Water Quality Report

Six Mile Creek and Kraft Drain

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Friends of Fort Erie's Creeks

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Executive Summary

This report focuses on the water quality of Six Mile Creek and Kraft Drain. They were both studied during the summer of 2019 between June and August. The purpose of this report is to assess the water quality of the two creeks and suggest possible remediation techniques. As there was only a small amount of time to do the tests, the readings are very narrow in scope. There were also some complications that prevented some of the measurements from being taken, for example, sometimes the lake was flowing into the creeks causing reverse flow, and other times there was magnetite particles in the sand that prevented the magnet on the flow meter from functioning properly.

The two nutrients measured, phosphates and nitrates, show one aspect of the quality of the water, while collecting the benthics shows another. The flow readings were taken to calculate an estimated discharge of total phosphorus into Lake Erie. We used the YSI 9300 photometer *in situ* to measure the nutrients, the Global Water FP211 Flow Probe was used to record an average flow reading into Lake Erie, which led to a calculation of the discharge.

Between the two creeks, all but two measurements for phosphates (PO_4^{3-}) surpassed the eutrophication safe limit for streams entering into lakes, which is 0.05 mg/L. For nitrates, all of the readings taken were within the safety limits; however, two key sites were dry. The results for both of the water bodies mostly fell into the hyper-eutrophic range of greater than 100 mg/L of phosphorus (P).

The benthos sampling showed that there were very few low tolerance species found. This means that the stream conditions are only moderate for both water bodies. Due to the stream conditions being moderate, and the water quality poor, this provides habitat for moderate to high tolerance species, but little or none for low tolerance species. It is also not an ideal water body to support the presence of fish and aquatic life due to the low percentage of Ephemeroptera, Plecoptera and Trichoptera (EPT).

Several aspects could benefit from remediation. This includes high nutrient levels and low tolerant benthic invertebrate species. The negative effects of runoff could be improved by planting vegetation, creating riparian buffers, preventing grass clippings and leaves from entering sewers, controlling the use of manure and fertilizers, educating the public widening, but not mowing the ditches. Finally, continue to monitor watersheds on a regular basis for nutrient loading in order to obtain more results to compare year-to-year progress.

Introduction

Purpose

This report was conducted by students from the Canada Summer Jobs program and co-op students from Niagara College and Guelph University. The purpose of this report is to assess the water quality of Six Mile Creek and Kraft Drain and suggest possible remediation techniques to help establish regular levels of phosphates and nitrates in the water bodies if needed.

Background

Six Mile Creek and Kraft Drain are sub-watersheds found in Fort Erie, Ontario that drain into Lake Erie. Six Mile Creek drains into Lake Erie from Bernard Avenue Beach and Kraft Drain drains into Lake Erie from Crescent Beach. Both of these bodies of water are used for drainage by the wetlands and watershed. During this study we used a YSI 9300 Photometer and a Global Water FP211 Flow Probe to measure the loading of phosphates from Kraft Drain and Six Mile Creek into Lake Erie. This will help to determine the water quality of these creeks and how they could be affecting our lake water.

Phosphorus is an important aspect in an environment where it is found in multiple different forms. It is an essential nutrient for plants and animals providing them with life-sustaining molecules that occur mainly as phosphates (PO4-3). Phosphates are accumulated in the biosphere through waste water discharge, agriculture run off and over-fertilization that end up polluting surface water. The natural levels of phosphates in water normally range from 0.005 to 0.05 mg/L (Kotoski, 1997). Exceeding these concentrations can alter the environment in negative ways, causing living organisms a great deal of stress.

Water quality can be affected when an oversupply of phosphates occurs, this causes algae growth and blooms. Phosphates are known to be a limiting factor for plants and algae, so when levels become too high, problems occur with overgrowth on the surface water, known as eutrophication. Without the sunlight being able to penetrate through to submergent plants it reduces photosynthesis and productivity, which then affects the water bodies.

Methods

Methods

Chemical Parameters

Phosphorus

To sample the water bodies for phosphates, we obtained samples from the desired sample sites. After obtaining the samples, the vials were rinsed three times, 20 mL of sample was then poured into two 10mL vials. One of the 10mL vials was left as a blank and the other 10mL vial was used to carry out the test. To complete the test, you crush up one #1 tablet until it is completely dissolved, after you would add #2 tablet until completely dissolved. We then waited 10 minutes until the sample had changed colours. Once the sample was ready, Phot 23 test was chosen, on the photometer, to analyze the blank. The sample was then inserted to obtain an answer in PO4 mg/L. We analyzed the vials in triplicates to then receive an average per sample.

Nitrates

To sample the water bodies for nitrates we used the NitraTest. Once we retrieved samples, 20 mL of the sample was poured in a container as well as 10 mL into a vial for a field blank. One spoonful of the NitraTest power along with one NitraTest tablet was added to the 20mL sample (YSI 9300 and 9500 Photometers: User Manual, 2017). The cap was put back onto the container, which was then shaken vigorously for one minute (YSI 9300 and 9500 Photometers: User Manual, 2017). After shaken, the container was left to stand for one more minute, then gently turned it upside down and right side up three to four times (YSI 9300 and 9500 Photometers: User Manual, 2017). The vial was then left for 3-4minutes to allow the substances to accumulate in the bottom and the clear liquid on the top was then collected in a 10 mL vial, one Nitricol tablet was then added and crushed until dissolved (YSI 9300 and 9500 Photometers: User Manual, 2017). The vial then had to be left standing for ten minutes to allow for the colour development process to happen. Upon completion of that process, the photometer was turned on and set to Phot 63 to get the NO3 results as mg/L. The photometer first read the field blank then the sample. This process was done three to four times. The sample was then poured into a waste container for proper disposal (YSI 9300 and 9500 Photometers: User Manual, 2017).

Figure 1: *YSI Photometer*

Benthic Biomonitoring

While sampling benthic invertebrates of Six Mile Creek (Fig 2) and Kraft Drain (Fig 3), we used the technique of a travelling kick and sweep transect method. This was done following guidelines from the Ontario Benthos Biomonitoring Network. To complete a kick and sweep we identify a sampling reach that includes 2 riffles and 1 pool (Jones, 2007). Within the areas of riffles and pools we sample a transect that will last 3 minutes long and be about 10 meters in length from left bank to right bank and back (Jones, 2007). While performing the transect it is important to kick the substrate up disturbing the substrate of up to 5cm deep into a 500-mm-mesh D-net (Jones, 2007). While kicking the substrate you must shuffle back and forth between the banks. After finishing transects within the desired riffle or pool, we emptied the contents into a container to later analyze and record the live samples.

When sorting through the samples we used the approach of random sampling. After sampling our specimens, the data allowed us to create a percent composition of orders showing us the percentage of different orders collected, shown in the results section (Fig 28 and Fig 32). We were also able to create a percent composition of Ephemeroptera, Plecoptera and Trichoptera (EPT) to help measure the quality of forage for aquatic life shown in the results section (Table 3 and Table 9).

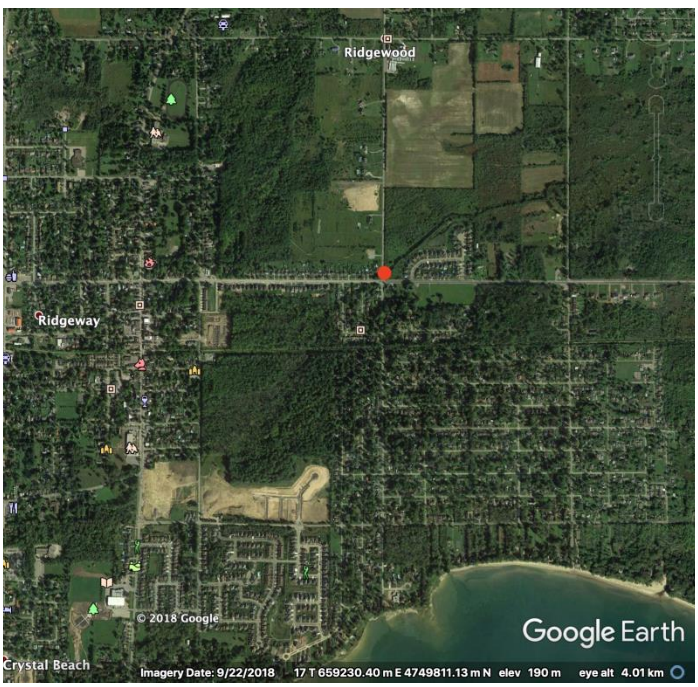

Figure 2: *Six Mile Creek Biomonitoring Site*

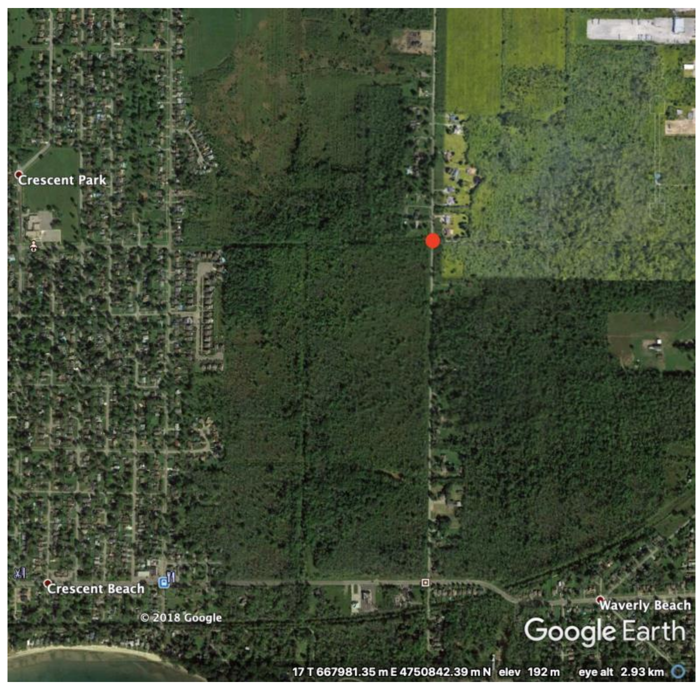

Figure 3: *Kraft Drain Biomonitoring Site*

Discharge

Surface flow is the continuous movement of water passing a cross section of an open channel (Meals and Dressing 2008) and the velocity of the water was measured in meters per second in our study. Discharge is the volume of water (in cubic meters) that passes through a channel cross section in a specific period of time, calculated from the flow and other measurements taken. Flow (velocity of water) and discharge (volume of water) data are essential for the estimation of loads of chemical pollutants exported from a river or stream (Meals and Dressing 2008). This data can be used to monitor how the watersheds are doing from year to year with regards to phosphorus loading amounts and Cladophora levels. We will be looking at the loading amount of phosphorus, which will be discussed below in further detail.

