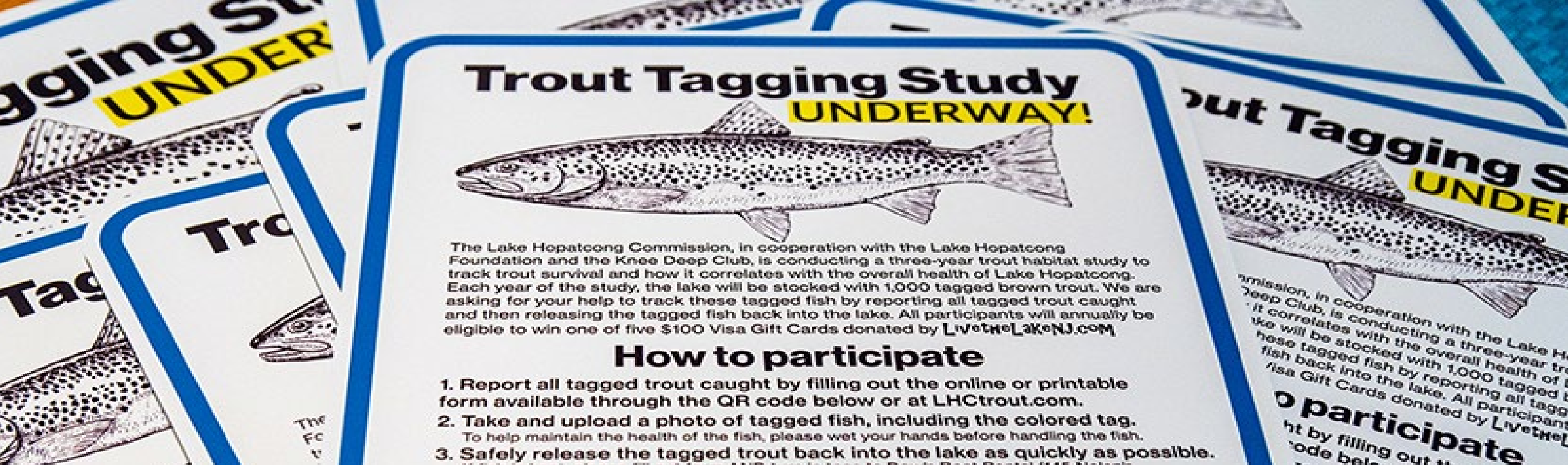

LAKE HOPATCONG TROUT HABITAT AND TAGGING STUDY

LAKE HOPATCONG, MORRIS AND SUSSEX COUNTIES, NEW JERSEY

Grant funding provided by the New Jersey Highlands Council

MARCH 2023

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1.0 INTRODUCTION

Lake Hopatcong is the largest lake in New Jersey, with a surface area of 2,686 acres and approximately 39 miles of shoreline. Located on the border of Morris and Sussex Counties, the lake is located entirely within the New Jersey Highlands in the headwaters of the Musconetcong River. With a maximum depth of 16.7 meters and a mean depth of 5.6 meters, the lake is dimictic and stably stratifies during the growing season each year. The lake provides regionally-significant environmental services and recreational opportunities; this includes fishing, boating, swimming, beach-use, and related activities centered on the use and aesthetics of the lake.

One of the most significant recreational draws to Lake Hopatcong is its trout fishery, recognized regionally by anglers and an important component of the local economy. Data collected over the past 30 years at the lake was recently analyzed and showed increasing surface water temperatures. This trend may suggest that the trout carryover habitat is being negatively impacted. Additionally, trout stocking practices at the lake have been modified over the last decade and have shifted towards stocking smaller trout that are potentially more vulnerable to changes in water quality and habitat quality. Together, these factors are viewed as potentially detrimental to the trout fishery.

Lake Hopatcong has a long history of trout stocking conducted under the supervision of various groups including private angling clubs and the New Jersey Division of Fish and Wildlife (NJDFW). The initial goal was to create a high-quality recreational trout fishery, a successful effort that resulted in the recognition of Lake Hopatcong as an outstanding trout fishery drawing a robust community of anglers from throughout the region and an important economic driver in the local economy.

Trout, including various species such as brown trout (*Salmo trutta*), rainbow trout (*Oncorhynchus mykiss*), and the native brook trout (*Salvelinus fontinalis*), are considered coldwater fishes, with specialized habitat requirements. They require relatively high dissolved oxygen (DO) concentrations and cool water temperatures. In regard to those habitat requirements, the critical period is the high summer months near peak water temperatures. At that time of year trout holdover habitat, that is the portion of the lake that meets the temperature and DO requirements for trout, compresses as a result of increased surface water temperatures and oxygen depression in the deeper water column. A recent analysis of water quality data collected at Lake Hopatcong indicates increasing water temperatures, potentially resulting in a reduction of carryover habitat volume or duration which could impact carryover populations of trout from one year to the next.

Historically, the lake has exhibited good holdover habitat, as evidenced by the catches of older, large trout that survived through multiple growing seasons and were much larger than any stocked fish at the time of their introduction. Research indicates that larger and older trout have a higher tolerance of marginal habitat conditions like high water temperatures and low DO concentrations than smaller fish. In the past, relatively large brown trout, sufficient to garner substantial angler interest, were stocked at Lake Hopatcong. More recently, the Division of Fish and Wildlife has started to stock smaller rainbow trout. The stocking of smaller fish combined with potential impacts to trout carryover habitat have drawn concern about the viability of the trout fishery at the lake.

In response to these concerns regarding the current stocking of trout in Lake Hopatcong, the Lake Hopatcong Commission (LHC) Trout Committee was formed in 2021. The Lake Hopatcong Commission, in cooperation with the Lake Hopatcong Foundation and the Knee Deep Club, initiated a three year trout tagging study. The study is focused on the introduction of larger trout to assess the long-term population dynamics of those stocked fish and the general health of the fishery. In particular, the Trout Committee is interested in the intersection between the stocking of larger brown trout and trout carryover habitat quality. 1,000 tagged brown trout, approximately 12-14 inches in length were released in Lake Hopatcong on 26 March 2022 to initiate the first year of the study. Tagging provides valuable information that can be used to track populations over time, and develop estimates of capture, mortality, growth, and most importantly age. This information will be collected through angler creel surveys and self-reporting of trout tag data, to be overseen by the Trout Committee.

In addition to stocking fish and managing the tag and creel survey, the Trout Committee and other stakeholders also seek to better define carryover habitat in the lake. This includes habitat in the limnetic area (open waters) of the lake, as well as potential trout refuge habitat near seeps, springs, tributaries, or other attractant features around the shoreline. Together, these data can be used to assess the quality and character of trout carryover habitat in Lake Hopatcong, examine the success of stocking larger trout, and to identify habitat management, stocking practices, and conservation projects that can sustain a high-quality trout fishery in the future.

In summary, this study is predicated on the four following questions:

- Did the stocking of larger brown trout with higher environmental stress tolerance in Lake Hopatcong result in substantial carryover populations relative to the potential restriction of trout carryover habitat during the critical summer months?
- Were the temperature and DO requirements for carryover trout habitat available in Lake Hopatcong in 2022?
- Are there potential nearshore refuge habitat that may be utilized by brown trout during the summer season?
- Are there areas along the shoreline of the lake where watershed-based actions, including those identified or recommended in the Watershed Implementation Plan (WIP), should be prioritized to protect or enhance nearshore refuge habitat for brown trout? What are the characteristics that contribute to the existence of those habitats, and what actions could be implemented to preserve, protect, or improve those habitat features?

To answer these questions, there were three main tasks completed in preparation of this report, including:

- *In-situ* water quality data was collected over the course of six sampling events from July through late August at five deep stations throughout the lake to track carryover brown trout habitat during the critical summer months. These six events were supplemented with the routine lake monitoring data collection activities performed monthly, such that eight events were conducted over the roughly two month period, and bound by two additional monthly events in June and September.
- The entire shoreline of the lake was evaluated over the course of the six sampling events for potential trout refuge habitat. This sampling included the collection of *in-situ* sampling data as well as evaluation of the physical structure along the shoreline.
- All available creel survey and fish tag data collected in 2022 that was made available by the LHC Trout Committee was analyzed to understand various trends in the population dynamics of stocked brown trout.

This project was funded by a grant issued by the New Jersey Highlands Council.

2.0 TROUT HABITAT WATER QUALITY DATA

This section of the report will provide an overview of how the State of New Jersey classifies waters relative to trout and the habitat requirements specific to the different classifications. The classification of Lake Hopatcong will be included. This section will also include the sampling methodology for the collection of the limnetic and near-shore water quality and habitat data over the course of the 2022 season. Weather data from the 2022 season will then be explored as it relates to the water quality conditions observed. Finally, results and analyses from the limnetic and near-shore water quality sampling program will be discusses.

2.1 CLASSIFICATION OF NEW JERSEY WATERS

The New Jersey Surface Water Quality Standards (SWQS), N.J.A.C. 7:9B, establishes the policies, stream classifications, and surface water quality criteria necessary to protect the quality of New Jersey's surface waters. The SWQS establish designated uses (ex: drinking water supply, recreation, etc.) for the State's surface waters, classify waters based on those uses (ex: FW1, FW2-TP, etc.), and set water quality criteria that protect the designated uses for each water classification. Freshwaters are designated as FW1 waters (not subject to any man-made wastewater discharges) or FW2 waters (the general surface water classification applied to all other freshwaters except Pinelands waters). FW1 waters are nondegradation waters set aside for posterity because of their unique ecological significance. FW2 waters are further classified based on their ability to support trout, which thrive in cooler temperatures. Trout classifications include trout production (FW2-TP), trout maintenance (FW2-TM), and nontrout (FW2-NT).

Trout production waters means waters designated for use by trout for spawning or nursery purposes during their first summer. Trout production waters have strict habitat requirements, including both temperature and DO criteria. Trout maintenance means waters designated for the support of trout throughout the year. While not as strict as trout production habitat requirements, the requirements for trout maintenance waters are still stringent and generally represent high quality waters.

Lake Hopatcong is classified as a FW2-TM waterbody. The NJDEP defines the DO requirements of trout maintenance waters as, "24-hour average not less than 6.0 mg/L. Not less than 5.0 mg/L at any time." There is also an upper temperature threshold for trout maintenance waterbodies. The NJDEP defines temperature requirements of trout maintenance as, "shall not exceed a daily maximum of 25.0 °C or rolling seven-day average of the daily maximum of 23.0 °C, unless due to natural conditions." This language guards against activities like the release of heated wastewater which could raise water temperature. The increase in water temperatures in recent years is believed to be largely climate driven, although loss of riparian vegetation and increases in impervious coverage may also be linked to temperature increase. Princeton Hydro typically classifies optimal trout habitat as waters with temperatures less than 24.0 °C at DO concentrations in excess of 5.0 mg/L, while carryover habitat is defined at temperatures between 24.0 °C and 26.0 °C at more than 5.0 mg/L.

To slightly complicate matters, the New Jersey Coldwater Fisheries Management Plan (New Jersey Division of Fish and Wildlife, 2005) has a slightly different temperature and DO classification for lakes that are defined as trout maintenance. Per the Coldwater Fisheries Management Plan, "To support trout lakes must have, throughout the year, a layer of water with favorable conditions of temperature (21.0 °C or less) and dissolved oxygen (4.0 mg/L or greater). Surveyed lakes that meet this criteria [in August] are classified as trout maintenance." Under this classification, temperature requirements are much more stringent while DO requirements are less stringent.

Because this study is interested in carryover trout habitat in Lake Hopatcong, the carryover habitat temperature and DO requirements of between 24.0 °C and 26.0 °C at more than 5.0 mg/L will form the basis of this evaluation criteria. However, the water quality figures presented in the report will present two different horizontal lines that represent the lower boundary of carryover trout habitat based on DO requirements of 4.0 mg/L and 5.0 mg/L. The discussions will largely be predicated on a lower DO threshold of 5.0 mg/L unless the difference in depth between the two thresholds is significant.

2.2 WATER QUALITY SAMPLING METHODOLOGY

2.2.1 LIMNETIC WATER QUALITY SAMPLING

Water quality events specific to this study consisted of six monitoring events. Water quality monitoring was conducted at five stations during each sampling event, including Byram Bay, Halsey Island, Mid-Lake, Great Cove, and King's Cove. A map with approximate sampling locations is provided in Appendix I. The lake was sampled on 5 July, 11 July, 18 July, 2 August, 10 August, and 16 August. Five additional monitoring events were conducted as part of the long-term baseline monitoring that has been occurring in Lake Hopatcong over the past 30+ years. These sampling events were conducted on 25 May, 22 June, 25 July, 24 August, and 6 October. There were eleven sampling stations associated with these monitoring events, STA-1 – STA-11. While most of these stations are in different locations than the stations that were monitored as part of this study, a few of the stations were included in both. For example, STA-2 represents Mid-Lake, STA-4 represents King's Cove, and STA-8 represents Great Cove. A second map with approximate sampling locations for these events is also provided in Appendix I.

The sampling conducted during the events specific to this study only included *in-situ* data collection. The *in-situ* data were collected in profile, at approximately 1.00 m intervals, and consisted of temperature (T), specific conductance (SpC), DO concentration, DO percent saturation, and pH. *In-situ* data were collected with an In-Situ Aqua TROLL 500 water quality meter. This meter was calibrated according to manufacturer's specifications prior to sampling. In addition, Princeton Hydro monitored transparency with a Secchi disk.

2.2.2 NEAR-SHORE AND STREAM WATER QUALITY SAMPLING AND HABITAT ASSESSMENT

For the near-shore analysis, the lake's shoreline was divided into roughly six sectors, and one of the sectors was surveyed during each sampling event. While the entire shoreline of the lake was assessed visually from a boat, areas with less developed shorelines and subwatersheds or closer proximity to greater depths were given increased scrutiny. Prior to the surveys, aerial photographs, maps, and other data sources were reviewed, as were knowledgeable lake users, to identify potential target areas.

The surveys focused on taking *in-situ* profiles, for the same parameters as the limnetic sampling, at 0.50 – 1.00 m intervals along the shoreline and in areas that contain some of the physical characteristics described above. The locations of these were GPS located. If water quality appeared to satisfy trout habitat demands, particularly if it was cooler than the open waters of the lake, some additional profiles were collected to try to better define the bounds of the feature in relation to the shoreline. Additionally, a portion of one of the sampling days was dedicated to traveling around the shoreline of the lake in a car to sample inlet streams for the same *in-situ* water quality parameters. A map with approximate sampling locations is provided in Appendix I.

2.3 WEATHER ANALYSIS

The following section will discuss the climatic conditions observed during the 2022 season compared to the long-term normal. It should be noted that 'normal' refers to the monthly averages over the 30-year period from 1991 – 2020. Princeton Hydro primarily utilized temperature data gathered through CLIMOD2 (http://climod2.nrcc.cornell.edu/) for this analysis. There were 18 days in which the weather data from CLIMOD2 was missing; data for those 18 days were gathered through TuTiempo (Climate - Climate data (tutiempo.net)). The weather station utilized for this analysis, from both websites, was Aeroflex-Andover Airport.

Table 2.1 includes various monthly temperature and precipitation metrics at Lake Hopatcong relative to normal conditions, represented as the average from 1991 – 2020. The temperature metrics represent the mean daily values over the course of the month, while the monthly precipitation represents the total rainfall for the month. For the monthly temperature and precipitation metrics, the higher value (2022 vs. long-term normal) is highlighted red. In addition to monthly metrics, additional weather data is provided for each sampling event from July – August. These additional data include temperature and precipitation data on the day of the sampling event, and the average temperature and accumulated rainfall of the preceding two and seven days.

Table 2.1: Lake Hopatcong Weather Summary 2022

Month		Mean Max. Temp	Mean Min. Temp	Mean Avg. Temp	Precip
			°F		in
May	2022	*75.3*	*53.4*	*64.3*	*5.75*
	Norm	71.0	48.0	59.5	3.83
June	2022	*81.5*	*57.9*	*69.7*	3.76
	Norm	79.1	57.1	68.1	*4.54*
July	2022	*89.7*	*65.9*	*77.6*	1.00
	Norm	83.6	61.8	72.7	*5.06*
August	2022	*90.3*	*64.9*	*77.5*	1.54
	Norm	81.5	60.1	70.8	*4.85*
September	2022	*78.2*	*54.9*	*66.1*	3.36
	Norm	74.4	52.4	63.4	*4.32*
5-Jul	2022.07.05	87.0	64.0	75.5	0.02
	2-Day Prior	87.0	57.0	72.0	0.00
	Week Prior	87.1	60.0	73.5	0.34
11-Jul	2022.07.11	88.0	61.0	74.5	0.00
	2-Day Prior	87.5	62.0	74.8	0.00
	Week Prior	86.7	63.9	75.0	0.02
18-Jul	2022.07.18	86.0	71.0	78.5	0.34
	2-Day Prior	88.5	66.0	77.3	0.01
	Week Prior	90.0	64.3	77.0	0.06
25-Jul	2022.7.25	89.0	73.0	81.0	0.15
	2-Day Prior	95.5	69.5	82.5	0.03
	Week Prior	93.4	70.1	81.8	0.46
2-Aug	2022.08.02	93.0	66.9	77.2	0.16
	2-Day Prior	85.0	63.5	74.3	0.32
	Week Prior	87.9	65.1	75.9	0.32
10-Aug	2022.08.10	90.0	69.0	79.5	0.00
	2-Day Prior	96.5	75.0	84.8	0.01
	Week Prior	94.9	70.3	82.5	0.01
16-Aug	2022.08.16	90.0	59.0	74.5	0.00
	2-Day Prior	88.5	56.5	72.5	0.00
	Week Prior	89.6	62.4	75.9	0.01
24-Aug	2022.08.24	91.0	64.0	77.5	0.00
	2-Day Prior	84.5	69.0	76.8	1.07
	Week Prior	89.3	63.0	76.1	1.11

All three of the temperature metrics from May – September were higher in 2022 relative to the long-term averages. These temperature departures were significant in July and August, with respective monthly mean average temperatures 4.9 °F and 6.7 °F higher. The average maximum temperature in July and August was extremely high, with respective temperatures of 89.7 and 90.3 °F. These maximum temperatures are 6.1 °F and 8.8 °F higher than the long-term average maximum temperatures.

May was the only month where total precipitation was slightly elevated relative to the long-term average. July and August were extremely dry, with respective precipitation totals of 1.00 and 1.54 inches. The total precipitation from July – August was 7.37 inches less than the long-term average during those two months. In summary, it was an extremely hot and dry summer at Lake Hopatcong which likely had a significant negative effect on temperature and DO metrics as they pertain to trout habitat.

The sampling event-specific weather data was particularly useful in evaluating how much of an effect the local weather had on temperature, thermal stratification, and DO concentrations in Lake Hopatcong. The 2022 *in-situ* data indicates that mid-July through mid-August represents the critical period where available trout habitat was either extremely limited or non-existent. A review of the weather metrics for the sampling events that spanned 18 July – 16 August reveals elevated temperatures and little precipitation. The 'week prior' metric likely has the most significant effect on the thermal stratification pattern present on the day of sampling, which in turn dictates the size of the epilimnion and hypolimnion and the extent of anoxia. The '2-day prior' and day of sampling weather metrics are also extremely useful and certainly have a significant effect on water temperatures in the upper water column on each sampling day. The maximum recorded daily temperature for each of the four sampling events in August met or exceeded 90.0 °F, which is an elevated temperature for northern New Jersey, even during the month of August.

Another important finding from the event-specific weather data is the large fluctuation in all of the temperature metrics for the three sampling events from 25 July – 10 August. All temperature metrics were extremely elevated on 25 July and 10 August, with respective mean maximum 'week prior' temperatures of 93.4 °F and 94.9 °F. These two dates were the only two sampling events where trout habitat was essentially non-existent based on measured temperature and DO profiles. However, the 2 August sampling event had a mean maximum 'week prior' temperature of 87.9 °F; this was at least 5.5 °F cooler than the other two dates. The water quality data from the 2 August sampling event revealed carryover trout habitat in the upper 5.7 m of the water column. It's important to note that temperatures in the epilimnion were just below the 26.0 °C threshold on 2 August, but it was an important drop in water temperature relative to the surrounding dates.

Figure 2.1 below presents daily temperature and precipitation in the Lake Hopatcong region from May – September.

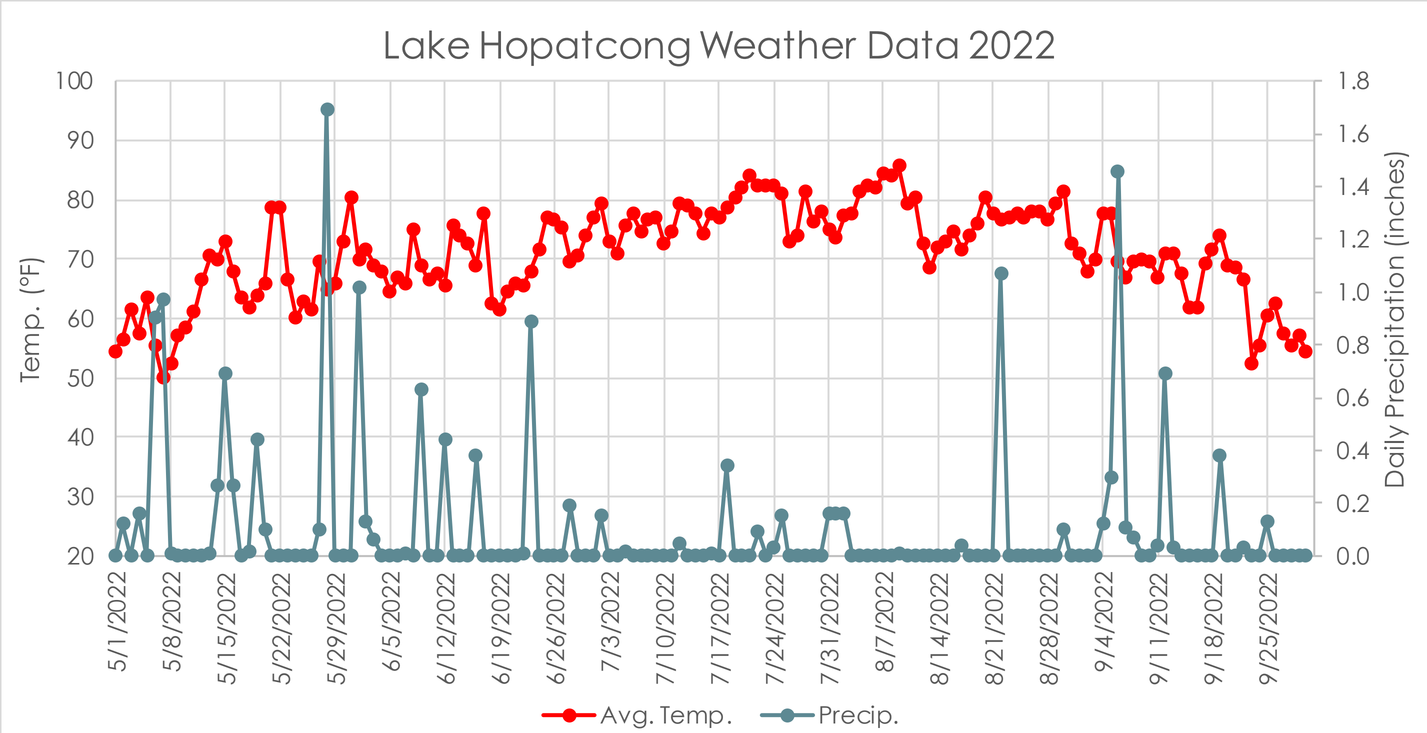


Figure 2.1: Daily temperature and precipitation in the Lake Hopatcong Region from May – September 2022

2.4 LIMNETIC WATER QUALITY ANALYSIS

2.4.1 TROUT HABITAT AVAILABILITY BY EVENT

A brief summary of thermal and DO properties in relation to brown trout carryover habitat in Lake Hopatcong will be presented for each sampling event below. The habitat range and total habitat listed for each date is predicated on a lower DO bound of 5.0 mg/L. However, if there were significant differences in available habitat between the two DO thresholds, it is noted in the text summaries. Figures 2.2 – 2.12 are provided after these summaries to help visualize the compression and expansion of carryover trout habitat over the course of the 2022 growing season. Lower DO thresholds of 4.0 mg/L and 5.0 mg/L are provided in these figures. Tables with the full *in-situ* sampling results from all eleven monitoring events are provided in Appendix II.

