Sanitary Survey Assessment Report for Lake Erie Beaches Located in Chautauqua County, NY

2012-2015

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Chautauqua County Department of Health and Human Services
2012-2015 Sanitary Survey Assessment Reports

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Preface

High indicator bacteria levels, resulting in beach closings, are observed annually at Chautauqua County's Lake Erie beaches. Beach closings mean increased risk to public safety, potential loss of summer income and indicate overall poor water quality in Lake Erie. With funding from the United States Environmental Protection Agency's (EPA) Great Lakes Restoration Initiative, through the New York State Department of Health (DOH) Chautauqua County Department of Health and Human Services (CCDHHS) completed comprehensive sanitary surveys of eight Lake Erie beaches including the watersheds of creeks that discharge onto or near the beaches in an effort to understand the reason behind the high bacteria levels.

The sanitary surveys were conducted over three years during the summers of 2012, 2013 and 2014. Additional City of Dunkirk storm sewer inspections were conducted in 2015. CCDHHS staff sampled beach water and stream watersheds weekly during multiple years in an effort to include the most variation in the short sampling season available in Western New York.

This sanitary survey was fairly comprehensive, featuring many different components, including monitoring of both beach and stream water quality; collection of environmental variables and observations; investigation of pollution sources in watersheds; development of predictive models using Virtual Beach software; inspections of City of Dunkirk storm sewer; mapping of unpermitted and aging septic systems in areas of concern with follow-up site investigations to identify failing septic systems, and; a review of historical water quality studies.

A large portion of information regarding Wright Park East, Wright Park West, Main Street, and Point Gratiot beaches was originally collected in the 2008-2009 sanitary survey efforts and updated for the 2012-2014 report. The CCDHHS staff collected and analyzed water samples for *Escherichia coli*. CCDHHS staff collected water samples for *Bacteroides* testing and shipped them to the NYSDOH Biggs Laboratory at Wadsworth Center for analysis.

Mapping work for the Lake Erie Beaches was completed by CCDHHS staff. Using a Trimble GeoXT® and ArcPad® software, GPS coordinates of discharge points, potential pollution sources and sample points along the beaches and creeks were uploaded to ArcGIS®. Digital watershed maps were downloaded from the USGS Streamstats program and imported into ArcGIS®. The Multi-Resolution Land Characteristics Consortium (MRLC) National Land Cover Database (2011) was used to calculate land use in the watersheds contributing to the creeks that flow into Lake Erie near the beaches of concern. Maps were created to demonstrate the routine and investigative sampling locations, SPDES discharge points, watersheds, potential pollution sources, and other valuable information.

The Chautauqua County Sanitary Survey report includes the following beaches: Town of Hanover, Sunset Bay Beach Club, Wright Park East, Wright Park West, Main Street, Point Gratiot, Sheridan Bay Park and Blue Water Beach Campground. For reporting purposes, the beaches are divided into three groups, based on their location and use.

1) Sunset Bay beaches: Town of Hanover and Sunset Bay Beach Club beaches.
2) Dunkirk beaches: Point Gratiot, Main Street, Wright Park West and East beaches.
3) Campground beaches: Sheridan Bay Park Campground and Blue Water Beach Campground beaches.

Acknowledgements

Several individuals and agencies have provided invaluable time, knowledge and experience to this project and deserve a great deal of credit for their efforts. We would like to extend our gratitude to: NYSDOH Bureau of Community Environmental Health and Health Research, Incorporated for providing funding for and oversight of this project; Bill Boria, Jim Metzger, and Mark Stow of the CCDHHS for guidance, assistance with investigations and providing comments; CCDHHS Beach Program interns (Darren Norris, Brian Schmidt, Jonathon Townsend, Kelci Yousett, Syndnie Shepland and Joylyn Kovatchev) for conducting some sampling and helping with analysis; Eric Weigert, Kelly St. Clair, Timothy Shay and their colleagues at NYSDOH Bureau of Community Environmental Health for providing guidance and answering questions; Dr. Ellen Braun-Howland and her staff of NYSDOH Wadsworth Center for conducting *Bacteroides* analysis; Dave Manzella, Randy Woodbury and Tony Gugino of the City of Dunkirk Department of Public Works for providing knowledge about the City of Dunkirk and its infrastructure and assisting with manhole sampling; Paul Heyden of the Dunkirk WWTP for providing information and literature regarding the City of Dunkirk's WWTP; Frank Flagella of the Fredonia WWTP for providing information about the Village of Fredonia's WWTP; Chautauqua County's Lake Erie Management Commission; the Lake Erie Watershed Protect Alliance; and finally, Brett Hayhurst of the USGS New York Water Science Center for providing sampling equipment and guidance on developing predictive models.

Executive Summary

Description of Chautauqua County and Lake Erie Beaches

Chautauqua County is the western gateway to New York State, located in the extreme southwest corner between Buffalo, NY and Erie, PA. The County is bordered by Erie County, PA to the south and west, Warren County, PA to the south and Cattaraugus County, NY to the east. The north/northwestern border of Chautauqua County is approximately 50 miles of Lake Erie shoreline (Figure 1). Chautauqua County is comprised of two cities, Dunkirk and Jamestown, as well as fifteen villages and twenty-seven towns. The County covers 1060 square miles of land with an estimated population of 132,053 [1].

Lake Erie beaches provide recreation opportunities for Chautauqua County residents as well as tourism revenue. Although manufacturing and agriculture are important industries in the County, the role of tourism in the County's economy is growing due to steady declines in manufacturing over the past thirty years. Of the eight beaches included in this study, half can be associated with tourism including the Town of Hanover and Sunset Bay beaches as well as the private beaches at Sheridan Bay Park and Blue Water Beach campgrounds.

Point Gratiot, Main Street, Wright Park West and Wright Park East, are located within the city limits of Dunkirk, NY. These beaches are frequented predominantly by Chautauqua County residents. Only two of the beaches, Point Gratiot and Wright Park West, were permitted with designated swim areas during the 2012-2014 swim seasons. Main Street and Wright Park East beaches do not currently operate designated swim areas. These beaches are frequented by beachcombers, sunbathers and occasionally by a small number of swimmers despite the present "No Swimming" signs.

The Town of Hanover and Sunset Bay Beach Club beaches are located in Irving, NY at the northwestern most border of Chautauqua County. The beaches are separated by private beachfront and are both surrounded by a small community (0.25 square miles) called Sunset Bay. Seasonal vacation homes as well as winterized residences make up the Sunset Bay community. Sunset Bay and Town of Hanover beaches provide recreational opportunities for Chautauqua County residents and draw tourists from the greater Buffalo area and beyond.

Sheridan Bay Park and Blue Water Beach Campground beaches are private beaches. Both of these beaches are used solely by campground and day use fee patrons, but only Blue Water Beach Campground operates a permitted swim area. The campgrounds and beaches are very different but they serve similar functions in the county by attracting seasonal visitors.

The beaches in Chautauqua County are used primarily in the summer months of June, July and August for swimming, sunbathing, beachcombing and sand play. Beach use beyond the three month swim season includes many of the same activities, with the exception of swimming, on warm spring and fall days. Additionally, all of the beaches have seen an increase in self-propelled watercraft activity including kayaking, canoeing, etc. throughout the spring, summer and fall months.

Figure 1. Map of Lake Erie Beaches in Chautauqua County. The map illustrates the geospatial relationships between the eight beaches, Chautauqua County, and New York State.

Description of Watersheds in Chautauqua County

Roughly a third of Chautauqua County is located in the Great Lakes watershed, while the remaining land drains to the Gulf of Mexico (Figure 2). Localized, direct surface drainage to the beaches is difficult to measure due to the high density of impermeable surfaces combined with surface drainage infrastructure in the urban areas which surround many of the beaches in our study. For many of the Chautauqua County beaches, the largest potential pollution contributions to the individual watersheds are from streams that empty onto or near the individual beaches. We therefore focused our attention on the watersheds of those streams that likely have the most direct effect on individual beach water quality (Figure 3).

Figure 2. Map of Lake Erie Watershed in Chautauqua County.[2] The area of Chautauqua County north/west of the red line is included in the Lake Erie and larger Great Lakes Watershed.

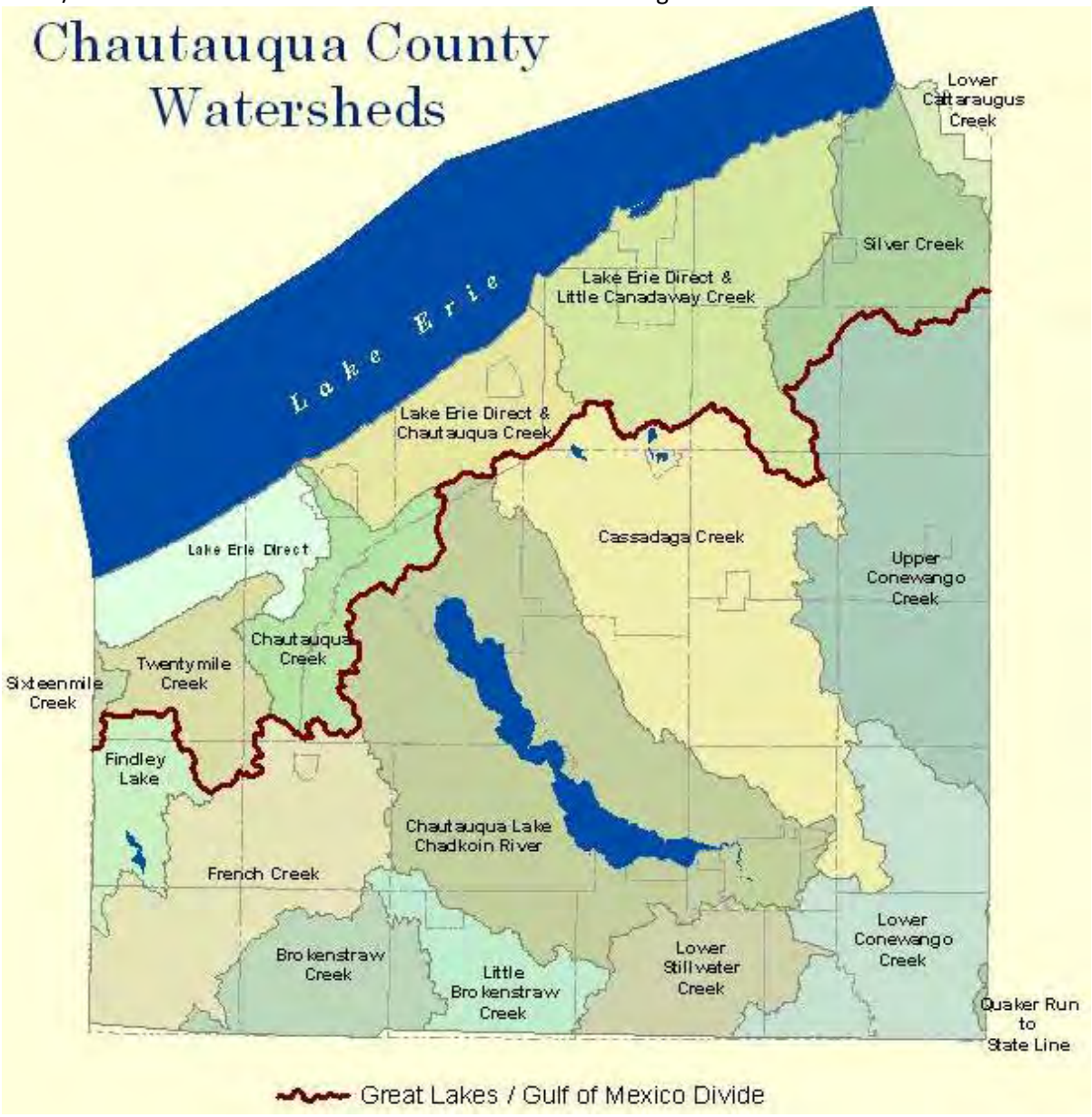


Figure 3. Map of Stream Watersheds and Beaches in the Sanitary Survey. The map illustrates the watersheds of the eight beaches and nearby tributaries.

History of Water Quality in Chautauqua County

Beaches

The CCDHHS has monitored bacteria levels in permitted bathing beach water since the 1970s. However, due to changes in EPA standards, CCDHHS bacteria data collected before 2004 is not comparable to recent data. Consistent with the evolving state standards, the CCDHHS stopped using fecal coliform as indicator bacteria and currently uses *E. coli*. Additionally, the existing EPA safe swimming standard bacteria limits are more conservative than previous guidelines, i.e. the number of colonies at which a sample is designated "unsatisfactory" has been lowered in recent years. CCDHHS currently uses the standard of 235 cfu/100mL to consider a sample "unsatisfactory".

On average, between 2007 and 2014, Wright Park East and Wright Park West had the highest percentages (31.1% and 30.9%) of unsatisfactory water samples (Chart 1). The beaches are adjacent to each other in the City of Dunkirk. The beaches have a variety of attributes which increase the likelihood of elevated *E. coli* levels, including the Hyde Creek and surface drainage culvert that separates them. Waterfowl, including gulls and geese, are frequently observed on the beaches as are their fecal droppings. Finally, physical characteristics of the beaches, including current interruption and sediment type, likely play an important role in the often elevated *E. coli* levels.

Other beaches with percentages exceeding 25% were Sunset Bay East, Main Street and Point Gratiot West. While Sunset Bay East (26.6%) and Point Gratiot West (28.1%) had relatively high percentages, their adjacent beaches Sunset Bay West (20.2%) and Point Gratiot East (22.8%) had notably lower percentages. The percentages were more comparable at the adjacent beaches on Town of Hanover (19.5% east, 18.5% west) and Blue Water Beach (22.8% east, 22.0% west). Sheridan Bay Beach had the lowest percentage by far with only 8.4% of samples being unsatisfactory.

Table 1 depicts the percentage of unsatisfactory samples collected per year per beach and the total number of samples collected each year. The total number of samples collected varies due to personnel availability and fluctuating intensities of data collection due to ongoing projects including sanitary surveys and predictive modeling. Three individual beach/year percentages (Town of Hanover East 2008 and 2011 as well as Sunset Bay East 2011) are italicized to identify them as percentages which *have not* been included in the Average Percentage by Beach or the Average by Year because the sample number was small (1-2 samples).

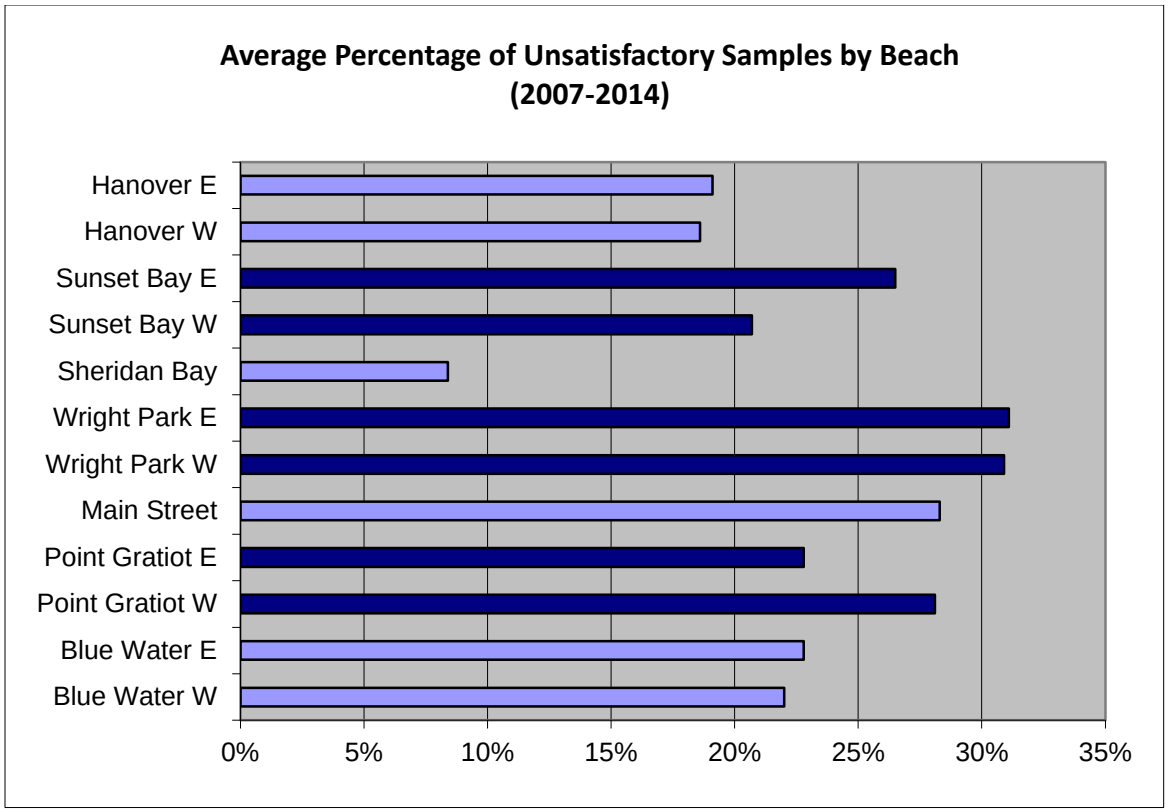


Chart 1. Average Percentage of Unsatisfactory Samples by Beach (2007-2014). The chart compares the percentages of unsatisfactory samples at Chautauqua County Lake Erie beaches. Beaches are divided into east and west when they operate multiple swim areas or have enough beachfront to allow for potentially different water conditions. Chart is based on Table 1 data.

Table 1. Percentage of Unsatisfactory Samples, with the total number of samples collected listed in parentheses. *Three percentages are not included in the averages due to the small number of samples collected.

BEACH NAME	2007	2008	2009	2010	2011	2012	2013	2014	Average
T. of Hanover East	0.0%	*0%**	31.3%	33.3%	*0%**	-	11.8%	-	**19.1%**
	(11)	*(2)*	(16)	(15)	*(1)*	-	(17)	-	
T. of Hanover West	15.4%	7.7%	23.5%	31.3%	23.5%	0.0%	20.0%	27.6%	**18.6%**
	(13)	(13)	(17)	(16)	(17)	(15)	(25)	(29)	
Sunset Bay East	16.7%	23.1%	43.8%	31.3%	*0%**	-	16.7%	27.3%	**26.5%**
	(12)	(13)	(16)	(16)	*(1)*	-	(18)	(22)	
Sunset Bay West	7.1%	28.6%	29.4%	31.3%	18.8%	0.0%	19.2%	31.0%	**20.7%**
	(14)	(14)	(17)	(16)	(16)	(15)	(26)	(29)	
Sheridan Bay Park	4.2%	5.3%	23.1%	4.0%	7.7%	6.7%	4.2%	12.0%	**8.4%**
	(24)	(19)	(26)	(25)	(13)	(15)	(24)	(25)	
Wright Park East	31.0%	18.2%	37.8%	37.8%	31.3%	33.3%	47.6%	11.5%	**31.1%**
	(42)	(22)	(45)	(45)	(16)	(18)	(42)	(26)	
Wright Park West	32.4%	20.0%	23.4%	32.7%	25.0%	38.9%	35.5%	39.3%	**30.9%**
	(74)	(25)	(47)	(55)	(20)	(18)	(76)	(61)	
Main Street	30.8%	9.5%	24.0%	43.2%	31.3%	35.3%	29.2%	23.1%	**28.3%**
	(26)	(21)	(25)	(44)	(16)	(17)	(24)	(26)	
Point Gratiot East	12.5%	13.0%	33.3%	24.5%	20.0%	15.8%	28.9%	34.0%	**22.8%**
	(40)	(23)	(36)	(53)	(20)	(19)	(45)	(50)	
Point Gratiot West	20.0%	13.0%	40.5%	37.2%	31.6%	27.8%	23.1%	31.3%	**28.1%**
	(45)	(23)	(37)	(43)	(19)	(18)	(13)	(16)	
Blue Water East	20.0%	14.3%	52.9%	30.8%	7.1%	12.5%	26.9%	17.9%	**22.8%**
	(15)	(14)	(17)	(13)	(14)	(16)	(26)	(28)	
Blue Water West	25.0%	18.8%	42.1%	13.3%	7.1%	6.3%	32.1%	31.0%	**22.0%**
	(16)	(16)	(19)	(15)	(14)	(16)	(28)	(29)	
Average	**17.9%**	**15.6%**	**33.8%**	**29.2%**	**20.3%**	**17.7%**	**24.6%**	**26.0%**	

Streams

It is difficult to describe historical water quality for many streams that were considered in the sanitary survey because CCDHHS does not routinely collect stream samples outside of special projects. Although stream investigation work is occasionally conducted by NYSDEC and SUNY Fredonia, projects generally focus on larger watersheds and are often limited in scope and duration. Therefore, stream information from external sources was also difficult to find, especially for the three streams which are not even named on Chautauqua County, NYSDEC or USGS maps.

However, the streams around the Dunkirk beaches have been monitored fairly frequently following peaked interest in Dunkirk beach water quality in the early 1990s. The Dunkirk streams are also good study subjects for SUNY Fredonia research due to their size and proximity to the university. For example, research by SUNY Fredonia Geomorphology students along with CCDHHS staff and community volunteers demonstrates that Canadaway Creek has the greatest flow among the Dunkirk streams, followed by Crooked Brook and Hyde Creeks.

The Lake Erie Schools Final Report (2002) described Canadaway Creek discharge at 1.8 ft^3/sec during low flow and 200 ft^3/sec during typical high flow. During rare and severe storm events, discharge has been measured as high as 4,000 ft^3/sec in Canadaway Creek.[3] The same source reported discharge for Crooked Brook at 0.4 ft^3/sec during low flow and 90.0 ft^3/sec during high flow. Additional student projects report an average discharge of 0.67 ft^3/sec for Hyde Creek.[4] Discharge measurements for Goose Creek were not recorded but summer observations by CCDHHS staff note that the small stream frequently dries up before the channel is directed underground into City of Dunkirk drainage infrastructure. Presence or absence of the stream is dependent on seasonal rain patterns. Additional water chemistry results for the streams were available to CCDHHS following SUNY Fredonia sampling efforts in 2007-2009 (Table 2).

Table 2. Dunkirk Stream Water Chemistry Averages (2007-2009). SUNY Fredonia sample results for stream discharge points.

	Phosphate (mg/l)	**Nitrate** (mg/l)	**pH** *(2007 only)*
Canadaway Creek *(2007-2009)*	0.16	0.29	7.21
Crooked Brook Creek *(2007-2009)*	0.63	0.31	7.10
Goose Creek / surface drainage *(2008 only)*	0.15	0.24	
Hyde Creek *(2007-2009)*	0.57	0.68	7.14

Based on CCDHHS records, the *E. coli* levels in the Dunkirk streams generally exceed EPA guidelines for safe recreational water. Canadaway Creek routinely demonstrates lower *E. coli* counts than Crooked Brook and Hyde Creeks. The lower Canadaway Creek *E. coli* levels were seen again in the 2013-2014 data. However, considering the size of the three stream watersheds and discharge volumes, Canadaway Creek probably transports more fecal indicator bacteria overall to Lake Erie.

The large culvert on Main Street Beach which includes the limited, and frequently non-existent, flow of Goose Creek as well as surface drainage from the City of Dunkirk consistently

has the highest *E. coli* levels. However the construction of the culvert below lake level results in stagnant water sitting in the shaded culvert and pooling out onto the east area of Main Street Beach. Additionally, dune construction on the beach created a trench along the retaining wall that connects to the culvert pool and frequently fills with water. Waterfowl and their feces are frequently observed in the pool area, making it impossible to discern how much *E. coli* originates from the culvert alone.

Table 3. Average Stream *E. coli* Results. The results are displayed in cfu/100 ml. Samples were collected from discharge points onto or near beachfronts. Minimum and maximum results are italicized under the averages. "X" indicates when samples were not routinely collected.

	2012	**2013**	**2014**
Sunset Bay stream	1823 *640-4320*	2918 *480-7300*	X
Sunset Bay drainage pond	33 *9-70*	X	X
Sheridan Bay Park stream	564 *9-1920*	X	X
Hyde Creek (Dunkirk)	1081 *40-6000*	1557 *40-10800*	1479 *40-13900*
Goose Creek/ surface drainage (Dunkirk)	2305 *310-8000*	60595 *1400-496000*	X
Crooked Brook Creek (Dunkirk)	1250 *160-4000*	2059 *80-12400*	2086 *340-11600*
Canadaway Creek (Dunkirk)	X	1250 *110-9000*	1149 *54-6400*
Blue Water Beach stream	2230 *640-3750*	1849 *120-8800*	1605 *300-3400*

CCDHHS used *E. coli* results, stream flow, and the distances between stream discharge and beachfront to determine which streams have the greatest potential effect on beach water quality. Streams were removed from routine sampling when they were determined to have low potential effect on beach water quality or when *E. coli* levels had been well documented. For example, CCDHHS stopped sampling at the at the Main Street Beach culvert location in 2013 because the high *E. coli* levels had been well established and the pooling problems continued to distort the *E. coli* contributions from Goose Creek and surface drainage alone.

Samples collected in 2009 and 2012 from the four Dunkirk streams and the small Sunset Bay stream were submitted for human specific *Bacteroides* analyses. Samples from the areas of discharge as well as samples further upstream tested positive for human specific *Bacteroides,* suggesting sewage contamination. The watersheds of the analyzed streams include rural areas where private sewage disposal systems (SDS) are required. While the positive *Bacteroides* results suggest there are inadequate SDSs throughout the watersheds CCDHHS is concerned that the test could also be detecting effluent from adequately functioning SDSs. Since the test

does not quantify the *Bacteroides* results it cannot be used to narrow the search for specific systems.

Chautauqua County Pollution Source Survey

The streams that discharge onto or near Chautauqua County beaches were identified as pollution sources. However, within the watersheds of the streams relatively few point sources of pollution have been identified in recent years. Rather, many of the sources identified are non-point sources and are therefore much more difficult to monitor, regulate, and control.

Wildlife

The effects of wildlife inhabiting the beaches and the watershed of the system are an example of a potential pollution source that is difficult to regulate and control. Wildlife within the watershed of the beach system contributes *E. coli* as surface water carries fecal material into the creeks and subsequently into Lake Erie. Wildlife also contributes directly to beach water pollution when they visit the beach and leave behind fecal material. Waterfowl and mammal carcasses that originate on the beach or are carried to the beach by streams also serve as infrequent pollution sources. While groundhogs, raccoons, feral cats and deer tracks have all been observed on Chautauqua County beaches, waterfowl are by far the most common wildlife observed on the beaches.

Waterfowl including gulls and geese maintain a presence on roughly half the beaches in Chautauqua County. The day to day changes in the number of waterfowl on a specific beach does not correlate with changes in day to day *E. coli* results. However, waterfowl are almost always observed on or near Wright Park West, Wright Park East, and Main Street beaches frequently in numbers greater than 100. Wright Park West, Wright Park East, and Main Street beaches have the highest overall percentages of unsatisfactory results among the Chautauqua County beaches investigated.

Agriculture

With 236,546 acres of "land in farms"[5] agriculture is one of the most important industries in Chautauqua County. A majority of the beaches in the sanitary study are bordered by urban areas, but the streams that discharge onto or near the beaches often extend beyond the urban areas into rural agricultural areas. General animal waste as well as manure used for fertilizer may contribute fecal bacteria, such as *E. coli*, as well as nitrogen and phosphorous to nearby waterways. Crop production including grapes, corn, legumes and berries is prevalent within the watershed of Lake Erie. Livestock are also present within the Lake Erie watershed, but are more common in other areas of the county outside the Lake Erie watershed.

Besides the bacterial problems associated with animal manure, there are a number of other ways in which agricultural runoff contributes to pollution. Chemical fertilizers containing nitrogen and phosphorous can get washed into streams and contribute to nutrient loading in the waterways. Additional chemicals from herbicides and pesticides can poison local flora and fauna. Silage leachate runoff can result in decreased oxygen availability in waterways while general erosion problems can decrease water clarity and reduce benthic fauna populations.

Urban Runoff

Six of the eight beaches in the sanitary survey are bordered by urban/residential areas. Animal feces from pets and urban wildlife as well as possible infrastructure leakage contribute to the *E. coli* levels in urban runoff. The impermeable surfaces of urban areas move water

quickly such that suspended contamination does not have the opportunity to settle out of the water before it reaches storm drains and tributaries. Urban runoff undoubtedly reaches all six of the beaches bordered by urban areas and potentially impacts water quality. However the size of the urban area, the change in elevation between the beach and the surrounding area, and the soil/sediment type all play a role in the actual impact of urban runoff on beach water quality.

Urban runoff is transported to the lake via storm drain infrastructure and/or urban waterways. Urban runoff is especially problematic for beach water quality when storm drains and/or urban water ways discharge on or very near beach areas. The four Dunkirk beaches, Point Gratiot, Main Street, Wright Park West and East all have urban runoff discharge bordering or emptying onto the beach area.

Chautauqua County Fairgrounds

The Chautauqua County Fairgrounds, specifically during Chautauqua County Fair week, were identified as a point source of pollution in a 2008/2009 sanitary survey of Dunkirk beaches. Very few animals are housed on the grounds year-round, but during the Chautauqua County Fair, held annually for a week in late July, the fairgrounds host hundreds of animals. The fairgrounds are located in the City of Dunkirk directly above Crooked Brook Creek. The creek has been manipulated to run under the fairgrounds and receives animal waste in the runoff that results from rain and the frequent hosing down of animals and stalls. However, Chautauqua County Fairgrounds authorities have enacted new policies regarding the way in which animals and waste are handled to reduce contamination runoff.

Additionally, the creek channel itself was altered in early 2012 to include a retention pond directly after the culvert that carries the final outfall from the fairgrounds to the open creek channel. The pond covers approximately 5000 ft^2 including 110 ft of the creek channel. The calm water of the pond allows contaminants to settle out of the water column while wetland vegetation acts as a filter to improve the overall water quality of the pond effluent. Based on sampling before, during and after the fair week, the pond decreased *E. coli* most efficiently when the incoming *E. coli* was relatively low (Table 4). As wetland vegetation density increases CCDHHS and CC Fairgrounds staff expects the retention pond will be even more effective at reducing bacterial contamination.

Table 4. Chautauqua County Fairgrounds Retention Pond Sampling. *E. coli* results are represented as cfu/ 100ml of sample water.

Sample Date	7/19/12	7/26/12	8/1/12	8/9/12	7/25/13	7/30/13
E. coli Before Retention Pond	1620	12000	2840	1700	13600	3100
E. coli After Retention Pond	150	9600	1240	450	9500	1400
Percent Reduction	90.7%	20.0%	56.3%	73.5%	30.1%	54.8%

Photograph 1. Retention Pond on Crooked Brook Creek, Chautauqua County Fairgrounds 2012.

Photograph 2. Retention Pond on Crooked Brook Creek, Chautauqua County Fairgrounds 2015.

Sewage

There are a few ways in which improperly treated sewage could be potentially transported through the watershed and into Lake Erie:

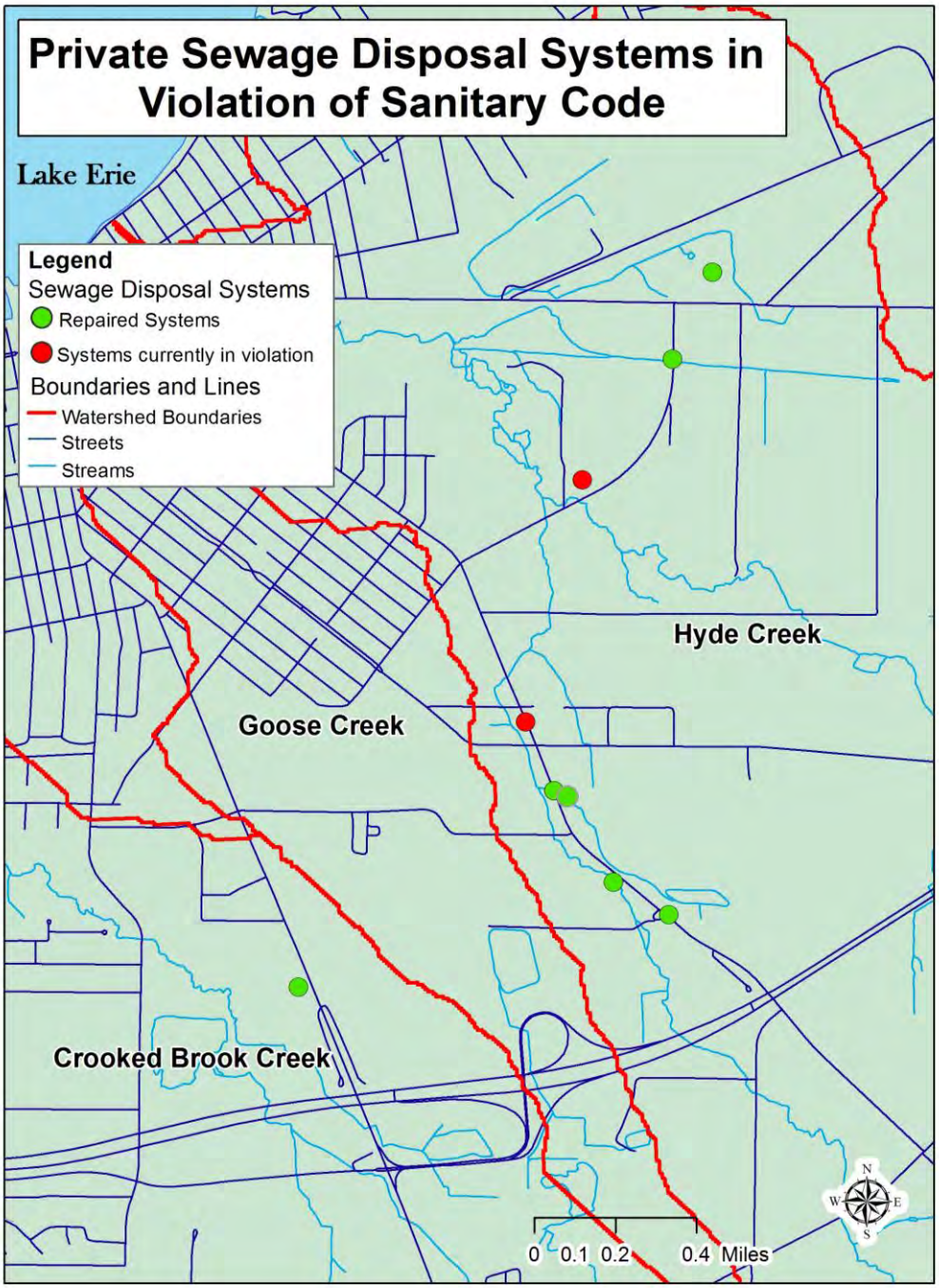
- Effluent outfalls from inadequate or illegal private sewage disposal systems may be located near ditches or stream channels.
- NYSDEC regulated wastewater treatment facilities with outfall pipes in the watershed and directly into Lake Erie may violate their allowable discharge standards and limits when the systems are stressed.
- Possible illegal connections to storm water systems may allow greywater or blackwater to pass into storm drains and be carried directly to the lakeshore.
- Aging infrastructure can rupture or leak, allowing wastewater to escape.
- Sewage waste may be dumped offshore by boaters; although it is not permitted it may occur at a small scale.

Large areas within the watersheds of concern are outside the boundaries of municipal sanitary sewer lines and residents are required to install sewage disposal systems (SDSs). Private SDSs are regulated through the CCDHHS but the enforcement of these regulations is sometimes difficult. Systems that were installed prior to 1968 did not require permits so CCDHHS cannot be sure if the systems are adequate or functioning correctly. Illegal systems are occasionally installed and represent another example of potentially inadequate and improperly functioning systems. The CCDHHS estimates that it has permit records for roughly 75% of the septic systems within the watersheds. Even when permit records exist there is no way of knowing for sure that homeowners are maintaining their systems appropriately.

CCDHHS aims to identify inadequate systems in a number of ways. Sewage surveys are mandated in "property sales and instances when a lending institution requires it for property refinancing" under the Sanitary Code of the Chautauqua County Health District, Article III – Real Property Transfers. The surveys also require septic tanks, treatment units and holding tanks be pumped by a NYSDEC–licensed waste hauler unless the property owner has proof that they've been pumped in the last three years. Unpermitted SDSs and those installed more than 30 years ago, on properties within 250 feet of Lake Erie, are subject to further scrutiny. In addition to the pumping requirements, the entire SDS must be uncovered so inspectors can observe and document the system. However if the property does not change hands, it is left to property owners or complaining neighbors to report a failing system.

