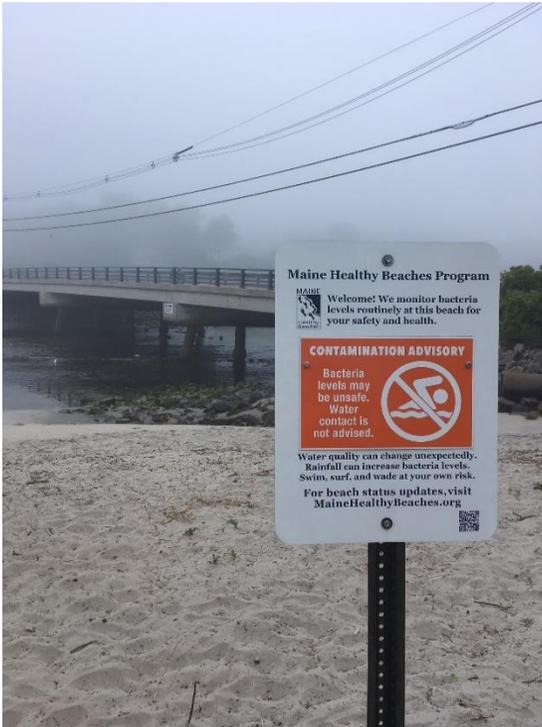


OGUNQUIT RIVER WATERSHED

2019 WATER QUALITY MONITORING AND TARGETED FECAL SOURCE TRACKING REPORT



April 2020

OGUNQUIT
Beautiful Place by the Sea

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2019 REPORT SUMMARY

The Ogunquit River estuary is listed as impaired due to elevated fecal indicator bacteria (Enterococci). The cause of this impairment is largely attributed to sources of nonpoint source pollution (e.g., stormwater runoff, malfunctioning septic systems, leaky sewer lines, etc.) in the watershed. The Town of Ogunquit and its partners have been working to remediate this impairment and monitor any changes in water quality in the estuary and near Riverside Beach.

In 2019, the baseline annual monitoring program was continued throughout the Ogunquit River watershed. These efforts included monitoring seven locations (some previously identified as “hotspots” of fecal contamination) for fecal indicator bacteria from June through October. This monitoring effort yielded several important results that will help direct management actions within the watershed and reduce fecal contamination in the Ogunquit River.

- **Fecal contamination** was evident throughout the watershed, as all sites exceeded the Maine Healthy Beaches water quality threshold for Enterococci, either for single sample or geomean or both. There was a 146% increase in beach swimming advisory days in 2019 at Riverside Beach compared to 2018. **See page 3.**
- In larger **rain events**, elevated fecal indicator bacteria continue to occur at OG-Pipe, a stormwater overflow conveyance from catch basins in the Main Beach parking lot and adjacent roadway to the Ogunquit River at Riverside Beach. The retrofitted catch basins are designed to treat all stormwater runoff from their drainage area (a portion of the parking lot) in rain events up to 1”. Two catch basins in the parking lot are still tied directly to OG-Pipe. Installation of another enhanced dry well and specialized bacteria filter cartridges are planned for the Maine DEP/USEPA 319 Watershed Assistance Grant Phase III project. **See page 6.**
- More data are needed before any potential water quality benefits from the **Lower Lot stormwater retrofit** can be measured at OR-13, the site downstream. The slight increases in annual mean levels of fecal indicator bacteria at OR-13 are also seen at upstream sites and are likely to be driven primarily by seasonal and antecedent weather conditions. OR-13 hit a record high count for fecal indicator bacteria during dry weather in 2019, suggesting that intermittent upstream sources of fecal contamination are still prominent. No obvious sources or known faulty septic systems were noted in the field. **See page 5.**
- **Targeted sampling** revealed that fecal contamination was evident in groundwater along the banks of the unnamed tributary between Littlefield Village and the Great Works Regional Land Trust property. The source was not directly assessed, but proximity to residential and commercial development suggests that septic system malfunction and sewer system leaks may be contributing to the elevated levels observed in nearby surface water. **See page 11.**



The Ogunquit River at sunrise.

