Bayfield Beach Stormwater Monitoring 2017

Prepared for the Bluewater Beach Committee

by
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Photo: Bayfield Main Beach – photo courtesy Municipality of Bluewater.

Introduction

Communities along the southeast shore of Lake Huron are in part dependent on the tourism industry (*i.e.*, swimming, fishing and boating opportunities in Lake Huron) for economic sustainability. Increased levels of bacteria, nutrients and sediment however, can sometimes result in degraded water quality and ultimately limit recreational opportunities. These contaminants are largely associated with both agricultural and urban non-point source pollution that gets washed into rivers, creeks and storm sewers during snow melts and rain events.

Since 2011 residents of the Main Bayfield watershed have been actively involved in a community-based watershed planning process to help improve water quality within the Bayfield River, which flows into Lake Huron at the village of Bayfield. The Bayfield Main Beach has been a recipient of the internationally-recognized Blue Flag program, which among other things, identifies beaches that meet strict criteria for water quality. To help maintain this certification and support water quality initiatives in the area, the Bluewater Beach Committee was formed. This committee is supported by the Pioneer Park Association, Municipality of Bluewater, Huron County Health Unit, and Ausable Bayfield Conservation Authority (ABCA).

The village of Bayfield has stormwater outlets along the beach. A stormwater monitoring program was initiated in the summer of 2014 to evaluate these proximate potential sources of pollution. The goal of this program was to gather initial water quality data from the stormwater outfalls along the beach at the village of Bayfield. This program was continued in 2015, 2016 and 2017, and will help in determining whether the stormwater from the village of Bayfield might be impacting the beach and nearshore water quality.

For the purposes of this program, all water quality data was collected by a dedicated group of citizen scientists. Citizen science is scientific work undertaken by members of the general public under the direction of professional scientists and organizations. Not only does citizen science allow participants to make valuable contributions to research, but it also serves the critical role of linking people with science to better understand and protect our natural environment. As this happens, citizen scientists can engage their fellow community members and enhance outreach and education initiatives.

Methods

Site Description

Water quality was monitored at two stormwater outfalls along the beach adjacent to the village of Bayfield, Ontario, and at one culvert along the road (Tuyll Street) adjacent to the shoreline (Figure 1). A new outlet for the Colina outfall (150 mm) was completed as part of the rain garden installation at Pioneer Park in the fall of 2016. It now outlets at the bottom of the bank, as does the Delevan outfall (750 mm). Despite the construction of the new outfall at Colina, some water still flows down the bank. The source of this ephemeral channel needs to be further investigated to determine where it originates. Both Colina and Delevan were designated stormwater outlets for the village of Bayfield (BM Ross 2014). The Tuyll site was also modified in 2016, and now includes a combination of a tile (which comes from under Tuyll Street) and catch basin, which then outlets at the bottom of the bank. According to a report on storm drainage for the village of Bayfield (BM Ross 1985), existing tile drainage for the most developed portion of the village is directed towards the Delevan outfall or an open water course that discharges at the top of the bank (*i.e.*, Tuyll).

The village of Bayfield, which is within the Municipality of Bluewater, is mostly residential with businesses along its main street. It is serviced by the Bayfield Sewage Treatment Plant.

Figure 1. Approximate locations of three stormwater monitoring sites and public beaches along the Lake Huron shoreline in Bayfield, Ontario.

Water Sampling

Beginning in June water samples were collected every other week until the end of August. These routine monitoring events took place on predetermined dates. They were not initiated by wet weather, but typically occurred during a dry weather day (dry sampling). Water samples were also collected after rain events (event sampling), which were characterized as greater than 2.6 mm of rain in less than one hour. If a rain event occurred overnight, sampling was done as soon as possible the following morning.

Grab samples were collected by holding the sample bottle within the flowing water from the outfall, and without touching surrounding surfaces. If water was not flowing from the outfalls, no sample was collected, regardless of whether ponded water was observed below the outfall.

Water samples were analyzed by ALS Environmental in Waterloo, Ontario, to determine the concentrations of *Escherichia coli* (*E. coli*) in colony forming units per 100 millilitres of water (cfu/100 mL), total phosphorus (TP) and soluble reactive phosphorus (SRP) in mg/L.

Data Interpretation

Geometric means were used to summarize *E. coli* and TP concentrations for each monitoring site. A geometric mean is a type of mean or average whereby the effect of uncommonly high or low concentrations on a mean is reduced. Geometric means (dry and event sampling) were calculated for each monitoring site for the months of June through August 2017. These geometric mean concentrations were compared to provincial guidelines for *E. coli* and TP. SRP and TP geometric mean concentrations were used to determine SRP as a percentage of the TP. In some cases SRP concentrations exceeded TP concentrations. These exceedances result from the analysis of separate aliquots of each water sample. Where SRP concentrations were higher than TP concentrations, percentages were determined to be 100 percent. Detection limits were used as actual concentrations for any *E. coli*, TP or SRP concentrations that came back from the lab as less than the detection limit.