Recognizing the potential pollution that faulty SDSs could be contributing to the watersheds and Lake Erie, the CCDHHS targeted areas outside municipal sanitary lines and identified 36 properties to specifically investigate. The properties were targeted based on the proximity of structures to waterways and the lack of recent information regarding existing SDSs. Specifically, CCDHHS investigated 36 properties that either did not have a SDS permit on record or had a SDS permit older than 25 years. The properties were visited by a CCDHHS Public Health Sanitarian and existing systems were dye tested to determine their efficiency. Eight SDSs were identified as inadequate along Hyde Creek; six of those handle human waste, one handles only grey water and pet waste. A single human waste system was identified as inadequate along Crooked Brook Creek (Figure 4. Map of Inadequate and Repaired SDSs).

Figure 4. Map of Inadequate and Repaired Private SDSs.

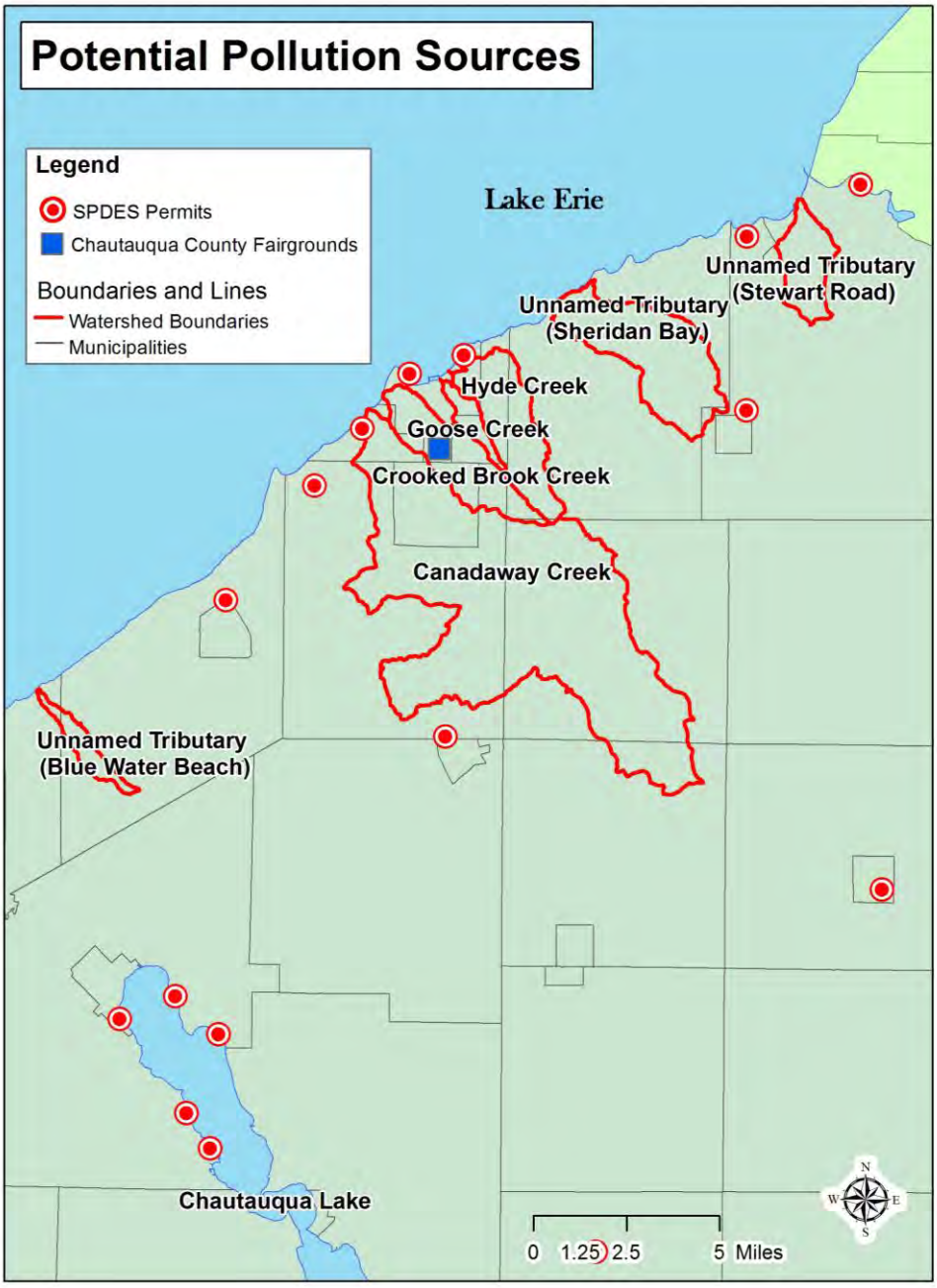


The private SDSs inspections revealed that some property owners knew nothing of their SDSs while others knew that their system was in violation and simply had not addressed the issues. The majority of failing systems found in the 2013/2014 investigation were corrected by August 2014. However, due to the high costs associated with installing SDSs or replacing their components, some property owners had a difficult time raising the money necessary to fix their

deficient systems. The high percentage, 25% of the systems investigated, of deficient systems raises concern for the state of private SDSs throughout Chautauqua County.

There are a number of facilities in Chautauqua County that have been issued NYSDEC SPDES permits including municipal wastewater treatment plants, campgrounds, mobile home parks, and businesses. Large facilities in Chautauqua County are shown in Figure 5. SPDES permits regulate the amount of discharge as well as water chemistry standards depending on the nature and location of the facility. All SPDES facilities are required to treat and monitor effluent to ensure that treatment is adequate.

Figure 5: Location Map of Pollution Sources.



The most obvious potential threat of sewage pollution to Lake Erie comes when exceptions to the SPDES treatment regulations are allowed. Combined sewer overflow events are occasionally allowed from municipal wastewater treatment plants that have combined surface drainage and sanitary line infrastructure, such as the City of Dunkirk WWTP. In times of heavy rainfall or snowmelt the lines carry uncommonly large amounts of water to the plant. Holding tanks provide some opportunity for treatment plants to dose the incoming combined wastewater with chlorine, but when the influx of water continues beyond holding tank capacity the plant is allowed to bypass treatment and discharge the combined wastewater without treatment. Inflow and infiltration due to aging infrastructure and illegal sanitary connections (i.e. basement sump pumps and downspouts) also contribute to the volume of water sent to the plant during periods of heavy rainfall or snowmelt.

Aging sanitary infrastructure may also be contributing to bacteria loading problems throughout Chautauqua County. Although CCDHHS has not been able to identify any illegal connections or major leaks in the sewer infrastructure unidentified small ruptures and leaks are possible. As the aging infrastructure in Chautauqua County continues to degrade, sanitary line ruptures and leaks will become more common. When sanitary line failures increase so, too, does the amount of untreated wastewater in urban runoff. The bacteria laden runoff then reaches surface drainage systems and empties into urban waterways or discharges directly onto beaches. The Dunkirk beaches (Point Gratiot, Main Street, Wright Park West and East) would be the most susceptible to contamination due to urban runoff.

Two areas of concern within the City of Dunkirk were investigated on May 20, 2015. The first area was a section of Crooked Brook Creek that has been manipulated to run underneath homes and streets before emerging near a forested residential area. The section of Crooked Brook Creek was chosen in large part because of its relative proximity to the mouth of the creek and a general lack of knowledge as to the structure and integrity of the tunnel. Samples were collected at either opening of the tunnel and at the midpoint (Table 5). CCDHHS staff did not observe any suspicious pipes or leaks in the tunnel so additional sampling was not warranted.

The second area lies upstream of the Main Street Beach culvert at a major intersection that was known to have connected sanitary lines into storm lines in the past. City of Dunkirk records show the problem was corrected in the 1970s but follow-up inspections had not been conducted to determine the efficiency and integrity of the repairs. The results of multiple sample locations gave no indication of sanitary line connection or leakage (Table 5).

Table 5. Dive Investigation of Storm Drainage and Urban Creeks in City of Dunkirk, 5/20/2015.

	E.coli cfu/ 100ml	*Bacteroides*	Nitrate (mg/L)	Nitrite (mg/L)	Total Phosphate (mg/L)	Caffeine (ppm)	Optical Brightener Tests
Crooked Brook Creek discharges as western border of Point Gratiot Beach							
Bridge @ Route 5	300	Positive	0.370	<0.0250	<0.0250	<1.0	NEGATIVE
Downstream of Brigham Rd. culvert	300	Positive	0.455	<0.0250	<0.0250	<1.0	NEGATIVE
mid-culvert between Brigham & Woodrow St.	200	Positive	0.440	<0.0250	<0.0250	<1.0	inaccessible
Upstream of Woodrow St. culvert	440	Positive	0.456	<0.0250	<0.0250	<1.0	NEGATIVE
Goose Creek / storm drain discharges onto Main St. Beach							
Main St. Beach culvert	1200	Positive	0.103	<0.0250	<0.0250	<1.0	tests invalid
*Manhole @ Roberts & Gazelle St. (substitute location for Goose Crk/storm sewer @ Main St. Beach)							NEGATIVE
Manhole @ Talcott & Townsend St.	760	Positive	0.317	<0.0250	<0.0250	<1.0	NEGATIVE
Roberts Rd storm drain before mixes w/Talcott St.	200	Positive	0.984	<0.0250	<0.0250	<1.0	inaccessible
clay pipe, upstream from sanitary line crossing	<20	not submitted	0.826	<0.0250	<0.0250	<1.0	inaccessible
junction box, upstream from sanitary line crossing	100	Positive	0.965	<0.0250	<0.0250	<1.0	inaccessible

Facilities other than those dealing with sewage waste also affect Lake Erie water quality, but if and how bacteria is affected is unclear. For example, located between Point Gratiot Beach and Main Street Beach, the Dunkirk Steam Generating Station (NRG Station) is a power plant that burns coal to generate steam and provide power to the region. The plant maintains a NYSDEC State Pollutant Discharge Elimination System (SPDES) permit (#NY-0002321) because it pulls water in from the lake to cool the machinery; the heated water is then discharged into the lake system. The hot water released into the lake could create stable temperature conditions beneficial for bacterial growth; however its actual impact on bacteria population dynamics is unknown.

Although offshore dumping in the Great Lakes is prohibited by the U.S. Coast Guard it is difficult to enforce the regulation. Within Chautauqua County a number of boat launch locations including Sunset Bay, the Dunkirk Harbor (Chadwick Bay Marina), and the Barcelona Harbor (in Westfield) have pump out stations for vessel sewage. However, it's difficult to evaluate the extent to which individual boaters use the pump out stations.

E. coli in Beach Sand, Stream Sediment, and Algal Mats

Numerous academic studies have revealed problems associated with using *E. coli* as an indicator of fecal contamination, in large part because *E.coli* bacteria originates from a wide variety of warm blooded animals and persists in the environment in the absence of recent contamination.[6] Multiple studies suggest that higher *E. coli* levels in beach and lake sediment point to sediment as a potential source of *E.coli* pollution because it acts as a "reservoir" for *E. coli*.[7,8] Beyond simply persisting in sediment, research demonstrates that *E. coli* replicates in moist sand environments independent of additional contamination.[9] Therefore, *E. coli* levels can be elevated anytime wave action extends the swash zone of a beach and washes bacteria into the nearshore area or resuspends lake sediment.

In 2007-2009, Dr. Ted Lee of SUNY Fredonia examined water and sediment samples from Dunkirk beaches and three creeks that discharge near the beaches. By comparing the DNA of *E. coli* isolated from beach water with known sources of *E. coli*, including beach sand, Dr. Lee concluded that significant portions of *E. coli* isolated from the beach and creek samples was "not fecal in origin". Rather, Dr. Lee's work supports research from other Great Lakes beaches suggesting *E. coli* present in the water column originates from a number of sources beyond human fecal contamination, including beach sand and lake sediment.[10]

Beyond the beach, USDA research demonstrates that *E. coli* can survive in stream sediment for several months and even through winter months.[11] In addition to underwater sediment, *E. coli* survives in "bank sediments and sediments along spring margins" often with survival rates related to sediment moisture.[12] Many of the Lake Erie beaches in Chautauqua County have tributaries that drain on or near the beach. *E. coli* counts above 235 cfu/100ml were frequently recorded near the outfalls of the tributaries that discharge onto or near the Chautauqua County beaches. Further investigation of the tributaries revealed elevated *E. coli* levels throughout the tributaries often regardless of the surrounding land use and in the absence of outfall pipes discharging into the stream channel. Therefore any disturbance to the stream sediment, including rain events or physical aggravation, has the potential to increase *E. coli* levels in stream water which discharges to the lake.

Algae, specifically *Cladophora*, can also act as an *E. coli* source. Varying amounts of *Cladophora* is frequently observed on the Chautauqua County beaches and in the nearshore areas especially following rough water conditions. Main Street and Wright Park East beaches frequently have large build-ups of *Cladophora* in late July and August, depending on wave activity. The research shows that *E. coli* not only survives but actually thrives in *Cladophora* accumulations due to the nutrient availability in algal leachate and protection from the sunlight that can kill *E. coli* bacteria.[13] Depending on weather and shoreline structure, *Cladophora* accumulations on the beaches may be present for a matter of days or even weeks during the summer. Subsequent wave activity can then bury the algae under sand where *E. coli* receives even more protection from sunlight and temperature fluctuations that can kill the bacteria. Furthermore, Byappabahalli and colleges showed that *E. coli* can survive in algal mats even through dry, winter conditions and grow upon rehydration of the mats.

Evaluation of Pollution Sources and their Magnitude

Following multiple years of investigation, relatively few point sources of pollution have been identified in the Lake Erie watershed of Chautauqua County. CCDHHS identified Chautauqua County Fairgrounds (CC Fairgrounds) and nine private sewage disposal system (SDS) violations as point sources of pollution. Stream investigation, including incremental sampling, revealed elevated *E. coli* levels throughout the creeks, up to the headwaters. Spikes in the *E. coli* levels of beach water and stream discharge following significant rainfall suggest that agricultural and urban runoff is a large contributor to the *E. coli* loading that occurs in beach water.

The CC Fairgrounds represent an annual, short-lived point source of animal fecal waste to Crooked Brook Creek. However, CC Fairgrounds staff recognizes the problem and continues to take remediation action including the construction of the retention pond and continued efforts to improve the methods by which animal waste is handled at the facility. Bacterial testing consistently showed a decrease in the *E. coli* concentrations downstream from the retention pond and revealed the pond to be especially effective when CC Fairgrounds was not hosting the CC Fair. Therefore, any year-round contributions from the fairgrounds are well mitigated by the retention pond.

Individual, faulty private SDSs may not have a major impact on beach water quality, especially if the system is a large distance upstream from the mouth of the tributary. However, the collective impact of faulty systems throughout Chautauqua County is potentially significant. The 2013/2014 targeted investigation of properties adjacent to Hyde and Crooked Brook Creeks revealed that 25% of the private SDSs inspected were failing or inadequate. Based on human positive *Bacteroides* results in multiple Chautauqua County streams, the percentage of inadequate SDSs found in the targeted investigation of Hyde and Crooked Brook Creeks, as well as anecdotal evidence CCDHHS suspects that additional failing or insufficient SDSs exist further upstream and in other Lake Erie tributaries. The collective contributions of faulty private SDSs represent a year-round source of *E. coli* in the Lake Erie watershed.

Other potential sewage sources are more variable and may have a negative effect on the overall health of Lake Erie but a minimal effect on Chautauqua County beaches. If boaters are dumping sewage waste offshore, this is probably happening at a large enough distance from the beachfront that beach water quality is hardly affected. Aside from occasional combined sewer outflow CSO events, SPDES permitted facilities in Chautauqua County are in good standing. When CSO events do occur, the location and proximity of discharge pipes from the beaches of concern limits their potential impact on beach water quality.

Sources of *E. coli* in agricultural and urban runoff include animal waste, manure fertilizer, sediment bacteria and possibly infrastructure leakage. Heavy rainfall highlights the impact of runoff on water quality. During periods of heavy rainfall (≥0.5 inches), regular stream sampling locations near corn and grape fields demonstrated *E. coli* counts more than double the normal counts (3,000-5,000 compared to 200-700) during the 2008-2009 Sanitary Survey Study of the Dunkirk Beaches.

Of the beaches investigated, urban runoff has the biggest impact on Dunkirk beach water quality due to the sheer size of the surrounding urban area and the surface drainage patterns of the city. The combined sewer system and funneling of surface drainage into streams within Dunkirk city limits makes it difficult to accurately assess the amount or impact of

urban runoff. Discharge from the small surface drainage pipes in the retaining wall that borders Wright Park West and Main Street beaches was only observed during or immediately following heavy rainfall, suggesting that the drains are not likely carrying water from consistent wastewater sources.

In contrast, the large culvert on Main Street beach always has water in it, often in a stagnant pool that extends into the trench along the retaining wall. The lack of flow makes it difficult to discern how much of the *E. coli* loading is from urban runoff or from the compounding problem of the stagnant pool. Regardless, the pool consistently has very high *E. coli* levels and typically connects to the lake through a small channel.

Although the severity of its impact is unknown, wildlife, livestock, and domestic animal feces add to bacterial pollution in streams and beach water throughout the year. When heavy rainfall or snowmelt flushes stream watersheds and urban areas bacteria loading at stream and drainage discharge points is especially problematic. The consistent presence of large numbers of waterfowl on Wright Park East, Wright Park West and Main Street beaches and the high ranking of these beaches based on unsatisfactory *E. coli* results suggests that waterfowl presence on beaches does impact water quality. Waterfowl feces that is not immediately washed into the nearshore area could augment the problem of naturalized bacteria in beach sand by introducing fresh *E. coli* and adding nutrients that existing *E. coli* need to grow.

Based on the growing research and the identified presence of *E. coli* in Dunkirk beach sand, CCDHHS suspects that naturalized fecal indicator bacteria may be contributing to the unsatisfactory results at a majority of Chautauqua County Lake Erie beaches. The impact of naturalized bacteria is complex, but is strongly related to the physical characteristics of individual beaches and the amounts of new bacteria and nutrients that are introduced to beach areas.

Physical Factors Affecting Distribution and Concentration of Microorganisms

Land Use

The physical characteristics of individual beaches and their surroundings determine the pathways by which contamination moves through a beach system. In an undeveloped area, runoff that is not absorbed into the ground would simply flow into natural stream channels or downhill where it could potentially cross beaches to reach the lake. The natural path of runoff is interrupted in developed areas where storm and street runoff is diverted by storm drains. This is especially true of combined sewer systems, like that in the City of Dunkirk, which divert surface water to wastewater treatment plants.

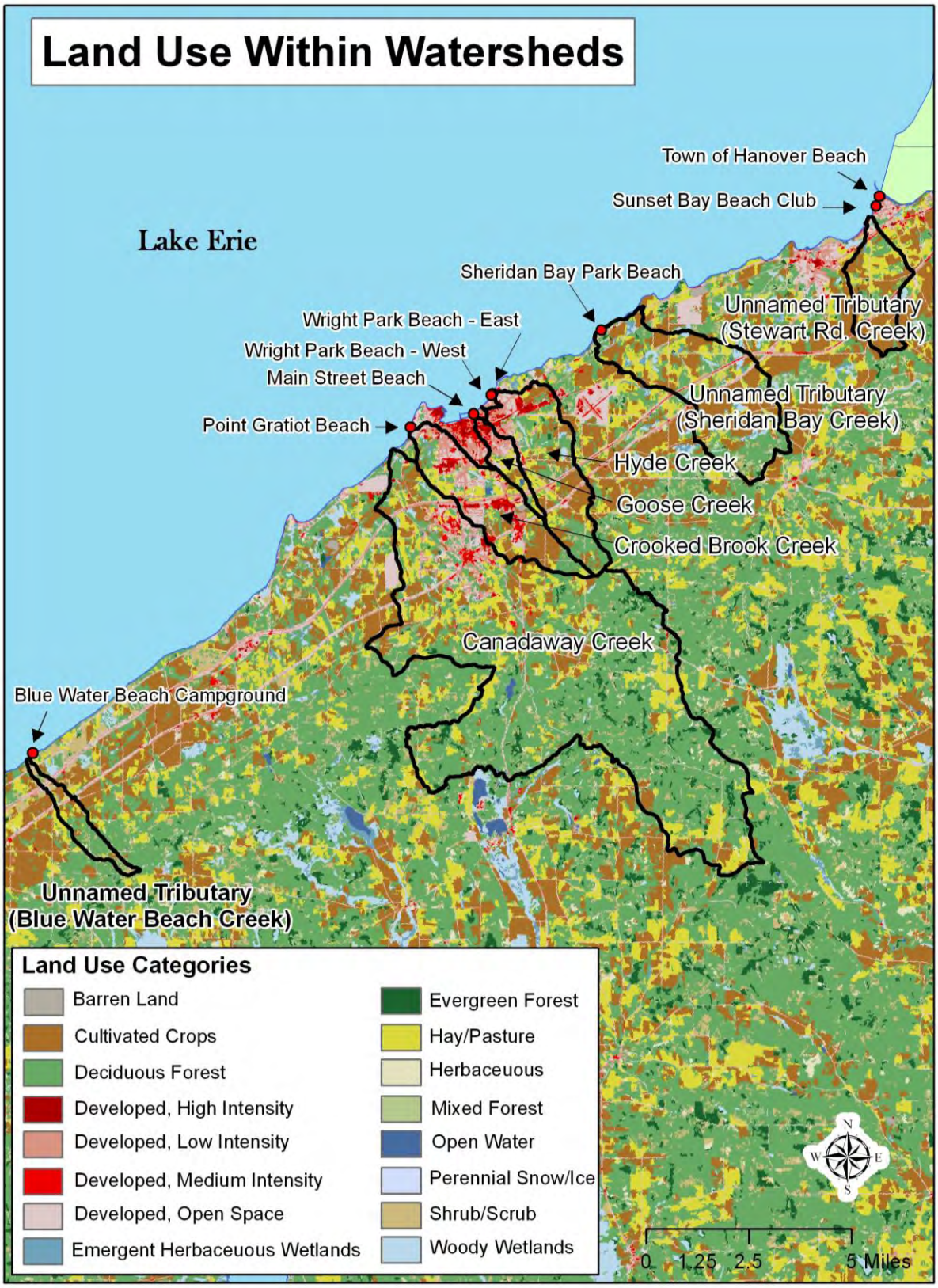
The impermeable surfaces associated with developed land serve to increase the amount of water that is diverted into storm drains and the speed at which it travels. As the speed of moving water increases, the potential for contamination to settle out of the water decreases and the potential for sediment disturbance increases. The majority of Lake Erie beaches in Chautauqua County are bordered by developed land to various degrees.

Land use within creek watersheds is also relevant to water quality, primarily when those creeks empty onto or near beaches. Much of Chautauqua County is rural and agricultural; including both crop fields and livestock pastures. Large areas of agricultural land lie within the watersheds of the creeks included in our sanitary surveys. Contaminants including animal wastes, pesticides, herbicides and fertilizers may be carried to the streams and Lake Erie in runoff water. Land use figures for watersheds contributing to the Lake Erie Beaches in Chautauqua County are outlined in the individual beach reports.

Land use was measured using a combination of ArcGIS Spatial Analyst, MRLC 2011 National Land Cover Database[14] maps and maps created in the USGS Streamstats Program[18]. The zonal histogram tool in ArcGIS Spatial Analyst Toolbox was used to calculate land use statistics from MRLC 2011 National Land Cover Database[14] , using watersheds as areas to capture. Tributary watersheds for each beach were downloaded from the USGS Streamstats Program[18].

The map figures were generated by CCDHHS staff. Sample locations and other point data were measured in the field. Most raster and vector overlays were generated from internal database connections. MRLC NLCD was downloaded from the USGS website, as were watersheds generated using the StreamStats tool.

Figure 6. Land Use in the Watersheds of Lake Erie Beaches.[14]



Elevation and Beach Slope

Land adjacent to beaches has at least a slightly higher elevation causing water to flow downhill onto the beaches. Big changes in elevation between the beach and the surrounding area could increase the speed at which runoff travels. Compared to other beaches in the sanitary survey, the Sunset Bay beaches have relatively small changes in elevation between the surrounding residential area and the beach area.

Drastic beach slopes can also increase the speed at which runoff travels to the lake. In contrast, water moves more slowly over gentle beach slopes, allowing contamination to settle out and water to be absorbed into the ground. Therefore, runoff crossing beaches with more drastic slopes is more likely to negatively impact water quality by carrying more contamination.

However, gentle beach slopes leave more surface area vulnerable to rising lake levels. Furthermore, the swash zone of a beach with a gentle slope will be larger than that of a beach with a drastic slope. This is particularly important when considering the potential for beach sand to act as a reservoir for fecal indicator bacteria.

Beach Sediment

The type of beach sediment in Chautauqua County varies from predominately small grain sandy beach sediment to pebbly and rocky beach sediment. The type of sediment both on the beach and in the nearshore areas is especially important when considering the potential role of beach sand as a source of fecal indicator bacteria contamination. For example, the flat shale in the nearshore areas of beaches like Sheridan Bay Park Beach does not support bacterial growth as well as nearshore areas with small grain sands or silts. Additionally, the rocky, pebbly, sand on Sheridan Bay Park Beach is less likely to support bacterial growth than the small grain sand beaches of Wright Park West and Sunset Bay Beach Club beaches.

Hydrographic and Meteorological Characteristics

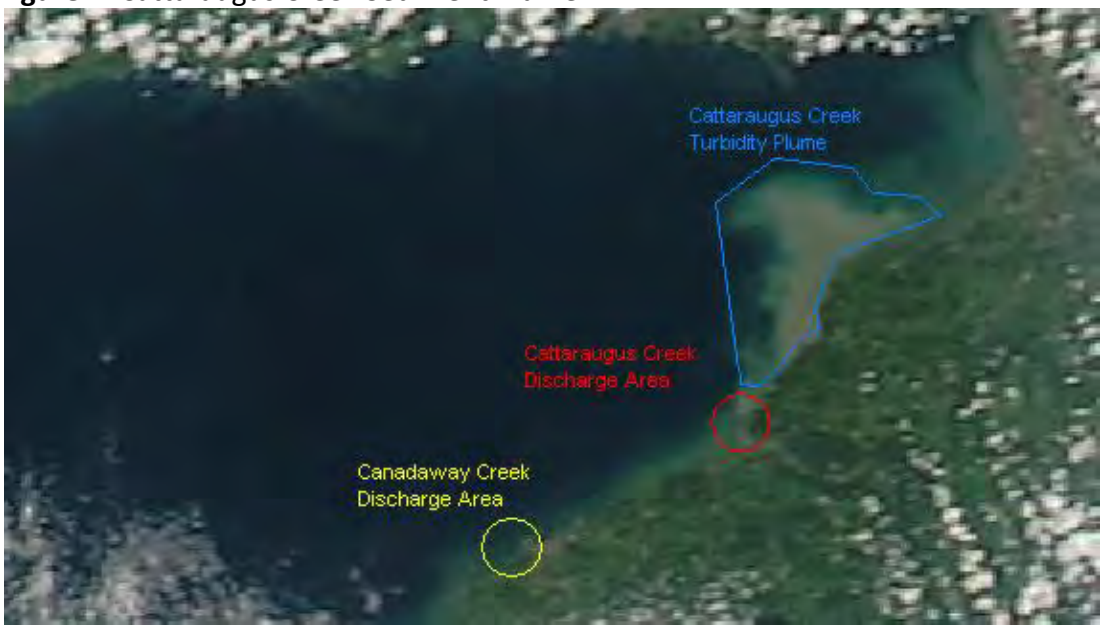
Currents

Beletsky, Saylor and Schwab (1999) characterized currents in the Eastern Basin of Lake Erie by season: currents were westward in the summer, eastward in the winter, and eastward as an annual average current in the Eastern Basin of Lake Erie.[15] Personal observations of Lake Erie currents and sediments by Dr. Mike Wilson of SUNY Fredonia were published in *Potential Uncontrolled Release of Radioactive Waste from WVDP Site and Contact with Waste Utilities* (2008).[16] Over forty years, Dr. Wilson has conducted numerous measurements of stream discharge, stream and lake ice growth and decay, and stream and coastal sediment transport. He determined that sediment transport in longshore drift was totally responsive to wind direction and consequent wave direction, frequently reversing from the general east to west pattern with passing weather fronts.[16]

Subsequent spring-time NOAA wind measurements and current directions supported Wilson's observations. The measurements determined that longshore currents adjacent to the southeast coast of Lake Erie were eastward approximately 78% of the time, westward approximately 18% of the time, and in transition approximately 4% of the time. These measurements indicate that Chautauqua County stream discharge into Lake Erie will likely travel east with predominant longshore currents.[16]

Additionally, satellite imagery (Figure 7) from the MODIS AQUA Polar Orbiter Satellite provides information regarding lake currents through the demonstration of turbidity plumes. On August 9th 2009, Chautauqua and neighboring counties experienced an extreme rainfall event in which roughly three inches of rain fell in the Dunkirk area and more than six inches of rain in the Silver Creek- Gowanda area. Figure 7 depicts turbidity plumes from Canadaway and Cattaraugus Creeks following the uncommon rain event. The photo was downloaded from the Space Science and Engineering Center at the University of Wisconsin-Madison.[17] The large, distinctive Cattaraugus Creek plume demonstrates the lake current's direction to the northeast.

Figure 7. Cattaraugus Creek Sediment Plume.[17]



Rainfall

Variation in the average percentages of unsatisfactory *E. coli* results (Table 1. Percentages Unsatisfactory *E. coli* Results, page 9) suggest that yearly fluctuations, such as meteorological activity, affect bacteria levels in beach water. A relationship between rainfall and the percentage of unsatisfactory samples is apparent in Chart 2. The total seasonal rainfall including June, July and August and the average percentage of unsatisfactory samples by year have a correlation coefficient of 0.608 indicating a moderate positive relationship. Steady flow from tributaries and localized runoff consistently bring sediment, bacterial contaminants, nutrients, etc. to Lake Erie, but increased rainfall means increased runoff.

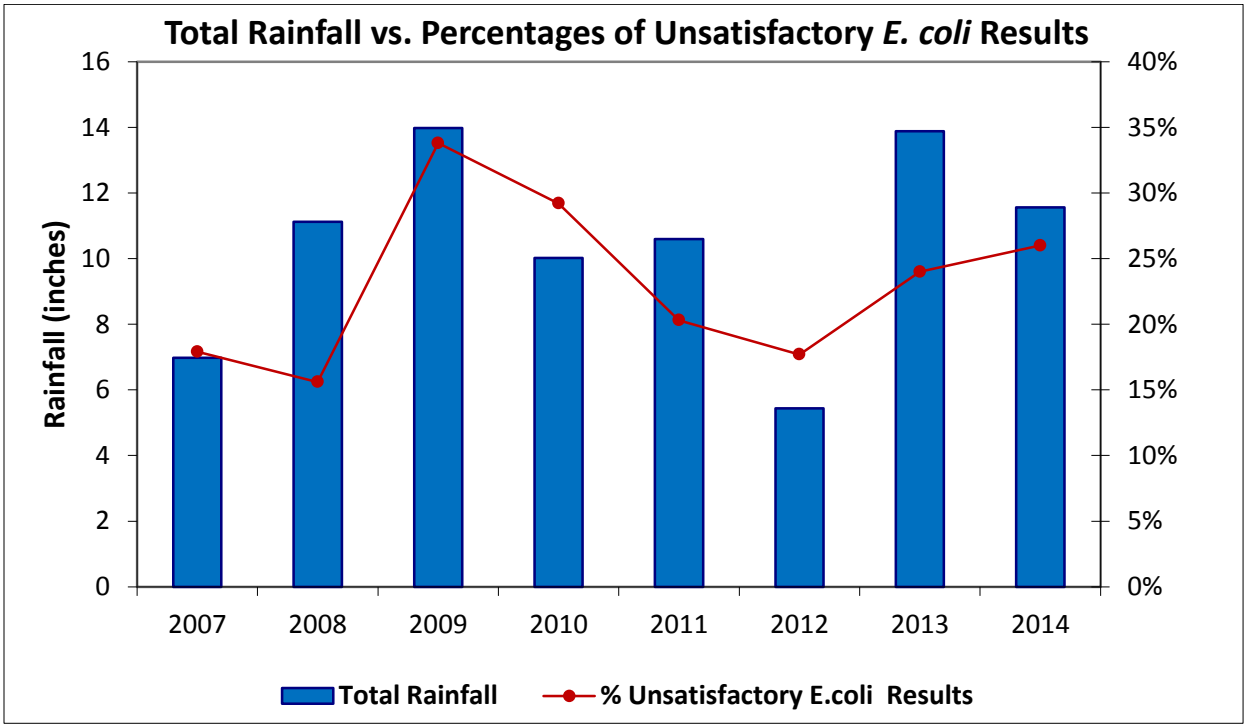


Chart 2. Rainfall vs. Percentage of Unsatisfactory Beach Water *E. coli* Results by Year. Dunkirk total rainfall proved to be the most reliable and includes June, July, and August totals. Correlation coefficient = 0.608.

While rainfall generally amplifies the amount of contamination that reaches the lake, differences in rainfall intensity and frequency are important. Heavy rainfall provides a sudden rush of water that "flushes" accumulated contamination through small drainage channels that may normally carry limited or no flow. In years when heavy rainfall is less common, fecal contamination has more time to build up in the dry or low flow channels which means heavy rainfall "flushes" will be especially loaded with contamination, but will not reach the lake shore as often. Light rain is absorbed more readily which diminishes any rush of runoff to tributaries.

Canadaway Creek is one of the largest tributaries in Chautauqua County. Charts 3 and 4 depict *E. coli* levels and the 24 hour rainfall prior to sampling during the 2013 and 2014 sampling season. While the correlation coefficients of both years show a positive relationship the 2013 coefficient (0.871) shows a much stronger relationship than the 2014 coefficient

(0.508). Differences in the frequency and intensity of rain events likely contribute to the variation in coefficient values but the large watershed is difficult to monitor and regulate so a variety of factors could have led to the variation.

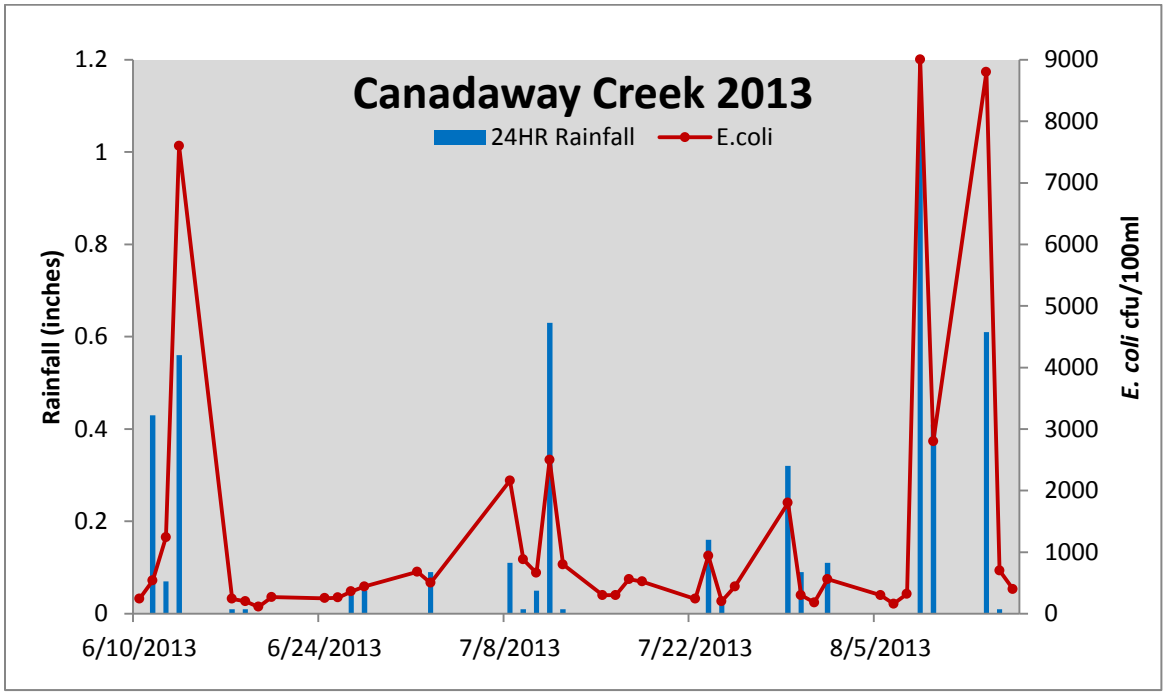


Chart 3. Canadaway Creek *E. coli* 2013. Correlation coefficient of 0.871 for *E. coli* and 24 hour rainfall.

