Strath Haven High School

2024 Little Crum Creek Water Quality Report

Created for the Friends of Little Crum Creek Park Board

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Spring Independent Study

May 2024

Overview

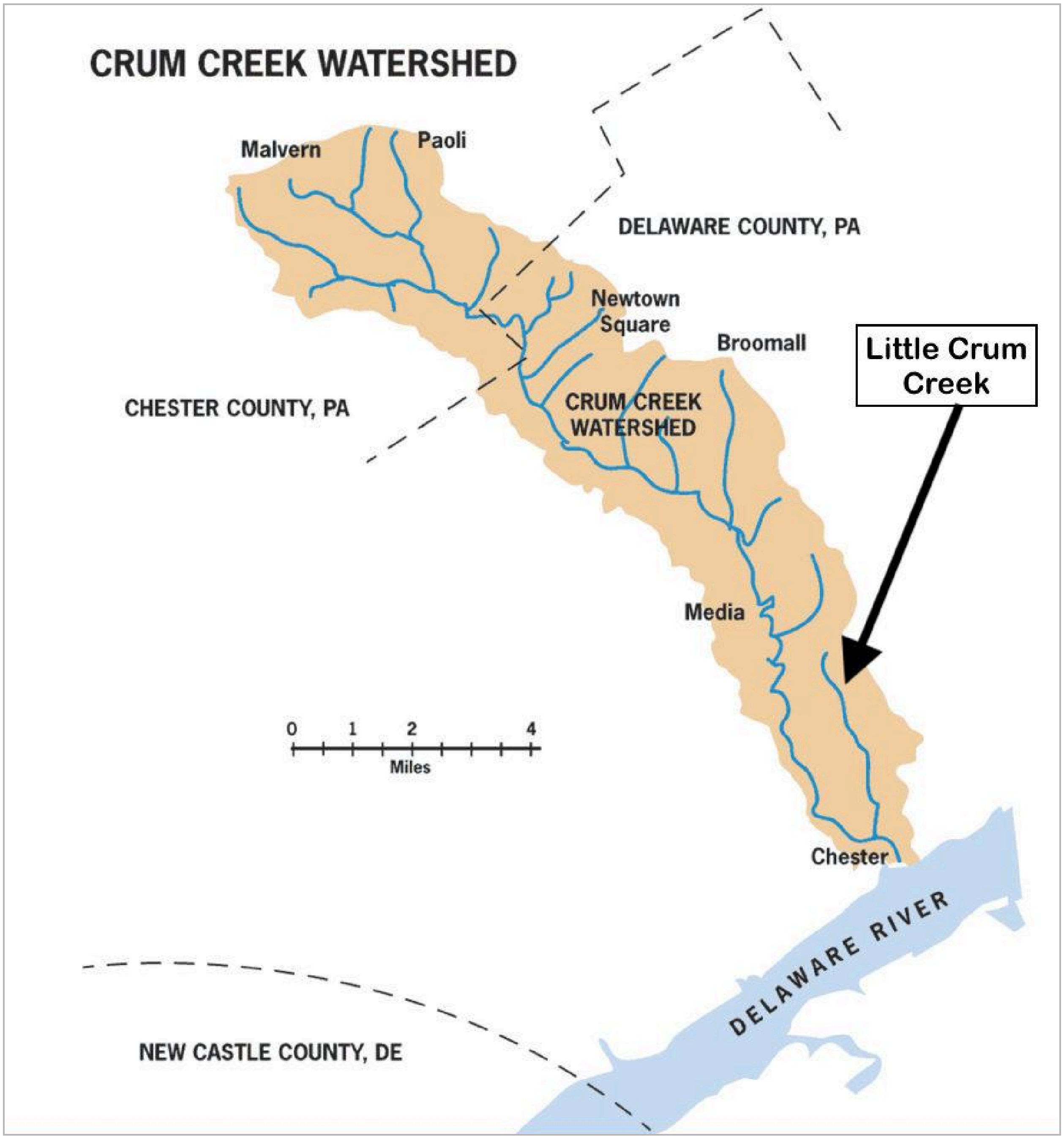
The Delaware River Basin is the drinking water source for 17 million people, across 13,539 square miles within five states, eventually discharging into the Atlantic Ocean ("Delaware River — Lifeblood of the Northeast"). The Delaware Basin is one of five major basins in Pennsylvania, with 216 tributaries ("Delaware Watershed"). Crum Creek originates in Chester County and flows south through Delaware County before joining the Delaware River (Map 1). The headwaters protect the health of the Delaware River Basin, as upstream waterways carry contamination and affect the quality of downstream waters.

The Crum Creek Watershed is the catchment area for the precipitation that falls in its 38 square miles and 15 municipalities (Cressler, 2022). The Crum Watershed is also made up of three subwatersheds, including the Little Crum Creek subwatershed. Swarthmore's Little Crum Creek Park (LCCP), established 1970, is the largest public park in Swarthmore and preserves an important open space in the Little Crum Creek Subwatershed (Map 2).

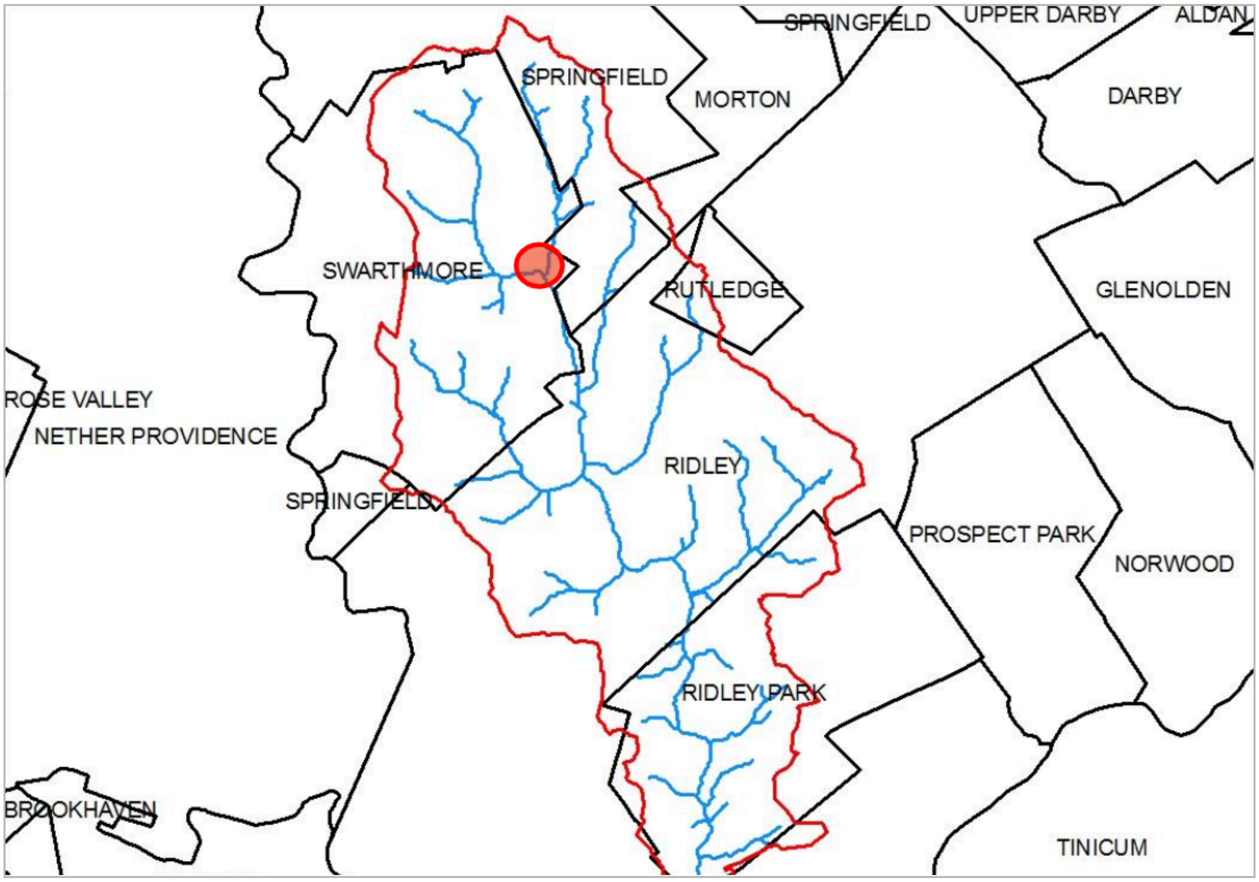
The site of this study is the stretch of Little Crum Creek within Little Crum Creek Park. Little Crum Creek is a stream that originates in Swarthmore and is a headwater stream that flows into Crum Creek. Little Crum Creek is a designated warm water fishery (WWF) by the PADEP and faces impairments due to nonpoint pollution and stormwater runoff issues (EPA, 2021) that are amplified by the heavily developed land surrounding it. Little Crum Creek does not meet the Pennsylvania water quality standards established in Title 25 Chapter 93 of the PA Code and is thus classified by the state as an unhealthy stream.