Daily precipitation levels were helpful for understanding some of the variability in *E. coli* and phosphorus concentrations. Precipitation data were obtained from the rain gauge maintained by the ABCA in Bayfield, Ontario.

Results and Discussion

Escherichia coli

Escherichia coli (E. coli) are fecal coliform bacteria commonly found in the intestinal tract of warm-blooded animals. While *E. coli* itself is not a threat to the environment, its presence in water collected from drains may indicate contamination by other harmful bacteria, viruses, or parasites that are associated with animal wastes. Sources may include human, pets, livestock and wild animals. The Ontario Ministry of Health and Long-term Care established a recreational guideline for *E. coli* of 100 colony forming units (cfu) per 100 mL (MOEE 1994).

Concentrations of *E. coli* at the outfalls ranged from 1 cfu/100 mL at Delevan (July 31) to 85000 cfu/100 mL at Tuyll (July 13) (Table 1). Concentrations of *E. coli* at Delevan and Tuyll were higher following rain events than routine (dry) sampling dates (no samples were collected from Colina on routine sampling dates as there was no flow). Elevated concentrations were greater than the provincial guideline, and exceeded it by one order of magnitude after two rain events (*i.e*., June 23 and July 7 at all three sites). The provincial guideline was further exceeded at all three sites by two orders of magnitude following a rain event that occurred on July 13. These concentrations were the highest concentrations recorded since the Bayfield Beach Stormwater monitoring program was initiated in 2014. The next highest *E. coli* concentration was 14700 cfu/100 mL recorded at Delevan in 2015 (Brock and Veliz 2014, 2015, 2016).

Table 1. *Escherichia coli* concentrations, in colony forming units (cfu) per 100 mL on each sampling day in 2017 for three stormwater monitoring sites draining into Lake Huron along the shoreline of Bayfield, Ontario. Highlighted values denote concentrations that exceed the Ontario Ministry of Health and Long-term Care guideline of 100 cfu/100 mL. Shaded columns indicate event sampling dates.

Site	Jun 5	Jun 18[ab]	Jun 19	Jun 23[ab]	Jul 4	Jul 7[ab]	Jul 13[ab]	Jul 17	Jul 31	Aug 4	Aug 14	Aug 23	Aug 28
Colina	ns	ns	ns	1520	ns	6800	44000	ns	ns	ns	ns	ns	ns
Tuyll	1000	ns	ns	1710	50	5200	85000	ns	ns	ns	ns	ns	ns
Delevan	1400	390	610	1990	20	5100	43000	20	1	130	14	90	13

[a] More than 10 mm of rainfall in 24 hours prior to sampling.
[b] More than 10 mm of rainfall in 48 hours prior to sampling.
[c] More than 70 mm of rainfall in 3 days prior to sampling.
ns = no sample was collected due to lack of flow.

In order to gain some understanding of where the *E. coli* might be coming from, water samples were collected from each outfall on November 16, 2017 and quantitatively analyzed for human, dog and bird DNA markers. Only dog DNA was detected in the *E. coli* at the Colina outfall, while dog and human DNA was detected in the Tuyll and Delevan outfalls (Table 2). These results are consistent with what would be expected in a residential land use watershed.

Table 2. Results from microbial source tracking at three stormwater outfalls draining into Lake Huron at Bayfield, Ontario on November 16, 2017. Analysis by Source Molecular, Miami, FL.

Stormwater Outfall	DNA Marker Analyzed	DNA Detection in Sample	Concentration of DNA Detected
Colina	Bird	Not detected	Not detected
	Dog	Detected	Low level
	Human	Not detected	Not detected
Tuyll	Bird	Not detected	Not detected
	Dog	Detected	Moderate level
	Human	Detected	Low level
Delevan	Bird	Not detected	Not detected
	Dog	Detected	Low level
	Human	Detected	Low level

On two occasions elevated concentrations were observed during a period without rainfall (*i.e.*, June 5 at Tuyll and Delevan and June 19 at Delevan). (Please refer to the Appendix for precipitation graphs.) This suggests that factors other than rainfall may influence bacteria concentrations at these outfalls.