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This report was funded by the Town of Ogunquit to maintain the baseline water quality monitoring program in order to protect public health and support ongoing 319 Grant work.

Cover photos: top left– Maine Healthy Beaches advisory sign, Riverside Beach; top right- view of Leavitt Stream outlet; bottom left- OG-Pipe viewed from Ogunquit River; bottom right- view along the unnamed tributary north of Littlefield Village.



OG-Seep photographed on September 29, 2019 showing beach erosion downstream of OG-Pipe and OG-04.

BACKGROUND

The Ogunquit River estuary (Class SB) is listed in the Maine Department of Environmental Protection (Maine DEP)’s 2016 Integrated Water Quality Monitoring and Assessment Report (Maine DEP, 2016) as impaired under Category 5-B-1: Estuarine and Marine Waters Impaired for Bacteria Only (fecal pollutants) – TMDL Required. The cause of this impairment is largely attributed to sources of nonpoint source pollution (e.g., stormwater runoff, malfunctioning septic systems, leaky sewer lines, etc.) in the watershed. Thus, the Ogunquit River is also listed on the Maine DEP Nonpoint Source Priority Watersheds List of Impaired Marine Waters and Threatened Streams.

Investigative and monitoring work over the last twenty years has been conducted in the Ogunquit River watershed and at the beaches by many different groups, including Maine Healthy Beaches, the Maine DEP, the Ogunquit Sewer District, the Ogunquit Conservation Commission, and FB Environmental Associates (FBE). Elevated fecal indicator bacteria (*Enterococci*) levels have been found throughout the watershed and at the beaches, with particularly high counts or “hotspots” found along Leavitt Stream, a tributary to the Ogunquit River (FBE, 2012, 2013, 2014, 2015, 2017, 2018, 2019). High fecal indicator bacteria counts have led to frequent contamination advisories at local beaches. In 2019 there were three separate contamination advisories spanning 15 days at Riverside Beach.

To minimize beach advisories and remediate impairments to the river, the Town of Ogunquit has collaborated with these groups to support an annual monitoring program. The goals of this monitoring program are to:

- 1) **Help identify and bracket sources of high fecal indicator bacteria levels in the Ogunquit River watershed.**
- 2) **Maintain a baseline of fecal indicator bacteria data for hotspot sites to assess trajectory of changes because of remediation efforts.**

In 2019, the Town of Ogunquit, the Ogunquit Conservation Commission, and FBE worked to maintain the annual watershed monitoring program for tracking success of remediation work funded through a Maine DEP/US Environmental Protection Agency (USEPA) Section 319 Watershed Assistance Grant for Phase I and II (following the approved QAPP for 2016-17 monitoring work; FBE, 2016). The town was awarded another Section 319 Watershed Assistance Grant for Phase III remediation work in the watershed (scheduled to be carried out beginning in 2020). The following report summarizes results from the 2019 monitoring program.

Enterococci bacteria are present in the intestinal tracts of warm-blooded animals and are used to indicate the presence of fecal contamination in waterbodies. Each gram of human feces contains approximately 12 billion bacteria, many associated with human health issues. Wastes from other warm-blooded animals, including pets, farm animals, and wildlife may also contribute bacteria and associated disease vectors to waterbodies. High concentrations of fecal indicator bacteria in waterbodies can lead to posted advisories at swimming beaches and closure of shellfish beds. These bacteria are used to signal human health risks, such as gastrointestinal, respiratory, eye, ear, nose, throat, and skin infections transmissible to humans through the consumption of contaminated fish and shellfish, skin contact, and/or ingestion of water.