Land use affects the health of the waterways; non-point pollution increases as open space diminishes. Because water cannot infiltrate the impervious surfaces found in developed areas–e.g. roadways, parking lots, sidewalks, and rooftops–large volumes of stormwater runoff are channeled through drains, which then end up in streams like Little Crum Creek.

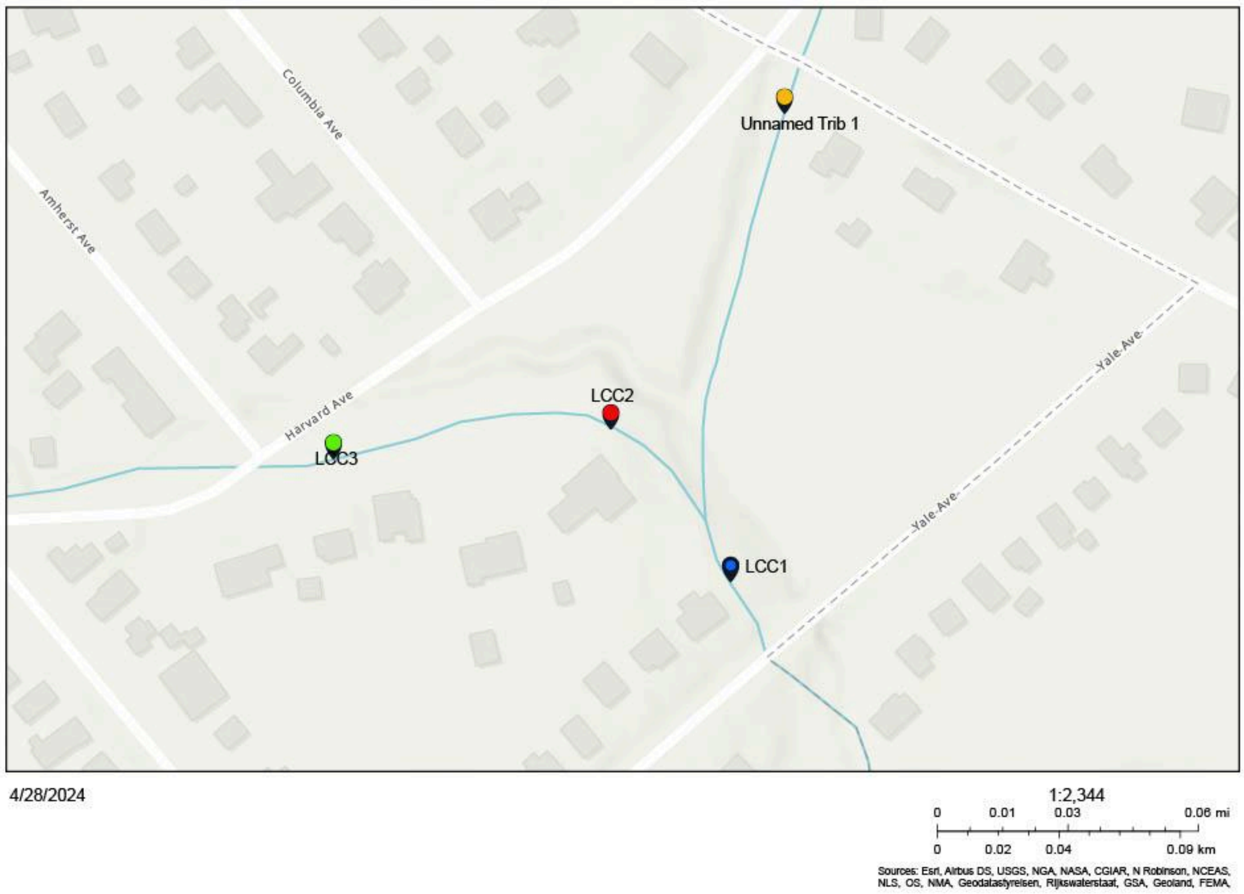
Major projects such as the construction of the Springfield Mall and Springfield Square in the early 1970s (atop a tributary to Little Crum) increased the impervious surfaces within the subwatershed. A data comparison of water quality data to a USGS monitoring station in Little Crum Creek from the same three-month period in 1971 (Map 4) was done using averages to estimate the impact of the increased land development on the health of Little Crum Creek.



