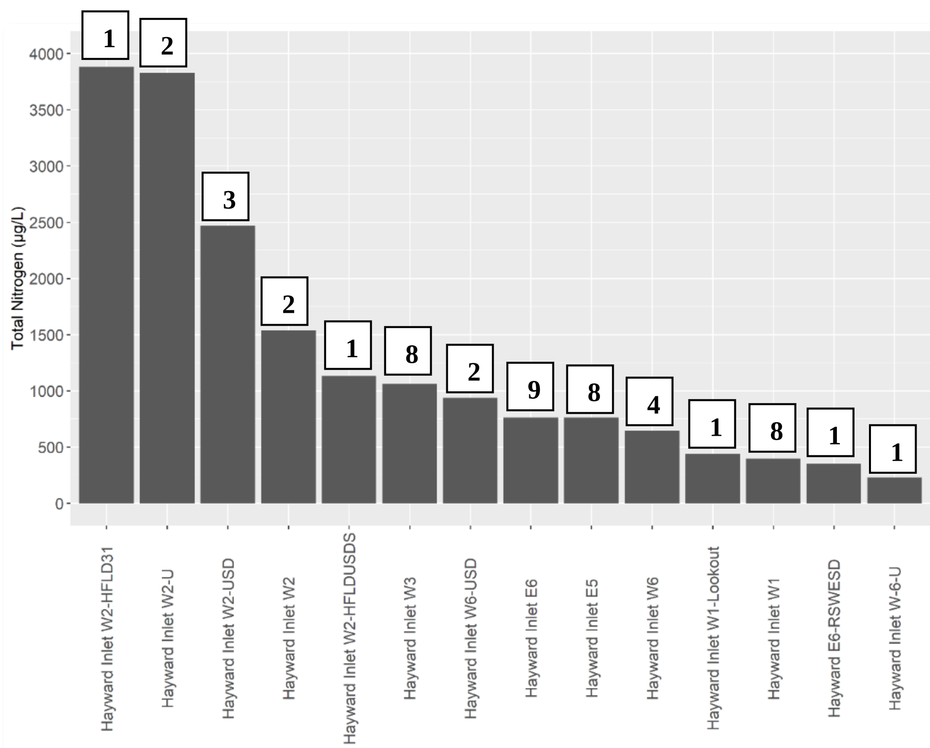

Figure 14. Mean total nitrogen values from Lake Hayward inlets. Numbers indicate number of individual samples per site.

Simple Method for Urban Runoff

To estimate the annual load of total phosphorus and total nitrogen entering the lake via stormwater, NEAR used the simple method (Schueler 1987)[1]. The simple method uses the percent impervious surface within sub-watersheds along with coefficients and estimated pollutant concentrations to determine the annual load. NEAR obtained estimates of sub-watershed area from the USGS streamstats application along with ARC GIS. Sub watersheds were broken down into stream sub watersheds indicated by a "W" or an "E" and direct drainage watershed indicated by a "D" (Table 6). Area and percent impervious surface were obtained using the CTDEEP CTECO portal for East Haddam and Colchester. Pollutant concentrations were derived using the on-site collected data by the Lake Hayward volunteers throughout the 2021 season. Using real data instead of coefficients allows for a more accurate estimate of runoff concentrations and loads. For sub-watersheds without any on-site water samples, an average of 0.091 and 0.886 mg/L P and N was used as the pollutant concentration.

Annual load was calculated using the following equation:

$$L = 0.226 * R * C * A$$

Where: L = Annual load (lbs.)
R = Annual runoff (inches)
C = Pollutant concentration (mg/L)
A = Area (acres)
0.226 = Unit conversion factor

NEAR calculated annual runoff using the equation:

$$R = P * P_j * Rv$$

R = Annual runoff (inches)
P = Annual rainfall (inches)
P_j = Fraction of annual rainfall events that produce runoff (usually 0.9)
Rv = Runoff coefficient

NEAR used the 2021 annual rainfall value from the Oakdale 2.6 WNW station (CLIMOD2). Rainfall in 2021 was higher than the past few years, therefore this loading estimate may not be typical of every year.

Total Annual Load TP: 110.6 lbs

Total Annual Load TN: 1118.2 lbs

It is important to note that this data is only for stormwater runoff, which is one part of the external nutrient load. This model doesn't take into account onsite wastewater contributions, which can enter the lake via groundwater and be undetected in normal stormwater sampling. Waterfowl loadings and atmospheric loading values are also not included in the model.