The geometric mean *E. coli* concentration for Delevan for dry sampling was 35 cfu/100 mL (n=7). Geometric means for Tuyll and Colina were not calculated for dry sampling as there were only two samples collected at Tuyll and none at Colina. Geometric mean *E. coli* concentrations increased to 1122 cfu/100 mL (n=6) at Delevan to 9109 cfu/100 mL (n=3) at Tuyll following rain events (event sampling) (Figure 2). Geometric mean *E. coli* concentrations at all three sites exceeded the provincial water quality guideline following rain events.

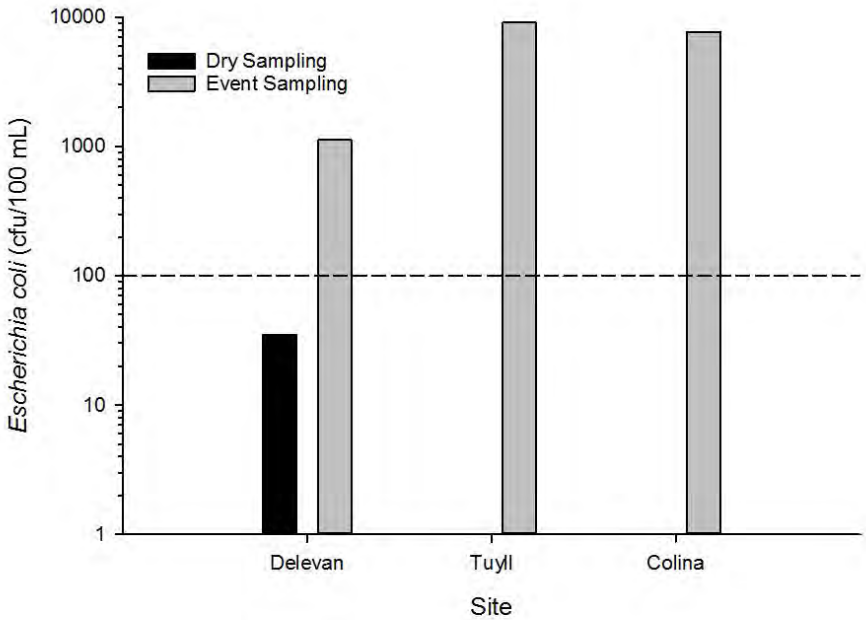

Figure 2. Dry (n=7)* and event (n=6)** sampling geometric mean *Escherichia coli* concentrations in colony forming units per 100 mL at three stormwater monitoring sites draining into Lake Huron along the shoreline of Bayfield, Ontario in 2017. Dashed line indicates Ontario Ministry of Health and Long-term Care guideline of 100 cfu/100 mL. (*dry sampling geometric mean *Escherichia coli* concentrations for Tuyll and Colina were not calculated due to lack of samples; **n=3 for event sampling geometric mean *Escherichia coli* concentrations for both Tuyll and Colina as samples could only be collected on three event sampling dates)

Bacterial contaminants in urban stormwater can originate from both human and animal sources. Since the village of Bayfield has a separate system for sanitary sewers, *E. coli* contamination is more likely a result of stormwater runoff that has come into contact with domestic and/or wild animal waste. Results from the November 16, 2017 stormwater microbial source tracking (Table 2) supports this theory. Pick up and proper disposal of pet waste should be encouraged throughout the village. It is also important the Municipality of Bluewater ensure there are no cross connections or leaks between sanitary sewers or old septic systems and stormwater drainage facilities in the areas drained by the outfalls.

The abundance of fecal bacteria has been strongly linked to the amount of impervious (not allowing water to pass through) surfaces within a watershed (Mallin *et al.* 2000). Protecting and creating green space in existing and new urban development is therefore an essential component of ensuring good water quality at the beach in the village of Bayfield. Low impact development (LID) is an approach to land development that mimics the natural movement of water in order to manage stormwater close to where it falls (CVC 2015). The following LID techniques reduce runoff in urban areas by increasing infiltration (process by which water on the ground surface enters the soil) and slowing water down:

- Naturalized landscapes (trees/shrubs/flowers absorb more rainwater than regular patch of grass)
- Rain barrels
- Rain gardens (shallow depressions that contain soil and plants that promote infiltration and treat pollutants)
- Green roofs (vegetation or roof-top gardens that absorb rainwater)
- Infiltration trenches/soakaways (underground reservoirs that collect and filter rainwater)

- Grass swales (open vegetated channels that slow stormwater, promote infiltration and trap and treat pollutants)
- Permeable pavement (concrete or asphalt that allows water to drain through and infiltrate into soil

Total Phosphorus

Total phosphorus (TP) includes phosphorus that is dissolved in water and insoluble phosphorus that binds to organic and inorganic material in water. In many aquatic systems, phosphorus is the nutrient that limits plant growth. When phosphorus is added to the system, the first response may be increased plant and algae growth. These conditions can result in aesthetic concerns, especially along shorelines and public beaches. Nutrient over-enrichment can result in excess plant growth and algal blooms, which can negatively impact aquatic life and further impede recreational waters. The Government of Ontario established a Provincial Water Quality Objective (PWQO) for TP of 0.030 mg/L to prevent eutrophication (excessive algae and aquatic plant growth, shortened food chains, changes in the aquatic plant and animal communities) (MOEE 1994).