25 MAY 2022

Habitat Range (Mid-Lake): 0.00 m to 10.70 m

Total Habitat (Mid-Lake): 10.70 m

The lake was still in the early stages of the annual growing season thermal stratification pattern in late May. Following the spring mixing event, in which temperatures were uniform throughout the water column, surface waters warmed rapidly as the ambient air temperatures and exposure to the sun both increased. During this time, the warmer upper water layer (epilimnion), transition zone (metalimnion or thermocline), and a cold, deep water layer (hypolimnion) had only recently formed. As a result, DO concentrations remained oxic (DO > 2.0 mg/L) throughout the entire waterbody. However, although DO concentrations remained oxic, they had already begun to drop below the lower brown trout DO limit of 5.0 mg/L in the deeper waters. As such, carryover brown trout habitat was present in the upper 10.70 m of the lake on 25 May 2022.

Once the hypolimnion is formed in a relatively deep lake like Lake Hopatcong, it is essentially cut off from the surface waters until the fall mixing event due to differences in water density. As a result, the deeper waters cannot be replenished with atmospheric oxygen that is circulating throughout the mixed epilimnion. In productive lakes such as Lake Hopatcong, the hypolimnion continually loses oxygen throughout the season due to bacterial decomposition of organic matter. As such, the lake will continue to lose DO in the hypolimnion moving towards peak summer stratification.

22 JUNE 2022

Habitat Range (Mid-Lake): 0.00 m to 6.10 m

Total Habitat (Mid-Lake): 6.10 m

By late June, the surface temperature of the Mid-Lake station had only increased slightly relative to the 25 May event. However, water temperatures deeper in the epilimnion (4.00 -6.00 m) had increased to a greater degree as this upper layer continued to mix, resulting in a more defined thermal stratification pattern. Water temperatures throughout the lake remained well below the upper temperature threshold of 26.0 °C during this time. However, the hypolimnion at the Mid-Lake station was already completely anoxic as a result of the persistent thermal stratification that prevented the replenishment of oxygen. All other stations remained oxic during this time, although no other stations were deeper than 7.50 m. Only two of eleven stations established lower bounds of trout habitat during this event as a result of depressed DO concentrations, including ST-2 (Mid-Lake) and ST-8 (Great Cove). The lower DO bounds for the Mid-Lake and Great Cove stations were 6.10 m and 5.20 m, respectively.

5 JULY 2022

Habitat Range (Mid-Lake): 0.00 m to 4.25 m

Total Habitat (Mid-Lake): 4.25 m

During the July 5 event all stations exceeded 25.0 °C at the surface, but they remained slightly below the temperature threshold and thus habitat should extend all the way to the surface. The lake was well stratified, and at all stations with sufficient depth (excluding the shallow King's Cove station) the lake was anoxic in the hypolimnion. As such, low DO established a lower bound of trout habitat at all those stations. At three of four stations, that lower bound was around 5.50 m or deeper. The Mid-Lake station had anoxia and general oxygen depression occurring at a significantly shallower depth, at an estimated 4.25 m.

11 JULY 2022

Habitat Range (Mid-Lake): 0.00 m to 4.80 m

Total Habitat (Mid-Lake): 4.80 m

Some interesting patterns began to develop during the 11 July event. Surface temperature showed a minute rise, but all stations remained below the 26.0 °C threshold. At the Mid-Lake station, due to increasing temperatures the surface layer or epilimnion started to migrate down in the water column. Because oxygenation occurs within the well-mixed surface layer, the DO threshold was also pushed deeper in the water column to about 4.80 m. As a result, at this station, trout habitat thickness increased by about 0.50 m which is positive news. The flipside of continued thermal stratification is that anoxia (DO < 1.0 mg/L) actually moved up in the water column to about 5.30 m versus 6.30 m one week earlier. This is a consequence of continued consumption or exhaustion of oxygen below the thermocline. At three of the four other stations, that lower bound was between approximately 5.20 m

– 5.90 m; the shallow King's Cove station remained mixed, with temperatures below 26.0 °C and DO concentrations above 5.0 mg/L.

18 JULY 2022

Habitat Range (Mid-Lake): 3.75 m to 4.20 m

Total Habitat (Mid-Lake): 0.45 m

The 18 July event showed a marked change in available trout habitat. During the preceding event the approximate bounds extended from the surface to a depth of about 5.50 m dependent on location in the lake. During the 18 July event it shrank significantly. At all five of the primary sampling stations surface temperatures exceeded the 26.0 °C threshold. As such, the upper bound was pushed down to 2.70 m to 4.40 m reflecting significant warming of the epilimnion. The thermocline, sometimes better thought of as a zone covering some depth termed the metalimnion rather than a sharp boundary, was not quite as sharply defined as before. As a result, DO concentrations did not plunge to anoxia quite as quickly as before, but this is a very subtle distinction. Despite this difference, there was still rapid oxygen depression and the lower bound defined by a DO concentration of 5.0 mg/L actually came up slightly in the water column. As a result, trout habitat thickness was significantly reduced. At the mid-lake ST-2 station, trout habitat thickness was just 0.45 m covering the depths from roughly 3.75 m to 4.20 m. During the previous event ST-2 exhibited the lowest trout habitat thickness, while during this event it was the highest with the other stations ranging from 0.20 m to 0.35 m.

This obviously marked a critical time for trout in the lake. While there is no suggestion that contravening these bounds causes immediate death, they do represent acute stressors to the fish. While the thermocline broadened somewhat and was not as well defined, its upper bound did not show considerable movement and the lower habitat bound defined by DO concentration rose up slightly.

25 JULY 2022

Habitat Range (Mid-Lake): No habitat at the time of sampling

Total Habitat (Mid-Lake): 0.00 m

Carryover trout habitat was non-existent at all eleven stations during the 25 July event. Water temperatures in the epilimnion increased as a result of the hot, dry weather. Temperatures increased almost 2.0 °C over the previous week at depths of 4.00 – 5.00 m at the Mid-Lake station. As a result, temperatures remained above the 26.0 °C threshold until below a depth of 5.0 m at all of the eleven stations. Due to the shallow epilimnion, at this time in the upper 4.00 m of the water column, DO concentrations dropped below the 5.0 mg/L threshold before temperatures dropped below 26.0 ° C at all stations with sufficient depth. While this obviously represented a critical time for trout in the lake, there were signs that the thermocline would soon begin to migrate downwards which would expand the depth of the epilimnion and potentially provide some thermal refuge near the bottom of the epilimnion. However, any additional thermal refuge would still be dependent on air temperatures and solar radiation; if the ambient air temperatures continued to rise or remain elevated, the epilimnion as a whole would continue to warm since this upper layer is continually mixed.

2 AUGUST 2022

Habitat Range (Mid-Lake): 0.00 m to 5.70 m

Total Habitat (Mid-Lake): 5.70 m

As during the previous two events, this early August event exhibited a marked change in available trout habitat in the lake, and this event showed a considerable expansion. First, there was a slight cooling at all stations near the surface, and two of the stations, including Mid-Lake and King's Cove, fell back under the 26.0 °C threshold thereby extending the habitat to the surface at those locations. The cooling, however, was not consistent through the epilimnion, and in fact, as a result of warming near the top of the thermocline and within the upper metalimnion, the epilimnion expanded and the thermocline migrated down through the water column. This was a predicted result consistent with water quality patterns recorded over time and a good illustration of metalimnetic erosion, the slow downward migration of the thermocline in the latter part of the growing season. Expansion of the epilimnion meant that deeper portions of the water column were starting to mix and become oxygenated. During the previous event, there was no available carryover trout habitat at any of the eleven sampling stations. However, trout habitat became widely available during this event, with an average lower DO bound of 6.0 m. As a result of both factors, but primarily the downward migration of the thermocline, average trout habitat at the four deeper stations jumped from 0.00 m on July 25 to 3.48 m, a significant expansion. At the Mid-Lake station, which has been used as the benchmark for understanding these data, habitat thickness increased to 5.70 m, from the surface (0.00 m) to 5.70 m depth.

Overall, this was positive news, although the results were tempered somewhat because temperatures in the epilimnion remained very high and small increases would substantially affect the assessed habitat. However, the expansion of the epilimnion and the downward movement of the thermocline would continue until the lake fully mixed theoretically establishing additional refuge at depth even if the surface temperatures should rise again. Conditions were still stressful to the fish on 2 August, but no longer be described as critical.

10 AUGUST 2022

Habitat Range (Mid-Lake): No habitat at the time of sampling

Total Habitat (Mid-Lake): 0.00 m

The 10 August event again showed a marked change in available trout habitat, as there was once again no carryover trout habitat available at any of the five stations. There is a very limited amount of carryover habitat present from 5.70 m to 5.85 m (0.15 m total habitat) if utilizing the 4.0 mg/L DO threshold. During the preceding event the approximate bounds extended from the surface to a depth of about 5.70 m at the Mid-Lake station, and all other stations had at least approximately 1.50 m of viable carryover trout habitat. However, water temperatures again increased significantly in the epilimnion and remained above 26.0 °C down to a depth of at least 5.0 m at all stations. Although the thermocline migrated downwards during the previous event which led to an expansion of the epilimnion, the continued hot weather led to an increase in water temperatures throughout the entire epilimnion. As a result, DO concentrations dropped below the 5.0 mg/L threshold before temperatures dropped below 26.0 °C at all stations with sufficient depth.

16 AUGUST 2022

Habitat Range (Mid-Lake): 0.00 m to 5.59 m

Total Habitat (Mid-Lake): 5.59 m

As with the previous four events, the 16 August event again represented a critical change in available trout habitat in the lake, but this event exhibited another considerable expansion. During this event, there was significant cooling throughout the epilimnion of all five stations. All stations had surface temperatures below the 26.0 °C threshold, which extended the upper habitat limit back to the surface at all stations. Additionally, the thermocline was still slightly deeper in the water column as a result of the expansion of the epilimnion that was first observed on 2 August. This is important because it means that deeper portions of the water column were mixed, resulting in the oxygenation of the entire upper layer. During the previous event, there was no available carryover trout habitat at any of the sampling stations. However, trout habitat became widely available during this event, with an average lower DO bound of 5.70 m. Since temperatures throughout the epilimnion were below the 26.0 °C threshold, average trout habitat at the four deeper stations jumped from 0.00 m on 10 August to 5.70 m, a significant expansion. At the Mid-Lake station, habitat thickness increased to 5.59 m, from the surface (0.00 m) to 5.59 m depth.

24 AUGUST 2022

Habitat Range (Mid-Lake): 0.00 m to 6.10 m

Total Habitat (Mid-Lake): 6.10 m

Carryover brown trout habitat continued to increase throughout much of the lake during the 24 August event. Surface water temperatures were still warm throughout the lake and exceeded the 26.0 °C threshold at four of the eleven stations. However, these elevated temperatures were generally restricted to the surface of the waterbody, and temperatures throughout the majority of the epilimnion were below the threshold. The depth of the epilimnion at the Mid-Lake station remained relatively consistent with what was measured one week prior, although the thermocline was not as clearly defined. This is a direct result of the slight cooling of the lower epilimnion and slight warming of the upper thermocline as air temperatures begin to cool relative to peak summer, which allows for some minor mixing between the two layers. Although the lake was still clearly stratified and would remain so for some weeks, the thermocline would continue to become less defined as temperatures in the epilimnion continued to decrease, eventually leading to fall turnover and complete mixing of the water column. Total brown trout habitat thickness increased to 6.10 m at the Mid-Lake station, from the surface (0.00 m) to 6.10 m depth.

6 OCTOBER 2022

Habitat Range (Mid-Lake): 0.00 m to 12.30 m

Total Habitat (Mid-Lake): 12.30 m

Water temperatures cooled significantly since the previous monitoring event, with surface temperatures below 17.20 °C at all stations. The lake was almost completely mixed at the Mid-Lake station on 6 October, although a slight thermal gradient was present in the lower 3.0 m which prevented the replenishment of DO below a depth of 12.00 m. As a result, there was viable carryover brown trout habitat in the upper 12.30 m of the Mid-Lake station, from the surface (0.00 m) to 12.30 m depth. All other stations had available trout habitat from the surface to the bottom, with the exception of ST-9 (Byram Cove) which had a DO concentration of 4.80 m at a depth of 7.00 m.

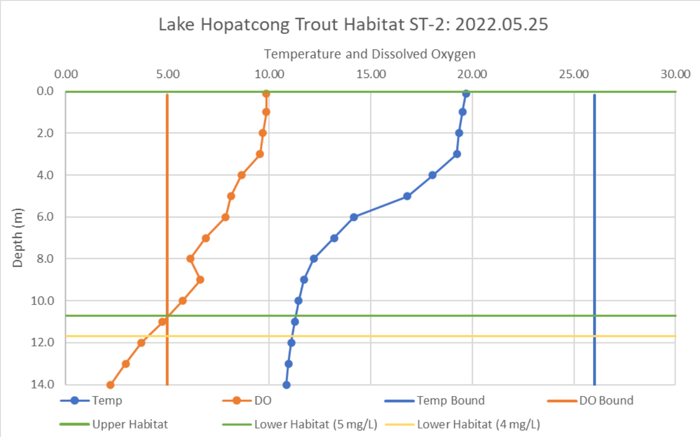


Figure 2.2: Habitat Range: 0.00 m to 10.70 m, Total Habitat: 10.70 m (5 mg/L), 11.70 m (4mg/L)

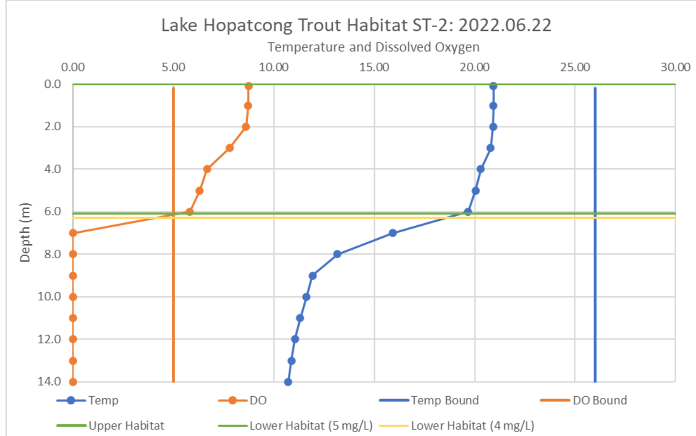


Figure 2.3: Habitat Range: 0.00 m to 6.10m, Total Habitat: 6.10 m (5 mg/L), 6.30 m (4 mg/L)

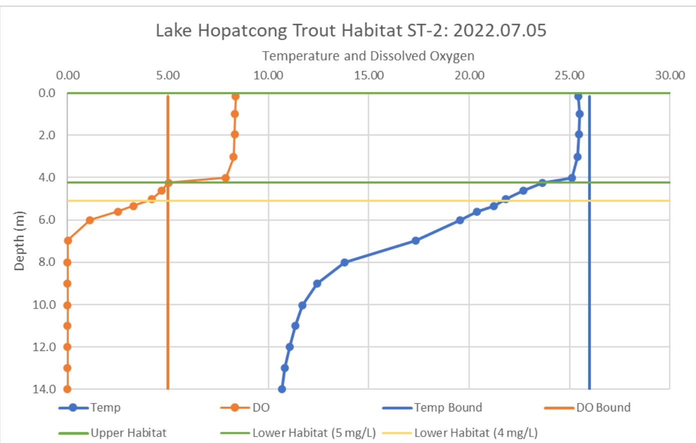


Figure 2.4: Habitat Range: 0.00 m to 4.25 m, Total Habitat: 4.25 m (5 mg/L), 5.10 m (4 mg/L)

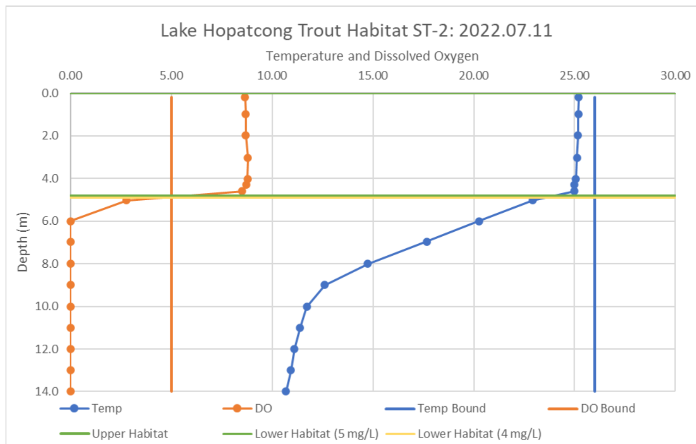


Figure 2.5: Habitat Range: 0.00 m to 4.80 m, Total Habitat: 4.80 m (5 mg/L), 4.90 m (4 mg/L)

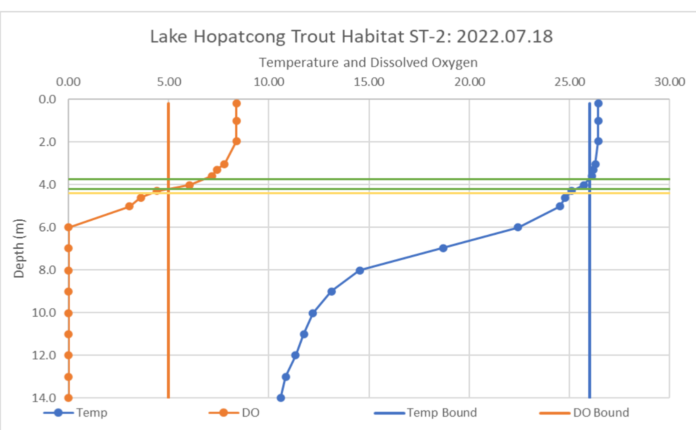


Figure 2.6: Habitat Range: 3.75 m to 4.20 m, Total Habitat: 0.45 m (5 mg/L), 0.65 m (4 mg/L)

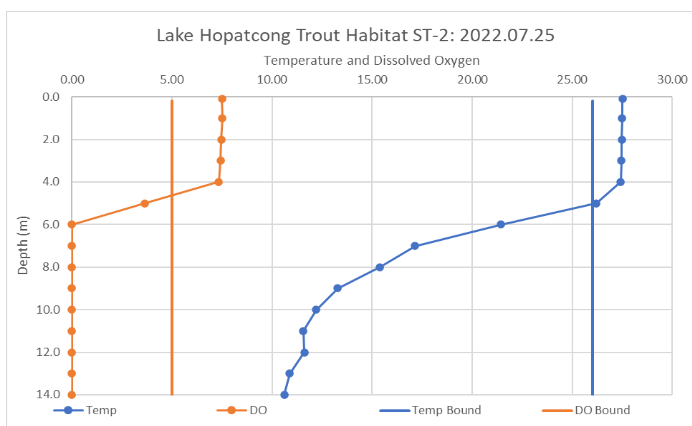


Figure 2.7: Habitat Range: NA, Total Habitat: 0.00 m (5 mg/L and 4 mg/L)

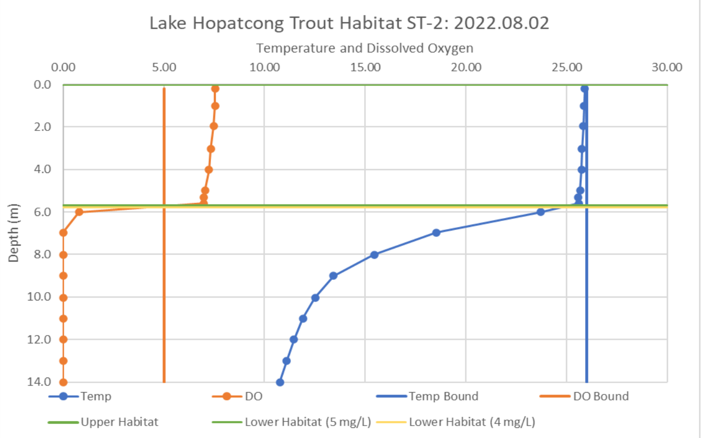


Figure 2.8: Habitat Range: 0.00 m to 5.70 m, Total Habitat: 5.70 m (5 mg/L), 5.80 m (4 mg/L)

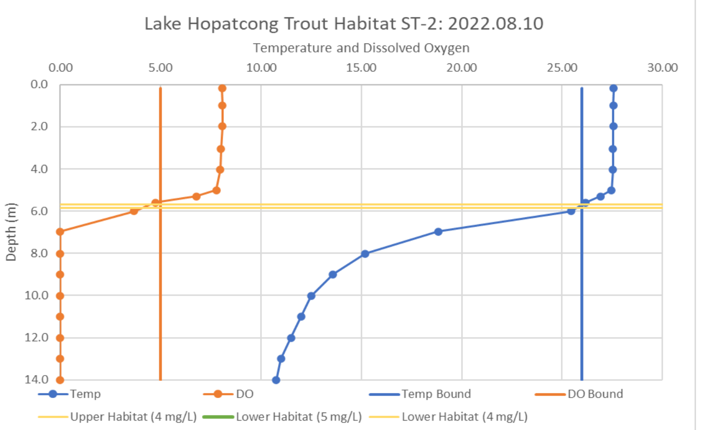


Figure 2.9: Habitat Range: NA, Total Habitat: 0.00 m (4 mg/L), 0.15 m (4 mg/L)

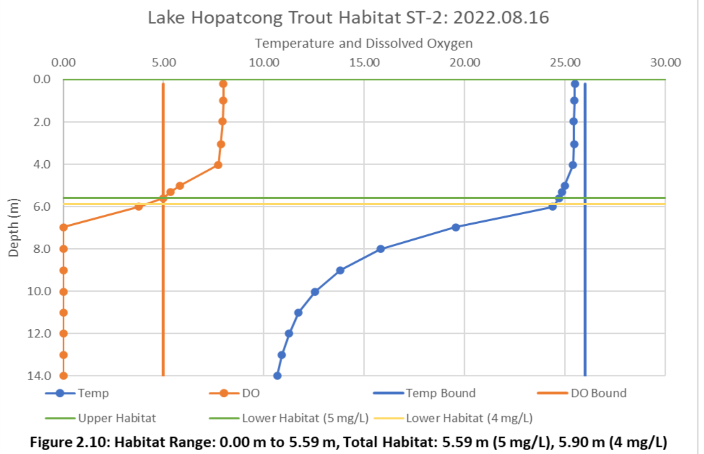


Figure 2.10: Habitat Range: 0.00 m to 5.59 m, Total Habitat: 5.59 m (5 mg/L), 5.90 m (4 mg/L)

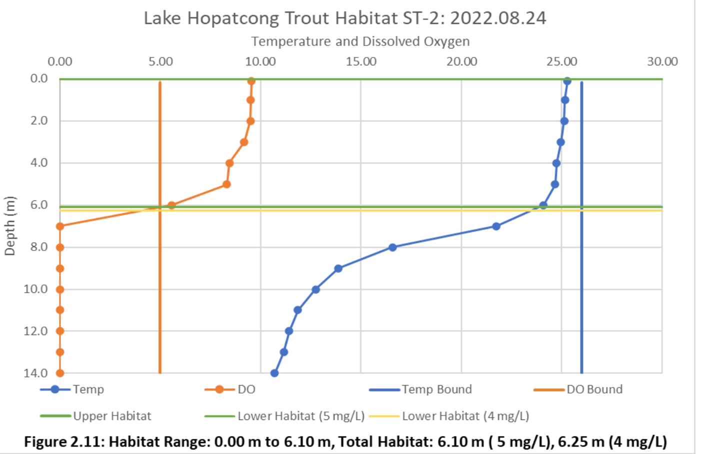


Figure 2.11: Habitat Range: 0.00 m to 6.10 m, Total Habitat: 6.10 m (5 mg/L), 6.25 m (4 mg/L)

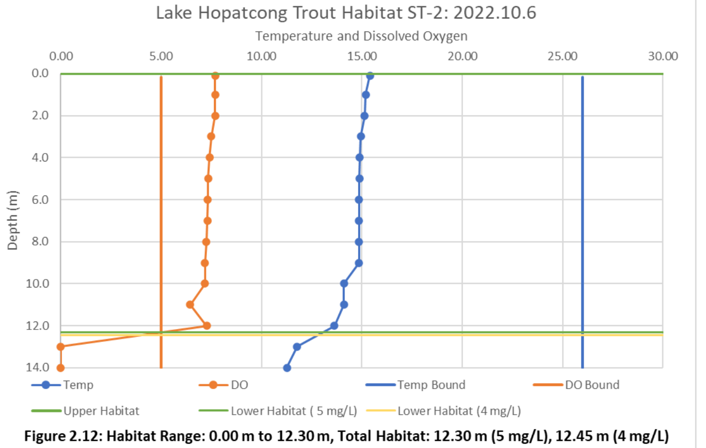


Figure 2.12: Habitat Range: 0.00 m to 12.30 m, Total Habitat: 12.30 m (5 mg/L), 12.45 m (4 mg/L)

2.4.2 TROUT HABITAT AVAILABILITY SUMMARY

A few additional figures are provided here to provide succinct visual summaries of some of the major factors that influence trout carryover habitat availability. Figures 2.13 and 2.14 include temperature and DO isopleths, which help to better illustrate the relationship between thermal stratification and DO concentrations throughout the season. These isopleth figures are meant to provide a snapshot of the relationship between thermal stratification and DO concentration and how the trout habitat becomes compressed from both the bottom (DO) and top (temperature) of the water column during the summer months. The dark red area on Figure 2.13 represents the portion of the water column where temperatures are too warm to sustain carryover trout habitat while the orange and red areas on Figure 2.14 represent the portion of the water column where DO concentrations are too low to support carryover trout habitat.