The largest load of TP and TN entering the lake via stormwater was from the N1 sub-watershed, followed by E3 and W2. Both N1 and E3 represent large drainage areas, which is why the loads are particularly high. W2 has a higher-than-average impervious cover and measured TP and TN concentrations, which drive the total and percent annual load upward.

Table 6. Summary of input parameters for the simple method for Lake Hayward. Please see the descriptions of simple model variables on the previous page.

Sub-watershed	Impervious cover percent	Acres	P	Pj	Rv	R	TP_mg/L	TN_mg/L	L_TP (lbs)	L_TN (lbs)	TP_%	TN_%
W1	1.4%	57.4	57.78	0.9	0.06	3.25	0.148	0.401	6.2	16.9	5.6%	1.5%
W2	10.4%	24.7	57.78	0.9	0.14	7.52	0.211	2.57	8.9	108.1	8.0%	9.7%
W3	6.0%	22.3	57.78	0.9	0.10	5.43	0.082	1.06	2.3	29.0	2.0%	2.6%
W4	3.6%	22.7	57.78	0.9	0.08	4.28	0.091	0.886	2.0	19.5	1.8%	1.7%
W5	6.0%	45.1	57.78	0.9	0.10	5.43	0.091	0.886	5.0	49.0	4.6%	4.4%
W6	2.5%	18.1	57.78	0.9	0.07	3.77	0.072	0.667	1.1	10.3	1.0%	0.9%
E7	0.2%	47.5	57.78	0.9	0.05	2.67	0.091	0.886	2.6	25.4	2.4%	2.3%
E6	0.6%	26.4	57.78	0.9	0.06	2.87	0.128	0.723	2.2	12.4	2.0%	1.1%
E5	1.0%	258.0	57.78	0.9	0.06	3.08	0.041	0.763	7.3	136.9	6.6%	12.2%
E4	0.7%	18.6	57.78	0.9	0.06	2.91	0.091	0.886	1.1	10.8	1.0%	1.0%
E3	2.5%	162.0	57.78	0.9	0.07	3.78	0.091	0.886	12.6	122.7	11.4%	11.0%
E1A	0.2%	1.0	57.78	0.9	0.05	2.68	0.091	0.886	0.1	0.5	0.1%	0.0%
N1	0.4%	421.4	57.78	0.9	0.05	2.79	0.091	0.886	24.2	235.7	21.9%	21.1%
D1	12.2%	28.7	57.78	0.9	0.16	8.39	0.091	0.886	5.0	48.2	4.5%	4.3%
D2	23.6%	19.8	57.78	0.9	0.27	13.79	0.091	0.886	5.6	54.7	5.1%	4.9%
D3	9.6%	16.0	57.78	0.9	0.14	7.14	0.091	0.886	2.3	22.9	2.1%	2.0%
D4	27.5%	7.5	57.78	0.9	0.30	15.63	0.091	0.886	2.4	23.5	2.2%	2.1%
D5	28.8%	3.4	57.78	0.9	0.31	16.21	0.091	0.886	1.1	11.0	1.0%	1.0%
D6	18.4%	16.0	57.78	0.9	0.22	11.32	0.091	0.886	3.7	36.3	3.4%	3.2%
D7	9.9%	25.2	57.78	0.9	0.14	7.28	0.091	0.886	3.8	36.8	3.4%	3.3%
D8	7.8%	37.9	57.78	0.9	0.12	6.31	0.091	0.886	4.9	47.9	4.4%	4.3%
D9	5.5%	11.9	57.78	0.9	0.10	5.18	0.091	0.886	1.3	12.3	1.1%	1.1%
D10	13.7%	1.0	57.78	0.9	0.17	9.08	0.091	0.886	0.2	1.9	0.2%	0.2%
D11	7.3%	11.3	57.78	0.9	0.12	6.07	0.091	0.886	1.4	13.7	1.3%	1.2%
D12	5.1%	3.0	57.78	0.9	0.10	5.02	0.091	0.886	0.3	3.0	0.3%	0.3%
D13	12.1%	17.2	57.78	0.9	0.16	8.31	0.091	0.886	2.9	28.6	2.7%	2.6%
Total		**1324.3**							**110.6**	**1118.2**		