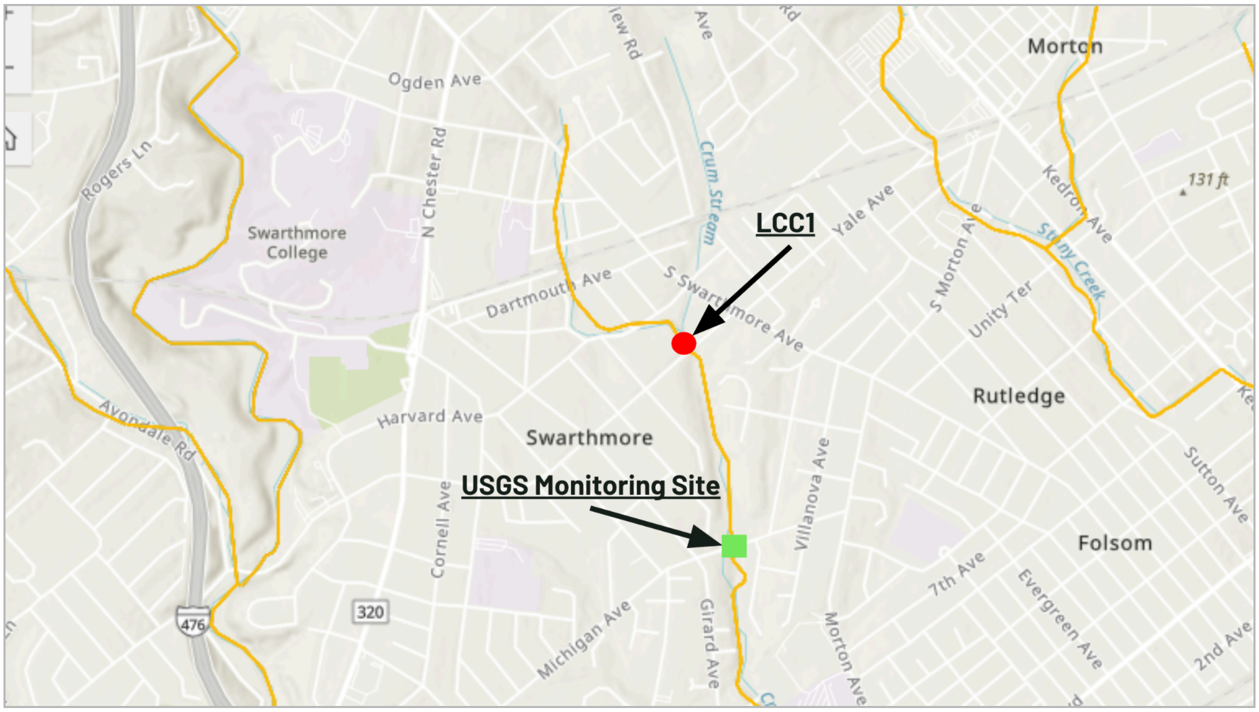
Map 1: Crum Creek watershed in southeastern Pennsylvania. Crum Creek originates in Chester County before flowing through Delaware County and discharging into the Delaware River by the city of Chester. Little Crum Creek is a major tributary that joins Crum Creek shortly before it enters the Delaware River (Aller, 2004).



Map 2: Little Crum Creek Watershed with stream segments, showing communities drained and nearby municipalities in Delaware County, Pennsylvania (McGarity, 2009). The red circle indicates the location of Little Crum Creek Park.



Map 3: Site locations for Little Crum Creek assessment, all within Little Crum Creek Park. LCC1 (blue) is the most downstream site where all parameters were tested. LCC2 (red) is the next upstream site above the confluence of the unnamed tributary and main stem Little Crum Creek, and LCC3 (green) is the most upstream location sampled. The Unnamed Trib 1 (yellow) was sampled at the most upstream location inside the park.



Map 4: Location of LCC1 sampling site (red circle) within Little Crum Creek Park in relation to United States Geological Survey's (USGS) water quality monitoring site at Michigan Avenue (green square) in 1971.

Assessment

The purpose of this study is to provide an updated assessment of the health of Little Crum Creek and examine the link between the water quality and surrounding land use in order for stakeholders such as the nonprofit group Friends of Little Crum Creek Park and Swarthmore Borough to establish best management practices to improve the stream's health.

The abiotic parameters assessed in this study were pH, conductivity, chloride, turbidity, water temperature, and dissolved oxygen, along with nutrient data for nitrogen and phosphorus. These tests provided a general picture of the issues present in Little Crum Creek within a three-month period. All parameters were tested at site LCC1 (Map 3).

The pH measures acidity on a scale of 0-14, which determines the bioavailability of the nutrients in the water. A change in pH from acceptable values in the liveable range of 6.5 to 9.0 indicates that a significant pollutant has affected the waterway.

Specific conductivity (SPC) measures the amount of ions present in the water such as chloride, nitrate, and phosphate. This test, combined with chloride, indicates the presence of salts dissolved in the waterway. High salt concentrations are toxic to aquatic organisms. Due to the roads and residential areas surrounding LCCP, elevated SPC and chlorides due to road salt runoff are likely to be an issue in the creek. Thus, three additional sites (LCC2, LCC3, and Unnamed Trib 1) located in LCCP were tested for SPC for further investigation to narrow down a potential source (Map 3).

Turbidity measures the clarity of water and provides an estimate of the sediment suspended in the water column. Cloudy water has high turbidity, and issues with clarity can indicate excess bacteria content. Little Crum Creek has had issues with fecal coliform exceeding state limits and the PADEP lists bacteria and other microbes as an impairment to Little Crum Creek.

Dissolved oxygen measures the amount of oxygen present in the water. Aquatic organisms rely on dissolved oxygen in the water column to breathe. Dissolved oxygen content is critical to the ability of the waterway to support life. Water temperature and salinity (measured by conductivity and chloride in this study) influence the stream's dissolved oxygen capacity. High temperatures and salts impede the presence of dissolved oxygen in the water.

In addition to abiotic factors of water quality, a biotic assessment of the macroinvertebrates in Little Crum Creek was performed. The macroinvertebrate study assessed the ability of the creek to provide healthy habitat. If many pollution-sensitive species were seen, it would indicate good overall stream health. Since macroinvertebrates can have a lifespan of years, the presence of diverse and pollution-sensitive species would suggest that the stream's health would have been consistently within livable parameters. The biodiversity of a waterway indicates the resiliency to rapid changes in the environment because organisms have varied tolerance to abiotic factors such as pH and dissolved oxygen.

A 2001 Swarthmore College macroinvertebrate diversity study reveals the stream to be polluted or very polluted per the Simpson Diversity, Pollution Tolerance, and Shannon Weaver diversity indices (McGarity, 2001). These results were compared to the macroinvertebrate assessment in this study.

Site Selection

Four sites were selected in Little Crum Creek Park, a public park owned by Swarthmore Borough and maintained by a non-profit group Friends of Little Crum Creek Park. Three sites were in the main stem of Little Crum Creek (LCC1, LCC2, LCC3), and one in the unnamed tributary that joins Little Crum Creek between LCC1 and LCC2 (Unnamed Trib 1) (Map 3). The Little Crum Creek is a low order stream surrounded by areas of open lawn in the park and residential lawns.

Field Methods

Beginning on March 14, 2024, water chemistry sampling was conducted every four weeks, concluding on May 8, 2024. In-field sampling and analysis occurred between 1:20 PM to 3:00

PM. Site LCC1 was sampled first for all parameters, followed by conductivity testing for Unnamed Trib 1, LCC2, and LCC3.

