Severn Sound

Environmental Association

Deanlea Beach Investigation

June 2018

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For: The Township of Tiny

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Background

Deanlea Beach is a community in the Township of Tiny, between the communities of Bluewater Beach and Georgian Heights (Figure 1). Within the Deanlea Beach area is Bluewater Beach Park, a municipally owned beach which attracts numerous beachgoers every summer. It is important to monitor beaches for swimming water quality to protect beachgoers from illness. The Simcoe Muskoka District Health Unit (SMDHU) has an ongoing *Public Beach Sampling Program*, and responds according to the level of bacteria detected at the beach: if the geomean of sampling results exceeds 200 Colony Forming Units (CFU) of *E. coli* /100 mL, the beach is posted immediately with a swim advisory. If the geomean is between 100-200 CFU/100 mL, a risk assessment is conducted to determine whether the beach should be posted. In either case, if the decision is made to recommend posting, the health unit makes this recommendation to the Township, who is responsible for posting a notice indicating for the public to use the beach at their own risk. The beach generally remains posted until sampling shows the risk to swimmers is within acceptable limits (SMDHU 2017). The posting guideline is set jointly by the Ministry of Health and Long Term Care (MOHLTC), Public Health Ontario (PHO) and Ministry of Environment and Climate Change (MOECC) (MOE 1994, Health Canada 1998, PHO 2013).

The Severn Sound Environmental Association (SSEA) was asked by the Township to investigate the water quality of runoff that discharges to the Deanlea Beach area at Bluewater Beach Park, in relation to the recreational water quality of the beach itself. Concerns were raised by the Deanlea Beach Association (DBA) that *E. coli* counts based on data from their volunteer sampling program appeared elevated in the Deanlea Beach area, and that these elevated counts were thought to be caused by runoff from the stormwater outlet that discharges onto the beach. The DBA expressed their interest to the Township in determining the source of bacteria, and in finding out how it can be mitigated, who then requested this study. Flow coming out of the drainage outlet is very low during dry periods, sometimes not flowing right into Georgian Bay but instead infiltrating through the sand. During storm events however, flow is substantial. There are two subdivisions (>100 units each) at the base of Conc. 4 at Tiny Beaches Rd., part of which drain to the beach (Figure 2). These subdivisions were built between 1977-1989, and are serviced by individual private septic systems. Developed lands represent approximately 12% of the total subwatershed area of Bluewater Creek, which originates in the mainly forested uplands east of the Conc. 4/Tiny Beaches Rd intersection and discharges at Bluewater Beach Park.

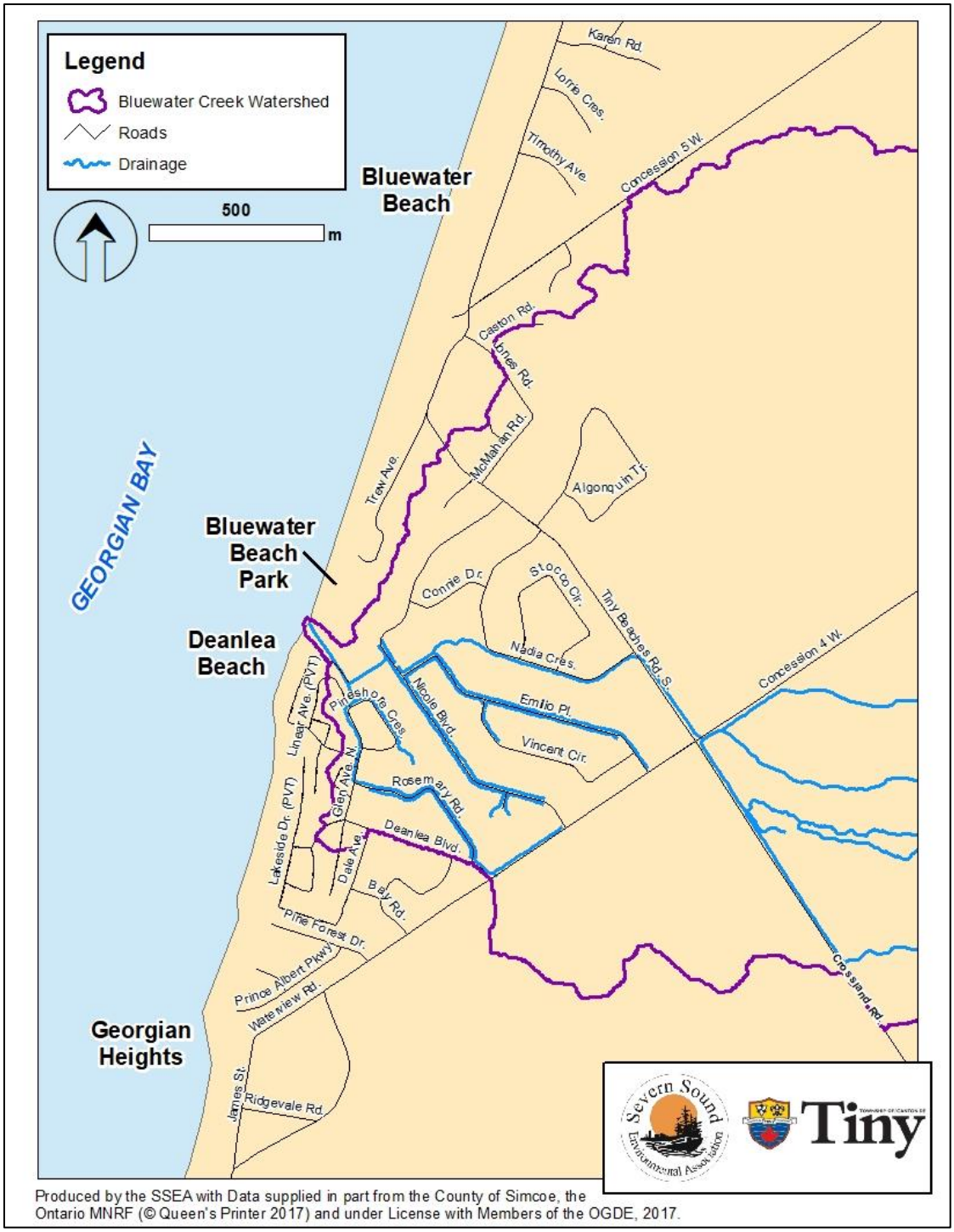

Figure 1. Deanlea Beach community, showing Bluewater Beach Park and neighbouring Georgian Heights and Bluewater Beach communities.