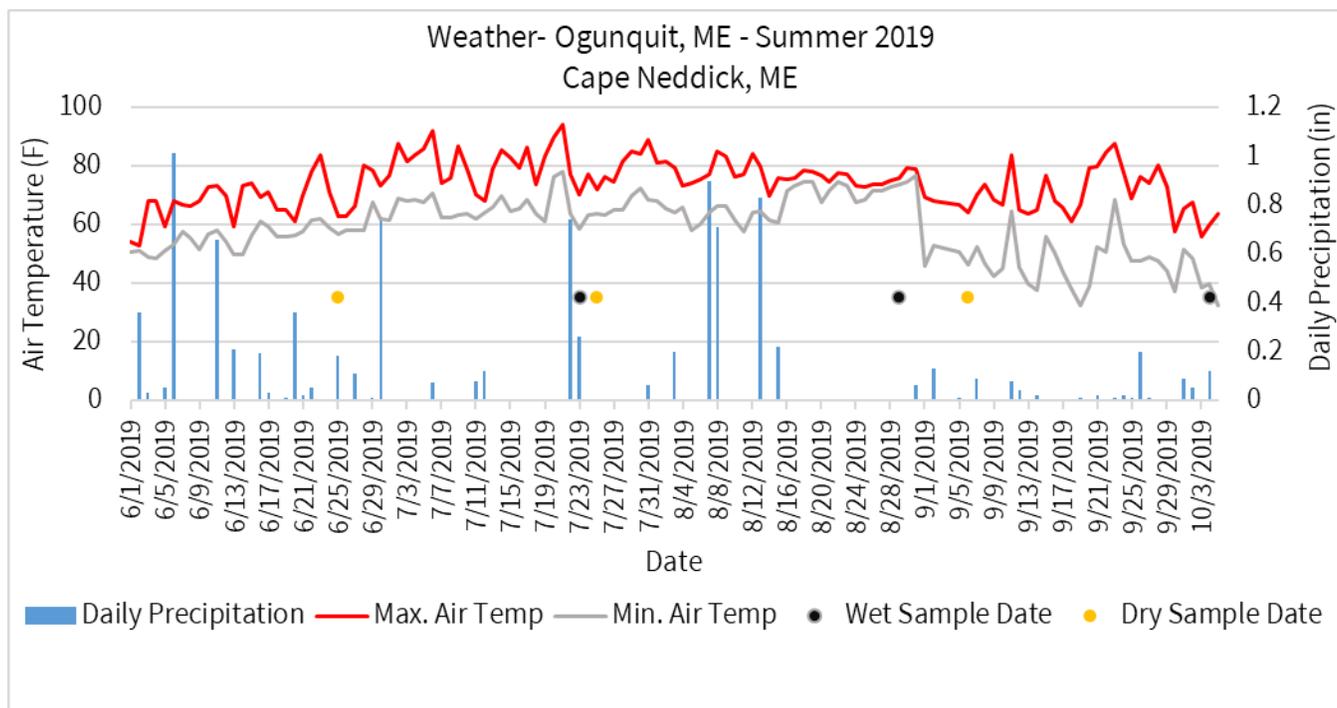
The Ogunquit River watershed spans 13,267 acres across four Maine towns: Wells, Ogunquit, South Berwick, and York.