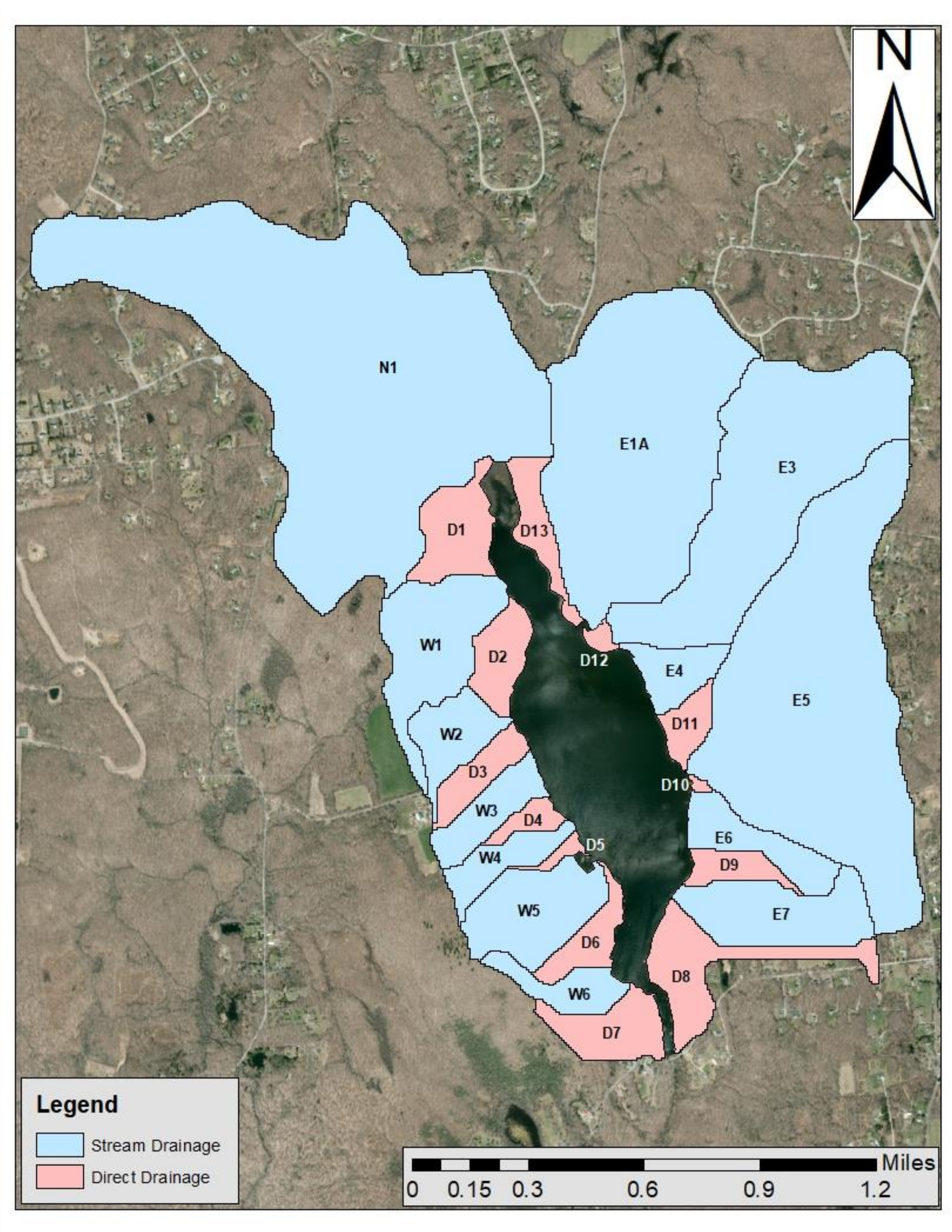

Figure 15. Locations of sub-watersheds in the lake hayward drainage area delineated by being either direct drainage to the lake or drainage from a stream.