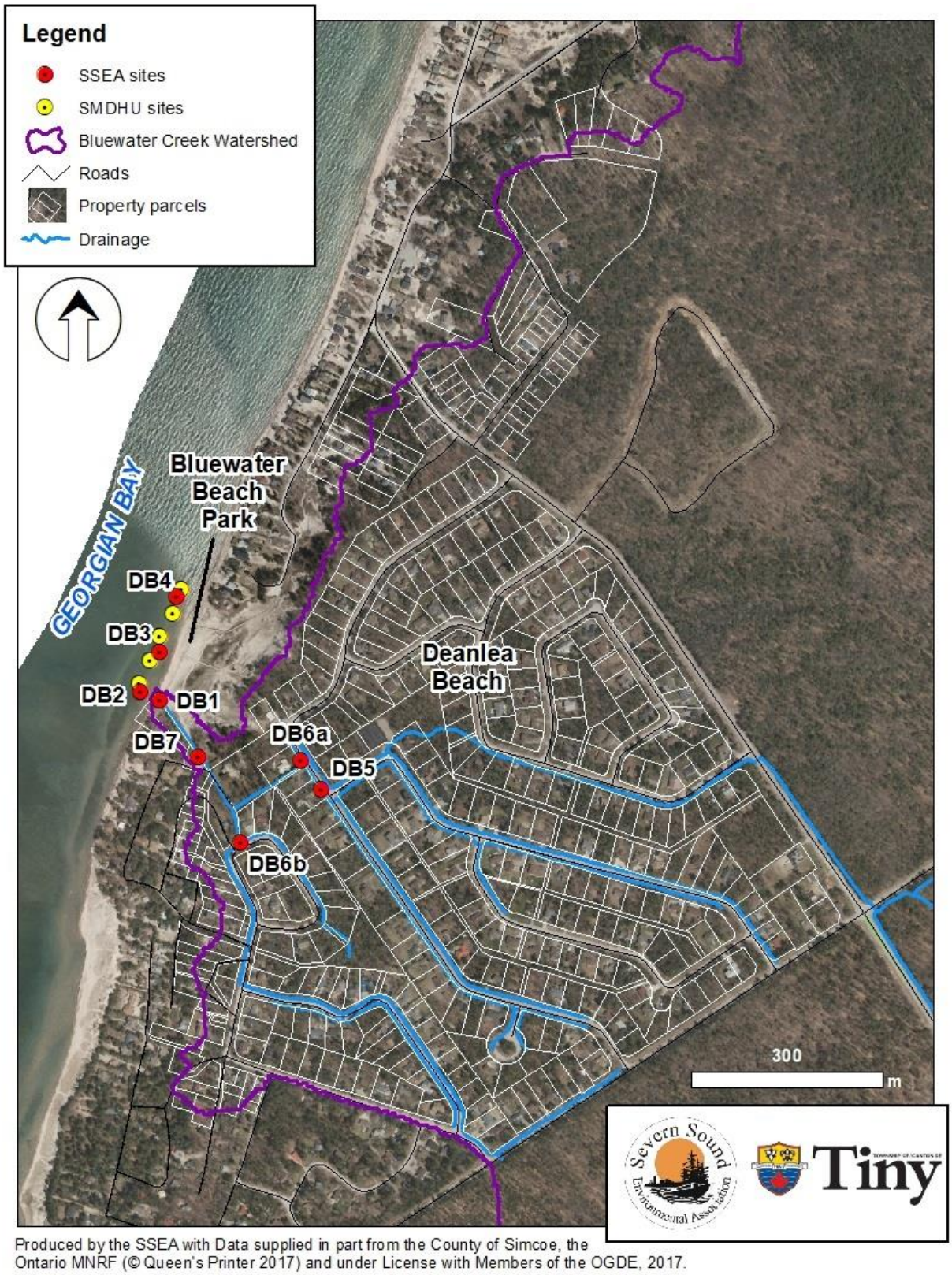

Figure 2. Map showing stormwater drainage to the outlet at the public beach, as well as locations sampled by SSEA (red) and the SMDHU (yellow). Ortho-imagery was taken in 2016 at a resolution of 20 cm.

Factors affecting beach quality along the Township of Tiny coastline include:

- Stream discharges and outfalls, and associated contaminants from runoff
- Sheltering of beach
- Time after onset of storm event
- Wind and wave action
- Birds and other animals (wild and domestic)
- Beach use (i.e. density of bathers)

This report will focus on the influence of storm discharges using water quality data collected by SSEA in 2016, and *E. coli* data collected by the Simcoe Muskoka District Health Unit (SMDHU) as part of their *Public Beach Sampling* Program mandated by the Ontario Ministry of Health and Long-Term Care, and the Federation of Tiny Township Shoreline Associations (FoTTSA) volunteer sampling program. In terms of other beach factors, the Deanlea Beach area is not sheltered by manmade or natural features, and geese are not reported to be an issue. Although the plume from the Nottawasaga River has the potential to reach the Deanlea Beach area shoreline, modelling studies show that it is often deflected by Spratt Point (SNC Lavalin, 2006).

Methods

SSEA

In 2016, SSEA established observation/sampling sites along four drainage ditch sites (DB5, DB6a, DB6b, and DB7), the stormwater outlet (DB1), and three sites across the beach at 1-1.5m depth (DB2, DB3, DB4) (Figure 4, Table 1). After a reconnaissance visit on Jul 6 (dry conditions), sites that had sufficient flow were sampled during a dry period (Aug 3), and during a major rain event (Aug 16, 73.8 mm of rain within 48 hours, 72.8 mm on the sampling date) (Figure 3). Samples were collected for *E. coli*, preserved in sodium thiosulfate, and analyzed at the Orillia Public Health Lab.

Field measurements were also made for temperature, dissolved oxygen, conductivity, pH and turbidity using a handheld multi-parameter sonde (YSI Pro DSS). Measurements of stream velocity were taken during the storm event (float method) and used to estimate discharge.

Rainfall data is available at Balm Beach from 2005-2016. The SSEA rain gauge is a tipping bucket style instrument which records cumulative rainfall in 0.2 mm increments from which daily totals can be calculated.

Additional hourly meteorological data and physical lake data was obtained from the Fisheries and Oceans Canada (DFO) meteorological buoy in the southern portion of Georgian Bay (C45143, 62 km NW from Deanlea Beach; 44.94, -80.63).