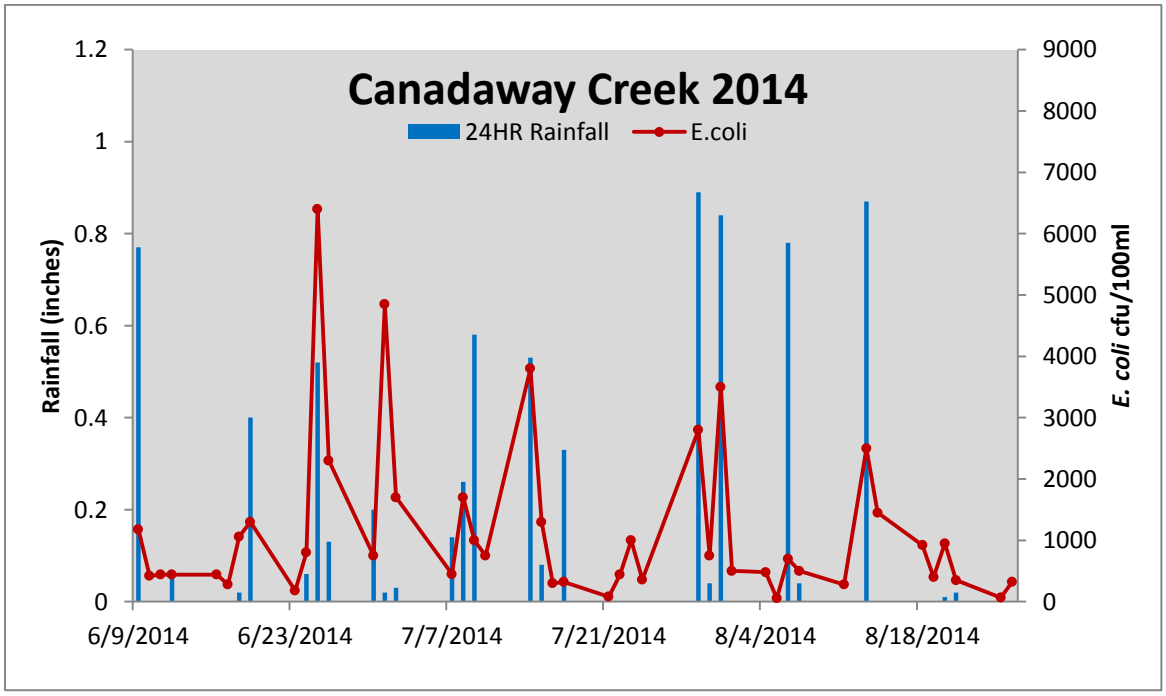


Chart 4. Canadaway Creek *E. coli* 2014. Correlation coefficient of 0.508 for *E. coli* and 24 hour rainfall.

Wind

The effects of wind on water quality are specific to individual beaches due to beach orientation, tributary proximity and location and the presence of jetties, groynes, etc. Wind direction, dependent on wind speed, can manipulate lake currents and alter the near-shore path of stream discharge. For beaches with tributaries that discharge onto or near the beach changes in lake current can result in drastic changes in water quality.

Wind speed also affects water quality by producing wave activity; as wind speed increases, wave height also increases. Crashing waves re-suspend lake sediments which harbor naturalized *E. coli*, thus the concentration of bacteria in the water column rises. Additionally, increased wave height means a larger swash zone so more beach pollution, including waterfowl feces and *E. coli*-laden beach sand, is washed into the lake.

Temporarily elevated water levels, resulting from seiche events, also wash waterfowl feces and beach sand *E. coli* into the lake. Lake Erie is especially prone to seiches due to the prevailing wind direction and elongated shape of the lake. Strong southwest winds blowing across the lake maximize wind fetch and push water up onto the northeast shoreline. As a result, all of the Chautauqua County beaches on the Lake Erie shoreline are subject to seiches.

Actual Effects of Transport of Pollution to the Area

Routine bacteriological monitoring supports suspicions that non-point source pollution from the watershed increases *E. coli* levels in bathing beach water. Human positive *Bacteroides* samples indicate that human waste is present throughout many of the streams included in this study. Nitrates and phosphates are transported to beach water by streams and promote algae growth in the lake. Algae may trap pathogens and harbor indicator bacteria such as *E. coli.* Suspended sediment and prevalent algae can hinder visibility and lead to safety issues in lifeguarded beaches. Pollutants also cause unpleasant appearances and odors which prevent visitors from enjoying the beaches.

Potential Effects of Transport of Pollution to the Area

From a local health department perspective, the greatest concern regarding the effects of pollution transport is the potential risk to the health and wellbeing of beachgoers. While indicator bacteria, such as *E. coli*, are not harmful except in specific forms, they suggest that other pathogens may be present in the water due to fecal contamination. The resources needed to test for all of the pathogens are not available to the Chautauqua County Department of Health and Human Services, but our concern is that even mild illnesses associated with undocumented pathogens can have unanticipated complications for some people.

The overall health of Lake Erie is affected by pollution and nutrient transport in the watershed as well. Transported nutrients including nitrogen and phosphorous encourage lake eutrophication. The process of eutrophication could be detrimental to the Lake Erie food web and lead to decreases in fish populations. Decreases in Lake Erie fish populations would reduce the growing popularity and revenue of fishing tourism in the county.

Sunset Bay Beaches

Town of Hanover and Sunset Bay Beach Club Beaches

Town of Hanover and Sunset Bay Beach Club Beaches

The Town of Hanover and Sunset Bay Beach Club (SBBC) beaches are bordered by the small community of Sunset Bay in Irving, NY. The area is developed and predominantly residential. Homes in Sunset Bay are densely concentrated and cover 0.25 square miles. The relatively flat landscape and proximity to Cattaraugus Creek frequently results in drainage and flooding problems for area residents. Surface drainage infrastructure in the Sunset Bay community carries much of the localized urban runoff to a drainage pond area.

Sunset Bay Watershed Description and Water Quality

Four waterways were investigated as potential pollution sources to the water quality of the Town of Hanover and SBBC beaches.

- Walnut Creek/ Silver Creek, 2miles west of SBBC Beach
- A small unnamed stream, 457 m west of SBBC Beach (Stewart Road Creek)
- Surface drainage (pond) from Sunset Bay residential area 190 m west of SBBC Beach
- Cattaraugus Creek, 437 m east of the Town of Hanover Beach shoreline

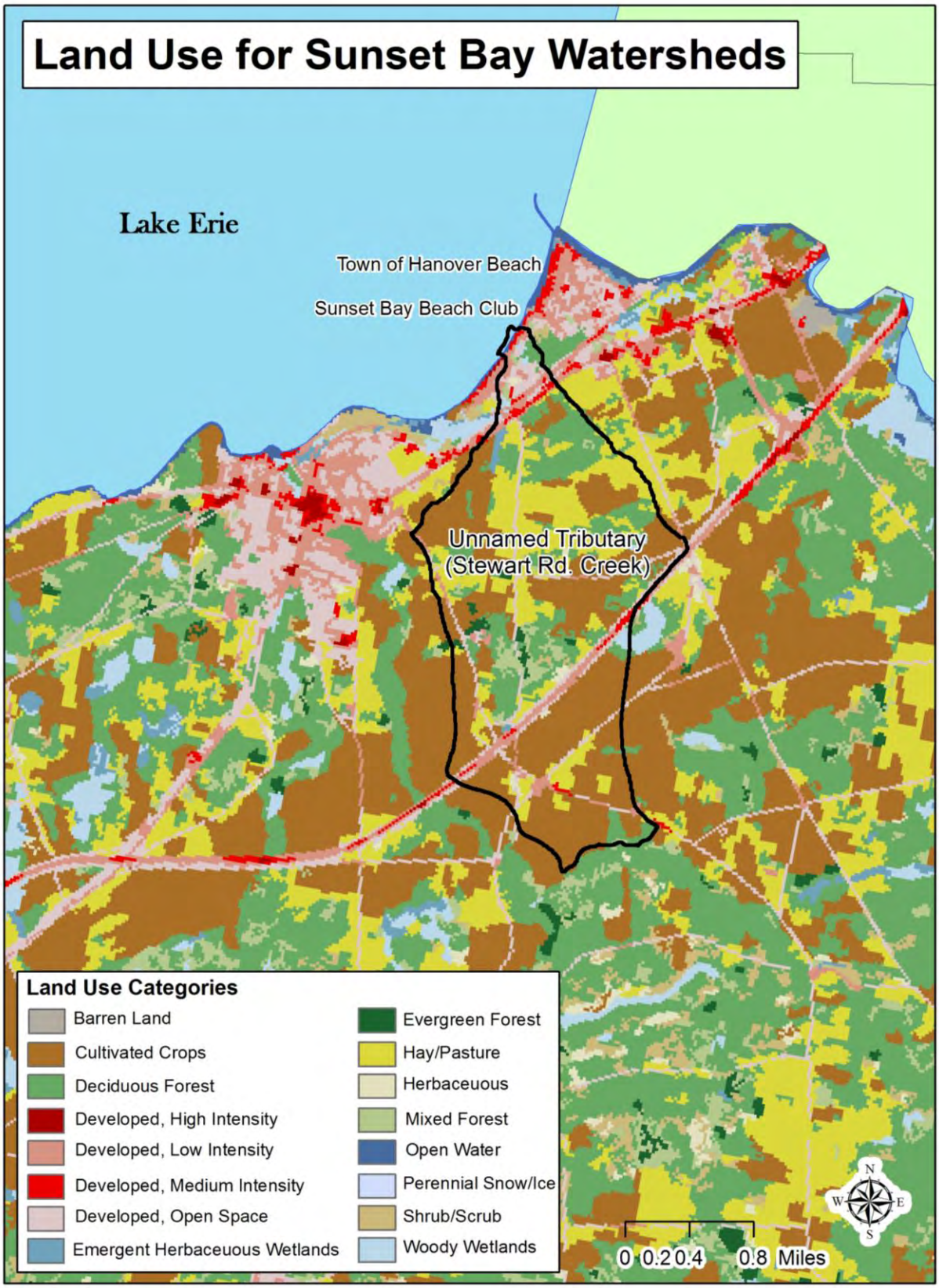
West of Sunset Bay two streams, Walnut Creek and Silver Creek, combine to form a medium sized stream that discharges to Lake Erie two miles from SBBC Beach. Before entering the lake the two streams combine in an urban area, the Village of Silver Creek. Effluent from the Silver Creek Waste Water Treatment Plant (SPDES# NY0022411) discharges to one of the streams just before they combine, approximately 375 m from the Lake Erie shoreline. Most of the watershed is rural, agricultural and undeveloped land. The size of the watershed and distance from the Sunset Bay beaches suggest that the streams do not have a large impact on beach *E. coli* results. However, the streams are prone to flooding in the Village of Silver Creek and for this reason may bring occasional bursts of very elevated *E. coli* to Lake Erie.

Continued flow to Lake Erie was observed from a small unnamed stream that discharges north of Stewart Ave., 457 m west of Sunset Bay Beach Club Beach. The 4.08 mile stream originates in a rural/agricultural area in the Town of Hanover and drains 3.19 square miles. Most of the watershed is undeveloped or agricultural, with 18.5% forested.[18]

The last leg of the stream, 2.47%[18] of the watershed, winds through a residential/urban area locally referred to as Hanford Bay. The small community is adjacent to Sunset Bay and slightly smaller at 0.12 square miles compared to 0.25 square miles. Drainage pipes protrude from the stream bank and retaining wall to empty surface drainage into the stream. The stream channel emerges from the shaded residential area to cross 50 m of sandy beach area before reaching the shoreline.

Land use in the watershed of Stewart Road Creek, which flows into Lake Erie upcurrent of the two beaches, is mainly comprised of cultivated crops (43.29%), forest (21.33%), and hay/pasture (20.73%). An additional 12.41% of the watershed is developed land of varying densities.[14] The land use and positive *Bacteroides* samples in the watershed implies potential pollution from manure, fertilizers, wildlife, urban runoff, and private SDSs.

Figure 8. Land Use for Sunset Bay Watershed.[14]



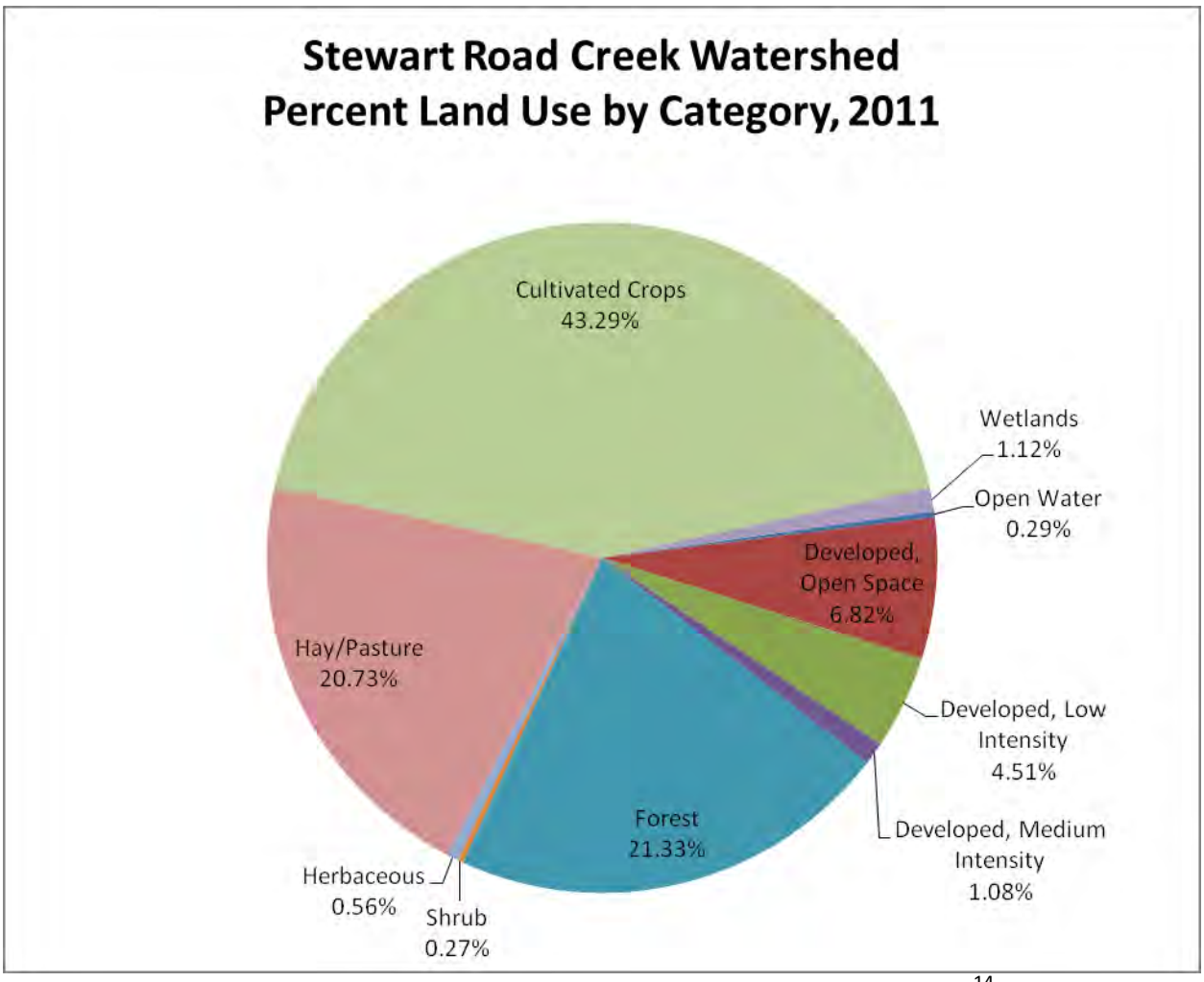


Chart 5. Stewart Road Creek Watershed Percent Land Use by Category, 2011.[14]

Aside from the data collected in the 2012-2014 seasons CCDHHS has limited information regarding the water quality of the small stream. Elevated *E. coli* counts, frequently above 1300 cfu/ 100 ml, were observed at the outlet of Stewart Road Creek throughout the 2012 and 2013 seasons. A 2012 investigation of the small stream showed *Bacteroides* present at multiple incremental sampling locations in the stream (Table 6). Although, stream walks revealed no obvious areas of point source pollution, CCDHHS suspects inadequate private SDSs, agricultural runoff and sediment bacteria are contributing to the high *E. coli* levels.

Table 6. Water sample results from the small tributary, "Stewart Road Creek", which discharges 457 m west of SBBC Beach. Samples were collected 8/14/2013.

	Bacteroides	**Human *Bacteroides***	***E. coli* (cfu/100 ml)**
Discharge point 457 m west of SBBC Beach	Positive	Positive	1760
Stream crossing at Route 5/20 bridge	Positive	Positive	2200
Stream crossing at Blanding Rd.	Positive	Positive	480

The majority of Sunset Bay surface drainage is discharged through a culvert on the north side of W. Erie St., 187 m from the lakeshore. During the 2012-2014 sampling seasons the channel resulting from the discharge widened at the culvert to form an elongated pond as it extended toward, but never reached, the lakeshore. In the spring, shoreline alterations resulting from accumulated beach ice/snow and the added flow from snowmelt in the watershed allow the channel to reach the lake. Aerial photos show discharge from the outfall reaching the shoreline in early spring approximately 190 m west of SBBC Beach.

Based on CCDHHS observations in 2012-2014 the drainage pond is not of concern to the water quality of the Town of Hanover and SBBC beaches during the summer season in large part because the flow does not reach the lakeshore. Additionally, early investigation of the drainage pond in 2012 revealed *E. coli* levels at the northern end of the pond consistently ≤70 cfu/100 ml suggesting that the drainage pond could be acting as a retention pond. Therefore, if an especially wet summer season did provide enough flow to create a full channel to the lakeshore, bacteria levels would be mitigated as the water is exposed to sunlight and bacteria are allowed to settle out of the water column.

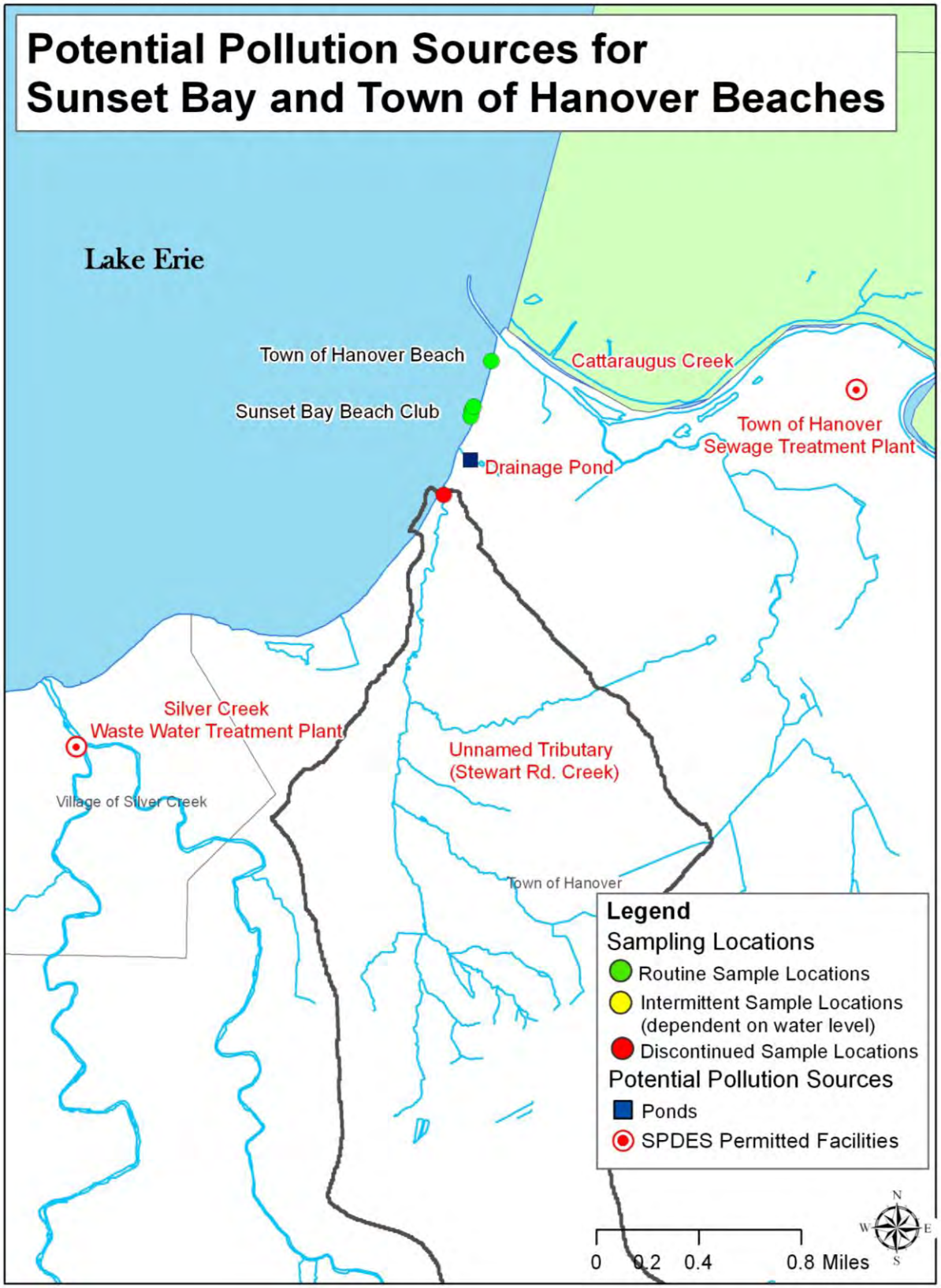
Cattaraugus Creek watershed is approximately 550 square miles and includes areas in five New York counties before its discharge point to Lake Erie. The large watershed carries a substantial amount of sediment and potential contamination to the lake. The vast watershed includes many types of land use and receives wastewater inputs from a variety of facilities including the Town of Hanover Sewer District #1 STP, (SPDES# NY0105104) which discharges into Cattaraugus Creek 1.6 miles from the discharge point to Lake Erie.

A large jetty has been in place for more than four decades defining the northern boundary of the Town of Hanover Beach and manipulating discharge from Cattaraugus Creek. The jetty was built by the Army Corps of Engineers with the intention of flood control and providing a protected area for the Cattaraugus Creek Harbor. Years later it has proven to be an effective tool in directing the sediment plume from Cattaraugus Creek east along the Lake Erie shoreline away from Town of Hanover Beach. Cattaraugus Creek discharge rarely reaches the nearshore area of either beach and is seldom a concern for beach water quality.

However, when exceptionally strong northeast winds change the normal current patterns and push sediment west, back toward the Sunset Bay beaches, Cattaraugus Creek discharge has a huge impact on Town of Hanover and SBBC beach water quality. Following strong northeast winds, turbid water gets trapped behind the large jetty and elevated *E. coli* levels are typically recorded until water clarity improves. Depending on the duration of strong northeast winds and wave activity turbid conditions can persist for many days. For example, in

June 2010, strong northeastern winds pushed the Cattaraugus Creek sediment plume west into the area of Town of Hanover and SBBC beaches. The sediment persisted for quite some time and was the most likely cause of the elevated *E. coli* levels that were observed for nearly two weeks in mid-June.

Figure 9. Map of Sunset Bay Beaches, Including Potential Pollution Sources.



Town of Hanover Beach Description

Town of Hanover Beach stretches from the south/west border at 42.567614, -79.137927 approximately 178 m to the north/east border at 42.569273, -79.137556. The defining edges of the beach are constant; the large jetty at the north border and a fence on the property line of the south border. However, as sand accumulates along the jetty and lake levels fluctuate, the actual beachfront changes.

The width of the beach area is fairly uniform and averaged 47 m between 2012 and 2014; dependent on lake levels. The beach is mostly sandy with some small pebbles. The sandy sediment continues into the nearshore area, creating a sandy bottom swim area. Dreissenid mussel shells are always present and are a consistently large portion of the debris observed on the beach.

Roughly 84% of the beach is separated from the Sunset Bay residential area to the east by sand dunes covered with low lying vegetation and beach grass. The remaining 16% of beach transitions from open beach sand to public park space with a playground, pavilion and sanitary facilities.

The beach is owned and maintained by the Town of Hanover. The two main access points to the beach from South Shore Drive originate at parking areas. From the northeast parking lot, a 60 m sandy path is maintained through the dune vegetation. The second sandy path, from the southeast parking lot, leads directly to the designated swim area by way of the public park space.

Sanitary facilities are located at 42.567554, -79.136838, at the southeast edge of the beach, approximately 91 m from the waterline of the designated swim area and 100-190 m from the waterline outside of the swim area. The facilities are well maintained and are cleaned daily during the swim season. Outside of the swim season, the facilities are locked.

When weather and water quality permits, Town of Hanover Beach operates a swim area seven days a week July through Labor Day weekend. Swimming is only allowed when lifeguards are on duty, 11 am – 5 pm. The swim area covers 50 yards of beachfront butted against the southern border of the beach area, adjacent to the public park and sanitary facilities.

Although the beach is open to the public, there is limited parking available near the beach and Town of Hanover resident parking permits are required. Therefore the beach is predominantly used by Sunset Bay residents who can walk to the beach and Town of Hanover residents who have authorized parking permits. According to the 2010 U.S. Census Town of Hanover population includes 2,656 Village of Silver Creek residents, 697 Village of Forestville residents and 7,127 Town of Hanover residents.[19]

People use the beach year-round for walking, running and beachcombing as the weather allows. During the summer season, the beach is also used by swimmers and sunbathers. People frequently walk dogs on the beach however dog feces was very rarely observed in the summer season. On calm water days, the beach also serves as a launch point for small self-propelled watercraft. Motorized watercraft is not common in the offshore area of Town of Hanover Beach.

Figure 10. Town of Hanover Beach Detailed Map.

Town of Hanover Beach Photographs

Photograph 3. Town of Hanover Beach, west area with lifeguard chair.

Photograph 4. Town of Hanover Beach, east area with Cattaraugus Creek jetty.

Photograph 5. Town of Hanover Beach, eastern border of grassy dunes, pathway from eastern parking area. Blue roof of park pavilion in background.

Photograph 6. Town of Hanover, south/west property line border and public park with slide, swing set, pavilion and sanitary facilities.

Sunset Bay Beach Club Beach Description

Sunset Bay Beach Club Beach is separated from the Town of Hanover Beach by 172 m of privately owned beachfront. The beach length of 142 m is defined by fence lines along the property borders; the south/west border at 42.564186, -79.139381, and the north/east border at 42.565373, -79.138778. Private beachfront borders the beach on both sides. The width of the beach area is fairly uniform and averaged 63.1 m in 2013 and 2014. The volleyball courts positioned in the southeast corner of the beach were not included in beach width measurements.

The beach is owned and maintained by the same private company that operates Sunset Bay Beach Club and Cabana Sam's Bar and Grill. Sunset Bay Beach Club, Cabana Sam's Bar and Grill and the unpaved restaurant parking lot create the eastern border of the beach. There is a single entrance to the beach from the unpaved restaurant parking lot. Additional parking is available in a 2.6 acre unpaved parking lot located 96 m from the beach.

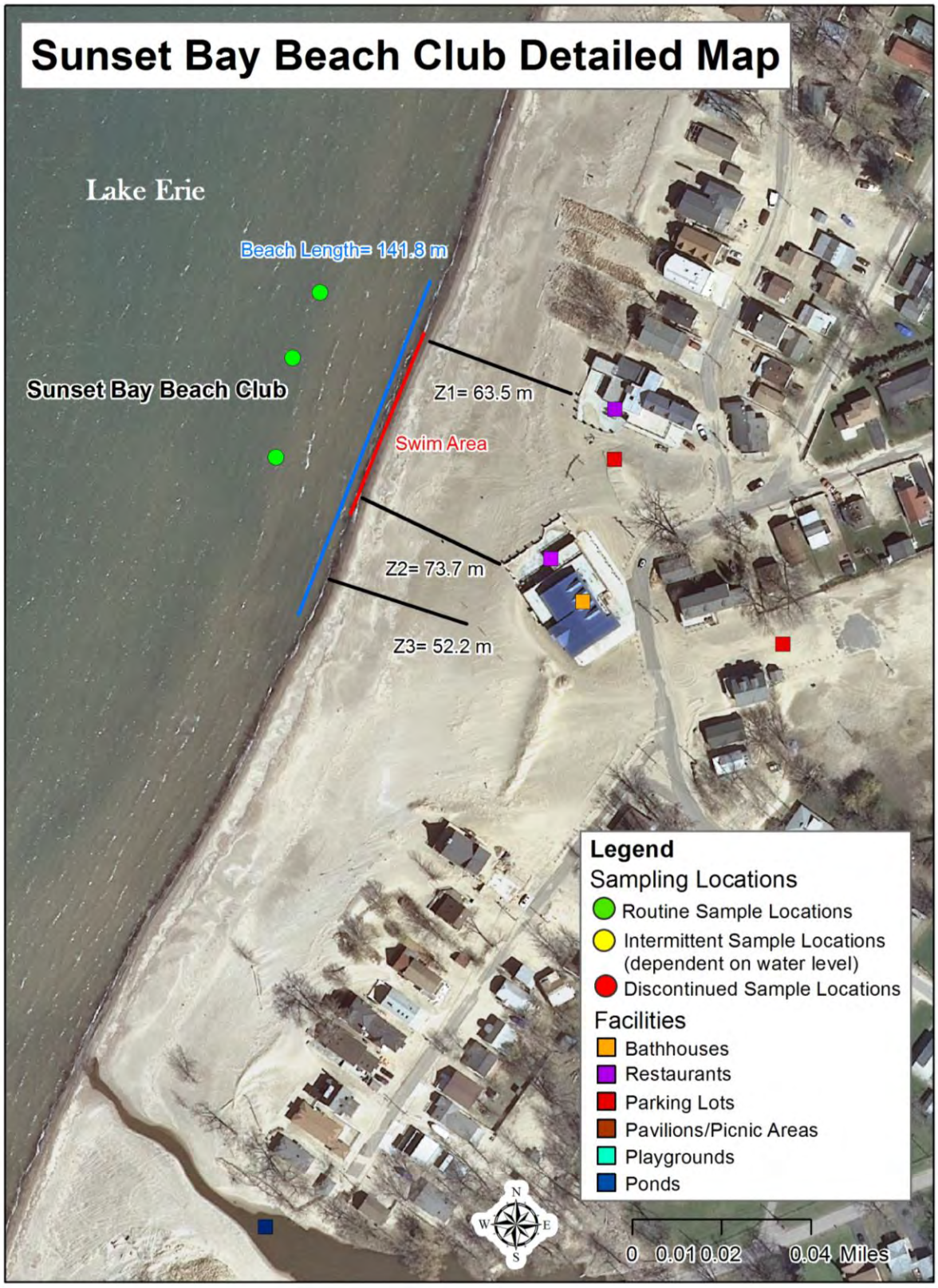
The sandy beach is very well maintained and raked daily such that debris is seldom observed anywhere but the very edge of the shoreline. Observed debris was predominantly algae and Dreissenid mussel shells. Sandy sediment continues into the nearshore area, creating a sandy swim area.

Sanitary facilities are located 72 m from the waterline at 42.567554, -79.136838, in the Beach Club. When beach attendance is low a single set of sanitary facilities are open to beachgoers and the second set is locked. When beach attendance is high, both sets are open. The sanitary facilities are well maintained and cleaned daily.

Sunset Bay Beach Club Beach typically opens in early to mid-June, depending on staff availability, and remains open through Labor Day weekend. However, lake temperature, weather, and school schedules largely dictate when people actually start using the beach. Early in the beach season, lifeguards are posted on the beach as needed or only on weekends depending on weather conditions and water quality. Beyond mid-June, lifeguards are on duty every day 11 am- 6 pm, weather and water quality permitting. The majority of beachfront operates as a designated swim area except for a small corridor near the northern border where boats are permitted close to the shoreline.

Beachgoers are charged fees to use the beach at the main entrance at the owner's discretion (i.e. in unfavorable weather conditions beach use is limited and beachgoers may not be charged). The beach is used by swimmers and sunbathers throughout the summer season. People also pass through the beach, along the shoreline while walking and running. Sunset Bay Beach Club and SBBC Beach operate in conjunction with each other to host weekly events throughout the summer. Events are held on evenings, weekends and holidays and frequently bring hundreds of people to the Sunset Bay Beach Club and Beach. Events and weekends also attract small motorized watercraft that anchor just outside the swim area.

Figure 11. Sunset Bay Beach Club Detailed Map.



Sunset Bay Beach Club Beach Photographs

Photograph 7. Sunset Bay Beach Club Beach and Cabana Sam's restaurant.

Photograph 8. Sunset Bay Beach Club, sanitary facilities, southeast corner volleyball courts.

Photograph 9. SBBC Beach, north/east border defined by property line fence. Town of Hanover Beach and Cattaraugus Creek jetty in background.

Sunset Bay Beaches: History of Water Quality

The Town of Hanover Beach (42.568382, -79.137889) and SBBC Beach (42.565108, -79.139407) were routinely sampled in 2012 once per week in the middle of the beach area. The samples were typically collected between 9:00am and 12:00pm. In an effort to better understand the factors affecting beach water quality, sampling increased to two consecutive days per week in 2013 and 2014. Additional sampling days were added when unsatisfactory *E. coli* results required follow-up samples.

Data from previous years has shown that water conditions, such as turbidity, can vary within the boundaries of each beach. In an effort to better understand beach dynamics and to ensure the water quality of multiple swim areas on a single beach, CCDHHS collects samples in different areas of individual beaches. Sampling locations are constant throughout a sampling season and typically constant between sampling seasons unless there is reason to change.

The charts below represent the water quality history of Town of Hanover and SBBC Beaches in 2007-2014. The "Total Samples" column represents all the samples collected from Chautauqua County beaches from early June through Labor Day weekend. *E. coli* results greater than 235 cfu/100 ml of sample water are declared unsatisfactory. Unsatisfactory samples are represented as a percentage of the total number of samples collected in a year. However, the "Days Closed" column only includes days when the beach managers had opened the beaches and lifeguards were monitoring swim areas, typically mid-June through Labor Day weekend. Because the beaches are not open for swimming in early June, follow-up samples to unsatisfactory samples are not given priority and including that time period would artificially inflate the number of days the beach was closed.

Table 7. Town of Hanover Water Quality History 2007-2014.

	TOWN OF HANOVER WEST			**TOWN OF HANOVER EAST**		
	Total Samples	**% Unsatisfactory**	**Days Closed**	**Total Samples**	**% Unsatisfactory**	**Days Closed**
2007	13	15.4%	12	11	0.0%	0
2008	13	7.7%	8	2	*0.0%*	0
2009	17	23.5%	4	16	31.3%	5
2010	16	31.3%	22	15	33.3%	22
2011	17	23.5%	6	1	*0.0%*	0
2012	15	0.0%	0	*not sampled*----------		
2013	25	20.0%	4	17	11.8%	4
2014	29	27.6%	9	*not sampled*----------		
Average		18.6%			19.1%	

A larger number of samples are typically collected from the western area of Town of Hanover Beach because that is where the lifeguard monitored, designated swim area is located. As reflected in the "Percent Unsatisfactory" column, the number of elevated *E. coli* results varies by year and is not necessarily related to the total number of samples collected each year. It follows that the average *E. coli* levels and ranges also vary by year. In 2012, the average *E. coli* level was 51 cfu/100 ml and ranged from 10 - 140 cfu/100 ml, while in 2014 the average *E.*

coli level was 335 cfu/100 ml and ranged from 4 - 1840 cfu/100 ml. The 2013 *E. coli* average and range lie between the 2012 and 2014 values. The highest percentage of unsatisfactory samples was in 2010 when there were strong winds from the northeast that altered nearshore currents and pushed Cattaraugus Creek sediment south/west towards Town of Hanover Beach area. The lowest percentage of unsatisfactory *E. coli* results occurred in 2012, which was an especially dry and sunny beach season.