Figure 4: *Flow Probe*

Flow readings were taken at two main locations: site 4 of Six Mile Creek, which is located at Bernard Beach, and site 4 of Kraft Drain, which is located at Crescent Beach; both drain into Lake Erie. Throughout June and July 2019, the flow was measured at Bernard Beach three times and at Crescent Beach four times. Water samples were also taken for phosphates and nitrates at these sites.

Figure 5: *Flow Probe*

To measure flow, we used a Global Water Flow Probe (Fig 4 and Fig 5). An open reel tape measure and meter stick were also used to measure the width and depth. First, a section of the creek is chosen. Water must be flowing outwards from the tributary into the lake water, or discharge readings cannot be obtained. The width of the creek in meters is taken for the section of stream that is chosen. The total width is then divided into 5 panels. The depth of stream is taken in the middle of each of the 5 panels. The average flow of the stream is then measured in meters per second in the middle of each panel using the flow meter. The area each panel is found by multiplying the average depth with the panel width (average depth x panel width = area). The velocity is found by using a flow meter to obtain a value in m/*s. The discharge is found by* multiplying the area by the velocity for each separate panel (area x velocity = discharge). Total discharge in cubic meters per second (m^3/s) is found by adding the discharge of each panel (5) together to get one sum.

Loading Amount

After all measurements and readings for flow are taken using the meter and the total discharge is calculated, the data can be used in a formula for the mass loading amount of an element, in this case phosphorus. Load is defined as the mass of a substance that passes a particular point in a given amount of time (Meals et al. 2013). Based on the phosphate readings taken with the photometer, for example 3 readings taken for Kraft Drain, an average was calculated. This phosphate average must then be converted to phosphorus before completing the loading amount formula calculations. The phosphate reading in mg/L is multiplied by 0.3262 to get total phosphorus. The result is in mg/ml. The general formula is as follows:

Phosphorus Discharge PD = Q x TP where Q is Total Discharge and TP is total phosphorus. The result is in mg/min.

Daily Phosphorus Discharge DPD = PD x WD where WD is 60 min/hr x 24 hr/day. The result is in kg/day.

Mass Loading of Phosphorus MLP = DPD x WS where WS is 365 days/yr. The result is in kg/yr.

The end result of the formula is an estimated daily and yearly amount of total phosphorus (in kilograms) that has loaded into the Lake from the creek. This can then be compared to historical and future data to monitor the quality of the lake water and the levels of Cladophora.

Site Selections

Site Selections

Six Mile Creek

Figure 6: *Map of Six Mile Creek*

Figure 6 shows a map of Six Mile Creek with the sample sites labeled. These sites are 1A, 1B, 1C, 1D, 2A, 2C, 3, 4. These sites were labeled specifically depending on where they are located within the tributaries. If labeled with a 1 this means they are the start of a new tributary, if labeled with a 2 and a corresponding letter matching the number 1 tributary this means the site is further down the tributary. For example, 1A and 2A are the same tributary but 2A is further down the tributary at a new road intersect. Site 3 is where all the tributaries meet and site 4 is where the creek meets Lake Erie.

Site 1A


Figure 7: *Site 1A (Six Mile Creek)*

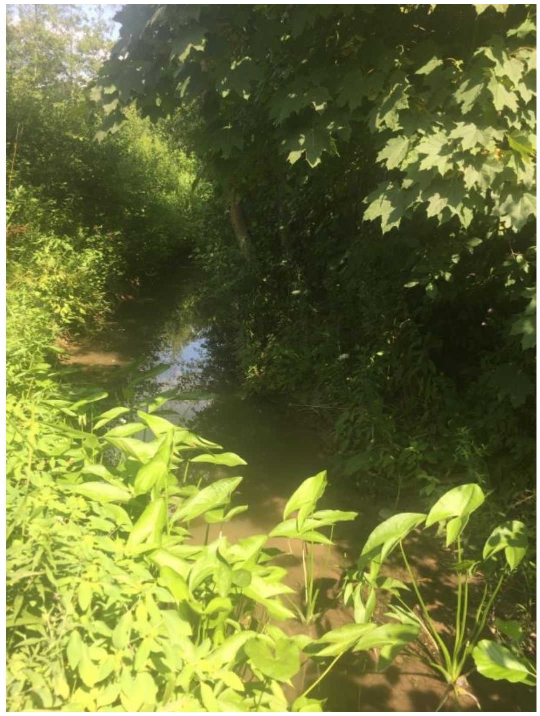
Figure 8: *Site 1A (Six Mile Creek)*

Site 1A is located on Burleigh Road adjacent to Shagbark Nature Park. This site is the beginning of a new tributary.

Site 1B


Figure 9: *Site 1B (Six Mile Creek)*


Figure 10: *Site 1B (Six Mile Creek)*

Site 1B is located on Bernard Ave near the intersection of Bernard and Nigh Road. This site is the beginning of a new tributary.

Site 1C

Figure 11: *Site 1C (Six Mile Creek)*

Figure 12: *Site 1C (Six Mile Creek)*

Site 1C is located on Centralia Avenue N beside a cemetery. This site is the beginning of a new tributary.

Site 1D

Figure 13: *Site 1D (Six Mile Creek)*

Figure 14: *Site 1D (Six Mile Creek)*

Site 1D is located on Nigh Road. This is the beginning of a new tributary which runs parallel to Nigh Road.

Site 2A

Figure 15: *Site 2A (Six Mile Creek)*

Figure 16: *Site 2A (Six Mile Creek)*

Site 2A is located on Bernard Avenue and is the second sample site to tributary 1A.

Site 2C

Figure 17: *Site 2C (Six Mile Creek)*

Figure 18: *Site 2C (Six Mile Creek)*

Site 2C is located on Nigh Road and is the second sample site to tributary 2A.

Site 3


Figure 19: Site 3 (Six Mile Creek)


Figure 20: Site 3 (Six Mile Creek)

Site 3 is located on Dominion Road and runs directly underneath an overpass. This site is also located adjacent to Sex Smith Farms.

Site 4


Figure 21: *Site 4 (Six Mile Creek)*

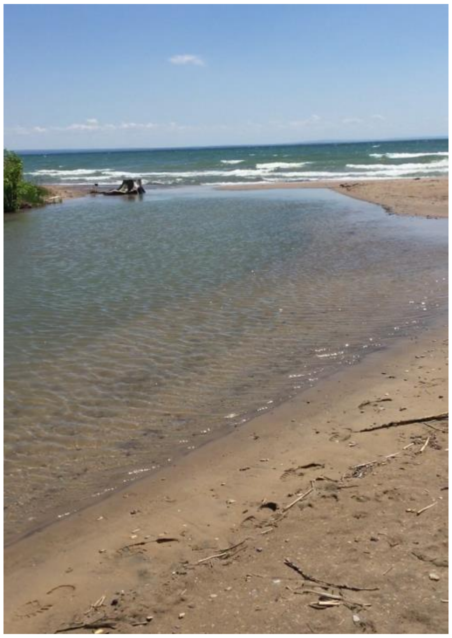
Figure 22: *Site 4 (Six Mile Creek)*

Site 4 is located at the end of Bernard Avenue at Bernard Beach. This site is where Six Mile Creek meets Lake Erie. This site is also where discharge readings were taken to determine the rate of phosphates being discharged into the lake.

Sites Garrison Road and Beach Avenue

Garrison Road and Beach Road were each sampled once in the hope of seeing if the high phosphates were coming from further upstream due to run off from highway 3 (Garrison Road).

Kraft Drain

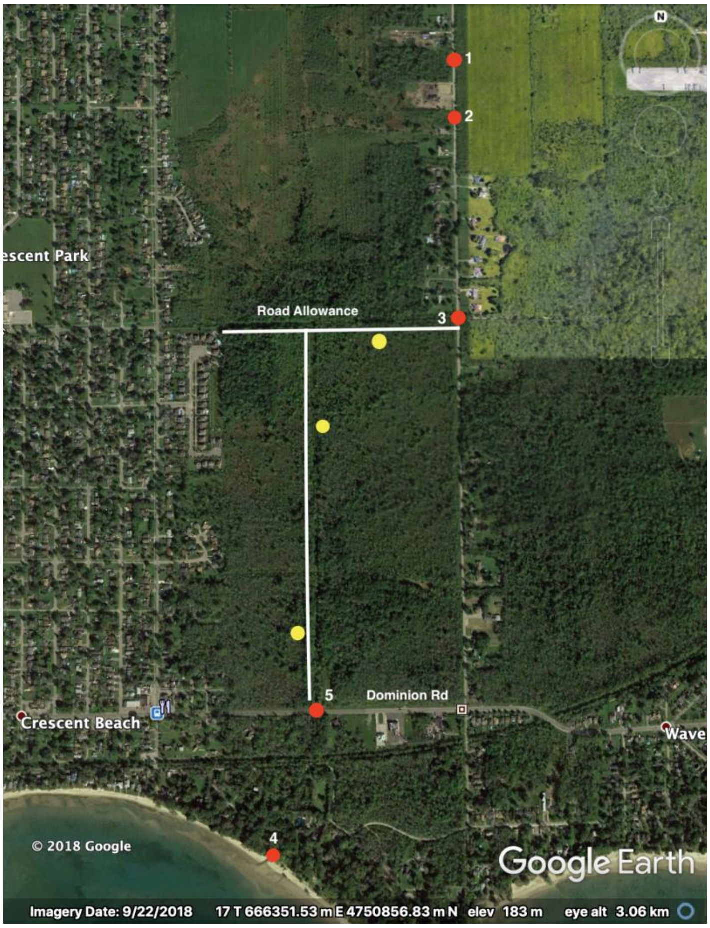

Figure 23: *Map of Kraft Drain*

Figure 23 shows a map of Kraft Drain with the labeled sample sites as red markers. These sites are 1, 2, 3, 4 and 5. Sites 1, 2 and 3 are all located on Kraft Road on the left side of the road facing north. Site 4 is where the drainage meets Lake Erie and site 5 is off of Dominion Road. Site 5 was added later on in the season after following the road allowance (located on map as white line) to ground truth where the drainage went through the forested area. Three other samples were taken within the road allowance to measure phosphates and see how these compared to the other Kraft Drain sample sites; these are also labeled on the map as yellow markers.