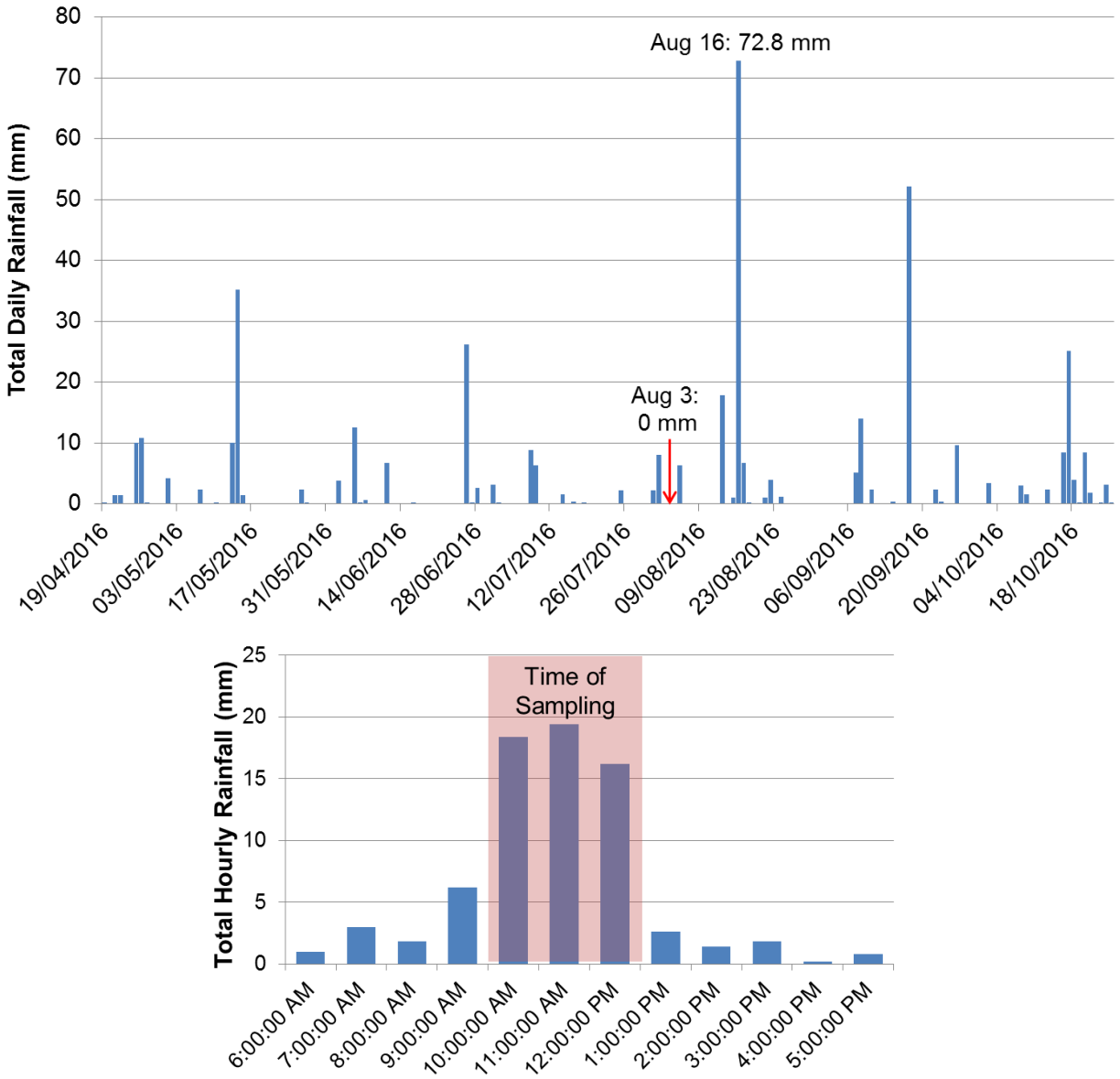

Figure 3. Top: Total daily rainfall graph for April-October 2016. Bottom: Hourly rainfall during the Aug 16 sampling event. The shaded box indicates the period over which samples were taken. Rain data from SSEA rain gauge at Balm Beach.