Two lifeguard chairs roughly 70 m apart allow nearly all of the beachfront at SBBC Beach to be a monitored swim area. To ensure the water quality of multiple swim areas CCDHHS typically collects samples in front of each lifeguard chair. The visual differences in water conditions that led CCDHHS to monitor both the west and east swim areas are supported by the differences in the percentages of unsatisfactory *E. coli* results. Further complicating the issue, the differences are not uniform between years, i.e. some years the west has a larger percentage of unsatisfactory results other years vice versa. Yearly differences in the percentages of unsatisfactory *E. coli* results are most likely due to differences in yearly weather activity.

Table 8. Sunset Bay Beach Club Beach Water Quality History 2007-2014.

	SUNSET BAY BEACH CLUB WEST			**SUNSET BAY BEACH CLUB EAST**		
	Total Samples	**% Unsatisfactory**	**Days Closed**	**Total Samples**	**% Unsatisfactory**	**Days Closed**
2007	14	7.1%	1	12	16.7%	9
2008	14	28.6%	17	13	23.1%	15
2009	17	29.4%	5	16	43.8%	15
2010	16	31.3%	14	16	31.3%	14
2011	16	18.8%	7	1	*0.0%*	0
2012	15	0.0%	0	*not sampled*----------		
2013	26	19.2%	4	18	16.7%	6
2014	29	31.0%	10	22	27.3%	10
Average		20.7%			26.5%	

Following recommendations from the EPA sanitary survey guide CCDHHS collected a single sample from the SBBC Beach in 2012. The 2012 summer was an especially dry, sunny season and yielded no observational differences between the water conditions of the west and east swim areas. However, the following 2013 and 2014 seasons were more variable and the differences in water conditions could not be ignored so CCDHHS resumed collecting samples from the west and east swim area. The *E. coli* levels averaged 58 cfu/100 ml and ranged from 9 - 200 cfu/100 ml during the mild 2012 summer. In 2013, the west swim area averaged 98 cfu/100 ml and ranged from 9-640 cfu/100 ml while the east swim area averaged 156 cfu/100 ml and ranged from 9 – 1040 cfu/100 ml. The 2014 results were even higher than the 2013 results; the west swim area averaged 331 cfu/100 ml and ranged from 5 – 2580, the east swim area averaged 367 cfu/100 ml and ranged from 9 – 2920 cfu/100 ml. Although the 2014 results are substantially higher than the 2012 results they are not uncommon to elevated *E. coli* levels observed in previous years.

Statistical Analysis of Data

Multiple years (2012-2014) of data were used to calculate the Pearson correlation coefficient values for the potential variables relating to beach water quality using the U.S. Environmental Protection Agency's Virtual Beach software. Pearson correlation coefficients indicate how closely data correlates but do not imply causation. Pearson correlation coefficients approaching "1" indicate that there is a strong positive relationship between data variables; as one variable's value increases so does the other.

Although CCDHHS collected beach observational data for 2012-2014, water samples from the small stream west of SBBC Beach were only regularly collected in 2012 and 2013. Therefore, the number of data points in the data sets used to determine Pearson correlation coefficients of stream *E. coli* is less than the number of data points used to determine coefficients of other observational beach data. Analyses suggest that there is a moderately positive relationship between stream *E. coli* and Town of Hanover Beach *E. coli* ($r = 0.4687$) as well as stream *E. coli* and SBBC Beach *E. coli* ($r = 0.4982$). As this correlation does not imply causation, the association may also be due to other factors. For example, an increase in rainfall could be the cause of both elevated beach *E. coli* and stream *E. coli.*

CCDHHS suspected rainfall would correlate strongly to beach water *E. coli* due to increases in surface drainage near/on the beach as well as the added flush effect rainfall has on the watershed. However, Pearson correlation coefficients derived from the 2012-2014 data did not support this prediction. Town of Hanover Beach *E. coli* results are only moderately correlated to total 24-hour rainfall ($r = 0.4243$) and total 48-hour rainfall ($r = 0.5020$). The SBBC Beach *E. coli* results are also moderately correlated to total 24-hour rainfall ($r = 0.4534$) and only weakly correlated to total 48-hour rainfall ($r = 0.3700$).

Stronger correlations were identified when observational factors were combined, especially when those combinations included lake turbidity. The three highest Pearson correlation coefficients for Town of Hanover Beach *E. coli* came with the combinations of: 1) lake turbidity and wind speed ($r = 0.5362$), 2) lake turbidity, cloud cover and wave category ($r = 0.5509$), and 3) lake turbidity, lake temperature and cloud cover ($r = 0.6365$). Although the Pearson correlation coefficient does not imply causation, disturbed sediment has been shown to contribute to elevated fecal indicator bacteria levels and UV light is commonly used to kill off *E. coli* bacteria.

Similar trends, including the importance of lake turbidity, were obvious in the SBBC Beach data as well. The three highest Pearson correlation coefficients for SBBC Beach *E. coli* came with the combinations of: 1) lake turbidity and wind speed ($r = 0.6260$), 2) lake turbidity, lake temperature and cloud cover ($r = 0.6007$), and 3) lake turbidity and wind speed ($r = 0.6260$). The Pearson correlation coefficient results and the knowledge regarding sediment disturbance and elevated *E. coli* suggest that weather activity responsible for maintaining or re-suspending sediment in the water column and the prevalence of UV light are important indicators of *E. coli* levels for both Sunset Bay beaches.

Weather data used for the Sunset Bay beaches came from a weather station located in Silver Creek, NY roughly 3.6 miles from the Town of Hanover Beach and 3.4 miles from the SBBC Beach. The data was accessed via http://newa.cornell.edu. The weather station provides temperature, rainfall and wind data. Data that could not be obtained from the Silver Creek

weather station was obtained from the Dunkirk Airport weather station (8.7 miles from SBBC Beach).

Pollution Sources Surveyed and Identified

Although signs are posted at both beaches prohibiting dogs, people were frequently observed walking dogs on Town of Hanover beach. Dogs were very rarely observed along the shoreline of SBBC Beach, likely because more staff are present to enforce the no dog rule. The lack of dog feces observed on SBBC Beach and limited amount observed on Town of Hanover Beach indicate that pet feces does not generally play a large role in beach water quality.

Waterfowl, specifically Ring-billed and Heron Gulls were often observed in small numbers on SBBC Beach and occasionally in the nearshore water. Waterfowl were observed in smaller numbers and less often on Town of Hanover Beach. Minimal numbers of crows and small shorebirds such as Common Plovers were occasionally observed on both beaches. Waterfowl numbers were not high enough or constant enough to suggest that they were a significant source of contamination to the beach water. However, waterfowl feces could be acting to enrich the bacterial population in beach sand with nutrients and fresh inoculations of bacteria.

While the number of trash bins is generally adequate at both beaches, the bins lack wind/wildlife guards which could reduce the amount of litter on the beach and reduce wildlife fecal material. The number of trash bins on and near the designated swim area of Town of Hanover Beach is usually adequate but occasionally the trash bin near the lifeguard chair was overflowing. The large number of trash bins on SBBC Beach appears to be adequate, but it is difficult to accurately assess because the biggest crowds gather on weekends and holidays when CCDHHS staff are not present. Additionally, the bins are emptied daily during the morning beach cleaning routine, frequently before CCDHHS staff arrives to sample. Trash bins are also located in SBBC Beach parking areas, at the main beach entrance and near the restrooms.

Minimal amounts of trash including food-related litter, street litter, and household waste were observed on both beaches. Based on CCDHHS staff observations, trash appeared to have been left behind by beachgoers not washed onto the beach from the lake. Small-sized trash, such as cigarette butts and plastic food wrappers, tend to get mixed into the sand at SBBC Beach when the beach is raked.

Debris was observed both on the beaches and in the nearshore area especially following rough water conditions and high wave heights. Floating debris other than leaf litter, algae or aquatic vegetation was rarely observed. On a couple of sampling dates cigarette butts and food-related litter was observed in the water but these instances followed high wave heights so litter may have been washed into the nearshore area from the beach.

Dreissenid mussel shells, leaf litter, algae, and aquatic vegetation were frequently observed on the beach and denoted the daily high water mark. Town of Hanover Beach consistently had larger amounts of debris on the beach, but the morning beach raking schedule employed by SBBC Beach staff likely skewed CCDHHS observations. Tracks from beach raking equipment were frequently present along the SBBC Beach shoreline when CCDHHS staff arrived to sample. Thick mats of *Cladophora* like those shown to harbor fecal indicator bacteria were not observed on either beach.

Continuously elevated *E. coli*, typically above 1300 cfu/100 ml, was recorded from the discharge of the small unnamed stream. However, the typical low flow observed from the stream and the distance from SBBC Beach suggest that while the stream discharge adds to local contamination it is not a major factor to water quality at the beaches. The positive *Bacteroides* results warrant concern, however, CCDHHS was not able to identify faulty private SDSs emptying to the stream. It is possible that the *Bacteroides* test was influenced by effluent from adequately functioning private SDSs, as the specific test does not distinguish between alive and dead bacteria.

Although urban runoff can transport bacteria and nutrient pollution to the lake the large surface drainage pond west of SBBC Beach did not provide a connection to the lake during the 2012-2014 beach seasons. While a channel from the surface drainage pond to the lake may be observed in the spring when winter runoff increases flow into the pond area, the connection is rarely maintained through the summer months. Extreme rain during the summer season could enable a connection to the lake and therefore flush ponded water into Lake Erie.

The large jetty structure at the mouth of Cattaraugus Creek typically manipulates creek discharge and prevents the sediment plume from reaching the Sunset Bay beaches. However strong, consistent northeast winds can change the predominant lake current pattern and push large doses of nutrients and bacteria into the nearshore areas of the Sunset Bay Beaches. Following such an event it can take many days for the turbid creek water to settle or escape the confines of the nearshore area. CCDHHS did not observe any prolonged contamination from Cattaraugus Creek reaching the nearshore areas of the Sunset Bay Beaches in the 2012-2014 summer seasons, but CCDHHS staff has observed the event in past years.

Dunkirk Beaches

Wright Park East, Wright Park West, Main Street, and Point Gratiot Beaches

Wright Park East, Wright Park West, Main Street, and Point Gratiot Beaches

Dunkirk is the second largest city in Chautauqua County with an estimated population of 12,563 and an additional 1,318 beyond the city limits in the Town of Dunkirk.[19] The City of Dunkirk comprises about 4.5 miles of the Lake Erie shoreline. Along with residential and park areas, several large businesses/facilities occupy the Lake Erie shore in Dunkirk, including: Chadwick Bay Marina, the Dunkirk Wastewater Treatment Plant, NRG Energy coal-burning power plant, Dunkirk Water Treatment Plant and the Clarion Hotel. The beaches are used predominantly by residents of Dunkirk and other Chautauqua County municipalities including the adjacent Village of Fredonia, with an estimated population of 11,230, and Town of Pomfret, with an estimated population of 14,965.[19] All four beaches are operated and maintained by the City of Dunkirk.

The nearest and most reliable weather station for the Dunkirk beaches is at the Dunkirk Airport, which is no more than 4 miles from each of the Dunkirk beaches. Rain data for 2012-2014 was downloaded from the Dunkirk Airport weather station website along with air temperature, wind speed and wind direction data for 2012. Temperature and wind data for 2013-2014 was collected directly from individual beaches with a WindMate™ device at the time of sampling.

Dunkirk Beaches Watershed Description

Four streams discharge near or directly onto Dunkirk beaches and have been identified as potential pollution sources for the Dunkirk beaches:

- Canadaway Creek, west of Point Gratiot Beach
- Crooked Brook Creek, forms the western border of Point Gratiot Beach
- Goose Creek culvert on Main Street Beach includes urban surface drainage
- Hyde Creek, splits the Wright Park (WP) Beach system into WP West and WP East

The Canadaway Creek watershed area is the largest by far, covering 40.24 square miles. The watersheds of Crooked Brook Creek and Hyde Creek are very similar at 5.76 and 5.56 square miles, respectively. The Goose Creek watershed was the smallest, covering only 0.82 square miles.[20] Figure 12 illustrates the tributaries of interest, their watersheds and corresponding beaches.

Dunkirk beach tributary watersheds are characterized by a combination of land uses Figure 13, Table 9. Goose Creek (52.45%) and Crooked Brook Creek (43.24%) demonstrate the highest proportions of developed land. The greatest proportions of land used for cultivated crops are present in the Hyde Creek (27.38%) and Crooked Brook Creek (18.40%) watersheds. Forest land use is most common within Canadaway Creek's (57.90%) and Hyde Creek's (29.33%) watersheds.[14]

Figure 12. Watersheds of Lake Erie Tributaries in Dunkirk, NY

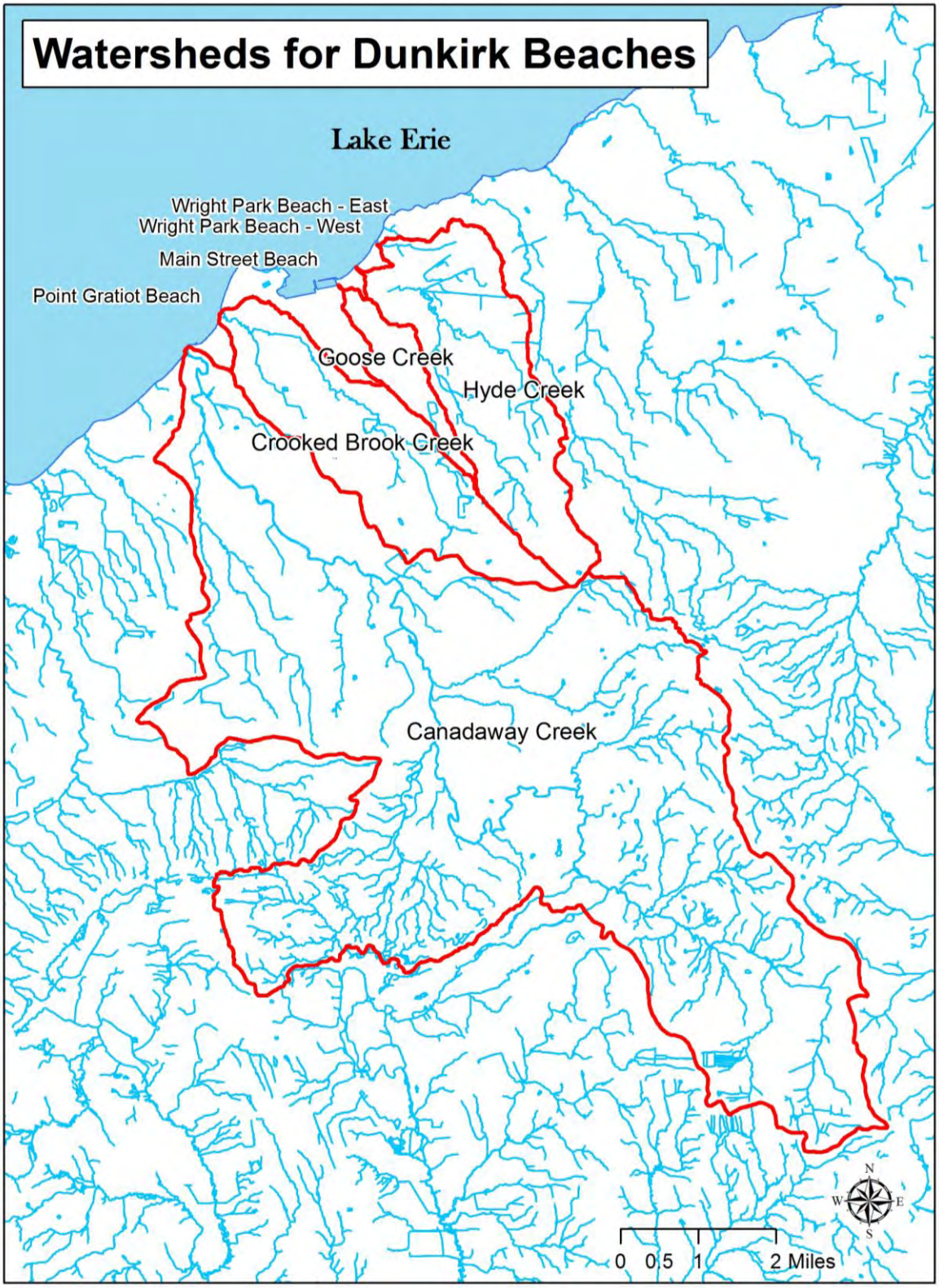


Figure 13. Land Use for Watersheds of Lake Erie Tributaries in Dunkirk, NY. [14]

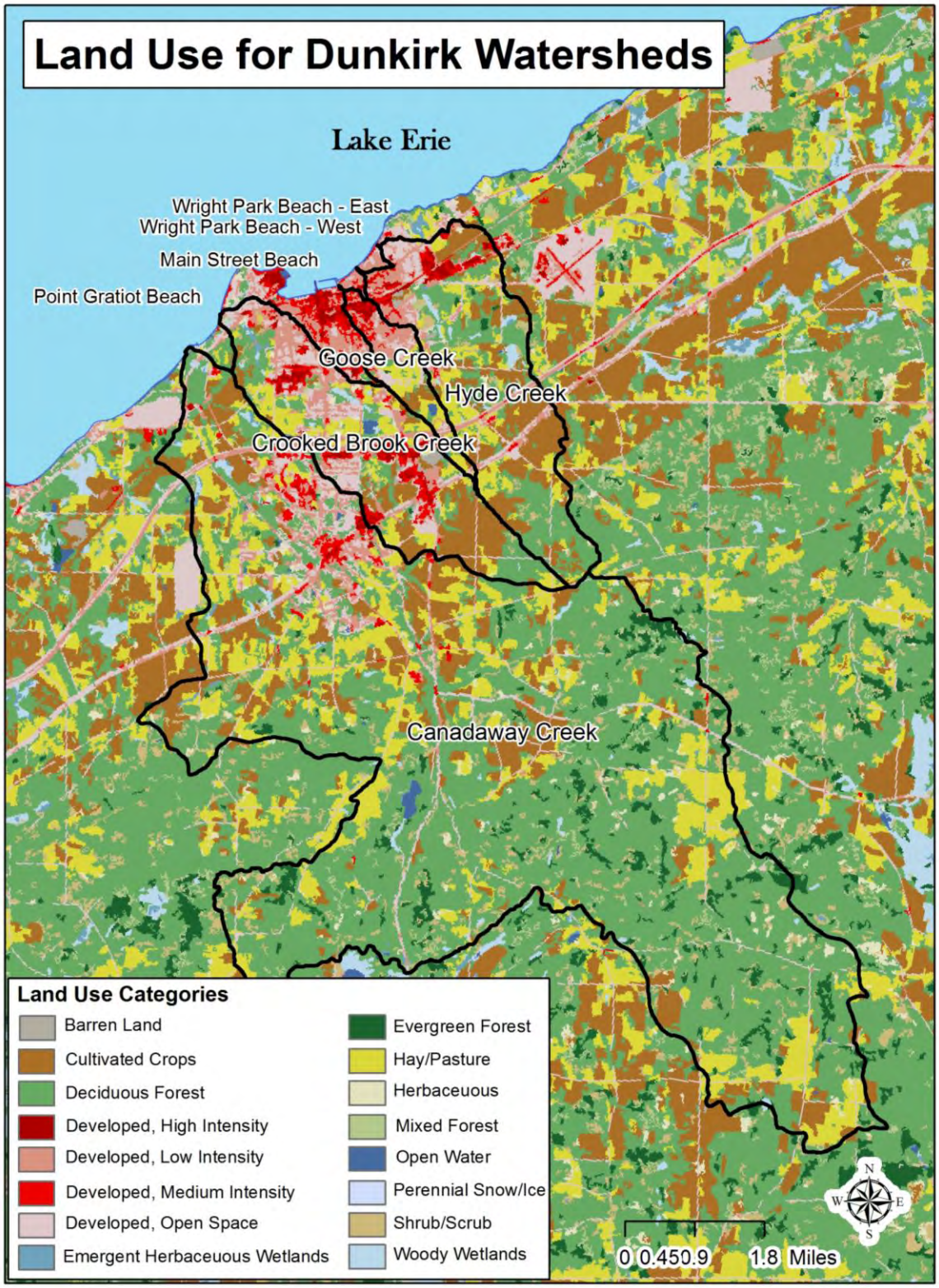


Table 9. Land Use Percentages by Watershed.[14]

	Percent of Land Cover			
Land Use Category	*Canadaway Creek*	*Crooked Brook Creek*	*Hyde Creek*	*Goose Creek*
Developed Land	8.70%	43.24%	23.16%	52.45%
Barren Land	0.01%	1.16%	0.52%	0%
Forest	57.90%	17.48%	29.33%	11.01%
Shrub	3.81%	1.20%	3.21%	0.03%
Herbaceous	1.46%	1.15%	0.67%	0.31%
Hay/Pasture	15.40%	14.72%	13.41%	25.63%
Cultivated Crops	11.59%	18.40%	27.38%	8.40%
Open Water and Wetlands	1.14%	2.66%	2.32%	2.17%

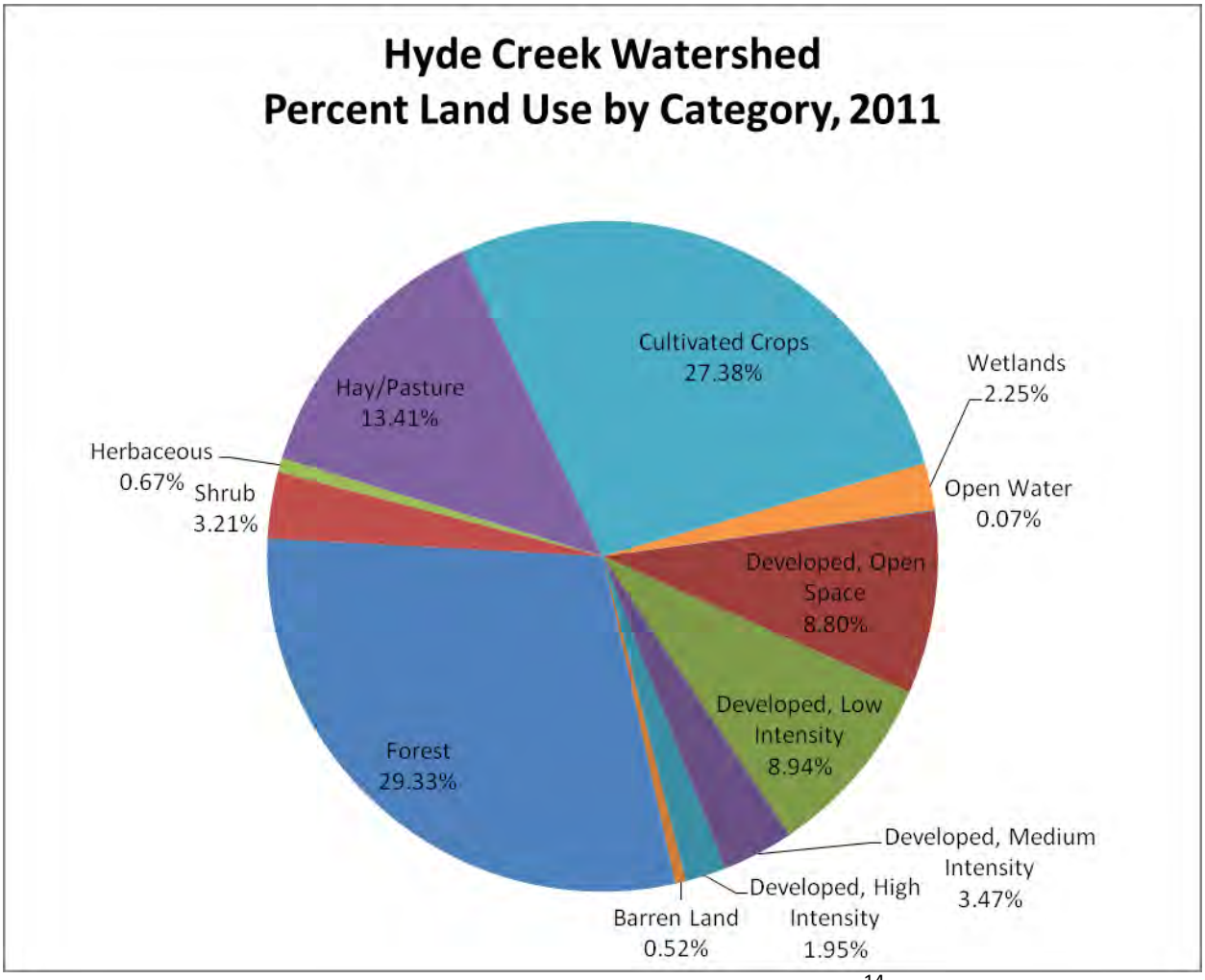


Chart 6. Hyde Creek Watershed Percent Land Use by Category, 2011.[14]

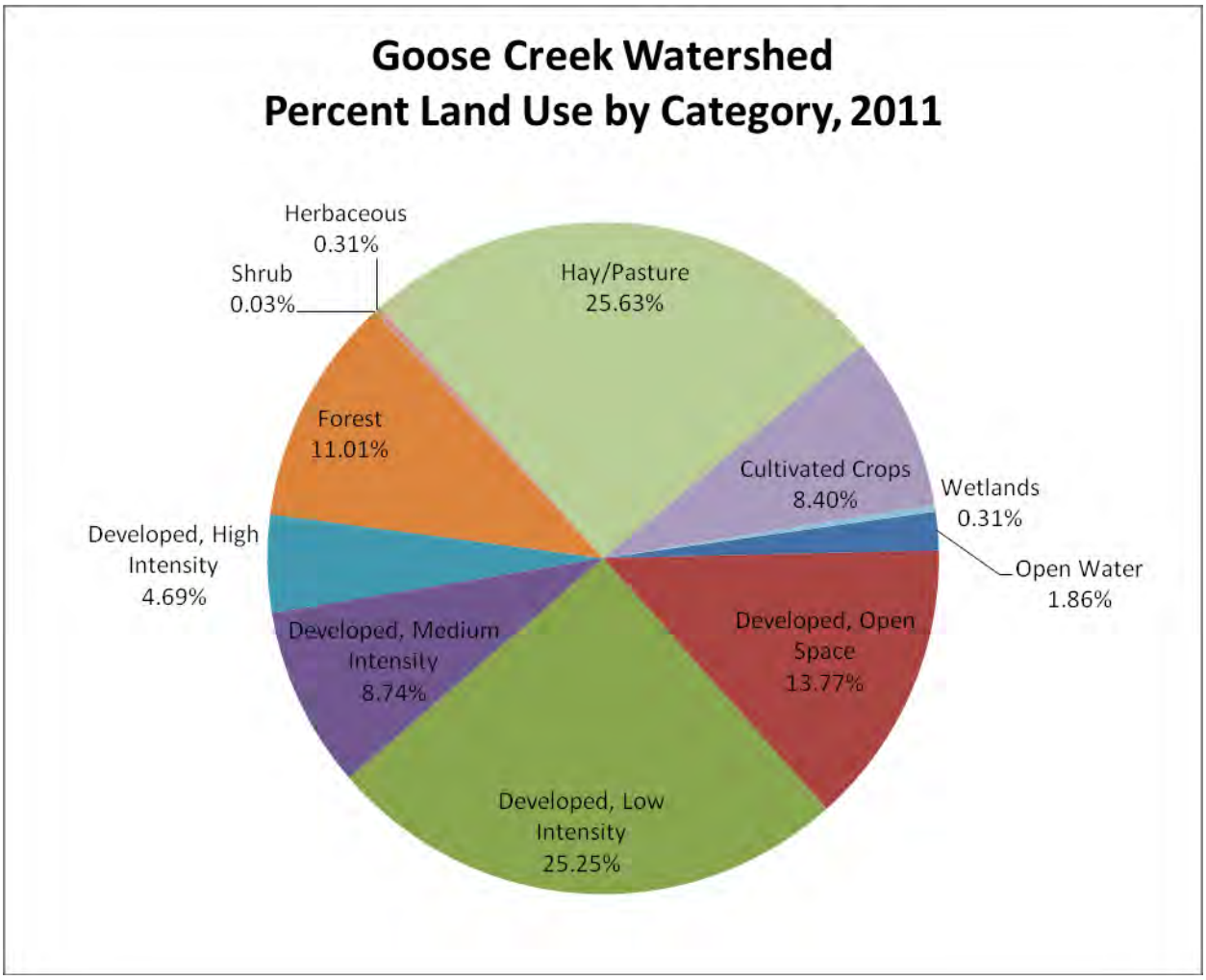


Chart 7. Goose Creek/ Main Street Beach Culvert Watershed Percent Land Use by Category, 2011.[14]

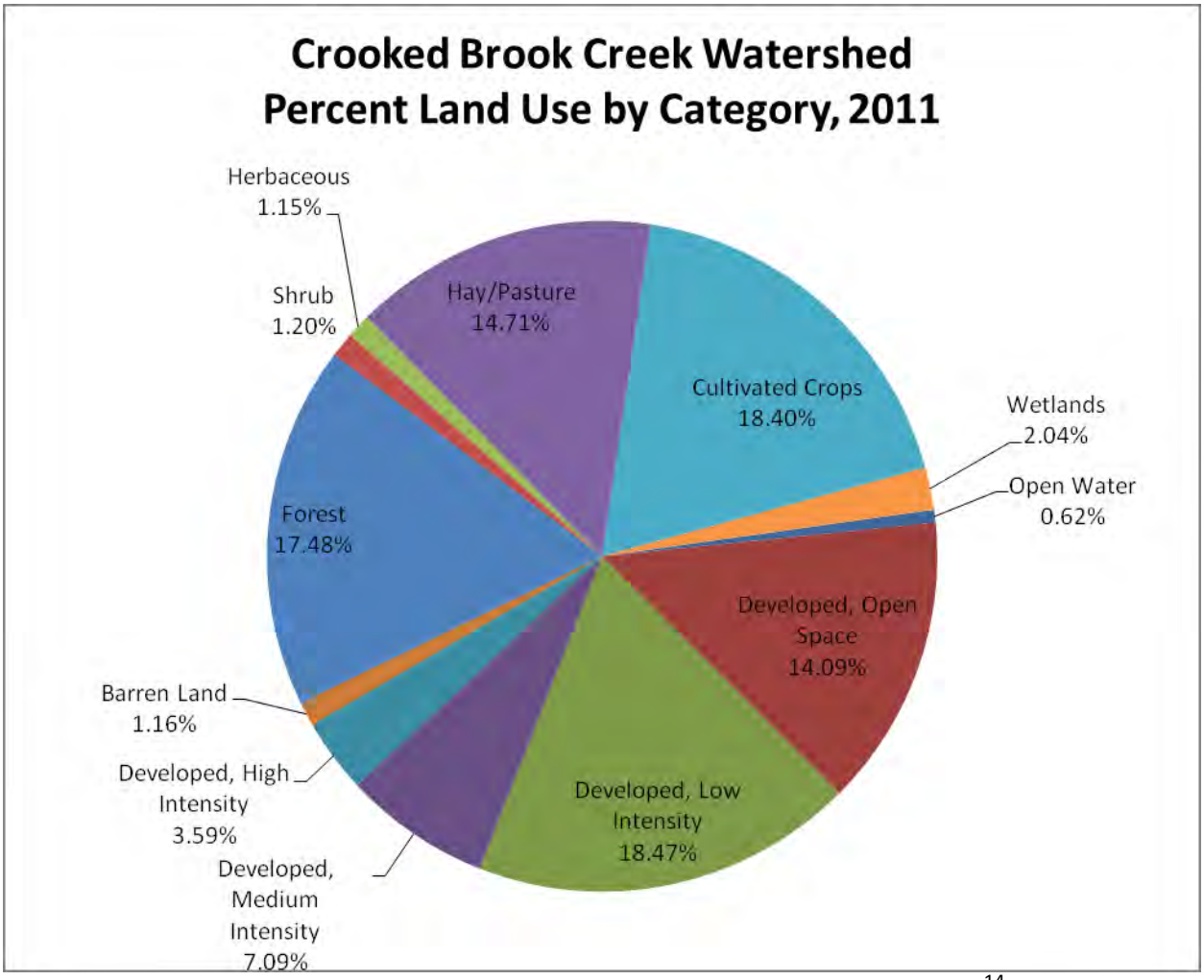


Chart 8. Crooked Brook Creek Watershed Percent Land Use by Category, 2011.[14]

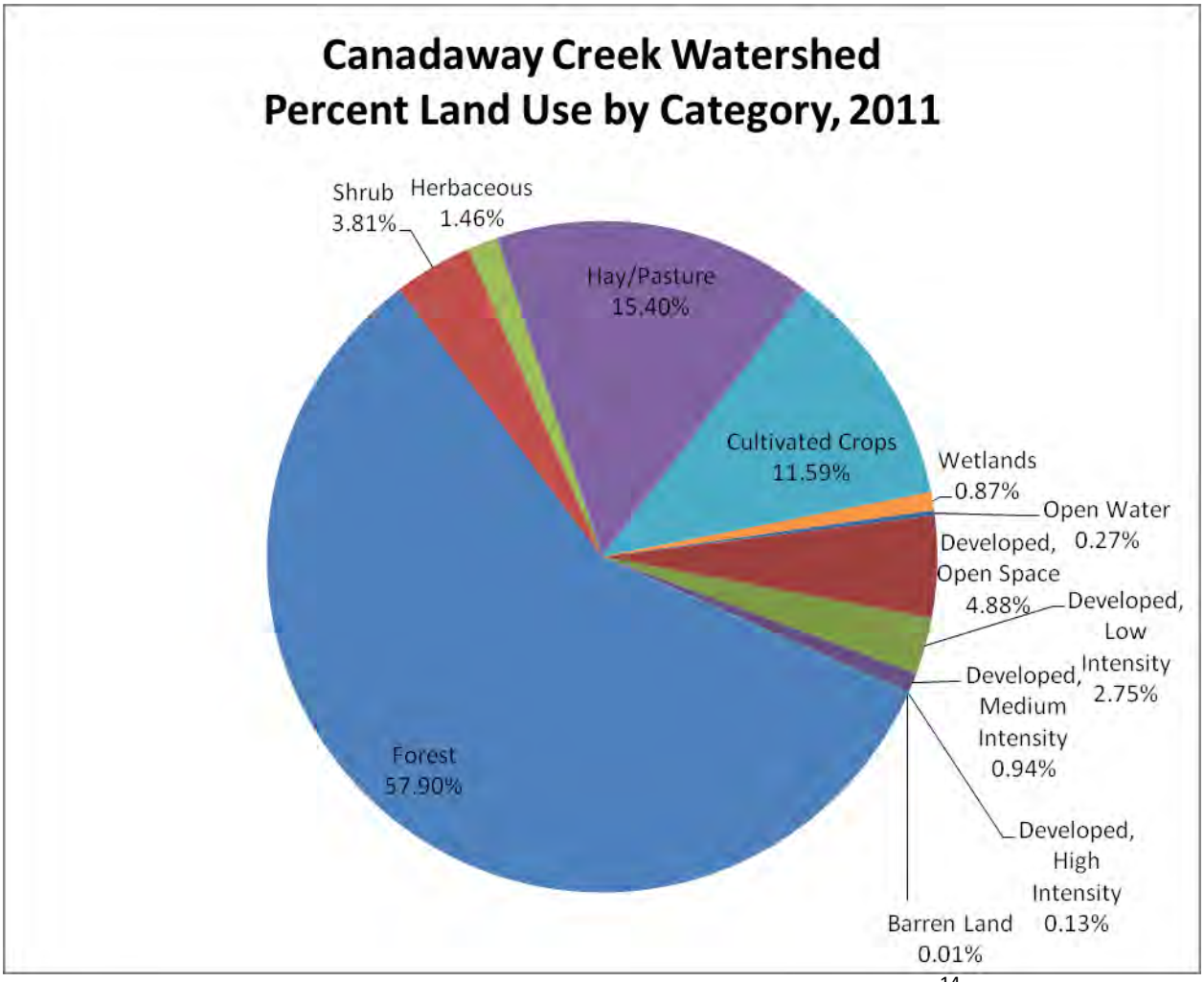


Chart 9. Canadaway Creek Watershed Percent Land Use by Category, 2011.[14]

Canadaway and Crooked Brook Creeks are potential pollution sources for Point Gratiot Beach. Canadaway Creek has been identified as the western boundary for the Dunkirk beach system watershed. The mouth of the stream lies approximately 1039 m west of PG Beach. As seen in Figure 7. Cattaraugus Creek Sediment Plume (page 30), the sediment plume from Canadaway Creek can be extensive and reaches the nearshore area of PG Beach provided general lake currents are not disrupted.