Site 1

Figure 24: *Site 1 (Kraft Drain)*

Figure 25: *Site 1 (Kraft Drain)*

Site 1 is located on Kraft Road and is located on the left side of the road facing north. This site is located after the lawn care service when travelling on the road north.

Site 2

Figure 26: *Site 2 (Kraft Drain)*

Figure 27: *Site 2 (Kraft Drain)*

Site 2 is located on Kraft Road and is located on the left side of the road facing north. This site is located directly before the lawn care service when travelling on the road north.

Site 3

Figure 28: *Site 3 (Kraft Drain)*

Site 3 is located on Kraft Road and is located on the left side of the road facing north. This site is located adjacent to Kraft Road mailboxes and directly north of the road allowance.

Site 4

Figure 29: *Site 4 (Kraft Drain)*

Figure 30: *Site 4 (Kraft Drain)*

Site 4 is located at Crescent Beach at the end of Crescent Road. This site is where Kraft Drainage meets Lake Erie. This site is also were discharge readings were taken to determine the rate of phosphates being discharged into the lake.

Site 5

Figure 31: *Site 5 (Kraft Drain)*

Figure 32: *Site 5 (Kraft Drain)*

Site 5 is located on Dominion Road and is adjacent to the fire hall also located on Dominion Road. This site was added later into the sampling season.

Sites RA1, RA2, RA3

Road allowance (RA) 1, 2 and 3 were all sampled, along with Dominion Road, in hopes to map and see if high phosphates were flowing within this large forested area. These sites are labeled on the map as yellow markers as well as the road allowance in is labels in white.

Results (Six Mile Creek)

Results (Six Mile Creek)

Chemical Parameters

Phosphorus

Phosphates were tested weekly at sample sites along Six Mile Creek. The maximum amount of phosphates that is considered safe for drinking water and for aquatic life is 0.05 mg/L (Kotoski, 1997). As seen in Table 1, all but two of the measurements surpass this level, meaning Six Mile Creek's phosphate levels were higher than recommended limits for the duration of this study.

Table 1: *Six Mile Creek Summary of Phosphate Data*

Water Body Name:					Six Mile Creek					
Date:					April – July 2019					
Phosphate (PO_4) Values (mg/L)										
	1A	1B	1C	1D	2A	2C	3	4	Garrison Rd	Beach Rd
Spring Melt	0.16	0.03	0.09	0.42	0.16	0.16	0.1	0.13		
06/11/19	0.13	0.02	1.27	0.25	0.14	1.68	3.57	0.69		
06/18/19	1.53	0.43	1.06	0.31	1.03	0.57	1.8	0.26	0.95	2.83
06/25/19	0.27	0.98	0.78	0.24	<0	0.83	0.5			
07/02/19	0.57	0.2	0.24	0.47	1.2	0.71	1.13	0.41		
07/08/19	2.05	0.06	3.2	0.22	0.75	0.75				
07/17/19	0.18	0.71	0.22	2.1	0.67	0.67	0.16	0.07		

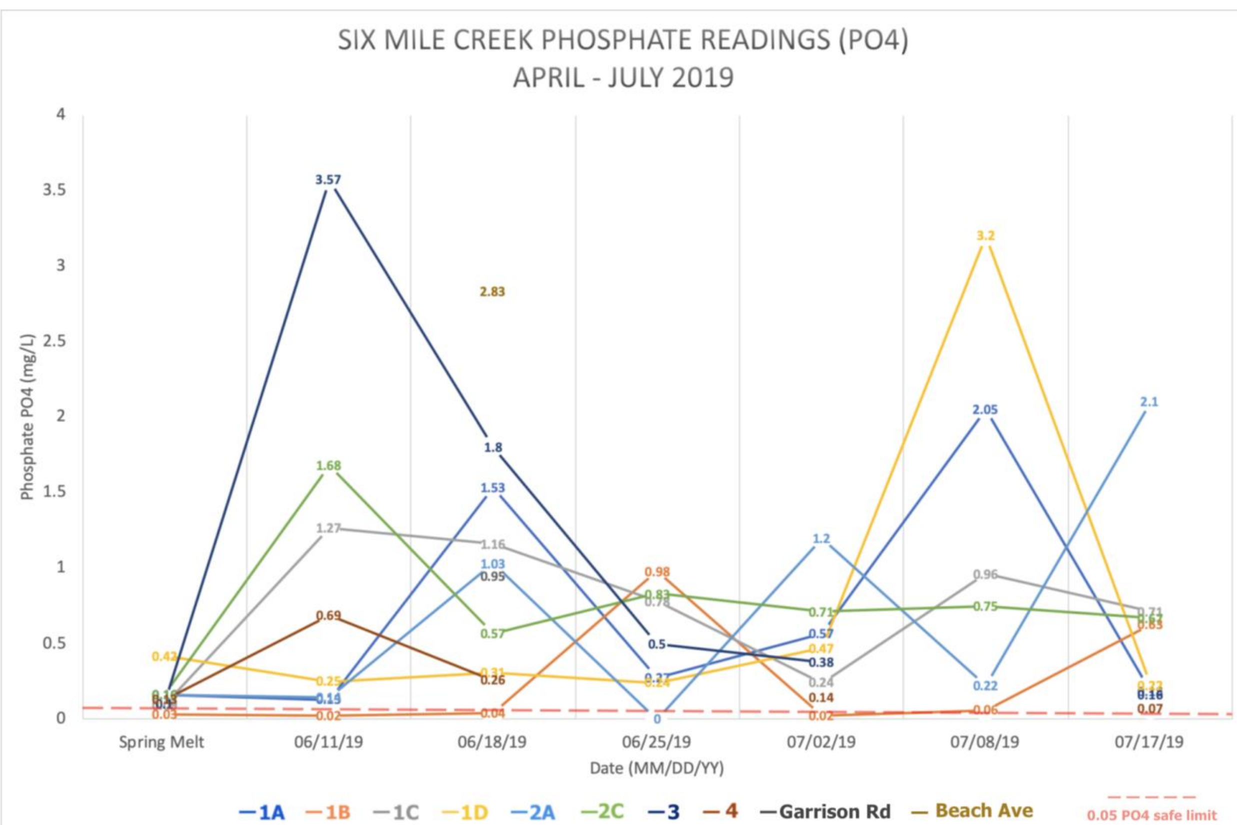

Figure 33: *Six Mile Creek Phosphate Data*

In Figure 33, we can see all the values of phosphate readings from Six Mile Creek over the study period from April until the end of July. In this graph we can see how the phosphates fluctuated over the course of the season. Generally reading this graph it can be seen that the phosphate levels were lowest during the spring melt and increased as it went into the first week of sampling during the month of June, the levels are seen to continuously fluctuate site to site with no significant relationship made between sites.

It can also be seen that sample site 1A, located on Burleigh Road off of Dominion Road, increased to 1.53mg/L in the 2nd week of sampling and again in the 5th week of sampling to 2.05. Reasons for this are unknown but it was observed that during the 2nd week of sampling (June 18) Dominion Road was being paved between Bernard Road and Burleigh Road. Due to run off from the construction this could be a reason the phosphates increased during this week. During the 5th week of sampling (July 8) it is believed that phosphates could potentially be high due the July 4th long weekend when American cottagers come to visit Fort Erie to use the local beaches and rent cottages along Lake Erie. Other than these peaks in phosphates 1A remained to have phosphate levels between 0.13mg/L and 0.57mg/L.

Site 1B is located on Bernard Avenue by the intersection of Bernard and Nigh Road, as is shown in Figure 9 and Figure 10. The results for this site were mostly below the recommended limit of 0.05mg/L. Other than the normal range of 0.02mg/L to 0.04mg/L the levels were seen to be increased during the week of June 25th, July 17th and very slightly July 18th. The reasons for the increased values are unknown. It was noted that there was construction being done on Dominion Road during the week of June 25th at site 3, but this is unlikely to be the cause as the other sample sites had not increased during this time.

Site 1C can be found south of the cemetery on Centralia Avenue North, as seen in Figure 11 and Figure 12. Photographs of the cemetery can be found in the Appendices section. Throughout the sampling period, the results were found to be between 0.24 mg/L to 1.27 mg/L other than a low reading during the spring melt of 0.09mg/L. This sight had no specific reasons why the phosphate readings were above guidelines, but the surrounding land use may reveal an answer.

Site 1D, located on Nigh Road west of Stonemill Road, had a significant increase in phosphates during the week of July 8th. Reasons for this are unknown but could potentially be due to the July 4th weekend as mentioned already. Excluding the irregular increase, sample site 1D had a range of phosphates between 0.22mg/L and 0.47mg/L during the sampling period.

Site 2A can be found on Bernard Avenue, south of site 1B, which is shown in Figure 15 and Figure 16. The results seemed to fluctuate between <0 and 1.2 mg/L, peaking at the end of July to 2.1 mg/L. This site is further down the tributary from site 1A, it can be seen in the graph above (Fig 33) that as site 1As values would fluctuate higher and lower, as would 2A.

