2017 Parlee Beach Sand Bacteria and Shallow Groundwater Flow Path Study

Final Report

Prepared for:
Strategic Procurement Division
Service New Brunswick
Suite 2300, 2nd Floor
300 St. Mary's Street
Fredericton, NB E3A 2S4

Prepared by:
Stantec Consulting Ltd.
115 Harrisville Boulevard
Moncton, NB CA E1H 3T3

File: 121812740

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1.0 OVERVIEW

This document presents the Parlee Beach Sand Bacteria and Shallow Groundwater Flow Path Study (hereafter referred to as the Study). The purpose of the Study is to investigate the presence and concentration of faecal indicator bacteria (FIB) in the beach sand, pore water and surface water, and to investigate whether FIB sources are flowing through groundwater into Shediac Bay within the study area (see Figure 1). These overall objectives were addressed through the completion of the following tasks:

1. Review and summarize available background information on nearshore beach and FIB levels, the local hydrogeology, and identify the potential sources of FIB that may interact with groundwater.

2. Conduct a field program to sample beach sand, pore water and surface water at Parlee Beach.

3. Attempt to identify how potential FIB sources may interact with groundwater.

4. Determine local groundwater flow directions between the potential FIB sources identified in Task 3 and Shediac Bay.

5. Investigate additional potential sources of FIB that may be transported to Shediac Bay.

This study is part of the scientific work planned to identify sources of FIB contamination for Parlee Beach (Government of New Brunswick (GNB) 2017).

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Study Area

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Figure 1

2.0 SUMMARY OF BACKGROUND INFORMATION REVIEW

2.1 BEACHES AND FAECAL INDICATOR BACTERIA

Research in the past two decades have identified that nearshore beach environments are potential sources of FIB in lake and coastal environments (e.g., Ishii *et al*. 2007, Halliday and Gast 2011). FIB can live in beach sand, groundwater, and in the surface water in the beach environment. Although *E. coli* is typically the more common FIB that is used to assess microbial quality of freshwater beaches, enterococci bacteria of the large genus *Enterococcus* may be the more representative of FIB contamination at saltwater beaches as they are more resistant to salt water than *E. coli*.

Beach sand is capable of sustaining FIB independent of water, human, or animal inputs in both freshwater and salt water beaches (Davies *et al.* 1995, Whitman and Nevers 2003). The distribution of FIB in sand is highly variable and wet sand enriched with organic substances provides a suitable environment for the survival of FIB. As summarized by Whitman and Nevers (2003), several researchers have found that FIB are often present in higher concentrations in sand and sediment than in the adjacent or overlying water column.

Whitman and Nevers (2003) observed that although *E. coli* is capable of surviving in groundwater, groundwater is only likely to be a source of bacterial contamination to surface water if it is heavily and directly contaminated from some upgradient source. Groundwater protection zones in New Brunswick assume that bacteria and viruses will not survive in groundwater beyond 250 days (NBDENV 2008).

In surface water, FIB have been observed to increase after some high precipitation events (Shah *et al.* 2007, NBOCMOH 2017). This has resulted in the establishment of preventative no swimming advisories following rainfall events at Parlee Beach.

E. coli is more appropriate as the FIB for microbial source tracking (MST) when the flow path originates from freshwater sources, such as through groundwater or surface runoff following precipitation events, to the marine environment. Enterococci is the FIB for MST used primarily in marine environments, but is generally not the preferred FIB for MST in both freshwater and marine environments. Therefore, to provide more interpretive capacity of the bacterial data and comparison between freshwater and marine environments, *E. coli* was preferred as the primary FIB in the Study, and is supplemented with enterococci data.

A review of the *E. coli* and enterococci data collected by GNB from Parlee Beach shows that of the 726 samples collected at the beach in 2017, *E. coli* was detected more frequently than enterococci (NBDELG 2017b). There were 388 samples that detected *E. coli* but did not detect enterococci, but only 25 samples that had detectable enterococci without detectable *E. coli*. This confirms that *E. coli* is a suitable indicator of FIB in this mixed freshwater/marine environment.

2.2 PREVIOUS HYDROGEOLOGICAL STUDIES

The hydrogeological studies of the area that were reviewed for this study include:

- A Municipal Water Supply Wellfield Protection Study for the Town of Shediac, New Brunswick (Washburn & Gillis 1996).
- Hydrogeological Assessment, Pointe-du-Chêne, New Brunswick (Stantec 2010).
- Hydrogeological Atlas of the South-Central Area of the Maritimes Carboniferous Basin (Rivard *et al*. 2005).
- Canadian Groundwater Inventory: Regional hydrogeological characterization of the south-central part of the Maritimes Basin (Rivard *et al*. 2008).

These studies found that regionally, the groundwater flow is through the fractured sandstone aquifer, which is overlain in the Parlee Beach area by blankets and plains of sand and silt with some gravel and clay, generally up to 3 m thick (Rampton 1984). Groundwater recharges in inland areas at a rate of approximately 192 mm/year (Rivard et al. 2008) and flows toward, and ultimately discharges to, Shediac Bay (see Rivard et al (2005) Plate 5-5).

Groundwater quality in the region is generally good, as is indicated by the presence of the municipal wellfield in the Town of Shediac to the southwest of Parlee Beach, and by the review of water quality in the Pointe-du-Chêne area to the south and west of Parlee Beach (Stantec 2010). A review of the New Brunswick online well log database indicated that no *E. coli* was detected in the 55 samples that were recorded for Pointe-du-Chêne, although groundwater use in and upgradient of Pointe-du-Chêne is inducing salt-water intrusion from the bay into the shallow bedrock aquifer in some locations (Stantec 2010).

2.3 POTENTIAL SOURCES OF BACTERIA

In addition to the beach sand and groundwater sources for FIB, the study also included an option to identify potential additional sources of FIB. Given the predominantly residential development in the areas upgradient of Parlee Beach, and the absence of FIB in groundwater collected from this residential area, other bacterial sources of FIB in the area included the following:

- Anecdotal evidence of an emergency sewage overflow to a small pond located between parking lots at Parlee Beach (see location HS-1 on Figure 2A).
- The effluent from the Greater Shediac Sewerage Commission wastewater treatment plant (see location of HS-9, HS-10 and DP-8 on Figure 2B).

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Study Sampling Locations - West

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Figure 2A

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Study Sampling Locations - East

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3.0 METHODS

3.1.1 Field Methods

Field activities were completed on and near Parlee Beach on August 28, August 30, September 1, and October 10, 2017. These activities included collecting samples of sand, pore water, and surface water for bacteria analysis, and efforts to characterize the groundwater flow dynamics of the area. More specific information on the field methods are provided below.

3.1.2 Bacterial Sampling of Beach Sand and Pore Water

Sampling for bacteria in beach sand and the associated pore water (i.e., groundwater migrating through the sand pores) was completed using the "careful excavation" method described by the Restore Group, University of Western Ontario (Vogel *et al*. 2017). Six test pits were excavated at the locations shown on Figure 2A and 2B, using flat shovels that were sterilized with an alcohol rinse between samples to reduce the potential for cross-contamination. All samples were collected near the high tide level on August 30, 2017 and included the careful digging of the unsaturated sand during excavation to an approximate depth of between 0.4 and 0.5 m. Samples were collected from the layer of sand approximately 5 cm above the water table and processed according to Vogel et al. (2017). A sand sample was collected at each location using a plastic spoon rinsed with alcohol prior to sampling. A separate spoon was used for each sampling event. A sterile 60 mL syringe was used at each test pit location to collect samples of the pore water that entered the excavation. All test pits were backfilled following the sampling. The locations of the test pits were recorded using a handheld GPS unit, which are presented provided in Table 1. A typical excavation is illustrated on Figure 3.

Table 1 Beach Sand and Pore Water Test Pit Locations and Parameters Sampled

Test Pit ID	Easting	Northing	Sand Quality Parameters Analyzed	Water Quality Parameters Analyzed
TP-1	2653862	7472984	*Escherichia coli*, DNA markers	*Escherichia coli*
TP-2	2653684	7473032	*Escherichia coli,* enterococci, DNA markers	*Escherichia coli,* Enterococci, DNA markers
TP-3	2653534	7473078	*Escherichia coli*, DNA markers	*Escherichia coli*
TP-4	2653400	7473128	*Escherichia coli*, DNA markers	*Escherichia coli*
TP-5	2653262	7473190	*Escherichia coli,* enterococci, DNA markers	*Escherichia coli,* Enterococci, DNA markers
TP-6	2653119	7473233	*Escherichia coli*, DNA markers	*Escherichia coli*

Notes:
All coordinates in CSRS98 NB Double Stereographic projection

Figure 3 Excavated beach sand and pore water test pit with samples

The sand and pore water samples were held on ice and transported to the RPC Laboratories in Fredericton, New Brunswick for the analysis of FIB including *Escherichia coli* (*E. coli*) and enterococci. *E. coli* analyses were conducted on all samples, supplemented with enterococci analyses in some samples to provide a reasonable basis for comparison of the *E. coli* and enterococci results. The analyses completed on the various samples are provided in Table 1. Laboratory processing was performed within 24 hours of receipt of the samples. *E. coli* analyses were meant to act as the primary indicator of faecal bacteria (see Section 2.1).

To better understand the potential sources of FIB, sand and select pore water samples were also analyzed for host-specific human, ruminant, dog and avian DNA markers by Dalhousie University's Centre for Water Resource Studies (CWRS). The following describes the analytical methods for the DNA sample analyses.

For water samples, volumes ranging from 50 to 300 mL were filtered. Captured cells were harvested by vortexing and centrifugation, and then DNA was extracted from the resuspended pellet (~ 250 µL) using a MoBio PowerSoil DNA extraction kit (VWR, Mississauga, ON, Canada) as per manufacturer's instructions. For sand samples, DNA was directly extracted from 0.25 g of sample using a MoBio PowerSoil DNA extraction kit. Host specific DNA markers for human,

ruminant, dog and avian hosts were quantified using Quantitative Polymerase Chain Reaction (qPCR). Human faeces were targeted using a TaqMan assay focusing on the HF183 cluster of human-specific Bacteroidales (Haugland *et al*. 2010). Ruminant and dog feces were targeted using the Taqman BacR (Reischer *et al*. 2006) primer/probes for ruminants and the BacCan (Kildare *et al*. 2007) primer/probes for dogs. Avian faeces were targeted using the GFD marker and SYBR green qPCR assay (Green *et al*. 2012).

3.1.3 Identification and Bacterial Sampling of Nearshore Surface Water 'Hot Spots'

A total of nine surface water 'hot spot' locations were sampled in both dry (August 30, 2017) and wet (October 10, 2017) conditions and submitted for analysis. For the purposes of this Study, a wet event is characterized as sampling following at least 12.5 mm of rainfall in the previous 24 hours, and a dry event is following as little precipitation as possible. Surface water sampling included three sample locations from potential sources of bacterial contamination (HS-1, HS-9 and HS-10), and six sample locations, spaced evenly across Parlee Beach, in Shediac Bay at the locations shown on Figure 2. Among the Shediac Bay locations, two were sampled at both low and high tide (HS-3H and HS-6H), whereas the remainder were sampled only at or near low tide (HS-2 to HS-8). The selected surface water sampling locations were determined using a handheld GPS unit and are provided in Table 2, with further information regarding the rationale for selecting these locations.