Discharge from Crooked Brook Creek crosses the western edge of PG Beach before reaching the Lake Erie shoreline. Prior to reaching the shoreline, Crooked Brook Creek creates a pool that attracts waterfowl to the western area of PG Beach. As the creek empties into the lake it creates a spit, interrupting a large portion of the shoreline at the westernmost section of the beach. A comparison of aerial photography over several years shows the spit growing and shifting northeast over time.

The eight foot diameter culvert on Main Street Beach empties a small stream referred to locally as Goose Creek and urban surface drainage onto the eastern edge of Main Street Beach at 42.490941 / -79.328506. The small stream channel is directed underground just south of Dunkirk City limits and contributes limited flow especially in summer months when the channel is frequently dry. Therefore, it appears that most of the summer outflow comes from urban surface drainage.

Flow is difficult to measure because the large culvert sits below the average lake level thereby allowing water to form a pool in the culvert and on the beach. A small channel typically carries water from the pool to the lake but the channel is not constant in size flow volume or direction. The channel can dry up following periods of dry weather, leaving the pool on the beach. In addition wave action can fill an existing channel with the debris and sand that gets pushed onto the beach. Furthermore, higher than average wave heights and/or seiches can result in lake water flowing into the culvert pool.

The pooling problem worsened in the summer of 2011 following dune construction on Main Street Beach in 2010. The dune was constructed in an attempt to mitigate the problem of wind-blown beach sand accumulating on Lake Shore Blvd. City of Dunkirk employees report that the dune has made a difference and far less sand has been observed on Lake Shore Blvd. since construction, particularly as vegetation spreads on the dune. However, the trench that was dug along the seawall during dune construction now provides an alternative path for culvert discharge and essentially expanded the area of pooling water on Main Street Beach.

Aside from the rush of water that results from heavy rainfall or snowmelt, measurable flow from the culvert is occasional at best, especially in dry summers. Although the culvert does not consistently contribute large amounts of water to the nearshore area of Main Street Beach, the high bacteria levels measured in the culvert and pool area are of concern. The culvert consistently has substantially higher *E. coli* levels than any of the other Chautauqua County stream/culvert watersheds included in the 2012-2014 sampling efforts.

However, the pool area hinders accurate *E. coli* measurements in a number of ways making it difficult to determine how much of the *E. coli* loading problem is actually from watershed discharge. First, the pool area concentrates the bacteria coming from the culvert. Second, the pool attracts some of the many birds observed on the beach, thereby increasing

the amount of fecal material and raising *E. coli* levels in and near the pool area. Lastly, the pool creates ideal conditions for bacterial and algal growth.

The Hyde Creek watershed marks the eastern boundary of the Dunkirk beach system. Much of Hyde Creek's length is contained by culverts underneath the city of Dunkirk where surface drainage increases the discharge that eventually reaches the Wright Park Beach system via an elevated culvert. The outflow from Hyde Creek separates Wright Park Beach into Wright Park West and Wright Park East.

Dunkirk Beaches: Historical Water Quality

Over the past 20 years, considerable time and money has been spent with the aim of discovering and eliminating the sources of *E. coli* and fecal coliform bacteria at the Dunkirk beaches. Significant pollution sources were identified and remediated in 1995 following extended beach closures at Wright Park in 1993 and 1995. Consequently, a bacteria monitoring program identified the East branch of Hyde Creek as a major contributor of bacteria to the lake. During the sanitary surveys following that conclusion, two residential sewage discharges were also discovered and corrected.

Despite the sewage corrections, bacteria levels remained high. Investigators suspected that the stagnant pools in the Hyde Creek channel were harboring bacteria and encouraging growth. To test their hypothesis, the city initiated a pilot project during which they lined 400 feet of the creek with oversized stone to eliminate the stagnant pools and reduce stream bank erosion. The project aimed to increase flow velocity and improve water aeration. By reducing erosion, the stone also decreased stream turbidity and allowed sunlight to reach more of the stream bed. Subsequent bacteria monitoring showed decreased concentrations of 10-fold (>50,000 down to <500 fecal coliform colonies per 100 ml water during low flows and <2,000 during high flow).

The 1995 investigation also found an overflow bypass from the wastewater treatment plant that was occasionally opened, allowing raw sewage to spill back into an abandoned 36 inch pipe under WP Beach. Sewage in the pipe under the beach likely leaked into the sand contributing to bacteria dosing of the sand and nutrient enrichment which supported bacterial growth. Following the discovery of the abandoned pipe, the sewer line was disinfected and flushed with chlorine to kill the fecal bacteria that it contained. The pipe was sealed with concrete plugs at both ends to prevent leaking and future contamination of the WP Beach.[21]

Another major investigation of Dunkirk beach water quality took place in 2008-2009. The sanitary survey identified the streams discharging onto or near the beaches as the most likely contributors to elevated *E. coli* levels at the beach and therefore focused on watershed sampling. Despite elevated *E. coli* levels and positive *Bacteroides* results throughout the streams, point source polluters were difficult to find. The study also included an assessment of naturalized *E. coli* in beach, lake and stream sediment using microbial source tracking. Although *E. coli* was found in beach sand, analysis proved difficult and CCDHHS was unable to identify the source(s) of the *E. coli*.

Based on 2007-2014 *E. coli* levels, Dunkirk beaches continue to have poor water quality and the highest average percentages of unsatisfactory results among the Chautauqua County beaches, Table 1. Percentages of Unsatisfactory Samples (total number of samples collected), page 9. The WP Beaches in particular have the greatest average percentages of unsatisfactory *E. coli* results. The average percentages of unsatisfactory *E. coli* results for Main Street and PG (West) Beaches are close behind.

Preemptive Beach Closures

Data analysis supported CCDHHS suspicions that beach *E. coli* levels tended to increase following heavy rainfall so the preemptive closure criteria was set at 0.50 inches of rainfall in a 24-hour period. Beginning in 2010, rain data was monitored during the beach season for rainfall amounts greater than 0.5 inches in a 24-hour period. When rainfall equaled or

exceeded 0.5 inches in a 24-hour period CCDHHS closed Dunkirk beaches until a subsequent beach water sample revealed *E. coli* levels less than 235 cfu/100 ml.

Wright Park Beach Description

Wright Park (WP) Beach is a relatively large beachfront area that has been recognized and treated as two separate beaches, Wright Park East (WPE) and Wright Park West (WPW), for many years. The beachfront extends from the shale cliffs near the City of Dunkirk WWTP along Lake Front Boulevard toward Armadillo Street. The two areas are separated by a culvert at the base of Serval Street which empties Hyde Creek and urban surface drainage onto the beach. The culvert location is constant at (42.497549 / -79.320749) but the path of the stream channel across the sand varies following changes in culvert discharge.

Prior to entering City of Dunkirk limits, Hyde Creek flows in a partly channelized stream bed with a silt bottom and stagnant pool areas. City of Dunkirk infrastructure directs the main stream channel underground through a series of culverts where surface drainage increases the amount of flow. Small tributaries within the watershed are also directed to the underground drainage channel before reaching the culvert and discharging onto the beach.

The eastern half of WPE Beach is bordered by forested land and the City of Dunkirk WWTP, which is roughly 40 m inland from the beach. A very small tributary, frequently dry in summer months, carries immediate localized drainage to the lake at the extreme eastern border. The remainder of WPE Beach is bordered by Wright Park public park space, including sports fields, picnic areas and playground equipment. Serval Street separates the public park from the residential area that is directly adjacent to WPW Beach. A small food service establishment operates May through September at the intersection of Serval Street and Lake Front Boulevard.

Both beaches are sandy with very few rocks or pebbles. Sandy sediment continues into the nearshore area for roughly six meters until it gives way to exposed shale covered with periphyton, attached algae and patches of sediment. CCHHS observed beach debris including large and small vegetation as well as leaf litter, algae and Dreissenid mussel shells. Most of the shoreline has a persistent layer of Dreissenid shells which usually thickens as the summer progresses.

Algal blooms have not been observed at either of the Wright Park beaches. When lake conditions are calm minimal amounts of algae are found on the shoreline or in the nearshore water. However, following rough water conditions *Cladophora* is washed into the nearshore area and onto the beach. Thick layers of *Cladophora* have been observed at both beaches but layers tend to be thicker and more persistent at WPE.

The cleaning schedule of the WP Beaches contributes to the greater persistence of *Cladophora* layers on WPE Beach compared to WPW Beach. City of Dunkirk employees conduct rough beach cleanings in the spring to clear large debris from the shoreline of both WP Beaches. However, during the summer, most beach clean-up efforts focus on WPW Beach and WPE receives little attention. The debris from shoreline clean-up efforts is unloaded on the eastern area of WPE Beach near deteriorating cement retaining walls. Community-led trash clean-up efforts are organized sporadically and occurred once or twice per season.

Food-related litter is consistently observed on both WP Beaches. Other litter including household and street-related litter is occasionally observed. Used diapers are also occasionally

observed both on the beach and at street level. Trash bins are not located directly on either beach but are present at street level near the stairs leading down to the beach. The litter includes items that appeared to be left by beachgoers as well as items that were transported to the beach by wind, wildlife, or surface runoff.

Parking along the entire length of WPW and half of WPE allows people to enjoy the beach and waterfront without actually going onto the sand. Throughout the year, especially in the summer, people routinely park and remain in their vehicles to consume take-out food and snacks. The majority of people dispose of their trash properly but empty packaging is regularly observed at street level and on the beach area. Although the number of trash bins is adequate, the bins do not have wind/wildlife guards so even trash that is disposed of properly can end up on the beach.

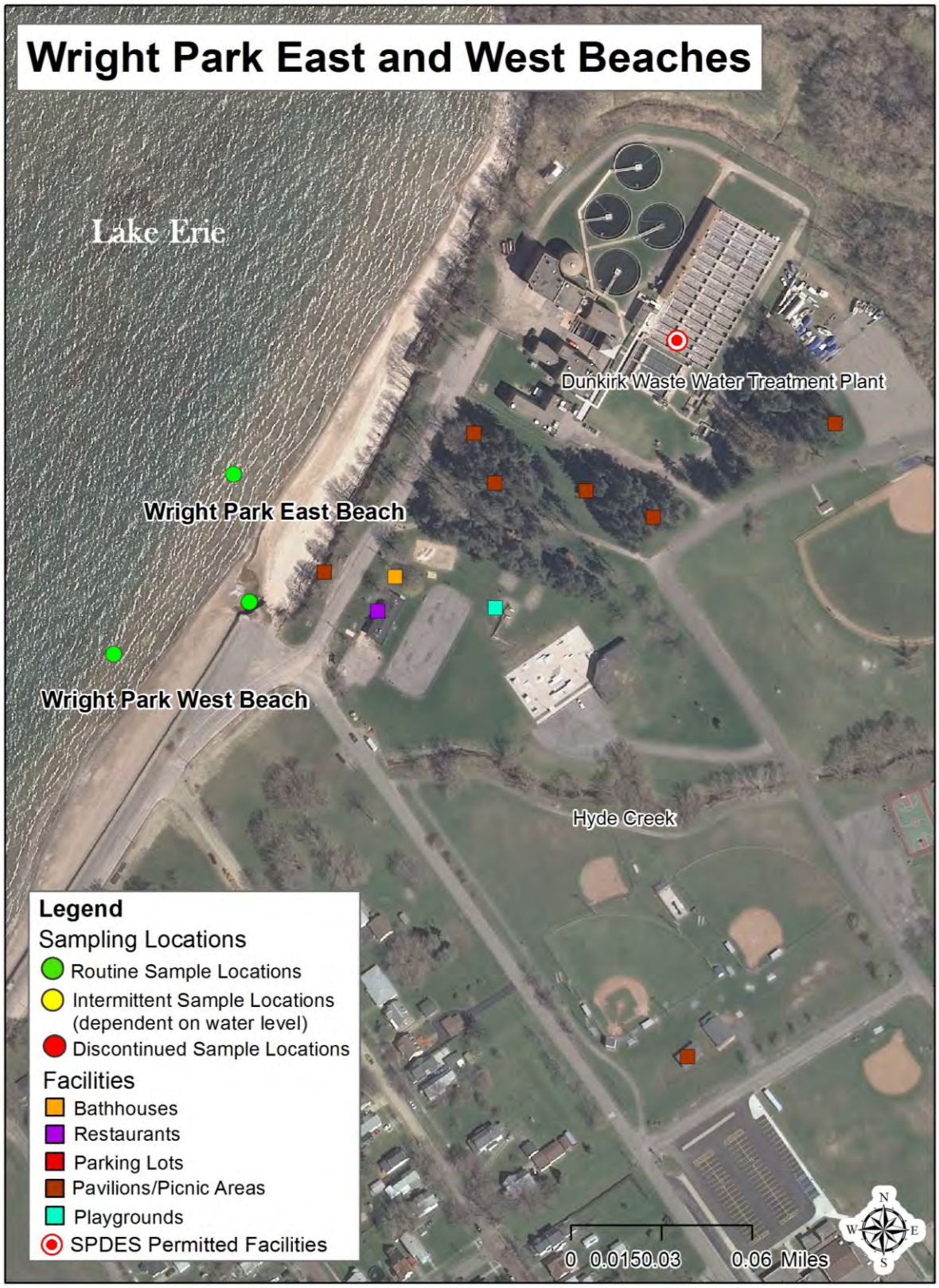
The large beachfront, open trash bins, proximity of public park/picnic space and people who intentionally feed waterfowl from their vehicles contribute to the presence of waterfowl at the WP Beaches. During the 2012-2014 seasons, the number of waterfowl on WPW Beach averaged 59 individuals with numbers as high as 200 observed. Waterfowl on WPE were generally present in lesser numbers. Gulls were the most common waterfowl on WP Beaches but Canada geese, common terns and ducks were also observed during the summer months. Gulls, Canada geese and ducks are typically observed in much smaller numbers throughout the year as long as open water is available. Turkey vultures are occasionally observed on the beaches throughout the year but were more common on WPE Beach.

Other wildlife from the nearby undeveloped regions also frequent WP Beaches. Small animal carcasses including opossum and muskrat were occasionally observed at the WP Beaches, but it is unclear if the animals died at the beach or were transported there. However, animal tracks on WPE Beach suggest that deer and raccoons occasionally visit the beaches.

Despite the “No Dogs on Beach” signs that are posted at street level, paw prints and people with dogs were regularly observed on the WP Beaches. Dogs were predominately observed outside the swim area on the western edge of WPW and on WPE. Occasionally dogs were observed passing through the swim area of WPW Beach but only when lifeguards were not present. Pet feces was not observed in the designated swim areas but were observed outside the swim areas on occasion. Pet feces was also occasionally observed at street level since the sidewalk along the retaining wall provides a popular path for people to walk dogs.

Although the WP Beaches share many similar characteristics, WPE Beach has a slight bay shape which disrupts nearshore currents and slows the rate at which material such as *Cladophora* can be swept away from the shoreline. Additionally, the action of the general nearshore lake currents, which travel west to east, appear to create a small sandbar that blocks the channel from traveling straight to the lake and instead pushes the channel toward WPE Beach. Thus, WPE Beach tends to receive more contamination from Hyde Creek discharge. However, northeasterly winds can change the nearshore currents such that WPW Beach will receive more of the contaminated Hyde Creek discharge. Changes in the channel’s path as it makes its way to the shoreline, as well as variations in wind speed and direction, result in nearshore current fluctuation. This fluctuation can cause surprising differences in nearshore *E. coli* levels. Because of this, WPE and WPW are sampled individually.

Figure 14. Wright Park East and West Beaches Detailed Map.



Wright Park East Beach Description

The shoreline at WPE Beach covers approximately 288.9 m long from the eastern shale cliff boundary at 42.499346 / -79.319581 to the Hyde Creek culvert stream channel. The average beach width was 38.5 meters in 2014 with the widest area of beachfront located near the Hyde Creek culvert.

While the City of Dunkirk does not operate a swim area on WPE Beach, the beach remains open to the public for sunbathing, sand play and beachcombing. The City of Dunkirk has not operated a lifeguarded swimming area on WPE Beach in many years and "No Swimming" signs are posted at the main entry points to the beach. However, people are occasionally observed disregarding the signs and swimming at WPE Beach.

Wright Park West Beach Description

Wright Park West is approximately 492.3 m along the shore, with 29.2 m at its widest point. The western border of the beach, defined by the point at which the sand and water interface meets the cement seawall, is typically just past the intersection of Armadillo Street and Lake Front Boulevard at 42.494481 / -79.323435.

The City operates a designated swim area on the eastern most area of Wright Park West Beach with three lifeguard chairs. The swim area is typically open late-June through Labor Day weekend dependent on staff availability. Within the designated swim area people are regularly observed sunbathing, swimming, beachcombing and playing in the sand. People engage in similar activities outside the designated swim area and lifeguards occasionally have to usher swimmers into the designated swim area. The beach is especially crowded on weekends and holidays.

Figure 15. Wright Park East Beach Detailed Map.

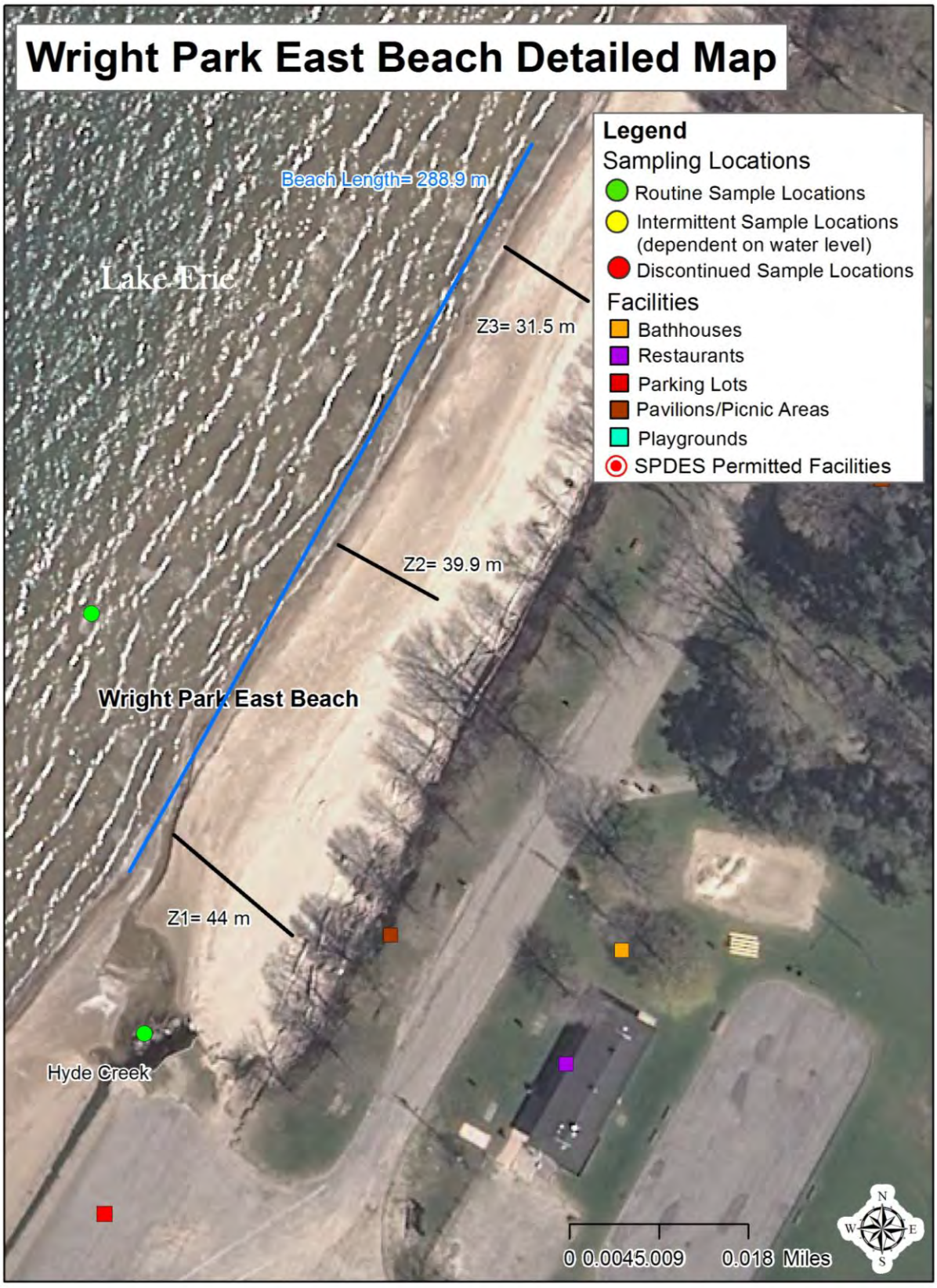
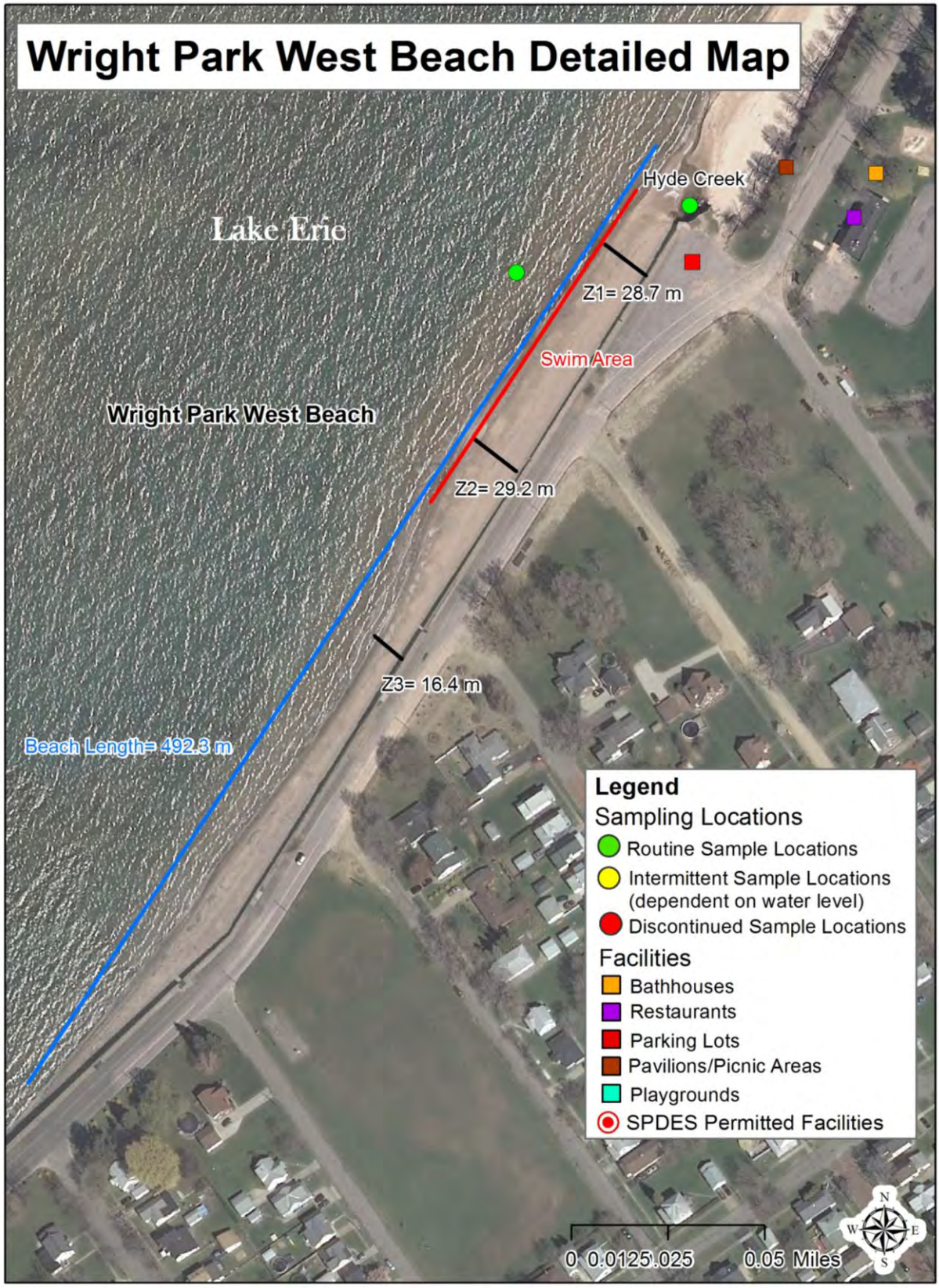


Figure 16. Wright Park West Beach Detailed Map.



Wright Park East and West Beach Photographs

Photograph 10. Wright Park East Beach.

Photograph 11. Hyde Creek Culvert separating WPE Beach (foreground) from WPW Beach.

Photograph 12. WPW Beach with lifeguard chairs in the designated swim area and waterfowl.

Photograph 13. WPW Beach western border, retaining wall extends west to Main Street Beach.

Main Street Beach Description

The seawall that supports Lake Front Boulevard and provides the inland border of WPW Beach extends west and also serves as the inland border for Main Street Beach. The eastern border of Main Street Beach is created where the sand/water interface meets the seawall. The distance between the two beaches varies as lower lake levels expose more sand, for instance in late summer 2012 a narrow (1-2 m) sandy area along the seawall connected Main Street Beach with WPW Beach. In 2014 Main Street Beach was separated from WPW by approximately 451 m of open water along the seawall. A breakwall separates Main Street Beach from the Chadwick Bay Marina and defines the western border.

The corner created by the retaining wall and breakwall results in a curved shoreline, the length of which varies slightly with changes in lake level. The beach area along the retaining wall is roughly 253 m, but the shoreline is nearly 334.4 m stretching from the eastern border at 42.491563 / -79.3279 to the western border at 42.49052 / -79.330688. The beach is widest at its western border, approximately 70 m, and narrows to the east until the beach ends at the concrete retaining wall.

The beach is sandy with scattered small rocks and pebbles. In 2011, a sand dune was created parallel to the retaining wall in an attempt to prevent beach sand from blowing onto the road. City representatives claim the dune has been successful at preventing the problematic sand movement. Grasses and other ground cover have taken root on the sand dune, which further stabilizes the dune.

The breakwall protecting the Chadwick Bay Marina extends into the lake approximately 52 m past the shoreline of Main Street Beach. Additionally, the greater harbor area is protected by an offshore breakwall, approximately 680 m from Main Street Beach. Together the breakwalls interrupt and reduce lake currents in the nearshore area of Main Street Beach, especially toward the western edge of the beach and typically result in the calmest water conditions observed among the eight permitted Lake Erie beaches in Chautauqua County.

The interrupted currents contribute to the growth of Main Street Beach as continued sand accumulation on the northeast side of the breakwall creates a sandy, shallow nearshore area off Main Street Beach. The generally calm water conditions also lead to low turbidity in the nearshore area. However, the generally calm water conditions also contribute to thick layers of algae, specifically *Cladophora*, accumulating during the mid-late summer months.

When high winds create rough water conditions, *Cladophora* accumulates in the nearshore area and along the shoreline of Main Street Beach. Under calm water conditions, thick layers of *Cladophora* reach widths of 3.5 m along the western shoreline during peak accumulation and persistent calm water conditions. Due to the lack of permitted swim area at Main Street Beach, the city typically does not focus cleaning efforts on accumulated algae. Thus, the interrupted current continues to trap the algae until instances of high winds and rough water are able to break up the accumulated algae or bury it under sand.

There are two main stairways down to the beach from Lake Front Boulevard. Sanitary facilities are located between the stairways, across Lakeside Boulevard, at 42.490138 / -79.329222 at 40 m from the water line. The sanitary facilities have been locked in recent years because the City of Dunkirk has not operated a designated swim area on the beach. The beach remains open to the public and a small number (<5) of people are frequently observed walking

on the beach or sunbathing on afternoons and weekends. Occasionally people are observed wading or swimming despite "No Swimming" signs posted near the beach entrances.

Waterfowl are by far the greatest contributors of animal feces on Main Street Beach, though dog feces were occasionally observed. Waterfowl are always present on the beach, typically in numbers greater than 70 individuals, and their feces consistently cover the shoreline of the beach. Gulls make up the majority of the Main Street Beach waterfowl population but smaller numbers of Canada geese, common terns and ducks are also frequently observed. Small numbers (≤ 5) of turkey vultures have become increasingly common on the beach in recent years. Feral cats and other small mammal tracks have been observed occasionally.

Beach litter on Main Street Beach is largely food-related but also includes household and street-related items. Occasionally, fishing and boating-related items such as lures, lines and rope are observed on the beach. Prior to 2014, fresh beach litter was not frequently observed on Main Street Beach, however the City of Dunkirk seemed to focus beach clean-up efforts to the more frequented beaches in the 2014 season which allowed litter to accumulate.

Although relatively few people use the sandy area of Main Street Beach, people frequently park along the shoulder of Lake Front Boulevard as they do near WPW Beach. Trash bins are located at street level near each beach entrance and, considering the limited use of Main Street Beach, are adequate in number for most of the summer season. However, the bins do not have wind/wildlife guards to reduce the possibility for wind or wildlife to transport trash even if it has been properly disposed. The neighboring residential area, waterfront and breakwall walkways are also potential sources for trash that could be transported to Main Street Beach.

Small beach debris including Dreissenid mussel shells and algae are common on Main Street Beach. Large debris is less common but tends to accumulate during the winter months. In general, large debris is removed by payloader in the spring and a beachraker is used to clean the sandy beach as needed throughout the summer season. However, in recent years the City of Dunkirk seems to have focused beach cleaning efforts on other Dunkirk beaches. For example, the initial Main Street Beach clean-up for the 2014 season occurred in early July just before the July 4th weekend. The July 4th weekend draws a significant crowd to Main Street Beach because the beach provides a good vantage point for the annual fireworks display. Sporadic "beach cleanings" are led by community volunteers associated with organizations such as the Alliance for the Great Lakes and the Boys and Girls Club.

Figure 17. Main Street Beach Detailed Map.

Main Street Beach Photographs

Photograph 14. Main Street Beach, looking west toward breakwall and Chadwick Bay Marina (Dunkirk Harbor) (2014).

Photograph 15. Main Street Beach, looking east toward WPW Beach (2014).

Photograph 16. Main Street Beach and culvert channel, *Cladophora* accumulated and rotting (2012).

Photograph 17. Main Street Beach, *Cladophora* accumulated and rotting (2012).

Photograph 18. Goose Creek and surface drainage culvert pool extending into trench behind sand dune on Main Street Beach, typical amount of algae in pool area (2013).

Photograph 19. Goose Creek and surface drainage culvert on Main Street Beach, algae in the pool was especially bad for nearly two weeks until a storm flushed the build-up to the lake (2013).

Point Gratiot Beach Description

Point Gratiot (PG) Beach stretches from the western border of Crooked Brook Creek at 42.484621 / -79.359879 approximately 748 m to a natural formation of shale cliffs at 42.490692 / -79.357495. Privately owned beachfront lies west of Crooked Brook Creek and shale cliffs continue east of the PG Beach area. The inland border of PG Beach is Point Gratiot Park.

Point Gratiot Park is a 26-acre park owned and maintained by the City of Dunkirk. The park is open to the public and includes open field space, picnic areas, playgrounds and parking lots. A narrow stretch of wooded area separates the open field space of Point Gratiot Park from adjacent residential areas.

The long beachfront is a mix of sand and rock, such that beach raking is difficult for City of Dunkirk machinery. Sand and rock continues into the nearshore area of PG Beach until a relatively steep drop (< 0.5 m) is followed by a 1.5 m wide layer of rounded rocks. Beyond the rock layer, exposed shale is covered with thin sandy patches, periphyton and attached algae.

General lake currents, beach angle and frequently rough water conditions contribute to the large amount of vegetative/tree debris that accumulates on PG Beach. City employees perform "rough" clean-ups with payloaders to remove large debris prior to the summer season and during the season as needed. The payloaders are typically needed multiple times per year because large amounts of vegetative debris including branches and small tree trunks are common on PG Beach especially following stormy weather. Community-led “beach sweeps” typically occur in the late spring and early fall but focus on litter rather than beach vegetative debris.

While Dreissenid mussel shells are constantly present on the beach, algae are present in very small amounts, if at all. The nearshore area is generally free of algae except when rough water conditions drastically increase the amount of *Cladophora*. However, even with increases in nearshore *Cladophora,* algae generally do not accumulate on the beach. Rather, algae is trapped in the nearshore area by the steep drop and typically remains for a few days at most before wave action and lake current sweeps the algae away from the beach.

As the name suggests, Point Gratiot Beach has developed along the western edge of a coastal geologic feature that juts, northeast, into the lake. The nearest similar geologic feature west of Point Gratiot that may disrupt shoreline wave/current activity is more than four miles to the west. The angle of the coastline and openness of the lake area around the beach encourages wave activity such that PG Beach frequently has the largest wave height measurements among the Chautauqua County beaches.

Beach litter is common at PG Beach, although floatable litter is seldom observed. Beachgoers are the most likely source of beach litter but some litter appears to get washed onto the beach following stormy weather. Food and street related litter are the most common types of litter on the beach followed by household waste. Sewage related litter such as disposable diapers and feminine hygiene products were rarely observed on the beach. Litter bins are not located directly on the beach. Litter bins are located around the parking lots and at the two main entryways to the beach but they do not have wind/wildlife guards or lids, making it possible for strong winds and wildlife to transport litter.

Some of the food and street related litter that is observed on PG Beach may originate from the adjacent park area. As a popular site for picnics and gatherings, Point Gratiot Park has numerous trash bins, specifically near parking lots, pavilions and playgrounds. Unfortunately,

the bins lack wind/wildlife guards so even trash that is disposed of properly could be contributing to the beach litter problem.

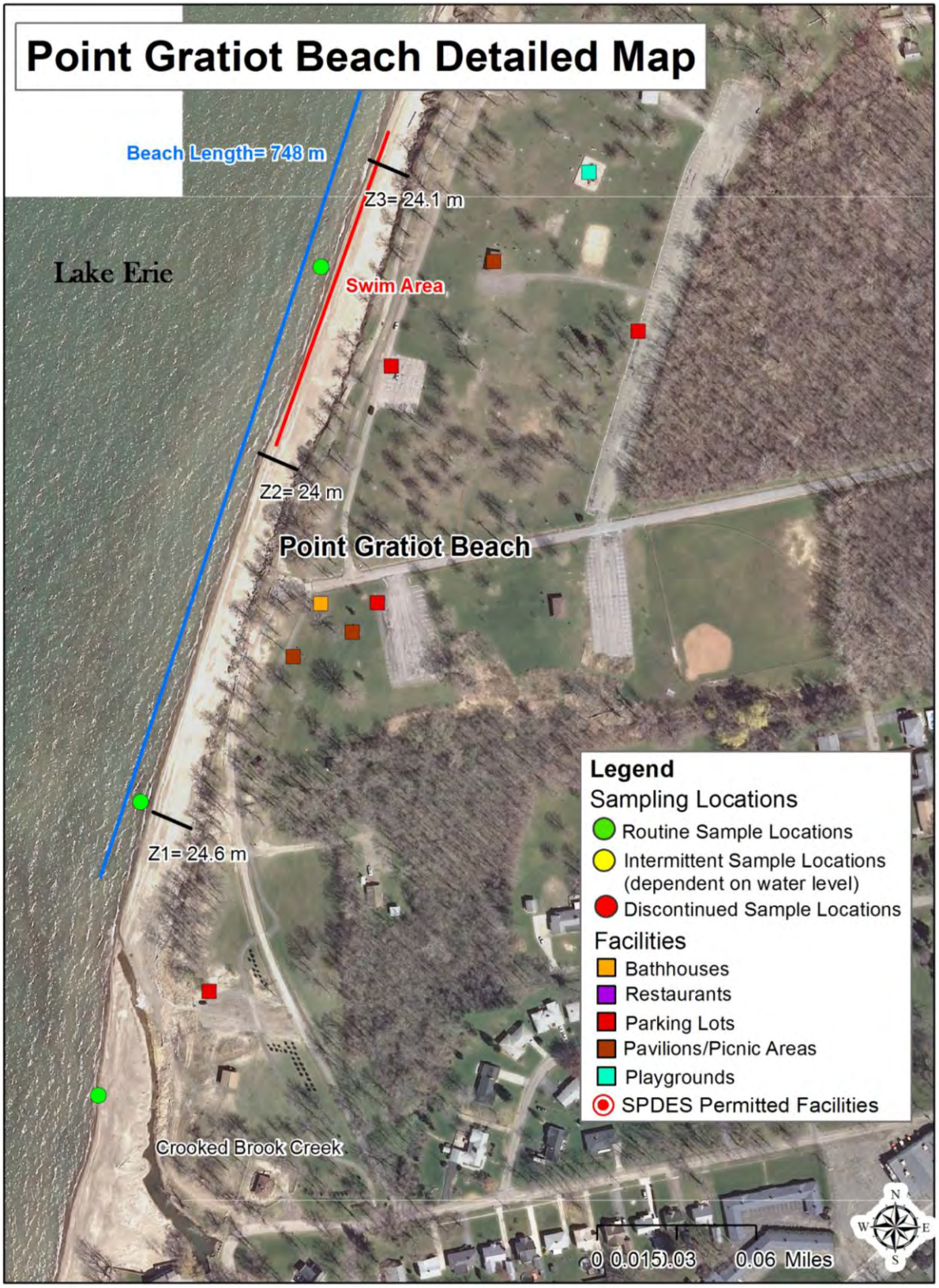
Sunbathing and swimming are routinely observed at PG Beach, weather permitting. The designated swim area roughly 95 m in length, is monitored from two lifeguard chairs and is located on the eastern side of the beach. The swim area operates daily, 12-7pm, from late June/early July through Labor Day weekend. A second swim area used to operate on the western side of the beach but has not for more than ten years.