ANNUAL BASELINE WATER QUALITY MONITORING

METHODS

FBE conducted sampling at six sites throughout the Ogunquit River watershed on six dates (three wet and three dry weather events¹) from June through October 2019 (Figure 1). Sample sites were selected from priority “hotspot” sites identified by 2012-2018 water quality sampling and canine detection efforts (FBE, 2012, 2013, 2014, 2015, 2017, 2018, 2019). A seventh site (OG-Pipe) draining stormwater from the Main Beach parking lot was also sampled whenever flow was present (sampled once on 7/23/2019). Two additional sites on the west bank across from OG-4 (OG-4-West-Up and OG-4-West-Down) were sampled a total of three times each (7/23/2019, 8/6/2019, 10/4/2019). All sampling of tidal sites (OG-04, OG-4-West-Up, OG-4-West-Down, OG-Pipe, OR-06, OR-13, and OR-18) occurred within ± 2 hours of low tide. All fecal indicator bacteria samples were analyzed for Enterococci bacteria using the Enterolert method² at Nelson Analytical Laboratory in Kennebunk, Maine. Temperature, dissolved oxygen, salinity, specific conductivity, and pH data were also collected at each site using a YSI 85 meter, YSI 30 meter, YSI 550A meter, and ExStik® II pH meter. Data collection was conducted in accordance with methods outlined in the 2016-17 QAPP (FBE, 2016). A more detailed discussion of any QAPP deviations is discussed in Appendix B.

Enterococci are used as an indicator of the presence of fecal material in brackish/marine waters by Maine Healthy Beaches, which applies USEPA water quality threshold of 104 mpn/100mL for a single sample maximum (a.k.a., the “instantaneous” threshold) and 35 mpn/100mL for the geometric mean of multiple samples³. Though the Ogunquit River is freshwater west of Route 1, the brackish/marine water quality threshold were used for both freshwater and brackish/marine sites to assess the impact of the Ogunquit River on beach advisories in Ogunquit.



¹ See Maine Healthy Beaches 2016. Conditions were considered “wet” if nearby weather stations recorded any of the following: >0.1” of precipitation in the prior 24 hours; or >0.25” in the prior 48 hours; or >2.0” in the prior 96 hours. Larger precipitation events were sampled when possible. Dry weather conditions were defined as periods when precipitation was less than 0.1” for each day within 72 hours.

² ASTM D6503-19, Standard Test Method for Enterococci in Water Using Enterolert, ASTM International, West Conshohocken, PA, 2019, www.astm.org.

³ mpn = most probable number of viable organisms

FIGURE 1. Daily high and low air temperature (red and gray lines, respectively) and precipitation data (blue bars) from June – October 2019 with wet and dry weather sample dates indicated by black and yellow points, respectively. Data were retrieved from wunderground.com, CAPE NEDDICK, ME US (Station: KMECAPEN2), data gaps filled in from the Middle Ogunquit River, ME US (Station: KMEYORK8).

RESULTS

Fecal contamination was evident throughout the watershed, as all sites exceeded the Maine Healthy Beaches water quality threshold, whether for geomean or single sample or both (Table 1, Figures 2-4, see Appendix A, Table A1 for full results).

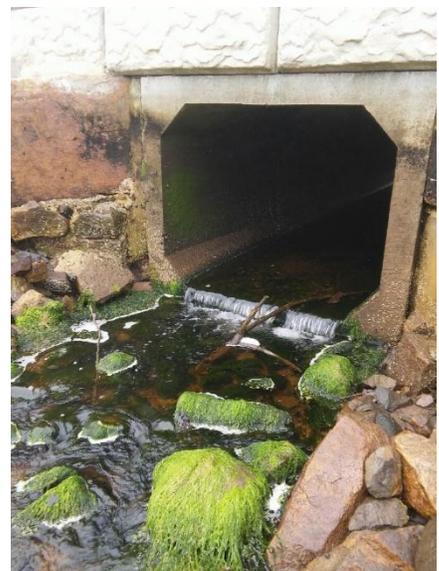
Two sites (**OR-15-1** and **OG-04**) had dry weather geometric means of fecal indicator bacteria counts that met the Maine Healthy Beaches threshold of 35 mpn/100mL. However, wet weather and all-weather geomeans exceeded the threshold, suggesting that fecal sources from surface runoff dominate.