Table 2 Surface Water Hot-Spot Sampling Locations and Parameters Sampled

Sampling Location	Easting	Northing	Location Rationale	Water Quality Sample Analysis by Date	
				August 30, 2017 (Dry Event)	October 10, 2017 (Wet Event)
HS-1	2653522	7472942	Pond at parking lots near outflow pipe that discharges to the pond. Strong sewage odour at time of sampling (Potential Source).	*Escherichia coli*, enterococci, DNA markers	*Escherichia coli*, enterococci, DNA markers
HS-2	2652710	7472948	Downstream of HS-1 at outlet to Shediac Bay.	*Escherichia coli*, enterococci	-
HS-3	2653263	7473270	Parlee Beach at low tide, spaced about every 150 m.	*Escherichia coli*, enterococci	*Escherichia coli*, enterococci
HS-3H	2653264	7473197	Collected at high tide near HS-3.	*Escherichia coli*, enterococci	*Escherichia coli*, enterococci
HS-5	2653542	7473127	Parlee Beach at low tide, spaced about every 150 m.	*Escherichia coli*, enterococci	-
HS-6	2653693	7473073	Parlee Beach at low tide, spaced about every 150 m.	*Escherichia coli*, enterococci	*Escherichia coli*, enterococci

Table 2 Surface Water Hot-Spot Sampling Locations and Parameters Sampled

Sampling Location	Easting	Northing	Location Rationale	Water Quality Sample Analysis by Date	
				August 30, 2017 (Dry Event)	October 10, 2017 (Wet Event)
HS-6H	2653691	7473041	Collected at high tide near HS-6	*Escherichia coli*, enterococci	*Escherichia coli*, enterococci
HS-7	2655262	7472904	Bottom of stairs to beach at end of Cap Brule Road, located between Greater Shediac Sewerage Commission (GSSC) wastewater treatment plant (WWTP) and Parlee Beach	*Escherichia coli*, enterococci	*Escherichia coli*
HS-8	2656082	7472632	Outlet of estuary downstream of GSSC WWTP	*Escherichia coli*, enterococci, DNA markers	*Escherichia coli*, DNA markers
HS-9	2655329	7472109	Drainage ditch along western toe of westernmost lagoon at GSSC WWTP (Potential Source)	*Escherichia coli*, enterococci	*Escherichia coli*
HS-10	2655554	7472162	Main outfall of GSSC WWTP (Potential Source)	*Escherichia coli*,	*Escherichia coli*, enterococci, DNA markers

Notes:
All coordinates in CSRS98 NB Double Stereographic projection
"-" indicates no samples submitted

Surface water 'hot spot' samples were collected in ankle deep water (i.e., about 10-15 cm water depth). The water samples were collected by using laboratory-supplied sterile bottles with the mouth of the water submerged below the water surface to reduce the potential for surface sediments to be drawn into the bottle. The samples were submitted to the RPC Laboratories for the analysis of *E. coli* and enterococci, or the Dalhousie University CWRS laboratory for DNA markers as indicated in Table 2.

3.1.4 Groundwater Flow Dynamics

To determine groundwater levels and flow dynamics at Parlee Beach, seven drive point piezometers (drive points) were installed between August 28 and 30, 2017. The drive points were assembled in the field using a stainless steel drive point tip fitted to a 2.5 cm diameter, 1.8-m long galvanized steel pipe. The drive points were rinsed with isopropyl rubbing alcohol (alcohol) prior to installation in the field to prevent cross-contamination between locations. The drive points were driven into the sand using a 25-lb rebar hammer, to a depth below the expected water table based on the low-tide level. The onshore drive points within Parlee Beach Provincial Park

(DP-1, DP-3, DP4, DP-6 and DP-8) were installed near permanent features, such as signs or beach access ramps, to reduce the potential for damage from the operation of the beach sweeping equipment and as recommended by park staff.

Two of the drive points were installed in the intertidal zone to both establish the groundwater flow direction relative to the bay, and to establish the relationship between the tide level and the groundwater level in the intertidal zone. Manual water level measurements inside the drive points are used to establish the groundwater level (i.e., the pore pressure in the sand), and water level measurements outside the drive points are used to connect the continuous water levels from tide measurements from Fisheries and Oceans Canada (see section 3.2.3) to the elevations established at the drive points.

The geographic location of the drive points was measured with a handheld GPS unit at the time of installation. A more detailed survey, including top of casing elevations, was completed using a survey-grade GPS unit. Two drive points were not included in the detailed survey, DP-2 and DP-8. The drive point at DP-2 was removed by beach visitors prior to the survey, and unsafe conditions at DP-8 due to the presence of a lynx prevented the inclusion in the survey. The survey location details are provided on Table 3, and on Figure 2. The top of casing elevation of DP-2 was estimated using a combination of the manual water level measurements collected, and the Fisheries and Oceans Canada tide levels (see Section 3.2.3).

Table 3 Drive Point Piezometer Installation Details and Water Quality Sample Analyses

Drive Point ID	Easting	Northing	Top of Casing Elevation (m)	Installation Date	Water Quality Sample Analyses
DP-1	2653860.586	7472974.043	1.837	2017-08-28	*Escherichia coli,* Kjeldahl Nitrogen, Nitrate/Nitrite
DP-2	2653872.9	7473004.8	2.294*	2017-08-28	*Escherichia coli*
DP-3	2653607.410	7473034.680	1.920	2017-08-28	*Escherichia coli*
DP-4	2652972.684	7473194.850	1.264	2017-08-28	*Escherichia coli*, Kjeldahl Nitrogen, Nitrate/Nitrite,
DP-5	2652961.672	7473221.613	1.507	2017-08-28	*Escherichia coli,* Enterococci, DNA markers
DP-6	2655703.004	7472741.219	1.886	2017-08-30	*Escherichia coli,* Enterococci, Kjeldahl Nitrogen, Nitrate/Nitrite, DNA markers
DP-8	2655559.153	7472165.130	n/a	2017-08-28	*Escherichia coli*, Kjeldahl Nitrogen, Nitrate/Nitrite

Notes:
All coordinates in CSRS98 NB Double Stereographic projection
n/a = not available

Water level depths were collected at each drive point location using a clean water well tape that was rinsed with alcohol prior to use at each drive point. Several of the drive points (DP-1, DP-3, DP-4, and DP-8) demonstrated slow groundwater inflow into the drive points immediately following the installations. A pressure transducer was inserted into each drive point to measure the water level changes over time. The transducers were rinsed with alcohol prior to insertion into each well. The transducers identification numbers (IDs) are listed on Table 3. An additional transducer to record the barometric pressure was given to the security staff and was placed on a shelf in the security office.

To provide additional pore water data, samples were collected from the drive points using a disposable bailer; following both collection and laboratory methods similar to that described in Section 3.1.2. Attempts to sample the drive points with a peristaltic pump proved unsuccessful due to the generally slow recovery from the wells. The bailers were rinsed with alcohol prior to sampling to reduce the potential for cross-contamination between samples. Pore water samples were collected from the drive points for analysis of *E. coli* and nitrogen parameters (nitrate/nitrite and total Kjeldahl nitrogen), where possible, and enterococci and DNA markers at select locations (see Table 3). Slow groundwater inflow from drive points DP-1, DP-3, DP-4, and DP-8 limited the volume of water that could be extracted from the drive points at these locations. This resulted in insufficient volume to conduct a nitrogen species analysis at these drive points. It was also not possible to collect the full volume required for the *E. coli* analyses at these drive points, resulting in the dilution of the samples by RPC Laboratories to complete their analyses.

3.2 PUBLISHED DATA SOURCES

Data were obtained from provincial and federal sources to assist with interpreting the data collected in association with the study field program. This included tide levels, weather data, bacterial surface water sampling results, and visitor count data for Parlee Beach Provincial Park.

3.2.1 GNB Surface Water Quality at Parlee Beach

Surface water quality data published by the Government of New Brunswick (GNB) for Parlee Beach were obtained from the GNB Website (NBDELG 2017b). The coordinates for the five sampling locations along Parlee Beach were provided by the NB Department of Environment and Local Government (NBDELG; Table 4) with the locations shown on Figure 2. Water quality data (*E. coli* and enterococci concentrations) were also available between May 15 and October 9, 2017.

Table 4 Routine Surface Water Sampling Locations visited by Parlee Beach Park Staff

Location ID	Easting	Northing
GNB1	2653272	7473173
GNB2	2653405	7473130
GNB3	2653534	7473075
GNB4	2653667	7473033
GNB5	2653803	7472998

Notes:
All coordinates in CSRS98 NB Double Stereographic projection

3.2.2 Meteorological Data

Meteorological data (e.g., precipitation, temperature, and wind direction) were obtained from the Environment and Climate Change Canada climate monitoring station at the Moncton Airport (Climate ID 8103201). These data are used to identify the rainfall in the past 24 hours from the site.

3.2.3 Tide Levels

Tide times and heights are reported from the Shediac Bay tidal station (#1805), operated by the Canadian Hydrographic Service. This information was accessed from the Marine Environmental Data Section of Fisheries and Oceans Canada (DFO MEDS 2017).

4.0 RESULTS AND DISCUSSION

4.1 METEOROLOGICAL CONDITIONS

Relevant environmental information including meteorological conditions (e.g., precipitation, temperature, and wind direction) and tidal information were collected at the sampling locations at the time of sampling. The weather conditions on the sampling days are provided in Table 5.

Table 5 Sampling Day Weather Summary

Sampling Date	Minimum Daily Temperature (°C)	Mean Daily Temperature (°C)	Maximum Daily Temperature (°C)	Total Daily Rainfall (mm)	Wind Direction (Degrees)
2017-08-30	8.9	23.3	16.1	0.0	260 (i.e., from west)
2017-09-01	8.0	18.1	13.1	0.8	240 (i.e., from west southwest)
2017-10-10	12.9	21.0	17.0	17.8	300 (i.e., from northwest)

Notes:

1. Weather based on ECCC Moncton International Airport Climate Station

Total daily rain accumulation reported represents the day prior to the sampling date

4.2 TIDE LEVELS

Tide times and heights were obtained from the Shediac Bay tidal monitoring station (DFO MEDS 2017). These data were adjusted to geodetic elevations based on water levels collected on the outside of drive points (see Section 3.1.3), and are presented with water level hydrographs in Section 4.4.

4.3 BEACH SAND BACTERIA AND POTENTIAL SOURCE CONTAMINATION

In total, eight beach sand samples were collected from six sampling locations on August 30, 2017 (Table 6). All beach sand samples were collected from test pits as described in Section 3.1.1. The concentrations of FIB (*E. coli* and enterococci) in all samples were very low (i.e., 4.1 MPN/g or less). Concentrations observed in other studies of FIB contamination in sand indicate that concentrations of FIB for an active source would be in the range of more than 1000 MPN/g (Halliday and Gast 2011, Vogel et al 2017).