Point Gratiot Park and Beach are easily accessible year-round and people routinely use the areas throughout the year, weather permitting. Park walking paths are frequented by people and dogs and despite signs prohibiting dogs on the beach, dogs were occasionally observed on the beach and in the water. The beach has also become a local hotspot for beachcombers so people are routinely observed walking and scavenging the shoreline in search of beach glass.

Aside from the occasional dog, most of the animal life observed on PG Beach is waterfowl. Ring-billed and Heron Gulls are often observed in large numbers on the western area of PG Beach along with occasional groups of Canada geese. Other waterfowl, including common terns and ducks, are occasionally observed. Animal sightings and tracks provide evidence that small mammals and even deer utilize the beach as well.

Maintenance of PG Beach includes little more than the seasonal and occasional beach cleaning via payloader. However, a small patch of beach grass was planted near the western most parking lot in June 2003 in an attempt to stabilize beach sand. The planting was a cooperative effort by Dunkirk Parks Department and Dunkirk High School students. The grass appears to be spreading and functioning as intended.

Figure 18. Point Gratiot Beach Detailed Map.



Point Gratiot Photographs

Photograph 20. Crooked Brook Creek outlet serves as the western border of PG beach.

Photograph 21. Point Gratiot West, large debris frequently accumulates on beach following rough water conditions.

Photograph 22. Point Gratiot East. The designated swim area has two lifeguard chairs.

Photograph 23. Point Gratiot Beach. Shale cliffs, in the background, define the eastern border.

Dunkirk Beaches: History of Water Quality

During the 2012-2014 seasons, and in recent years, only two swim areas operated on the Dunkirk beaches, one at WPW Beach, the other on the eastern area of PG Beach. Routine samples were collected from all beach locations at least once per week in 2012-2014, in compliance with the Beach Act. Sampling increased in 2013 and 2014 for WPW and PG (East) Beaches because they operate designated swim areas and large amounts of data was needed to develop predictive models specific to the individual beaches. Sample collection increased for the other Dunkirk beaches, which do not operate swim areas, as well in an effort to better understand the potential effect of weather variation on beach water quality.

Tables 10 and 11 describe the total number of samples collected and the percentages of samples that were unsatisfactory because they exceeded the 235 cfu/100 ml standard. When water conditions, such as turbidity and nearshore algal presence, vary within a swim area CCDHHS collects multiple samples to assess *E. coli* variation. Following unsatisfactory results, swim areas were closed, however beaches without swim areas were never actually open for swimming so unsatisfactory results did not warrant additional "closing" actions.

Table 10. Wright Park and Main Street Beaches: History of Water Quality.

	WRIGHT PARK WEST *(swim area)*				**WRIGHT PARK EAST**		**MAIN STREET**	
	Total Samples	**% Unsatisfactory**	**Days Closed**	**Rain Advisory Days**	**Total Samples**	**% Unsatisfactory**	**Total Samples**	**% Unsatisfactory**
2007	74	32.4%	21	n/a	42	31.0%	26	30.8%
2008	25	20.0%	7	n/a	22	18.2%	21	9.5%
2009	47	23.4%	14	n/a	45	37.8%	25	24.0%
2010	55	32.7%	17	3	45	37.8%	44	43.2%
2011	20	25.0%	12	4	16	31.3%	16	31.3%
2012	18	38.9%	14	4	18	33.3%	17	35.3%
2013	76	35.5%	29	1	42	47.6%	24	29.2%
2014	61	39.3%	25	4	26	11.5%	26	23.1%
Average		30.9%				31.1%		28.3%

Table 11. Point Gratiot Beaches: History of Water Quality.

	POINT GRATIOT EAST *(swim area)*				**POINT GRATIOT WEST**	
	Total Samples	**% Unsatisfactory**	**Days Closed**	**Rain Advisory Days**	**Total Samples**	**% Unsatisfactory**
2007	40	12.5%	3	n/a	45	20.0%
2008	23	13.0%	2	n/a	23	13.0%
2009	36	33.3%	11	n/a	37	40.5%
2010	53	24.5%	7	3	43	37.2%
2011	20	20.0%	6	4	19	31.6%
2012	19	15.8%	5	3	18	27.8%
2013	45	28.9%	19	2	13	23.1%
2014	50	34.0%	18	5	16	31.3%
Average		22.8%				28.1%

Watershed samples for the four streams identified as potential pollution sources to the Dunkirk beaches were routinely collected in 2012-2014. Samples were collected more frequently in 2013-2014 from Canadaway, Crooked Brook and Hyde Creeks following the decision to develop predictive models for WPW and PG (East) Beaches. The 2012-2014 stream results (Table 3. Average Stream *E. coli* Results, page 11) were consistent with the general trends in *E. coli* results from prior years.

Dunkirk Beaches: Pollution Sources Surveyed and Identified

Streams in the Dunkirk Beach Watersheds

The four streams carrying water from throughout the watershed including urban surface drainage from within the City of Dunkirk have been identified as the biggest contributors to poor water quality at the beaches. However it is difficult to pinpoint exact pollution point sources within the stream channels due to the large watersheds and underground channels beneath the City of Dunkirk. In response to positive *Bacteroides* results from stream discharge locations which include urban runoff and storm sewer water; CCDHHS worked with the City of Dunkirk to investigate the integrity of surface drainage infrastructure within the City of Dunkirk. Hohl Industrial was contracted to conduct a video inspection and collect samples in two specific sections of storm sewer infrastructure.

The first section investigated is on Crooked Brook Creek where the creek channel is diverted underground at Woodrow and Fifth Streets. The creek travels beneath city streets and homes until it emerges from the culvert on the western side of Brigham Road. The section was identified for investigation due to a general lack of knowledge regarding the tunnel structure and integrity. Dunkirk authorities are not even sure of a construction year for the structure. Through real-time video surveillance, CCDHHS staff did not observe any suspicious pipes emptying or leaking into the stream channel. Water samples were collected at the inflow, outflow and midway point of the tunnel.

The second section identified for investigation is upstream of the large Main Street Beach culvert and includes Goose Creek as well as urban surface drainage. The section is a meeting point of two branches of storm sewer. The Talcott Street branch carries Goose Creek flow and urban surface drainage. Goose Creek flow is forced underneath the City of Dunkirk through a large bar grate at Franklin and Tenney Streets. During the summer months, Goose Creek typically has very low flow and appears to be little more than a series of roadside ditches upstream of the large grate. The South Roberts Road branch is a storm sewer that allegedly carries surface drainage alone. The two branches join at the South Roberts Road and Talcott Street intersection and a main storm sewer line continues to Main Street Beach.

Dunkirk authorities know that sanitary sewer lines were connected to storm sewer lines on the South Roberts Road branch prior to the 1970s. The connections were separated and sealed in the 1970s but there's no record of a follow-up investigation to evaluate the repair work. This section of storm sewer is especially interesting because its investigation helps tease out the *E. coli* problems associated with the pool area on Main Street Beach. Video surveillance showed the storm sewer structure is in good condition and with no evidence of sanitary sewer connection or leakage.

Water samples collected during the investigation were analyzed for Nitrates, Phosphates, caffeine, *E. coli*, and *Bacteroides* when indicated (Table 5. Dive Investigation of Storm Drainage and Urban Creeks in the City of Dunkirk, page 20). Additionally, optical brightener tests were constructed and launched twice at each location were water samples were collected or at other relative points which allowed easier access. In general the samples did not indicate any areas where sanitary sewer connected or leaked into the underground section of Crooked Brook Creek or the storm sewers on South Roberts Road and Talcott Street (Table 5). CCDHHS staff expected that the Crooked Brook Creek samples as well as the Talcott

Street samples would test positive for *Bacteroides* since the creeks undoubtedly carry effluent from private SDSs. However, the positive *Bacteroides* results from the South Roberts Road storm sewer line were surprising. The results indicate either a sanitary sewer line problem upstream or a surface runoff connection from outside municipal sanitary sewer lines is reaching the storm sewer.

Stream Channel Pools on the Dunkirk Beaches

Crooked Brook, Goose, and Hyde Creeks all form pools on the beaches where they discharge. The pools that are created on the beaches from stream and surface water drainage magnify bacteria problems in a number of ways. The pools create expanded areas of continuously moist sand where stream bacteria can survive and multiply. Pools that are cut off from the lake concentrate bacteria and nutrients from the stream, encouraging algal growth which blocks the sunlight that would normally kill bacteria and decomposes to release nutrients for bacterial growth.

The pools also attract wildlife and thereby increase the amount of feces on the beach and in the pools themselves. Wildlife feces can replenish fecal indicator bacteria populations in the beach sand and provide nutrients that encourage bacterial growth. When heavy rainfall flushes stagnant pool water to the lake, it also flushes the elevated *E. coli* populations, concentrated nutrients, and algal growth into the nearshore area.

The discharge pool on Main Street Beach is the largest among the Dunkirk beaches, particularly since dune construction in 2011 left a trench along the seawall that connects to the previously existing pool. The culvert pool consistently has *E. coli* levels that are greater than any other tributary and frequently has large amounts of algal growth. Waterfowl are frequently observed in and around the pools on both Main Street and Point Gratiot Beaches. While Hyde Creek typically has the shallowest pool and is rarely cut off from the shoreline it frequently harbors algal growth that is washed into the Wright Park beach areas when rain events promote heavy creek flow.

Sewage Disposal Systems

Private sewage disposal systems (SDSs) exist within Canadaway, Crooked Brook and Hyde Creek watersheds. After installation, private SDSs are only routinely monitored when property transfers occur, and homeowners are not always vigilant about recommended maintenance practices. Despite CCDHHS regulations, inadequate and faulty SDSs exist within the stream watersheds and contribute to bacterial and nutrient loading in the streams.

Larger SDSs are regulated with NYSDEC State Pollutant Discharge Elimination System (SPDES) permits and require routine monitoring. Three such facilities exist within the Dunkirk beach system watershed. The Dunkirk wastewater treatment plant (WWTP), permit #NY-0027961, and the Fredonia WWTP, permit #NY-0026409, drain directly into Lake Erie. The third SPDES permitted facility is McClenethan's Mobile Home Park, which operates under permit #NY-0170861 and discharges into Crooked Brook Creek.

The wastewater treatment plants for Dunkirk and Fredonia are located in close proximity to the beaches of concern. The Fredonia WWTP is located west of the Dunkirk Beach system and mouth of Canadaway Creek, with an outfall pipe discharging into Lake Erie approximately 805 m from shore. The Dunkirk WWTP is located just inland of the eastern

boundary of Wright Park East (the easternmost beach in the Dunkirk system) with an effluent pipe 661.5 m from shore below 5 m of water. The SPDES permits of these facilities require them to treat their wastewater and perform routine monitoring to ensure that treatment adequately maintains the discharge limits allowed by the NYSDEC. The Fredonia sewer system has a separated sanitary sewer and storm sewer system, while Dunkirk's system is partially combined. A diagram illustrating the portions of Dunkirk's system that are combined or separated is available for reference in Appendix F.

Dunkirk WWTP's Long Term Control Plan Combined Sewer Overflow Evaluation provides a description of what happens during combined sewer overflow bypass events:

> The treatment facility has the capacity to provide primary clarification for a total flow of 20 MGD. The facility can also provide secondary treatment to a wastewater flow of 12 MGD. Additional flows in excess of 12 MGD are diverted to the chlorine contact system, which also has a total flow capacity of 20 MGD. Under high flow conditions, both primary and secondary treated wastewater flow simultaneously and enter the chlorine contact tank, before being discharged through the plant's 84 inch effluent discharge pipe to the single outfall to Lake Erie.[22]

In the past, several combined sewer outlets emptied into the watershed during heavy rain events without passing through the Dunkirk WWTP. The combined outlets have been closed off and all untreated wastewater is directed to the WWTP. The outfall pipe is located east of WP Beach offshore from the Dunkirk WWTP at 42.503611 / -79.323889.[22]

The majority of bypass events occur during winter and spring months following periods of excessive snowmelt or rainfall. The June through early September sampling season limits the number of bypass events for which CCDHHS has comparative beach *E. coli* results. Table 12 represents those recent bypass events for which CCDHHS does have comparative beach samples.

Table 12. Dunkirk WWTP CSO/Bypass Events During the Beach Season (2007-2014). *E. coli* is represented as cfu/100 ml. No CSO events were reported in the 2012 or 2014 summers.

CSO Bypass Event Date	Bypass Volume (millions of gallons)	24 HR Rain (in)	Beach Sampling Date	WP East *E. coli*	WP West *E. coli*	24 HR Rain (in)
6/19/2007	3.33	1.56	6/21/2007	1600	800	0
7/9/2008	3.42	1.1	7/15/2008	<10	20	0
8/9/2009	5.85	2.7	8/10/2009	4900	6600	0.03
7/24/2010	0.63	1.32	7/24/2010	not sampled	90	0.06
7/25/2010	2.79	2.37	7/26/2010	110	80	0.94
7/29/2011	2.7	1.48	8/1/2011	50	10	0
8/10/2011	3.15	1.05	8/11/2011	50	70	0
8/21/2011	3.78	1.3	8/22/2011	not sampled	230	1.24
8/25/2011	2.43	1.17	8/25/2011	1240	220	1.24
			8/26/2011	210	130	0
6/2/2013	2.7	1.45	6/3/2013	190	510	0
8/26/2013	2.58	0.99	8/26/2013	1100	380	0
			8/28/2013	1600	1800	0.92

While CSO events undeniably empty relatively untreated sewage into Lake Erie, it is important to recognize that CSO events are triggered by stormy weather conditions which can affect beach water *E. coli* levels independently of CSO events. For example, intense rain events increase runoff in streams including Hyde Creek which empties directly onto the WP Beach system. Additionally, intense rain often comes with high winds that increase lake turbidity. Therefore, elevated *E. coli* at the WP Beaches cannot be directly attributed to CSO events.

Deteriorating infrastructure is an ongoing issue for the Dunkirk WWTP. However, modifications were made to improve the plant's activated sludge, aeration, and clarification systems in 2005.[22] Additionally, the plant upgraded its primary sedimentation tanks including new sludge collection mechanisms, new chemical storage facilities and variable frequency drives for pump motors, control building, and a dechlorination system. The City of Dunkirk continues to make efforts to secure funds necessary to upgrade bar screens, grit removal units, and chlorination facilities.

A dye test conducted by the NYSDEC and the Dunkirk WWTP in September 2007 checked for leaks in the combined sewer pipes to determine their integrity. The test indicated that there were no leaks in the pipes at the time. The Dunkirk Fire Department dive team carried out an underwater inspection in September of 2007 and verified that the outfall pipe was in good condition.[22]

Dunkirk Waterfront Changes with Potential to Affect Lake Erie Water Quality

Dunkirk Steam Generating Plant

The Dunkirk Steam Generating Plant is scheduled to transition from a coal burning facility to a natural gas burning facility by fall 2015. The plant will retain coal burning abilities so coal can be used as a back-up fuel, but natural gas will be the primary fuel. Whether the facility burns coal or natural gas, the wastewater discharges (SPDES# NY0002321) do not contribute fecal indicator bacteria to Lake Erie. However, other pollutants in the discharge as well as thermal contamination could affect the health of lake organisms.

New Seawall Construction at Wright Park and Main Street Beaches

The City of Dunkirk, with grant and municipal funds, is rejuvenating a section of the City's waterfront area including the seawall that creates the inland borders of Main Street and WPW beaches. The full project is scheduled to take two years to complete. Construction on the seawall began in August 2014 slightly east of Main Street Beach where lake water typically reaches depths up to 1 m against the wall. Roughly half of the wall along WPW Beach, the area bordering the swim area, was also largely completed by the winter of 2014.

The wall itself is not likely to impact beach water quality, but the construction process will mix the sand and disturb sediment bacteria. During the construction process at WPW Beach, sand was removed from the base of the old wall and piled on the beach. The old wall was removed and pre-formed concrete wall sections were set and secured in place of the old wall. The sand piles were leveled and graded by late November 2014. In May of 2015 construction began again on the WPW seawall.

Changes in the street level surface drainage infrastructure may also affect water quality at Wright Park Beach. Previously, localized street runoff flowed over the sidewalk and onto the beach. New drainage construction aims to capture surface runoff in storm sewer grates before it reaches the sidewalk. The correction should prevent, or at least limit, water from flowing over the sidewalk which should reduce sidewalk and wall deterioration. The additional water from the immediate street area will increase the flow from the surface drainage pipes that protrude through the wall. With more surface drainage being captured by the localized storm sewer small channels and pools may form on the beach area.

However, City of Dunkirk and CCDHHS officials are optimistic that the project will have a positive effect on the pooling problems associated with the Goose Creek and surface drainage culvert on Main Street Beach. During seawall construction, City of Dunkirk authorities intend to raise the Main Street Beach culvert in the hope of reducing the pooling problem at Main Street Beach. The highly elevated *E. coli* levels in the pool area have been an ongoing problem for Main Street Beach water quality.

With improvements to the seawall, the City of Dunkirk aims to rejuvenate the waterfront and public park areas. CCDHHS has suggested that trash bins with wind and wildlife guards be placed along Main Street and Wright Park beaches and throughout the Wright Park public park area to prevent food-related trash from being transported to the beach and attracting waterfowl.

Seawall Construction in Progress on Wright Park West Beach Photographs.

Photograph 24. Wright Park West, old seawall removal (10/2014).

Photograph 25. Wright Park West, new seawall being set and secured. (10/2014).

Predictive Models for Wright Park West and Point Gratiot (East) Beaches

Currently, CCDHHS determines whether a beach is open or closed to the public for water quality issues based largely on prior day *E. coli* sampling. Following the 2008-2009 sanitary survey work conducted on the Dunkirk beaches, CCDHHS identified rainfall as an indicator of nearshore *E. coli* levels. Therefore preemptive beach closures began in the 2010 beach season following 24-hour rainfall of 0.50 inches or more. However, following implementation, CCDHHS found that rainfall alone was not adequately predicting *E. coli* levels.

CCDHHS staff collaborated with Brett Hayhurst of USGS in late summer 2012 to develop a sampling schedule and determine relevant field observations required to develop predictive models using the EPA Virtual Beach Program. High percentages of unsatisfactory *E. coli* results along with the high volume of swim area use at WPW and PG (East) Beaches suggested these two beaches were ideal candidates for predictive models. Intense sampling schedules in 2013 and 2014 collected enough data to develop predictive models for WPW and PG (East) Beaches.

Predictive models were not developed for Main Street Beach or Wright Park East because the City of Dunkirk has not maintained a swim area on the beaches in recent years. Pearson correlation coefficients were calculated for the beaches based on *E. coli* results, weather, and field observations. The highest Pearson coefficients for Main St. Beach came with 1) the combination of turbidity, cloud cover, and wave intensity ($r = 0.5824$); 2) turbidity alone ($r = 0.5145$); 3) the combination of lake turbidity and wave intensity ($r = 0.4811$). Main Street Beach *E. coli* results were only moderately correlated with 24 hour rainfall ($r = 0.4322$) and with the sum of the past 72 hours of rainfall ($r = 0.4799$). The highest Pearson coefficients for WP East Beach came with 1) the combination of wave intensity, turbidity, and 24 rainfall (0.5319); 2) wave intensity and turbidity (0.4193); 3) 24 hour rainfall (0.3910).

Field data, watershed, and beach water samples were collected regularly Monday through Thursday from WPW and PG (East) beaches. Using the large amount of water quality and environmental variable data from 2013-2014 two models were developed for each beach. The first model includes observational data that would have to be collected from the field daily. The second model was developed without field observations and relies solely on information provided online from the Dunkirk airport and the National Oceanic and Atmospheric Administration (NOAA).

For each beach, both models improve the specificity, sensitivity, and accuracy performance standards used by the EPA to evaluate predictive model success. In particular, both models exceed the specificity (80%) and sensitivity (50%) standards set by the EPA to allow predictive model use. Specificity measures the number of satisfactory water quality days that are correctly predicted. Sensitivity measures the number of unsatisfactory water quality days that are correctly predicted.

Accuracy percentages denote the percent of time the beach status, as defined by CCDHHS current methods or the predictive models, correctly represented the observed water quality. For example, during the 2013-2014 beach seasons CCDHHS correctly anticipated beach water quality 58.3% of the time for WPW Beach. In contrast, both predictive models for WPW Beach had significantly better accuracy percentages of 83.3% (with field observations) and 81.4% (excluding field observations) (Table 13).

PG East Beach models follow a similar trend and have higher accuracy percentages than the current method used by CCDHHS. The current method was 58.2% accurate at determining the correct beach status for the observed water quality. The predictive model including field observations was 81.7% accurate, while the predictive model excluding field observations was 80.0% accurate (Table 13).

Table 13. Predictive Model Statistics for Wright Park West and Point Gratiot East Beaches. The calculations are based on 2013-2014 data when the "Actual Method" was used to predict water quality. Accuracy calculates the percentage of days that water quality was correctly predicted.

	WRIGHT PARK WEST			POINT GRATIOT EAST		
	Specificity	Sensitivity	Accuracy	Specificity	Sensitivity	Accuracy
Prior Day Method	66.7%	47.1%	58.8%	75.0%	34.8%	63.9%
Actual Method	59.6%	56.4%	58.3%	65.1%	42.9%	58.2%
Model with Field Data	78.4%	90.9%	83.3%	78.6%	88.9%	81.7%
Model NO Field Data	73.6%	93.9%	81.4%	87.1%	60.9%	80.0%

In those circumstances where the beach status does not accurately represent the water quality the public suffers in one of two ways. When the beach is open despite unsatisfactory water quality there is an increased risk to public health. When beaches are closed despite satisfactory water quality the public is denied beach access and localized businesses may experience diminished patronage. As a public health agency, CCDHHS is especially interested in reducing the potential for public exposure to unsatisfactory water quality when the beach is declared open.

During the 2013-2014 beach seasons WPW Beach was open with unsatisfactory water quality 18% of the time. The WPW Beach models could have reduced the percentage of time the beach was open with unsatisfactory water to 3% with the model including field observations and 2% with the model excluding field observations (Chart 10). The predictive models for PG (East) Beach would also reduce the number of times the beach was open with unsatisfactory water from 18% under the current method to 3% (model including field observations) and 11% (model excluding field observations) (Chart 11).

Although the accuracy percentages for both beaches are slightly better when the field observations are included in the predictive models CCDHHS has decided that the models excluding field observations will be more successfully implemented at WPW and PG (East) Beaches for a number of reasons. First, due to time and weekday constraints, typical CCDHHS summer staff will not be able to visit the beaches daily to gather field observations. Additionally, because seasonal beach staff frequently changes year to year CCDHHS is concerned that individuals who are not familiar with individual beach norms may interpret field conditions differently year to year, thereby affecting model performance.

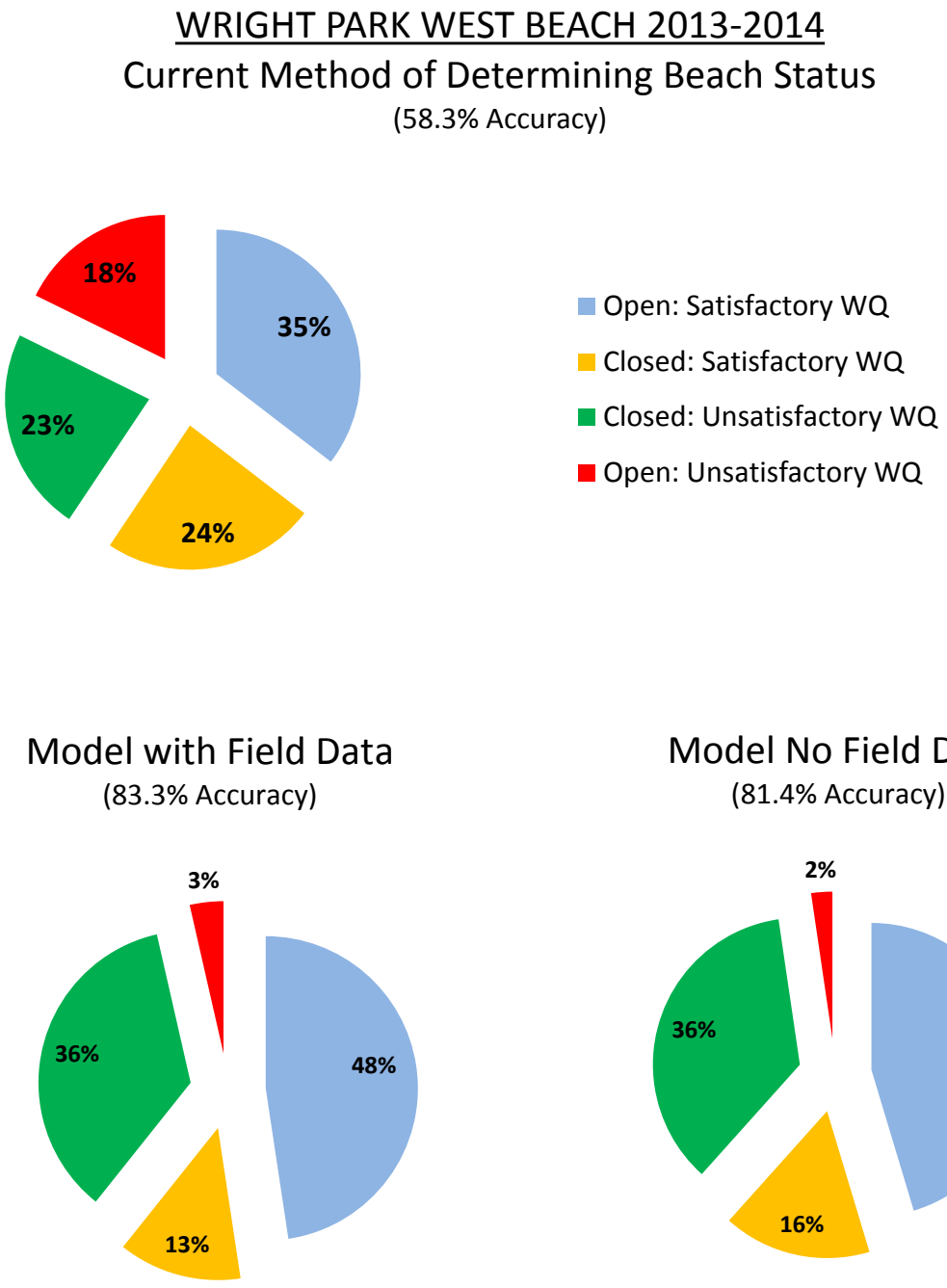
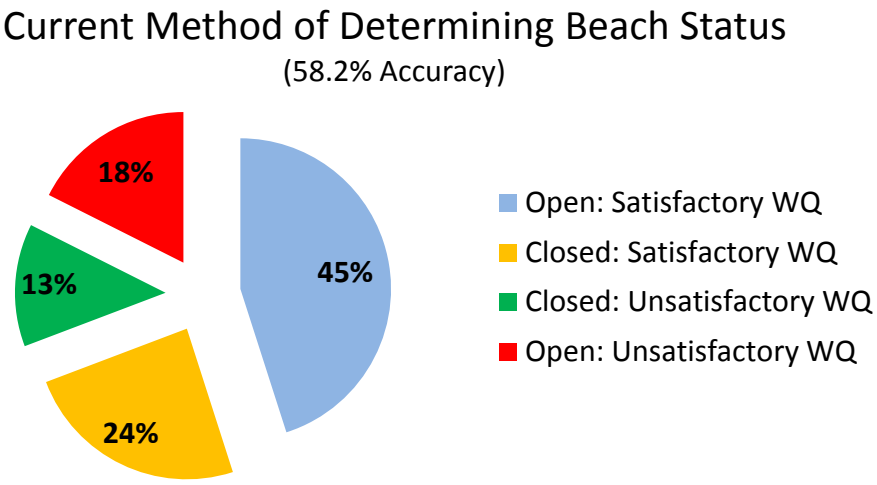
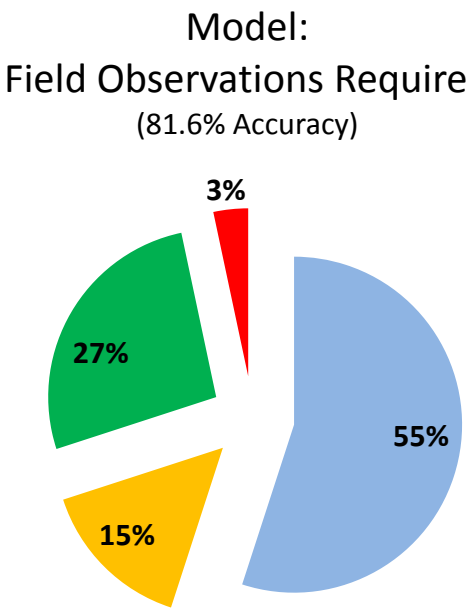


Chart 10. Wright Park West Beach Status Comparison. Beach status (open/closed) is compared to the observed beach water quality (satisfactory/unsatisfactory) with the current method of determining beach status and the two predictive models developed in 2014. The legend is the same for all three pie charts. Water quality (WQ) was determined to be unsatisfactory when samples were ≥ 235 cfu/100ml.

POINT GRATIOT (EAST) BEACH 2013-2014





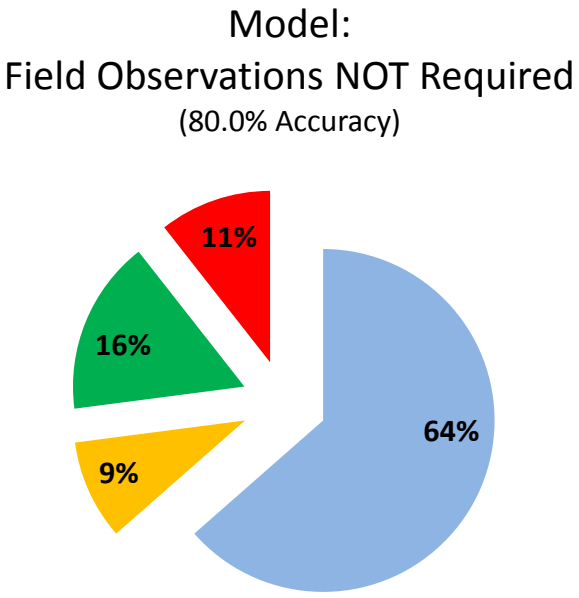


Chart 11. Point Gratiot East Beach Status Comparison. Beach status (open/closed) is compared to the observed beach water quality (satisfactory/unsatisfactory) with the current method of determining beach status and the two predictive models developed in 2014. The legend is the same for all three pie charts. Water quality (WQ) was determined to be unsatisfactory when samples were ≥ 235 cfu/100ml.

The predictive models developed for Wright Park West and Point Gratiot (East) beaches suggest that a variety of variables are needed to predict water quality. Individual variables can also be combined to create component variables, for example the combined effect of wind speed and direction may be more useful in predicting water quality than either variable alone. The variables included in the predictive model equations and the actual equations are listed below.

Wright Park West Predictive Model (with Field Data) Variables and Equation

- Lake Turbidity
- Air Temperature
- 24 Hour and 48 Hour Rainfall
- Water Temperature
- Wind Speed and Direction

LOG10(Ecoli) = -2.778 + 1.752*(POWER(Lake_Turb_NTU,0.1)) +
0.001991*(SQUARE(Air_Temp_C)) + 0.6908*(SQUAREROOT(AirportRain24_in)) -
0.001798*(SQUARE(WaterTemp_24hr)) +
0.4478*(LOG10(WindO_comp(WindSpInst_mph,WindDirInst_deg,-145))) +
1.064*(POLY(WindDirAnt24_deg,2.04013,0.0031857082,-9.6551546e-06)) +
0.1896*(POWER(AirportRain48_in,0.1))

Wright Park West Predictive Model (NO Field Data) Variables and Equation

- 24 Hour Rainfall
- Barometric Pressure
- Lake Level
- Wave Height and Direction
- Wind Speed and Direction

LOG10(Ecoli) = -23.04 + 0.813*(SQUAREROOT(AirportRain24_in)) +
738.8*(INVERSE(BarPressureInst_inhg,14.37)) + 0.1794*(POWER(LL_PreDay,0.1)) -
0.007787*(INVERSE(Parallel_WaveHt_24hr,0.00484879)) -
0.1996*(POLY(Parallel_WaveDir_24hr,2.2157981,0.87099959,-1.160378)) +
0.4885*(LOG10(WindO_comp(WindSpInst_mph,WindDirInst_deg,-145)))

Point Gratiot (East) Predictive Model (with Field Data) Variables and Equation

- Air Temperature
- Debris Category (1-5 Scale)
- 72 Hour Rainfall
- Prior Day Stream Height (Canadaway Creek)
- Prior Day Stream Turbidity (Canadaway Creek)
- Wind Direction

LOG10(Ecoli) = -3.678 + 2.795*(LOG10(Air_Temp_C)) + 0.258*(Debris_Cat) +
0.1895*(AirportRain72W_in) + 0.1928*(POWER(Stream2_Ght_PreDay,0.1)) +
0.04666*(INVERSE(Stream2_Turb_PreDay,-0.015)) +
0.5953*(POLY(WindDirAnt24_deg,1.6711943,0.010033101,-3.2726303e-05))

Point Gratiot (East) Predictive Model (NO Field Data) Variables and Equation

- Wind Speed and Direction
- 24 Hour Rainfall
- Wave Height and Direction

LOG10(Ecoli) = 1.954 - 2.071*(INVERSE(WindSpInst_mph,1.5)) +
0.744*(SQUAREROOT(AirportRain24_in)) -
0.002425*(INVERSE(Perp_WaveHt_24hr,-0.00093095664)) -
0.05256*(WindA_comp(WindSpAnt24_mph,WindDirAnt24_deg,-161)) +
0.1823*(POWER(WindO_comp(WindSpInst_mph,WindDirInst_deg,-161),0.1)) -
0.3544*(WaveO_comp(WaveHeight_24hr,WaveDir_24hr,-161))

Campground Beaches

Sheridan Bay Park and Blue Water Beach Campground

Sheridan Bay Park Beach and Blue Water Beach Descriptions

Sheridan Bay Park and Blue Water Beaches are physically separated by nearly 18 miles, but their association with seasonal campgrounds means that they have common use patterns and are maintained in an effort to attract campground patrons. They typically see the greatest usage on weekends and holidays. In the off-season, the campgrounds are closed, so use is limited to campground staff and beach maintenance activities. Located among agricultural and undeveloped lands, the land use surrounding these two campgrounds is also similar.

Sheridan Bay Park Beach Description

Sheridan Bay Park (SBP) Beach is owned and maintained by the Sheridan Bay Park Campground located at 3193 Route 5 in Sheridan, NY. The Town of Sheridan is predominantly rural with a total area of 37.3 square miles and a population of 2,673.[19] The campground has 30 campsites that are typically occupied by recreational vehicle (RV) units, though tent sites are available.