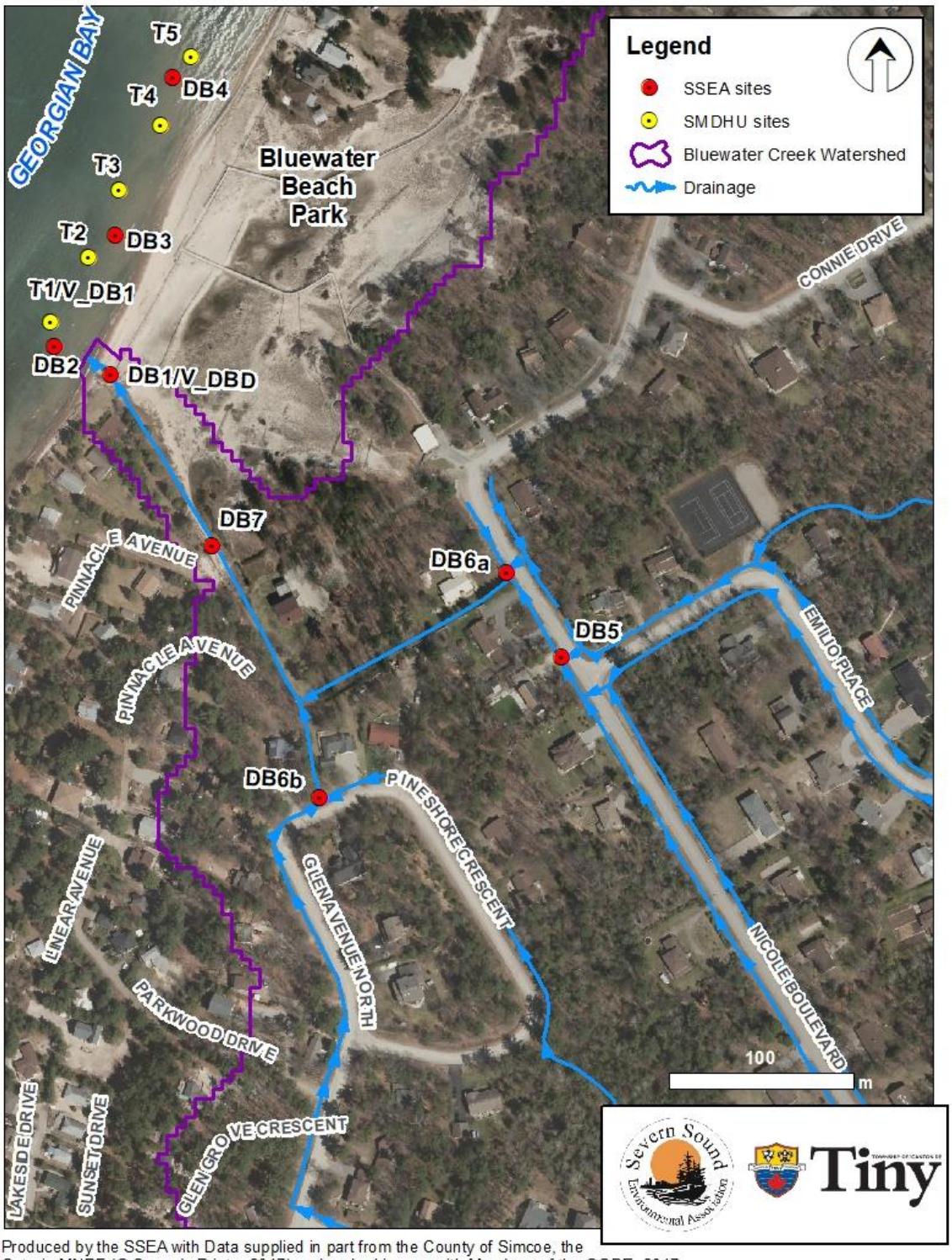

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Figure 4. Map showing locations sampled by SSEA (red, DB1-7) and the SMDHU (yellow, T1-5). FOTTSA volunteer sampling locations that approximately overlap with SSEA or SMDHU monitoring are also labelled (V_DB1 and V_DBD). Flow directions are depicted by the blue arrows. Ortho-imagery was taken in 2016 at a resolution of 20 cm.

SMDHU Public Beach Sampling Program

The SMDHU samples for *E. coli* each year at Bluewater Beach Park and has been doing so since 2003, collecting samples at 5 locations across the beach on between 5-12 sampling events per year. Samples are collected at 1-1.5 m depth, preserved in sodium thiosulfate, and analyzed at the Orillia Public Health Lab. Field observations are also made of weather and beach conditions.

FoTTSA Volunteer Program

E. coli samples have also been collected through the volunteer beach sampling program coordinated by FoTTSA. Samples have been collected in 2001-2006, 2008, 2010, 2012, 2014 and 2016, and include between 5-9 samples per season at 3 locations along the Deanlea Beach shoreline: at the south end of the public beach, the outlet stream, and at a location further south in front of private residences. The first two locations will be used to compare with health unit and SSEA data. Samples and field observations are collected by volunteers, and over the period of record, samples have been analyzed at the Orillia Public Health Lab, the Central Ontario Analytical Lab, and recently the Aquatic and Environmental Lab. Samples are collected at the same depth as the health unit (1.0-1.5m).

Table 1. Descriptions of sampling locations for each agency, as well as UTM coordinates (NAD 83, zone 17).

Agency	Station ID	Location	Easting	Northing
SMDHU	T1	off culvert at S. end of public beach	579504.6738	4941030.681
SMDHU	T2	midway between T1/T3	579525.3933	4941065.786
SMDHU	T3	middle of public beach	579541.5523	4941102.295
SMDHU	T4	midway between T3/T5	579563.9898	4941137.018
SMDHU	T5	off north edge of public beach	579580.4688	4941174.090
FOTTSA	V_DB1	off culvert	579510.5565	4941022.693
FOTTSA	V_DB2	off largest boulder	579363.4825	4940560.431
FOTTSA	V_DBD	culvert N. end Deanlea (S. end of public beach)	579536.0265	4941001.486
SSEA	DB1	outfall	579537.0625	4941002.595
SSEA	DB2	sound end of public beach	579506.9948	4941017.628
SSEA	DB3	center of public beach	579539.5375	4941077.727
SSEA	DB4	north end of public beach	579570.5020	4941163.332
SSEA	DB5	culvert at corner of Emilo Place Rd.	579780.9997	4940850.035
SSEA	DB6a	U.S. of pipe storm cover	579751.1581	4940895.550
SSEA	DB6b	US culvert Pineshore Cres.	579650.0605	4940773.432
SSEA	DB7	path to Pinnacle Ave. (underground pipe)	579591.9623	4940909.922

Statistical Methods

Statistical tests were computed using the software package R. Significance of test results were evaluated using α= 0.05; that is if the *p* value for the test was less than 0.05, it was deemed statistically significant.

Results

Ditch Conditions During Dry and Wet Periods

The drainage network in the study area is complex and is best described using photographs. Dry conditions are depicted first from upstream to downstream, followed by storm conditions.

Dry Conditions

Jul 6 DB6a - Confluence of road ditch from both sides of road. After entering the rectangular culvert (foreground), the drainage disappears to manhole (circled) and onward to DB7.

Jul 6 manhole downstream of DB6a - Water could be seen through manhole cover on both dry days (Jul 6 and Aug 3). Flow observed in culvert coming from DB5 direction (culvert in bottom photo). No flow observed in culvert coming from across the road, opposite DB6a (culvert in top photo).

Jul 6 upstream of DB5 - Sump pump discharge on left, wet spot at right; both contributing to flow at DB5 during this dry period.

Jul 6 DB5 – Confluence showing overflow ditch culvert which flows in at this location (upper right culvert, dry), road crossing culvert (bottom, water seen flowing in during this dry period) and main culvert that goes to the manhole downstream of DB6a (upper left culvert, small amount of flow).

Jul 6 DB6b – No flowing or standing water coming into culvert, which would flow to DB7.

Jul 6 DB7 –Could not hear running water through manhole cover on beach just upstream of DB1 during dry period.

Jul 6 DB1 – A small amount of flow always discharges from the outlet, sometimes pools on beach.

Jul 6 DB1 - River rock has been added at the outlet and inside the culvert (source of river rock unknown).

Jul 6 DB1 –Stream sometimes seeps into the sand and doesn't flow directly to the lake via overland flow.

Storm Conditions

Aug 16 DB6a – Steady runoff to manhole during storm event.

Aug 16 downstream of DB5 - Backflow towards DB5 (underground flow goes opposite way to DB6a).

Aug 16 upstream of DB6b - Water pooling upstream and not flowing through ditch to DB6b (connecting driveway culvert was higher than water level, thus not allowing water through). Pooling was due to excessive rainfall received.

Aug 16 DB6b - No flow entering culvert despite very heavy rainfall.