Concentrations of TP ranged from 0.011 mg/L at Tuyll (June 5) to 0.165 mg/L at Tuyll (July 13) (Table 3). The PWQO for TP was exceeded at Delevan for all sampling dates (dry and event), whereas TP concentrations only exceeded the PWQO after rain events at Tuyll and Colina.

The dry sampling geometric mean TP concentration for Delevan was 0.044 mg/L. Geometric means for Tuyll and Colina were not calculated for dry sampling as there were only two samples collected at Tuyll and none at Colina. Event sampling geometric mean concentrations ranged from 0.066 mg/L (n=6) at Delevan to 0.119 mg/L (n=3) at Tuyll (Figure 3). All dry and event sampling geometric mean TP concentrations exceeded the water quality objective.

Table 3. Total phosphorus (TP) and soluble reactive phosphorus (SRP) in mg/L on each sampling day in 2017 for three stormwater monitoring sites draining into Lake Huron along the shoreline of Bayfield, Ontario. Highlighted values denote concentrations that exceed the Provincial Water Quality Objective (PWQO) of 0.030 mg/mL. Shaded columns indicate event sampling dates.

Site	Jun 5	Jun 18[ab]	Jun 19	Jun 23[ab]	Jul 4	Jul 7[ab]	Jul 13[ab]	Jul 17	Jul 31	Aug 4	Aug 14	Aug 23	Aug 28
Colina – TP	ns	ns	ns	0.052	ns	0.118	0.114	ns	ns	ns	ns	ns	ns
Colina – SRP	ns	ns	ns	0.037	ns	0.072	0.012	ns	ns	ns	ns	ns	ns
Tuyll – TP	0.015	ns	ns	0.081	0.017	0.126	0.165	ns	ns	ns	ns	ns	ns
Tuyll – SRP	0.011	ns	ns	0.052	0.012	0.079	0.113	ns	ns	ns	ns	ns	ns
Delevan – TP	0.050	0.042	0.042	0.098	0.045	0.093	0.108	0.054	0.040	0.047	0.044	0.044	0.036
Delevan - SRP	0.046	0.049	0.049	0.058	0.045	0.054	0.065	0.047	0.046	0.047	0.044	0.040	0.041

[a] More than 10 mm of rainfall in 24 hours prior to sampling.
[b] More than 10 mm of rainfall in 48 hours prior to sampling.
[c] More than 70 mm of rainfall in 3 days prior to sampling.
ns = no sample was collected due to lack of flow.