A small stream and narrow tree/vegetation line creates the inland border of the beach and separates the beach from the SBP Campground. A 2.4 meter-wide bridge near the middle of the beach area provides a means for campground patrons to cross by foot, or campground staff to transport maintenance equipment to the beach. When the bridge is not being used by staff vehicles, a large chain blocks vehicle access. A second foot bridge leads to the pavilion on the western border of the beach.

The beach stretches from the western border at 42.520016 / -79.269459 approximately 90m to the eastern border at 42.520695 / -79.268875. The beach is in a small bay area that is defined by shale cliffs on both sides. Shale bluffs form the eastern border of SBP Beach but the western border is a 30m area of rip rap that runs parallel to the shoreline. Beyond the rip rap, a small private beach area separates SBP Beach from the western shale cliff that defines the bay.

The beach is a mix of sand, pebble, and shale rock with an average width of 30.17m. Beyond the shoreline, the lake bottom is predominantly exposed shale with occasional patches of sandy sediment that gets trapped in the cracks of the rock. The shale is covered with periphyton and filamentous algae. In years with low lake levels, such as 2012, the shoreline is difficult to decipher because the shale rock that is typically under water is open to the air.

Litter and debris are seldom observed on the beach. Although trash bins are not provided on or near the beach, there is a dumpster available to campground patrons 12m from the main bridge that leads to the beach. The dumpster area is well maintained; CCDHHS staff observed trash in bags and the dumpster lids consistently shut. The occasional beach litter included food and household-related litter that was likely left behind by beachgoers. Other litter including rope and fishing/boating-related items were rarely observed.

Campground staff conducts yearly beach clean-ups in the spring and pile large debris including tree trunks and branches on the northeastern beach area using tractor equipment. Additional large debris clean-ups occur throughout the summer as needed. Small debris is not addressed by campground staff, so debris that is washed onto the beach remains there until wave action carries it away. Dressenid mussel shells are constantly present on the beach,

especially following rough water conditions. Small amounts of aquatic vegetation and *Cladophora* are frequently present on the shoreline but rarely present in the nearshore areas unless rough water conditions exist.

"No Swimming" signs facing the campground and the beach are posted at the bridge leading to the beach. The beach has not had a monitored swim area since the early 1990s. Campground patrons use the beach for sunbathing and beachcombing. Kayaks have been observed in the campground area suggesting that the beach may also serve as a launch point for self-propelled watercraft. Jet skis are occasionally anchored in the nearshore area of the beach.

Despite the secluded location of SBP Beach, waterfowl were only observed on 14% of CCDHHS sample days. In 2012, there were three consecutive weeks that 10-20 gulls were observed on the beach. Aside from the 2012 pattern, waterfowl presence on the beach is transient.

Although neither live animals nor wildlife feces was observed on the beach, raccoon carcasses were present on two occasions and animal tracks were occasionally observed. The observations suggest that wildlife from the wooded, undeveloped surrounding areas could use the beach when humans are not present. Dogs were frequently observed in the campground, but rarely observed on the beach. Dog feces were not observed on the beach.

The sanitary facilities that serve the beach and the campground are located at the top of a hardened dirt path/road at 42.519616 / -79.268643, 96m from the water line. The facilities are cleaned daily by campground staff. The sanitary facilities are connected to a sand filter septic system within the campground. The effluent from the septic system is chlorinated and discharges to the small creek, southwest of the beach (SPDES # NY0242811). Many of the RV units have sanitary facilities inside the unit which are emptied at the septic "dump station" as needed.

Sheridan Bay Park: Weather Data

All 2012 weather-related data came from the Dunkirk Airport weather station, less than 2 miles from the beach. Precipitation and temperature data for 2013-2014 also came from the airport weather station. Wind data for 2013-2014 was collected at the lakeshore of Wright Park West Beach, 3 miles from SBP Beach, with a WindMate™ meter. Wind data from Wright Park West was used in 2013-2014 in consideration of the land interferences that may skew wind data from the airport weather station. Limited equipment did not allow wind measurements to be taken directly from SBP Beach.

Sheridan Bay Park: Potential Pollution Sources Surveyed and Identified

The limited number of beach closings indicates that there are not any major pollution contributors in the immediate area of SBP Beach. General current patterns in Lake Erie suggest that pollution sources west of the beach would be the most likely contributors to poor beach water quality. However, the distances from the discharge points of a number of small and medium sized streams as well as the Dunkirk WWTP suggest there is little direct impact on SBP Beach.

The stream that discharges closest to SBP Beach lies approximately 540 m west in a separate small bay area. Prior to 2012, CCDHHS had not collected water samples from the

stream. The location and relatively small size of the stream render the stream less interesting for scientific research, and therefore CCDHHS was unable to locate any outside information related to the stream, including a name. The small stream actually separates the beach area from the campground and continues flowing west beyond the campground border.

The stream drains approximately 8.84 square miles.[18] The Sheridan Bay Park Creek watershed is largely rural with 34.68% used for cultivated crops and 16.33% used for hay/pasture. A large percent, 29.96%, of the watershed is forested land. Only 7.04% of the watershed is developed land of varying intensities.[14] Considering land use within the watershed, it is extremely likely that agricultural runoff and wildlife feces contamination are transported to the lake in the stream. Despite the lack of suspicious drain pipes in the stream banks, inadequate private SDSs may exist in the watershed and potentially contribute to poor water quality.

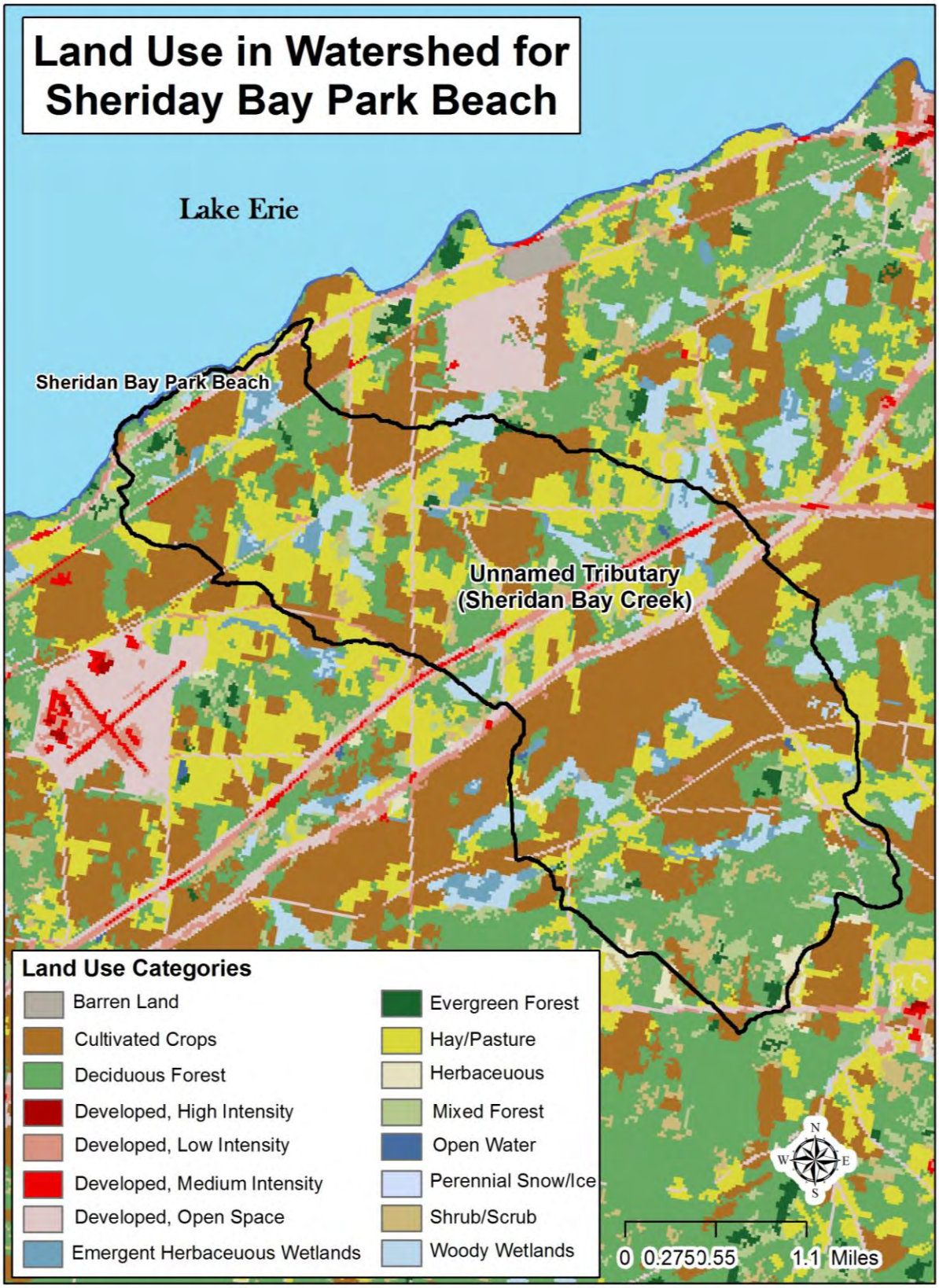
Effluent from the campground's SPDES permitted (NY0242811) sewage disposal system is added to the creek slightly west of the beach area (42.5194 / -79.2694). The SDS includes a septic tank, sand filter, leach field and chlorinator. The system receives wastewater from the bathhouse. The 2014 annual inspection of SBP Campground revealed a lack of chlorine tablets for the chlorinator, but otherwise the system is in compliance and operating effectively.

Weekly stream samples collected in 2012 showed that the stream had unsatisfactory levels of *E. coli* in 85% of the samples. The average *E. coli* level was 564 cfu/100 ml and ranged 9 – 1920 cfu/100ml. In consideration of the distance and coastline shape between the stream and SBP Beach, as well as the historically low beach *E. coli* levels, CCDHHS discontinued stream sampling in 2013.

The location of the stream between the campground and the beach may actually be buffering the beach area from potential pollution. The stream generally prevents localized runoff from reaching the beach area. While truly intense rainfall could result in flooding such that the stream could spill over onto the beach, there is no evidence to suggest that the stream channel has ever traversed the beach.

The limited use of SBP Beach and the types of sediment at the beach also limit the potential contribution of fecal indicator bacteria in sediment. The stream provides a source of fresh water for wildlife, so it is not necessary for wildlife to cross the open beach area. With limited wildlife, waterfowl and human activity on the beach fecal indicator bacteria in the sand is probably less concentrated on SBP Beach than other beaches included in the sanitary survey. Additionally, the nearshore area of SBP Beach is predominantly exposed shale and has minimal sediment that could potentially maintain fecal indicator bacteria populations.

Figure 19. Land Use in Sheridan Bay Park Beach Watershed.[14]



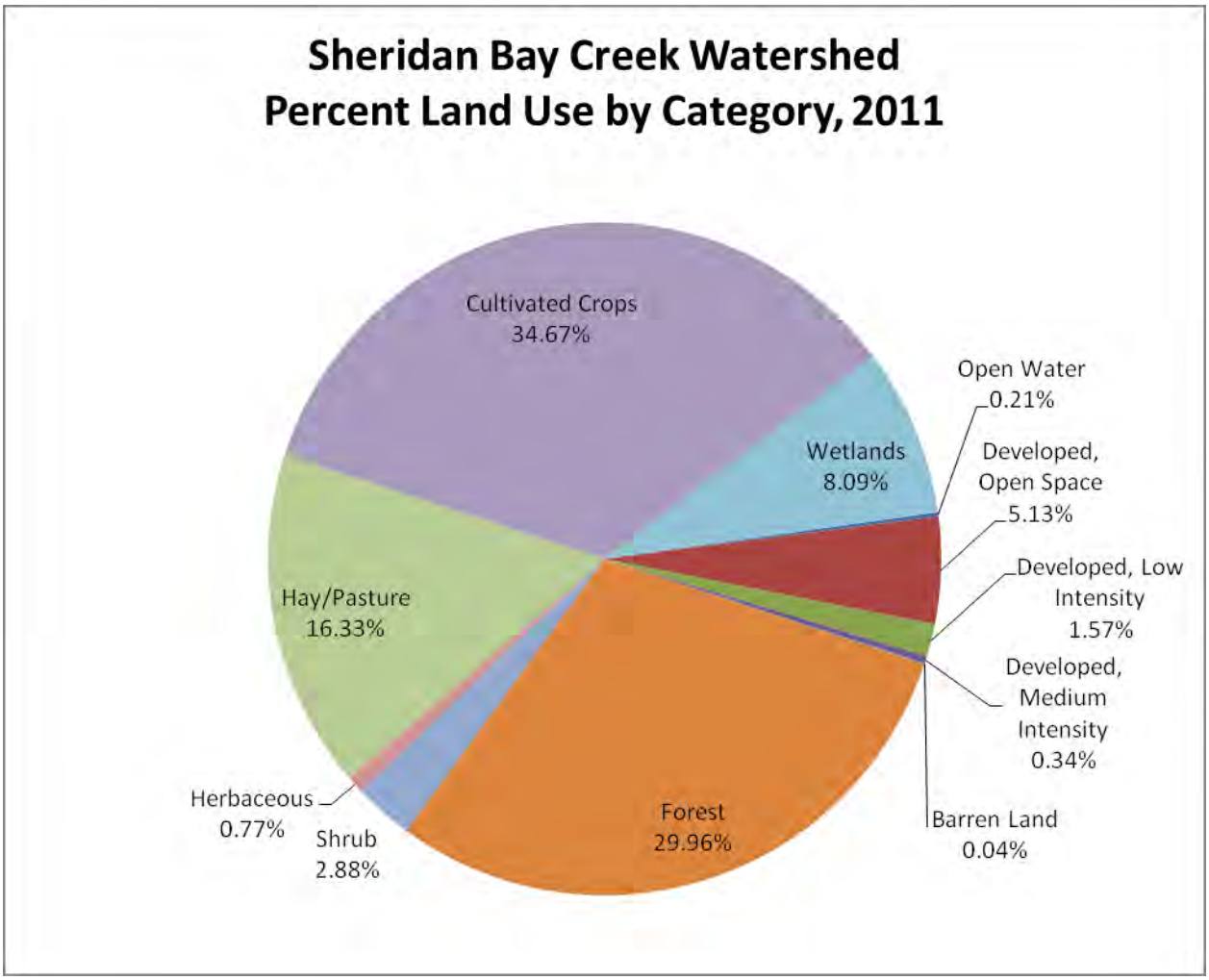


Chart 12. Sheridan Bay Creek Watershed Percent Land Use by Category, 2011.[14]

Figure 20. Sheridan Bay Park Beach Detailed Map.

Sheridan Bay Park Beach Photographs

Photograph 26. Sheridan Bay Park Beach (East).

Photograph 27. Sheridan Bay Park Beach (West). The pile of rip rap defines the western border of the beach. The blue structure is a pavilion.

Photograph 28. Sheridan Bay Park Beach Bordered by Stream. The inland border is a stream, denoted by the row of trees in the background. The blue building is the campground/beach bathhouse.

Photograph 29. Sheridan Bay Park Beach Stream. The inland border is a stream that discharges 540 m west of the beach.

Blue Water Beach Campground Beach Description

Blue Water (BW) Beach is owned and maintained by Blue Water Beach Campground located at 7364 Lake Road in Westfield, NY. The campground property covers 33.1 acres (0.05 square miles). The campground owners live on site, so the campground includes two permanent residences, a cottage (no plumbing) and 137 campsites. Roughly 50 sites are occupied by RV trailers year-round but only used during the May – October campground operating season. The remaining sites are completely seasonal. The campground is located in the Town of Westfield in a rural area approximately 3 miles from the densely residential area of the Village of Westfield.

The relatively narrow strip of beach is separated from the surrounding campground by steep shale cliffs to the southeast. There are two ways to reach the beach from the campground, each of which leads directly to a designated swim area. A worn, dirt path and stream channel lead from the campground to the west swim area. The path has been worn down by frequent beachgoers as well as the golf carts and ATVs used by campers and campground staff. A wooden staircase leads down from the campground to the east swim area.

The full length of BW Beach stretches approximately 316 m from the western border at 42.366638 / -79.540833 to the eastern border at 42368973 / -79.538654. The beach is bordered to the west by a natural formation of shale cliffs. The official eastern border is marked by a property line but beach area continues approximately 45 m beyond the property line and campground patrons frequently treat this area as an extension of BW Beach.

According to the current campground owner, the sandy beach area has widened since the 1960s when the original owner used small boulders to create seven groynes along the beach, each extending approximately 3-4 m from the shoreline. Presently, the average width of BW Beach is 13.43 m. However, the eroding cliffs complicate the question of beach width. Particularly rough winters can increase cliff erosion and large chunks of cliff and topsoil fall to the beach. Cliff erosion creates areas of soil and debris that are not exactly beachfront but are not well defined inland borders for the beach either.

The beach is a mix of sand and rock, from the eroded cliff faces. Along the beach/lake interface, the beach is much sandier than near the base of the cliffs. The nearshore area of BW Beach is a mix of sand and rock. Approximately 3 m from the shoreline, the sand/rock sediment gives way to large shale rocks that are covered with patches of thin sand, periphyton and filamentous algae.

Masses of *Cladophora* accumulate in the nearshore area of BW Beach especially following storm events and high winds. Beach morphology and current activity typically result in greater algal accumulation at the western swim area. Despite increased turbidity and foul odors during the algal accumulation events, the algal masses do not consistently affect the *E. coli* levels of the beach water.

Every spring, campground staff and volunteers remove major debris, including vegetation that has washed onto the beach and debris from cliff erosion. Any additional debris that accumulates throughout the summer is removed as needed. Driftwood and eroded vegetation that is not collected by campground patrons for individual campfires is typically burned during campground sponsored and supervised beach cleaning parties on the beach.

Although litter is rarely present on the beach, food-related items and household litter were occasionally observed. The litter appeared to have been left behind by beachgoers or been transported from the campground area by wind or wildlife. Trash bins are not located on or near the beach. Trash bins are provided at sanitary facilities and common spaces such as the recreation area. Patrons are expected to bag and dispose of all trash in the large dumpsters located near the campground entrance.

Very little wildlife was observed on BW Beach. Ring-billed gulls and songbirds were occasionally observed in groups of less than five but there was seldom any additional evidence of wildlife on the beach. Dogs and paw prints were occasionally observed, but fecal material was not. Because the beach is bordered by undeveloped land as well as the wooded campground, area wildlife capable of scaling the cliffs likely frequent the beach when people are not around.

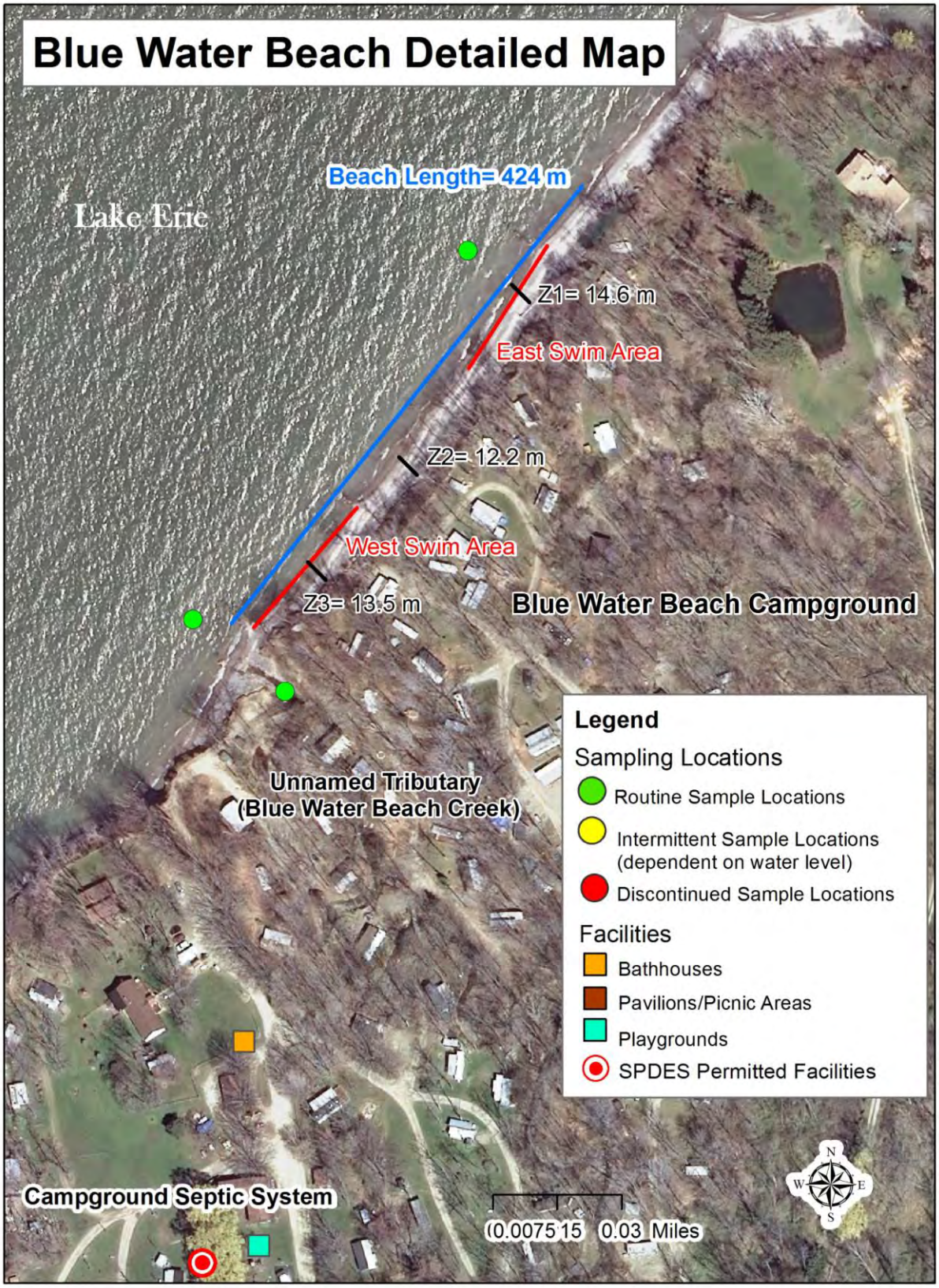
Sanitary facilities (42.490138N, -79.329222) are located at the top of the hardened dirt path/road near the west swim area, 39 m from the shoreline. The facilities are cleaned daily by campground staff. Many beachgoers likely use the sanitary facilities that are present in their personal RV units.

The beach is permitted without lifeguards and has two designated swim areas with the required safety equipment. The west and east swim areas are roughly 120 m apart. The areas are defined by posted signs and each includes approximately 50 m of beachfront. The beach is available to campers and "day use fee" patrons only. During the June through September sampling season people were often observed walking the beach and sunbathing, occasionally swimmers were observed. The number of beachgoers varies with campground occupancy and is not tracked. General observations by campground staff indicate that beach use is typically greater on weekends and holidays. No more than six people at a time were observed on the beach during the weekday sampling efforts.

Blue Water Beach: Weather Station Data

Weather data including air temperature, rainfall, and wind data was retrieved from the Cornell Cooperative Extension website (http://newa.cornell.edu/index.php?page=daily-weather). The weather station is located approximately 2.8 miles from the beach at 6592 Route 20 Portland NY, 14769 (42.37 / -79.49).

Figure 21. Blue Water Beach Detailed Map



Blue Water Beach: Potential Pollution Sources Surveyed and Identified

The primary pollution source to BW Beach is a small Lake Erie tributary that discharges directly onto the beach and into the western swim area. The stream is referred to as "Brown Brook" in the Campground's NYSDEC SPDES permit, the campground owner calls the stream "Corel Creek"; CCDHHS was not able to verify either name. The stream drains 1.43 square miles.[18] The watershed of Blue Water Beach Campground Creek is mainly undeveloped forest (43.36%), and shrub land (17.55%). A significant area of the watershed is agricultural with 16.84% cultivated crops and 11.96% hay/pasture land. An additional 8.51% is developed land of varying intensities.[14]

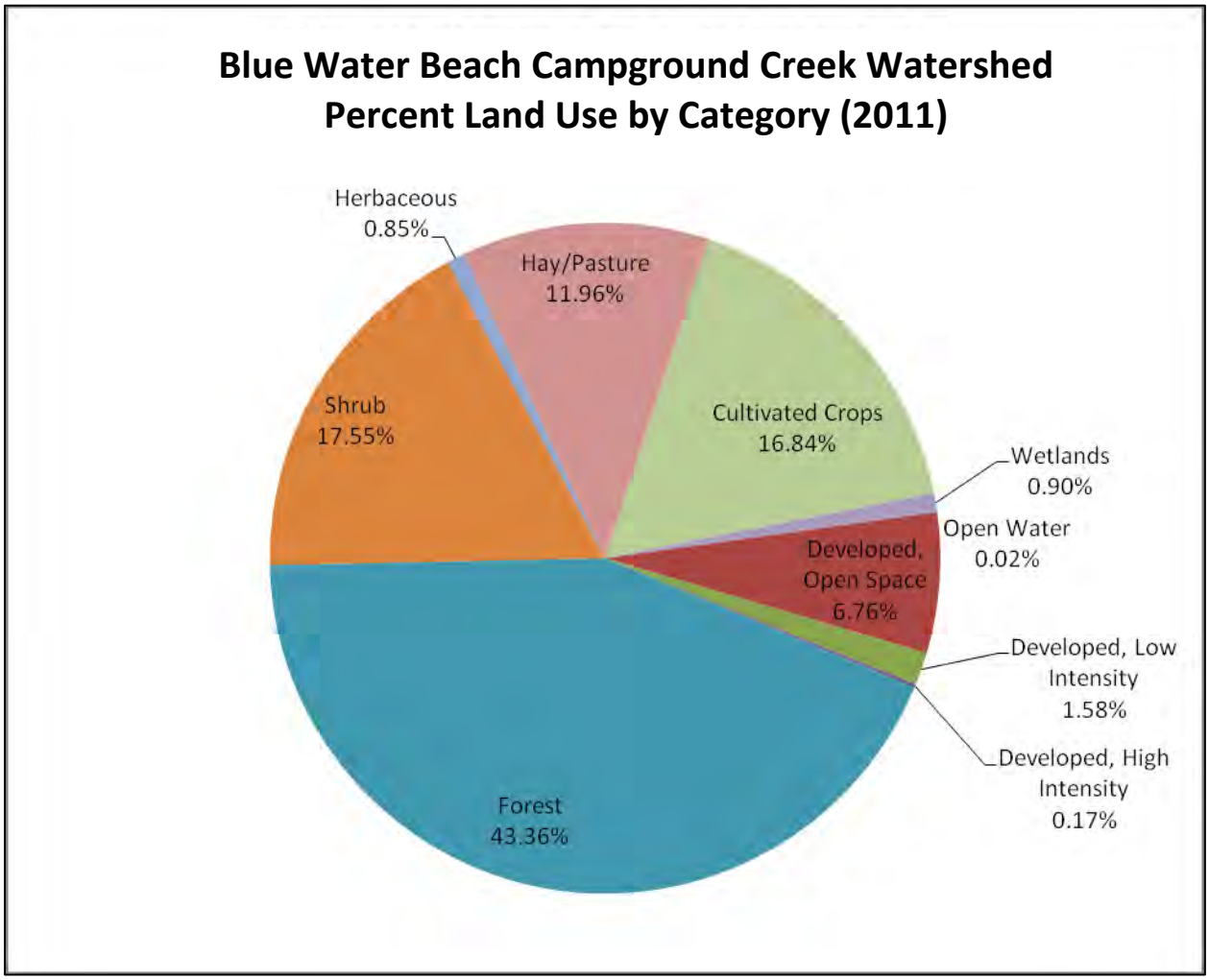
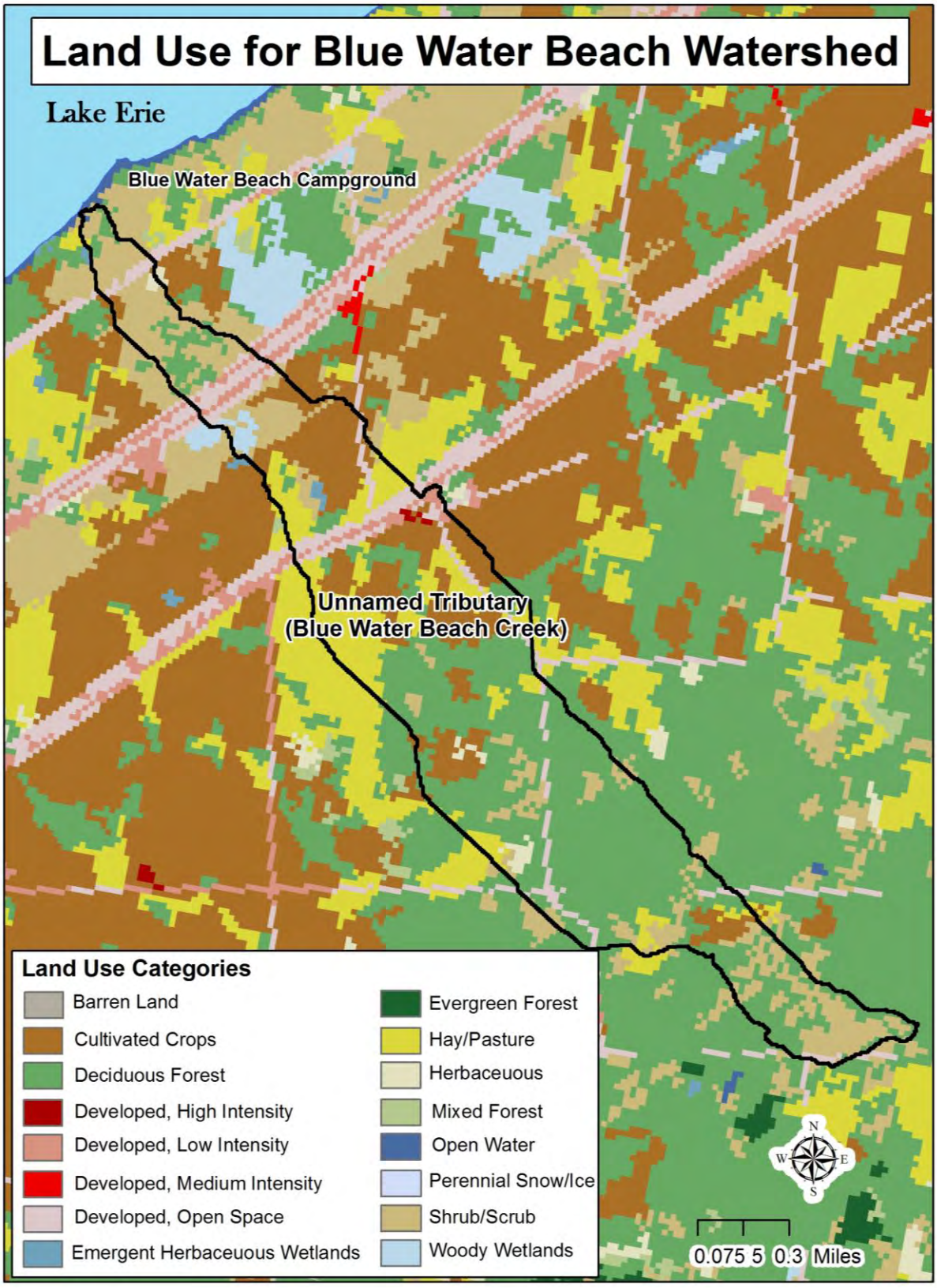


Chart 13. Blue Water Beach Campground Creek Watershed Percent Land Use by Category, 2011.[14]

Figure 22. Land Use for Blue Water Beach Campground Beach Watershed.[14]



The proprietor noted that although the creek has consistent flow in the spring, summertime flow is typically very low and the creek frequently "dries up" except in the event of rain. The minimal flow of the stream made sampling at the point of discharge and further upstream difficult. Few samples were collected in 2012 and 2014 because the below average rainfall made it nearly impossible to sample without sediment contamination. The greatest number of samples was collected in 2013 which had slightly higher than average rainfall. However, even in 2013, sampling upstream from the campground was difficult due to the wide channel and very shallow stream depth.

The small size of the tributary and the tendency of the stream to "dry up" in the summertime means there has not been much, if any, previous work investigating water quality in the stream. The average *E. coli,* based on all the 2013 samples, was 1849 cfu/100 ml with 14 samples ranging from 120 – 8800 cfu/100 ml. However two of the sample days had extremely high *E. coli* levels of ≥8400 cfu/100 ml. Excluding the two samples ≥8400, the average *E. coli* level was 724 cfu/ 100 ml with a range of 120 – 2500 cfu/100 ml.

The sporadic flow of the stream following rainfall provides a good example of the "flushing" effect described earlier. When the typically dry stream channel is inundated with runoff, the pockets of pooled water throughout the stream channel, as well as any accumulated wildlife feces in the stream bed, are quickly carried to the point of discharge on the beach. The high winds and rough lake conditions that are commonly associated with rain events prolong the length of time stream sediment remains suspended in the BW Beach water. Due to the general current patterns of Lake Erie, discharge from the stream into the nearshore area of western BW Beach will eventually move east where it will affect the water quality of the eastern BW Beach.

The other tributaries that discharge on either side of BW Beach are not likely to significantly affect beach water quality due to coastline shape, low flow and/or distance from the beach area. East of BW Beach, a small, unnamed tributary discharges into a small bay approximately 160 m from the eastern BW Beach border. The small watershed and general lake currents suggest that discharge is not likely reaching BW Beach nearshore areas.

Tributaries west of BW Beach are not likely to play a major role in BW Beach water quality either. Roughly 620 m west of BW Beach, a small, unnamed, tributary discharges into Lake Erie. The small watershed implies limited potential impact on BW Beach water quality. Bournes Creek is the nearest tributary large enough to be named on maps. Although the creek does have a drainage basin of 3.21 square miles the discharge point is approximately 1,070 m from BW Beach.

Only slightly west of the western border of BW Beach is a small ravine that receives the effluent from the SPDES permitted (NY0104507) campground sewage disposal system. With septic tanks, a sand filter and leach field the SDS for BW Beach Campground treats wastewater from the two houses, the bathhouse and the dump station. Wastewater from stationary trailers is collected by a "scavenger system" twice a week as needed. The outfall pipe is located west of the western border of BW Beach at 42.365, -79.540556 where it discharges to a small ravine and out to Lake Erie.

The SPDES permit allows for 5,520 gallons per day of chlorinated water into the absorption field. The campground operates a private water system that pulls water from Lake Erie, near the western edge of the beach area, and treats it with filtration and chlorination.

Water flowing out of the system has residual chlorine from pre-use chlorination with no additional chlorine added to the effluent. The required SPDES testing suggests the SDS is functioning well and there is no reason to suspect that the outfall contributes to elevated bacteria levels in the beach water.

Two municipal wastewater treatment plants (WWTP) lie west of BW Beach but are not likely to have a major impact on BW Beach water quality due to the distance. The Westfield WWTP is a combined sanitary and storm sewer system that discharges effluent to Chautauqua Creek roughly 1.4 miles upstream from the lakeshore. Chautauqua Creek enters Lake Erie nearly 4 miles from BW Beach. The Ripley WWTP is even farther west and discharges to Lake Erie nearly 11 miles from BW Beach.

Blue Water Beach Photographs

Photograph 29. Blue Water Beach Campground Beach (West Border).

Photograph 30. Blue Water Beach Campground Beach: West Swim Area. Boulder groynes protrude from beach.

Photograph 31. Blue Water Beach Campground Beach Cliff Erosion, following the 2013-2014 winters.

Photograph 32. Blue Water Beach Campground Beach (Small Tributary) onto western beach area.

Campground Beaches: History of Water Quality

Prior to the 2012-2014 sanitary survey, neither Sheridan Bay Park Beach nor Blue Water Beach had been extensively investigated. The beaches were routinely sampled once per week June through September 1st, as required under the Beach Act. Additional samples were collected from BW Beach when unsatisfactory samples required follow-up sampling. The two swim areas at BW Beach can have surprisingly different *E. coli* levels so CCDHHS consistently collects samples from both swim areas.

Sample collection at SBP Beach was slightly more variable because the beach does not allow swimming. Typically a single sample is collected from the middle of the beach area but occasionally, west and east samples were collected to monitor potential differences between the two sides of the beach. Since SBP Beach does not allow swimming, follow-up samples were not typically collected. Furthermore, because SBP Beach is never actually open for swimming, CCDHHS does not report unsatisfactory results as beach closings.