Table 6 FIB Concentrations Measured in Sand on Parlee Beach (August 30, 2017 – Dry sampling event)

Sampling Location	Concentration (MPN/g)	
	Escherichia coli	**Enterococci**
TP-1	<1	-
TP-2	<1	<1
TP-3	<1	-
TP-4	<1	-
TP-5	<1	4
TP-6	4.1	-

Host-specific DNA markers were analyzed on August 30, 2017at all six beach sand sampling locations, to better understand the potential sources for bacterial contamination (Figure 4). A direct comparison of the DNA marker counts on Figure 4 to the FIB concentrations in Table 6 is not possible due to the nature of the analyses. FIB results in Table 6 are based on the number of living bacteria that form colonies when the sample is cultured for 24 hours. The results of the DNA marker analyses are based on the detection of DNA from either living or dead cells. The persistence of live culturable colonies could be different that the persistence of DNA. Therefore, direct comparisons would be difficult depending the timing of faecal contamination of the environmental media.

The relative proportion of host-specific DNA observed among the six sites was generally consistent with the patterns expected for typical beach use. No evidence of ruminant or canine sources was observed. Evidence of human faecal sources was found at one sampling location and (TP-2), avian faecal sources was found at three sites (TP-2, TP-5 and TP-6). The overall concentration of DNA detected from all sources was relatively low, which is consistent with the low bacterial levels observed in the sand samples.

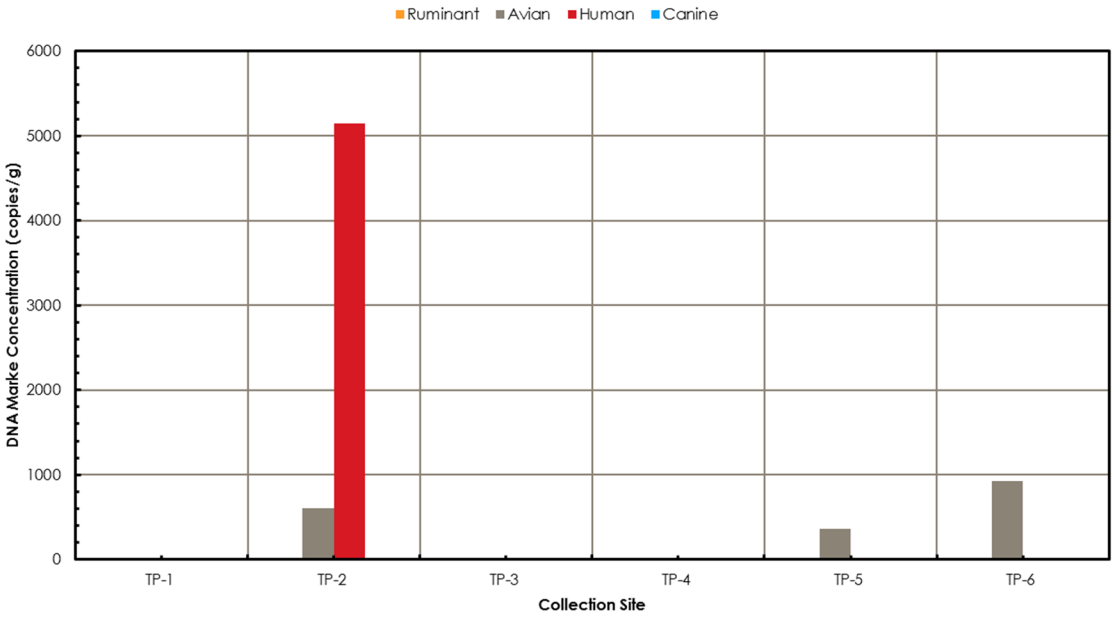

Figure 4 Host-specific Bacterial DNA Concentrations Measured in Sand on Parlee Beach

4.4 GROUNDWATER FLOW DIRECTION

Groundwater flow directions at Parlee Beach were determined using the drive points, based on the observed water levels. The top of casing elevations and manual water level measurements are presented in Table 7, and water level hydrographs from the transducers installed in the drive points are presented in Figures 5 to 10. The corresponding tide level in Shediac Bay from the DFO monitoring station is also presented on the hydrographs for comparison. The DFO tide levels were adjusted to geodetic elevation based on the tide elevations calculated from the depth to tide levels measured outside the drive points at DP-2 and DP-5 (see Table 7).

As shown on the hydrographs, the water levels observed at DP-1, DP-5 and DP-6 mimic the tide levels. The responses at DP-4 and DP-8 show a slow recovery of water levels after the installation of the drive points on August 28, and again following the sampling of the drive points on August 30 and/or September 1. The slow recovery and the lack of tidal effects on the groundwater levels in DP-4 and DP-8 suggest that the sediments at these depths are relatively fine grained.

The response at DP-2 shows a strong barometric efficiency effect, which explains the larger variation in water levels observed than the tide level. The water level response at DP-2 was adjusted to remove the effect of the barometric efficiency response, as shown on Figure 6. The response at DP-5 (Figure 8) is short due to a transducer error after two days in the field. The response at DP-2 was also shortened (Figure 6) as the drive point was removed from the sediments by beach visitors.

Table 7 Drive Point Elevation and Manually Measured Water Level

Location	Date	Depth to water inside casing (m)	Groundwater Elevation (m geodetic)	Depth to water outside casing (m)	Tide Elevation (m geodetic)
DP-1	2017-08-28 14:40	2.049	-0.212	n/a	n/a
	2017-08-30 17:52	1.81	0.027	n/a	n/a
	2017-09-01 8:00	1.615	0.222	n/a	n/a
	2017-10-10 12:15	1.765	0.072	n/a	n/a
DP-2	2017-08-28 14:25	1.555	0.739	2.047	-0.210
	2017-09-01 9:00	1.53	0.764	Dry	n/a
DP-3	2017-08-28 15:15	2.035	-0.115	n/a	n/a
	2017-08-30 11:03	1.735	0.185	n/a	n/a
	2017-09-01 10:00	1.59	0.33	n/a	n/a
DP-4	2017-08-28 16:00	2.03	-0.766	n/a	n/a
	2017-08-30 13:06	1.59	-0.326	n/a	n/a
	2017-09-01 11:00	1.315	-0.051	n/a	n/a
	2017-10-10 10:30	1.345	-0.081	n/a	n/a
DP-5	2017-08-28 16:18	1.563	-0.056	1.27	0.237
	2017-08-30 12:30	1.53	-0.023	Dry	n/a
DP-6	2017-08-30 14:34	1.198	0.688	n/a	n/a
	2017-10-10 16:00	0.655	1.231	n/a	n/a
DP-8	2017-08-28 17:19	2.061	n/a	n/a	n/a
	2017-08-30 15:27	1.57	n/a	n/a	n/a
	2017-10-10 14:20	0.126	n/a	n/a	n/a