Temperature and conductivity were measured in-stream using a Vernier LabQuest 3 (model LABQ3) sensor and a calibrated HANNA DiST 3 EC Tester. Stream sampling containers were triple-rinsed in the stream before collection. A 1-liter bottle was collected for turbidity analysis in the WCT lab. Lamotte Wide Range pH Test Kit (model P-3100), Lamotte Dissolved Oxygen (model EDO), Lamotte Nitrate-Nitrogen, and Lamotte Low Range Phosphate used to perform pH, DO, nitrate, and phosphate analysis respectively. Chloride and sodium chloride concentration was tested using Hach Quantab strips, with care to use strips from the same lot. Processing followed instructions within each kit and occurred within ten minutes of sampling. Weather conditions, qualitative site assessments, and site photos were recorded after sampling.

A brief macroinvertebrate survey was performed on May 8 starting at LCC1 and ending upstream at LCC3. Rocks, leaf litter, and other debris was examined for macroinvertebrates and the presence of organisms were noted.

Lab Analysis

Turbidity was measured using a Hach 2100 Portable Turbidimeter (Cat. No. 2100Q01) that was calibrated immediately before analysis. Turbidity analysis took place within one week of sampling.

Stream Water Sampling Results

Detailed data readings from each sampling labeled with site locations (Map 3) can be found in summary tables within Appendix A.

Sampling Conditions

On March 14, the weather conditions were sunny and clear with similar conditions the day before and an air temperature of 22.7°C. On April 18, there was light rain (0.1 inches) in the early morning and cloudy skies during sampling with an air temperature of 13.3°C. On April 20, there was light rain (0.08 inches) and sampling occurred in the morning with an air temperature of 13.3°C. On May 8, there were thunderstorms and rain in the morning (0.02 inches).

Sample Results at LCC1

- *Dissolved Oxygen (DO):* The minimum dissolved oxygen concentration for a WWF is a 7-day average of 6.0 ppm between February 15 and July 31. The water quality data across all samples remained above this minimum with the lowest DO reading being 6.58 ppm (Fig. 4).

- *Temperature:* On March 14 and May 8, the water temperature exceeded the maximum temperature for warm water fisheries (WWF) for their respective time ranges per the PA Code Title 25 Chapter 93 (Fig. 1)

- *Chloride:* The chloride readings for March 14 and April 18 were elevated but not exceeding the maximum chloride concentration for WWF of 250 ppm. May 8 had a lower chloride concentration than previous samples.

- *Nutrients:* The nitrate readings did not exceed the maximum concentration of 10 ppm for WWF and remained at 8.8 ppm at each sampling. The phosphate readings remained at 0.2 ppm across all samples. This remains below the United States Environmental Protection Agency (USEPA) limit of 0.3 ppm phosphate (0.1 ppm total phosphorus*3) in flowing water.

- *pH, Turbidity, Specific Conductivity (SPC):* The pH was consistently 7 for each sample at LCC1. Each turbidity reading remained under 1 NTU. SPC stayed within the 645-665 ppm range except for the additional April 20 sampling in the early morning with an SPC reading of nearly 300 ppm less.

Sampling Results at All Sites

- *Temperature:* The unnamed tributary was the warmest site on March 14 and May 8, and the upstream LCC3 site was the warmest site on April 18. All sites have temperatures exceeding the allowable maximum WWF standard at each sampling (Fig. 4).

- *Specific Conductivity:* Unnamed Trib 1 had the highest SPC reading of over 200 µS/cm more than LCC1, the site with the second-highest conductivity reading. The upstream LCC3 and LCC2 sites before the unnamed tributary have a significantly lower SPC than at Unnamed Trib 1 at all time points (Fig. 2).

- *Chloride:* Unnamed Trib 1 had the greatest chloride concentration on May 8, double the chloride concentration of LCC1, the site with the second-highest chloride reading. LCC2 and LCC3 had the same chloride level of 83 ppm (Fig. 3).

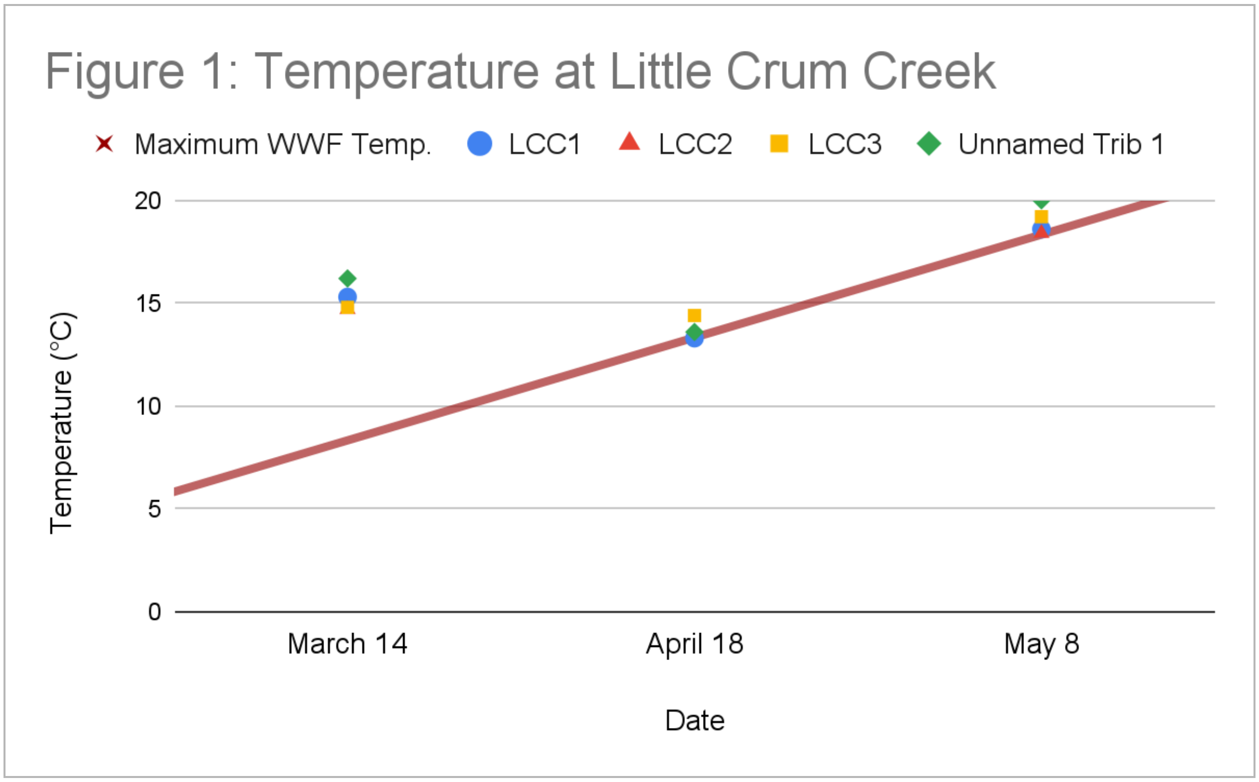


Figure 1. Water temperature of all Little Crum Creek sites at three samplings. The red line represents the maximum allowable temperature for WWF in PA.