The 2012-2014 sanitary survey sampling schedule was similar for SBP and BW Beaches. Water samples were collected once per week in 2012 and increased to twice per week in 2013 and 2014. The samples were typically collected between 9am and 12pm. A single sample was collected from the middle of the beach area (42.520464/ -79.269499) at SBP Beach. Two samples were routinely collected from the middle of the east (42.368438 / -79.539413) and west (42.367183 / -79.540646) swim areas at BW Beach. The "Total Samples" are not equal for the BW Beach swim areas in Table 14 due to differences in the required follow-up samples.

Table 14. Campground Beaches: History of Water Quality.

	BLUE WATER BEACH WEST			BLUE WATER BEACH EAST			SHERIDAN BAY PARK	
	Total Samples	% Unsatisfactory	Days Closed	Total Samples	% Unsatisfactory	Days Closed	Total Samples	% Unsatisfactory
2007	16	25.0%	8	15	20.0%	5	24	4.2%
2008	16	18.8%	2	14	14.3%	1	19	5.3%
2009	19	42.1%	17	17	52.9%	10	26	23.1%
2010	15	13.3%	9	13	30.8%	15	25	4.0%
2011	14	7.1%	2	14	7.1%	2	13	7.7%
2012	16	6.3%	1	16	12.5%	2	15	6.7%
2013	28	32.1%	22	26	26.9%	6	24	4.2%
2014	29	31.0%	15	28	17.9%	10	25	12.0%
Averages		22.0%			22.8%			8.4%

Campground Beaches: Water Quality Studies and Statistical Analysis

Table 14 clearly shows that *E. coli* at the two BW Beach swim areas varies both during a season and between years. The easiest explanation for differences between the two swim areas would be the tributary that discharges onto the western beach area. However, the west swim area only has higher *E. coli* half the time. Therefore, CCDHHS suggests that typical weather variation including wind direction and speed are probably responsible for shifting stream discharge and *E. coli* between the two swim areas of BW Beach. Additionally, the tributary carves a slightly different path to the lake each year; in fact, the tributary sometimes

splits and enters the lake on either side of the groyne near the eastern border of the west swim area.

The relationships between *E. coli* levels and observational factors at the beaches were statistically analyzed for Pearson correlation coefficients using Virtual Beach. Analysis suggests that *E. coli* levels on the eastern area of BW Beach are moderately related to rainfall, specifically 24-hour rainfall (0.5209) and 72-hour rainfall (0.5137). When 24-hour rainfall was observed as an interactive term with lake turbidity, there is a very slight increase in the moderate relationship (0.5227).

The strongest results for the western area of BW Beach include more diverse observational factors. Moderate relationships were identified between *E. coli* levels and wave height (0.5296) as well as the interactive terms of lake turbidity and 24-hour rainfall (0.5391). The strongest relationship between *E. coli* levels was revealed when lake turbidity, cloud cover and wave height were considered interactive terms (0.6258).

In general, SBP Beach has the least unsatisfactory results among the Chautauqua County beaches included in the sanitary survey (Table 1. Percentage of Unsatisfactory Samples, page 9). With so few unsatisfactory results, it is difficult for CCDHHS to statistically analyze which factors contribute to the high *E. coli* levels that were occasionally observed. Based on three years of sampling, SBP Beach did not show a strong statistical association with any of the factors included in the sanitary survey. Aside from a Pearson correlation coefficient value of 0.4845, signaling a moderate relationship between *E. coli* levels and the interactive terms of lake turbidity and wind direction, other factors showed weak relationships at best.

Identified Pollution Sources in Chautauqua County

The CCDHHS identified stream and surface runoff as the largest contributors to the poor water quality frequently observed in the nearshore areas of Chautauqua County beaches. The surface runoff appears to be predominantly non-point source pollution and is therefore more difficult to remediate. Runoff from throughout the watershed is carried to the beaches in storm drains and tributaries while localized runoff flows directly onto or over the beaches from adjacent areas. Intense rainfall increases runoff and flushes areas that may accumulate pollution in dry weather.

Due to the elevated *E. coli* throughout much of the stream channel lengths it was difficult to narrow down the search for point source polluters. However a limited investigation of Crooked Brook and Hyde Creeks did reveal nine faulty private SDSs in the Point Gratiot and Wright Park Beach watersheds, respectively. The relatively high percentage, 25%, of faulty systems found in the targeted area of the investigation suggests there are many more private SDSs contributing to poor water quality in Chautauqua County tributaries. The continued effort of CCDHHS staff to identify faulty SDSs at the time of property transfer will inevitably reveal more inadequate private SDSs.

Pool areas on the beaches from surface runoff and tributary discharge also contribute to the problem of *E. coli* loading in the nearshore areas. By enticing waterfowl to the beach, maintaining sediment moisture and frequently harboring algal growth, shallow pool areas can act as bacteria reservoirs. During rain events pool contents, including the potentially concentrated bacteria and nutrient loads are flushed into the nearshore areas. Depending on the severity of a rain event, wind direction, and wave activity nearshore water may remain turbid with elevated *E. coli* for many days. Pool areas and stagnant water are an ongoing problem at the Dunkirk beaches, specifically at Main Street Beach.

Combined sewer overflow (CSO) events, also known as bypass events, continue to contribute to poor water quality in Lake Erie as a whole. The proximity of the Dunkirk WWTP to the Wright Park beach system does raise concern for caution. However it is difficult to say how much direct influence CSO events have on beach water quality because the rainfall or snowmelt that results in CSO events also increases the volume of streamflow in Hyde Creek.

Illegal, inadequate, and outdated private SDSs likely exist throughout the Lake Erie watershed to some extent. Faulty SDSs contribute to nutrient loading and elevated bacteria in tributaries. Excess nutrients and bacteria in tributary flow adds to the contamination problems in Lake Erie as a whole but also creates poor water quality conditions in the nearshore areas where tributaries discharge onto or near beaches.

Conclusions

Sewage Pollution Reaching Lake Erie

Continued efforts to upgrade aging municipal sewage infrastructure and technology, including wastewater treatment plants will benefit the overall health of Lake Erie. The persistent problems associated with private SDSs are more difficult to address because the systems are spread out over large areas and are rarely monitored beyond installation. Illegal, outdated, and faulty SDSs tend to continue operating unless a property transfer or complaint initiates an investigation by CCDHHS. A thorough investigation of properties throughout Chautauqua County, specifically properties near tributaries, would potentially reveal a large number of outdated and faulty private SDSs.

Beach Maintenance

When pools of surface runoff and creek discharge form on or near beaches they represent a potential source of concentrated bacteria and nutrient pollution. Stream discharge should be directed away from the beach area and channels should be maintained so wide pools don't form. Additionally, low spots in beach sand should be leveled to deter pool formation. Pools and trash attract wildlife, specifically water fowl to beach areas. Beach operators can make beaches less attractive to wildlife by maintaining trash bins with lids or wildlife deterrents and regularly removing litter, especially food related litter from the beach area.

Cyanotoxins

The harmful algal blooms (HABs) that were recorded in the western basin of Lake Erie in August 2014 were so severe that lake water could not be used as a drinking water source for certain Ohio municipalities. Although Chautauqua County beaches did not show any visual evidence of cyanobacteria in 2014, the concern raised by the eastern basin bloom spread to New York and led to microcystin testing at multiple beaches and drinking water treatment plants on August 5th and 6th, 2014. The results showed microcystin levels at <10 ppb at Town of Hanover, Sunset Bay Beach Club, Wright Park, Point Gratiot and Blue Water Beach beaches. Four Chautauqua County drinking water treatment plants tested raw intake and finished water from Lake Erie, all of which had microcystin levels <0.15 ppb. The Chautauqua and Erie County results indicate that cyanobacteria were not present in harmful levels in the eastern basin of Lake Erie. However, as average lake temperatures and nutrient inputs continue to rise, HABs could be on the horizon for the eastern basin.

Naturalized Bacteria

Several studies have found that *E. coli* and other fecal indicator bacteria can persist independently in beach sand, lake sediment, and stream sediment. When sand and sediment are disturbed by rough water conditions and severe weather, bacteria is circulated throughout the water column, contributing to *E. coli* exceedances. Recent research also suggests these "naturalized" *E. coli* are non-pathogenic and are not reliable indicators of human waste.

Predictive Models Allow Increased Accuracy in Beach Closures

The incubation period required for the standard *E. coli* test allows for drastic changes in weather and beach conditions, and therefore drastic changes in *E. coli* levels. Implementation of a strong predictive model that relies on current day information improves the accuracy with which beach status is determined. Predictive models were developed for the Point Gratiot and Wright Park West beaches in collaboration with Brett Hayhurst of the USGS and will be implemented in the 2015 beach season.

Project Evaluation

E. coli and Bacteroides Test Reliability

Despite the standard use of *E. coli* and *Bacteroides* tests to evaluate water quality, the tests may not be providing the most accurate picture of beach water quality. There is a large amount of research regarding the existence of naturalized *E. coli* in beach and lake sediment as well as stream and watershed soils.[6] Therefore the results of Chautauqua County *E. coli* testing could be inflated with sediment *E. coli* and therefore inaccurately suggesting sewage contamination.

While *Bacteroides* tests are human specific, the test does not quantify bacteria and does not distinguish between live and dead bacteria. Chautauqua County has a large rural population that utilizes private SDSs to deal with their wastewater. Because expired bacteria are likely transported to our waterways even after passing through effective SDSs, it's difficult to rely on *Bacteroides* positive results from the tributaries to determine sewage contamination.

Dunkirk Storm Sewer Investigation

Miscommunication and a variety of ongoing projects within the City of Dunkirk prevented CCDHHS staff from completing the Dunkirk storm sewer investigation before inclement weather in 2014. However, following an extension of the GLRI grant, two areas of the Dunkirk storm sewer were successfully inspected on May 20, 2015.

CCDHHS staff had some difficulty placing and retrieving optical brightener tests following the May 20, 2015 storm sewer investigation with in the City of Dunkirk. Ideally, the optical brightener tests would have been placed in the exact locations from which samples were collected during the storm sewer investigation. However, many of the locations were not accessible without the proper dive equipment and therefore could not be used as optical brightener test locations. Additionally, some optical brightener tests were lost to public interference and could not be retrieved. In lieu of the exact same locations, CCDHHS staff in cooperation with City of Dunkirk staff placed optical brightener tests at incremental locations in the storm sewer and in creek channels to represent the inaccessible and compromised locations.

Weather Variation

An important part of the sanitary survey includes rain event sampling and creek investigation. However, the 2012 summer season brought significantly less precipitation than normal. The lack of precipitation resulted in a limited number of "rain event" samples for the 2012 season. Additionally, the lack of rain made it difficult to assess specific watersheds due to low stream flow. The small stream flowing onto Blue Water Beach Campground beach was especially difficult to sample in 2012. In anticipation of year-to-year weather variation all eight beaches in the survey were sampled throughout the 2012, 2013, and 2014 seasons.

Table 15. Rainfall Averages Near Chautauqua County Beaches. Websites were accessed July 2014 for precipitation *averages (weather.com) and ** totals (newa.cornell.edu).

DUNKIRK, NY (Dunkirk Beaches and Sheridan Bay Park Beach)

	June	July	August	Totals
Monthly Precipitation Averages (inches)*	3.71	4.09	3.70	11.50
Monthly Precipitation Totals (inches)**				
2012	1.98	1.47	1.99	5.44
2013	4.62	4.11	5.15	13.88
2014	3.19	5.71	2.66	11.56
Average High Temperature (°F)	77	81	79	
Average Low Temperature (°F)	58	63	62	

WESTFIELD, NY (Blue Water Beach Campground Beach)

	June	July	August	Total
Monthly Precipitation Averages (inches)*	4.37	4.15	4.45	12.97
Monthly Precipitation Totals (inches)**				
2012	2.50	4.80	2.72	10.02
2013	6.85	3.27	3.15	13.27
2014	4.62	4.29	2.70	11.61
Average High Temperature (°F)	78	82	79	
Average Low Temperature (°F)	58	63	62	

SILVER CREEK, NY (Sunset Bay Beaches)

	June	July	August	Total
Monthly Precipitation Averages (inches)*	3.73	3.81	3.23	10.77
Monthly Precipitation Totals (inches)**				
2012	2.28	0.69	1.28	4.25
2013	5.40	1.36	1.21	7.97
2014	1.46	7.20	3.01	11.67
Average High Temperature (°F)	77	81	79	
Average Low Temperature (°F)	55	60	58	

Illegal, Inadequate, and Outdated Private Sewage Disposal Systems (SDSs)

Resource and staff limitations prevented CCDHHS staff from investigating the full range of properties in Chautauqua County that could be operating illegal, inadequate, or outdated SDSs. Small areas of the Dunkirk beach watersheds were targeted for investigation due to the popularity and frequent poor water quality of the beaches. Seven private SDS violations were identified in fall 2013 and corrected by summer 2014. CCDHHS is aware that additional faulty private SDSs likely exist in Chautauqua County and continues to test private SDSs when property transfers and complaints initiate an investigation.

Success of This Project

The project provided CCDHHS staff with additional resources to investigate potential pollution sources in both urban and rural settings. Frequent *E.coli* sampling and stream walks revealed the importance of non-point runoff as a source of pollution in Chautauqua County. The investigation also indicated the significance of urban surface runoff as a potential pollution source to beach water quality, especially in the densely urban residential area of Dunkirk. Furthermore, CCDHHS identified the pool areas created by creek and surface runoff as reservoirs for bacterial and nutrient pollution that will eventually be flushed into nearshore areas.

CCDHHS staff identified areas of concern within the City of Dunkirk and outside the municipal sanitary sewer lines. Storm sewer inspections within the City of Dunkirk were successfully completed in May 2015 and consequently eliminated two suspicious areas within the City of Dunkirk storm sewer as potential sources of sewage contamination. Outside municipal sanitary sewer lines, CCDHHS identified nine properties with private sewage disposal systems adjacent to Hyde and Crooked Brook Creeks that were operating inadequate or faulty septic systems. All but two of the private SDSs have been completely corrected.

In cooperation with USGS, predictive models were developed using Virtual Beach software to predict *E. coli* levels at Point Gratiot and Wright Park West Beaches. The models will be implemented for the 2015 beach season. The models are projected to correctly predict water quality more accurately than the persistence model by 22% at Point Gratiot Beach and by 23% at Wright Park West Beach. Additionally, in the process of working with USGS, CCDHHS staff gained a better understanding of the Virtual Beach software and used it to analyze which environmental variables are significant in determining beach water quality at the other Lake Erie beaches in Chautauqua County.

Recommendations

Local Recommendations

- Beach operators should limit the amount of stream discharge and surface runoff pooling on or near beaches. The Dunkirk beaches are especially prone to pooling problems given the stream and urban surface discharge located on the beaches.
- Aging sanitary infrastructure issues should be addressed to limit the potential for contamination reaching Lake Erie via CSO events or contaminated surface runoff.
- Include the use of green infrastructure in municipal planning to reduce surface runoff.
- More education for private sewage disposal system operators and post installation monitoring could encourage property owners to maintain healthy sewage disposal systems.
- A county wide investigation of private SDSs, specifically focused on outdated and unpermitted systems, would identify properties with inadequate or illegal systems.
- Improved trash handling practices on the beaches could reduce wildlife and waterfowl presence. Trash bins should have lids or wildlife deterrents, be readily available to the public and be emptied frequently.

State and Federal Recommendations

- More reliable water quality standards that give same day results should be developed to indicate potential sewage contamination and determine beach water quality.
- Ongoing contamination problems such as wastewater reaching the lake due to overtaxed combined sewer infrastructure, aging infrastructure, and inadequate private sewage disposal systems should be addressed and eliminated.
- Strict regulations on outdated systems, specifically those discharging near lakefront or lake tributaries should be developed and enforced.
- Continued support and education should be available to private SDS owners who want to correct and maintain their systems but lack the resources to do so.
- Continued support for local authorities and beach operators in the development and implementation of predictive models to determine daily beach status.
- Continued public outreach and education regarding the ways in which people affect water quality and the actions they can take to improve water quality locally and globally.

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Appendix

Appendix A. Town of Hanover Beach *E. coli* Results 2012-2014. Town of Hanover Beach operates a swim area on the west side of the beach area. Sampling efforts are focused on the swim area of the beach.

2012 Date	Hanover Center/West	2013 Date	Hanover Center/West	Hanover East	2014 Date	Hanover Center/West
6/7/12	22	6/3/13	*280*		6/5/14	130
6/13/12	100	6/10/13	100		6/10/14	80
6/20/12	10	6/11/13	*1100*		6/11/14	10
6/26/12	30	6/17/13	140		6/16/14	30
7/2/12	20	6/18/13	30		6/17/14	40
7/9/12	10	6/24/13	130		6/23/14	<5
7/16/12	40	6/25/13	*460*		6/24/14	*1840*
7/23/12	120	6/27/13	<10		6/25/14	*260*
7/26/12	140	7/1/13	20		6/26/14	200
7/27/12	20	7/2/13	20	10	7/1/14	120
7/30/12	20	7/8/13	*280*	<20	7/8/14	100
8/6/12	110	7/9/13	40	20	7/9/14	*320*
8/13/12	30	7/15/13	10	*440*	7/10/14	60
8/21/12	10	7/16/13	20	20	7/14/14	*1280*
8/29/12	40	7/22/13	50	40	7/15/14	*1130*
		7/23/13	*1020*	10	7/16/14	100
		7/24/13	40	130	7/21/14	*600*
		7/25/13	30	*780*	7/22/14	10
		7/29/13	100	60	7/29/14	120
		7/30/13	20	40	7/30/14	10
		8/5/13	<10	120	8/4/14	120
		8/6/13	<10	<20	8/5/14	95
		8/12/13	10	<10	8/6/14	40
		8/13/13		<10	8/11/14	40
		8/20/13	220	<10	8/12/14	*1480*
		8/28/15	110	160	8/13/14	*1250*
					8/15/14	230
					8/19/14	5
					8/25/14	10

Appendix B. Sunset Bay Beach Club Beach *E. coli* Results 2012-2014. Sunset Bay Beach Club Beach operates two adjacent swim areas. Occasionally the physical conditions of the areas indicate possible differences in *E. coli* results, therefore multiple samples were collected in 2013 and 2014 to assess the possible differences.

2012 Date	SBBC Center	2013 Date	SBBC Center/West	SBBC East	2014 Date	SBBC Center/West	SBBC East
6/7/12	48	6/3/13	*420*		6/5/14	20	
6/13/12	70	6/10/13	110		6/10/14	<20	
6/20/12	70	6/11/13	*2250*		6/11/14	5	
6/26/12	10	6/17/13	140		6/16/14	*400*	
7/2/12	20	6/18/13	70		6/17/14	180	
7/9/12	<10	6/24/13	130		6/23/14	15	
7/16/12	10	6/25/13	*360*		6/24/14	*370*	*670*
7/23/12	90	6/27/13	20	20	6/25/14	*760*	
7/26/12	200	7/1/13	40	20	6/26/14	60	70
7/27/12	20	7/2/13	10	60	7/1/14	110	130
7/30/12	80	7/8/13	*440*	*520*	7/8/14	*380*	220
8/6/12	140	7/9/13	40	40	7/9/14	*410*	*470*
8/13/12	30	7/15/13	30	20	7/10/14	100	120
8/21/12	<10	7/16/13	30	20	7/14/14	220	210
8/29/12	90	7/22/13	10	<10	7/15/14	*1110*	*1100*
		7/23/13	*640*	*1040*	7/16/14	190	180
		7/24/13	80	60	7/21/14	40	10
		7/25/13	60	130	7/22/14	30	10
		7/29/13	40	20	7/29/14	10	80
		7/30/13	20	20	7/30/14	20	10
		8/5/13	<10	10	8/4/14	*360*	*380*
		8/6/13	50	50	8/5/14	210	110
		8/12/13	130	<10	8/6/14	120	200
		8/13/13	-	*740*	8/11/14	20	<10
		8/15/13	20	<20	8/12/14	*1490*	*940*
		8/20/13	70		8/13/14	*2580*	*2920*
		8/28/13	100		8/15/14	160	190
					8/19/14	25	10
					8/25/14	195	35

Appendix C. Wright Park East and West *E. coli* Results 2012-2014. Wright Park East and West are separated by the discharge of Hyde Creek. Wright Park West operates a swim area, Wright Park East does not.

2012 Date	WPE	WPW	2013 Date	WPE	WPW	2014 Date	WPE	WPW	WPW2
6/13/12	20	*520*	6/3/13	190	*510*	6/5/14	20	10	
6/20/12	130	120	6/10/13	*770*	130	6/9/14	*350*	*670*	
6/26/12	30	20	6/11/13	*2480*	*1680*	6/10/14	*280*	*380*	
7/2/12	30	20	6/12/13	80	*250*	6/11/14	60	60	
7/9/12	150	160	6/13/13	*440*	*8000*	6/12/14		10	
7/16/12	*320*	*250*	6/17/13	*640*	*640*	6/16/14	10	30	
7/17/12	*950*	*990*	6/18/13	*440*	*510*	6/17/14	35	40	
7/18/12	*370*	*310*	6/19/13	30	30	6/18/14		*630*	
7/19/12	110	40	6/20/13	10	20	6/19/14		*300*	
7/20/12	*290*	*300*	6/24/13	*570*	*340*	6/23/14	20	40	
7/21/12	170	130	6/25/13	*2260*	*2360*	6/24/14	10	70	
7/23/12	200	160	6/26/13	220	*640*	6/25/14		*2000*	
7/26/12	*780*	*880*	6/27/13	60	120	6/26/14		200	
7/27/12	*240*	*380*	7/1/13	120	60	6/30/14	*330*	100	
7/30/12	200	170	7/2/13	10	210	7/1/14	80	80	
8/6/12	40	70	7/8/13	160	200	7/2/14		*280*	*320*
8/13/12	<10	20	7/9/13	40	40	7/3/14		30	90
8/21/12	<10	<10	7/10/13	*480*	*2800*	7/7/14		90	
			7/11/13	*1900*	*2800*	7/8/14	230	140	
			7/12/13	<100	<100	7/9/14	160	*400*	*300*
			7/15/13	200	40	7/10/14	40	120	40
			7/16/13	*260*	100	7/14/14		*350*	*280*
			7/17/13	80	100	7/15/14	190	*430*	160
			7/18/13	*500*	*260*	7/16/14	230	*310*	*450*
			7/19/13		*1600*	7/17/14		200	120
			7/22/13	60	20	7/21/14	70	*5200*	
			7/23/13	*280*	120	7/22/14	10	220	
			7/24/13	<20	20	7/23/14		*3200*	
			7/25/13	20	20	7/24/14		160	100
			7/29/13	*1520*	40	7/28/14		*4900*	
			7/30/13	60	120	7/29/14	50	*550*	
			7/31/13	<20	<20	7/30/14	110	60	
			8/1/13	120	<20	7/31/14		*660*	
			8/5/13	<20	<20	8/1/14	<10	20	

Appendix C. Wright Park East and West *E. coli* Results 2012-2014 (continued).

2012 Date	WPE	WPW	2013 Date	WPE	WPW	2014 Date	WPE	WPW	WPW2
			8/6/13	20	<10	8/4/14	10	55	
			8/7/13	40	20	8/5/14	10	12	
			8/8/13	*2240*	*2600*	8/6/14		140	
			8/9/13	*360*	*500*	8/7/14	160	210	
			8/13/13	*520*	*440*	8/11/14	125	156	
			8/14/13	80	180	8/13/14		*4280*	
			8/15/13	700	40	8/14/14		*360*	
			8/19/13	*300*	*230*	8/15/14		*440*	
			8/20/13		*930*	8/18/14	40	40	
			8/26/13	*1100*	*380*	8/19/14		20	
			8/28/13	*1600*	*1800*	8/20/14		*350*	
			8/29/13		220	8/21/14		220	
						8/25/14	10	60	
						8/26/14		*640*	
						8/28/14		*800*	*880*
						8/29/14		20	70

Appendix D. Main Street Beach *E. coli* Results 2012-2014. Main Street Beach does not operate a swim area, samples are collected from the middle of the beach area.

2012 Date	Main Street	2013 Date	Main Street	2014 Date	Main Street
6/13/12	*530*	6/3	*470*	6/5/14	30
6/20/12	40	6/10	90	6/10/14	160
6/26/12	120	6/11	30	6/11/14	180
7/2/12	80	6/17	60	6/16/14	20
7/9/12	*400*	6/18	*270*	6/17/14	60
7/16/12	150	6/24	20	6/23/14	5
7/23/12	*1440*	6/25	20	6/24/14	100
7/26/12	*920*	7/1	60	6/30/14	*690*
7/27/12	*1400*	7/2	20	7/1/14	<20
7/30/12	70	7/8	20	7/8/14	*900*
8/6/12	210	7/9	180	7/9/14	*900*
8/7/12	90	7/15	40	7/10/14	200
8/13/12	100	7/16	60	7/15/14	100
8/21/12	20	7/22	160	7/16/14	160
		7/23	*360*	7/21/14	10
		7/29	*4800*	7/22/14	40
		7/30	80	7/29/14	*350*
		8/5	40	7/30/14	*960*
		8/6	<10	7/31/14	180
		8/8	*2600*	8/1/14	80
		8/14	*360*	8/4/14	60
		8/15	80	8/5/14	104
		8/19	40	8/7/14	230
		8/28	*290*	8/11/14	100
				8/18/14	*1000*
				8/26/14	30

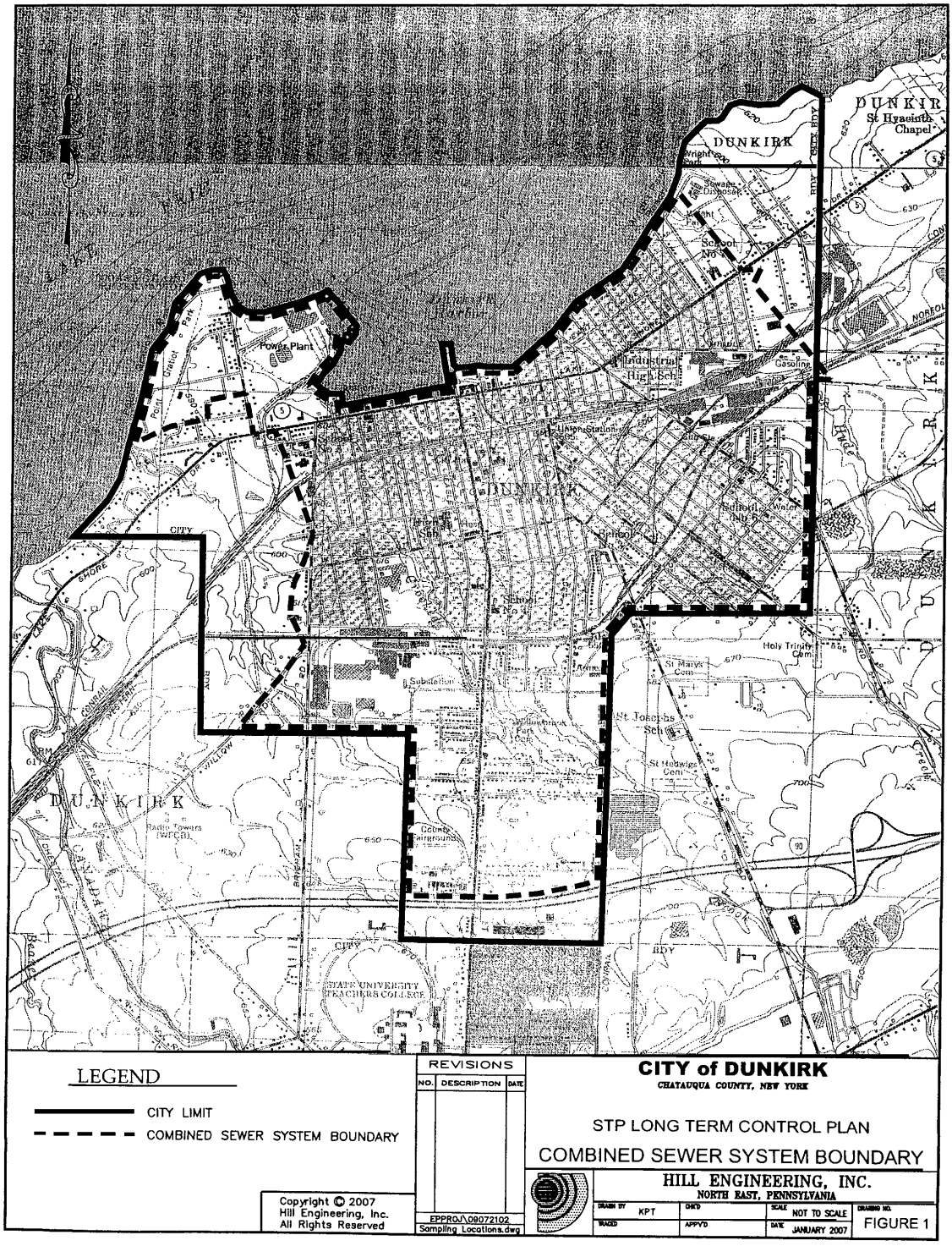
Appendix E. Point Gratiot E. coli Results 2012-2014. In recent years a single swim area, with two lifeguards chairs has operated on the eastern area of Point Gratiot Beach; however two swim areas have operated in the past.

2012			2013			2014			
Date	**PGE**	**PGW**	**Date**	**PGE**	**PGW**	**Date**	**PGE**	**PGE-2**	**PGW**
6/13/12	80	*360*	6/3/13	*270*		6/5/14	40		10
6/20/12	70	140	6/10/13	20		6/9/14	*1020*		
6/26/12	40	40	6/11/13	*840*		6/10/14	40		<20
7/2/12	10	<10	6/12/13	160		6/11/14	*1480*		
7/9/12	30	10	6/13/13	160		6/12/14	100		
7/16/12	*290*	*400*	6/17/13	100		6/16/14	70		100
7/17/12	220		6/18/13	140		6/17/14	40		
7/18/12	150	170	6/19/13	10		6/18/14	200		
7/20/12	*250*	*320*	6/20/13	<10		6/19/14	120		
7/21/12	30	220	6/24/13	40		6/23/14	<10		
7/23/12	230	170	6/25/13	*600*		6/24/14	*780*		*720*
7/26/12	160	*420*	6/26/13	200		6/25/14	*600*		
7/27/12	*310*	*350*	6/27/13	<5		6/26/14	*260*		
7/30/12	110	170	7/1/13	60	80	6/30/14	*400*		60
8/6/12	20	20	7/2/13	50	20	7/1/14	*380*		
8/13/12	230	230	7/8/13	*480*	*440*	7/2/14	*260*	*260*	
8/21/12	10	<10	7/9/13	100	220	7/3/14	30	230	
			7/10/13	420		7/7/14	190		
			7/11/13	*400*		7/8/14	*430*		
			7/12/13	<100		7/9/14	*740*		
			7/15/13	220	20	7/10/14	120	160	80
			7/16/13	120		7/14/14	*270*	*460*	*960*
			7/17/13	*4000*		7/15/14	210		
			7/18/13	200		7/16/14	160		
			7/19/13	*720*		7/17/14	10		80
			7/22/13	20		7/21/14	40		110
			7/23/13	*940*		7/22/14	8		
			7/24/13	20		7/23/14	*1100*		
			7/25/13	<20	<20	7/24/14	200		
			7/29/13	140		7/29/14	100		
			7/30/13	100		7/30/14	150		
			7/31/13	<20	<20	7/31/14	*3200*		*5120*
			8/1/13	80		8/1/14	*380*		*300*
			8/5/13	20		8/4/14	10		30

Appendix E. Point Gratiot E. coli Results 2012-2014 (continued).

2012 Date	PGE	PGW	2013 Date	PGE	PGW	2014 Date	PGE	PGE-2	PGW
			8/6/13	<10		8/5/14	220		
			8/7/13	20		8/6/14	120		
			8/8/13	*2760*		8/7/14	80		*280*
			8/9/13	180		8/11/14	75		10
			8/13/13	20		8/13/14	*1850*		
			8/14/13	40		8/14/14	190		
			8/15/13	80	60	8/18/14	5		<10
			8/19/13	*610*	70	8/19/14	50		
			8/20/13	*1120*		8/20/14	60		
			8/28/13	*2100*	*2200*	8/21/14	70		
			8/29/13	10	40	8/25/14	15		
						8/26/14	155		20

Appendix F. Combined and Separated Sewer Area Distinctions in Dunkirk, NY



Appendix G. Sheridan Bay Park Beach *E. coli* Results 2012-2014. Sheridan Bay Park Beach does not operate a swim area. A single sample is collected from the middle of the beach area.

2012 Date	Sheridan	2013 Date	Sheridan	2014 Date	Sheridan
6/13/12	10	6/3/13	200	6/5/14	60
6/20/12	60	6/10/13	10	6/10/14	100
6/26/12	*450*	6/11/13	*2420*	6/11/14	<10
7/2/12	60	6/17/13	200	6/16/14	<10
7/9/12	50	6/18/13	50	6/17/14	20
7/16/12	70	6/24/13	10	6/23/14	<5
7/23/12	130	6/25/13	140	6/24/14	<10
7/26/12	20	7/1/13	20	7/1/14	50
7/27/12	20	7/1/13	40	7/8/14	120
7/30/12	<10	7/2/13	<10	7/9/14	*520*
8/6/12	60	7/2/13	20	7/10/14	30
8/13/12	100	7/8/13	140	7/14/14	210
8/21/12	10	7/9/13	20	7/15/14	70
		7/15/13	40	7/21/14	10
		7/16/13	40	7/22/14	<10
		7/22/13	10	7/29/14	30
		7/23/13	100	7/30/14	180
		7/29/13	160	8/4/14	<10
		7/30/13	40	8/5/14	5
		8/5/13	40	8/11/14	<10
		8/6/13	<10	8/12/14	*420*
		8/12/13	<10	8/13/14	*1220*
		8/13/13	40	8/15/14	70
		8/20/13	20	8/18/14	120
		8/28/13	140	8/25/14	18

Appendix H. Blue Water Beach Campground Beach *E. coli* Results 2012-2014. Blue Water Beach Campground operates two swim areas on the beach. A small tributary discharges in the middle of the western swim area. Samples are collected from each of the swim areas.

2012 Date	BWB East	BWB West	2013 Date	BWB East	BWB West	2014 Date	BWB East	BWB West
6/6/12	6	<2	6/3/13	-	*770*	6/5/14	20	50
6/13/12	10	10	6/10/13	20	10	6/10/14	220	180
6/20/12	40	10	6/11/13	*1600*	*1690*	6/11/14	90	*430*
6/26/12	60	<10	6/17/13	120	220	6/16/14	<10	10
7/2/12	20	10	6/18/13	*300*	*250*	6/17/14	10	30
7/12/12	20	20	6/20/13	<10	50	6/23/14	<5	<5
7/16/12	100	60	6/24/13	20	10	6/24/14	*600*	*480*
7/23/12	140	110	6/25/13	*320*	*310*	6/25/14	*820*	*1340*
7/26/12	*400*	*460*	6/27/13	<10	10	6/26/14	*320*	*360*
7/27/12	110	230	7/1/13	*1160*	*960*	6/27/14	70	50
7/30/12	20	20	7/2/13	*840*	*760*	7/1/14	*250*	220
8/6/12	*390*	230	7/8/13	*1100*	*700*	7/8/14	200	*240*
8/7/12	60	40	7/9/13	100	120	7/9/14	*1000*	*800*
8/13/12	20	40	7/15/13	<10	10	7/10/14	160	180
8/21/12	<10	<10	7/16/13	50	40	7/14/14	70	60
8/28/12	210	200	7/22/13	40	40	7/15/14	90	170
			7/23/13	40	<20	7/21/14	10	20
			7/29/13	220	140	7/22/14	<10	<10
			7/30/13	<20	<20	7/29/14	50	*1910*
			8/5/13	<10	30	7/30/14	110	100
			8/6/13	<10	<10	8/4/14	10	<10
			8/8/13	*1640*	*5100*	8/5/14	5	25
			8/9/13	100	160	8/6/14	120	20
			8/12/13	<10	10	8/11/14	<10	<10
			8/13/13	60	*400*	8/12/14	50	*260*
			8/15/13	-	20	8/13/14	-	*2400*
			8/20/13	20	40	8/15/14	100	90
			8/28/13	<10	<10	8/19/14	<10	<10
						8/26/14	<10	10