Site **OR-18** in 2019 showed elevated fecal indicator bacteria counts during both wet and dry weather. In previous years, bracketed sampling of the unnamed tributary flowing between OR-18 (downstream) and OR-18-1 (upstream near Route 1) suggested that fecal contamination to **OR-18** is sourced from the adjacent land (Littlefield Village or the Great Works Regional Land Trust) or from incoming estuarine waters. A groundwater investigation was conducted on 8/29/2019 to identify the potential sources of fecal bacteria to **OR-18** (see section: Targeted Fecal Source Tracking).

Fecal indicator bacteria generally increased from upstream to downstream along the Leavitt Stream. The most upstream site along Leavitt Stream sampled in 2019, **OR-15-1**, did not exceed the geometric mean threshold during dry weather, and only slightly exceeded the threshold for the all-weather geometric mean. **OR-Theatre** and the further downstream **OR-13** (both downstream of OR-15-1) had elevated geometric means of fecal indicator bacteria during both dry and wet weather. **OR-Theatre** exceeded the instantaneous threshold in 5 out of 6 samples collected. Previous monitoring showed that fecal sources to these areas are a combination of wildlife, human, and dog waste (FBE, 2013). The neighborhoods surrounding the Leavitt Stream west of Route 1 are largely serviced by private septic systems. As part of the Maine DEP/USEPA 319 Watershed Assistance Grant Phase I project, two bioretention systems were installed in the regraded Lower Lot parking lot in early 2016 (prior to the 2016 sample season). Fecal indicator bacteria at **OR-13** were below the instantaneous threshold during each of the dry weather samplings, but above the threshold during wet weather (including the record high of 13,000 mpn/100mL on 8/29/2019, over twice as high as the next highest record of 6,130 mpn/100mL at OG-04 on the same day). The annual geomean at **OR-13** (downstream of the parking lot) has shown slight increases each year from 2016-2019 (Figure 4), and the same trend is seen at OR-Theatre. It is worth noting that 2016 was dryer than subsequent years and wet years typically see elevated bacteria counts. Notable amounts of algae and aquatic plants covered the rocks at OR-13 throughout the season once again, indicating the possibility of nutrient enrichment.

DID YOU KNOW?

High fecal indicator bacteria during dry weather indicate that fecal contamination is likely derived from groundwater sources (e.g., malfunctioning septic systems or leaky sewer pipes). High fecal indicator bacteria during wet weather indicate that fecal contamination is likely derived from stormwater (e.g., dog or wildlife waste picked up in runoff); however, large storm events can also raise the water table to intercept malfunctioning septic systems and flush out pollutants from leach fields.



At OR-13, a thick mat of aquatic vegetation persisted throughout the season.

Upon request from the Town of Ogunquit, sites **OG-04-West-Up** and **OG-04-West-Down** were added to the sampling procedure on 7/23/2019 following a spill from a small commercial sewer line at 22 Beach Street. On 7/23/2019 during wet weather, fecal indicator bacteria concentrations exceeded the instantaneous threshold at 2,382 mpn/100mL (OG-04-West-Up) and 4,884 mpn/100mL (OG-04-West-Down). However, fecal indicator bacteria concentrations were also elevated on that day just upstream on the eastern shore of the Ogunquit River at sites **OG-04** (3,784 mpn/100mL) and **OG-Pipe** (5,172 mpn/100mL), thus not explicitly detecting a breach in the sewer line entering the Ogunquit River near 22 Beach Street. These two sites (OG-04-West-Up and OG-04-West-Down) were revisited for further sampling on 9/6/2019 and 10/4/2019 and did not have elevated concentrations of fecal indicator bacteria in either of the grab samples collected.