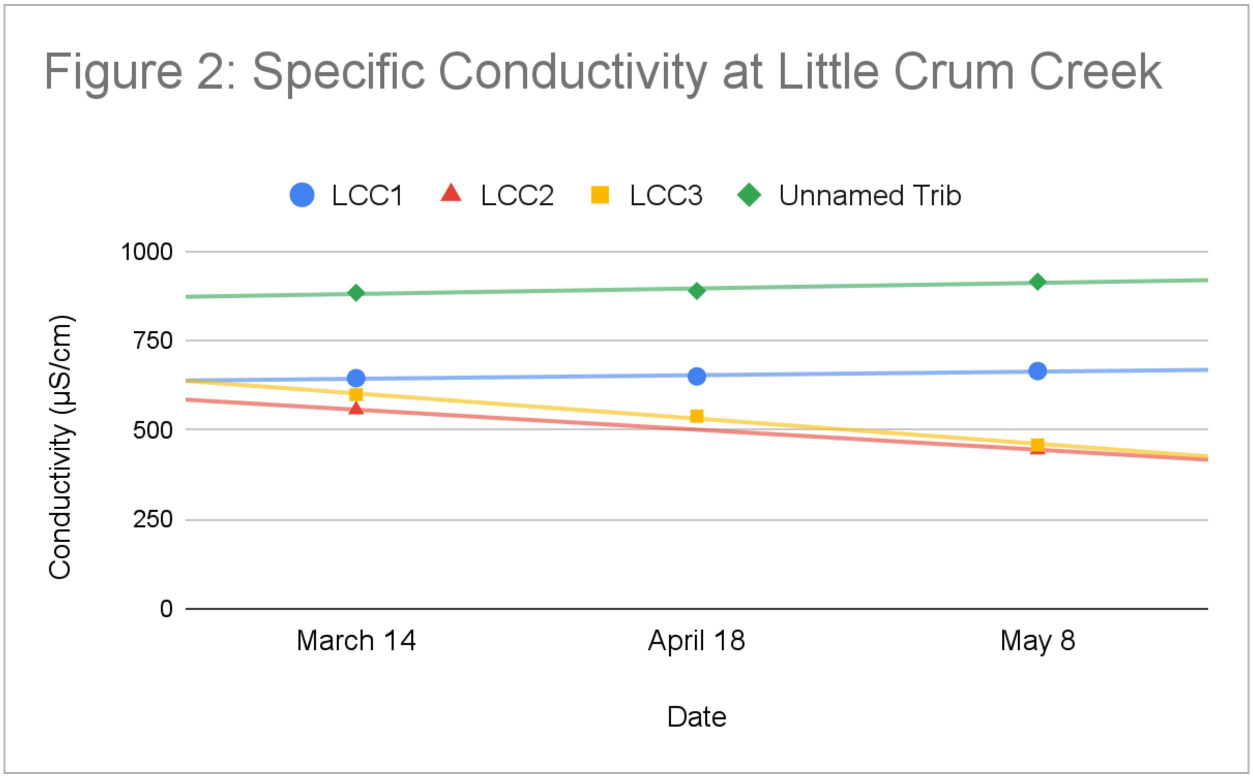


Figure 2. Specific conductivity at Little Crum Creek sites. Unnamed Trib 1 had the highest SPC at all time points.The upstream LCC3 and LCC2 had significantly lower SPC than at Unnamed Trib 1.

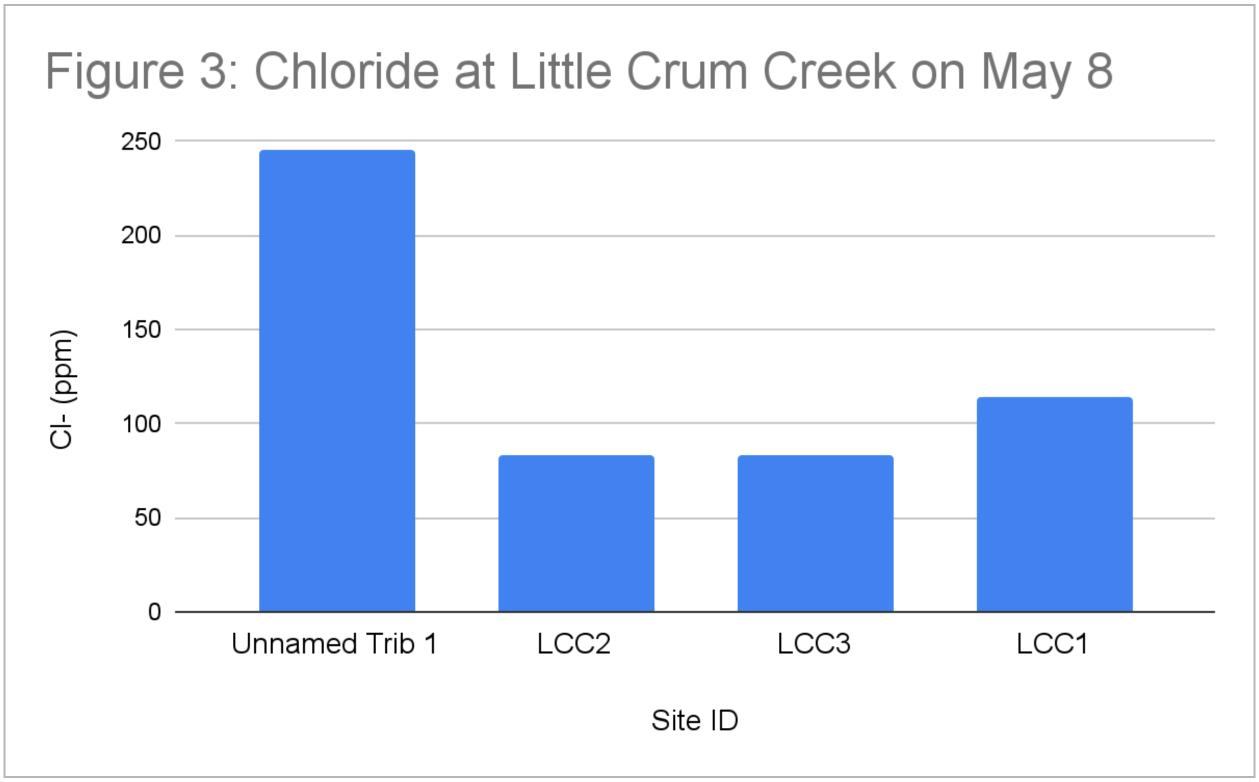


Figure 3. Chloride concentration at four sites in Little Crum Creek on May 8, 2024. Unnamed Trib 1 had the greatest chloride concentration, almost double the chloride concentration of LCC1.

Brief Macroinvertebrate Survey Results

In the lower main stem of Little Crum Creek near LCC1, blackfly larvae, worms, snails, midges, and a few net-spinning caddisflies were found. The same organisms were observed in the upstream area near LCC3 but in lesser numbers.

Discussion

Little Crum Creek is a small stream system, making it highly sensitive to environmental changes. From 1971 to 2024, the land use in the Little Crum Creek subwatershed has become increasingly developed for residential and retail purposes, directly harming the water quality of Little Crum Creek (McGarity, 2005).