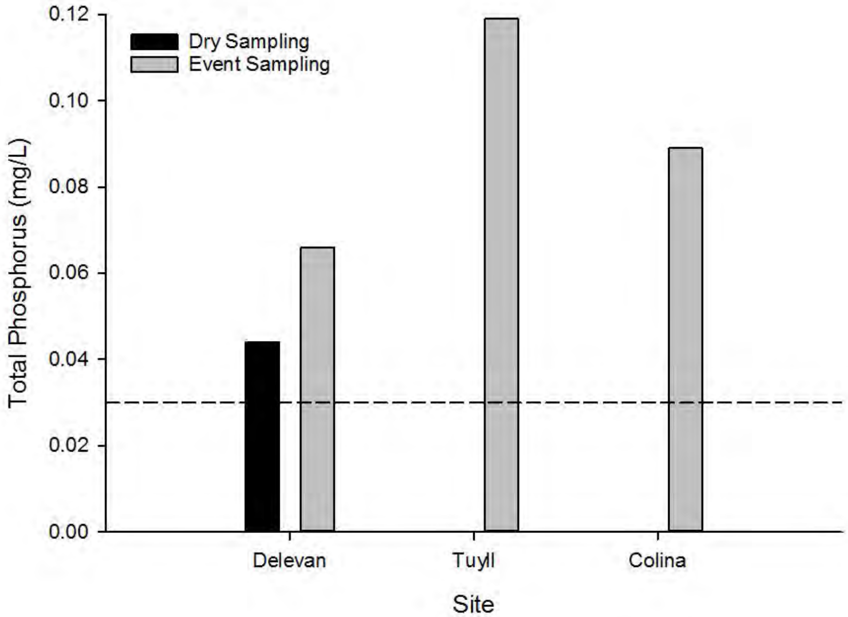

Figure 3. Dry (n=7)* and event (n=6)** sampling geometric mean total phosphorus concentrations in mg/L at three stormwater monitoring sites draining into Lake Huron along the shoreline of Bayfield, Ontario in 2017. Dashed line indicates Provincial Water Quality Objective of 0.030 mg/L. (*dry sampling geometric mean total phosphorus concentrations for Tuyll and Colina were not calculated due to lack of samplse; **n=3 for event sampling geometric mean total phosphorus concentrations for both Tuyll and Colina as samples could only be collected on three event sampling dates).

Soluble Reactive Phosphorus

Soluble reactive phosphorus (SRP), also known as phosphate, is the portion of phosphorus that is readily available to aquatic plants. This fraction of TP can stimulate algal growth and contribute to algal blooms, and the increased loading of SRP has been cited as the main cause of the recent blooms in Lake Erie (IJC 2014).

SRP varied from 0.011 mg/L at Tuyll (June 5) to 0.113 mg/L at Tuyll (July 13) (Table 3). SRP as a percentage of TP was 100 percent at Delevan for dry sampling dates (Figure 4). Following rain events (event sampling) SRP as a percentage of TP ranged from 36 percent at Colina to 78 percent at Delevan. SRP as a percentage of TP was not calculated for Tuyll or Colina for dry sampling events as there were only two samples collected at Tuyll and none at Colina.

These SRP percentages indicate there is potential for eutrophication and algal blooms to occur along the shoreline if other required conditions (*e.g.*, temperature) are also met.

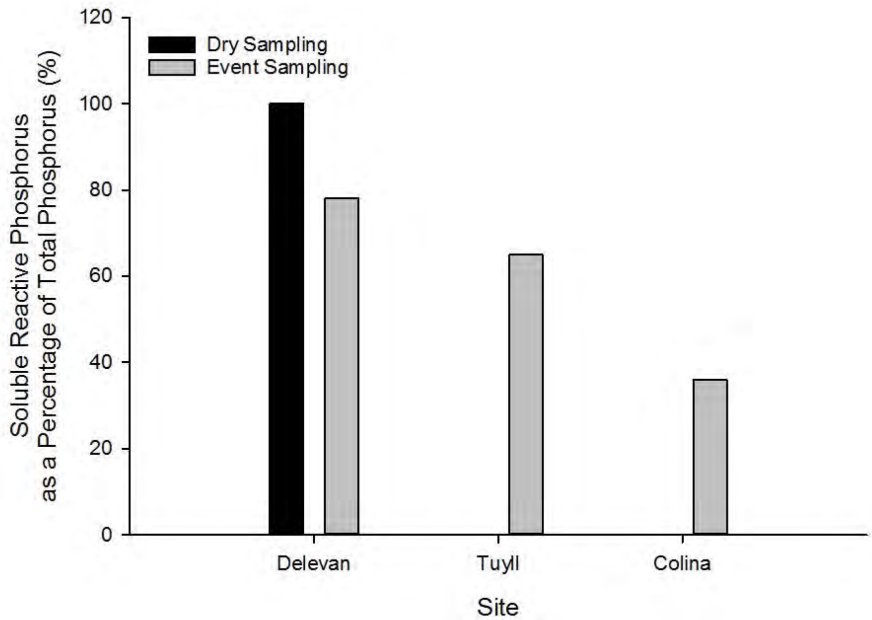

Figure 4. Dry (n=7)* and event (n=6)** sampling soluble reactive phosphorus as a percentage of total phosphorus at three stormwater monitoring sites draining into Lake Huron along the shoreline of Bayfield, Ontario in 2017. (*dry sampling percent soluble reactive phosphorus for Tuyll and Colina were not calculated due to lack of samples; **n=3 for event sampling percent soluble reactive phosphorus for both Tuyll and Colina as samples could only be collected on three event sampling dates).