One site (**OG-Pipe**) draining a catch basin from the Main Beach parking lot and a roadway storm water grate showed elevated fecal indicator bacteria counts during wet weather on 7/23/2019. As part of the Maine DEP/USEPA 319 Watershed Assistance Grant Phase II project, an enhanced dry well and specialized bacteria filter cartridges were installed in two catch basins at the lower end of the parking lot in early 2018 (prior to the 2018 sample season); The retrofitted catch basins are designed to treat all stormwater runoff from their drainage area (a portion of the parking lot) in rain events up to 1", so the high fecal indicator bacteria counts measured at the outfall (OG-Pipe) in 2018 (n=1) and 2019 (n=1) are likely the result of larger storms or of pollutants picked up in the stormwater runoff from the roadway. Installation of another enhanced dry well and specialized bacteria filter cartridges are planned for the upcoming Maine DEP/USEPA 319 Watershed Assistance Grant Phase III project.

Seasonal water temperatures ranged from 10.5°C (OR-Theatre, heavily shaded site) to 25.6°C (OR-18, open tidal channel) with an average of 16.7°C for all sites (Appendix A, Table A2). Two regularly sampled sites (**OR-15-1** and **OR-06**) experienced persistent low dissolved oxygen, likely due to low flow conditions. Other sites periodically experienced low dissolved oxygen over the course of the sampling season. Salinity and specific conductivity were tightly correlated, indicating that specific conductivity was largely driven by saline, tidal waters (and not excess ionic nutrients from human activities).

Contamination advisories and beach closures occurred at the Ogunquit Riverside Beach (near **OG-04**) throughout the summer of 2019. The Maine Healthy Beaches Program placed a contamination advisory sign alerting the public that bacteria levels in the water may be unsafe and contact is not advised from 6/5-12/2019, 6/19-20/2019, 7/3-5/2019, and 7/24-26/2019. A rainfall advisory was posted from 6/12-17/2019, 6/26-7/2/2019, and on 7/23/2019. A beach closure was issued from 6/24-25/2019. On 6/20/2019 a Contamination Advisory sign was posted at the end of the walkway down from the Main Beach parking lot to Riverside Beach. Riverside Beach had an active contamination or rainfall advisory for 29 days and an active closure for two days. In total, recreation at Riverside Beach was not advised or allowed on 31 days, or roughly one third of the summer season.



A Contamination Advisory sign posted at the Riverside Beach.