Notes:
n/a = not available

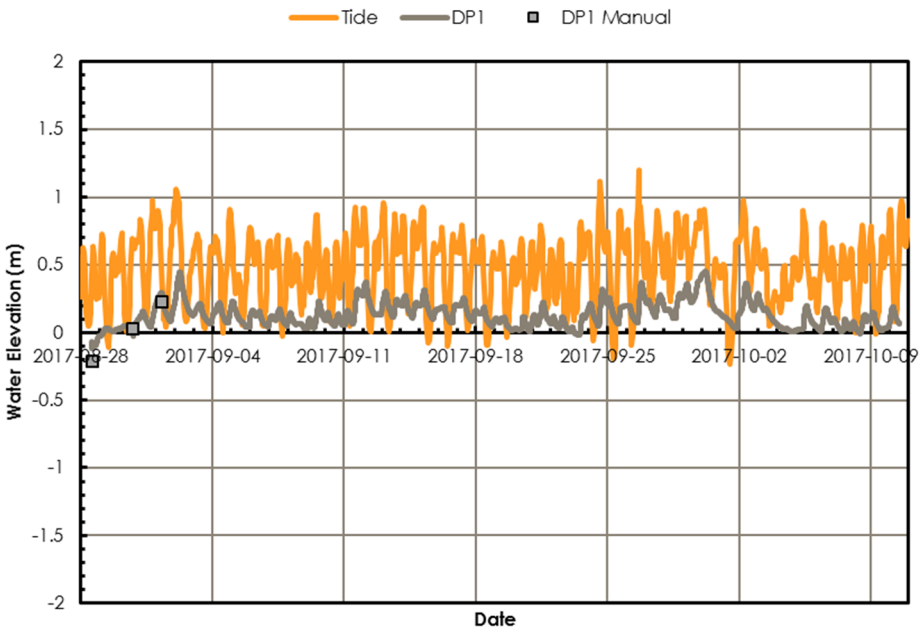

Figure 5 Water level hydrograph at DP-1

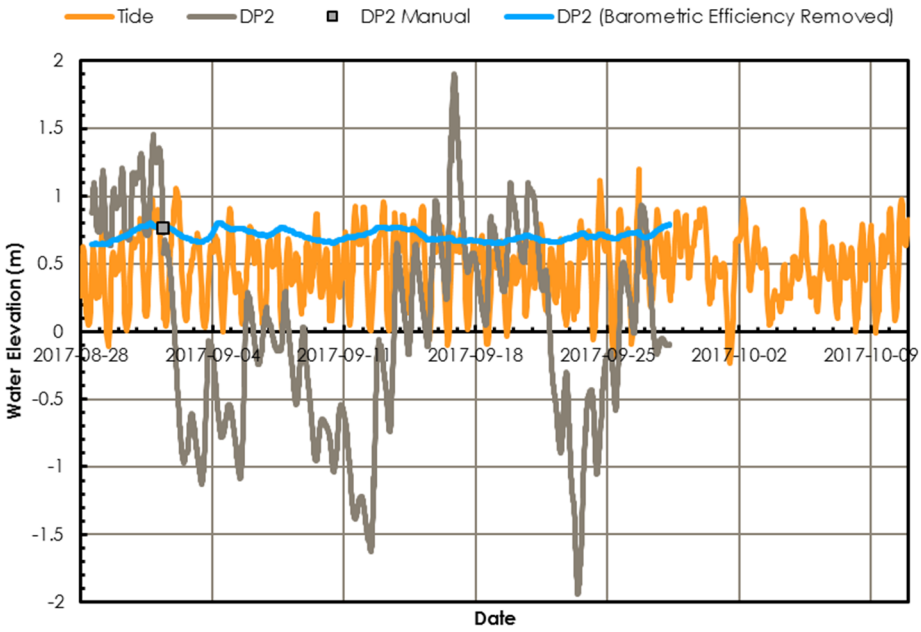

Figure 6 Water level hydrograph at DP-2

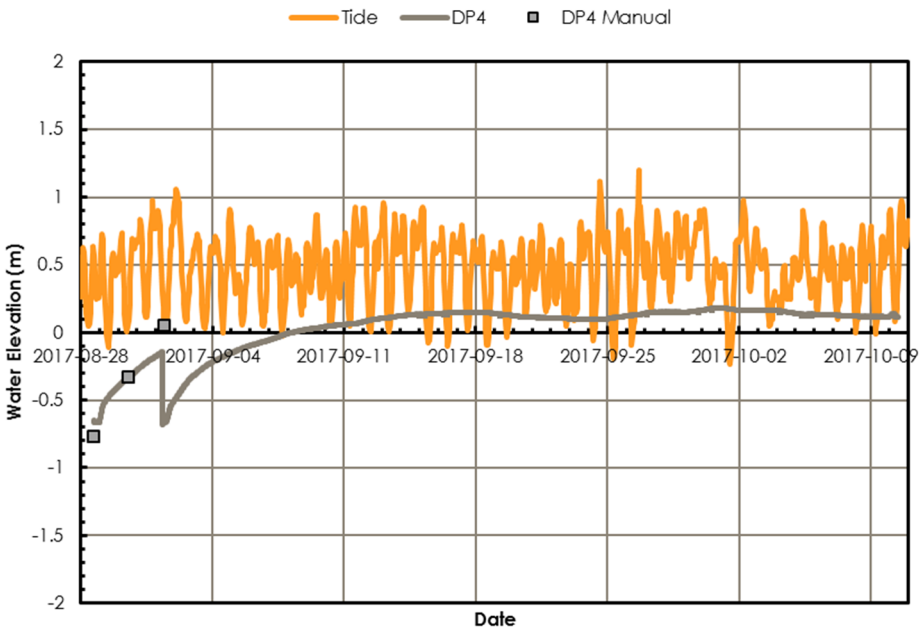

Figure 7 Water level hydrograph at DP-4

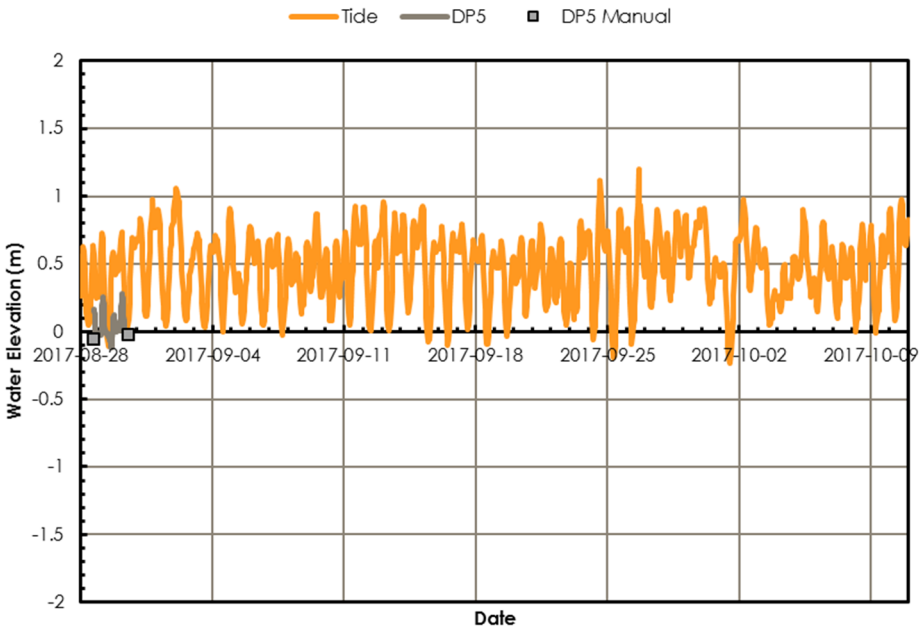

Figure 8 Water level hydrograph at DP-5

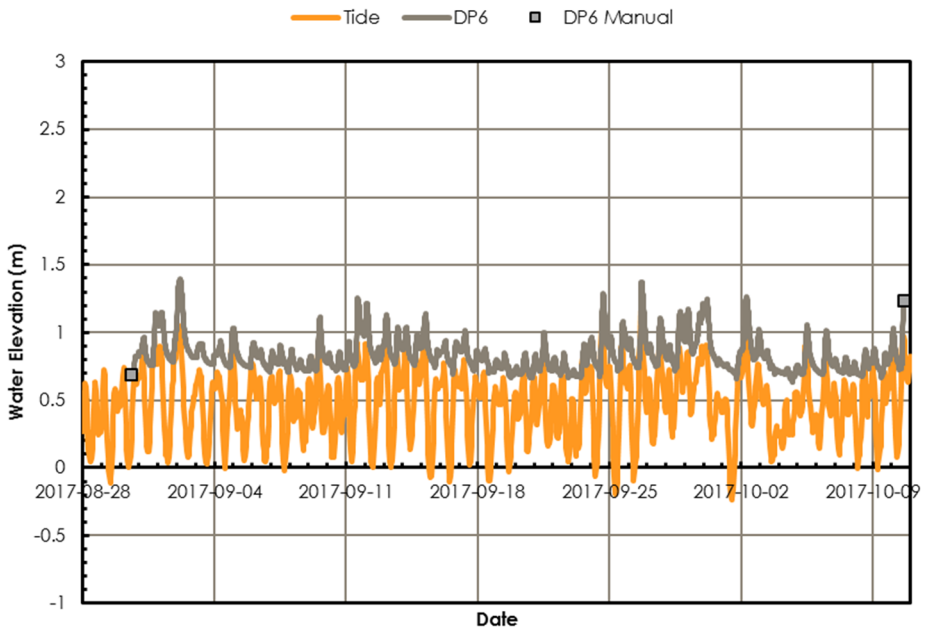

Figure 9 Water level hydrograph at DP-6

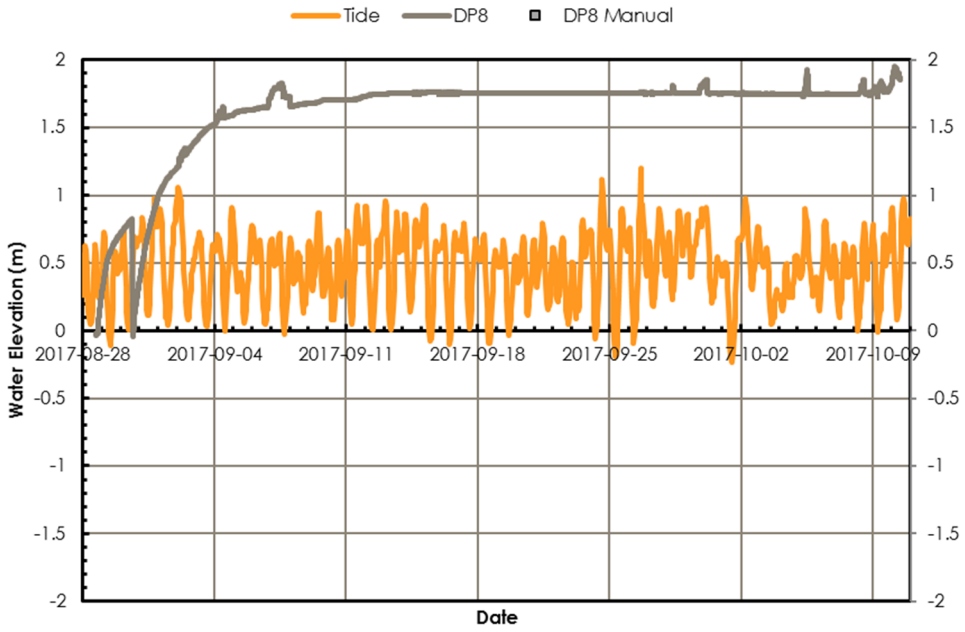

Figure 10 Water level hydrograph at DP-8

Based on the water level responses, the groundwater flow direction at Parlee Beach is confirmed to be from inland to Shediac Bay.

4.5 GROUNDWATER BACTERIA AND NUTRIENTS

Groundwater samples were collected from 13 sampling locations in both dry conditions (August 30, 2017 and September 1, 2017) and wet conditions (October 10, 2017.) Drive points accounted for seven of the sampling locations with the remaining six from test pits. The concentrations of FIB in groundwater are presented on Table 8. As shown on the table, the FIB concentrations in all samples were below the Guidelines for Canadian Recreational Water Quality (GCRWQ; Health Canada 2012).

Table 8 *Escherichia coli* and Enterococci Concentrations Measured in Groundwater on Parlee Beach

Sampling Location	Concentration (MPN/100 mL)			
	Escherichia coli		Enterococci	
	Dry Event	Wet Event	Dry Event	Wet Event
DP-1	<10	0	-	-
DP-2	<10	-	-	-
DP-3	<10	-	-	-
DP-4	<10	0	-	-
DP-5	0	-	<10	-
DP-6	0	0	41	<10
DP-8	<2	0	-	-
TP-1	38	-	-	-
TP-2	44	-	<10	-
TP-3	33	-	-	-
TP-4	38	-	-	-
TP-5	31	-	52	-
TP-6	73	-	-	-

Notes:
"-" indicates no sample collected or submitted
Guidelines for Canadian Recreational Water Quality (Health Canada 2012):

- *E. coli*: ≤ 400 MPN/100 mL
- Enterococci: ≤ 70 MPN100 mL

Nutrient data (i.e., nitrogen species data) in groundwater samples are provided on Table 9. As shown on the table, the concentrations of the nutrients are low for all but the Kjeldahl nitrogen sample collected at DP-8, and do not suggest a large source of nutrients that may be available for bacterial growth. DP-8 is located downgradient of the GSSC WWTP, which is likely influencing the relatively higher concentration at this location.

Only one sample location (DP-6) was sampled on both the wet and dry sampling event. However, one of the two drive points at the paired locations (i.e., DP-1 / DP-2 and DP-4 / DP-5) was sampled on each event, and could be used for comparison. As shown on Table 9, the concentrations for the wet event samples are slightly increased compared to the dry event samples, with the exception of Kjeldahl nitrogen at DP-4/DP-5.

Table 9 Nutrient Concentrations Measured in Groundwater on Parlee Beach

Sampling Location	Concentration (mg/L as N)			
	Nitrate+Nitrite		Kjeldahl Nitrogen	
	Dry Event	Wet Event	Dry Event	Wet Event
DP-1	-	0.95	-	0.8
DP-2	<0.05	-	0.6	-
DP-4	-	0.23	-	1.7
DP-5	<0.5	-	2.6	-
DP-6	<0.5	<0.5	1.4	0.6
DP-8	-	0.25	-	6.3

Notes:
"-" indicates no sample collected or submitted
Guidelines for Canadian Recreational Water Quality (Health Canada 2012):

- *E. coli*: ≤ 400 MPN/100 mL
- Enterococci: ≤ 70 MPN/100 mL

As indicated in Section 4.4, the groundwater flow direction at the beach was observed to be from inland to the bay, therefore drive points DP-1, DP-3, and DP-4 are located upgradient of the test pits. If groundwater was a source of FIB contamination, the FIB concentrations upgradient should be higher than or equal to those observed downgradient (i.e., the concentrations should be higher in the drive point groundwater samples compared to the test pit pore water samples). However, as shown in Table 6, the opposite is observed for the dry event. Although no test pit water samples were collected during the wet sampling event, no FIB were detected in groundwater samples collected from the drive points for the wet sampling event, and therefore the conclusions for the dry event remain valid.

The low FIB concentrations observed in the beach sand from test pit samples for the dry sampling event (Section 0), coupled with the observations on the drive point groundwater samples from both the wet and dry sampling events, suggests that both sand and groundwater are not significant sources of bacterial contamination at Parlee Beach during the period of the sampling period. However, as bacteria populations in sand can be highly transient, it is recommended that additional sampling be conducted to confirm these results.