Site 2C can be found on Nigh Rd east of Centralia Road. The results of this site show the phosphate levels to peak from the spring melt up to 1.68 mg/L in the first week of sampling. The normal range for this site was between 0.57 mg/L and 0.83 mg/L.

Site 3 off of Dominion Road, had fluctuating levels of data with the highest being 3.57mg/L and the lowest being 0.10mg/L. Due to this site being under construction for most of the sampling period this may account for the fluctuation in data.

Site 4 is on the east side of Bernard Beach, where Six Mile Creek drains out into Lake Erie, as is shown in Figure 29 and Figure 30. Samples were unable to be obtained during some of the weeks of sampling due to backflow from the lake into the creek giving false readings. For the weeks where there are results, the range was between 0.25 mg/L and 0.70 mg/L. The residential properties surrounding the end of the creek could be the result of high phosphate levels.

During the sampling period, Garrison Road and Beach Road were also sampled to allow us to map if the phosphates were coming from further upstream where agricultural land use and Highway 3 can be found. The results for these samples were high with Garrison Rd having a value of 0.95 and Beach Road access having a value of 2.83mg/L.

Nitrates

Table 2: *Six Mile Creek Summary of Nitrate Data*

Water Body Name:	Six Mile Creek
Date:	July 24, 2019
Nitrate (NO_3) Values	
Sample Site	Value (mg/L)
1A	1.65
1B	0.64
1C	2.11
1D	0.61
2A	0.33
2C	1.98
3	2.8
4	1.67

Nitrates were tested once throughout the duration of this study. Table 2 shows the results of those tests. The safety limit in the short term is 550 mg/L and in the long term, it's 13 mg/L (Canadian Council of Ministers of the Environment, 2012). The recorded measurements from these sites are all well below both limits. However, the question remains why some are over 1 mg/L while others are under that mark. When comparing sites 1B, 1D, and 2A to 1A, 1C, 2C, 3, and 4, sites 1B, 1D, and 2A are close to very few houses and businesses while the ditches tend to not be mowed. The other sites, on the other hand seem to be near a lot of small houses, big farms or a couple companies with a lot of land and the ditches appear to be mowed. Site 4 is also surrounded by cottages. The owners don't necessarily live there all year long or even all throughout the summer so the levels at this site would increase or decrease depending on the population as they come and go.

Benthic Biomonitoring

Table 3 (below) shows a summarization of the benthic invertebrate data collected from Six Mile Creek. This allows us to see a total within each order and a total order count accumulated from both riffles and pools, we can use this information to look at the total percent composition of Ephemeroptera, Plecoptera and Trichoptera (EPT). We can also use this information towards the evaluation classification developed by the University of Puget Sound (UPS Classification).

Based on the information found in table 3, we can see that out of the total 415 specimens found they were divided into a total of 10 orders. Out of the 415 specimens found, 21% of the species were a high tolerant species (can survive in poor water quality conditions), 79% of the species were a moderate tolerant species (can live in a wide range of water quality conditions) and 0% of the species were a low tolerant species (need to live in good water quality conditions). Looking at these results, we can see that the water quality condition is average based on organic pollution. This provides habitat for a variety of benthic macroinvertebrates that have a moderate to high tolerance to pollution based on 100% of indicator species being moderate to high tolerance species (Bouchard, 2004).

Table 3: *Six Mile Creek Summary of Benthic Invertebrate Data*

Water Body Name:		Six Mile Creek	
Date:		July 9, 2019	
Total Benthic Invertebrates Collected			
Common Name	Order	Amount Collected	Tolerance Value
Aquatic Earth Worm	Oligochaete	7	Moderate
Leeches	Hirudinea	4	High
Sow Bugs	Isopoda	69	High
Clams & Mussels	Bivalvia	7	High
Scuds	Amphipoda	318	Moderate
Crayfish	Decapoda	2	Moderate
True Bugs	Hemiptera	1	High
Beetles	Coleoptera	1	Moderate
Snails & Limpets	Gastropoda	1	High
Midges	Chironomidae	5	High
Total	10	415	
% Composition of EPT			
Common Name	Order		Amount Collected
Mayflies	Ephemeroptera		0
Stoneflies	Plecoptera		0
Caddisflies	Trichoptera		0
EPT %			0%

Figure 34 shows a percent composition of total benthic invertebrate orders from Six Mile Creek. From this chart we can see that a majority (77%) of specimens were from the Amphipoda order and 17% of specimens were from the Isopoda order. The other 6% were orders Oligochaete, Hirudinea, Hemiptera, Coleoptera, Bivalvia Decapoda, Gastropoda and Chironomidae, ranging from 0.20% to 1.70% total.

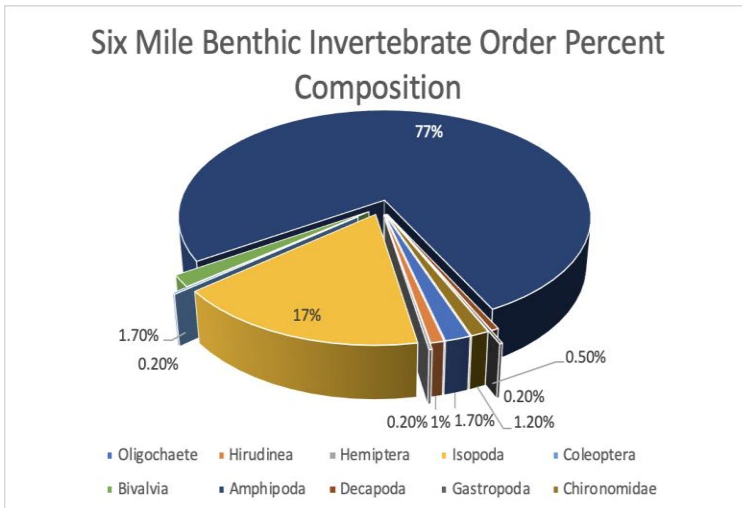

Figure 34: *Six Mile Creek Percent Composition of Benthic Invertebrate Orders*

Based on the UPS Classification (University of Puget Sound) it states that if the stream has a total number of orders < 8, then the stream conditions are considered poor. If the stream has a total number of orders between 8 and 15 then the stream conditions are considered moderate, and if > 15 than the stream conditions are considered good. When looking at the data collected, in table 3, we can see that a total of 10 orders were counted, making Six Mile Creek considered to have moderate stream conditions.

Discharge

Figure 35 *Six Mile Creek Discharge Monitoring Site (North)*

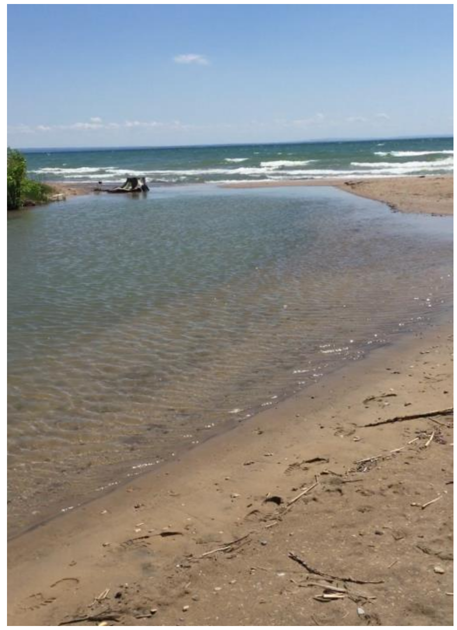

Figure 36: *Six Mile Creek Discharge Monitoring Site (South)*

Flow readings were taken at the mouth of Six Mile Creek at Bernard Beach (site 4), where it connects with Lake Erie. Flow data is based on 3 days readings were taken for our small study. Phosphate readings were taken 5 times at the same location, including once right after the spring thaw. This data can be used to look at how much total phosphorus may be loading into Lake Erie. Below are charts recreated from flow data taken at Bernard Beach.

At times, we were unable to obtain flow readings for Six Mile and/or Kraft; either the water was too still, the waves were forcing the creek water in the wrong direction, and at times some sand would become stuck to the end of the flow meter due to a magnetic component.

Average total discharge: 0.29 m^3/s

Table 4: *Six Mile Creek Summary of Flow Data*

Location : Six Mile Creek, Site 4, Bernard Beach Date : June 14, 2019 Total Width= 6.6 m Weather: Sunny, 17 degrees C, high wind					
Panel Number	width (m) A	Depth (m) B	Panel Area (m^2) (A x B) = C	Velocity (m/s) D	Flow (m^3/s) (C x D) = E
1	1.32	0.1	0.132	0.4	0.0528
2	1.32	0.52	0.6864	0.3	0.2059
3	1.32	0.74	0.9768		
4	1.32	0.69	0.9108		
5	1.32	0.31	0.4092		
Total Discharge (sum of E! to E5) =					0.2587

Note: there was interference with the flow meter due to a magnetic element in the sand, possibly iron. Readings were only obtained for the first and second panel.

Total Discharge: 0.26 m^3/s

Table 5: *Six Mile Creek Summary of Flow Data*

Location : Six Mile Creek, Site 4, Bernard Beach Date : June 20, 2019 Total Width= 11.0 m Weather: raining					
Panel Number	width (m) A	Depth (m) B	Panel Area (m^2) (A x B) = C	Velocity (m/s) D	Flow (m^3/s) (C x D) = E
1	2.2	0.29	0.638	0.1	0.0638
2	2.2	0.82	1.804	0.1	0.1804
3	2.2	0.93	2.046	0.1	0.2046
4	2.2	0.68	1.496	0.1	0.1496
5	2.2	0.47	1.034	0	0
Total Discharge (sum of E! to E5) =					0.5984

Total Discharge: 0.60 m^3/s

Table 6: *Six Mile Creek Summary of Flow Data*

Location : Six Mile Creek, Site 4, Bernard Beach Date : July 18, 2019 Total Width= 1.75 m Weather: windy with waves					
Panel Number	width (m) A	Depth (m) B	Panel Area (m^2) (A x B) = C	Velocity (m/s) D	Flow (m^3/s) (C x D) = E
1	0.35	0.9	0.315	0	0
2	0.35	0.17	0.0595	0	0
3	0.35	0.165	0.05775	0	0
4	0.35	0.17	0.0595	0.1	0.00595
5	0.35	0.1	0.035	0.2	0.007
Total Discharge (sum of E! to E5) =					0.01295

Note: some readings not available due to still water.