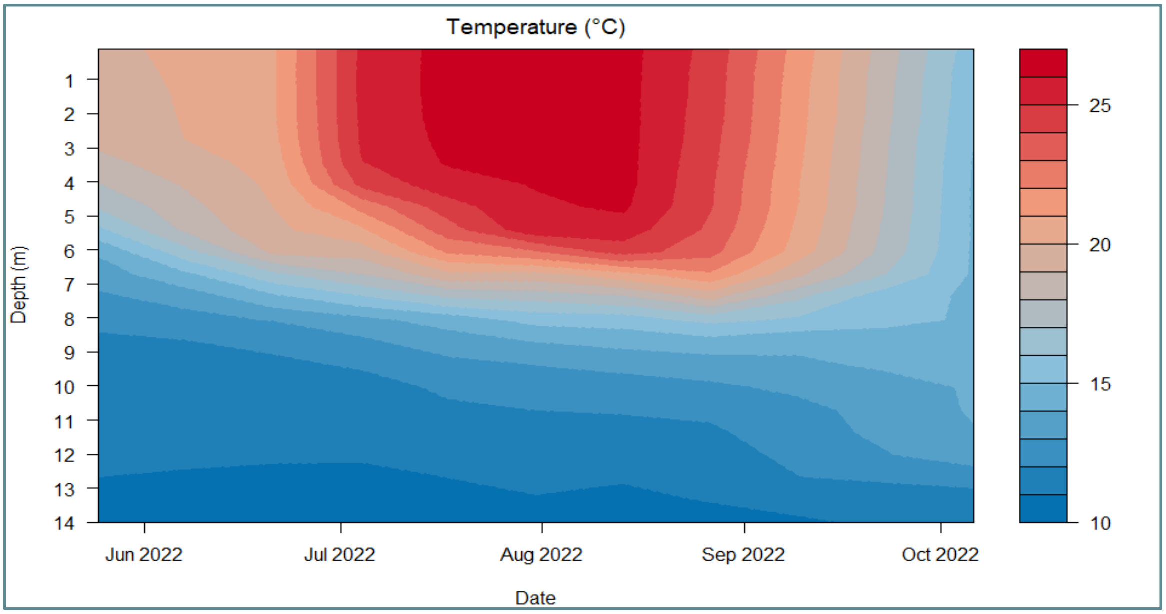


Figure 2.13: Temperature isopleths at the Mid-Lake station throughout the 2022 season

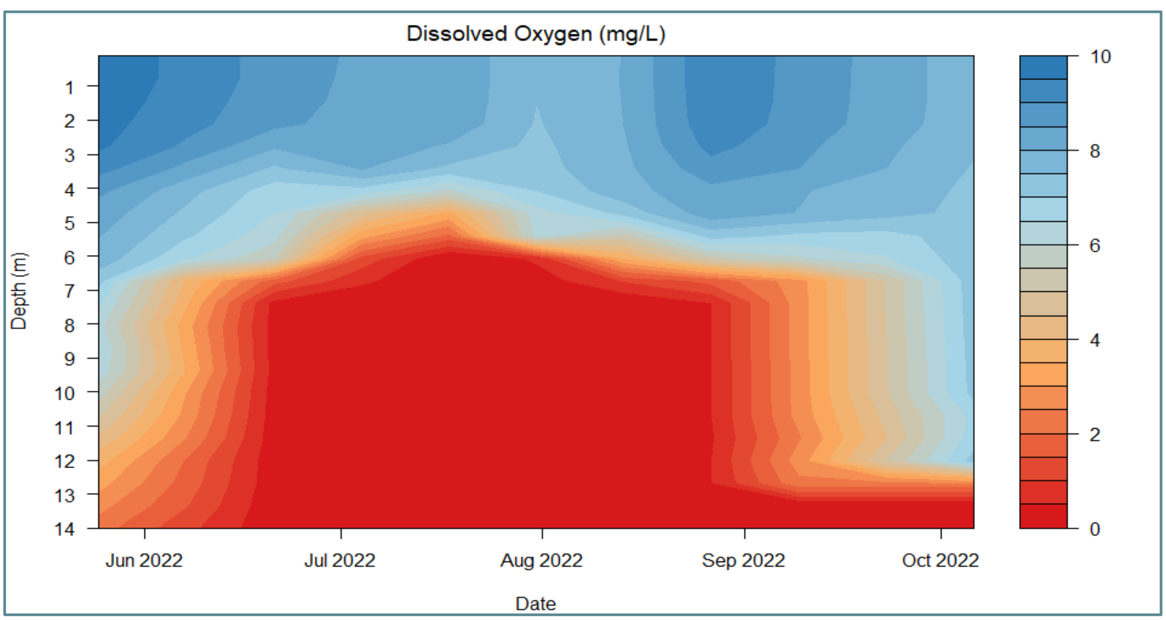


Figure 2.14: Dissolved oxygen isopleths at the Mid-Lake station throughout the 2022 season

Figure 2.15 provides the depths of the upper and lower boundaries of available carryover brown trout habitat during each monitoring event, using both the 4.0 mg/L and 5.0 mg/L DO thresholds as well as the standard temperature criteria. If the upper habitat bound was suitable for both 5.0 mg/L and 4.0 mg/L, only the 5.0 mg/L upper habitat datapoint is represented on the figure. If there was no available habitat for either the 4.0 mg/L or 5.0 mg/L thresholds, then no datapoints are represented on the figure; this only occurred on 25 July. However, on 10 August, there was no available carryover habitat using the 5.0 mg/L threshold, but there was a very small amount of habitat available using the 4.0 mg/L threshold.

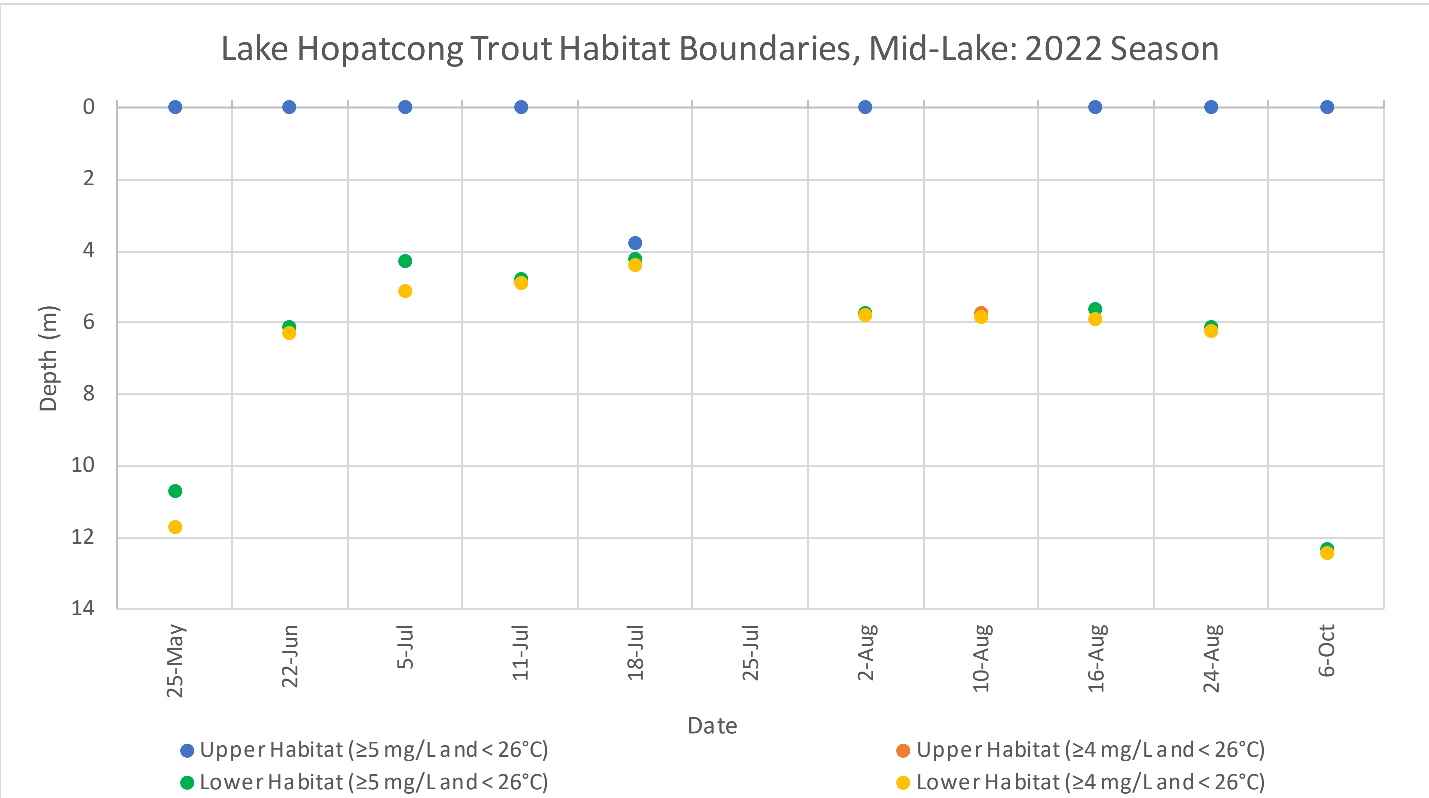


Figure 2.15: Upper and lower trout habitat boundaries at the Mid-Lake station throughout the 2022 season

Figure 2.16 displays the total vertical extent of available trout habitat during each monitoring event, which is the difference between the lower boundary and upper boundary from Figure 2.15. Again, both the 4.0 mg/L and 5.0 mg/L thresholds with temperature criteria are represented here. Unsurprisingly, brown trout carryover habitat was widely available at the beginning and end of the season but became compressed during the peak summer months of July and August. There were two events, 25 July and 10 August, where there was no carryover brown trout habitat present at the time of sampling using the 5.0 mg/L threshold; a limited amount of habitat was available on 10 August using the 4.0 mg/L threshold. However, on 2 August, the sampling event in between the two events where there was extremely limited to no habitat, there was almost 6.0 m of available habitat at the Mid-Lake station because temperatures in the epilimnion had cooled just enough to drop below the 26.0 °C. This indicates that carryover brown trout habitat availability is dynamic on a weekly and likely diel basis during the peak summer months as surface water temperatures cool at night and warms during the day. It is worth noting the minimal difference in trout habitat thickness between the 4.0 mg/L and 5.0 mg/L thresholds during the summer months. As the thermal stratification pattern persists throughout the season and any available DO in the hypolimnion is consumed, DO concentrations drop rapidly below the epilimnion.

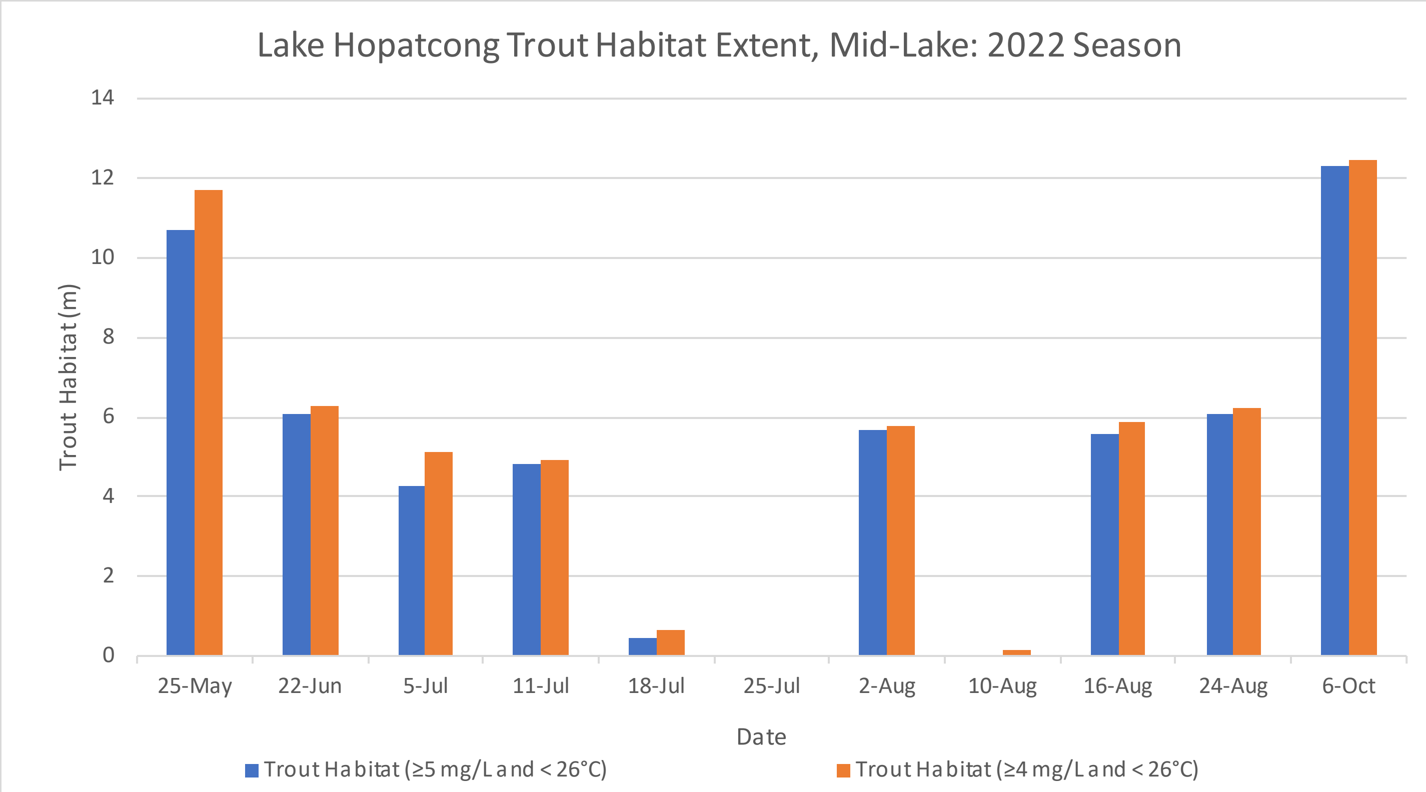


Figure 2.16: Trout carryover habitat thickness at the Mid-Lake station throughout the 2022 season

Figure 2.17 was developed to display the data from Figures 2.14 and 2.15 in a succinct visual summary. A scale from 0.0 – 2.0 was developed to represent a range of carryover trout habitat in Lake Hopatcong. A 0.0 on the scale represents available carryover trout habitat, based on the 2022 temperature and DO data, while a 2.0 represents non-available trout habitat. A color schematic was developed along with this scale to visually represent trout habitat availability throughout the season. The 2022 water quality data was converted to this binary scale and all of the data values, represented by different shades of red, displayed by dates in between sampling events was interpolated. For example, if the surface of the lake had temperature and DO values conducive for carryover trout habitat on a sampling date, but the next sampling date did not, the first sampling event would be represented by a 0.0 on the scale while the following date would be represented by a 2.0; the data values in between these two dates is interpolated and would include the range of values between 0.0 and 2.0. The range of values between 0.0 and 2.0 represent a continuum of habitat availability, with increasing values representing increased stress on the fish. It is evident from the 2022 water quality data that the carryover trout habitat availability is dynamic during the hot summer months.

Figure 2.16 is particularly useful in visualizing the lack of trout habitat availability during the critical summer period in 2022, from July through mid-August. While Figure 2.14 shows that carryover trout habitat was present in the upper 5.70 m on 2 August, in between two sampling events in which trout habitat was non-existent, a review of the temperature data shows that the temperatures were just below the 26.0 °C threshold. Thus, while that range of trout habitat was available during the time of sampling, it's very likely that the temperatures exceeded that threshold at times within the days before and after that sampling event. Similarly, it's possible that temperatures at night time were dropping below the 26.0 °C threshold around the two dates of 25 July and 10 August. Thus, this entire time period is represented by a range of values between 1.8 – 2.0, with values of 2.0 representing measured data and the lesser values representing interpolated data that hovers around the upper temperature limit of carryover trout habitat.

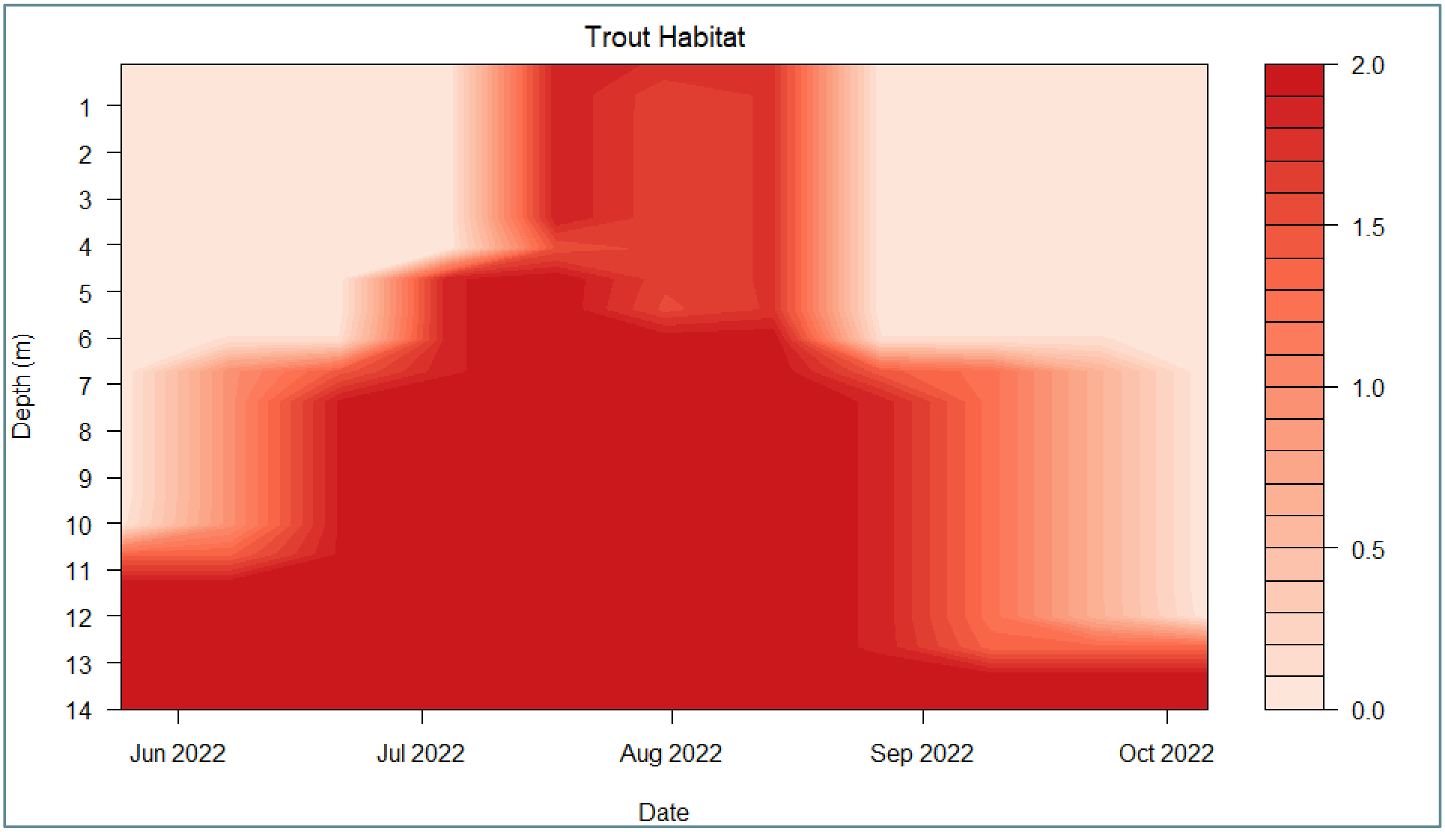


Figure 2.17: Trout habitat availability isopleth. 0 represents available habitat and 2.0 represents no habitat

The use of strict thresholds in determining habitat quality does present a problem in explaining the findings; in reality the habitat quality and availability should be viewed along a spectrum. This is one of the benefits of using isopleths to interpret the data as they indicate the dynamics of the system in space time as shown in Figure 2.13 and 2.14 as well as in Figure 2.17. Fundamentally, departure from those threshold values used for analysis and time spent outside those bounds represents increasingly difficult conditions to the fish and higher risk of mortality.

2.5 NEAR-SHORE AND STREAM WATER QUALITY AND HABITAT ANALYSIS

2.5.1 SUMMARY OF WATER QUALITY DATA

Table 2.2 presents a summary of the total number (N) of nearshore sites that were sampled during each event. The number of sampling sites that supported carryover trout habitat (n) during each sampling event is also provided. Finally, the total depth of available carryover habitat at the Mid-Lake Station during each event is also provided as a reference. Please note that this analysis only utilized the DO threshold of 5.0 mg/L. However, the limiting factor at almost all of the nearshore sites was temperature rather than DO because of the shallow depth associated with most nearshore sites. Anoxic conditions are not typically observed in Lake Hopatcong in areas of the lake less than at least 3.00 m. However, that is not a rule and anoxic conditions can at times and under certain circumstances be observed in shallow areas of the lake. Tables with the full *in-situ* sampling results from all eleven monitoring events are provided in Appendix III.

The percentage of total nearshore sites that supported carryover trout habitat shrunk considerably during the critical summer period from 18 July through 10 August, with 0% of the nearshore sites supporting carryover trout habitat on 18 July and 10 August. However, 7 of the 30 (23%) nearshore sites sampled on 2 August supported carryover habitat. This is consistent with the water quality data collected from the deep stations during the critical period, as carryover habitat expanded to the upper 5.70 m at the Mid-Lake Station on 2 August due to a temporary cooling of the waters.

Ten of the twelve sites sampled on 16 August were stream sites that discharge into Lake Hopatcong. Most of these sites were significantly cooler than the in-lake temperatures. However, due to the extremely hot and dry summer, flow was minimal in all of the stream sites that were sampled. Additional stream sites were visited but were not sampled because they were completely dry. Even here this indicates that potential refuge habitat within the tributary network discharging to Lake Hopatcong is subject to weather and climate driven impacts.