Temperature

Elevated water temperatures coincide with elevated air temperature, evident on the May 8 sampling day when the air temperature and water temperature were significantly higher than the previous sampling days (Fig. 1). As the season warms, the stream should also warm in moderation, however, factors such as stormwater runoff and lack of stream shading are likely to increase the water temperature to exceed temperature standards.

An explanation for the high water temperatures is the land developments surrounding LCCP. As rain falls on impervious surfaces such as the sidewalks and roads near the park, which heat up under direct sunlight, the water travels through storm drains into the creek. When large amounts of hot rainwater enter the creek, it changes the temperature drastically.

Although the park is a large open space, the lack of similar spaces and permeable land in the Little Crum Creek subwatershed creates elevated water temperatures. Additionally, the area that surrounds Little Crum Creek is mainly residential and lacks proper riparian buffering zones that can provide shade for the creek.

Dissolved Oxygen

DO and water temperature are inversely related (Fig. 4). Due to a significantly higher water temperature on May 8, the dissolved oxygen concentration was much lower than on other sample days. Although the DO did not drop below the minimum for the respective time range, decreasing dissolved oxygen concentration may pose an issue later in the warming season, especially with higher water temperatures and excess salts in the waterway that will lower the presence of DO. Further study should be conducted through multiple seasons to understand the implication of high stream temperature in the spring for Little Crum Creek.

Specific Conductivity

The SPC levels are significantly higher in the unnamed tributary than in the main stem of Little Crum Creek (Fig. 2). After the unnamed tributary joins the main stem, the specific conductivity of the creek at the downstream site LCC1 is elevated. Because SPC is influenced by many ions such as chloride, nitrate, and phosphate, and has such variability, there is no established water quality standard for SPC on the state or federal level.

The specific conductivity and chloride likely have a direct relationship, indicated by the R^2 value of 0.859 (Fig. 5) so the increase in conductivity is likely to be driven in large part by increased chloride concentration.

On May 8, the SPC of LCC2 and LCC3, the two upstream sites, decreased due to the dilution from the brief morning rain. However, the Unnamed Trib 1 site had a significant increase in SPC, which caused the downstream LCC1 to also experience an increase.

This was confirmed as the unnamed tributary had the highest chloride concentration out of the four sites in the May sampling, with 245 ppm (Fig. 3). The PADEP maximum level of chloride concentration is 250 ppm, which can cause acute stress in aquatic life. The May 8 data point correlates to Unnamed Trib 1's high conductivity reading at each month's sampling. There is no chloride data from previous sampling days at Unnamed Trib 1, however, due to the evident relationship between the chloride and SPC, it can be inferred that Unnamed Trib 1 has elevated chloride levels at baseflow.

These findings suggest that salts, particularly road salt, are being washed into the unnamed tributary during rain events, increasing the salt concentration in Little Crum Creek as the tributary joins the main stem downstream.

The chloride concentrations found at Little Crum Creek are significantly higher than historical data of the same spring months. The 1971 chloride data from the USGS monitoring site on Michigan Avenue, downstream from LCC1 (Map 4), reveals a chloride concentration of 24 ppm (USGS 1971) which is nearly six times less chloride than at the LCC1 site in this 2024 study (Fig. 6).

The high chloride and SPC levels in 2024 follow the state and national trend of rising salinity in waterways. Road salt application has increased while snow accumulation has not (Wilson, 2023). The excess salt from road application remains an issue even after the winter, as seen in the data of this study conducted during the spring months.

Nutrients

The elevated nitrate in Little Crum Creek is likely due to fertilizer runoff from the surrounding residential lawns. Although the nitrate has not exceeded acceptable values, it is important to prevent the levels from rising further (Appendix A). Community groups and other local organizations can reach out to homeowners with streamside properties and encourage proper lawn fertilizing practices and the implementation of native riparian buffers.

The stable phosphate reading is also reflected in the historical comparison, there has been little change to the phosphate concentration in Little Crum Creek from 1971.

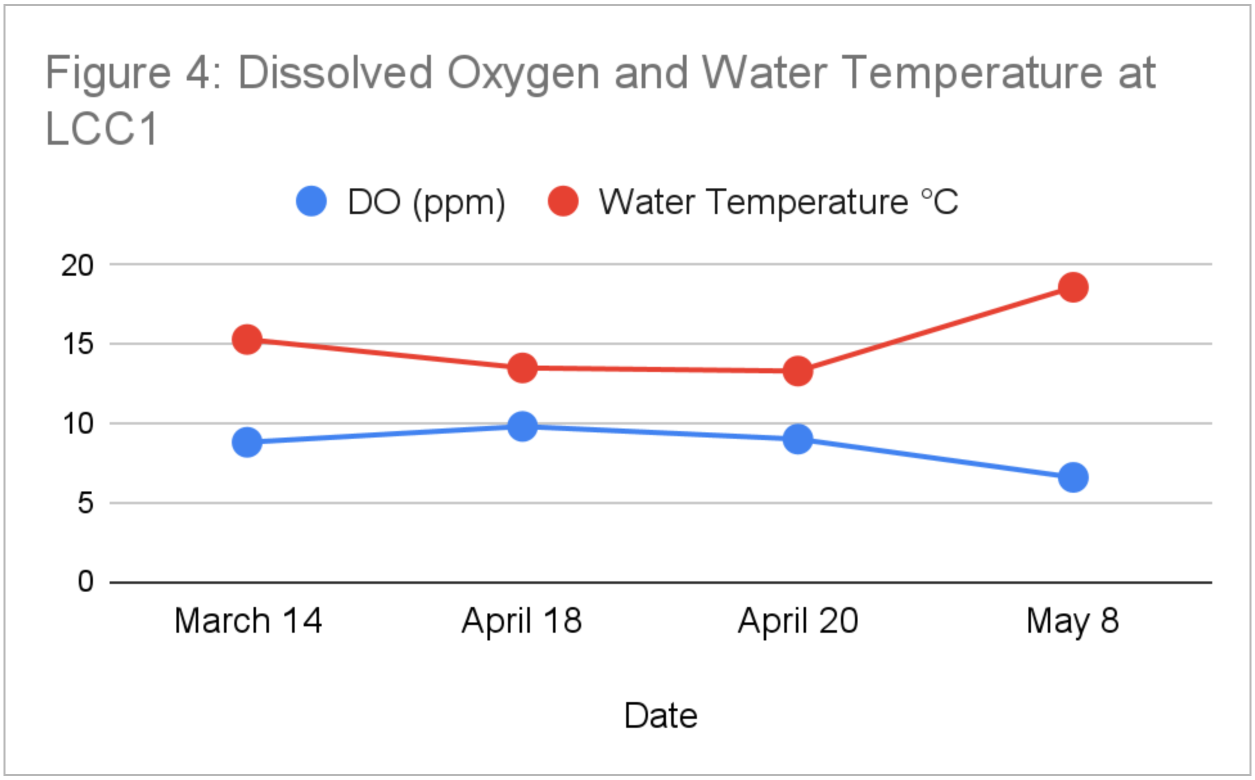


Figure 4. The relationship between dissolved oxygen and water temperature at LCC1. On May 8, increased air temperatures caused an increase in water temperatures, resulting in decreases in DO.