Aug 16 DB1 – Heavy rains caused large stormwater flows to discharge at the outlet, creating significant channelling; very dynamic channel.

Beach Conditions During Dry and Storm Periods

During the dry sampling event, the outflow stream did not reach the lake but instead infiltrated through the sand. The observed nearshore waters from 1.5 m depth to shore were clear.

The rainstorm that was captured during sampling on Aug 16 created a plume that flowed south, away from the public beach. This flow direction was likely due to shoreline currents that carried the plume in this direction. Winds were offshore during this time. Due to the similarity in water temperature between the plume and the open water on Aug 16, the plume likely dispersed rapidly into the bay. The stream plume could travel in either direction depending on wind and current conditions, making the effect of each rain event difficult to predict, however the predominant along-shore current direction is southward.

Aug 16 DB1 - Visible plume heading away from the public beach area (southward).

Aug 16 DB2 - Beach near outlet shows high turbidity.

Aug 16 DB4 - Beach at north end shows no turbidity.

Flow Conditions

During the dry period, there was no flow at DB6a or DB6b, and only stagnant water at DB5. However, water could be heard in the manhole downstream of DB6a.

During the rain event, stream flows were high at DB5 and DB6a, however there was still no flow at DB6b. Based on observations, a driveway culvert along a ditch leading to DB6b was too high to allow water to flow, and following excessive rainfall, caused pooling in the ditch. Due to the predominantly sandy soil, this pooled water likely infiltrated and travelled towards the lake as subsurface (i.e. shallow groundwater) flow. During the storm, the discharge at the outlet was 0.18 m^3/s. Discharge was 0.10 m^3/s at DB5 compared to 0.01 m^3/s at DB6a.

SSEA's drainage layer does not show drainage along the north part of Nicole Blvd, Connie Dr, Stocco Cir, or Nadia Cres but reconnaissance indicated there are roadside ditches and culverts along these roads. During storm events, stormwater from properties along these roads likely flows to the ditch then infiltrates through the sandy soil. These ditches were often separated by undeveloped properties that did not have ditches, and thus they did not appear to connect to the drainage network that discharges onto the beach.

Wind, Waves and Water Levels

According to the DFO buoy, waves on Aug 3 were less than 0.5 m, which was consistent with field observations during sampling. Winds increased from 5 km/h at midnight on Aug 2 to 25 km/h during sampling, and shifted from an easterly (offshore) direction overnight to westerly (onshore) by end of sampling. A westerly wind likely produced a northerly along-shore current, although this could not be confirmed since there was no stream plume to indicate current movement.

On Aug 16, waves were between 0.5-0.6 m at the DFO buoy, however no waves were observed during sampling since the wind was offshore. Winds increased from 9 km/h at midnight to 30 km/h by the end of sampling period. Winds were consistently from the SSE prior to and during sampling period, creating offshore wave conditions.

The southward circulation pattern on Aug 16 was evident in the water levels recorded at Collingwood Harbour. Over short timespans, water levels fluctuate in response to wind forcing, and these water movements have an effect on along-shore currents and thus the direction of flow of tributary plumes. In the 24 hr prior to sampling on Aug 16, water levels dropped, reaching a low point of 0.697 m above datum four hours prior to sampling and indicating water movement out of Nottawasaga Bay. Levels then rose

steadily, indicating movement into Nottawasaga Bay (Figure 5, right). The circulation pattern of the bay is complex, but this sustained wind and resulting water movement likely contributed to southward along-shore pattern as water was carried NNW across the bay and then circled back around.

In the 24 hr previous to sampling on Aug 3, Georgian Bay was oscillating over a period of 6 hours on average and fluctuating between 0.745-0.830 m above datum (Figure 5, left). This represents smaller water fluctuation events.

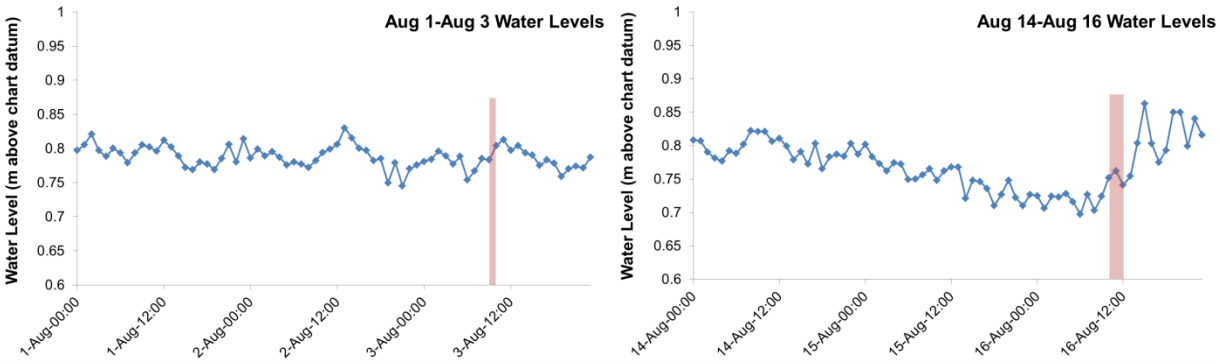

Figure 5. Water levels (m above chart datum of 176 m.a.s.l.) measured at Collingwood Harbour before and during the dry sampling period (left) and storm sampling period (right). Shaded bars indicate the exact sampling times.

Field Water Chemistry

During the dry period, the water temperature at the outlet was low (14.6 °C), indicating that groundwater dominated the stream flow (Table 2). During the storm event, the temperature was much higher at 20.3 °C, indicating the dominance of surface runoff. High turbidity (66.4 FNU) at the outlet during the storm also indicated surface runoff influence, as did low conductivity (69.7 µS/cm indicates runoff comprised of mostly rainwater). In comparison, conductivity during the dry period was high (479.6 µS/cm), which is indicative of groundwater influence. While it was not specified as a sample location, field measurements were also taken in the middle of stream plume at 0.5 m depth after it entered Georgian Bay during the storm to determine how quickly water was diluted. Here it was found that conductivity had nearly doubled to 112.7 µS/cm and turbidity had dropped by a third to 43.3 FNU due to mixing with the bay.

Table 2. Water chemistry and discharge measurements taken during a dry (Aug 3, brown shading) and wet (Aug 16, blue shading) period. Bolded values indicated the higher value of the pair. Stations are listed from upstream to downstream.