Non-point sources of phosphorus in urban areas can originate from construction sites, lawn and garden activities, leaves and animal waste (IJC 2014). In order to improve water quality at the beach and prevent algal blooms, the following actions can be taken to reduce phosphorus inputs to stormwater systems:

- Protect and create more naturalized areas
- Establish ground covers or use mulch on bare soil to prevent runoff
- Plant native plants, which require less fertilizer and water
- Install rain barrels
- Install filter strips, grass swales and rain gardens to slow water and increase filtration
- Reduce or eliminate the use of fertilizers containing phosphorus
- Leave lawn clippings and mulch leaves as opposed to piling leaves on the curb sides
- Clean eavestroughs and install gutter guards
- Pick up and properly dispose of pet waste
- Use designated car wash centres to wash vehicles
- Use permeable pavement to increase filtration

Next Steps

1. Continue to monitor water quality, specifically *E. coli*, total phosphorus and soluble reactive phosphorus at the Colina, Tuyll and Delevan stormwater outfall sites.
2. As part of the stormwater master plan for the village of Bayfield, gain a better understanding of the watershed drained by 1) the Tuyll outfall, and 2) the ephemeral channel that emerges on the bank near Colina Street.
3. Continue to engage the local community with information about stormwater management and low impact development technologies (*e.g.*, rain barrels, rain gardens) through outreach activities of the Main Bayfield Watershed Plan.
4. Continue to support community actions such as demonstration rain gardens.
5. Assist the Municipality of Bluewater in implementing low impact development technologies (*e.g.*, permeable pavement, grass swales, rain gardens) for existing infrastructure and proposed developments.

Helpful Links

Low Impact Development
http://www.creditvalleyca.ca/low-impact-development/

Low Impact Development for Existing Development
https://www.lsrca.on.ca/Pages/Retrofitting-Existing-Development.aspx

Low Impact Development Stormwater Management Planning and Design Guide
http://www.creditvalleyca.ca/low-impact-development/low-impact-development-support/stormwater-management-lid-guidance-documents/low-impact-development-stormwater-management-planning-and-design-guide/

Rain Gardens in Bayfield
http://www.abca.on.ca/page.php?page=rain-gardens

Soak it Up! Toolkit
http://www.raincommunitysolutions.ca/en/toolkit/

Stormwater Management
https://trca.ca/conservation/stormwater-management/

Sustainable Stormwater Planning
http://conservationontario.ca/conservation-authorities/planning-and-regulations/sustainable-stormwater-planning/