Total Discharge: 0.01 m^3/s

Below are the averages from flow data and results of calculations for the estimated mass loading of total phosphorus discharging from Six Mile Creek into Lake Erie. These are based on flow readings and phosphate readings from Six Mile. The average phosphate concentration and average discharge were used in the formula to get an estimated mass loading amount.

Average discharge - June 14 to July 18, 2019:	0.29 m^3/s
Average measured phosphate - spring thaw April 16 to July 17, 2019:	0.312 mg/L
Average total phosphorus - spring thaw April 16 to July 17, 2019:	0.1017 mg/L
Average daily phosphorus load:	2.54 kg/d
Mass loading of total phosphorus estimate:	930.55 kg/yr

It was necessary to convert our measured phosphate levels to total phosphorus in order to get an accurate phosphorus loading amount. We first measured for phosphates in the water samples taken, then converted the amount into total phosphorus. “Phosphorus exists in water almost solely as phosphates which can be dissolved, attached to particles, or found in aquatic organisms. Orthophosphate is the simplest form of phosphorus to measure, but total phosphorus is considered the best indicator of phosphorus levels in water because it measures all forms” (Hach, 2018).

Results (Kraft Drain)

Results (Kraft Drain)

Chemical Parameters

Phosphates

Phosphates were tested weekly for sample sites along Kraft Drain. The maximum amount of phosphates that is considered safe for drinking water and aquatic life is 0.05 mg/L (Kotoski, 1997). As seen in Table 7, all sites but Crescent beach exceeded this limit, meaning Kraft Drains phosphate levels were higher than guideline limits for the duration of this study.

Table 7: *Kraft Drain Summary of Phosphate Data*

Water Body Name:					Kraft Drain			
Date:					April – July 2019			
Phosphate (PO_4) Values (mg/L)								
	1	2	3	4	5	RA1	RA2	RA3
Spring Melt	0.15	0.68	0.11					
06/11/19	0.42	0.83	0.16	0.05				
06/18/19	0.43	1.13	0.14		0.29			
06/25/19	0.95	0.24	0.24		0.39	<0	0.25	0.46
07/02/19			0.66	0.33	0.14			
07/08/19			0.51		2.02			
07/17/19			0.36	0.05				

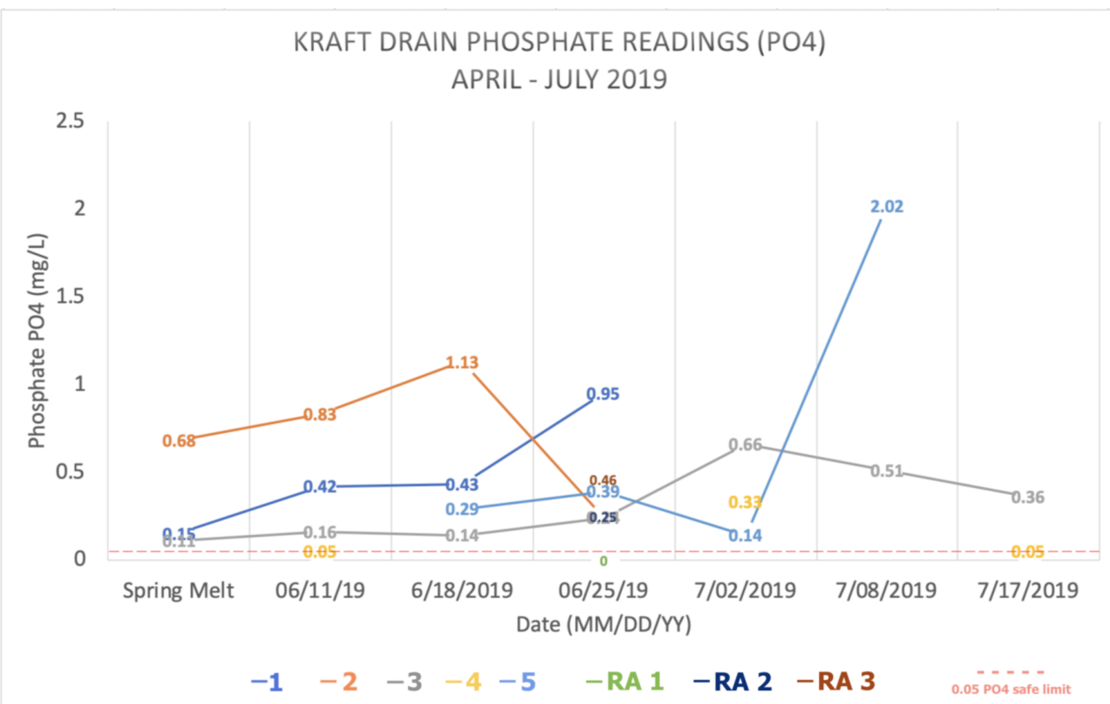

Figure 37: *Kraft Drain Phosphate Data*

In Figure 37, we can see all the values of phosphate readings from Kraft Drain over the study period from April until the end of July. Generally reading this graph it can be seen that all sites, excluding the beach site, were well over the safe limit of 0.05mg/L. Though the results show high readings, for site 1 and 2, at the beginning of the season, we were unable to attain samples after the date of June 25th as these sites were completely dry. It can be seen that the phosphate levels had no significant relationship made between sites.

As can be seen in Figure 24 and Figure 25, site 1 is located on the north end of Kraft Road, towards the intersection of Kraft Road and Garrison Road intersect. The results here were seen to be under 1 mg/L, with a range between 0.15 mg/L to 0.95 mg/L. It is also noted that samples from site 1 and 2, were only able to be obtained until the 25th of June as during the rest of the sampling period the sites were dry.

Site 2 was located approximately 160 meters south of site 1, as seen in Figure 26 and Figure 27. The lowest reading at this site was 0.68 mg/L during the month of April, and the readings peaked at 1.13 mg/L on June 18th. After that, it declined to 0.24 mg/L on June 25th. A possible cause for the increase is the nearby landscaping business.

Site 3 is the most southern site located on Kraft Road, as seen in Figure 28. Samples were able to be obtained here throughout the entire sampling time frame. All were recorded to be well below 1 mg/L, with the highest being at 0.66 mg/L. Site 3 is also where the road allowance began, from here on the drain flowed through the forested area.

As can be seen in Figure 29 and Figure 30, site 4 is located on the left side of the Crescent Park where the Kraft Drain connects to Lake Erie. The results here are usually very low, except for on July 8th. This was just after the long weekend for Independence Day and a lot of Americans own cottages along the beach. Some American products might have phosphates in them where the Canadian versions of those same products do not, like laundry and dishwasher detergents. So, if they buy those products in the US then bring them here to use, the phosphates could get into the water, thus causing the increase.

Site 5 can be found on Dominion Road where the road allowance is going into Crescent Park, as shown in Figure 31 and Figure 32. Samples were retrieved four times from this site during the sampling time frame. The normal range was between 0.14mg/L and 0.39mg/L but had a large peak to 2.02mg/L on July 8th. The reason for the high peak was unknown.

Site RA1 is roughly 180 meters west of Kraft Road, located within Crescent Park and just off the road allowance, as seen in Figure 31. It is likely that due to the natural surrounding forest, the phosphate levels here too low to be read by the photometer.

Approximately 320 meters south west of site RA1 is site RA2, which can be seen on the map in Figure 23. It's kind of odd that in a thickly forested area that doesn't see much human traffic that there would be an increase in phosphates, yet the phosphates at this site were recorded to be 0.25 mg/L. It might be from the nearby residences and businesses, but more likely from decaying plant matter. However, if there is a lot of rainfall, the soil can become completely saturated, thus not allowing the soil to absorb as much phosphorus and there will be more runoff into bodies of water (Adams et al. n.d.).

Finally, site RA3 is approximately 200 meters north of where the road allowance connects with Dominion Road, as seen on the map in Figure 23. The phosphates here were measured to be at 0.46 mg/L.

Nitrates

Table 8: *Kraft Drain Summary of Nitrate Data*

Water Body Name:	Kraft Drain
Date:	July 25, 2019
Nitrate (NO_3) Values	
Sample Site	Value (mg/L)
1	No data
2	No data
3	3.53
4	1.66
5	2.12

On the day when the nitrates were sampled, the first two sites were dry, but samples were obtained from the other three sites. The results of these tests are shown in Table 8. While it's impossible to say what the first two sites would have been measured at, the other three were within the safe limit. Site 3 is near a row of houses on both sides of the street, which could be adding some nitrates to the drain. The wooded areas and areas of the ditches that are not cut down provide a lot of remediation, so they are definitely helping. The next location, site 5, is by where the road allowance connects with Dominion Road, downstream from site 2 and the water flows through a forest, so it is definitely absorbing a lot of nitrates, as it flows along the Kraft Drain in that area The final site is where the Kraft Drain connects to Lake Erie and is surrounded by cottages, as well as wooded areas. The population here fluctuates as cottages are owned by people who don't necessarily live at these residences year-round. So, that could mean that the nitrate levels may also fluctuate, depending on the population, as it is possible that people may be putting nitrates into the environment through the use of certain products.

Benthic Biomonitoring

Table 9 (below) shows a summarization of the benthic invertebrate data collected from Kraft Drain. This allows us to see a total within each order and a total order count accumulated from both riffles and pool. As mentioned before, we can use this information to look at the total percent composition of Ephemeroptera, Plecoptera and Trichoptera (EPT). We can also use this information towards the evaluation classification developed by the University of Puget Sound (UPS Classification).