Station Description	Station	Temperature °C		Dissolved Oxygen mg/L		pH	
upstream culvert on Nicole Blvd	DB6a	DRY	20.8	DRY	7.98	DRY	7.59
downstream culvert on Nicole Blvd	DB5	DRY	21.1	DRY	8.72	DRY	8.69
storm outlet	DB1	14.6	**20.3**	**9.13**	8.63	8.16	**8.18**
middle of plume from outlet	plume	-	21.0	-	8.58	-	8.32
south end of beach, 1.5m depth	DB2	**22.6**	22.5	**9.19**	8.64	**8.5**	8.38
middle of beach, 1.5m depth	DB3	**22.8**	22.6	**9.2**	8.63	**8.48**	8.41
north end of beach, 1.5m depth	DB4	**22.8**	22.9	**9.22**	8.59	**8.48**	8.45

Station Description	Station	Conductivity µS/cm		Turbidity FNU		Discharge m^3/s
upstream culvert on Nicole Blvd	DB6a	DRY	83.5	DRY	5.1	0.01
downstream culvert on Nicole Blvd	DB5	DRY	33.2	DRY	13	0.10
storm outlet	DB1	**479.6**	69.7	10	**66.4**	0.18
middle of plume from outlet	plume	**-**	112.7	-	43.3	-
south end of beach, 1.5m depth	DB2	**201.3**	186	0.8	0.8	-
middle of beach, 1.5m depth	DB3	**201.2**	186.1	0.5	**0.7**	**-**
north end of beach, 1.5m depth	DB4	**201**	190.7	0.5	**1.8**	**-**

E. coli Results

During dry conditions, *E. coli* densities at the outlet were elevated (830 CFU/100mL), and were even higher during storm conditions (>1000 CFU/100mL) (Table 3). However, at the beach site directly offshore from the outlet (DB2), *E. coli* densities were very low during both periods (<10 CFU/100mL). By coincidence, the SSEA sampled the public beach at the same time as the health unit during the dry period (Aug 3), and their results corroborated those from SSEA. Since the storm runoff plume flowed southward away from the swimming area on Aug 16, densities remained low across the beach (max. 30 CFU/100mL). If the plume had been going northward, it is possible that at least the southern beach station would have had higher densities.

Table 3. Results from *E. coli* samples taken during a dry (Aug 3, brown shading) and wet (Aug 16, blue shading) period. Bolded values indicated the higher value of the pair. SMDHU beach data from Aug 3 are also shown for comparison.

Location Description	Station	*E. coli* (CFU/100mL)		
		Dry		Wet
		SSEA	SMDHU	SSEA
upstream culvert on Nicole Blvd	DB6a	DRY	-	**>1000**
downstream culvert on Nicole Blvd	DB5	DRY	-	**>1000**
storm outlet	DB1	830	-	**>1000**
south end of beach, 1.5m depth	DB2	<10	1	<10
middle of beach, 1.5m depth	DB3	<10	1	**30**
north end of beach, 1.5m depth	DB4	<10	1	**20**

During the storm event, *E. coli* densities were very high in the storm runoff at DB6a and DB5. It is likely that the land draining to DB6a and DB5 contributes bacteria to the outlet on the beach. However, during the dry period, there was no flow at DB6a and little to none at DB5, yet bacteria levels were still elevated at the outlet. This may indicate a subsurface source of bacteria.

Long Term E. coli Trends

Based on *E. coli* data from the SMDHU (2003-2016) and the volunteer program, densities are generally low at Bluewater Beach Park. The table below illustrates this point using health unit data, showing that since 2009, none of the sampling events have exceeded the MOHLTC recreational water quality guideline for safe swimming conditions at public beaches (geomean of 100 CFU/100mL) (Table 4). The SMDHU reduced their sampling frequency from weekly to biweekly in 2009-2012 due to the generally low bacterial levels observed, but have increased frequency to 7-11 sampling events/year since 2013 and exceedances remained at zero. There was a significant decrease in maximum geomean and in % exceedances since 2003 (Mann Kendall test, p = 0.05 and 0.03 respectively).

Table 4. Long term *E. coli* data for Bluewater Beach Park collected by the SMDHU. The first and last sampling dates are given, along with the percentage of geomeans that were greater than 100 CFU/100mL. The maximum geomean and number of samples collected per year are also show.

Year	First Date	Last Date	%Exceedance	Maximum Geomean (CFU/100mL)	# Sampling Events per year
2003	16-Jun-03	25-Aug-03	36%	300	11
2004	22-Jun-04	30-Aug-04	0%	76	11
2005	14-Jun-05	29-Aug-05	8%	148	12
2006	12-Jun-06	28-Aug-06	0%	59	12
2007	18-Jun-07	27-Aug-07	9%	257	11

2008	17-Jun-08	25-Aug-08	9%	188	11
2009	29-Jun-09	24-Aug-09	0%	32	5
2010	28-Jun-10	30-Aug-10	0%	19	6
2011	5-Jul-11	30-Aug-11	0%	17	5
2012	19-Jun-12	28-Aug-12	0%	47	6
2013	25-Jun-13	27-Aug-13	0%	24	9
2014	24-Jun-14	26-Aug-14	0%	93	7
2015	16-Jun-15	1-Sep-15	0%	58	10
2016	21-Jun-16	30-Aug-16	0%	25	11

Statistical tests comparing the south end of the beach (where the storm outlet discharges) to the north end of the beach showed that the south end did not have higher *E. coli* densities according to the health unit data (Wilcoxon test, p= 0.74; data from 2003-2016) (Figure 6). The south end had higher *E. coli* densities according to the volunteer sampling data compared to the health unit data at the south end, although this difference was not statistically different (Wilcoxon test, p= 0.40; data from T1 and V_DB1 in 2001-2016). Samples collected by the volunteer program at station V_DB1 were collected in the same location and at the same depth (1.0-1.5m deep) as the health unit station T1. The discrepancy in bacteria densities may be a result of a bias due to data availability. The volunteer program had data for 2001-2002 (higher densities occurred) where the health unit did not, and the volunteer program did not have data for every other year starting in 2007 (lower densities occurred) where the health unit did. It should be noted that while the Township will review independent testing, it will only recognize and respond to results from the health unit.