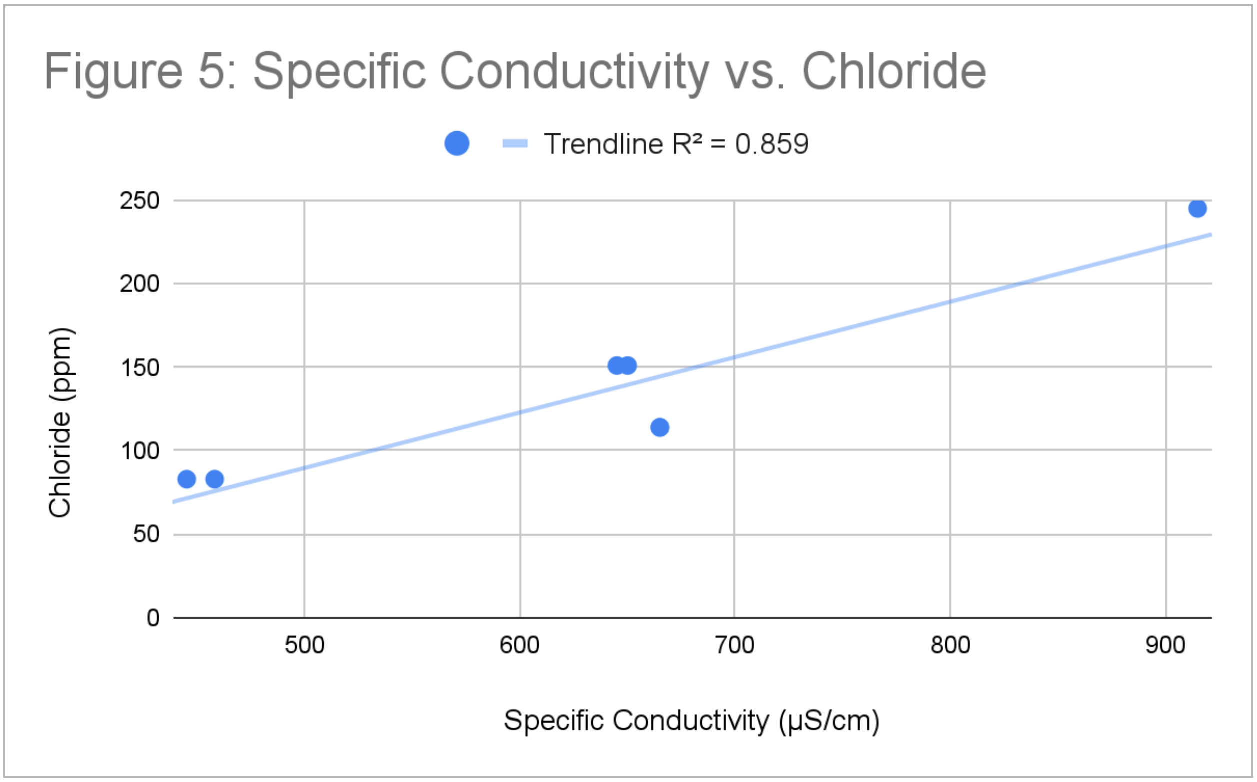


Figure 5. Specific conductivity and chloride correlation at four sites on May 8. The R^2 value of 0.859 suggests a close relationship between elevated chloride levels and high SPC readings.

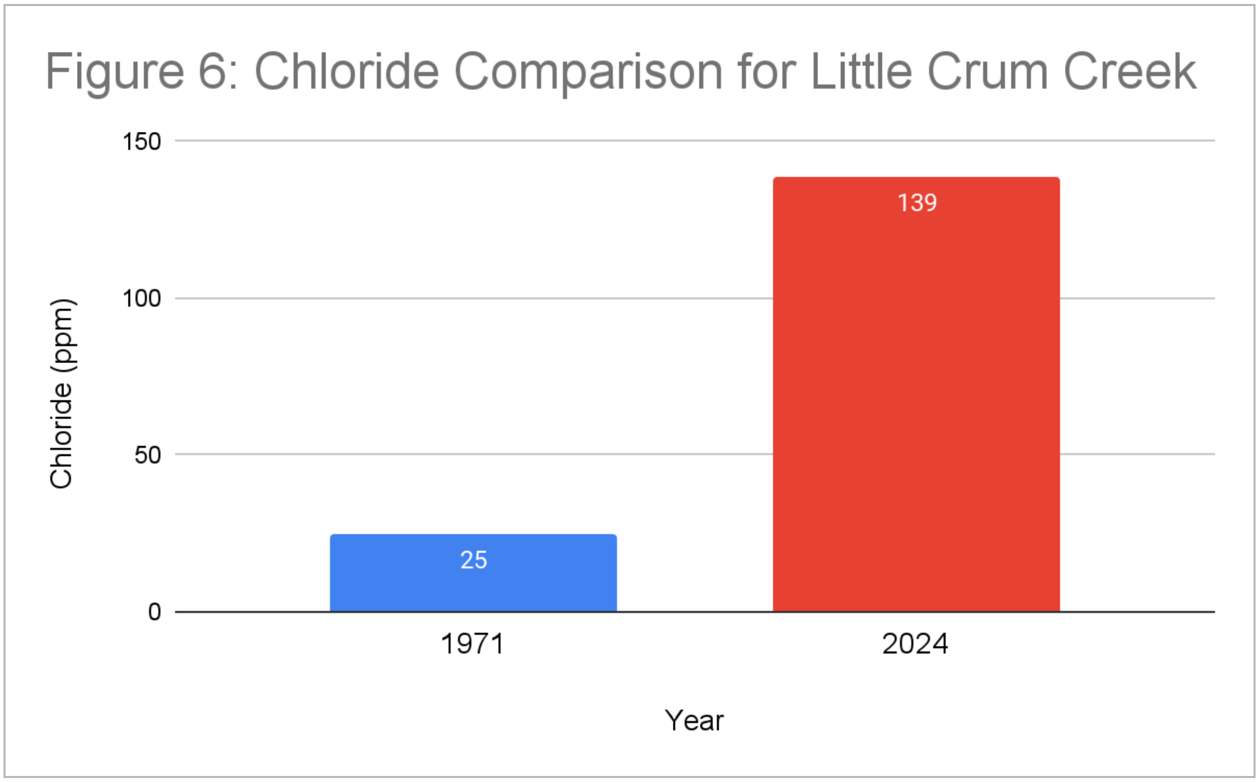


Figure 6. Chloride concentration comparison of LCC1 with 1971 USGS data of Little Crum Creek at Michigan Ave. Between 1971 and 2024 there was a 6 fold increase of chloride levels.