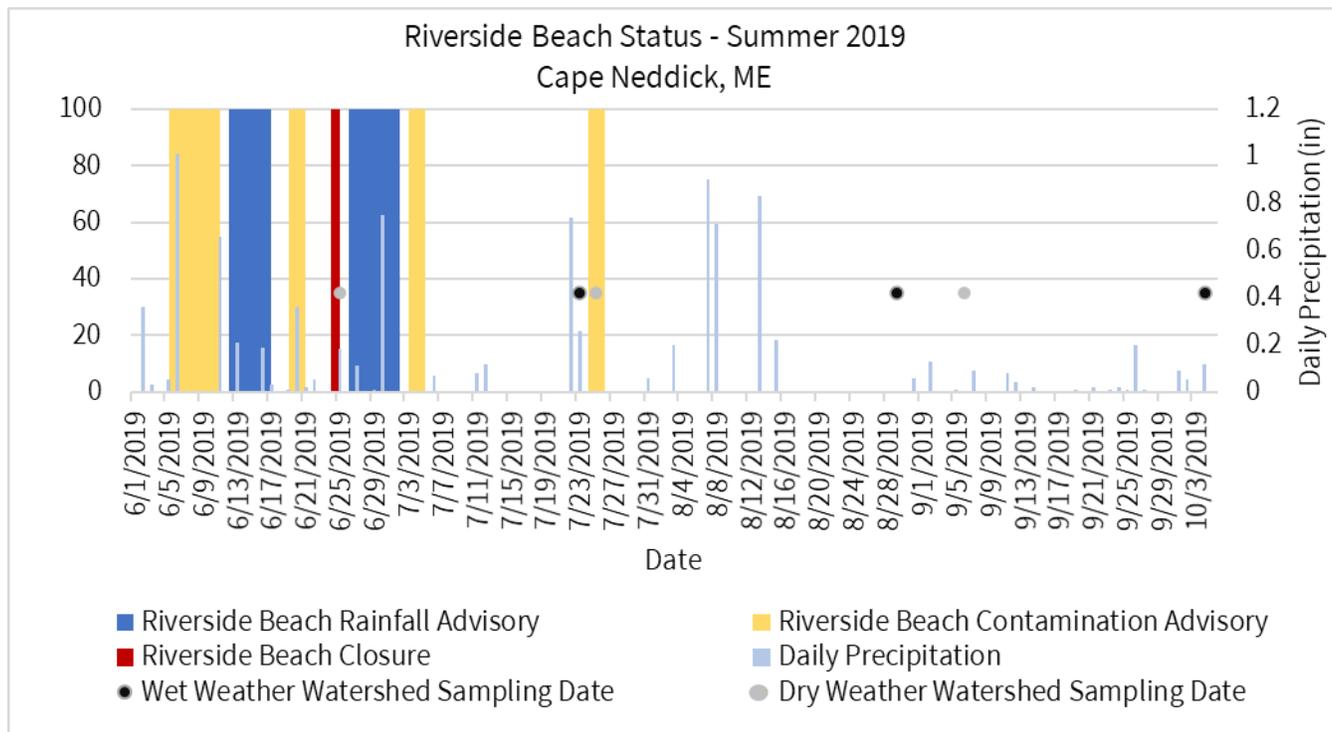


FIGURE 2. Daily status of the Riverside Beach in Ogunquit (near OG-04) with dates containing Rainfall Advisories shaded in dark blue, Contamination Advisories shaded in yellow, and Beach Closures shaded in red. The amount of daily precipitation is represented with light blue bars. Data shown from 6/1/2019- 10/4/2019 with wet and dry weather watershed sampling dates marked with black or grey points. Beach status data were retrieved from the Maine Healthy Beaches; precipitation data were retrieved from wunderground.com, CAPE NEDDICK, ME US (Station: KMECAPEN2), data gaps filled in from the Middle Ogunquit River, ME US (Station: KMEYORK8)

TABLE 1. Summary of Enterococci (mpn/100mL) results for sampling locations within the Ogunquit River watershed in 2019. For individual samples <10 mpn/100mL, a value of 5 mpn/100mL (half the detectable limit) was used in calculating the geomean. Sites are ordered from upstream to downstream. Red text indicates an exceedance of the Maine Healthy Beaches Enterococci water quality threshold of 35 mpn/100mL for the geomean of multiple samples or 104 mpn/100mL for a single sample (applied to OG-Pipe). No samples were collected from OG-Seep in 2019.

Site	Location	n	Enterococci Dry Weather Geomean (mpn/100mL)	Enterococci Wet Weather Geomean (mpn/100mL)	Enterococci All Data Geomean (mpn/100mL)
OR-06	Main Stem	5	83	990	366
OR-18	Tributary to Main Stem	6	445	1,013	770
OR-15-1	Leavitt Stream	5	24	420	135
OR-Theatre	Leavitt Stream	6	107	1,000	475
OR-13	Leavitt Stream	6	44	800	305
OG-04	Main Stem	6	7	312	88
OG-Pipe	Stormwater Pipe to Main Stem	1	-	5,172	5,172
OG-Seep	Beach Seep to Main Stem	0	-	-	-
OG-04-West-Up	Main Stem	3	10	313	99
OG-04-West-Down	Main Stem	3	20	389	145