Host-specific DNA markers in groundwater were measured at two test pit and two drive point sampling locations for the dry sampling event (Figure 11). Evidence of avian faecal sources was found at all locations, with human faecal sources detected at the three sampling locations on Parlee Beach. Canine faecal sources were identified in one sample from Parlee Beach, and a low level ruminant DNA signal was also identified at one location at Parlee Beach. The overall concentration of DNA from all hosts was relatively low, which is consistent with the low bacteria levels observed in the groundwater samples.

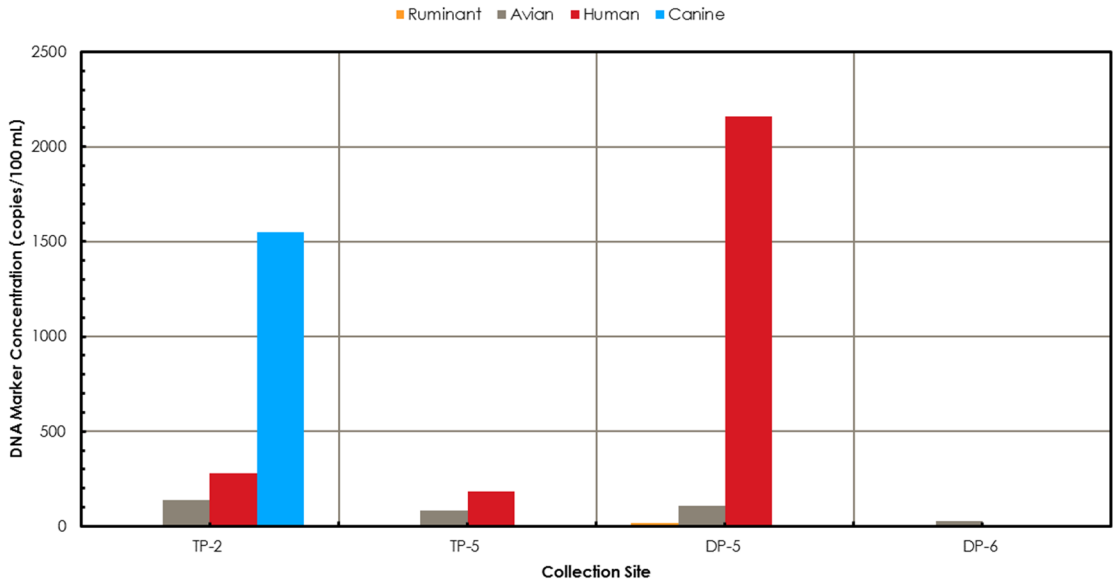

Figure 11 Host-specific Bacterial DNA Concentrations Measured in Groundwater on Parlee Beach for Dry Sampling Event

4.6 SURFACE WATER BACTERIA AND POTENTIAL SOURCE CONTAMINATION

In total, 36 surface water bacteria samples were collected from 11 potential 'hot spot' locations in both dry (August 30, 2017) and wet (October 10, 2017) conditions, as shown in Table 7. The concentrations of both *E. coli* and enterococci were generally greater following a substantial rain event (i.e., the wet event). As shown in Table 7, the single-sample maximum concentration GCRWQ (Health Canada 2012) were exceeded in three samples; all of which were collected under wet conditions (HS-3, *E. coli*; HS1 and HS-9, enterococci).

There was more variation in bacterial concentrations in the surface water 'hot spot' samples than in the groundwater and beach sand samples. Both *E. coli* and enterococci concentrations for the dry sampling event were similar to those collected for groundwater; specifically, in the test pits (Section 0). However, the increase in bacterial concentrations in response to wet conditions was far greater in surface water relative to groundwater. This may reflect the fact that the groundwater sampled under wet conditions came from above upgradient drive point piezometer locations; this appears to confirm the dry sampling event data that indicates that groundwater is not a major source of bacterial contamination on Parlee Beach.

Among the surface water 'hot spot' locations, two were sampled at both low tide and high tide (i.e., HS-3 (low tide)/HS-3H (high tide), HS-6 (low tide)/HS-6H (high tide)) to provide insight into any variability in bacterial concentration that may be associated with inflow from Shediac Bay. Bacterial concentrations were similar between high and low tides, with variation seemingly being influenced more by recent precipitation events than tidal ebb and flow. However, the bacterial concentrations were markedly different between the tidal stages for the wet event and depending on the sampling location (refer to Table 7).

Surface water sample locations HS-8 (downstream outlet), HS-9 (potential source), and HS-10 (potential source) were selected to better understand the influence of effluents from the Greater Shediac Sewage Commission wastewater treatment plant (GSSC WWTP) on bacterial concentrations (Table 7). Based on the *E. coli* concentrations determined at these locations, there is no obvious evidence suggesting the GSSC WWTP is a major source of bacterial contamination. Under dry conditions, *E. coli* concentrations were similar among sites HS-8, HS9, and HS-10. Under wet conditions, the downstream outlet to the estuary (HS-8) had an *E. coli* concentration approaching the GCRWQ; however, neither potential source (i.e., HS-9 and HS-10) can be attributed to the extent of this increase. It should be noted, though, that the HS-9 enterococci concentration for wet conditions was two times above Health Canada's single-sample maximum concentration guideline. This suggests that the GSSC WWTP may potentially overflow through this drainage ditch, resulting in a potential source for bacterial contamination after rainfall events. Thus, although the GSSC WWTP is unlikely to be a major and consistent point source of bacterial contamination in the surface waters off Parlee Beach, it may contribute some bacterial contamination to Shediac Bay under certain conditions.

Host-specific DNA markers were measured at three surface water 'hot spot' locations (HS-1, dry/wet; HS-8, dry/wet; HS-10, wet), to better understand the potential bacterial contamination sources (Figure 12). All three site locations showed evidence of avian and human bacterial sources. However, evidence of ruminant bacterial sources was also found at a pond near the outflow pipe (HS-1), and the main outfall of the GSSC WWTP (HS-10). These ruminant signals were not expected at these locations and may represent bacterial contributions from wild ruminant mammals (e.g., deer or moose).

Table 10 *Escherichia coli* and Enterococci Concentrations Measured in Surface Water 'Hot Spots' on Parlee Beach.

Sampling Location	Concentration (MPN/100 mL)			
	Escherichia coli		Enterococci	
	Dry Event	Wet Event	Dry Event	Wet Event
HS-1	44	84	<10	14136†
HS-2	13	-	10	-
HS-3	1	2575†	10	20
HS-3H	77	327	20	52
HS-5	0	-	<10	-
HS-6	3	65	10	20
HS-6H	2	223	<10	52
HS-7	0	45	<10	-
HS-8	11	377	20	-
HS-9	33	113	-	171†
HS-10	19	16	-	<10

Notes:

"-" indicates not sampled

† indicates results exceeding the Guidelines for Canadian Recreation Water Quality (Health Canada 2012):

- *E. coli*: ≤ 400 MPN/100 Ml
- Enterococci: ≤ 70 MPN/100 mL

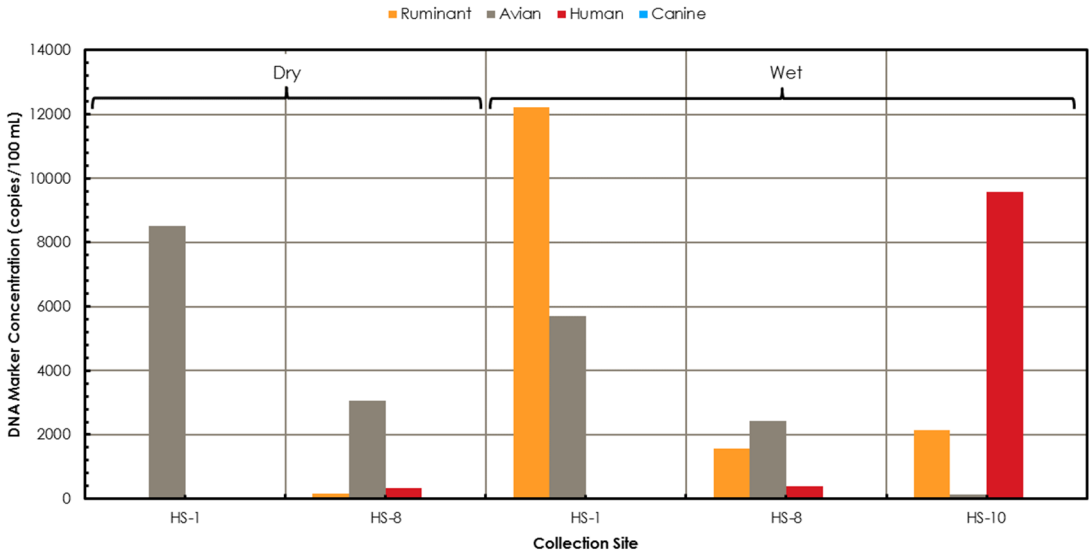

Figure 12 Host-specific Bacterial DNA Concentrations Measured in Surface Water 'Hot Spots' on Parlee Beach.

4.7 GNB SURFACE WATER BACTERIA

The number of days Parlee Beach bacterial concentrations exceeded the GCRWQ are summarized in Table 10. Out of 146 days, bacterial concentrations at Parlee Beach exceeded the guidelines eight times between May 15, 2017 and October 9, 2017. As a precaution, Parlee Beach Provincial Park issued swimming advisories on an additional 14 days in response to rainfall accumulations.

Table 11 Parlee Beach Provincial Park Surface Water Quality Advisory Guidance Between May and October 2017

Beach Status	Number of Days
No Swimming Advisory	124
Swimming Advisory (Rainfall)	14
Swimming Advisory (Bacterial Concentration)	8
Total	**146**

The relationship between daily surface water bacterial concentrations (geometric mean among sampling sites) were related to rainfall (previous 24 hours) and beach visitation traffic. For both rainfall and beach traffic, no apparent trends were observed with either *E. coli* or enterococci concentrations. Runoff from rain accumulation is known to be a major source of bacterial input into waterbodies and is difficult to quantify due to non-point sources of bacteria from surface runoff.

5.0 CONCLUSIONS

Based on the results of the field data collection for this study, the following conclusions are provided:

- Concentrations of faecal indicator bacteria (FIB) and DNA markers indicate that beach sand is not a significant source of FIB to Shediac Bay during the sampling period. Concentrations of FIB observed in the sand are not indicative of a reservoir of bacteria living in the organics attached to the beach sand. The maximum concentration observed at Parlee Beach (4.1 MPN/g) is more than 100 times lower than literature reported concentrations for FIB sources in sand.

- Groundwater flow directions observed at the beach, and concentrations of FIB and DNA markers from drive points and test pits indicate that groundwater is not a significant source of bacteria to Shediac Bay. Low concentrations in the upgradient drive points are lower than those observed in test pits or the Bay.

- Low levels of FIB were observed in samples collected at the effluent outfall of the Greater Shediac Sewage Commission wastewater treatment plant, and in samples collected downgradient of the effluent outfall (HS-8, HS-9, and HS-10). UV treatment of the effluent appears to provide adequate disinfection of the effluent, and concentrations of FIB detected in groundwater samples collected from a drive point located downgradient of the treatment plant (i.e., DP-8) indicate FIB is not being transported by groundwater from the treatment lagoons to Shediac Bay.

It is recommended that additional sampling of surface water be conducted to continue to investigate the potential source or sources of FIB contamination in Shediac Bay, particularly after rainfall events (i.e., wet sampling events).