Table 2.2: Summary of near-shore sampling in Lake Hopatcong

Date	Total Sites	Carryover Habitat	Mid-Lake Carryover Habitat
	N	n	Meters
7/5/2022	19	12	4.25
7/11/2022	23	11	4.80
7/18/2022	5	0	0.45
8/2/2022	30	7	5.70
8/10/2022	30	0	0.00
8/16/2022	12	11	5.59
8/19/2022	6	5	6.10

NEAR-SHORE ANALYSIS

Figure 2.18 presents the temperature departures from all nearshore sampling points relative to the closest deep station on the same day. Positive values indicate that the near-shore site was warmer than the closest deep station, while negative values indicate the near shore station was cooler. Please note that this includes all sampling points from the nearshore sites, not just the surface temperature. For example, if a nearshore site was 2.00 m deep, temperature data was collected at the surface, 1.00 m, and just above the sediment, for a total of three data points. If the nearshore station was deeper than 2.00 m, the temperature data below a depth of 2.00 m was compared with the respective depth from the deep sampling station that was used as a reference. The majority of the temperature data from the nearshore sampling stations were warmer than the respective deep station, although there were a number of instances where the nearshore temperatures were slightly cooler. The three datapoints from 25 July that are over 1.0 °C cooler than the closest deep station were collected in profile at a relatively deep (4.00 m) spot off the eastern point of Bertrand Island. The *in-situ* DO measurement from a depth of 4.00 m was less than 3.0 mg/L and thus did not represent available carryover, but the upper 3.00 m did.

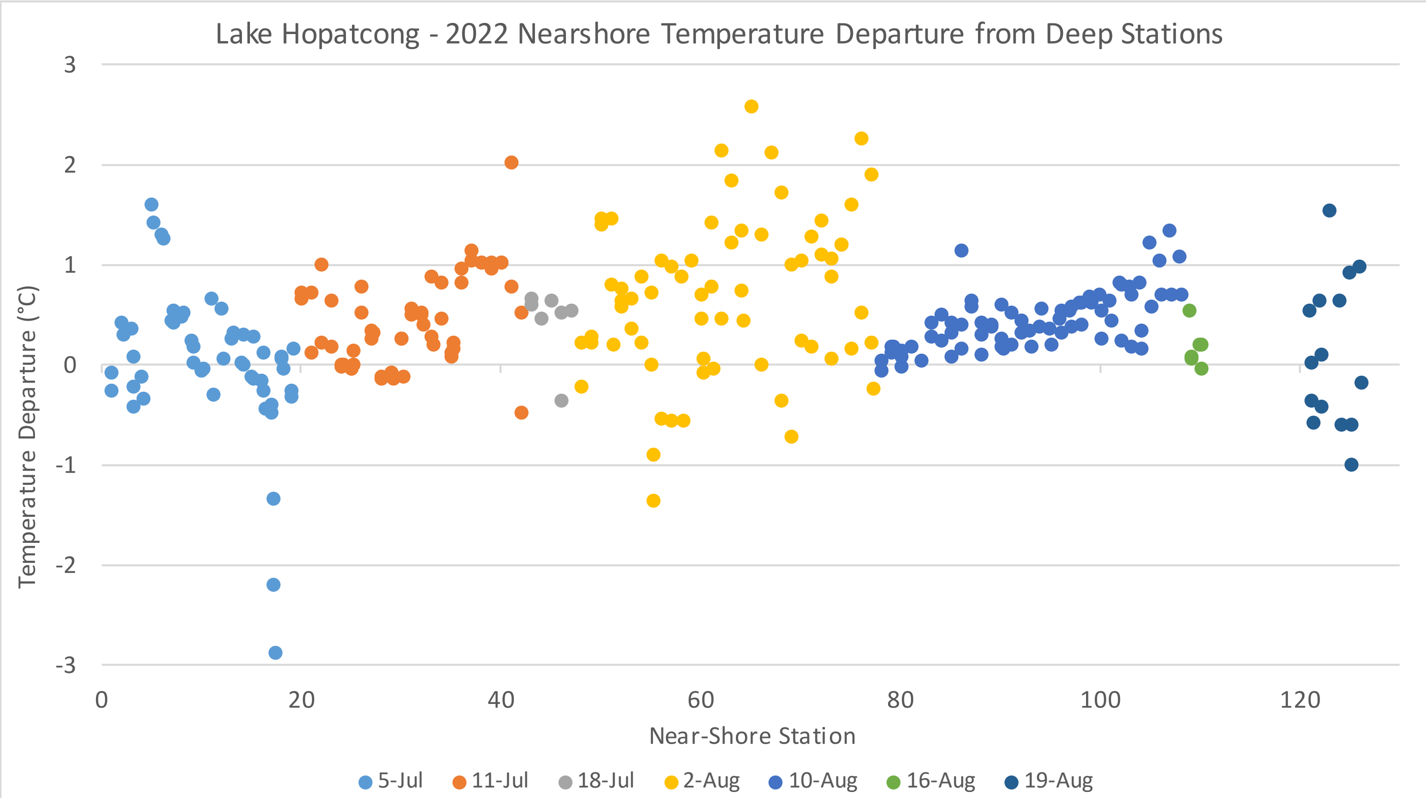


Figure 2.18: Near-shore temperature departures from the closest deep station in Lake Hopatcong

Figure 2.19 presents the temperature departures from all nearshore sampling points relative to the closest deep station on the same day during the critical summer period only. The critical summer period is defined here as 18 July through 10 August. This period was determined through an analysis of the available carryover trout habitat at the deeper stations and represents the time of year when available habitat is at a minimum. Negative temperature departures (cooler water) at the nearshore sites became increasingly rare as the summer progressed. The near-shore analysis is extremely important during this time of the year because this is when carryover trout habitat becomes scarce, due to a warming of the surface water and a loss of oxygen in the deeper water. Thus, this is the time of year when any refuge trout habitat around the shoreline of the lake would become vital to the survival of trout.

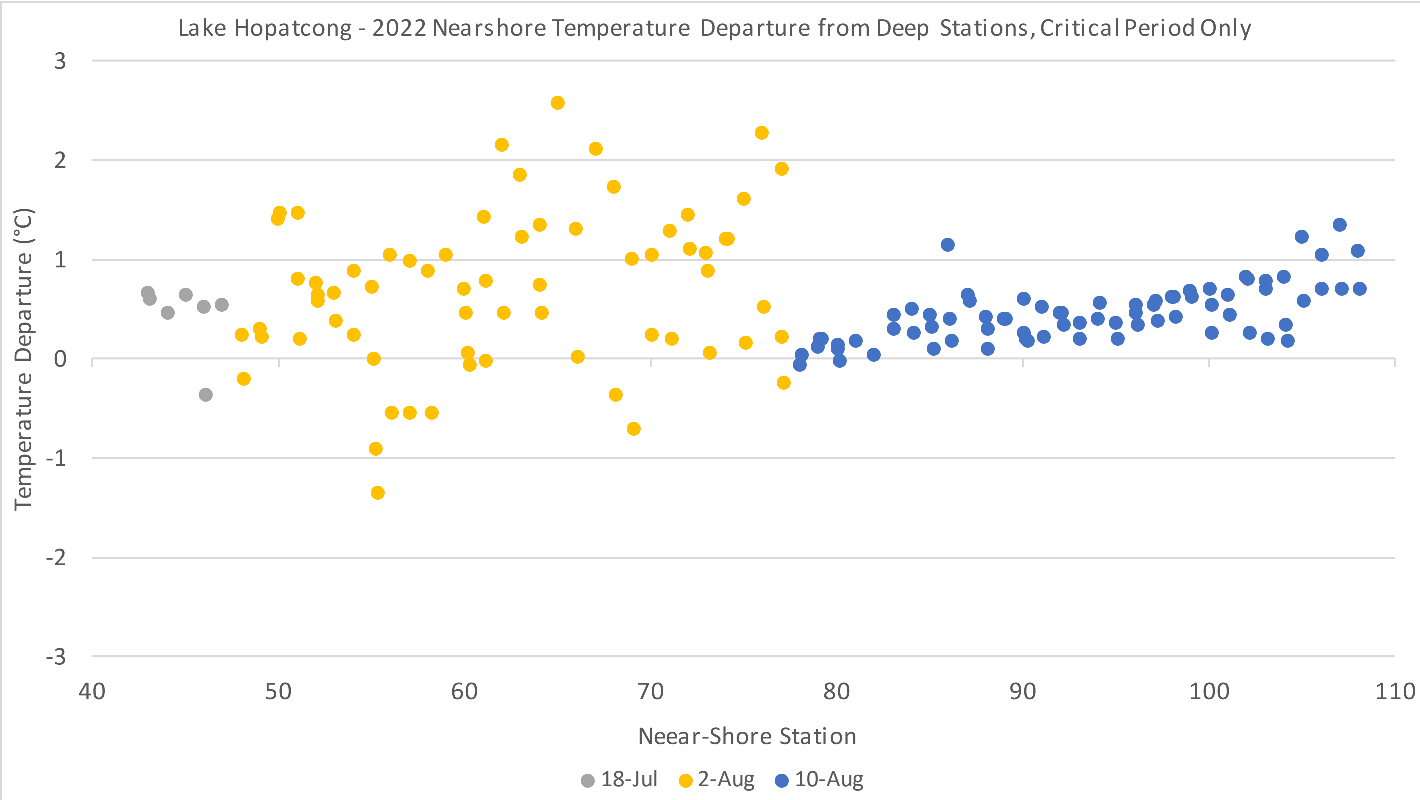


Figure 2.19: Near-shore temperature departures from the closest deep station during the critical summer period

The recorded temperatures of two of the data points (Sites 46 and 48) that represent negative temperature departures on 18 July and 2 August were still above 26.0 °C and thus did not represent carryover trout habitat.

The cluster of five data points from 2 August, representing near-shore Sites 55 – 58, that range from 0.5 °C to 1.4 °C cooler than the closest deep station, was collected at the very northern end of Lake Hopatcong, from the inlet of Bright's Cove west to Woodport Bay. It is worth noting that the surface temperature at all four of these stations were above 27.0 °C but all depths below the surface were much cooler and below the temperature threshold of 26.0 °C. All DO concentrations remained above 5.0 mg/L in this section of the lake as well, resulting in carryover trout habitat below the surface at the very northern end of the lake on 2 August.

There are two likely explanations for the temperature disparity below the surface in this location. It is possible that there are indeed underground seeps that are releasing cooler groundwater to the northern end of the lake. The two streams that discharge into Bright's Cove, S-6 and S-7, were both significantly cooler than the Mid-Lake Station when they were sampled on 16 August. A second possible explanation could be related to the abundance of suspended solids and the associated increase in turbidity in this section of the lake. A review of water quality data from the long-term monitoring program at Lake Hopatcong in 2022 reveals elevated total suspended solids (TSS) and a decrease in water clarity relative to the main portion of the lake. An increase in TSS at the surface of the lake can affect how heat is circulated throughout the water column. Because the water is darker at the surface, the sun's rays and the associated heat is attenuated to a greater degree at the surface, resulting in the surface waters heating up much more rapidly than the "deeper" water that is less affected than the surface water. When this occurs on hot summer days, the surface of the lake can heat up rapidly resulting in small thermal gradients near the surface. Regardless of how it happened, this section of the lake may have been able to serve as a refuge for brown trout during this hot summer day.

The two other data points, representing near-shore Sites 68 and 69, that were 0.4 °C and 0.7 °C cooler than the respective deep station on 2 August were also recorded in the northern end of Lake Hopatcong but further south than the other five data points. These temperatures were recorded just north of Brady Bridge along the northern shoreline. There is a small tributary that feeds into the lake near the location of near-shore Site 69 that was discharging cooler water. A review of the stream data indicates that this tributary (S-8) was 4.6 °C cooler than the Mid-Lake Station on the day that they were both sampled.

STREAM ANALYSIS

Ten streams that discharge into Lake Hopatcong were sampled on 16 August. However, due to the extremely hot and dry summer, flow was minimal in all of the stream sites that were sampled. Additional stream sites were visited but were not sampled because they were completely dry. A review of the *in-situ* data collected at the stream sites reveals elevated specific conductivity values at most sites which is indicative of groundwater influence (Table 2.3) and typical of stream baseflow. Specific conductivity is a direct measure of the ability to conduct electricity and is an indirect measure of the concentration of dissolved ions in solution.

Table 2.3: Lake Hopatcong Inlet Stream *In-Situ* Data 16 August 2022

Station	Depth	Temperature	Specific Conductance	Dissolved Oxygen		pH
	m	°C	µS/cm	Conc. (mg/L)	Sat. (%)	s.u.
S-1	0.1	17.67	1,574.2	6.85	74.5	6.32
S-2	0.1	21.21	1,314.0	8.80	102.4	7.45
S-3	0.1	20.83	962.6	6.69	77.3	7.18
S-4	0.1	24.48	578.9	6.52	80.6	6.9
S-5	0.1	21.72	212.3	6.84	80.3	7.24
S-6	0.1	19.32	902.7	6.15	68.9	7.03
S-7	0.1	19.07	639.7	6.90	76.3	7.57
S-8	0.1	20.86	305.9	6.92	79.3	7.76
S-9	0.1	19.82	813.1	2.97	33.8	7.06
S-10	0.1	19.60	2,027.3	8.98	102.3	8.12

As groundwater moves through soil, it dissolves some of the minerals and salts which raises the specific conductivity of the water. The upper saturation boundary is known as the water table. Groundwater seeps into streams and waterways and provides what is known as baseflow. This provides a source of water to streams during periods of dry weather. The water table is not static and moves downward during periods of dry weather due to evapotranspiration in the soil. When the local water table drops below the elevation of the stream channel there is no longer groundwater exchange to support baseflow. Some of the stream sites that were visited on 16 August were completely dry, meaning that the water table had receded to below a depth that would provide baseflow to the stream. The streams that did have water were all extremely low flow, but the water table was still high enough to provide a small amount of baseflow. This water is often much cooler than ponded surface waters during the summer months because the soil insulates the groundwater from the heat at the surface.

Although none of the stream sites had enough water to sustain any trout during the site visit, the cooler water they provide to the lake is still important for carryover trout habitat. As these cooler streams discharge into the lake, they can create localized areas within the lake that are cooler than the surrounding lake water. Additionally, during summers with normal precipitation patterns, some of these sites may have enough flow to provide an area of refuge for trout. Thus, it is important to analyze these sites and determine which areas in the lake would benefit from the cooler water.

Figure 2.20 below illustrates the temperature departures from all ten stream sites relative to the surface water temperature at Mid-Lake Station on 16 August. All ten sites were cooler than the Mid-Lake Station and eight sites were over 4.0 °C cooler than the Mid-Lake Station.

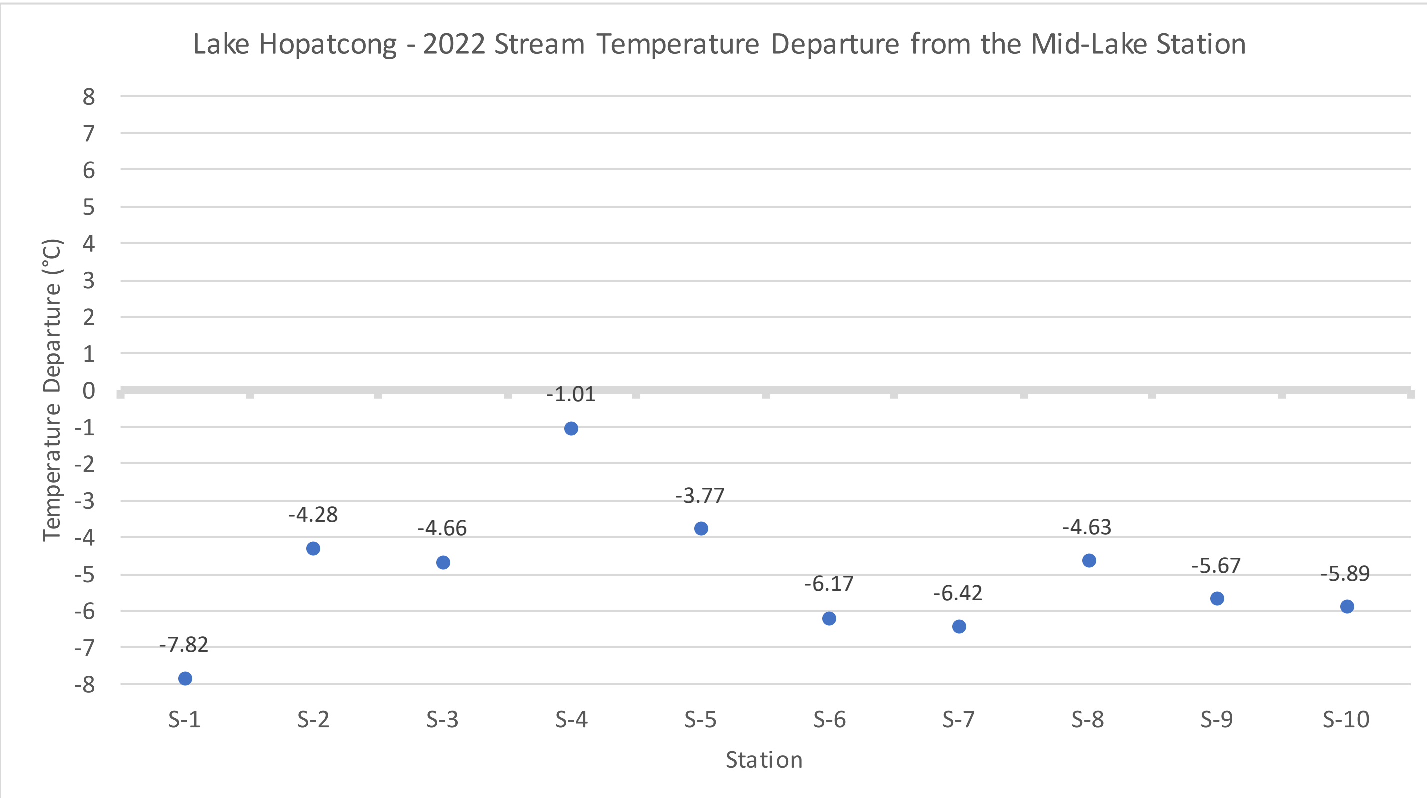


Figure 2.20: Stream temperature departures from the surface temperature of the Mid-Lake station 16 August

S-1 is located in Glen Brook just upstream of Memorial Pond in Mount Arlington and was 7.8 °C cooler than the Mid-Lake Station. This station was sampled to serve as a reference point to compare with S-2 which was sampled further downstream. S-1 discharges into Memorial Pond directly downstream of where it was sampled before discharging into Memorial Brook, and eventually into Lake Hopatcong via a large pipe adjacent to Memorial Beach. The flow in S-1 was no more than a trickle and most of the water was pooled in small depressions. Memorial Pond appeared to be close to the normal water level but there was very low flow over the outlet structure that discharges into Glen Brook downstream of the pond.


Photos 2.1 – 2.2: S-1 (left) and Memorial Pond (right)

S-2 was sampled just upstream of the Memorial Beach parking lot at the furthest point downstream before it flows under the parking lot. Although considerably warmer than the temperature at S-1, S-2 was still over 4.0 °C cooler than the Mid-Lake Station. Memorial Pond acts as a settling pond, removing sediment and nutrients before discharging downstream. While this is an important service for the overall management of Lake Hopatcong, the increased retention time in the pond increases the temperature of the water. However, based on the cooler temperatures at S-2, it's evident that this stream is providing a source of cooler water to the lake during the summer months which may provide some refuge for trout. It is possible that Memorial Pond has more of a warming effect on the water in Glen Brook downstream of the pond during periods of normal flow; however, additional sampling during a summer with more normal precipitation patterns would need to be conducted. Glen Brook just upstream of S-2 lacks a sufficient riparian buffer that would provide shade to the stream reach, resulting in cooler temperatures.


Photos 2.3 – 2.4: Glen Brook upstream of S-2 (left) and S-2 (right)

S-3 was sampled in an unnamed tributary in front of Edith M. Decker Elementary School and the water temperature was 4.7 °C cooler than the Mid-Lake Station. There was minimal flow on 16 August and the water that was sampled was in a small pool just upstream of the culvert. This tributary flows under Howard Boulevard and discharges into the lake in Van Every Cove. It is believed that the discharge pipe is located on or adjacent to private property and thus was not sampled. However, given the cooler temperature, the inflow from this stream may provide a small refuge area for trout in Van Every Cove during the warm summer months. Given that the stream was barely flowing, it is not likely that the pipe was actually discharging much water into the lake during the dry 2022 summer.

Photos 2.5 – 2.6: Culvert at the S-3 stream (left) and S-3 (right)

S-4 was sampled in Great Cove at the exact location where a small tributary discharges into the lake via a pipe. This tributary has a drainage area of 450 acres of mostly forested and residential land. The tributary is piped underground for approximately 500 ft., traveling under Felter Place and Espanong Road before discharging into the lake next to the State Police building. While this tributary would not be able to serve as a direct area of refuge for trout, the lake water was 1.0 °C cooler than the Mid-Lake Station next to the inlet pipe. Thus, this area of the lake may serve as a small refuge area during the summer months. However, this area of the shoreline is mostly bulkhead and the pipe is located in the corner of the cove between the State Police building and a marina. Thus, while temperatures may be slightly cooler here, there is not much physical habitat that would be particularly attractive to trout.


Photos 2.7 – 2.8: S-4 (left) and the shoreline adjacent to the pipe in Great Cove

S-5 was sampled immediately downstream of the Lake Shawnee dam on the west side of East Shawnee Trail. There was no water flowing over the spillway at the Lake Shawnee dam during the sampling event but groundwater was still providing baseflow to the tributary. The water here was 3.8 °C cooler than the Mid-Lake Station on 16 August. However, this inflow has to travel through the very shallow Jefferson Canals before mixing with the main body of the lake north of Brady Bridge. The cooler water from the inlet likely warms considerably as it mixes with the water in the shallow Jefferson Canals. Additionally, the stream temperature is likely warmer when it is receiving water from Lake Shawnee due to the warming effect in surface water impoundments.


Potos 2.9 – 2.10: Lake Shawnee dam (left) and S-5 (right)

S-6 was sampled at the inlet stream from Lake Winona from the southwestern side of Lorettacong Drive. This inlet flows directly into Bright's Cove in the northeastern end of Lake Hopatcong. Similar to the Lake Shawnee outlet, there was no surface water from Lake Winona discharging into the tributary. However, there was still a small volume of baseflow flowing into Lake Hopatcong from the inlet stream. The water in this stream was 6.2 °C cooler than the surface water at the Mid-Lake Station. Bright's Cove discharges into the main body of Lake Hopatcong at near-shore Site 55 where cooler water was measured during the sampling conducted during the critical summer period.


Photos 2.11 – 2.12: Downstream view of the dry streambed from the outlet of Lake Winona (left) and S-6 (right)

S-7 was sampled just down the road from S-6 in an unnamed tributary that also drains to Bright's Cove. Similar to S-6, the water here was over 6.0 °C cooler than the Mid-Lake Station. It is evident from these two streams that Bright's Cove is receiving significantly cooler water and may be an area of refuge for trout during the warm summer months. Any potential future sampling associated with the trout study should measure temperature and DO directly in Bright's Cove.

Photo 2.13: S-7

S-8 was sampled at a small stream on the west side of Brady Road, approximately 350 ft. north of where the stream discharges into the lake near Beebe Marina. The stream travels underground just across Brady Road from where it discharges into the lake via a pipe. This pipe also receives road runoff from the immediate area. The water temperature in the stream was 4.6 °C cooler than the Mid-Lake station on 16 August. Near-shore Site 69, sampled during the critical summer period on 2 August, was 0.7 °C cooler than the nearest deep station at a depth of 1.0 m. Thus, this inlet may be providing a small refuge area for trout during the warm summer months.


Photos 2.14 – 2.15: Upstream (left) and downstream (right) views at S-8

S-9 was sampled in the backyard of a private residence near the intersection of New Jersey Avenue and Ohio Street. This inlet drains an area of approximately 49 acres of mostly forested and residential land. This inlet is not a traditional stream inlet and is mostly conveyed to the lake in the subsurface stormwater system. The location of the residence where the inlet was sampled is where the subsurface drainage discharges to a small surface stream that empties into a very small cove across the channel from Raccoon Island. The water level was extremely low on 16 August and thus is assumed to be mostly groundwater influenced. The water temperature was 5.7 °C cooler than the surface water temperature at the Mid-Lake station. While the water temperature was significantly cooler here, it is a very small stream and thus may not be providing enough flow to significantly cool the lake water in the immediate vicinity of the inlet. Near-shore Site 74, sampled in the small cove where S-9 discharges into the lake, was 1.2 °C warmer than the Mid-Lake station on 2 August.