Acknowledgements

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References

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Appendix

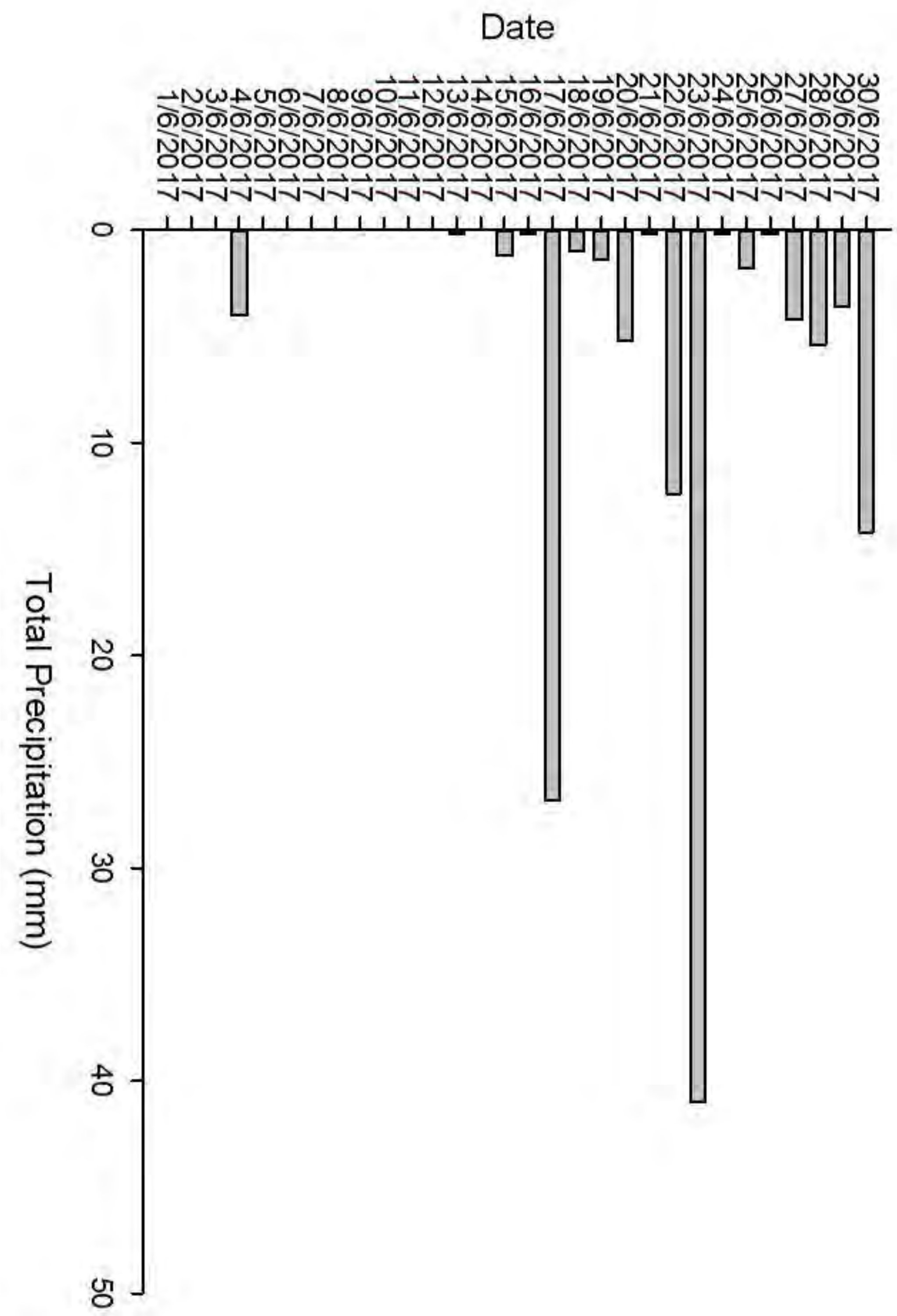

Figure A1. Total daily precipitation at Bayfield, Ontario during June 2017.

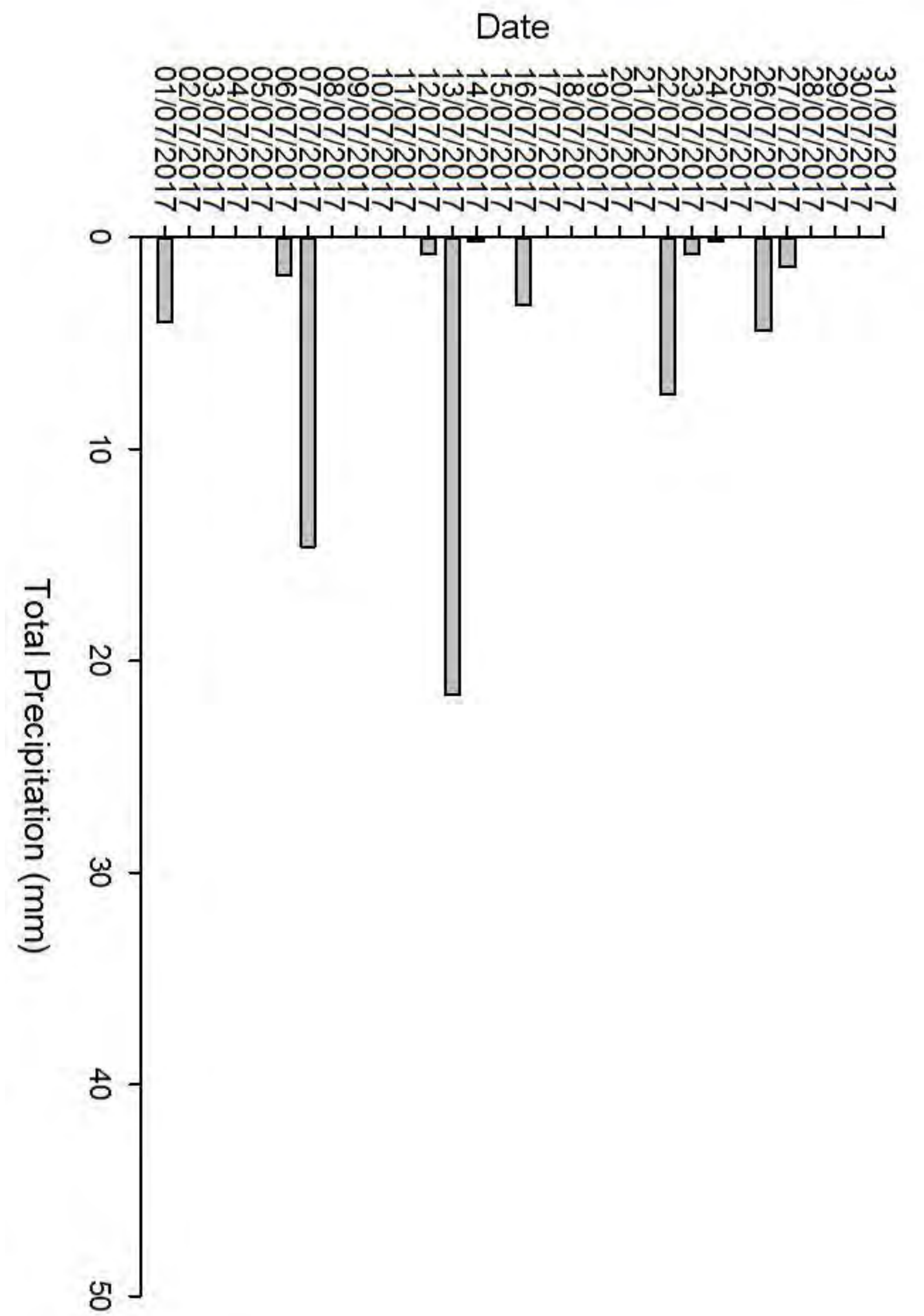

Figure A2. Total daily precipitation at Bayfield, Ontario during July 2017.