It is further recommended that additional sampling of bacteria in beach sand and groundwater be conducted to confirm the results of this study, due to the transient nature of bacteria populations in sand. Sampling events at the beginning, middle and end of the beach season are suggested.

It is also recommended that a study of tidal currents future bacterial studies focus on sampling following more intense rainfall events when there is additional runoff to the bay. In addition, currents should be measured in the nearshore environment of Parlee Beach, to identify primary flow directions within the bay and the direction of the source for the potential FIB contamination. This could be facilitated using an acoustic Doppler current profiler to obtain near real-time, three-dimensional current data, flow volume, and the direction of littoral transport and longshore drift along Parlee Beach.

6.0 CLOSURE

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This report has been prepared by Jonathan Keizer, M.Sc.E., P.Eng. and Darek Moreau, PhD, with contributions from Rob Jamieson, PhD, P.Eng. It has been reviewed by Sam Salley, M.Sc., Robert MacLeod, M.Sc., P.Geo., and Rob Jamieson, PhD, P.Eng.

7.0 REFERENCES

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Appendices
January 25, 2018

APPENDIX A
Laboratory Certificates

2017 PARLEE BEACH SAND BACTERIA AND SHALLOW GROUNDWATER FLOW PATH STUDY

Appendices
January 25, 2018

Stantec

File: 121812740

Report ID: 252039-1-ML
Report Date: 12-Oct-17
Date Received: 11-Oct-17

CERTIFICATE OF ANALYSIS

for
Stantec Consulting Ltd
115 Harrisville Boulevard
Moncton, NB E1H 3T3

rpc
921 College Hill Rd
Fredericton NB
Canada E3B 6Z9
Tel: 506.452.1368
Fax: 506.452.1395
www.rpc.ca

Attention: Matthew Kinnie

Project/Job #: 121812740.200.200
Client Location: Shediac, NB

Microbiological Examination of Water

RPC Sample ID:				252039-01
Client Sample ID:				DP-1
Date Sampled:				10-Oct-17
Time Sampled:				12:15:00 PM
Analytes	**Method ID**	**Date Analyzed**	**Units**	
E. coli	FFA01	11-Oct-17	MPN/100mL	0

This report relates only to the sample(s) and information provided to the laboratory.

Tests were performed according to the corresponding Compendium of Analytical Methods, Health Protection Branch and/or AOAC Official Methods.

Cathy Hay
Microbiology Supervisor
Food, Fisheries & Aquaculture

Cornelia Maston
Microbiology Technician
Food, Fisheries & Aquaculture

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CERTIFICATE OF ANALYSIS

for
Stantec Consulting Ltd
115 Harrisville Boulevard
Moncton, NB E1H 3T3

rpc
921 College Hill Rd
Fredericton NB
Canada E3B 6Z9
Tel: 506.452.1368
Fax: 506.452.1395
www.rpc.ca

Attention: Matthew Kinnie

Project/Job #: 121812740.200.200
Client Location: Shediac, NB

Microbiological Examination of Water

RPC Sample ID:				252039-02
Client Sample ID:				DP-4
Date Sampled:				10-Oct-17
Time Sampled:				10:30:00 AM
Analytes	**Method ID**	**Date Analyzed**	**Units**	
E. coli	FFA01	11-Oct-17	MPN/100mL	0

This report relates only to the sample(s) and information provided to the laboratory.

Tests were performed according to the corresponding Compendium of Analytical Methods, Health Protection Branch and/or AOAC Official Methods.

Cathy Hay
Microbiology Supervisor
Food, Fisheries & Aquaculture

Cornelia Maston
Microbiology Technician
Food, Fisheries & Aquaculture

Report ID: 252039-3-ML
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Date Received: 11-Oct-17

CERTIFICATE OF ANALYSIS

for
Stantec Consulting Ltd
115 Harrisville Boulevard
Moncton, NB E1H 3T3

rpc
921 College Hill Rd
Fredericton NB
Canada E3B 6Z9
Tel: 506.452.1368
Fax: 506.452.1395
www.rpc.ca

Attention: Matthew Kinnie

Project/Job #: 121812740.200.200
Client Location: Shediac, NB

Microbiological Examination of Water

RPC Sample ID:				252039-03
Client Sample ID:				DP-6
Date Sampled:				10-Oct-17
Time Sampled:				4:00:00 PM
Analytes	**Method ID**	**Date Analyzed**	**Units**	
Enterococcus	FFA35	11-Oct-17	MPN/100mL	<10
E. coli	FFA01	11-Oct-17	MPN/100mL	0

This report relates only to the sample(s) and information provided to the laboratory.

Tests were performed according to the corresponding Compendium of Analytical Methods, Health Protection Branch and/or AOAC Official Methods.

Cathy Hay
Microbiology Supervisor
Food, Fisheries & Aquaculture

Cornelia Maston
Microbiology Technician
Food, Fisheries & Aquaculture

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CERTIFICATE OF ANALYSIS

for
Stantec Consulting Ltd
115 Harrisville Boulevard
Moncton, NB E1H 3T3

rpc
921 College Hill Rd
Fredericton NB
Canada E3B 6Z9
Tel: 506.452.1368
Fax: 506.452.1395
www.rpc.ca

Attention: Matthew Kinnie

Project/Job #: 121812740.200.200
Client Location: Shediac, NB

Microbiological Examination of Water

RPC Sample ID:				252039-04
Client Sample ID:				DP-8
Date Sampled:				10-Oct-17
Time Sampled:				2:20:00 PM
Analytes	**Method ID**	**Date Analyzed**	**Units**	
E. coli	FFA01	11-Oct-17	MPN/100mL	0

This report relates only to the sample(s) and information provided to the laboratory.

Tests were performed according to the corresponding Compendium of Analytical Methods, Health Protection Branch and/or AOAC Official Methods.

Cathy Hay
Microbiology Supervisor
Food, Fisheries & Aquaculture

Cornelia Maston
Microbiology Technician
Food, Fisheries & Aquaculture

Report ID: 252039-5-ML
Report Date: 12-Oct-17
Date Received: 11-Oct-17

CERTIFICATE OF ANALYSIS

for
Stantec Consulting Ltd
115 Harrisville Boulevard
Moncton, NB E1H 3T3

rpc
921 College Hill Rd
Fredericton NB
Canada E3B 6Z9
Tel: 506.452.1368
Fax: 506.452.1395
www.rpc.ca

Attention: Matthew Kinnie

Project/Job #: 121812740.200.200
Client Location: Shediac, NB

Microbiological Examination of Water

RPC Sample ID:				252039-05
Client Sample ID:				HS-1
Date Sampled:				10-Oct-17
Time Sampled:				11:35:00 AM
Analytes	**Method ID**	**Date Analyzed**	**Units**	
Enterococcus	FFA35	11-Oct-17	MPN/100mL	14,136
E. coli	FFA01	11-Oct-17	MPN/100mL	84

This report relates only to the sample(s) and information provided to the laboratory.

Tests were performed according to the corresponding Compendium of Analytical Methods, Health Protection Branch and/or AOAC Official Methods.

Cathy Hay
Microbiology Supervisor
Food, Fisheries & Aquaculture

Cornelia Maston
Microbiology Technician
Food, Fisheries & Aquaculture

Report ID: 252039-6-ML
Report Date: 12-Oct-17
Date Received: 11-Oct-17

CERTIFICATE OF ANALYSIS

for
Stantec Consulting Ltd
115 Harrisville Boulevard
Moncton, NB E1H 3T3

rpc
921 College Hill Rd
Fredericton NB
Canada E3B 6Z9
Tel: 506.452.1368
Fax: 506.452.1395
www.rpc.ca

Attention: Matthew Kinnie

Project/Job #: 121812740.200.200
Client Location: Shediac, NB

Microbiological Examination of Water

RPC Sample ID:				252039-06
Client Sample ID:				HS-3
Date Sampled:				10-Oct-17
Time Sampled:				10:50:00 AM
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Enterococcus	FFA35	11-Oct-17	MPN/100mL	20
E. coli	FFA01	11-Oct-17	MPN/100mL	2,575

This report relates only to the sample(s) and information provided to the laboratory.

Tests were performed according to the corresponding Compendium of Analytical Methods, Health Protection Branch and/or AOAC Official Methods.

Cathy Hay
Microbiology Supervisor
Food, Fisheries & Aquaculture

Cornelia Maston
Microbiology Technician
Food, Fisheries & Aquaculture

Report ID: 252039-7-ML
Report Date: 12-Oct-17
Date Received: 11-Oct-17

CERTIFICATE OF ANALYSIS

for
Stantec Consulting Ltd
115 Harrisville Boulevard
Moncton, NB E1H 3T3

rpc
921 College Hill Rd
Fredericton NB
Canada E3B 6Z9
Tel: 506.452.1368
Fax: 506.452.1395
www.rpc.ca

Attention: Matthew Kinnie

Project/Job #: 121812740.200.200
Client Location: Shediac, NB

Microbiological Examination of Water

RPC Sample ID:				252039-07
Client Sample ID:				HS-3H
Date Sampled:				10-Oct-17
Time Sampled:				4:40:00 PM
Analytes	**Method ID**	**Date Analyzed**	**Units**	
Enterococcus	FFA35	11-Oct-17	MPN/100mL	52
E. coli	FFA01	11-Oct-17	MPN/100mL	327

This report relates only to the sample(s) and information provided to the laboratory.

Tests were performed according to the corresponding Compendium of Analytical Methods, Health Protection Branch and/or AOAC Official Methods.

Cathy Hay
Microbiology Supervisor
Food, Fisheries & Aquaculture

Cornelia Maston
Microbiology Technician
Food, Fisheries & Aquaculture

Report ID: 252039-8-ML
Report Date: 12-Oct-17
Date Received: 11-Oct-17

CERTIFICATE OF ANALYSIS

for
Stantec Consulting Ltd
115 Harrisville Boulevard
Moncton, NB E1H 3T3

rpc
921 College Hill Rd
Fredericton NB
Canada E3B 6Z9
Tel: 506.452.1368
Fax: 506.452.1395
www.rpc.ca

Attention: Matthew Kinnie

Project/Job #: 121812740.200.200
Client Location: Shediac, NB

Microbiological Examination of Water

RPC Sample ID:				252039-08
Client Sample ID:				HS-6
Date Sampled:				10-Oct-17
Time Sampled:				11:50:00 AM
Analytes	**Method ID**	**Date Analyzed**	**Units**	
Enterococcus	FFA35	11-Oct-17	MPN/100mL	20
E. coli	FFA01	11-Oct-17	MPN/100mL	65

This report relates only to the sample(s) and information provided to the laboratory.

Tests were performed according to the corresponding Compendium of Analytical Methods, Health Protection Branch and/or AOAC Official Methods.