Photos 2.16 – 2.17: Dry stream upstream of S-9 (left) and downstream view from S-9 (right)

S-10 was sampled in a stream that discharges into the southern end of Crescent Cove, just before the stream travels under the Crescent Cove Beach Club parking lot. This is a fairly large stream that generally flows throughout the year and had a light flow during the sampling event. The water temperature in the stream was 5.9 °C cooler than the Mid-Lake Station surface water temperature. The stream discharges into the southern end of Crescent Cove via a pipe. Although the water temperature was cool, this stream should be considered low priority due to the location of where it discharges into Lake Hopatcong. Crescent Cove is a very secluded, shallow, and narrow cove that has little shade coverage. Thus, water temperatures in the cove are usually significantly warmer than the main body of the lake during the warm summer months.

DISCUSSION OF NEAR-SHORE AND STREAM MONITORING RESULTS

Overall, the near-shore sampling results indicate a very limited presence of locations that may have been serving as localized refuge areas for brown trout during the critical summer period in 2022. It's important to stress that the 2022 summer was one of the warmest and driest summers on record which obviously had a significant impact on water temperatures. The hot and dry summer directly increased the surface water temperatures in the lake as a result of the higher ambient air temperatures and intense solar irradiance. The dry summer also affected the temperature of the lake by limiting the volume of water that entered the lake via the numerous streams throughout the watershed. As shown in the *in-situ* results from the stream sampling, these streams have the potential to provide a source of cooler water to the lake during the warm summer months. These streams were either completely dry or had limited flow due to the depletion of the groundwater reserve that provides a source of water to these streams during periods of baseflow. The depletion of the groundwater reserve as the dry summer progressed likely resulted in the abatement of potential seeps and springs around the shoreline and lake bottom that may be providing a direct source of cooler water to the lake during more normal weather conditions. Thus, Princeton Hydro deems it prudent to conduct another full season of limnetic, near-shore, and stream water quality sampling under different weather conditions to better characterize potential trout carryover habitat.

There were still a few sites around the shoreline of the lake that had temperatures that were cooler than the deeper limnetic stations that are worth discussing. The primary location, based on both near-shore and stream *in-situ* data collected during the critical summer period, is the very northern end of the lake near Bright's Cove and Woodport Bay. Both of the streams that discharge into Bright's Cove were over 6.0 °C cooler than the Mid-Lake Station on 16 August. Additionally, near-shore Sites 55 – 58 located at the inlet from Bright's Cove west to Woodport Bay, were 0.5 °C to 1.4 °C cooler than the closest deep station on 2 August. The surface temperature at all four of these stations were above 27.0 °C but all depths below the surface were much cooler and below the carryover trout habitat temperature threshold of 26.0 °C. All DO concentrations remained above 5.0 mg/L in this section of the lake as well, resulting in carryover trout habitat below the surface at the very northern end of the lake on 2 August. Any future water quality sampling associated with this trout study should put an emphasis on this section of the lake, including the two inlet streams to Bright's Cove.

Another location north of Brady Bridge worth monitoring with increased scrutiny in the future, based on near-shore and stream *in-situ* data, is the area around near-shore Site 69. The water temperature in S-8, which discharges into the lake near near-shore Site 69, was 4.6 °C cooler than the Mid-Lake station on 16 August. Near-shore Site 69 was 0.7 °C cooler than the nearest deep station at a depth of 1.0 m on 2 August. Thus, this inlet may be providing a small refuge area for trout during the warm summer months.

In summary, the entire shoreline of Lake Hopatcong was monitored in 116 locations, resulting in valuable temperature and DO *in-situ* data to help identify potential brown trout habitat refuge locations. Additionally, 10 of the major stream sites that discharge into Lake Hopatcong were monitored for the same parameters. Additional stream sites were visited but not sampled due to a lack of flow. While the data gathered in 2022 was extremely valuable, the results are likely somewhat limited due to the drought conditions experienced in New Jersey in summer 2022. However, the data was still valuable in that it provides insight into a few locations in the northern end of the lake that may have been serving as a refuge area for trout during the hot summer. It also identified at least 10 stream sites that were still flowing to some degree during the dry summer. All ten of these stream sites were cooler than the in-lake temperatures, and eight of the sites were over 4.0 °C cooler.

Princeton Hydro supports a second season of a similar water quality and habitat sampling study to further refine the results from the first year of the study. The trout tagging will be conducted for three consecutive years; 2022 was the first year. Although it's impossible to predict what the weather conditions in the summer of 2023 will be, it is expected that the summer should at least be wetter, given that this was one of the driest summers on record. Thus, conducting a similar sampling plan under varying weather conditions will offer additional insight into potential trout carryover habitat in and around Lake Hopatcong.

3.0 PRIORITIZATION OF WATERSHED LOCATIONS TO PRESERVE VITAL TROUT HABITAT

One of the major goals of this study is the identification of potential locations in the watershed that can be preserved and/or enhanced to protect near-shore and stream habitat that may be providing refuge to brown trout during the critical summer period. Unfortunately, much of the Lake Hopatcong shoreline is either private residential or commercial land and/or bulkhead rather than naturalized shoreline. However, given the extensive length of the shoreline, there are still a number of locations in the immediate watershed that can be preserved or enhanced.

A revised Watershed Implementation Plan (WIP) for the Upper Musconetcong River Watershed, which includes Lake Hopatcong, was recently updated. This document outlines 52 sites throughout the watershed that can be enhanced to improve water quality conditions in Lake Hopatcong. These sites include areas that can accommodate stormwater best management practices (BMPs), in addition to shoreline sites directly on Lake Hopatcong, as well as stream and riparian sites. This section will provide an overview of a few select sites as they are related to preserving or enhancing some of the near-shore and stream sites that were sampled in 2022 and deemed as potential trout refuge habitat. Additional sites will be listed if applicable. Finally, a few general watershed recommendations will be included at the end, such as riparian buffer enhancements.

The areas around Lake Hopatcong and the watershed that will be prioritized in this section, based on a review of the project data, includes sections of the lake north of Brady Bridge, in addition to some of the stream sites. Any stormwater related sites included for enhancement will be mostly focused on green infrastructure. Green infrastructure refers to natural and engineered ecological systems that treat stormwater in a way that mimics natural process; ex: bioretention systems or rain gardens that receive stormwater and sequester nutrients. Thermal pollution is the primary threat to carryover trout habitat in the epilimnion of Lake Hopatcong. Associated with increased temperatures is a decrease in DO concentration, as warmer water has reduced capacity to store oxygen. Metabolic rates also increase with warmer temperatures, resulting in an increased biological oxygen demand (BOD). Thus, implementing green infrastructure practices such as bioretention systems, wetlands, filter strips, riparian and shoreline buffers, and native plantings in general will help alleviate the thermal pollution that's occurring as a result the warming ambient temperatures in conjunction with an increase in impervious surface throughout the watershed.

3.1 WATERSHED, STREAM, AND SHORELINE LOCATIONS FOR ENHANCEMENT

3.1.1 SITE ONE: LAKE HOPATCONG SHORELINE NEAR BEEBE MARINA

This stretch of shoreline runs parallel to Brady Road, and the lake is only separated from the road by a few feet of mowed grass. The shoreline here lacks any type of vegetative buffer that would otherwise intercept stormwater runoff from Brady Road. The installation of a native shoreline buffer here would help to absorb stormwater flow, resulting in increased infiltration and filtration of pollutants, including thermal pollution. The land use around this site on the Sampling and Land Use Map is primarily urban land.

Photos 3.1 – 3.2: Lack of shoreline buffer along Brady Road near near-shore Site 69

3.1.2 SITE TWO: STREAM ALONG BRADY ROAD (S-8)

The small stream, S-8, that discharges into Lake Hopatcong just north of Brady Bridge lacks a sufficient riparian buffer. Riparian buffers help to keep stream water cool by providing shade. The root structures of the vegetation also stabilizes the streambanks which prevents erosion. Extensive erosion can directly increase the temperature in streams by increasing the turbidity of the water; the darker, turbid water absorbs more heat than clear water. Finally, a riparian buffer helps to absorb stormwater flow, resulting in increased infiltration and filtration of pollutants. This would be especially important in this location due to its proximity directly adjacent to the busy Brady Road. The land use around this site on the Sampling and Land Use Map is primarily urban land.

Photo 3.3: Lack of riparian buffer at S-8

3.1.3 SITE THREE: LAKE HOPATCONG SHORELINE NEAR MASON STREET

This stretch of shoreline is located along the parking lot of a restaurant/bar near Mason Street. The shoreline of the restaurant here lacks any type of vegetative buffer that would act as a nutrient filter for any stormwater that drains from the road or parking lot. In addition, the parking lot here appeared to be composed of loose material, either uncapped asphalt or soil that can easily get mobilized in stormwater and deposited in the lake. A vegetative shoreline buffer in this location would provide multiple benefits, including the prevention of potential shoreline erosion and increased filtration of pollutants from stormwater runoff. The conversion of the parking lot to porous pavement would also provide a significant benefit.

Photos 3.4 – 3.5: Impervious surface and lack of shoreline buffer between near-shore Sites 59 and 60

3.1.4 SITE FOUR: OAKWOOD ROAD AND SHORE ROAD

Oakwood Road is a steep street that runs straight down to Lake Hopatcong with no swales or vegetative surfaces to capture stormwater before it enters the lake. There are a number of catch basins on the street that capture the stormwater. One of the relatively large catch basins is located at the end of the street, before the water is eventually discharged into the lake. It is not currently known if the extension of Oakwood Road that extends down to the shoreline of the lake is private property or not, but an ambitious recommendation involves daylighting the south of Oakwood Road and converting the area to a bioswale that discharges directly into the lake. This would offer significant benefits over the current subsurface pipe, such as increased infiltration, pollutant removal, and a cooling of the water before it enters the lake.

Photos 3.6 – 3.7: Oakwood Road (left) and the location of the pipe that discharges to Lake Hopatcong (right)

3.1.5 SITE FIVE: INLET STREAM NORTH OF LORETTACONG DRIVE (S-7)

An unnamed stream that drains a small lake located in Willow Lake Day Camp travels south before flowing through a culvert and under Lorettacong Drive before entering Lake Hopatcong. The stream reach just upstream of the culvert is showing signs of minor streambank / streambed erosion and associated sedimentation. A large tree has fallen across the stream causing the streambed to be more than a foot deeper downstream of the fallen tree. An excessive amount of sedimentation is accumulating just upstream of the fallen tree; this sediment is likely transported downstream during periods of heavy flow. Most of this sedimentation is a result of eroding streambanks upstream of the fallen tree.

The fallen tree and streambank and streambed erosion should be addressed to prevent an excessive amount of sediment from discharging into Bright's Cove. Extensive erosion can directly increase the temperature in streams by increasing the turbidity of the water; the darker, turbid water absorbs more heat than clear water.

Photos 3.8 – 3.9: Upstream (left) and downstream (right) views of fallen log and erosion

3.1.6 SITE SIX: OUTLET OF LAKE WINONA

An unnamed stream between the outlet of Lake Winona and Lake Hopatcong is only approximately 150 ft. in length but the erosion is extensive and the most severe that was observed during field assessments conducted for the WIP in 2019. The water was flowing relatively slowly during the site visit in summer 2019. The streambanks on both sides varied between approximately 6 – 10 ft. in height along the stretch and severe erosion was evident to the top of the bank in multiple locations. Extensive widening and bank scouring were observed on both the right and left bank. Large tree roots were exposed and multiple trees have the potential to become dislodged from the streambank; some trees had already been dislodged and fallen across the stream. It is important to note that there are residential properties located adjacent to each streambank with houses located relatively closely to each bank.

Although accessibility may be difficult in this location without access to through private properties, this location should be a priority due to the extent of the erosion and the very cool water that was measured during the stream sampling in 2022; this stream could be providing a valuable source of cold water to the lake. If possible, the streambanks should be regraded and stabilized, but space is likely limited here. This site may also be a candidate for grade control to slow down the streamflow; the streambed is approximately 6 feet lower than Lake Winona and this drop occurs abruptly as the water drains from Lake Winona.


Photos 3.10 – 3.11: Extensive erosion in the stream channel between Lake Winona and Lake Hopatcong

3.1.7 SITE SEVEN: EDITH M DECKER SCHOOL (DRAINS TO S-4)

This site consists of an elementary school and large paved parking lot in front of the school that has a grassy area located in the center. There is a small stream that runs along the front of the site, between the parking lot and Howard Blvd. The stream travels through a culvert and under Howard Blvd. before discharging into Lake Hopatcong down the street. There are two large catch basins located between the parking lot and the stream in front of the school. There is also a curbside storm drain and multiple smaller catch basins on the side of the parking lot that drain to the same location as the stream.

Due to the relatively large size of the parking lot and multiple stormwater structures, this site is an ideal candidate for multiple BMPs. This would involve breaking up the impervious surfaces throughout the parking lot through the installation of small bioretention islands and/or the conversion of some of the parking lot to pervious pavement. Additionally, the riparian buffer around the stream could be further enhanced with native plantings.

Photos 3.12 – 3.13: Impervious parking lot at Edith Decker School

3.1.8 SITE EIGHT: GLEN BROOK AND RIPARIAN ZONE (BETWEEN S-1 AND S-2)

This streambank site is located in Memorial Park, between S-1 and S-2. This stream reach travels through the open section of the park and the majority of the right bank lacks a vegetative buffer. The few sections along the stream that have a small vegetative buffer are covered in the invasive Japanese stilt grass (*Microstegium vimineum*). In addition to the lack of a vegetative buffer, there is a section of roughly 25 linear feet along the right bank that is eroding. Specifically, the upper section of the streambank is widening, exposing tree roots and loose sediment.

This site was awarded funds from a 2021 National Fish and Wildlife Foundation (NFWF) – Delaware Watershed Conservation Fund Grant for streambank restoration. Specifically, restoration efforts will mostly involve native plantings along this stream reach to enhance the riparian buffer, with the goal of reducing erosion, increasing the filtration of pollutants from overland runoff, and providing a healthier stream for fish and other wildlife. Additional funds were awarded through the NJDEP 319 grant program to stabilize the steep shoreline of Memorial Pond located just upstream of this location.

Photos 3.14 – 3.15: Section of the Glen Brook streambank that will be stabilized as part of a NFWF grant

3.1.9 SITE NINE: GLEN BROOK UPSTREAM OF MEMORIAL BEACH (S-2)

The downstream reach of Glen Brook runs parallel to Altenbrand Avenue before entering the culvert. The culvert under the beach access road was mostly blocked and discharges at an erosional angle into the park portion of the channel under the Memorial Beach parking lot, and eventually onto the Memorial Beach swim area. The streambanks in this area are lined with rounded rock for erosion control but lack vegetation and are covered with sand at points. The lack of a riparian buffer along Altenbrand Ave should be addressed due to the proximity to the road; there are no stormwater conveyance structures in place on Altenbrand Ave and the majority of the stormwater from this street flow into Glen Brook. There was also evidence of erosion along this streambank caused by stormwater flow from Altenbrand Ave.

The streambanks, especially the streambank that runs along Altenbrand Avenue, could be amended with soils and native plants, creating riparian buffers to capture and treat stormwater runoff. This can be done through the establishment of a riparian buffer or through the installation of a vegetative filter strip between Altenbrand Ave and Glen Brook. Due to the location of these streambanks in a heavily trafficked public area, the riparian buffer plantings should be aesthetically pleasing.

Photos 3.16 – 3.17: Lack of shoreline buffer (left) and erosion (right) along Glen Break upstream of S-2

4.0 ANALYSIS OF FISHERIES DATA

The final component of the project at the conclusion of the first year of the study is the analysis of fisheries data. Earlier sections of the report focused on characterizing holdover trout habitat, surveying potential refuge habitat in near shore areas of the lake, and identifying projects that could help foster the protection or expansion of trout holdover habitat. This section will describe the analysis of fisheries data.

As described in the introduction of the report, the Trout Committee (TC) designed and implemented a trout stocking program. The primary goal of the endeavor was to explore trout population dynamics in Lake Hopatcong, particularly as it relates to holdover trout habitat. Trout, as described above, are coldwater fishes that have specific water temperature and oxygen demand requirements. One of the primary physiological responses to exposure to high water temperatures and low DO concentrations is that fish will stop actively feeding. Eventually, if the duration is long enough, this will start to cause the fish to starve. As indicated by Elliott, survival time is function of water temperature, fish size, and body composition. Larger fish can both tolerate higher temperatures and protracted periods of starvation relative to smaller fish; in part, this has to do with body mass, fat availability, and general metabolic efficiency[1]. As larger brown trout should exhibit better survivability when habitat volume and habitat quality is reduced, the TC wanted to examine the implications of that fact.

Additionally, the TC expressed concerns that recent changes in NJDFW trout stocking practices at the lake may not fully support maintenance of a high quality trout fishery. Historically, stocking efforts in Lake Hopatcong, including private stocking events, focused on the introduction of relatively large brown trout. These efforts were successful and for decades supported a regionally important brown trout fishery. More recently, NJDFW has started to stock smaller rainbow trout. In light of the demonstrated annual growing season trout holdover habitat compression, caused by both high water temperature and low DO conditions, the TC wanted to explore if survivability would be enhanced by a return to stocking relatively large brown trout.

In order to test this theory, the TC developed a trout stocking and creel survey program. On March 26, 2022, 1,000 brown trout, 12 to 14 inches in total length, were stocked in Lake Hopatcong by the TC and volunteers. The fish were sourced from Musky Trout Hatchery in nearby Asbury, New Jersey, and stocking was conducted through the authorization of stocking permit obtained from the Bureau of Freshwater Fisheries. The fish were all jaw tagged. The tags included various information, including the year of stocking, and for 2022 were color code blue. The intent of using tagged fish was to allow examination of population dynamics over time, focused on fish survivability and carryover through the critical period of July and August when available habitat is at a seasonal minimum. Raw data would be collected through establishing a volunteer creel survey data. Creel surveys are a means in which anglers report catch data. For this study, the TC promoted the creel survey through the establishment of signage around the lake, information posted at local marinas and bait shops, through reporting in local media, and participation and advertisement at the trout contest. A website and supporting QR code was established in which relevant information regarding the capture of a tagged trout could be reported. This included information such as date, tag color, length, location, and other comments. Prizes were also advertised to increase participation rates. Critically, the 2022 stocking was conducted prior to the opening day of trout season on April 9 and before the trout contest held on April 24.

Three annual stocking events are planned in total, including the one conducted in 2022, an upcoming event in the spring of 2023, and a final event in 2024. As of now, all will be focused on stocking 1,000 jaw tagged fish. Examination of capture data will likely continue as long as reports continue to be submitted.

To date, the returns from the creel survey have been limited, and 15 fish have been reported. Of those, 14 fish are part of this study; a silver tagged fish of 11 inches was captured on April 29. Both the size and the tag

[1] Elliott, J.M. Quantitative ecology and the brown trout. 1994. Oxford University Press.

coloration indicate this fish was not part of this study. The first reported fish was caught April 5. Three fish were caught on the opening day of trout season April 9. The Knee Deep Club's trout contest was held on April 24, and the club had conducted a separate and unrelated stocking event on April 16. In advance of the contest, three more trout were caught on April 23 and another on the day of the contest. An additional four fish were captured between April 29 and May 5. One more fish was caught in May, followed by one each in June and July. Notably, the June and July fish were measured at 16 inches and 15 inches respectively, indicating fairly vigorous growth in the months following stocking.

Overall, the return of the creel data was lower than had been hoped for. There appears to be a number of factors at play here. Weather was a significant factor, especially near the time of the trout contest, which was expected to yield higher catches of tagged trout. Conditions were reported as quite poor and windy. April, the prime month for most trout fishing in New Jersey, was particularly stormy and rainy, which likely reduced angling participation in general and temperatures vacillated between unusually cold and exceedingly warm. May is another prime month before interest in trout fishing tends to wane with increasing temperatures moving into summer. It too was very wet with total rainfall nearly 2 inches above the 30 year mean. Besides the immediate impacts of weather during the prime fishing season, there are systemic issues that impact fishing effort at the lake. Local bait shops and marinas report decreasing angling traffic, highlighted by decreasing boat rentals. Boat traffic in general has shown a significant increase at the lake, and the increased use of personal watercraft and waterskiing may also discourage more sedate angling from smaller vessels. There also seems to be a shift in targeted species at the lake. Bass fishing and bass boats have become more popular at the lake with a targeted bass fishery, perhaps supplanting the more traditional pursuit of trout. The rainbow trout stocking program, which favors the use of smaller fish, may also be a factor in declining angler participation.

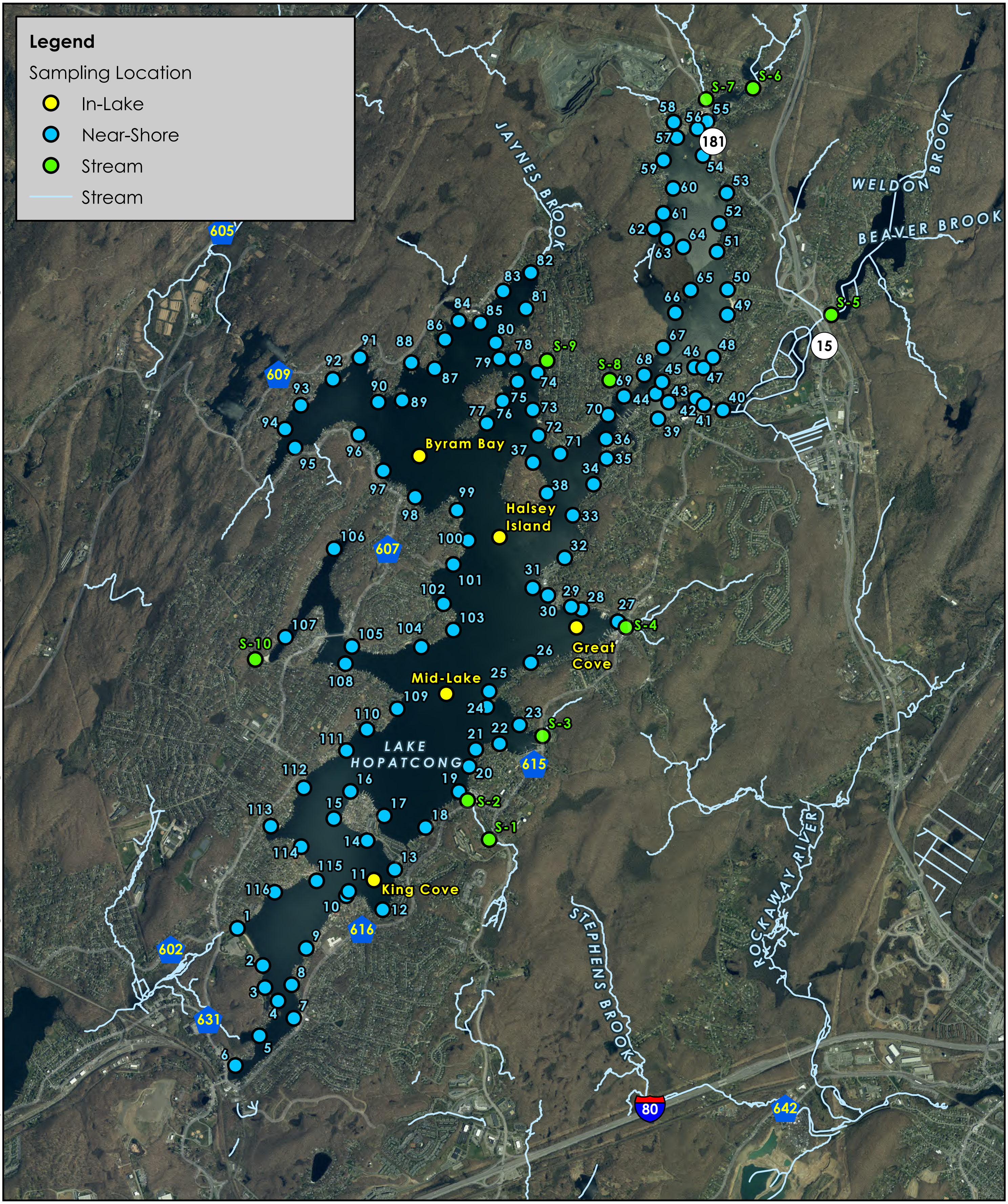
Despite the limited catch and some of the mitigating circumstances, there is still much to be gleaned from this study. While more fish being reported would be preferable, this study was always conducted with the expectation that annual survival was the metric of greatest interest. While no fish were reported after early July, this is not necessarily unexpected. Trout fishing has a strongly seasonal component. Part of this has to do with the physiology and life history habits of trout; high summer water temperatures tend to discourage feeding and therefore fishing is poor and hence there is little effort to actively target trout during the summer. The fall months can provide good trout fishing, but the dedicated cohort of fall anglers is small and recent spring interest and awareness regarding the creel survey had likely faded by that point. It is expected that more data will be generated around and after opening day in 2023, a reflection of angler anticipation, traditional focus on spring trout, as well as the trout contest, another round of stocking, and renewed efforts to advertise the creel survey, all of which will spur higher interest. Additionally, any capture of fish stocked in 2022 in the spring of 2023 will provide the highest quality data and that of most interest as it directly addresses survival through the summer critical period and over the course of a year. 2022 was undoubtedly a historically warm and dry summer at the lake with corresponding impacts to habitat availability. Even traditional refuge sites, like tributary mouths, which continued to provide some refuge habitat and cool temperatures as demonstrated in the data above, were flowing at a much lower than normal rate and many small tributaries exhibited no flow. Survival through those conditions, and subsequent capture, and crucially, reporting of those captured fish, will be extremely valuable in 2023, as well as in subsequent years of the study.