Table 9: *Kraft Drain Summary of Benthic Invertebrate Data*

Water Body Name:		Kraft Drain	
Date:		July 11, 2019	
Total Benthic Invertebrates Collected			
Common Name	Order	Amount Collected	Tolerance Value
Sow Bugs	Isopoda	123	High
Clams	Bivalvia	2	High
Scuds	Amphipoda	73	Moderate
Mayflies	Ephemeroptera	1	Low
Crayfish	Decapoda	5	Moderate
True Bugs	Hemiptera	2	High
Beetles	Coleoptera	7	Moderate
Midges	Chironomidae	80	High
Alderflies, Dobsonflies & Fishflies	Megaloptera	2	Low
Total	9	295	
% Composition of EPT			
Common Name	Order	Amount Collected	
Mayflies	Ephemeroptera	1	
Stoneflies	Plecoptera	0	
Caddisflies	Trichoptera	0	
EPT %		0.34%	

Based on the information found in table 9, we can see that out of the total 295 specimens found they were divided into a total of 9 orders. Out of the 295 specimens found, 70% of the species were a high tolerant species (can survive in poor water quality conditions), 29% of the species were a moderate tolerant species (can live in a wide range of water quality conditions) and 1% of the species were a low tolerant species (need to live in good water quality conditions). Looking at these results, we can see that the water quality condition is poor to average based on organic pollution. This provides habitat for a variety of benthic macroinvertebrates that have a high to moderate tolerance to pollution based on 99% of indicator species being high to moderate tolerance species (Bouchard, 2004). It can also be seen that based on the total percent of EPT being 0.34% this indicates poor quality of forage for inhabited fish species.

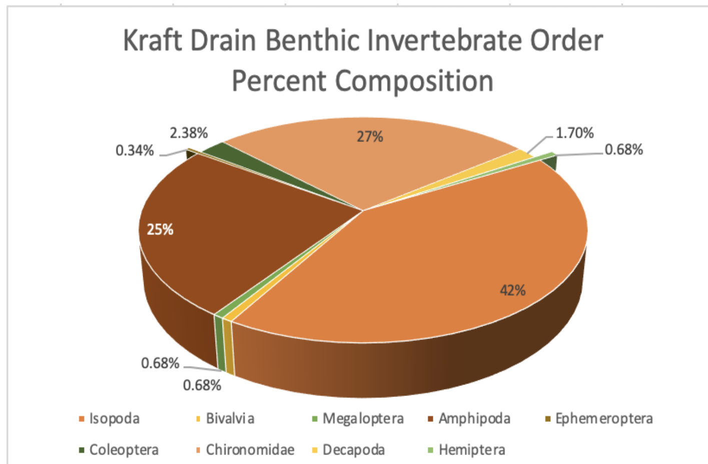

Figure 38: *Kraft Drain Percent Composition of Benthic Invertebrate Orders*

Figure 38 shows a percent composition of total benthic invertebrate orders from Kraft Drain. From this chart we can see that a majority of specimens were from the Isopoda order with 42%, the Chironomidae order with 27% and the Amphipoda order with 25%. The other 6% were orders Bivalvia, Hemiptera, Coleoptera, Decapoda, Megaloptera, and Ephemeroptera, ranging from 0.34% to 1.70% total.

Based on the UPS Classification (University of Puget Sound), it states that if the stream has a total number of orders < 8, then the stream conditions are considered poor. If the stream has a total number of orders between 8 and 15 than the stream conditions are considered moderate, and if > 15 than the stream conditions are considered good. When looking at the data collected, in table 9, we can see that a total of 9 orders were counted, making Kraft Drain considered to have moderate stream conditions.

Discharge

Figure 39: *Kraft Drain Discharge Monitoring Site (North)*

Figure 40: *Kraft Drain Discharge Monitoring Site (South)*

Flow readings were taken at the mouth of the Kraft Drain at Crescent Beach, where it connects with Lake Erie. Flow data is based on 4 days readings were taken for our small study. Phosphate readings were taken 3 times at the same location. This data can be used to look at how much total phosphorus may be loading into Lake Erie. Below are charts recreated from flow data taken at Crescent Beach.

Six Mile Creek had a higher total discharge amount than Kraft Drain.

Average total discharge: 0.132 m^3/s

Table 10: *Kraft Drain Summary of Flow Data*

Location: Kraft Drain, site 4, Crescent Beach Date: June 14, 2019 Total Width: 4.4 m Weather: sunny and windy					
Station Number	width (m) A	Depth (m) B	Panel Area (m^2) (A x B) = C	Velocity (m/s) D	Flow (m^3/s) (C x D) = E
1	0.9	0.12	0.108	0.1	0.0108
2	0.9	0.44	0.396	0.1	0.0396
3	0.9	0.46	0.414	0.1	0.0414
4	0.9	0.475	0.4275	0.1	0.04275
5	-0.9	0.26	0.234	0.1	0.0234
Total Discharge (sum of E! to E5) =					0.1580

Total Discharge: 0.16 m^3/s

Table 11: *Kraft Drain Summary of Flow Data*

Location: Kraft Drain, site 4, Crescent Beach Date: June 20, 2019 Total Width: 5.85 m					
Station Number	width (m) A	Depth (m) B	Panel Area (m^2) (A x B) = C	Velocity (m/s) D	Flow (m^3/s) (C x D) = E
1	1.3	0.5	0.065	0	0
2	1.3	0.43	0.559	0.1	0.0559
3	1.3	0.94	1.222	0.1	0.1222
4	1.3	0.89	1.157	0.1	0.1157
5	1.3	0.22	0.286	0	0
Total Discharge (sum of E! to E5) =					0.2938

Total Discharge: 0.29 m^3/s

Table 12: *Kraft Drain Summary of Flow Data*

Location: Kraft Drain, site 4, Crescent Beach Date: July 18, 2019 Total Width: 1.4 m					
Station Number	width (m) A	Depth (m) B	Panel Area (m^2) (A x B) = C	Velocity (m/s) D	Flow (m^3/s) (C x D) = E
1	0.28	0.02	0.0056	0.1	0.00056
2	0.28	0.45	0.126	0.1	0.0126
3	0.28	0.64	0.1792	0.2	0.03584
4	0.28	0.39	0.1092	0.1	0.01092
5	0.28	0.005	0.0014	0.1	0.00014
Total Discharge (sum of E! to E5) =					0.0601

Total Discharge: 0.06 m^3/s

Table 13: *Kraft Drain Summary of Flow Data*

Location: Kraft Drain, site 4, Crescent Beach Date: July 2019 Total Width: 1.32 m					
Station Number	width (m) A	Depth (m) B	Panel Area (m^2) (A x B) = C	Velocity (m/s) D	Flow (m^3/s) (C x D) = E
1	0.4	0.04	0.016	0.3	0.0048
2	0.44	0.09	0.0396	0.2	0.00792
3	0.44	0.05	0.022	0.1	0.0022
Total Discharge (sum of E! to E5) =					0.01492

Note: Due to the small width of this section of creek, only 3 panels were taken instead of 5.

Total Discharge: 0.02 m^3/s

Below are the averages of our flow data and results of calculations for the estimated mass loading of total phosphorus discharging from Kraft Drain into Lake Erie.

Average discharge - June 14 to July 18, 2019:	0.1317 m^3/s
Average measured phosphate - June 11 to July 17, 2019:	0.1433 mg/L
Average total phosphorus - June 11 to July 17, 2019:	0.0467 mg/L
Average daily phosphorus load:	0.52 kg/d
Mass loading of phosphorus estimate:	191.01 kg/yr

Six Mile Creek's total phosphorus loading amount was considerably higher than Kraft Drain's loading amount. Six Mile Creek was estimated to have an amount of approximately 930.55 kg per year, while Kraft had an amount of approximately 191.01 kg per year.

Discussion

Six Mile Creek

Based on the evaluation classification developed by the University of Puget Sound (UPS Classification) stated previously in the results/Six Mile Creek section, we can see (table 9) that a total of 10 orders were counted for making Six Mile Creek considered to have moderate stream conditions. With this being said, it can also be seen that due to there being 0% of low tolerant species present we can assume the water quality condition is poor based on organic pollution (Bouchard, 2004). This provides habitat for a variety of benthic macro invertebrates that have a moderate to high tolerance to pollution (Bouchard, 2004).

Based on the total collected amount of EPT for Six Mile Creek, shown in table #, we can see that from the total EPT collected it gives a percent composition of 0%. Using this number, we can receive a relative measure of quality forage for fish and aquatic life. If the value is ≥ 50% this is considered good. If the value is between 50% and 25% this is considered moderate and if the value is < 25% this is considered poor. With the percent composition being 0% this puts Six Mile Creek as a value <25% making the sub-watershed considered a poor-quality forage for fish and aquatic life

Looking at the support of these statements we can assume Six Mile Creek has poor water quality and does not have the ideal water conditions to support low tolerant benthic invertebrate species. We can also assume Six Mile Creek is not an ideal water body to support the presence of fish and aquatic life due to the low percentage of EPT.

By going through the data collected from all of the sites, the phosphorus and nitrogen levels do seem to vary from site to site. This is due to the topography of the area, surrounding land use, and vegetation in and around the bodies of water.

There are some sources of phosphates and nitrates that are quite common, especially in residential areas. The common sources found while doing research for this report are food (Ritz et al. 2012), swimming pool treatment (Donohue, 2013), fertilizers, pesticides, herbicides, detergents, personal hygiene, auto maintenance, and household cleaning products (Household Products Database, 2019). For detergents and household cleaning products, specifically, phosphates are not allowed to be part of the ingredients in Canada (Concentration of Phosphorus in Certain Cleaning Products Regulations, 1989), but some US citizens do have cottages along the beaches in Fort Erie and they could bring such products from the US to use here.