Cathy Hay
Microbiology Supervisor
Food, Fisheries & Aquaculture

Cornelia Maston
Microbiology Technician
Food, Fisheries & Aquaculture

Report ID: 252039-9-ML
Report Date: 12-Oct-17
Date Received: 11-Oct-17

CERTIFICATE OF ANALYSIS

for
Stantec Consulting Ltd
115 Harrisville Boulevard
Moncton, NB E1H 3T3

rpc
921 College Hill Rd
Fredericton NB
Canada E3B 6Z9
Tel: 506.452.1368
Fax: 506.452.1395
www.rpc.ca

Attention: Matthew Kinnie

Project/Job #: 121812740.200.200
Client Location: Shediac, NB

Microbiological Examination of Water

RPC Sample ID:				252039-09
Client Sample ID:				HS-6H
Date Sampled:				10-Oct-17
Time Sampled:				4:25:00 PM
Analytes	**Method ID**	**Date Analyzed**	**Units**	
Enterococcus	FFA35	11-Oct-17	MPN/100mL	52
E. coli	FFA01	11-Oct-17	MPN/100mL	223

This report relates only to the sample(s) and information provided to the laboratory.

Tests were performed according to the corresponding Compendium of Analytical Methods, Health Protection Branch and/or AOAC Official Methods.

Cathy Hay
Microbiology Supervisor
Food, Fisheries & Aquaculture

Cornelia Maston
Microbiology Technician
Food, Fisheries & Aquaculture

Report ID: 252039-10-ML
Report Date: 12-Oct-17
Date Received: 11-Oct-17

CERTIFICATE OF ANALYSIS

for
Stantec Consulting Ltd
115 Harrisville Boulevard
Moncton, NB E1H 3T3

rpc
921 College Hill Rd
Fredericton NB
Canada E3B 6Z9
Tel: 506.452.1368
Fax: 506.452.1395
www.rpc.ca

Attention: Matthew Kinnie

Project/Job #: 121812740.200.200
Client Location: Shediac, NB

Microbiological Examination of Water

RPC Sample ID:				252039-10
Client Sample ID:				HS-7
Date Sampled:				10-Oct-17
Time Sampled:				12:50:00 PM
Analytes	**Method ID**	**Date Analyzed**	**Units**	
E. coli	FFA01	11-Oct-17	MPN/100mL	45

This report relates only to the sample(s) and information provided to the laboratory.

Tests were performed according to the corresponding Compendium of Analytical Methods, Health Protection Branch and/or AOAC Official Methods.

Cathy Hay
Microbiology Supervisor
Food, Fisheries & Aquaculture

Cornelia Maston
Microbiology Technician
Food, Fisheries & Aquaculture

Report ID: 252039-11-ML
Report Date: 12-Oct-17
Date Received: 11-Oct-17

CERTIFICATE OF ANALYSIS

for
Stantec Consulting Ltd
115 Harrisville Boulevard
Moncton, NB E1H 3T3

rpc
921 College Hill Rd
Fredericton NB
Canada E3B 6Z9
Tel: 506.452.1368
Fax: 506.452.1395
www.rpc.ca

Attention: Matthew Kinnie

Project/Job #: 121812740.200.200
Client Location: Shediac, NB

Microbiological Examination of Water

RPC Sample ID:				252039-11
Client Sample ID:				HS-8
Date Sampled:				10-Oct-17
Time Sampled:				1:10:00 PM
Analytes	**Method ID**	**Date Analyzed**	**Units**	
E. coli	FFA01	11-Oct-17	MPN/100mL	377

This report relates only to the sample(s) and information provided to the laboratory.

Tests were performed according to the corresponding Compendium of Analytical Methods, Health Protection Branch and/or AOAC Official Methods.

Cathy Hay
Microbiology Supervisor
Food, Fisheries & Aquaculture

Cornelia Maston
Microbiology Technician
Food, Fisheries & Aquaculture

Report ID: 252039-12-ML
Report Date: 12-Oct-17
Date Received: 11-Oct-17

CERTIFICATE OF ANALYSIS

for
Stantec Consulting Ltd
115 Harrisville Boulevard
Moncton, NB E1H 3T3

rpc
921 College Hill Rd
Fredericton NB
Canada E3B 6Z9
Tel: 506.452.1368
Fax: 506.452.1395
www.rpc.ca

Attention: Matthew Kinnie

Project/Job #: 121812740.200.200
Client Location: Shediac, NB

Microbiological Examination of Water

RPC Sample ID:				252039-12
Client Sample ID:				HS-9
Date Sampled:				10-Oct-17
Time Sampled:				1:30:00 PM
Analytes	**Method ID**	**Date Analyzed**	**Units**	
Enterococcus	FFA35	11-Oct-17	MPN/100mL	171
E. coli	FFA01	11-Oct-17	MPN/100mL	133

This report relates only to the sample(s) and information provided to the laboratory.

Tests were performed according to the corresponding Compendium of Analytical Methods, Health Protection Branch and/or AOAC Official Methods.

Cathy Hay
Microbiology Supervisor
Food, Fisheries & Aquaculture

Cornelia Maston
Microbiology Technician
Food, Fisheries & Aquaculture

Report ID: 252039-13-ML
Report Date: 12-Oct-17
Date Received: 11-Oct-17

CERTIFICATE OF ANALYSIS

for
Stantec Consulting Ltd
115 Harrisville Boulevard
Moncton, NB E1H 3T3

rpc
921 College Hill Rd
Fredericton NB
Canada E3B 6Z9
Tel: 506.452.1368
Fax: 506.452.1395
www.rpc.ca

Attention: Matthew Kinnie

Project/Job #: 121812740.200.200
Client Location: Shediac, NB

Microbiological Examination of Water

RPC Sample ID:				252039-13
Client Sample ID:				HS-10
Date Sampled:				10-Oct-17
Time Sampled:				1:40:00 PM
Analytes	**Method ID**	**Date Analyzed**	**Units**	
Enterococcus	FFA35	11-Oct-17	MPN/100mL	<10
E. coli	FFA01	11-Oct-17	MPN/100mL	16

This report relates only to the sample(s) and information provided to the laboratory.

Tests were performed according to the corresponding Compendium of Analytical Methods, Health Protection Branch and/or AOAC Official Methods.

Cathy Hay
Microbiology Supervisor
Food, Fisheries & Aquaculture

Cornelia Maston
Microbiology Technician
Food, Fisheries & Aquaculture

Report ID: 252039-IAS
Report Date: 20-Oct-17
Date Received: 11-Oct-17

CERTIFICATE OF ANALYSIS

for
Stantec Consulting Ltd
115 Harrisville Boulevard
Moncton, NB E1H 3T3

rpc
921 College Hill Rd
Fredericton NB
Canada E3B 6Z9
Tel: 506.452.1212
Fax: 506.452.0594
www.rpc.ca

Attention: Matthew Kinnie
Project #: 121812740.200.200
Location: Shediac, NB

Analysis of Water

RPC Sample ID:			252039-01	252039-02	252039-03	252039-04
Client Sample ID:			DP-1	DP-4	DP-6	DP-8
Date Sampled:			10-Oct-17	10-Oct-17	10-Oct-17	10-Oct-17
Analytes	**Units**	**RL**				
Kjeldahl Nitrogen	mg/L	0.25	0.8	1.7	0.6	6.3
Nitrate + Nitrite (as N)	mg/L	0.05	0.95	0.23	< 0.5	0.25

This report relates only to the sample(s) and information provided to the laboratory.

RL = Reporting Limit

A. Ross Kean, M.Sc.
Department Head
Inorganic Analytical Chemistry

Peter Crowhurst, B.Sc., C.Chem
Analytical Chemist
Inorganic Analytical Chemistry

Report ID: 252039-IAS
Report Date: 20-Oct-17
Date Received: 11-Oct-17

CERTIFICATE OF ANALYSIS
for
Stantec Consulting Ltd
115 Harrisville Boulevard
Moncton, NB E1H 3T3

rpc
921 College Hill Rd
Fredericton NB
Canada E3B 6Z9
Tel: 506.452.1212
Fax: 506.452.0594
www.rpc.ca

Methods

Analyte	RPC SOP #	Method Reference	Method Principle
Kjeldahl Nitrogen	4.M16	APHA 4500-NORG	Digestion, Phenate Colourimetry
Nitrate + Nitrite (as N)	4.M48	APHA 4500-NO_3 H	Hydrazine Red., Derivitization, Colourimetry

Report/Rapport: 247650-ML-W1
Date: 06-Sep-17
Date Received/Reçu: 31-Aug-17

CERTIFICATE OF ANALYSIS / CERTIFICAT D'ANALYSE

for/pour
Stantec Consulting Ltd
845 Prospect Street
Fredericton, NB E3B 2T7

rpc
921 College Hill Rd
Fredericton NB
Canada E3B 6Z9
Tel: 506.452.1368
Fax: 506.452.1395
www.rpc.ca

Attention: Jonathan Keizer / Matthew Kinnie

Project/Job #: 121812740

Client Location: Parlee Beach

Microbiological Examination of Water/Qualité microbiologique de l'eau potable

RPC Sample ID/No. d'échantillon de RPC:				247650-01	247650-02	247650-03	247650-04
Client Sample ID/ID d'échantillon du client:				DP-5	DP-6	DP-8	TP-1
Date collected/Date du prélèvement				30-Aug-17	30-Aug-17	30-Aug-17	30-Aug-17
Analytes/Paramètre(s)	**Method/Méthode**	**Date Analyzed Date Analysé**	**Units Unités**				
Enterococcus	FFA35	31-Aug-17	MPN/100mL	<10	41	-	-
E. coli	FFA01	31-Aug-17	MPN/100mL	0	0	<2	38

This report relates only to the sample(s) and information provided to the laboratory.

Le présent rapport ne s'applique qu'aux échantillons et à l'information transmis au laboratoire.

Cathy Hay
Microbiology Supervisor
Food, Fisheries & Aquaculture

Gillian Hodges
Microbiology Technician
Food, Fisheries & Aquaculture

Report/Rapport: 247650-ML-W1
Date: 06-Sep-17
Date Received/Reçu: 31-Aug-17

CERTIFICATE OF ANALYSIS / CERTIFICAT D'ANALYSE

for/pour
Stantec Consulting Ltd
845 Prospect Street
Fredericton, NB E3B 2T7

rpc
921 College Hill Rd
Fredericton NB
Canada E3B 6Z9
Tel: 506.452.1368
Fax: 506.452.1395
www.rpc.ca

Attention: Jonathan Keizer / Matthew Kinnie

Project/Job #: 121812740

Client Location: Parlee Beach

Microbiological Examination of Water/Qualité microbiologique de l'eau potable

RPC Sample ID/No. d'échantillon de RPC:				247650-05	247650-06	247650-07	247650-08
Client Sample ID/ID d'échantillon du client:				TP-2	TP-3	TP-4	TP-5
Date collected/Date du prélèvement				30-Aug-17	30-Aug-17	30-Aug-17	30-Aug-17
Analytes/Paramètre(s)	**Method/Méthode**	**Date Analyzed Date Analysé**	**Units Unités**				
Enterococcus	FFA35	31-Aug-17	MPN/100mL	<10	-	-	52
E. coli	FFA01	31-Aug-17	MPN/100mL	44	33	38	31

Report/Rapport: 247650-ML-W1
Date: 06-Sep-17
Date Received/Reçu: 31-Aug-17

CERTIFICATE OF ANALYSIS / CERTIFICAT D'ANALYSE

for/pour
Stantec Consulting Ltd
845 Prospect Street
Fredericton, NB E3B 2T7

rpc
921 College Hill Rd
Fredericton NB
Canada E3B 6Z9
Tel: 506.452.1368
Fax: 506.452.1395
www.rpc.ca