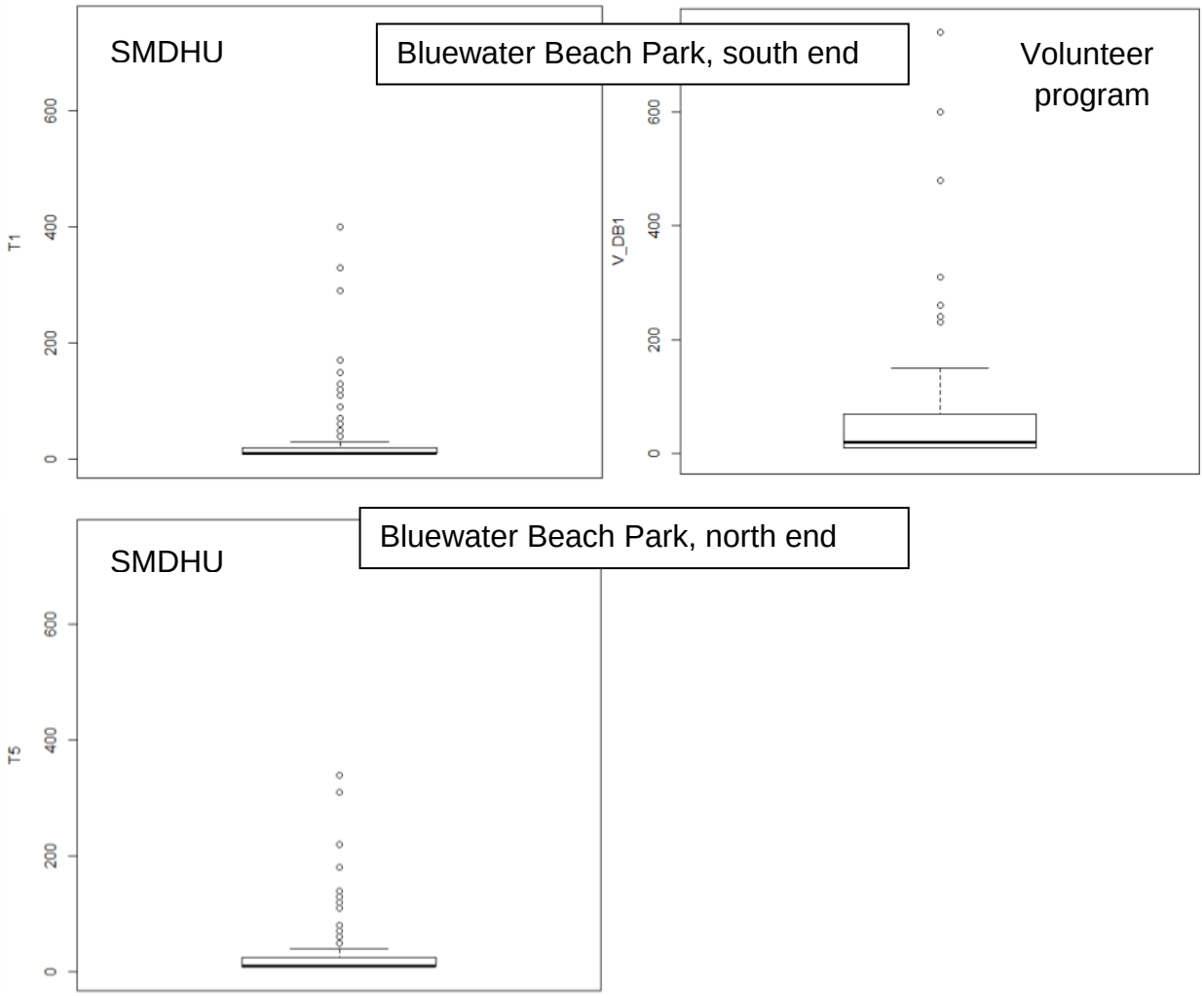

Figure 6. Boxplots showing the spread of *E. coli* data (CFU/100 mL) at the south (top) and north (bottom) end sampling locations from the SMDHU (left, 2003-16) and volunteer (right, 2001-16) sampling programs. The volunteer program does not have a comparable location at the north end of the beach.

To determine the relationship between rainfall and *E. coli* densities, data was used from the SSEA rain gauge along with *E. coli* data from the health unit. Kendall's tau correlation test showed a weak but non-significant relationship between rainfall and overall geomean *E. coli* (p=0.08, Figure 7) and between rainfall and *E. coli* density close to the outlet at T1 and V_DB1 (p=0.08 and 0.06, Figure 8). Note that results from an individual location are not compared to the provincial guideline since the protocol is to use a geomean of at least 5 sites per sample to represent overall quality at a public beach. In this case it is useful to look at data from samples taken in front of the storm outlet to determine the influence of rain events on bacteria load from this source. Based on overall beach results from the health unit, and results from in front of the outlet, there does not appear to be a strong relationship between bacterial densities and rainfall at

this location. There are instances were rainfall was high but bacterial densities were low, and vice versa.

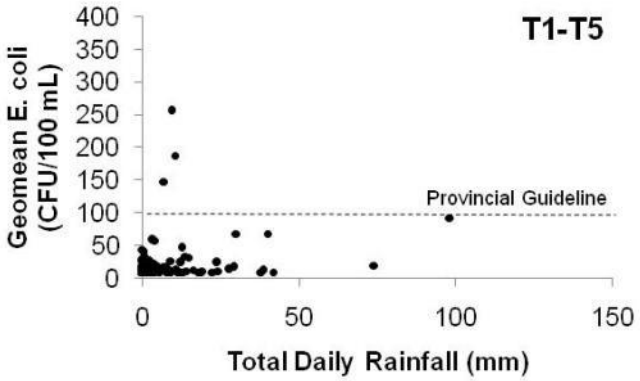

Figure 7. Geomean *E. coli* density using health unit data for T1-T5 from 2005-2016 vs. total daily rainfall from the SSEA rain gauge at Balm Beach. Also shown is the provincial guideline of 100 CFU/100 mL.

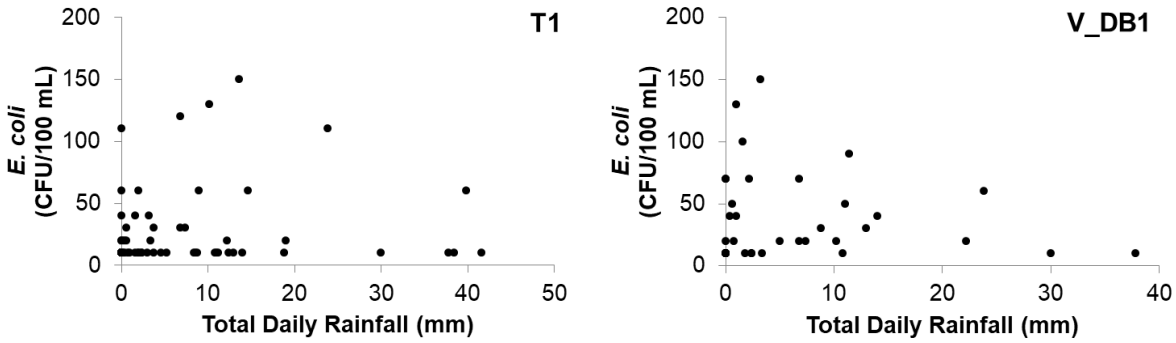

Figure 8. *E. coli* densities at health unit station T1 (left) and volunteer station V_DB1 (right) vs. total daily rainfall from the SSEA rain gauge at Balm Beach. Data period: 2005-2016. Note that one outlier was removed on each plot.