Starting with site 1A, the phosphate levels ranged from 0.13 - 2.05 mg/L and the nitrates were measured at 1.65 mg/L. Now when looking at the area, there is a greenhouse business at the north end of the street as well as residential properties, several of which have swimming pools. The creek goes through a wooded area before reaching the site and the land is slanted down to the south east. It is possible that the business uses a fair number of products that have phosphates and nitrates in them, and that usage may go up and down as needed. The residences may also be using products that contain one or both of the nutrients. Decaying plant matter could also be a source. As runoff would take them to the creek, and then through the wooded areas, the vegetation would be absorbing as many nutrients as they can.

Moving onto sites 1B and Garrison Road, all of the results that were obtained for phosphates and nitrates were under 1 mg/L. The surrounding land use is primarily farmland with a few residences, some of which has swimming pools, and the area is slanted towards the south east. Garrison Road is also fairly busy and does have some construction going on sometimes. The sources could be fertilizers, pesticides and herbicides used by the farmers and various products used at the residences.

The Beach Road site is just one street south of a hair salon. There are also some residences with a couple swimming pools, farmland, wooded areas and a house being built nearby. The level of phosphates that was recorded there is 2.83 mg/L, which is high in comparison to all of the readings, and nitrates were not measured here, so those levels are not known. In addition to fertilizer, pesticides and herbicides being possible sources, various types of phosphates and nitrates are found in hair and skin products (Sodium Phosphate, 2016) (Nitrosamines, 2019) as well as in concrete. The ingredients of concrete are water, aggregate (rock, sand, or gravel), and Portland cement (What is Concrete: Concrete and Cement Defined, 2019).

Now, within Portland cement are various types of materials including, but not limited to sandstone, limestone, iron, marl, shale, fly ash, and clay (The Process for Making Portland Cement, 2018). The amount of phosphates in sandstone was averaged to be 1127 PPM, limestone is listed as 1560 PPM and shale is a classification of rocks that includes claystone, mudstone, and siltstone, which have phosphates ranging from 2797 - 5159 PPM on average (Porder and Ramachandran 2012). Phosphatic marls are also found all over the world in large sedimentary deposits (Jasinski, 2013). A marl is a mix of clay with chalk from the hardened bones of ancient animals and phosphates are in those bones (Shuler and Bailey 2004). There is no recorded average amount of phosphates within the marls, but it must be a fairly significant amount most of the time because corporations do mine them in a process called marling (Shuler and Bailey 2004). Clay also has no recorded average amount of phosphates, but the particles do tend to hold on to or fix phosphorus in the soil (Essential Role of Phosphorus in Plants, 2019). Fly ash is created through a process of burning pulverized coal in electric power generating plants (Basham et al. 2007). After that, phosphates can adsorb onto fly ash. No PPM amount or adsorption rate is on record for fly ash, but a modified version of the fly ash is reported to have a high adsorption rate, whereas the unmodified version does not (Dhanke et al. 2018). Iron does not actually have any phosphates in it, but it can be combined with phosphates to make chemical compound known as Iron (III) Phosphate ($FePO_4$) (Ferric Phosphate, n.d.). The same goes for nitrates. There are no nitrates in iron, but the two can be combined together to form the chemical compound Iron (III) Nitrate (FeN_3O_9) (Iron Trinitrate, n.d.).

There isn't as much data available on the amount of nitrates in those same materials. That said, sandstone in California was sampled and found to have nitrates ranging from 33 - 1974 PPM, shale had 113 - 4832 PPM, black claystone marl had 400 - 7000 PPM and limestone (of the green claystone variety) had 20 - 300 PPM (Holloway and Dahlgreen 2002). Fly ash is made up of approximately 2.63% of nitrates (Ammonium, Nitrate and Total Nitrogen Determination in Fly Ash, 2016). No such information is available for clay, but it is an excellent adsorbent of nitrate contaminated water (Ouardi et al. 2015) so the chances of finding at least some nitrates in clay soil at any time is high.

Site 1C is near some residences with a couple swimming pools, farmland and a small, inactive cemetery, the Hershey Cemetery, which can be traced back to the 19th century (Hershey Cemetery Records, n.d.). The phosphate levels range from 0.09 - 3.2 mg/L and nitrates were recorded at 2.11 mg/L. The residences and farmland would have the typical possible sources of phosphates and nitrates, like personal hygiene products, fertilizer, pesticides and herbicides. Beyond that, the cemetery is also a possible source. Photographs of the cemetery can be found in the Appendices section. The headstones seem to be made from limestone and granite. As stated above, limestone has 1560 PPM of phosphates (Porder and Ramachandran, 2012) and 20 - 300 PPM of nitrates (in the green claystone, specifically) (Holloway and Dahlgreen 2002). No similar information is available on the other colours of limestone. For granite, the average amount of phosphates is 568 PPM (Porder and Ramachandran 2012) and the range of nitrates is 1 - 243 PPM (Holloway and Dahlgreen 2002). The land is also slanted towards the south east and the water flows through wooded areas, which helps to remediate the water as much as possible.

Site 1D has a couple residences nearby, one swimming pool, some farmland, as well as a lot of wetland and forest. The land is also slanted towards the south west. The phosphate levels ranged from 0.22 - 2.1 mg/L and stayed under 1 mg/L most of the time. Nitrates were recorded at 0.61 mg/L. Possible sources would be decaying plant matter, personal hygiene products, fertilizer, pesticides and herbicides. The wetlands and forest would be able to remediate a lot of the pollutants. No specific reason is known why the phosphates increased by more than 4 times from the second highest reading though.

Site 2A is surrounded mainly by farmland, forests, some residences and a couple swimming pools. The land in this specific area is also slanted to the east and north east. Phosphate levels range from too low to be readable - 1.2 mg/L and nitrates were measured at 0.33 mg/L. Possible sources would be decaying plant matter, personal hygiene products, fertilizer, pesticides and herbicides. The wooded areas would be remediating a lot of the nutrients.

Site 2C is near farmland, wetland, forests and a couple residences. The land is slanted toward the south and south east. Much like at site 2A, possible sources would be decaying plant matter, personal hygiene products, fertilizer, pesticides and herbicides. The wetland areas would be remediating a lot of phosphates and nitrates.

Site 3 has a co-operative farm business on the west side and a greenhouse business on the east side, as well as wetlands, farmland, a couple residences and one swimming pool. The land is also slanted down on the east and west sides towards the creek. Phosphates at this site range from 0.1 - 3.57 mg/L and nitrates were recorded at 2.8 mg/L. Both businesses, and maybe even the residences, could be using fertilizers, pesticides and herbicides could all be possible sources of phosphates and nitrates, along with personal hygiene products and decaying plant matter.

Site 4 is located at the beach where the Six Mile Creek drains into Lake Erie. The site is surrounded by residences (some of which have swimming pools), forests and wetlands. Topographical maps of the area show that the land is slanted towards the south as well. Phosphate levels range from 0.07 - 0.41 mg/L and the nitrates were recorded at 1.67 mg/L. Possible sources would be decaying plant matter, personal hygiene products, fertilizers, pesticides and herbicides.

Kraft Drain

Based on the evaluation classification developed by the University of Puget Sound (UPS Classification) stated previously in the results/Kraft Drain section, we can see (Table 9) that a total of 9 orders were counted for making Kraft Drain considered to have moderate stream conditions. With this being said, it can also be seen that due to there being 0.34% of low tolerant species present we can assume the water quality condition is poor based on organic pollution (Bouchard, 2004). This provides habitat for a variety of benthic macro invertebrates that have a high to moderate tolerance to pollution (Bouchard, 2004).

Based on the total collected amount of EPT for Kraft Drain, shown in table #, we can see that from the total EPT collected it gives a percent composition of 0.34%. Using this number, we can receive a relative measure of quality forage for fish and aquatic life. If the value is ≥ 50% this is considered good. If the value is between 50% and 25% this is considered moderate and if the value is < 25% this is considered poor. With the percent composition being 0.34% this puts Kraft Drain as a value <25% making the sub-watershed considered a poor-quality forage for fish and aquatic life

Looking at the support of these statements we can assume Kraft Drain has poor water quality and does not have the ideal water conditions to support low tolerant benthic invertebrate species. We can also assume Kraft Drain is not an ideal water body to support the presence of fish and aquatic life due to the low percentage of EPT.

By going through the data collected from all of the sites, the phosphorus and nitrogen levels do seem to vary from site to site. This is due to the topography of the area, surrounding land use, and vegetation in and around the bodies of water.

There are some sources of phosphates and nitrates that are quite common, especially in residential areas. The common sources found while doing research for this report are food (Ritz et al. 2012), swimming pool treatment (Donohue, 2013), fertilizers, pesticides, herbicides, detergents, personal hygiene, auto maintenance, and household cleaning products (Household Products Database, 2019). For detergents and household cleaning products, specifically, phosphates are not allowed to be part of the ingredients in Canada (Concentration of Phosphorus in Certain Cleaning Products Regulations, 1989), but some US citizens do have cottages along the beaches in Fort Erie and they could bring such products from the US to use here.

Site 1 is at the north end of Kraft Road. The surrounding area is a school bus company, restaurant, car dealership, residence with a pool and what seems to be an open field or farm land. Land slants to the south. Phosphate levels ranged from 0.15 – 0.95 mg/L, but no samples could be taken to measure the nitrates as there was no runoff and the day the samples were being collected. The owner of the residence says he lets the weeds in the ditch grow to help remediate the run-off water. Other than the common sources, another possible source would be decaying plant matter.

Site 2 is roughly 160 meters south of site 1 on Kraft Road. In addition to the school bus company, restaurant, car dealership, residences, and an open field (or farm land), the site is right beside a landscaping business. Land is slanted to the south. Phosphate levels ranged from 0.24 – 1.13 mg/L, but no samples could be taken to measure the nitrates as there was no runoff and the day the samples were being collected. Other than the common sources, another possible source would be decaying plant matter.

Site 3 is just south of a bunch of residences on Kraft Road, next to the road allowance. The land is slanted towards the south west. Three or four of them have swimming pools. Phosphate levels ranged from 0.11 – 0.66 mg/L and nitrates were recorded at 3.53 mg/L. In addition to the typical possible sources, another possible source would be decaying plant matter.