Attention: Jonathan Keizer / Matthew Kinnie

Project/Job #: 121812740

Client Location: Parlee Beach

Microbiological Examination of Water/Qualité microbiologique de l'eau potable

RPC Sample ID/No. d'échantillon de RPC:				247650-09	247650-10	247650-11	247650-12
Client Sample ID/ID d'échantillon du client:				TP-6	HS-1	HS-2	HS-3
Date collected/Date du prélèvement				30-Aug-17	30-Aug-17	30-Aug-17	30-Aug-17
Analytes/Paramètre(s)	**Method/Méthode**	**Date Analyzed Date Analysé**	**Units Unités**				
Enterococcus	FFA35	31-Aug-17	MPN/100mL	-	<10	10	10
E. coli	FFA01	31-Aug-17	MPN/100mL	73	44	13	1

Report/Rapport: 247650-ML-W1
Date: 06-Sep-17
Date Received/Reçu: 31-Aug-17

CERTIFICATE OF ANALYSIS / CERTIFICAT D'ANALYSE

for/pour
Stantec Consulting Ltd
845 Prospect Street
Fredericton, NB E3B 2T7

rpc
921 College Hill Rd
Fredericton NB
Canada E3B 6Z9
Tel: 506.452.1368
Fax: 506.452.1395
www.rpc.ca

Attention: Jonathan Keizer / Matthew Kinnie

Project/Job #: 121812740

Client Location: Parlee Beach

Microbiological Examination of Water/Qualité microbiologique de l'eau potable

RPC Sample ID/No. d'échantillon de RPC:				247650-13	247650-14	247650-15	247650-16
Client Sample ID/ID d'échantillon du client:				HS-5	HS-6	HS-7	HS-8
Date collected/Date du prélèvement				30-Aug-17	30-Aug-17	30-Aug-17	30-Aug-17
Analytes/Paramètre(s)	**Method/Méthode**	**Date Analyzed Date Analysé**	**Units Unités**				
Enterococcus	FFA35	31-Aug-17	MPN/100mL	<10	10	<10	20
E. coli	FFA01	31-Aug-17	MPN/100mL	0	3	0	11

Report/Rapport: 247650-ML-W1
Date: 06-Sep-17
Date Received/Reçu: 31-Aug-17

CERTIFICATE OF ANALYSIS / CERTIFICAT D'ANALYSE

for/pour
Stantec Consulting Ltd
845 Prospect Street
Fredericton, NB E3B 2T7

rpc
921 College Hill Rd
Fredericton NB
Canada E3B 6Z9
Tel: 506.452.1368
Fax: 506.452.1395
www.rpc.ca

Attention: Jonathan Keizer / Matthew Kinnie

Project/Job #: 121812740

Client Location: Parlee Beach

Microbiological Examination of Water/Qualité microbiologique de l'eau potable

RPC Sample ID/No. d'échantillon de RPC:				247650-17	247650-18	247650-19	247650-20
Client Sample ID/ID d'échantillon du client:				HS-9	HS-10	HS-3H	HS-6H
Date collected/Date du prélèvement				30-Aug-17	30-Aug-17	30-Aug-17	30-Aug-17
Analytes/Paramètre(s)	**Method/Méthode**	**Date Analyzed Date Analysé**	**Units Unités**				
Enterococcus	FFA35	31-Aug-17	MPN/100mL	-	-	20	<10
E. coli	FFA01	31-Aug-17	MPN/100mL	33	19	77	2

Report ID: 248067-ML-W1
Report Date: 06-Sep-17
Date Received: 31-Aug-17

CERTIFICATE OF ANALYSIS

for
Stantec Consulting Ltd
845 Prospect Street
Fredericton, NB E3B 2T7

rpc
921 College Hill Rd
Fredericton NB
Canada E3B 6Z9
Tel: 506.452.1368
Fax: 506.452.1395
www.rpc.ca

Attention: Jonathan Keizer / Matthew Kinnie

Project/Job #: 121812740
Client Location: Parlee Beach

Microbiological Examination of Sand

Analytes:			Enterococcus	E. coli
Units:			MPN/g	MPN/g
Method ID:			FFA35	FFA10
Date Analyzed:			31-Aug-17	31-Aug-17
RPC Sample ID	**Client Sample ID**	**Date Sampled**		
248067-1	TP-1	30-Aug-17	-	<1
248067-2	TP-2	30-Aug-17	<1	<1
248067-3	TP-3	30-Aug-17	-	<1
248067-4	TP-4	30-Aug-17	-	<1
248067-5	TP-5	30-Aug-17	4.0	<1
248067-6	TP-6	30-Aug-17	-	4.1

This report relates only to the sample(s) and information provided to the laboratory.
Tests were performed according to the corresponding Compendium of Analytical Methods,
Health Protection Branch and/or AOAC Official Methods.

Cathy Hay
Microbiology Supervisor
Food, Fisheries & Aquaculture

Gillian Hodges
Microbiology Technician
Food, Fisheries & Aquaculture

Report ID: 247650-IAS
Report Date: 08-Sep-17
Date Received: 31-Aug-17

CERTIFICATE OF ANALYSIS

for

Stantec Consulting Ltd
845 Prospect Street
Fredericton, NB E3B 2T7

rpc
921 College Hill Rd
Fredericton NB
Canada E3B 6Z9
Tel: 506.452.1212
Fax: 506.452.0594
www.rpc.ca

Attention: Jonathan Keizer
Project #: 121812740
Location: Parlee Beach

Analysis of Water

RPC Sample ID:			247650-01	247650-02
Client Sample ID:			DP-5	DP-6
Date Sampled:			30-Aug-17	30-Aug-17
Analytes	**Units**	**RL**		
Kjeldahl Nitrogen	mg/L	0.25	2.6	1.4
Nitrate + Nitrite (as N)	mg/L	0.05	< 0.5	< 0.5

This report relates only to the sample(s) and information provided to the laboratory.

RL = Reporting Limit

A. Ross Kean, M.Sc.
Department Head
Inorganic Analytical Chemistry

Peter Crowhurst, B.Sc., C.Chem
Analytical Chemist
Inorganic Analytical Chemistry

Report ID: 247650-IAS
Report Date: 08-Sep-17
Date Received: 31-Aug-17

CERTIFICATE OF ANALYSIS

for
Stantec Consulting Ltd
845 Prospect Street
Fredericton, NB E3B 2T7

rpc
921 College Hill Rd
Fredericton NB
Canada E3B 6Z9
Tel: 506.452.1212
Fax: 506.452.0594
www.rpc.ca

Methods

Analyte	RPC SOP #	Method Reference	Method Principle
Kjeldahl Nitrogen	4.M16	APHA 4500-NORG	Digestion, Phenate Colourimetry
Nitrate + Nitrite (as N)	4.M48	APHA 4500-NO_3 H	Hydrazine Red., Derivitization, Colourimetry

Report/Rapport: 247864-MB
Date: 05-Sep-17
Date Received/Reçu: 01-Sep-17

CERTIFICATE OF ANALYSIS / CERTIFICAT D'ANALYSE

for/pour
Stantec Consulting Ltd
115 Harrisville Boulevard
Moncton, NB E1H 3T3

rpc
150 Lutz St
Moncton NB
Canada E1C 5E9
Tel: 506.855.6472
Fax: 506.855.8294
www.rpc.ca

Attention: Matthew Kinnie

Project/Job #: 121812740.200.200

Location: Shediac, NB

Examination of Water/Examen de l'eau

RPC Sample ID/No. d'échantillon de RPC:				247864-1	247864-2	247864-3	247864-4
Client Sample ID/ID d'échantillon du client:				DP-1	DP-2	DP-3	DP-4
Date collected/Date du prélèvement:				1-Sep-17	1-Sep-17	1-Sep-17	1-Sep-17
Time sampled/Heure du prélèvement:				10:15:00 AM	9:45:00 AM	9:30:00 AM	7:45:00 AM
Analytes/Paramètre(s)	**Method Méthode**	**Date Analyzed Date Analysé**	**Units Unités**				
E. coli	MB04	1-Sep-17	cfu/100mL	< 10	< 10	< 10	< 10

This report relates only to the sample(s) and information provided to the laboratory.

Tests were performed according to the corresponding Compendium of Analytical Methods, Health Protection Branch and/or AOAC Official Methods.

Le présent rapport ne s'applique qu'aux échantillons et à l'information transmis au laboratoire.

Les analyses ont été menées conformément au Compendium de méthodes pour l'analyse correspondant ou aux méthodes officielles de la Direction générale de la protection de la santé ou de l'Association of Official Analytical Chemists (AOAC).

RL/SD = Reporting Limit/Seuil de déclaration cfu/ufc = Colony Forming Units/Unités formant des colonies

Michael Lawlor
Lab Supervisor
Moncton Laboratory/Laboratoire de Moncton

Nadine Godin
Microbiology Technician
Moncton Laboratory/Laboratoire de Moncton

CERTIFICATE OF ANALYSIS / CERTIFICAT D'ANALYSE

for/pour
Stantec Consulting Ltd
115 Harrisville Boulevard
Moncton, NB E1H 3T3

rpc
150 Lutz St
Moncton NB
Canada E1C 5E9
Tel: 506.855.6472
Fax: 506.855.8294
www.rpc.ca

General Report Comments

Elevated Reporting Limit due to dilution.

Report ID: 247864-IAS
Report Date: 11-Sep-17
Date Received: 01-Sep-17

CERTIFICATE OF ANALYSIS

for

Stantec Consulting Ltd
115 Harrisville Boulevard
Moncton, NB E1H 3T3

rpc
921 College Hill Rd
Fredericton NB
Canada E3B 6Z9
Tel: 506.452.1212
Fax: 506.452.0594
www.rpc.ca

Attention: Matthew Kinnie
Project #: 121812740.200.200
Location: Shediac, NB

Analysis of Water

RPC Sample ID:			247864-2
Client Sample ID:			DP-2
Date Sampled:			1-Sep-17
Analytes	**Units**	**RL**	
Kjeldahl Nitrogen	mg/L	0.25	0.6
Nitrate + Nitrite (as N)	mg/L	0.05	< 0.05

This report relates only to the sample(s) and information provided to the laboratory.

RL = Reporting Limit

A. Ross Kean, M.Sc.
Department Head
Inorganic Analytical Chemistry

Peter Crowhurst, B.Sc., C.Chem
Analytical Chemist
Inorganic Analytical Chemistry

Report ID: 247864-IAS
Report Date: 11-Sep-17
Date Received: 01-Sep-17

CERTIFICATE OF ANALYSIS

for
Stantec Consulting Ltd
115 Harrisville Boulevard
Moncton, NB E1H 3T3

rpc
921 College Hill Rd
Fredericton NB
Canada E3B 6Z9
Tel: 506.452.1212
Fax: 506.452.0594
www.rpc.ca

Methods

Analyte	RPC SOP #	Method Reference	Method Principle
Kjeldahl Nitrogen	4.M16	APHA 4500-NORG	Digestion, Phenate Colourimetry
Nitrate + Nitrite (as N)	4.M48	APHA 4500-NO_3 H	Hydrazine Red., Derivitization, Colourimetry