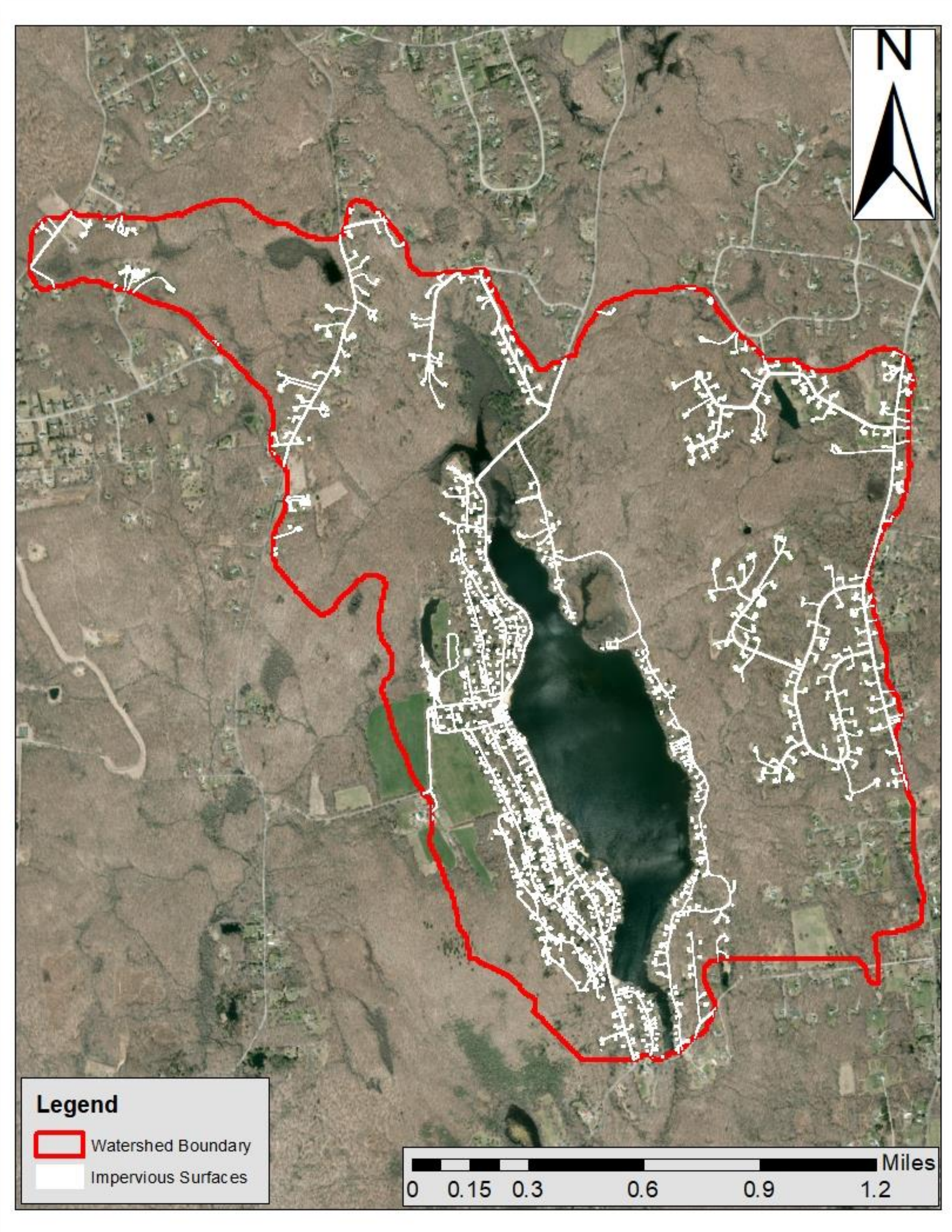

Figure 16. Locations of impervious surfaces in the lake hayward drainage area. Source: CTDEEP CTECO portal for East Haddam and Colchester.

Comparisons to Internal Loading

Comparing the 2021 simple model estimates to the 2020 internal loading estimate, at this moment, the internal load (80kg, 176 lbs) of P is the higher potential source of P entering the lake compared to stormwater. These estimates will change on a yearly basis as precipitation and the anoxic boundary shifts. Low precipitation summers will mean that the internal load will increase in importance relative to stormwater. Also, if the anoxic boundary is lower in future years, either due to a deeper thermocline or some other factor, the internal load will decrease in importance.

The internal load differs from the stormwater load also in the fact that only a portion of the phosphorus that enters the lake from stormwater is in a bioavailable form. Stormwater contains phosphorus that is bound to organic matter, inorganic clays and sediments along with soluble, free forms, which are available for algae growth. Often, the soluble, free forms of phosphorus in stormwater are a small percentage of the total phosphorus entering the lake. The load that is coming out of the sediment via internal loading is all in the soluble, free forms of phosphorus.