It should also be noted that brown trout in general continue to survive the marginal habitat conditions in 2022. On October 9, a large (approximately 18 inch) brown trout was captured in the lake. While this fish was not tagged, it still illustrates that large brown trout can and do survive even during harsh conditions. The fish (Photo XXX), shows an extremely healthy fish.

Overall, little can be stated at this time regarding carryover trout populations. More data on which to analyze those factors should be generated this spring, and will continue to be developed over the course of this multi-year study.

Photo XXX: Brown trout captured October 9, 2022

APPENDIX I: MAPS



NOTES:
1. Sampling locations are approximate
2. Streams obtained from the NJDEP GIS website: www.state.nj.us/dep/gis/
3. 2020 orthoimagery obtained from the NJ Geographic Information Network (NJGIN) Open Data portal: https://njgin.nj.gov/

0 2,000 4,000 Feet

Spatial Reference: NAD 1983 StatePlane New Jersey FIPS 2900 Feet

SAMPLING LOCATION MAP

LAKE HOPATCONG TROUT HABITAT CHARACTERIZATION STUDY
SUSSEX AND MORRIS COUNTIES, NEW JERSEY

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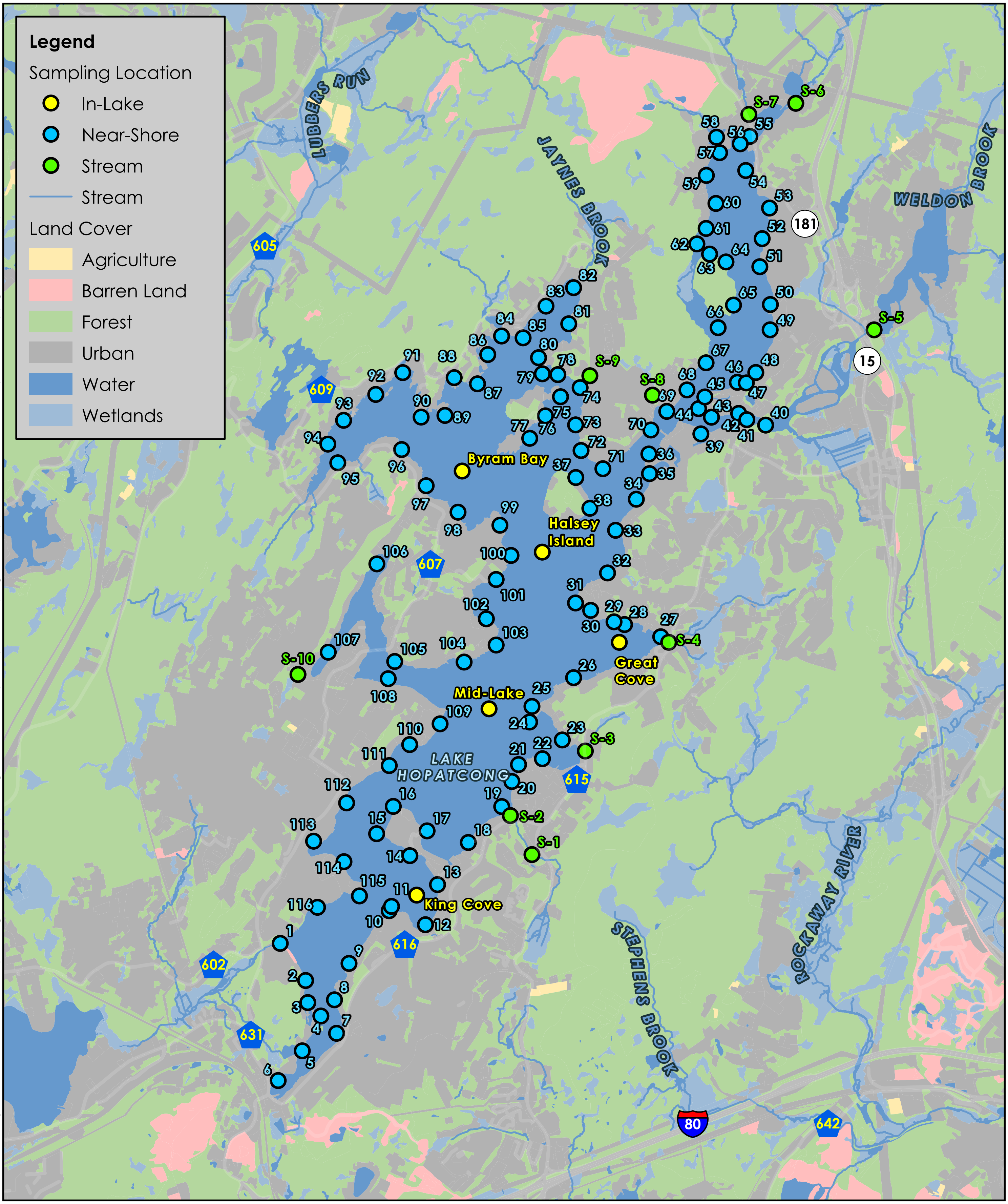

File: P:\0783\Projects\0783002\GIS\APRX\Hopatcong_Trout_Habitat\Hopatcong_Trout_Habitat.aprx, Layout: Sampling_LULC, Exported: 2/21/2023, Drawn by bsmith, Copyright Princeton Hydro, LLC.

NOTES:
1. Sampling locations are approximate
2. Streams obtained from the NJDEP GIS website: www.state.nj.us/dep/gis/
3. 2015 Land Cover obtained from the NJDEP GIS website: www.state.nj.us/dep/gis/

0 2,000 4,000 Feet

Spatial Reference: NAD 1983 StatePlane New Jersey FIPS 2900 Feet

SAMPLING AND LAND COVER MAP

LAKE HOPATCONG TROUT HABITAT CHARACTERIZATION STUDY
SUSSEX AND MORRIS COUNTIES, NEW JERSEY

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APPENDIX II: LIMNETIC *IN-SITU* DATA

Lake Hopatcong *In-Situ* Monitoring Data 5/25/2022

Station	Depth (m) Total	Secchi	Sample	Temperature °C	Specific Conductance µS/cm	Dissolved Oxygen Conc. (mg/L)	Sat. (%)	pH s.u.
STA-1	2.20	1.30	0.1	22.09	0.366	8.55	99.7	7.6
			1.0	21.24	0.363	8.54	98.1	7.6
			2.0	20.78	0.366	8.28	94.2	7.5
STA-2	14.30	1.50	0.1	19.69	0.428	9.86	109.6	8.1
			1.0	19.52	0.428	9.87	109.3	8.1
			2.0	19.34	0.428	9.69	107.0	8.1
			3.0	19.24	0.428	9.55	105.2	8.0
			4.0	18.04	0.424	8.65	92.9	7.6
			5.0	16.80	0.424	8.13	85.2	7.5
			6.0	14.19	0.424	7.87	72.9	7.3
			7.0	13.20	0.423	6.88	66.5	7.0
			8.0	12.20	0.422	6.12	57.8	7.0
			9.0	11.71	0.422	6.63	62.2	6.9
			10.0	11.45	0.422	5.74	52.6	6.9
			11.0	11.27	0.423	4.76	44.2	6.8
			12.0	11.10	0.424	3.72	34.4	6.8
			13.0	10.95	0.426	2.94	26.9	6.7
			14.0	10.85	0.427	2.20	19.6	6.7
STA-3	2.00	1.80	0.1	20.56	0.640	8.96	101.6	8.2
			1.0	20.24	0.662	9.18	103.5	8.3
			1.8	19.88	0.578	9.06	101.1	8.3
STA-4	2.80	1.50	0.1	19.74	0.434	9.43	105.0	8.0
			1.0	19.60	0.433	9.30	103.4	8.0
			2.0	19.43	0.431	9.08	100.5	7.9
			3.0	19.26	0.432	8.11	89.1	7.7
STA-5	3.00	2.10	0.1	20.04	0.437	10.62	118.3	9.0
			1.0	19.79	0.437	10.41	116.2	9.0
			2.0	19.14	0.441	8.19	90.5	8.3
			2.5	18.69	0.443	5.61	61.2	7.7
STA-6	3.10	1.30	0.1	20.75	0.409	10.44	118.2	8.3
			1.0	20.93	0.422	10.43	118.1	8.1
			2.0	20.26	0.422	10.51	118.2	8.0
			2.8	18.60	0.421	9.93	108.7	7.8
STA-7	1.50	1.50+	0.1	21.42	0.221	5.97	68.8	7.1
			1.0	20.93	0.219	5.86	66.8	7.2
STA-8	7.20	1.50	0.1	20.14	0.427	9.84	110.8	7.7
			1.0	19.51	0.427	10.05	111.4	7.9
			2.0	19.11	0.426	9.82	107.1	7.9
			3.0	18.95	0.427	9.77	107.0	7.9
			4.0	18.05	0.424	8.36	89.6	7.6
			5.0	15.15	0.422	7.46	75.4	7.5
			6.0	13.64	0.420	6.76	66.1	7.3
			7.0	13.20	0.421	6.61	63.9	7.2
STA-9	8.50	1.50	0.1	20.50	0.430	10.54	119.5	7.9
			1.0	20.21	0.430	10.62	119.7	8.0
			2.0	20.15	0.430	10.52	118.1	8.0
			3.0	19.40	0.431	10.51	116.4	8.0
			4.0	19.15	0.431	10.32	113.2	7.9
			5.0	18.97	0.435	9.60	105.4	7.6
			6.0	14.87	0.425	7.38	74.4	7.3
			7.0	12.67	0.424	5.16	49.4	7.0
			8.0	12.20	0.423	4.68	44.5	7.0
STA-10	1.40	1.10	0.1	22.56	0.390	9.05	106.5	7.7
			1.0	21.45	0.404	9.28	105.6	7.8
STA-11	1.20	1.20+	0.1	21.21	0.181	6.47	74.1	7.0
			1.0	20.66	0.182	6.48	73.7	7.6

Trout Habitat Highlighted in Pale Blue (5 mg/L) and Gray (4 mg/L)

Lake Hopatcong *In-Situ* Monitoring Data 6/22/2022

Station	Depth (m)			Temperature	Specific Conductance	Dissolved Oxygen		pH
	Total	Secchi	Sample	°C	µS/cm	Conc. (mg/L)	Sat. (%)	s.u.
STA-1	2.20	0.90	0.1	21.00	0.373	8.68	100.3	7.9
			1.0	21.05	0.373	8.67	106.2	8.0
			2.0	21.04	0.373	8.58	98.9	8.0
STA-2	14.30	1.50	0.1	20.93	0.431	8.74	100.9	8.0
			1.0	20.93	0.432	8.73	100.6	8.0
			2.0	20.91	0.432	8.61	99.5	8.0
			3.0	20.80	0.431	7.79	89.1	7.8
			4.0	20.30	0.430	6.67	76.3	7.6
			5.0	20.05	0.429	6.31	71.6	7.5
			6.0	19.67	0.428	5.82	65.6	7.4
			7.0	15.92	0.424	0.00	0.0	6.8
			8.0	13.17	0.424	0.00	0.0	6.7
			9.0	11.92	0.422	0.00	0.0	6.6
			10.0	11.63	0.423	0.00	0.0	6.6
			11.0	11.32	0.427	0.00	0.0	6.6
			12.0	11.05	0.434	0.00	0.0	6.6
			13.0	10.87	0.440	0.00	0.0	6.6
			14.0	10.71	0.441	0.00	0.0	6.6
STA-3	2.00	1.30	0.1	21.29	0.643	8.25	95.9	7.8
			1.0	21.37	0.650	8.25	96.0	7.8
			1.8	21.37	0.649	8.24	95.9	7.8
STA-4	2.80	1.30	0.1	21.19	0.438	8.97	104.1	8.0
			1.0	21.20	0.438	8.89	103.1	8.0
			2.0	21.19	0.438	8.89	103.3	8.0
			3.0	21.16	0.439	8.59	99.7	7.9
STA-5	2.30	1.40	0.1	21.33	0.441	9.02	111.9	8.3
			1.0	21.33	0.441	9.61	111.8	8.3
			2.0	21.32	0.441	9.63	112.0	8.3
STA-6	3.10	1.20	0.1	21.16	0.428	8.82	102.1	7.8
			1.0	21.21	0.426	8.82	102.3	7.8
			2.0	21.24	0.426	8.76	101.7	7.9
			2.8	21.20	0.426	8.19	94.7	7.8
STA-7	1.50	1.10	0.1	20.78	0.282	8.16	93.2	7.5
			1.0	21.05	0.279	8.07	93.3	7.4
STA-8	7.20	1.40	0.1	20.66	0.383	8.19	93.9	7.7
			1.0	20.74	0.384	8.17	94.1	7.8
			2.0	20.73	0.386	8.13	93.4	7.8
			3.0	20.70	0.388	7.88	89.6	7.7
			4.0	20.22	0.390	6.72	76.3	7.6
			5.0	19.37	0.392	5.35	59.9	7.4
			6.0	18.72	0.394	3.97	43.8	7.2
			7.0	17.57	0.396	2.14	23.0	7.2
STA-9	7.50	1.30	0.1	21.88	0.430	8.91	103.1	8.0
			1.0	21.15	0.429	8.88	103.1	8.0
			2.0	21.16	0.429	8.92	103.3	8.0
			3.0	21.10	0.429	8.98	104.1	8.0
			4.0	21.02	0.429	8.97	103.7	8.1
			5.0	20.98	0.429	8.90	102.6	8.0
			6.0	20.91	0.429	8.79	101.3	8.0
			7.0	20.91	0.429	8.74	100.8	8.0
STA-10	1.40	0.70	0.1	21.20	0.394	9.03	104.7	8.2
			1.0	21.27	0.400	9.00	104.3	8.2
STA-11	1.20	1.20+	0.1	20.27	0.225	7.04	80.6	7.1
			1.0	20.34	0.231	6.94	79.1	7.1

Trout Habitat Highlighted in Pale Blue (5 mg/L) and Gray (4 mg/L)

Lake Hopatcong *In-Situ* Monitoring Data 2022.07.05

Station	Depth (m)			Temperature	Specific Conductance	Dissolved Oxygen		pH
	Total	Secchi	Sample	°C	µS/cm	Conc. (mg/L)	Sat. (%)	s.u.
Byram Bay	10.40	1.90	0.2	25.02	435.83	8.04	100.2	7.54
			1.1	25.02	436.07	8.05	100.3	7.50
			2.1	24.97	435.77	8.00	99.8	7.45
			3.0	24.92	435.45	7.98	99.2	7.34
			4.0	24.85	435.18	7.92	98.3	7.16
			5.0	24.04	430.78	6.49	79.4	6.91
			5.3	22.70	427.86	5.26	62.8	6.81
			5.6	21.49	427.97	3.96	46.2	6.64
			6.0	20.38	425.42	2.38	27.1	6.55
			7.1	18.33	420.12	0.19	2.0	6.44
			8.0	15.64	421.62	0.00	0.0	6.40
			9.0	13.51	427.39	0.00	0.0	6.46
			10.0	12.01	432.04	0.00	0.0	6.57
Halsey Island	10.40	1.90	0.3	25.41	435.73	8.21	103.1	7.57
			1.0	25.36	436.34	8.22	103.1	7.60
			2.0	25.30	436.41	8.19	102.6	7.54
			3.0	25.25	436.51	8.16	102.1	7.48
			4.0	25.23	436.71	8.09	101.2	7.31
			5.1	25.19	436.75	7.94	99.3	7.17
			5.3	23.97	438.93	6.33	77.3	6.84
			5.6	23.08	430.25	5.70	68.6	6.79
			6.0	19.98	426.46	1.05	12.7	6.57
			7.0	17.44	422.30	0.09	1.0	6.44
			7.9	15.72	424.43	0.00	0.0	6.41
			10.1	12.10	423.47	0.00	0.0	6.51
Mid-Lake	14.30	1.80	0.2	25.44	436.38	8.38	105.3	7.75
			1.0	25.51	436.48	8.33	104.8	7.75
			2.0	25.45	436.32	8.32	104.5	7.70
			3.0	25.38	436.27	8.27	103.7	7.60
			4.0	25.10	435.91	7.88	98.3	7.35
			4.2	23.63	435.97	5.03	61.1	6.83
			4.6	22.69	431.30	4.70	56.1	6.79
			5.0	21.81	427.34	4.18	49.0	6.72
			5.3	21.23	427.45	3.28	38.1	6.64
			5.6	20.38	426.62	2.49	28.4	6.51
			6.0	19.56	424.94	1.11	11.7	6.47
			7.0	17.32	420.24	0.01	0.1	6.39
			8.0	13.79	418.11	0.00	0.0	6.38
			9.0	12.42	420.65	0.00	0.0	6.44
			10.0	11.68	419.57	0.00	0.0	6.51
			11.0	11.34	426.47	0.00	0.0	6.58
			12.0	11.05	431.68	0.00	0.0	6.70
			13.0	10.83	439.16	0.00	0.0	6.87
			14.0	10.68	444.68	0.00	0.0	7.02
Great Cove	7.10	1.90	0.2	25.62	436.17	8.48	106.9	7.80
			0.9	25.59	436.19	8.44	106.4	7.83
			2.0	25.56	436.40	8.43	106.1	7.80
			3.0	25.49	436.16	8.42	105.9	7.71
			4.0	25.45	436.41	8.36	105.0	7.57
			4.3	25.41	436.42	8.29	104.2	7.45
			4.5	25.40	436.62	8.29	104.1	7.38
			5.0	25.40	437.43	7.87	98.8	7.27
			5.3	25.37	436.92	7.88	98.9	7.25
			5.6	22.73	434.66	3.92	46.7	6.89
			6.0	19.97	422.90	0.67	7.6	6.67
			7.0	17.77	426.07	0.03	0.3	6.47
King's Cove	2.50	1.30	0.2	25.94	443.01	7.65	97.0	7.41
			1.1	25.92	442.65	7.67	97.3	7.40
			2.0	25.50	440.60	7.32	91.5	7.29

Trout Habitat Highlighted in Pale Blue (5 mg/L) and Gray (4 mg/L)

Lake Hopatcong *In-Situ* Monitoring Data 2022.07.11

Station	Depth (m) Total	Depth (m) Secchi	Depth (m) Sample	Temperature °C	Specific Conductance µS/cm	Dissolved Oxygen Conc. (mg/L)	Dissolved Oxygen Sat. (%)	pH s.u.
Byram Bay	10.30	1.70	0.2	25.83	442.10	8.71	110.5	7.81
			1.0	25.74	442.20	8.73	110.6	7.82
			2.0	25.58	441.70	8.71	109.9	7.80
			3.0	25.43	441.90	8.67	109.2	7.78
			4.0	35.31	442.30	8.49	106.8	7.73
			5.0	25.24	442.30	8.18	102.7	7.67
			5.3	23.43	436.70	2.90	35.5	7.21
			6.0	21.78	431.90	0.00	0.0	6.95
			7.0	18.50	429.30	0.00	0.0	6.85
			8.0	14.89	432.90	0.00	0.0	6.85
			9.0	12.91	434.50	0.00	0.0	6.89
			10.0	12.14	437.60	0.00	0.0	6.93
Halsey Island	10.20	1.60	0.3	25.56	444.70	8.71	110.0	7.86
			1.0	25.53	444.50	8.73	109.9	7.87
			2.0	25.53	444.30	8.73	110.0	7.87
			3.0	25.48	444.40	8.71	110.8	7.86
			4.0	25.45	444.40	8.70	109.7	7.84
			5.0	25.41	444.40	8.63	108.7	7.81
			5.3	25.39	444.30	8.54	107.5	7.79
			5.6	25.31	444.40	8.32	105.3	7.72
			6.0	23.65	439.90	3.99	48.6	7.31
			6.3	19.60	419.60	0.00	0.0	6.96
			7.0	17.69	424.70	0.00	0.0	6.87
			8.0	15.10	429.90	0.00	0.0	6.84
			9.0	13.95	430.60	0.00	0.0	6.85
			10.0	12.79	430.30	0.00	0.0	6.88
Mid-Lake	14.40	1.80	0.2	25.21	446.20	8.65	108.7	7.91
			1.0	25.18	444.40	8.69	108.9	7.92
			2.0	25.17	444.90	8.69	108.9	7.93
			3.0	25.12	444.80	8.79	110.1	7.95
			4.0	25.06	444.90	8.77	109.8	7.97
			4.3	25.00	445.40	8.72	109.1	7.89
			4.6	24.98	448.10	8.51	106.0	7.87
			5.0	22.92	438.10	2.78	33.5	7.15
			6.0	20.26	431.10	0.00	0.0	6.91
			7.0	17.66	428.50	0.00	0.0	6.88
			8.0	14.75	429.00	0.00	0.0	6.93
			9.0	12.61	427.00	0.00	0.0	6.97
			10.0	11.71	428.20	0.00	0.0	6.98
			11.0	11.38	431.90	0.00	0.0	6.99
			12.0	11.11	434.80	0.00	0.0	7.60
			13.0	10.93	440.90	0.00	0.0	7.00
			14.0	10.69	446.60	0.00	0.0	7.02
Great Cove	8.20	1.80	0.2	25.77	443.80	9.06	114.9	8.15
			1.0	25.71	443.70	9.08	114.9	8.14
			2.0	25.56	443.50	8.94	112.5	8.06
			3.0	25.46	443.80	8.76	110.2	8.00
			4.0	25.40	444.10	8.37	105.4	7.83
			4.3	25.37	444.50	8.21	103.2	7.78
			4.6	25.35	444.70	8.21	103.1	7.74
			5.0	25.32	444.90	8.04	101.8	7.68
			5.3	25.28	445.10	7.80	97.8	7.62
			5.6	24.11	442.10	4.70	58.7	7.41
			6.0	21.12	431.20	0.00	0.0	7.07
			7.0	17.64	428.60	0.00	0.0	6.94
			8.0	16.70	431.50	0.00	0.0	6.87
King's Cove	2.70	1.00	0.2	25.36	446.80	7.48	94.1	7.38
			1.0	25.34	447.00	7.46	93.5	7.37
			2.0	25.35	446.90	7.44	93.5	7.36
			2.5	25.31	447.10	7.35	92.4	7.33

Trout Habitat Highlighted in Pale Blue (5 mg/L) and Gray (4 mg/L)