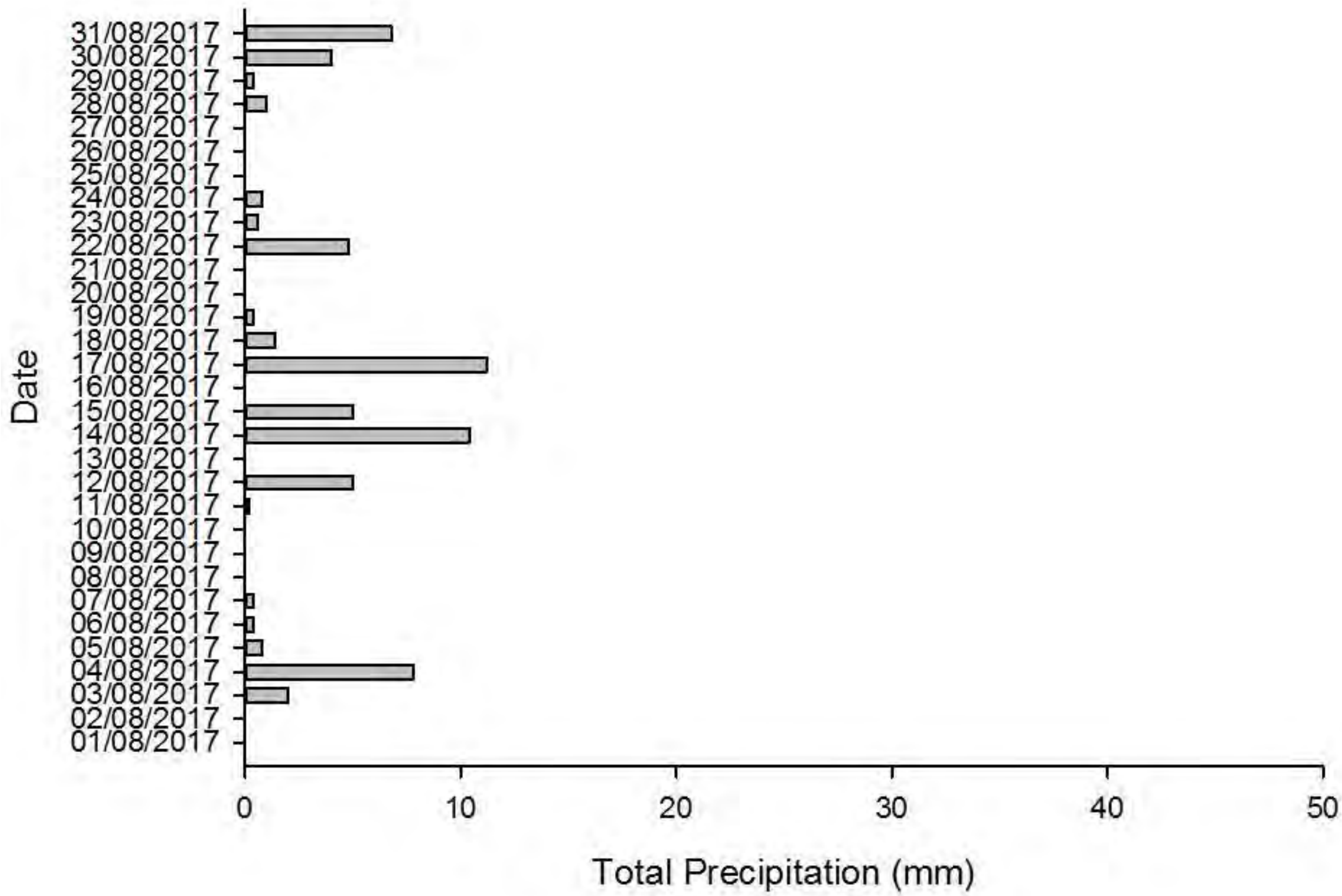

Figure A3. Total daily precipitation at Bayfield, Ontario during August 2017.