Bacteria densities are low at DB4 (SSEA sampling) and T5 (health unit sampling) at the north end of the public beach. The immediate surface drainage area of the beach is very localized and does not include any of the dwellings on the east side of the dune directly behind beach. However, subsurface drainage from these dwellings has the potential to influence beach quality.

Discussion

Overall, swimming water quality at Bluewater Beach Park is good, and health unit sampling has shown no exceedances of the provincial recreational water quality

guideline since 2008. The exception in beach quality is in the area directly offshore from the storm outlet during a storm event, and possibly during lower flow periods whenever flow is present from the outlet, even if it doesn't directly connect to the bay. The influence of the storm outlet is highly dependent on the direction of the plume as it enters Georgian Bay. If it is flowing southward, *E. coli* densities at the public beach will be low, as was the case during the SSEA's wet period survey, but may be elevated along the private shoreline section of Deanlea Beach. If it is flowing northward, densities are likely to be higher at the public beach. High densities are associated with turbid waters; thus if the water is clear, there is likely to be a lower risk of contamination. Predominant currents along the Township of Tiny shoreline are in a southerly direction. During the summer months when the temperature of the discharge and bay are similar, dispersion of the plume will be rapid.

Previous studies done by the SSEA and the SMDHU have shown that *E. coli* levels are often significantly higher after a wet event (rainfall within 48 hrs) than during a dry event (no rainfall within 48 hrs). Rainfall effects on bacteria levels have the potential to impact all parts of the Township coastline, not just public beaches. Looking at the historical *E. coli* densities in front of the outlet from the health unit and volunteer sampling programs, along with rainfall within 48 hrs, this relationship is not strong. There are many instances where a large rain event did not cause high bacterial densities, and where high bacterial densities do not correspond to a rain event.

The present SSEA study corroborated this finding, showing that *E. coli* levels at the outlet were high during the dry period as well as the wet period. The relationship between *E. coli* density and rainfall could be confounded by: a) the influence of the plume direction, which may cause low levels in front of the outlet during wet periods if flowing southward, and b) subsurface flow originating from the residential area that may contain bacteria, which would cause high levels in front of the outlet during dry periods.

Another possible reason for low bacterial levels despite a source of contamination (storm outlet) is the diluting effect of the bay. Conductivity values at the three beach sites were approximately 200 µS/cm during dry period. Values dropped slightly during the rain event due to the effect of surface water runoff from the landscape, which influences the nearshore zone as a whole. During the rain event, conductivity was 69 µS/cm in the storm runoff outflow, and 112 µS/cm in outflow plume at 0.5 m depth in the lake. This rapid increase was due to high conductivity lake water mixing with low conductivity runoff and demonstrates the significant dispersing effect of the bay. The low conductivity during the rain event also indicates the influence of rain water in the runoff carrying the bacteria and sediment to the storm sewer and to the discharge.

Despite the dispersing influence of the lake and the fact that the outflow plume is often directed away from public beach, there are signs of bacterial contamination in the stormwater outflow that could be addressed by ensuring that all septic systems are up to standard, and that pet waste is properly disposed of. The Township should ensure that up-to-date septic inspections have been done for all of the properties, including ones that drain into the storm outlet at the public beach, and that repairs are made to any faulty or substandard systems. The Township has an effective system for septic re-inspection.

While bacterial levels are generally low at Bluewater Beach Park, there have been changes in land cover and lot level drainage that may increase the risk for bacterial contamination in the future. Factors that reduce infiltration at the lot level, such as reduction in the number of vacant lots, dwelling footprint, paved area, and downspout redirection directly to the beach, can all influence how much rainfall leaves a property as surface runoff versus how much infiltrates. Infiltration is an important mechanism to improve water quality by natural filtration processes in the soil. Climate change impacts include more intense storm events, and this combined with a landscape that does not promote infiltration could cause more frequent beach contamination issues in the future. Additional factors to consider for future recreational water quality are increased water temperature, which promotes bacterial growth, changes in Georgian Bay water levels, which impacts how groundwater flows into the bay, and conversion of summer use properties to year-round residences.

Recommendations

The current health unit monitoring program is an effective means of detecting bacterial contamination and informing the public of the swimming safety status of public beaches. This program should continue.

Septic inspections and subsequent correction of faulty and substandard sewage systems should continue.

Residents can improve infiltration and runoff quality on their properties by reducing the amount of paved area, connecting downspouts to soaker pits or rain gardens, and ensuring that pet waste is removed from yards.

Summary

Following concern from residents over discharge of stormwater containing elevated bacterial levels onto Bluewater Beach Park, the SSEA did an investigation of the public

beach and surrounding Deanlea Beach area in 2016 to determine the degree and potential sources of bacterial contamination in runoff reaching the beach. Sampling was conducted during a dry and a wet period. *E. coli* data from the SMDHU and FoTTSA volunteer sampling programs were used along with SSEA rainfall data to provide additional insight into beach conditions. Long term *E. coli* trends showed that recreational beach quality at Bluewater Beach Park is good overall, with no exceedances of the provincial guideline since 2008. In 2016 during the dry sampling period, flow from residential drainage ditches was minimal, and yet bacterial densities in water discharging at the storm outlet were elevated. During the rain event, bacterial densities were elevated in drainage ditches as well as at the storm outlet, however due to the direction of the runoff plume, *E. coli* levels at the public beach were low. These findings, along with analysis of historical *E. coli* data, indicate that plume direction and potential contamination of subsurface flow likely impact beach recreational water quality. The Township has committed that they will be continuing the septic inspection process. Other potential factors impacting beach quality include: reduced infiltration at the lot level, conversion to year round residences, increased rainfall intensity, increase water temperature, and water level fluctuation.

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