Lake Hopatcong *In-Situ* Monitoring Data 2022.07.18

Station	Depth (m) Total	Secchi	Sample	Temperature °C	Specific Conductance µS/cm	Dissolved Oxygen Conc. (mg/L)	Sat. (%)	pH s.u.
Byram Bay	10.30	1.40	0.2	26.43	446.40	8.16	104.9	7.27
			1.0	26.49	446.20	8.14	104.7	7.39
			2.0	26.50	446.00	8.12	104.4	7.45
			3.0	26.44	446.20	8.07	103.8	7.46
			3.3	26.46	446.60	8.06	103.5	7.46
			3.6	26.42	446.70	8.02	102.9	7.47
			4.0	26.40	446.60	7.97	102.1	7.48
			4.3	26.19	445.60	7.39	94.3	7.42
			4.6	25.27	442.80	5.20	65.6	7.12
			5.0	24.54	440.90	2.91	36.2	6.96
			6.0	22.14	433.20	0.00	0.0	6.77
			7.0	19.11	432.70	0.00	0.0	6.65
			8.0	15.00	430.90	0.00	0.0	6.54
			9.0	13.79	432.70	0.00	0.0	6.52
			10.0	12.52	436.40	0.00	0.0	6.54
Halsey Island	11.50	1.30	0.3	26.40	447.80	8.21	105.4	7.67
			1.0	26.46	447.00	8.20	105.9	7.72
			2.0	26.48	447.00	8.19	104.8	7.75
			3.0	26.46	447.00	8.14	104.7	7.71
			3.3	26.45	446.80	8.06	102.7	7.66
			3.6	26.32	446.40	7.68	98.2	7.63
			4.0	25.60	444.50	5.25	66.2	7.28
			4.3	24.96	443.30	3.58	44.9	7.08
			5.0	23.97	439.80	1.45	17.6	6.89
			6.0	22.11	434.20	0.00	0.0	6.67
			7.0	18.24	430.00	0.00	0.0	6.51
			8.0	15.70	425.70	0.00	0.0	6.46
			9.0	13.11	429.70	0.00	0.0	6.47
			10.0	12.17	429.30	0.00	0.0	6.48
			11.0	11.56	431.10	0.00	0.0	6.49
Mid-Lake	14.40	1.50	0.2	26.43	463.90	8.39	107.8	7.88
			1.0	26.44	459.80	8.39	107.8	7.92
			2.0	26.43	447.90	8.38	107.6	7.88
			3.0	26.29	448.70	7.78	99.5	7.61
			3.3	26.19	448.70	7.41	94.7	7.45
			3.6	26.13	448.00	7.17	91.5	7.32
			4.0	25.71	445.90	6.05	76.3	7.09
			4.3	25.12	444.30	4.42	54.8	6.87
			4.6	24.79	443.60	3.60	44.8	6.71
			5.0	24.52	443.50	3.04	35.8	6.64
			6.0	22.43	443.40	0.00	0.0	6.47
			7.0	18.69	429.40	0.00	0.0	6.40
			8.0	14.53	429.70	0.00	0.0	6.39
			9.0	13.12	429.40	0.00	0.0	6.43
			10.0	12.19	429.30	0.00	0.0	6.51
			11.0	11.75	432.00	0.00	0.0	6.56
			12.0	11.33	437.00	0.00	0.0	6.65
			13.0	10.84	447.90	0.00	0.0	6.79
			14.0	10.59	455.20	0.00	0.0	6.94
Great Cove	8.50	1.40	0.2	26.52	447.50	8.50	109.3	8.03
			1.0	26.54	447.50	8.48	109.3	8.02
			2.0	26.54	447.50	8.44	108.9	8.02
			2.3	26.44	448.10	8.43	108.3	7.89
			2.6	26.33	447.70	7.62	97.9	7.73
			3.0	25.76	445.20	5.70	72.2	7.45
			3.3	25.18	443.80	4.32	54.2	7.28
			3.6	24.88	443.40	3.69	46.0	7.12
			4.0	24.60	443.10	3.14	38.9	7.03
			5.0	24.10	439.90	1.81	22.3	6.90
			6.0	22.36	433.80	0.00	0.0	6.56
			7.0	18.33	430.60	0.00	0.0	6.45
			8.0	15.89	431.40	0.00	0.0	6.47
King's Cove	2.70	1.10	0.2	26.47	448.10	7.02	90.2	7.36
			1.0	26.48	448.20	7.05	90.6	7.42
			2.0	26.47	448.20	6.94	89.1	7.42
			2.5	26.02	448.60	5.35	68.6	7.32
			2.9	25.47	447.10	3.49	43.4	7.16

Trout Habitat Highlighted in Pale Blue (5 mg/L) and Gray (4 mg/L)

Lake Hopatcong *In-Situ* Monitoring Data 2022.07.25

Station	Depth (m) Total	Depth (m) Secchi	Sample	Temperature °C	Specific Conductance µS/cm	Dissolved Oxygen Conc. (mg/L)	Dissolved Oxygen Sat. (%)	pH s.u.
STA-1	1.80	0.80	0.1	28.62	401.0	6.70	89.5	7.3
			1.0	28.69	401.0	6.58	86.8	7.3
			1.6	28.73	401.0	6.39	85.2	7.3
STA-2	14.30	1.70	0.1	27.50	453.0	7.50	93.4	7.7
			1.0	27.48	453.0	7.51	98.4	7.7
			2.0	27.47	453.0	7.46	97.7	7.7
			3.0	27.45	453.0	7.42	97.1	7.6
			4.0	27.41	453.0	7.33	95.9	7.4
			5.0	26.20	449.0	3.64	76.6	6.8
			6.0	21.44	440.0	0.00	0.0	6.5
			7.0	17.15	434.0	0.00	0.0	6.5
			8.0	15.38	431.0	0.00	0.0	6.4
			9.0	13.27	432.0	0.00	0.0	6.4
			10.0	12.20	431.0	0.00	0.0	6.5
			11.0	11.56	434.0	0.00	0.0	6.5
			12.0	11.61	440.0	0.00	0.0	6.7
			13.0	10.88	447.0	0.00	0.0	6.7
			14.0	10.61	467.0	0.00	0.0	6.9
STA-3	2.20	0.50	0.1	28.32	541.0	6.69	89.2	7.7
			1.0	28.44	597.0	6.71	89.3	7.8
			2.0	28.34	581.0	6.43	85.4	7.7
STA-4	3.00	1.20	0.1	27.13	453.0	6.05	86.7	7.4
			1.0	27.16	452.0	6.00	86.0	7.4
			2.0	27.15	452.0	6.49	84.4	7.3
			2.7	26.98	452.0	5.34	69.4	7.2
STA-5	2.30	0.80	0.1	27.91	455.0	6.47	85.4	7.3
			1.0	27.76	454.0	5.59	73.1	7.3
			2.0	27.37	453.0	4.08	53.1	7.1
STA-6	3.10	1.00	0.1	28.32	451.0	7.17	95,6	7.5
			1.0	28.43	452.0	7.11	94.8	7.5
			2.0	28.43	452.0	6.94	92.3	7.5
			3.0	28.39	452.0	6.76	89.4	7.4
STA-7	1.50	0.90	0.1	28.43	335.0	6.38	84.9	7.4
			1.0	28.52	433.0	6.36	84.6	7.4
STA-8	7.20	1.50	0.1	27.90	454.0	7.68	101.1	7.9
			1.0	27.92	454.0	7.67	101.2	7.9
			2.0	27.90	454.0	7.59	99.9	7.8
			3.0	27.88	454.0	7.54	99.4	7.7
			4.0	27.86	454.0	7.50	98.9	7.7
			5.0	27.52	452.0	6.71	87.8	7.4
			6.0	23.04	437.0	0.00	0.0	6.6
			7.0	17.81	432.0	0.00	0.0	7.0
STA-9	7.50	1.30	0.1	28.09	454.0	7.99	105.7	7.9
			1.0	28.13	453.0	8.05	106.6	7.9
			2.0	28.13	453.0	7.96	105.5	7.8
			3.0	28.14	453.0	7.94	105.2	7.8
			4.0	27.87	454.0	6.43	84.5	7.3
			5.0	26.55	449.0	4.31	55.5	6.9
			6.0	23.48	438.0	0.00	0.0	6.6
			7.0	19.62	440.0	0.00	0.0	6.5
STA-10	1.40	0.70	0.1	28.34	430.0	7.69	102.3	7.8
			1.0	28.52	429.0	7.59	100.9	7.1
STA-11	1.20	1.00	0.1	27.98	432.0	4.68	62.8	7.1
			1.0	27.93	432.0	4.58	60.3	7.1

Trout Habitat Highlighted in Pale Blue (5 mg/L) and Gray (4 mg/L)

Lake Hopatcong *In-Situ* Monitoring Data 2022.08.02

Station	Depth (m) Total	Secchi	Sample	Temperature °C	Specific Conductance µS/cm	Dissolved Oxygen Conc. (mg/L)	Sat. (%)	pH s.u.
Byram Bay	10.30	1.70	0.2	26.29	452.40	7.43	95.4	7.31
			1.0	26.23	452.60	7.34	94.7	7.39
			2.0	26.04	452.60	7.14	91.4	7.39
			3.0	26.00	452.80	7.00	89.5	7.35
			4.0	25.91	452.90	6.93	88.5	7.34
			5.0	25.83	453.10	6.88	87.7	7.34
			5.3	25.63	454.20	6.64	84.5	7.11
			5.6	25.63	453.70	6.61	83.9	7.11
			6.0	24.77	443.80	2.60	34.0	6.99
			7.0	19.26	443.70	0.00	0.0	6.91
			8.0	15.34	437.80	0.00	0.0	6.80
			9.0	12.44	440.50	0.00	0.0	6.67
			10.0	11.65	442.20	0.00	0.0	6.67
Halsey Island	10.20	1.70	0.3	26.31	454.90	7.75	99.6	7.57
			1.0	26.27	454.20	7.75	99.5	7.54
			2.0	26.16	454.30	7.74	99.1	7.58
			3.0	26.11	454.30	7.65	97.8	7.60
			4.0	26.01	454.40	7.41	95.1	7.55
			5.0	25.99	454.40	7.33	93.8	7.52
			6.0	25.65	455.60	6.03	79.1	7.15
			6.3	22.89	439.00	0.00	0.0	6.82
			7.0	17.84	444.80	0.00	0.0	6.83
			8.0	15.59	437.50	0.00	0.0	6.57
			9.0	14.14	439.00	0.00	0.0	6.55
			10.0	12.99	436.40	0.00	0.0	6.59
Mid-Lake	14.50	1.80	0.2	25.90	458.80	7.54	96.3	7.59
			1.0	25.87	455.00	7.54	96.3	7.59
			2.0	25.83	454.90	7.47	95.4	7.59
			3.0	25.77	454.70	7.34	93.4	7.56
			4.0	25.74	454.60	7.25	92.2	7.51
			5.0	25.67	454.70	7.05	89.6	7.49
			5.3	25.57	455.40	6.99	88.7	7.33
			5.6	25.61	455.20	6.97	88.5	7.39
			6.0	23.70	445.10	0.79	9.0	7.04
			7.0	18.55	440.30	0.00	0.0	6.90
			8.0	15.44	443.90	0.00	0.0	6.64
			9.0	13.43	433.10	0.00	0.0	6.56
			10.0	12.51	432.60	0.00	0.0	6.57
			11.0	11.90	434.40	0.00	0.0	6.58
			12.0	11.47	442.40	0.00	0.0	6.59
			13.0	11.10	447.00	0.00	0.0	6.63
			14.0	10.76	451.70	0.00	0.0	6.67
Great Cove	7.30	1.60	0.2	26.13	448.10	7.75	99.4	7.57
			1.0	26.10	448.40	7.74	99.1	7.60
			2.0	26.05	448.90	7.68	98.1	7.57
			3.0	26.04	449.60	7.81	97.3	7.57
			4.0	26.00	456.30	7.46	95.3	7.54
			5.0	25.96	451.20	7.42	94.9	7.49
			6.0	25.93	452.40	7.18	91.6	7.49
			6.3	25.41	456.10	6.17	78.1	7.10
			6.6	21.41	456.60	0.00	0.0	6.92
			7.0	19.61	450.00	0.00	0.0	6.87
King's Cove	2.70	1.20	0.2	25.65	452.20	6.43	85.5	7.37
			1.0	25.63	455.10	6.62	84.0	7.35
			2.0	25.52	455.40	6.48	82.1	7.33
			2.5	25.42	455.50	5.89	73.4	7.27

Trout Habitat Highlighted in Pale Blue (5 mg/L) and Gray (4 mg/L)

Lake Hopatcong *In-Situ* Monitoring Data 2022.08.10

Station	Depth (m)			Temperature	Specific Conductance	Dissolved Oxygen		pH
	Total	Secchi	Sample	°C	µS/cm	Conc. (mg/L)	Sat. (%)	s.u.
Byram Bay	10.30	1.40	0.2	27.82	455.7	8.25	107.4	7.82
			1.0	27.79	456.3	8.26	107.9	7.97
			2.0	27.75	456.0	8.14	106.2	7.92
			3.0	27.73	455.9	8.05	105.1	7.88
			4.0	27.70	456.0	7.93	103.5	7.80
			5.0	26.68	453.1	5.15	65.9	7.20
			5.3	25.12	446.6	1.92	23.4	6.82
			6.0	22.04	433.2	0.00	0.0	6.65
			7.0	19.72	447.0	0.00	0.0	6.60
			8.0	16.80	442.5	0.00	0.0	6.55
			9.0	14.30	440.5	0.00	0.0	6.54
			10.0	12.54	445.5	0.00	0.0	6.55
Halsey Island	10.20	1.50	0.3	27.55	456.2	8.03	104.6	8.00
			1.0	27.56	456.3	8.03	104.5	8.01
			2.0	27.56	456.4	8.01	104.3	7.96
			3.0	27.55	456.5	7.96	103.8	7.91
			4.0	27.47	456.1	7.69	99.7	7.78
			5.0	26.72	454.3	5.89	75.6	7.30
			5.3	25.57	449.6	3.48	43.7	6.70
			6.0	24.50	441.1	1.22	15.0	6.50
			7.0	18.76	446.2	0.00	0.0	6.54
			8.0	15.70	440.5	0.00	0.0	6.53
			9.0	13.20	439.5	0.00	0.0	6.52
			10.0	12.38	440.1	0.00	0.0	6.55
Mid-Lake	14.50	1.50	0.2	27.56	456.6	8.06	104.9	7.99
			1.0	27.54	456.7	8.09	105.4	7.99
			2.0	27.54	456.7	8.08	105.3	7.97
			3.0	27.53	456.7	8.01	104.3	7.83
			4.0	27.53	456.7	7.97	103.6	7.72
			5.0	27.46	456.6	7.78	100.8	7.02
			5.3	26.90	455.9	6.77	87.3	7.01
			5.6	26.17	452.9	4.74	60.2	6.75
			6.0	25.44	449.2	3.68	38.7	6.55
			7.0	18.83	442.9	0.00	0.0	6.50
			8.0	15.20	436.6	0.00	0.0	6.46
			9.0	13.59	436.2	0.00	0.0	6.50
			10.0	12.49	438.9	0.00	0.0	6.59
			11.0	12.00	436.5	0.00	0.0	6.68
			12.0	11.50	438.5	0.00	0.0	6.75
			13.0	11.00	450.0	0.00	0.0	6.85
			14.0	10.77	455.8	0.00	0.0	6.93
Great Cove	7.30	1.50	0.2	27.94	457.0	8.13	106.2	7.48
			1.0	27.65	456.3	8.13	106.1	7.56
			2.0	27.65	456.3	8.16	106.6	7.65
			3.0	27.62	456.3	8.14	106.1	7.71
			4.0	27.15	455.2	6.71	86.7	7.30
			5.0	26.76	454.9	6.22	79.9	7.20
			5.3	26.45	453.3	5.36	68.3	7.13
			5.6	26.38	452.9	5.18	65.9	7.12
			6.0	26.28	453.1	5.12	65.2	7.10
			6.3	24.69	443.9	1.30	16.1	6.80
			7.0	19.85	446.8	0.00	0.0	6.82
King's Cove	3.00	1.00	0.2	27.17	455.8	6.95	89.9	7.51
			1.0	27.17	456.1	6.97	90.1	7.52
			2.0	27.10	455.8	6.87	88.8	7.49
			2.8	26.80	457.8	2.18	28.0	7.07

Trout Habitat Highlighted in Pale Blue (5 mg/L) and Gray (4 mg/L)

Lake Hopatcong *In-Situ* Monitoring Data 2022.08.16

Station	Depth (m) Total	Secchi	Sample	Temperature °C	Specific Conductance µS/cm	Dissolved Oxygen Conc. (mg/L)	Sat. (%)	pH s.u.
Byram Bay	10.30	1.20	0.2	25.37	453.5	7.81	98.2	7.48
			1.0	25.41	453.8	7.84	98.3	7.53
			2.0	25.37	453.7	7.82	98.4	7.54
			3.0	25.31	453.7	7.74	97.0	7.51
			4.0	25.19	453.1	7.46	93.2	7.45
			5.0	25.14	453.1	7.37	92.2	7.42
			5.3	25.13	453.0	7.30	91.4	7.40
			5.6	25.12	453.1	7.30	91.2	7.40
			6.0	25.11	453.0	7.23	90.0	7.38
			6.3	25.04	452.8	6.84	85.3	7.35
			6.6	24.76	451.2	6.31	77.3	7.26
			7.0	19.41	451.2	0.00	0.0	7.07
			8.0	16.14	443.0	0.00	0.0	6.85
			9.0	13.44	443.7	0.00	0.0	6.70
			10.0	12.41	447.0	0.00	0.0	6.67
Halsey Island	10.20	1.30	0.3	25.34	455.1	8.02	101.0	7.62
			1.0	25.37	454.7	8.01	100.5	7.68
			2.0	25.34	454.7	7.99	100.4	7.66
			3.0	25.30	454.2	7.90	98.9	7.66
			4.0	25.26	454.7	7.81	97.7	7.59
			4.6	25.21	454.9	7.76	97.3	7.53
			5.0	24.70	449.2	4.12	51.1	7.22
			6.0	24.00	447.9	2.74	35.0	6.98
			7.0	19.71	448.9	0.00	0.0	6.93
			8.0	15.22	440.8	0.00	0.0	6.78
			9.0	13.66	439.9	0.00	0.0	6.67
			10.0	12.71	440.4	0.00	0.0	6.67
Mid-Lake	14.50	1.30	0.2	25.49	456.4	7.98	100.6	7.74
			1.0	25.47	456.4	7.98	100.4	7.73
			2.0	25.45	456.7	7.95	99.9	7.72
			3.0	25.46	456.3	7.86	98.9	7.68
			4.0	25.41	456.3	7.72	97.1	7.63
			5.0	24.99	453.2	5.82	72.1	7.25
			5.3	24.85	452.0	5.36	66.7	7.20
			5.6	24.72	454.4	4.99	61.0	7.06
			6.0	24.40	449.7	3.75	46.7	6.99
			7.0	19.55	451.0	0.00	0.0	6.96
			8.0	15.81	438.7	0.00	0.0	6.75
			9.0	13.82	437.6	0.00	0.0	6.61
			10.0	12.55	430.3	0.00	0.0	6.64
			11.0	11.73	435.5	0.00	0.0	6.63
			12.0	11.25	441.6	0.00	0.0	6.64
			13.0	10.89	447.9	0.00	0.0	6.69
			14.0	10.67	455.2	0.00	0.0	6.65
Great Cove	7.30	1.20	0.2	25.47	455.1	8.33	104.9	7.61
			1.0	25.43	455.1	8.36	105.1	7.69
			2.0	25.43	454.8	8.32	104.7	7.76
			3.0	25.27	454.4	7.82	97.4	7.63
			4.0	25.11	454.6	7.00	94.9	7.57
			5.0	24.95	455.4	7.30	91.2	7.49
			5.3	24.81	455.6	6.90	85.4	7.41
			5.6	24.50	454.9	5.63	69.6	7.21
			6.0	23.52	443.4	1.36	16.0	6.91
			7.0	17.84	448.7	0.00	0.0	6.96
King's Cove	3.00	0.90	0.2	25.22	457.3	7.81	97.9	7.62
			1.0	25.19	454.4	7.80	94.6	7.59
			2.0	25.19	454.5	7.67	95.9	7.58
			2.5	25.16	457.6	7.17	90.1	7.47

Trout Habitat Highlighted in Pale Blue (5 mg/L) and Gray (4 mg/L)

In-Situ Monitoring for Lake Hopatcong 8/24/2022

Station	Depth (m) Total	Depth (m) Secchi	Sample	Temperature °C	Specific Conductance µS/cm	Dissolved Oxygen Conc. (mg/L)	Dissolved Oxygen Sat. (%)	pH s.u.
STA-1	2.20	0.80	0.1	26.19	0.434	9.90	126.0	8.6
			1.0	25.88	0.434	9.77	123.0	8.4
			2.0	25.20	0.433	8.38	104.0	8.0
STA-2	14.30	1.30	0.1	25.28	0.398	9.54	119.5	8.5
			1.0	25.16	0.454	9.52	119.5	8.5
			2.0	25.11	0.455	9.49	118.5	8.5
			3.0	24.96	0.455	9.19	114.3	8.4
			4.0	24.74	0.456	8.44	104.7	8.0
			5.0	24.67	0.456	8.33	103.2	8.0
			6.0	24.09	0.456	5.57	68.7	7.4
			7.0	21.75	0.443	0.00	0.0	6.9
			8.0	16.56	0.445	0.00	0.0	7.0
			9.0	13.88	0.439	0.00	0.0	6.7
			10.0	12.75	0.437	0.00	0.0	6.5
			11.0	11.85	0.438	0.00	0.0	6.6
			12.0	11.43	0.443	0.00	0.0	6.6
			13.0	11.15	0.447	0.00	0.0	6.6
			14.0	10.70	0.460	0.00	0.0	6.5
STA-3	2.00	0.70	0.1	25.80	0.531	8.57	104.0	8.3
			1.0	25.14	0.519	7.26	90.2	7.9
			1.5	24.56	0.507	6.62	82.4	7.7
STA-4	3.10		0.1	24.89	0.461	8.21	102.1	7.8
			1.0	24.84	0.461	8.16	101.5	7.8
			1.0	24.70	0.460	7.75	96.1	7.7
			3.0	24.61	0.460	7.23	89.5	7.6
STA-5	2.30	1.00	0.1	25.18	0.462	8.01	100.2	7.5
			1.0	24.94	0.463	7.49	99.6	7.5
			2.0	24.74	0.402	7.22	89.2	7.5
STA-6	2.70	1.20	0.1	26.43	0.470	9.41	120.7	8.4
			1.0	26.05	0.469	9.65	122.2	8.4
			2.0	25.31	0.468	9.56	120.5	8.3
			2.5	25.14	0.468	8.11	101.4	7.8
STA-7	1.50	0.90	0.1	26.70	0.513	8.79	113.0	7.9
			1.0	25.83	0.524	8.44	107.1	7.8
STA-8	7.20	1.30	0.1	25.63	0.459	9.17	115.6	8.3
			1.0	25.44	0.460	9.25	116.5	8.4
			2.0	25.42	0.462	9.25	116.3	8.3
			3.0	25.27	0.461	9.21	115.5	8.3
			4.0	25.17	0.463	9.04	113.1	8.2
			5.0	24.97	0.464	8.42	104.6	8.0
			6.0	23.44	0.458	2.10	28.4	7.2
			7.0	22.20	0.454	0.00	0.0	6.8
STA-9	7.50	1.30	0.1	26.07	0.472	9.52	121.3	8.7
			1.0	25.86	0.470	9.61	121.2	8.1
			2.0	24.91	0.469	9.29	115.8	8.1
			3.0	24.61	0.469	7.90	97.9	7.6
			4.0	24.33	0.468	6.14	76.6	7.3
			5.0	24.00	0.466	3.72	45.9	6.9
			6.0	22.02	0.453	0.00	0.0	6.7
			7.0	20.67	0.468	0.00	0.0	6.6
STA-10	0.80	0.70	0.1	26.82	0.499	10.64	137.1	8.7
			0.7	25.89	0.442	9.88	125.5	8.5
STA-11	1.00	1.00+	0.1	25.38	0.596	6.67	83.8	7.5
			1.0	25.04	0.598	6.67	83.0	7.4