Macroinvertebrates

The brief macroinvertebrate survey found blackfly larvae and midge larvae which are tolerant to pollution, and net-spinning caddisfly larvae which are somewhat pollution-sensitive. There were no sightings of highly pollution-sensitive organisms. The lack of diversity and pollution-sensitive species may be due to the small size of the waterway, as well as the lack of diverse, native plant input to the stream which is the source of nutrients for many organisms. These results align with the chemical sampling results and verify that the water quality issues such as elevated temperature and SPC impact Little Crum Creek's ability to support diverse aquatic life. These results also support the findings of the 2001 Swarthmore College macroinvertebrate assessment at Little Crum Creek.

Study Limitations

There were uncertainties based on the testing supplies. The chemicals to perform DO, phosphate, and nitrate tests were found to be expired after being used in the first sampling. The DO chemicals expiration dates ranged from January 2023 to August 2024. The phosphate chemicals expired in May and December 2023. On May 8, a phosphate kit that expired in December 2023 was used to check the results of the expired May 2023 kit. The results were 0.2 ppm phosphate different. The newer kit showed 0.2 ppm with the older kit showing 0 ppm. The nitrogen tablets expired in March and August 2021. On May 8, two non-expired nitrate kits were used to cross-check the results of the expired kit, one being the same Lamotte kit tablet procedure, and the other being a Lamotte Nitrogen-Nitrate titration kit. The results were inconclusive because all three kits produced differing data. The results from the expired nitrogen tablets were 1 ppm different from the non-expired nitrogen tablets which when multiplied by the conversion factor for nitrate, would result in a 4.4 ppm difference. All data included in the study was done with the expired kits to keep consistency and reduce variables.

The nitrogen kit's color comparator method compared the sample's color to the given color slides. This proved to be an unreliable method because the sample would often not match any color slides, e.g., the sample would show a yellow-orange tint while the color slides showed shades of pink. Future studies should be carried out with up-to-date kits with more precise methods to produce better results.

On the April 18 sampling day, the LCC2 site was not tested for conductivity. April 20 was an extra sampling day in the morning for only dissolved oxygen, temperature, conductivity, and pH at LCC1.

The turbidity was initially tested with a turbidity sensor that produced inaccurate results, likely due to a loose cover that allowed excess light to interfere with the turbidity readings. Thus, the methods of the study were changed and turbidity readings were assessed in the WCT lab within a week after sampling.

Seasonal fluctuations will impact the water quality testing results so further research must be done to assess the quality of Little Crum Creek over multiple seasons. Because this study only had three complete samples across three months, the conclusions of this study have limited certainty. The comparisons made with historical data used the same three-month average so the scope of the study was limited to the spring season.

This study provides a general guide on Little Crum Creek's health in the spring season and should be replicated with improvements to testing equipment and a longer study period of multiple seasons.

Conclusion

Understanding the health of small headwater tributaries like Little Crum Creek is important so pollutant issues can be addressed to limit downstream effects in the Crum Creek and the Delaware River, a major drinking water source for millions.

In this study, water temperature, pH, turbidity, SPC, DO, and nutrient data were collected to examine the water quality of Little Crum Creek. The water chemistry results reveal that Little Crum Creek has elevated water temperatures and excessive salt concentration. The unnamed tributary is likely to be a source of salt contamination with significantly higher SPC and chloride concentrations than the other sites, increasing salinity at all downstream sites. A brief macroinvertebrate survey supports that the stream is polluted because there were no sightings of highly pollution-sensitive organisms along Little Crum Creek.

Compared to historical data from 1971, the increase in chloride and SPC levels is significant and indicates a salt problem amplified by the increased developed land area with the construction of major retail buildings such as the Springfield Mall in the Little Crum Creek subwatershed. The increased salinity also follows the national trend of increased road salt application trend in the winter.

These issues should be managed with community outreach to encourage planting native streamside vegetation to address elevated stream temperature and create a buffer between the stormwater runoff and the creek. A riparian buffer can regulate stream temperature by shading the water from solar energy. Spreading awareness to reduce road salting in the winter and avoiding lawn fertilization 48 hours before rain events are easy community led first steps to address the contamination issues in Little Crum Creek.

This study should be replicated across a longer study period to further understand Little Crum Creek's water quality throughout multiple seasons. More data is needed to establish trends in water chemistry. The salinity and temperature concerns should be further examined with better instruments to ensure more precise and accurate data, and a nutrient study should be established with more accurate tests to establish a baseline.

This study reveals the importance of maintaining open spaces like Little Crum Creek Park, which protects the crucial headwater streams of the larger river network.

Acknowledgments

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Appendix A - Data Tables

Table 1: Water temperature, pH, dissolved oxygen, turbidity, chloride, nitrate, and phosphate at LCC1.

Date	Water temp °C	pH	DO (mg/L)	Avg. Turbidity (NTU)	Cl- (ppm)	Nitrate (ppm)	Phosphate (ppm)
March 14	15.3	7	8.8	0.71	151	8.8	0.2
April 18	13.5	7	9.8	0.56	151	8.8	0.2
April 20	13.3	7	9				
May 8	18.6	7	6.58	0.91	114	8.8	0.2

Table 2: Water temperature (°C) for Little Crum Creek sites compared with maximum water temperature for PA warm water fisheries.

Date	PA Code Maximum	LCC1	Unnamed Trib 1	LCC2	LCC3
March 14	7.8	15.3	16.2	14.7	14.8
April 18	14.4	13.5	13.6		14.4
May 8	17.8	18.6	20	18.4	19.2

Table 3: Specific conductivity (µS/cm) at all four sampling sites in Little Crum Creek.

Date	LCC1	Unnamed Trib	LCC2	LCC3
March 14	645	884	557	599
April 18	650	889		539
May 8	665	915	445	458

Table 4: Comparison of water quality data between historical data averages from the United States Geological Survey monitoring station in 1971 and data averages from LCC1 in 2024.

Measurement	USGS 1971 (3 month avg)	Current 2024 (3 month avg)
Water temperature (°C)	10	15.8
Turbidity (NTU)	11.3	0.73
Specific Conductivity (µS/cm)	295	653
Chloride (ppm)	25	139
Dissolved Oxygen (ppm)	11.51	8.4
pH	8.2	7

Nitrate (ppm)	11.8	8.8
Phosphate (ppm)	0.19	0.2

Appendix B - Glossary

Baseflow: portion of the streamflow that is not runoff

Best management practice: most effective ways to improve water quality

Catchment: an area defined by natural boundaries where all surface water flows into a stream

Confluence: the junction of two waterways to form a single channel

Designated use: established purpose based on the ecological and human health uses of the water body

Headwater: source of a river network, smallest tributaries

Impervious: surfaces that prevent the natural soaking of water into the ground

Macroinvertebrate: aquatic invertebrate that is large enough to see with the naked eye

Nonpoint pollution: pollution that has no single source

Riparian buffer: vegetated area of a streambank, providing shade and stream protection

Runoff: draining of water from land's surface

Tributary: stream feeding into a larger water body

Appendix C - List of Acronyms and Abbreviations

DO: dissolved oxygen

NTU: Nephelometric Turbidity Unit

PADEP: Pennsylvania Department of Environmental Protection

ppm: parts per million

SPC: specific conductivity

USEPA: United States Environmental Protection Agency

USGS: United States Geological Survey

WWF: warm water fisheries