Neither of these models took into account the contribution of onsite wastewater, which can be a large source of nutrients as well. The entire Lake Hayward watershed uses onsite wastewater as its waste disposal system, which can in-turn contribute a large portion of soluble nutrients to the lake. Nitrogen moves more freely through the soil, but phosphorus can enter the lake as well, especially if there are older systems with leach fields that have reached their capacity for treatment. There is also the issue of stormwater flows being partially influenced by onsite wastewater. As a rain even happens and the ground becomes more saturated, the water table can rise to the point where effluent from the leach field is drained offsite and into stormwater swales. Without a comprehensive inventory and modeling of the septic systems and use patterns, we do not have a good estimate of their contribution to the nutrient load of Lake Hayward.

Conclusions

Volunteer-collected data in 2021 showed that Lake Hayward's water quality was generally similar to 2020, with some notable differences within parameters. Water clarity in 2021 regularly shifted between being better than and worse than 2020 throughout the season, with no discernable pattern present. The anoxic boundary in 2021 reached a shallower depth earlier in the season as compared to 2020, however, the shallowest depth of the last three years occurred in 2020. Phosphorus concentrations were generally lower at the beginning of the season as compared with 2020, with increasing concentrations documented at the end of the season. Nitrogen concentrations were generally higher in 2021 as compared to 2020.

The high *Microcystis* counts that took place on August 1st coincided with the poorest water clarity observed in three seasons of volunteer monitoring. While it is unknown exactly what caused the bloom to form, *Microcystis* is a genus of cyanobacteria that is known to sink into deeper, high nutrient waters and then pop back up to the surface to increased light conditions. During most of the year, high nutrient concentrations are present during the summer in the deeper waters. This is a common mechanism present not only among *Microcystis*, but other cyanobacteria such as *Dolichiospermum* and *Woronichinia*, which have both been present in past algae samples. The surface nutrient concentrations are not consistently high enough to sustain continuous, frequent blooms, therefore, the major nutrient source for growth originating from bottom waters makes sense.

In terms of the immediate management of algae blooms, there are two choices that are available. The first is frequent algaecide treatments, aimed at reducing the frequency and severity of algae blooms. The effects of algaecides are not long-lasting, and blooms may return on an infrequent basis in between treatment. however, these treatments may stop the accumulation of cyanobacteria cells and lessen the duration of blooms. Because of the infrequent nature of the blooms, the treatments would have to be done on a regular basis (every two weeks during the summer). Copper based products and hydrogen peroxide products are the two most commonly used active ingredients for algae control. Both require permits from CTDEEP to use. Copper is the cheaper of the two active ingredients but carries potential long term sediment toxicity issues.

The second option is using a water column phosphorus stripping technology, either an aluminum sulfate or a Eutrosorb® WC treatment. This would be done in the early spring, when there are the highest concentrations of soluble reactive phosphorus, which is available for algae growth. Early spring also does not have a thermocline, which allows the product to mix throughout the entire water column. The Eutrosorb® WC is a relatively new product which is a proprietary mix of phosphorus binding minerals, therefore, there is not too many field examples to point to, but NEAR believes through internal conversations that this can be a promising technique that should be explored further. Both aluminum sulfate and Eutrosorb® WC would require permits from CTDEEP.

Stream Sampling

Stream nutrient sampling was conducted for the first time since the original Lake Hayward diagnostic study in 2001. This provided insights into which streams consistently had the highest concentrations of nutrients entering Lake Hayward. Stream inlet W2 had consistently the highest values of total phosphorus and total nitrogen across the study period, with W1, W3, and E6 having either high total phosphorus or total nitrogen values. The sub-watershed of W2 should be investigated further to delineate where the large amount of nutrients is originating from. There are two large farm complexes within the W2 sub watershed: Cold Springs Farm, and Allegra Farm Horse and Carriage. Those groups should be engaged to determine proper strategies to reduce nutrient inputs to Lake Hayward. Stream restoration techniques, erosion controls, and manure disposal practices should be discussed.