Trout Habitat Highlighted in Pale Blue (5 mg/L) and Gray (4 mg/L)

				***In-Situ* Monitoring for Lake Hopatcong 10/6/2022**				
Station	**Depth (m)**			**Temperature**	**Specific Conductance**	**Dissolved Oxygen**		**pH**
	Total	**Secchi**	**Sample**	**°C**	**µS/cm**	**Conc. (mg/L)**	**Sat. (%)**	**s.u.**
STA-1	2.20	1.80	0.1	13.76	0.430	10.34	102.8	7.8
			1.0	13.17	0.430	10.39	102.1	7.8
			2.0	12.56	0.428	10.27	99.6	7.7
STA-2	14.30	1.30	0.1	15.40	0.445	7.69	79.2	7.5
			1.0	15.20	0.446	7.69	79.0	7.5
			2.0	15.13	0.446	7.69	78.9	7.5
			3.0	14.95	0.446	7.50	76.6	7.5
			4.0	14.89	0.446	7.42	75.6	7.4
			5.0	14.88	0.446	7.34	74.8	7.4
			6.0	14.86	0.446	7.32	74.6	7.3
			7.0	14.86	0.446	7.30	74.3	7.3
			8.0	14.86	0.446	7.25	73.8	7.3
			9.0	14.85	0.446	7.19	73.2	7.3
			10.0	14.10	0.446	7.18	73.2	7.3
			11.0	14.10	0.444	6.45	64.5	7.2
			12.0	13.64	0.443	7.27	72.1	7.2
			13.0	11.77	0.466	0.00	0.0	6.9
			14.0	11.27	0.472	0.00	0.0	6.8
STA-3	2.00	1.30	0.1	13.89	0.444	9.05	90.8	7.4
			1.0	13.14	0.448	9.40	92.4	7.4
			1.5	12.74	0.449	9.60	93.5	7.4
STA-4	2.80	1.40	0.1	14.59	0.444	8.62	87.5	7.5
			1.0	14.49	0.445	8.66	87.1	7.5
			1.0	13.60	0.442	9.12	90.4	7.6
			2.5	13.23	0.440	9.11	89.6	7.5
STA-5	2.30	1.20	0.1	17.56	0.443	9.15	98.4	7.7
			1.0	16.83	0.444	9.50	100.8	7.8
			2.0	15.63	0.448	8.92	93.2	7.8
STA-6	2.70	1.50	0.1	17.18	0.445	7.03	75.3	7.7
			1.0	16.27	0.443	6.79	71.3	7.6
			2.0	15.61	0.442	7.46	77.2	7.6
			2.5	15.16	0.446	7.60	78.1	7.5
STA-7	1.70	1.60	0.1	13.42	0.436	8.87	87.6	7.3
			1.0	12.36	0.317	9.43	91.4	7.2
STA-8	7.20	1.20	0.1	15.71	0.445	7.35	76.3	7.6
			1.0	15.54	0.444	7.27	74.7	7.5
			2.0	14.95	0.445	7.05	71.8	7.4
			3.0	14.89	0.445	6.96	70.9	7.4
			4.0	14.86	0.445	6.93	70.6	7.3
			5.0	14.83	0.445	6.92	70.5	7.2
			6.0	14.81	0.445	6.85	69.7	7.2
			7.0	14.73	0.447	6.74	68.5	7.2
STA-9	7.50	1.50	0.1	16.52	0.444	7.55	79.7	7.5
			1.0	15.95	0.444	7.39	77.5	7.4
			2.0	15.44	0.443	6.17	63.5	7.3
			3.0	15.27	0.443	6.10	62.5	7.2
			4.0	15.16	0.444	5.96	61.6	7.2
			5.0	15.09	0.445	5.86	60.0	7.1
			6.0	14.99	0.445	5.69	58.0	7.0
			7.0	14.82	0.447	4.80	48.7	7.0
STA-10	0.80	0.70	0.1	15.46	0.440	10.36	100.7	8.0
			0.7	14.70	0.442	10.55	106.9	8.0
STA-11	1.00	1.00+	0.1	13.36	0.298	9.36	92.1	7.6
			1.0	13.18	0.304	9.42	92.3	7.4

Trout Habitat Highlighted in Pale Blue (5 mg/L) and Gray (4 mg/L)

APPENDIX III: NEAR-SHORE AND STREAM *IN-SITU* DATA

***In-Situ* Monitoring for Lake Hopatcong 7/5/2022**

Station	Depth	Temperature	Specific Conductance	Dissolved Oxygen		pH
	m	°C	µS/cm	Conc. (mg/L)	Sat. (%)	s.u.
1	0.1	25.86	444.26	8.33	105.3	7.65
	0.5	25.69	442.81	8.27	104.0	7.64
2	0.1	26.36	445.94	7.88	100.5	7.47
	1.0	26.24	445.07	7.94	101.7	7.51
	1.5	26.02	444.85	7.96	100.9	7.40
3	0.1	26.30	445.88	7.43	95.9	7.40
	1.0	25.73	443.85	6.71	83.3	7.26
	1.5	25.52	443.86	5.68	71.5	7.07
4	0.1	25.82	446.42	7.20	91.4	7.33
	1.0	25.61	446.20	6.78	85.5	7.29
5	0.1	27.55	459.11	8.04	104.7	7.58
	1.0	27.37	456.89	7.90	102.0	7.52
6	0.1	27.25	459.11	8.04	104.7	7.58
	1.0	27.21	456.89	7.90	102.0	7.52
7	0.1	26.39	453.23	8.01	102.2	7.52
	1.0	26.36	453.19	8.02	102.6	7.45
	1.5	26.49	453.35	8.08	103.8	7.43
8	0.1	26.43	453.85	7.99	102.3	7.56
	1.0	26.46	453.12	7.99	102.3	7.48
9	0.1	26.18	442.76	7.89	100.5	7.45
	1.0	26.12	442.61	7.82	99.1	7.37
	1.5	25.96	442.39	7.65	97.2	7.27
10	0.1	25.89	443.70	7.59	95.7	7.38
	1.0	25.91	443.75	7.46	94.4	7.33
11	0.1	26.61	443.97	7.71	97.8	7.37
	1.0	25.65	443.49	7.44	94.7	7.27
12	0.1	26.51	464.76	7.25	93.2	7.33
	1.0	26.01	494.86	7.44	95.2	7.29
13	0.1	26.21	442.63	8.04	102.7	7.55
	1.0	26.27	442.68	7.98	102.1	7.50
	1.5	26.24	442.76	7.88	100.5	7.34
14	0.1	25.96	442.68	8.16	103.6	7.59
	1.0	25.95	442.48	8.13	103.6	7.50
	2.0	25.80	444.14	7.69	98.5	7.30
15	0.1	25.82	441.63	7.98	101.0	7.46
	1.0	25.81	441.52	7.96	100.6	7.39
	2.0	25.79	441.00	7.82	99.1	7.29
16	0.1	25.78	439.92	8.16	103.6	7.57
	1.0	25.69	439.95	8.05	101.6	7.51
	2.0	25.63	440.48	8.04	102.3	7.48
	3.0	25.07	438.89	6.30	80.0	6.90
17	0.1	25.55	442.52	7.94	100.4	7.64
	1.0	25.46	439.62	7.84	98.8	7.54
	2.0	24.17	435.01	6.94	85.2	7.25
	3.0	23.31	437.00	5.05	61.5	6.80
	4.0	22.62	432.41	2.79	33.6	6.58
18	0.1	26.00	440.49	8.24	104.9	7.70
	1.0	26.02	439.87	8.23	104.8	7.67
	1.5	25.90	439.50	8.12	102.5	7.60
19	0.1	25.63	442.64	7.33	93.4	7.51
	1.0	25.69	442.32	7.45	94.8	7.46
	2.0	25.66	443.09	6.90	87.8	7.25

Trout Habitat Highlighted in Pale Blue

In-Situ Monitoring for Lake Hopatcong 7/11/2022

Station	Depth	Temperature	Specific Conductance	Dissolved Oxygen		pH
	m	°C	µS/cm	Conc. (mg/L)	Sat. (%)	s.u.
20	0.2	26.29	444.9	8.75	112.1	8.04
	1.0	26.29	444.6	8.81	112.9	8.03
21	0.2	27.79	439.6	8.83	115.9	7.64
	1.0	26.55	436.9	10.27	135.1	7.86
22	0.2	26.80	425.8	8.63	111.6	7.61
	1.0	26.80	425.1	8.61	110.2	7.52
23	0.2	26.79	437.1	8.43	108.0	7.74
	1.0	26.73	436.8	8.41	108.8	7.69
24	0.2	26.44	354.6	7.41	94.9	7.40
	1.0	26.50	355.3	7.14	91.3	7.35
25	0.2	26.49	381.5	6.78	86.8	7.23
	1.0	25.89	317.6	6.94	88.9	7.20
26	0.2	26.77	381.1	5.71	71.3	7.03
	1.0	26.00	376.2	5.81	73.9	7.00
27	0.2	26.41	382.7	7.44	96.1	7.25
	1.0	25.96	378.8	7.74	98.2	7.23
28	0.2	25.76	446.8	8.40	113.8	8.07
	1.0	25.77	446.8	8.42	113.2	8.07
	1.7	25.78	447.9	8.42	113.3	8.07
29	0.2	25.74	446.4	8.99	113.8	8.12
	1.0	25.74	446.4	8.99	113.9	8.11
	2.0	25.71	446.3	8.98	113.9	8.11
	2.5	25.57	444.9	8.88	112.3	8.05
30	0.2	26.55	449.4	8.48	108.9	7.86
	1.0	26.30	448.7	8.48	108.9	7.90
31	0.2	26.11	446.8	8.80	112.1	8.04
	1.0	26.03	446.6	8.84	112.6	8.04
	2.0	25.88	446.9	8.44	102.6	8.05
32	0.2	25.65	445.9	9.24	116.7	8.30
	1.0	25.64	445.8	9.31	117.3	8.32
33	0.2	25.70	445.9	9.40	119.0	8.39
	1.0	25.70	445.9	9.41	119.5	8.38
	1.8	25.64	446.0	9.40	119.0	8.40
34	0.2	26.04	446.3	8.79	112.0	8.04
	1.0	26.04	446.3	8.78	111.7	8.03
	1.5	25.66	445.8	8.50	107.7	7.93
35	0.2	26.33	439.7	9.11	116.7	8.13
	1.0	26.28	438.7	9.25	118.4	8.19
36	0.2	26.30	442.0	8.84	113.3	8.04
	1.0	26.28	441.8	8.83	113.2	8.04
	2.0	25.97	441.3	8.99	114.3	8.05
37	0.2	26.66	447.1	8.79	113.6	8.01
	1.0	26.05	445.2	9.08	115.6	8.11
	1.5	25.98	444.9	9.45	119.8	8.26
38	0.2	26.60	447.6	9.01	115.9	8.11
	1.0	26.24	444.9	11.44	145.2	8.86
39	0.2	25.90	444.4	9.06	115.2	8.13
	1.0	25.86	444.5	9.06	115.3	8.09
	2.0	25.78	445.0	9.07	115.1	8.09
	3.0	25.72	444.2	8.85	111.8	8.03
40	0.2	26.74	449.0	8.50	109.1	7.89
	1.0	26.60	448.4	8.15	110.3	7.85
41	0.2	26.91	445.8	8.78	113.8	8.06
	1.0	26.81	445.6	8.57	110.8	7.99
42	0.2	26.79	442.8	9.22	119.2	8.17
	1.0	26.79	442.3	9.24	119.1	8.18

Trout Habitat Highlighted in Pale Blue

***In-Situ* Monitoring for Lake Hopatcong 7/18/2022**

Station	Depth	Temperature	Specific Conductance	Dissolved Oxygen		pH
	m	°C	µS/cm	Conc. (mg/L)	Sat. (%)	s.u.
43	0.2	27.07	346.1	6.62	86.1	7.27
	1.0	27.00	395.7	6.38	87.7	7.28
44	0.2	26.87	397.6	7.65	99.1	7.40
45	0.2	27.05	398.2	7.32	95.0	7.36
46	0.2	26.92	396.5	7.74	100.3	7.62
	1.0	26.04	397.1	7.15	91.9	7.64
47	0.2	26.95	396.7	7.70	99.3	7.65

Trout Habitat Highlighted in Pale Blue

***In-Situ* Monitoring for Lake Hopatcong 8/2/2022**

Station	Depth	Temperature	Specific Conductance	Dissolved Oxygen		pH
	m	°C	µS/cm	Conc. (mg/L)	Sat. (%)	s.u.
48	0.2	26.54	411.7	8.38	107.4	7.81
	1.0	26.10	411.7	9.15	118.3	8.23
49	0.2	26.60	408.1	8.19	105.4	7.64
	1.0	26.53	408.2	8.63	103.5	7.57
50	0.2	27.72	406.7	8.35	110.4	7.80
	1.0	27.78	404.1	8.47	110.8	7.76
51	0.2	27.77	381.5	8.12	107.1	7.66
	1.0	27.11	384.5	7.91	103.4	7.50
	2.0	26.36	407.5	7.29	98.6	7.33
52	0.2	27.08	408.5	8.39	109.3	7.54
	1.0	26.96	407.9	8.39	108.7	7.55
	1.5	26.90	407.9	8.12	105.7	7.53
53	0.2	26.97	410.1	9.14	118.7	7.79
	1.0	26.68	413.8	9.13	118.1	7.80
54	0.2	27.19	403.8	9.20	120.7	7.99
	1.0	26.54	406.1	9.07	116.4	8.01
55	0.2	27.03	421.5	9.70	126.7	8.22
	1.0	26.31	430.3	9.72	123.1	8.30
	2.0	25.26	450.7	7.26	92.0	7.84
	3.0	24.81	460.2	5.46	68.2	7.45
56	0.1	27.35	422.5	9.69	126.7	8.22
	1.0	25.77	426.7	9.25	118.2	8.10
57	0.2	27.30	437.7	10.26	132.1	8.56
	1.0	25.76	422.6	9.78	124.7	8.23
58	0.2	27.19	444.3	10.50	137.1	8.65
	2.0	25.61	445.7	10.10	128.4	8.47
59	0.2	27.35	406.9	9.28	121.8	8.09
60	0.2	27.01	408.6	8.22	106.0	7.72
	1.0	26.77	408.0	7.93	102.3	7.59
	2.0	26.22	407.1	7.02	90.1	7.45
	2.5	26.09	408.3	6.73	86.5	7.31
61	0.2	27.73	396.9	8.02	113.1	7.64
	1.0	27.10	399.8	8.52	110.5	7.69
	1.8	26.28	399.5	6.85	88.6	7.38
62	0.2	28.46	410.3	8.79	117.5	7.81
	1.0	26.78	404.7	8.85	115.1	7.87
63	0.2	28.15	432.1	8.87	117.1	7.89
	1.0	27.54	429.4	8.52	112.1	7.72
64	0.2	27.65	399.2	8.68	113.9	7.74
	1.0	27.05	399.1	8.57	111.7	7.70
	2.0	26.61	399.5	8.00	103.5	7.59
65	0.2	28.89	411.8	8.29	112.0	7.69
66	0.2	27.62	404.3	8.52	112.2	7.61
	0.9	26.32	381.7	6.94	89.4	7.35
67	0.2	28.43	407.4	9.14	122.5	7.81
68	0.2	28.04	393.2	9.31	123.4	7.98
	1.0	25.95	388.5	8.29	108.3	7.70
69	0.2	27.32	432.5	9.78	128.0	7.87
	1.0	25.60	421.9	8.64	109.5	7.72
70	0.2	27.35	448.5	9.60	125.9	7.95
	1.0	26.55	441.6	10.26	132.6	8.09
71	0.2	27.59	451.7	9.13	120.2	7.86
	1.0	26.50	449.3	9.29	119.8	7.85
72	0.2	27.76	453.6	8.29	109.8	7.71
	1.0	27.42	452.0	8.55	111.8	7.82
73	0.2	27.38	456.8	8.19	107.5	7.58
	1.0	27.20	455.1	8.11	105.9	7.54
	1.5	26.37	453.3	7.94	103.3	7.36
74	0.2	27.52	480.1	8.67	113.9	7.78
	1.0	27.52	461.3	8.81	115.0	7.46
75	0.2	27.91	458.4	8.42	121.9	7.09
	1.0	26.47	452.7	10.24	132.1	8.47
76	0.2	28.58	459.3	7.73	103.7	7.80
	1.0	26.84	452.2	9.10	125.3	8.35
77	0.2	28.22	458.8	7.48	99.2	7.79
	1.0	26.53	458.6	8.23	107.2	7.71
	2.0	25.92	453.1	6.41	80.7	7.48

Trout Habitat Highlighted in Pale Blue

***In-Situ* Monitoring for Lake Hopatcong 8/10/2022**

Station	Depth m	Temperature °C	Specific Conductance µS/cm	Dissolved Oxygen Conc. (mg/L)	Dissolved Oxygen Sat. (%)	pH s.u.
78	0.2	27.49	458.5	7.70	100.1	7.61
	1.0	27.59	456.6	7.39	95.9	7.61
79	0.2	27.67	457.1	7.62	99.4	7.66
	1.0	27.74	456.6	7.53	98.3	7.66
	2.0	27.75	456.3	7.46	97.2	7.56
80	0.2	27.64	458.8	7.05	92.0	7.69
	1.0	27.69	457.8	6.73	87.8	7.62
	2.0	27.54	456.5	5.60	71.3	7.50
81	0.2	27.73	485.9	8.45	110.9	8.00
82	0.2	27.59	461.8	7.50	91.4	7.35
83	0.2	27.84	454.9	7.75	101.7	7.76
	1.0	27.98	454.9	7.79	102.5	7.72
84	0.2	28.06	458.6	8.09	100.3	7.85
	1.0	27.80	456.6	6.75	88.3	7.77
85	0.2	27.98	456.4	7.49	98.3	7.71
	1.0	27.87	453.9	7.25	95.1	7.69
	2.0	27.65	452.7	7.21	93.9	7.60
86	0.2	28.69	456.3	8.30	100.2	7.95
	1.0	27.95	447.3	8.24	107.8	8.00
	2.0	27.73	446.3	6.20	82.1	7.74
87	0.2	28.19	457.0	8.48	111.6	8.11
	1.0	28.13	456.9	8.51	111.0	8.15
88	0.2	27.97	457.7	8.18	106.8	8.60
	1.0	27.85	456.9	7.70	100.5	7.87
	1.5	27.65	456.7	7.13	92.9	7.68
89	0.2	27.94	457.5	8.75	115.1	8.24
	1.0	27.95	456.1	8.34	111.0	8.28
90	0.2	28.15	457.4	8.21	108.3	8.10
	1.0	27.81	455.8	8.13	106.6	8.02
	2.0	27.75	455.7	7.61	99.5	7.81
	2.5	27.73	455.9	7.15	97.4	7.61
91	0.2	28.07	456.8	8.41	110.7	8.14
	1.0	27.76	455.7	8.88	114.3	8.47
92	0.2	28.00	456.4	8.72	114.5	8.31
	1.0	28.00	456.1	8.66	113.1	8.25
	2.0	27.89	456.0	8.38	110.4	8.12
93	0.2	27.90	456.7	8.83	116.1	8.36
	1.0	27.74	456.2	8.61	112.7	8.29
94	0.2	27.94	456.6	8.97	117.7	8.40
	1.0	28.11	457.4	8.42	117.4	8.39
95	0.2	27.91	456.9	8.82	115.4	8.35
	1.0	27.75	455.1	8.47	110.8	8.11
96	0.2	28.02	456.9	8.54	112.9	8.23
	1.0	28.09	456.5	8.57	112.9	8.20
	2.0	27.89	456.4	7.99	104.5	7.96
97	0.2	28.09	456.9	8.79	115.8	8.34
	1.0	28.14	456.6	8.79	115.9	8.32
	2.0	27.94	455.9	8.37	109.9	8.16
98	0.2	28.17	456.9	8.68	114.6	8.31
	1.0	28.17	456.7	8.68	114.4	8.28
	2.0	27.97	456.9	8.99	118.3	8.26
99	0.2	28.24	456.6	8.75	119.5	8.39
	1.0	28.18	456.3	9.16	123.8	8.52
100	0.2	28.26	457.8	8.65	114.2	8.35
	1.0	28.09	457.6	8.48	111.5	8.30
	2.0	27.82	456.7	8.59	112.6	8.24
101	0.2	28.19	457.3	8.08	106.3	8.04
	1.0	27.99	457.3	8.10	106.4	7.98
102	0.2	28.37	459.7	8.68	115.1	8.26
	1.0	28.35	457.9	8.70	115.1	8.25
	2.0	27.81	456.4	8.31	108.7	8.00
103	0.2	28.34	460.7	8.38	113.5	8.25
	1.0	28.26	459.6	8.58	113.3	8.22
	2.0	27.75	457.9	7.97	102.0	8.05
103	0.2	28.37	458.6	8.57	113.5	8.22
	1.0	27.89	457.2	8.42	110.9	8.19
	2.0	27.73	456.9	8.60	112.5	8.12
105	0.2	28.78	495.7	10.31	137.8	8.88
	1.0	28.13	457.3	8.94	117.0	8.44
106	0.2	28.60	549.9	9.45	126.4	8.85
	1.0	28.26	552.9	6.34	90.7	8.44
107	0.2	28.90	566.1	9.07	121.5	8.64
	1.0	28.26	555.5	8.34	106.1	8.50
108	0.2	28.64	468.3	9.78	124.4	8.65
	1.0	28.25	459.6	8.97	118.1	8.50

Trout Habitat Highlighted in Pale Blue

***In-Situ* Monitoring for Lake Hopatcong 8/16/2022**

Station	Depth	Temperature	Specific Conductance	Dissolved Oxygen		pH
	m	°C	µS/cm	Conc. (mg/L)	Sat. (%)	s.u.
109	0.2	26.03	451.5	8.42	106.7	7.89
	1.0	25.56	452.9	8.42	106.1	7.86
	2.0	25.53	453.4	8.32	104.9	7.72
110	0.2	25.70	458.3	8.48	106.9	7.70
	1.0	25.69	458.9	8.46	106.9	7.67
	2.0	25.42	456.9	8.23	101.1	7.61
S-1	0.2	17.67	1574.20	6.85	74.5	6.32
S-2	0.2	21.21	1314.0	8.80	102.4	7.45
S-3	0.2	20.83	962.6	6.69	77.3	7.18
S-4	0.2	24.48	578.9	6.52	80.6	6.90
S-5	0.2	21.72	212.3	6.84	80.3	7.24
S-6	0.2	19.32	902.7	6.15	68.9	7.03
S-7	0.2	19.07	639.7	6.90	76.3	7.57
S-8	0.2	20.86	305.9	6.92	79.3	7.76
S-9	0.2	19.82	813.1	2.97	33.8	7.06
S-10	0.2	19.60	2027.3	8.98	102.3	8.12

Trout Habitat Highlighted in Pale Blue

***In-Situ* Monitoring for Lake Hopatcong 8/19/2022**

Station	Depth	Temperature	Specific Conductance	Dissolved Oxygen		pH
	m	°C	µS/cm	Conc. (mg/L)	Sat. (%)	s.u.
111	0.2	25.85	457.1	9.03	113.9	8.19
	1.0	25.33	457.6	9.30	110.4	8.33
	2.0	24.89	455.5	9.40	116.7	8.35
	3.0	24.67	455.0	7.94	96.7	8.00
112	0.2	25.95	457.4	8.67	112.2	8.17
	1.0	25.41	456.4	9.03	113.2	8.22
	2.0	24.84	455.9	8.95	111.1	8.19
113	0.2	26.84	477.1	8.71	111.6	8.06
114	0.2	25.94	461.3	8.77	110.4	7.96
	1.0	24.71	457.8	8.30	102.1	7.92
115	0.2	26.23	461.7	8.79	112.1	7.92
	1.0	24.70	456.4	8.96	110.8	8.03
	2.0	24.26	458.7	7.01	86.1	7.76
116	0.2	26.29	458.6	8.94	113.9	7.87
	1.0	25.12	452.6	9.61	118.3	8.15

Trout Habitat Highlighted in Pale Blue