Site 4 is on the east side of Crescent Beach, where the Kraft Drain empties out into Lake Erie. The surrounding land use is a lot of residences, a few swimming pools, and businesses. Land is slanted towards the south west. Phosphate levels ranged from 0.05 – 0.33 mg/L and nitrates were recorded at 2.12 mg/L. Many of the cottages along the beach here are owned by US residents. As said earlier, detergents and household cleaning products that are sold in Canada are not allowed to have phosphates in the ingredients, but that is still allowed in some US states, so it is possible that some US residents are bringing such products that they bought in the US across the border to use here.

Site 5 is on Dominion Road, approximately 100 meters west of the Fort Erie Fire Station 3. Surrounding land use includes the aforementioned fire station, residential properties, a couple swimming pools, car mechanic shop, a church, and a wetland within a forest. Phosphate levels ranged from 0.14 – 2.02 mg/L and nitrates were recorded at 2.12 mg/L. Due to the proximity of the of the auto maintenance shop to the site, more pollutants than usual would be coming from auto maintenance products. Beyond that, the only sources would most likely be the common sources as listed earlier.

Sites RA1 – RA3 are all within the heavily forested area of Crescent Park. The topography of the area is mostly slanted to the south, but some small sections are slanted more towards the west or east. Other than the forest, the surrounding land use is primarily for residential properties, some of which have swimming pools. There are also a couple restaurants at the north end of the park and a church on the south east side. These sites were not measured for nitrates, but the phosphate levels, while from site RA1 they were so low that they were not readable, sites RA2 and RA3 were recorded at 0.25 and 0.46 mg/L, respectively. Most of the nutrients from the surrounding areas should be getting remediated by all of the vegetation. The biggest source would probably be decaying plant matter.

Discharge

In the future when studying discharge, many additional readings should be taken throughout different seasons and weather conditions in order to arrive at a more precise loading amount. In our study, enough readings were taken to give an idea of the loading amount of total phosphorus. Averages were created from phosphate and discharge readings and used in the calculations. The end result of our mass loading of TP is simply an estimation. Water flow and the concentration of phosphates can vary over time, and the frequency of sampling can influence the accuracy of load estimation as well. (Meals et al. 2013). Other factors can influence the accuracy of the loading amount for phosphorus. For example, on high flow days the levels could be higher, or at times the water may be flowing backwards due to the waves coming in from the beach, or after a rainfall it could be heavily diluted.

As discharge was not a focus of the co-op study in previous year(s), we don't have historical data with specific amount in kilograms per year for total phosphorus discharging from these creeks to Lake Erie to compare our current data to. Although, we can look at the recommended limit of 0.05 mg/L for our phosphate readings, which as you can see above (in tables 10 - 13) were almost all above the limit. The 0.05 mg/L limit falls in the eutrophic range of the total phosphorus trigger ranges, which can be seen below. It is likely that the loading amount is too high for these creeks, although again further study is recommended.

Total phosphorus trigger ranges for Canadian lakes and rivers:

Trophic Status	*Total phosphorus [mg/L]*
Ultra-oligotrophic	< 4
Oligotrophic	4-10
Mesotrophic	10-20
Meso-eutrophic	20-35
Eutrophic	35-100
Hyper-eutrophic	> 100

The collected phosphate water sample data was analyzed to see where the samples fell in the phosphorus trigger ranges. The results for Six Mile Creek were that most of the samples fell into the hypereutrophic range, with only a few falling in the meso eutrophic range (sites 1B on two days, 1D one day) and in the eutrophic range (sites 1B, 1C, 3, 4 - once each). There was one exception - site 2A fell in the ultra-oligotrophic range.

The results for Kraft Drain were similar; most sample readings also fell in the hypereutrophic range, but with no samples falling in the meso eutrophic range, and one site falling in the eutrophic range (site 4, two samples). There was the exception of one site (RA1, one sample day) in the ultra-oligotrophic range.

TP Loading Amount:
As mentioned previously, Six Mile Creek's total phosphorus loading amount was considerably higher than Kraft Drain's loading amount. Six Mile Creek was estimated to have an amount of approximately 930.55 kg per year, while Kraft had an amount of approximately 191.01 kg per year. Six Mile Creek did have the spring melt phosphate sample included in the calculations whereas Kraft Drain did not. This could account in part for the larger total phosphorus loading amount.

Six Mile Creek:	Kraft Drain:
0.52 kg/day or 191.01 kg/year	2.54 kg/day or 903.55 kg/year

Remediation Options

As observed in the results, there are several issues that could benefit from remediation efforts. These issues include high phosphorus levels which may be contributing to the eutrophication of the lake water and the algae issue in Lake Erie. There are 0% low tolerance benthic invertebrate species sampled in Six Mile Creek may be an indicator of this. High levels of nutrients can be detrimental to benthic habitats. If remediation efforts are made, this should improve the community and diversity of invertebrates.

Also, the negative effects of runoff could be improved in many ways such as by planting of vegetation, creating riparian buffers, preventing grass clippings and leaves from entering sewers, controlling the use of manure and fertilizers and educating the public.

It is recommended to maintain healthy riparian areas, which is a vegetated area between a river or lake and land that is in use and create new buffers in areas that may need them, between land and waterways. This vegetated area can trap the phosphorus and nitrogen in the water flowing through it. Using a buffer zone like this can trap up to 97% of these nutrients before they reach the body of water (Minnesota Pollution Control Agency, n.d.). Ditches should be widened but the vegetation in them should not be mowed when possible. Using deep-rooted plants along ditches and waterways help to absorb nutrients from runoff. Ornamental grasses and shrubs can be used instead of grass that needs to be cut (Minnesota Pollution Control Agency, n.d.). This can help with roadway runoff and help prevent the leaching of pollutants into waterways.

Also, in order to reduce the phosphate and nitrate levels along Six Mile Creek, it is recommended to plant additional vegetation such as common cattails (*Typha latifolia*) at random spots in the ditches along roads connected to the creek and lesser duckweed (*Lemna minor*) at sites 1C, 2C, 3 and 4. The same is recommended for the Kraft Drain, at sites 3, 4 and 5. Tests have been done on common cattails to show that they do an excellent job of absorbing phosphates and an annual harvesting of the cattails to stop them from putting nutrients back into the water would be a good idea (Brix et al. 2010). Similar tests have been done on lesser duckweed to show their ability to absorb nitrates (Arias et al. 2015).

Grass clippings contribute to runoff, they contain nitrogen and phosphorus which can contribute to eutrophication and high nutrient levels. Grass may also have been treated with fertilizers. There were greenhouses in close proximity to some sample sites, 1A and 3 by Six Mile Creek. Some fertilizers can be high in phosphorus and nitrogen content which compounds the problem. One way to reduce nutrients going into waterways is by using phosphorus-free fertilizer on lawns, and do not let fertilizer spill into streets. Another is to keep grass clippings and leaves off the street so that they don't wash into sewers that drain into the lakes and rivers. This also counts for city employees being careful when mowing ditches and applying fertilizer along roadways and near streams (Minnesota Pollution Control Agency, n.d.).

Wetlands (possibly constructed wetlands) can also be used to help remove nitrogen and phosphorus. Wetlands can naturally adsorb/absorb, transform, sequester, and remove nutrients and other chemicals as water flows through the wetland (Kostel, n.d.).

Manure contains amounts of phosphorus and nitrogen as well. For human sewage, the tanks in older buildings should be checked for leakage which can contribute to phosphate and nitrate levels in water. Enforce laws on pet waste and litter disposal. The town can provide the proper waste bins to collect them and keep them out of the landfill areas that may seep into waterways. Manure should be managed appropriately on any nearby farmland, including setbacks from water resources. Over-fertilizing should be discouraged. Manure from farms is a primary source of nitrogen and phosphorus to surface and groundwater (Minnesota Pollution Control Agency, n.d.).

To summarize, watersheds should be continued to be monitored on a regular basis, investigate or monitor for phosphorus and nitrate leaching in order to obtain more information and precise results to compare year to year for progress, and if remediation efforts listed above are made, pollutant levels will hopefully decrease. It is important that the public be educated about the facts and make efforts to keep grass clippings and leaves out of storm sewers, refraining from over-fertilizing, and keeping human, pet and manure waste away from waterways, and refrain from removing vegetation on their properties. All contribute to phosphate runoff and discharging into the lakes. With combined efforts, the issues with Lake Erie and our local watersheds can be improved.

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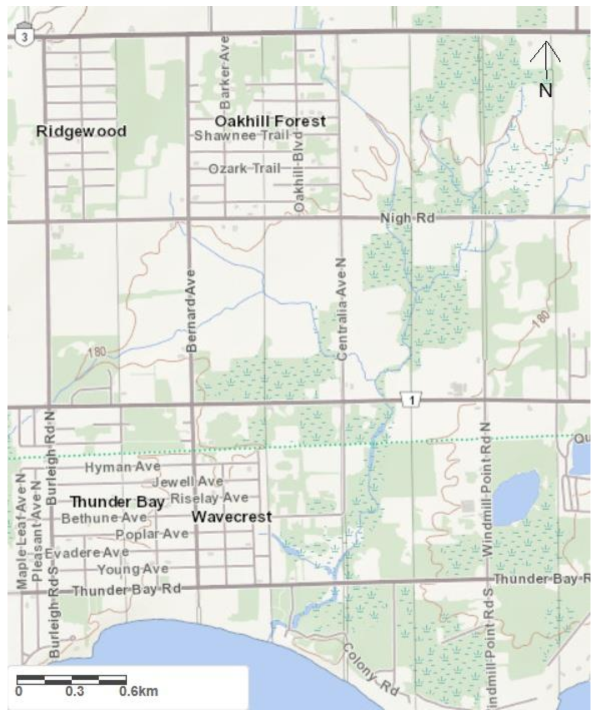
Appendices

Appendix A: Field Sheets

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