Specifically at sub-watershed W2, stormwater concerns should be addressed along Hayfield Road, abutting the cold springs farm property, the drainage ditch between East Lane and Lakeshore Drive and the washout present at the base of Hayfield Road (Lake Hayward Stormwater Sampling Initiative 2021 Data and Test Results). During storm events, there is a water ditch that funnels water from the farm into the drainage area along hayfield road. This water should be diffused across the land so flow velocity reduces and nutrients can be retained onsite. The drainage ditch should be vegetated along its borders and potentially captured in a bioretention basin to slow down flow. The washout at hayfield road is indicative of poor sediment management upland and poor stormwater flow paths. NEAR suggests that the association engage with the highway department to remedy the drainage and erosion control practices.

For all streams entering Lake Hayward, nutrient interception via filter media should be explored. Two potential products, Eutrosorb™ and biochar, can be placed inside the stream channels and can uptake a certain quantity of pollutants. Both products are contained within porous filter bags that can be placed in a variety of locations. Eutrosorb is a filtering technology that specifically targets soluble phosphate ions, which is the most readily available form for algae and plant uptake. Biochar is a charcoal-like substance that is made by burning organic material in a controlled process called pyrolysis. Biochar also removes soluble phosphate, along with a few other organic pollutants. Both products are meant to be supplements for larger stream restoration and are not designed to filter out 100% of incoming phosphorus. Used correctly, they may trap a significant amount of soluble P from streams and stormwater. These filter bags can also be placed in catch basins and dry swales/ditches that exhibit periodic flows.

Future testing should focus on the following inlets: W2, W3, W6, E5, and E6 and should include TP, TN and E. coli. E. coli sampling will provide the health department with a rationale to open an investigation into a particular area to determine if there are any faulty onsite wastewater practices taking place upstream of the sample. Continuing to sample TP and TN is important for maintaining a long-term dataset and to measure if a remediation effort was effective at reducing nutrient concentrations. E. coli should only be sampled during baseflow, as NEAR's experience is that health departments consider stormwater E. coli data too difficult to determine if its source is ultimately a failure in onsite wastewater. TP and TN can be collected during a mix of baseflow and storm events.

Property Owner Management Strategies

Individual properties within a watershed do contribute a portion of nutrients to Lake Hayward. There are many small-scale practices that can be undertaken to reduce the amount of runoff and pollutants leaving properties. For rainfall that hits the roof and runs off, it is important to have gutters installed and maintained correctly, as well as ensuring that once that water leaves the gutter, it does not flow onto impervious surface. This can be done by either directing gutters into a natural wooded or vegetated area, installing a rain barrel to capture water and re-use for gardening/general irrigation or install a rain garden and plant saturation tolerant vegetation.

For lawn care, using little to no fertilizer is suggested, especially in areas directly next to the road. Storms can flush the fertilizer into the drain system. If fertilizer is desired, use of slow-release nitrogen fertilizer is suggested as this allows the vegetation to uptake nutrients in a fashion that minimizes wash off. Grass clippings and leaves should never be blown onto roads or into drainpipes. Considering changing landscaping practices and vegetation away from short grass and to more shrubbery/mulch will also help keep nutrients on site. New or ongoing construction should adhere to all proper protocols for stormwater prevention, especially the use of silt fences and other erosion control devices. If a new driveway or patio is being planned, using alternatives to impervious materials such as pavers or porous pavement help reduce runoff.

For onsite wastewater, all systems should be pumped and inspected every three years to ensure proper functioning. Inspections should not only involve looking at the tank structure but the integrity of the distribution box and leach field. Failures that lead to increased nutrient input to lakes often start at the leach field. The leach fields could be at capacity for binding pollutants and if there is a potential backup situation starting, it will commonly show up in the leach field as a small area of ponded water or localized increased vegetation growth.

[1]Schueler, Thomas R. 1987. Controlling urban runoff: A practical manual for planning and designing urban BMPs. Washington DC: Washington Metropolitan Water Resources Planning Board

Recommendations for 2022

- Continue monitoring in-lake conditions using volunteer efforts.
- Obtain quotes for both algaecide treatments and nutrient inactivation treatments (preferably lanthanum-based products) from reputable applicators.
    - The algaecide treatments should be explored for the July to August timeframe when clarity and cyanobacteria cell counts are the worst.
- Follow up on high-nutrient inlets identified in 2021 with continued monitoring, adding E. coli sampling during baseflow conditions.
    - Provide data to the health department, which has the authority to inspect individual septic systems and require compliance.
- Investigate the use of filter media such as Eutrosorb and biochar to absorb a portion of the phosphorus and nitrogen entering from select streams.