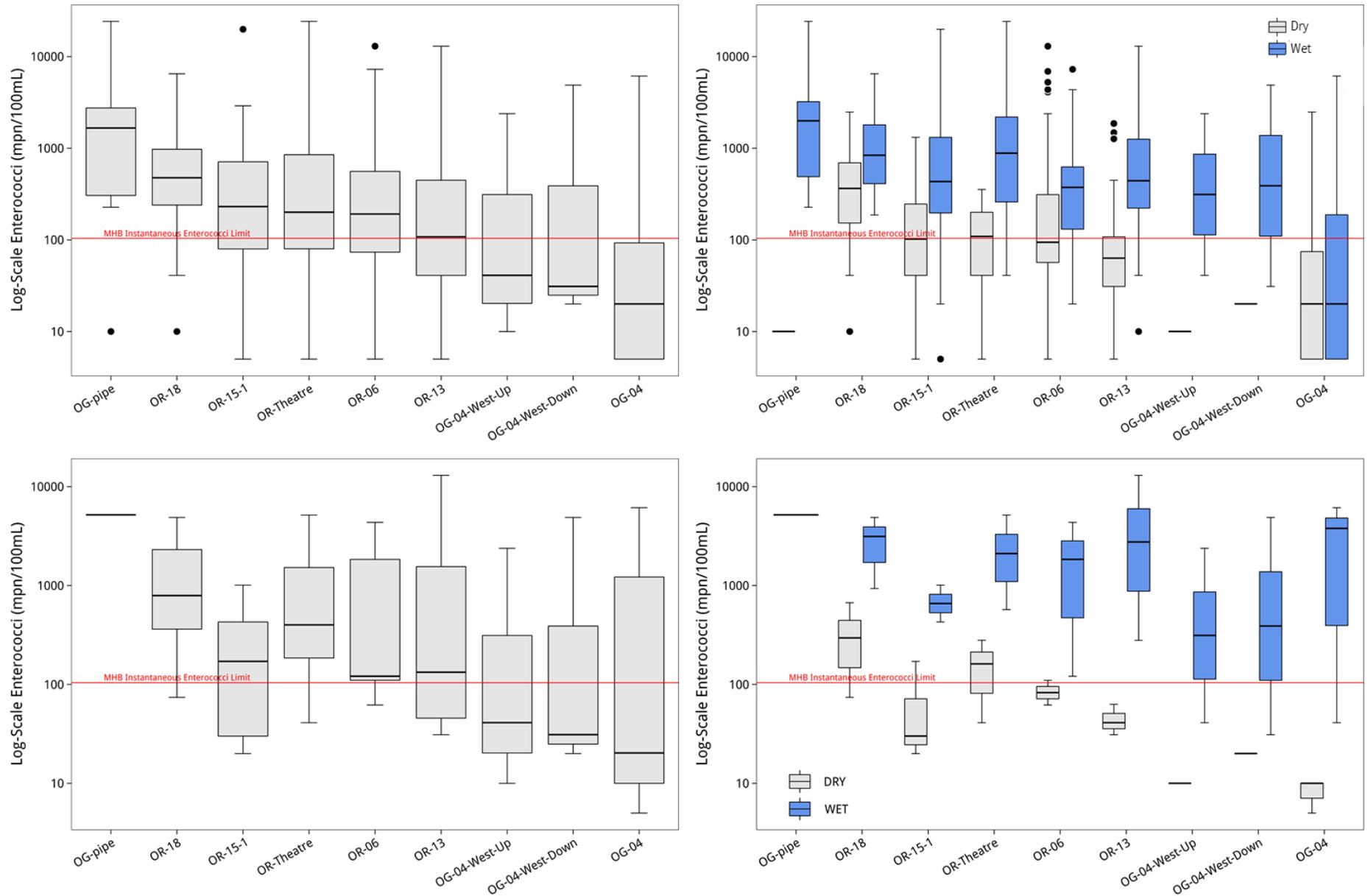


Figure 3. All data (2003-2019; top) and 2019 (bottom) distribution for nine sites in the Ogunquit River watershed (left) and by antecedent weather condition (right). Sites are ordered from highest to lowest median value according to the all data (2003-2019) distribution (top left). The red line represents the Maine Healthy Beaches instantaneous Enterococci threshold of 104 mpn/100mL.

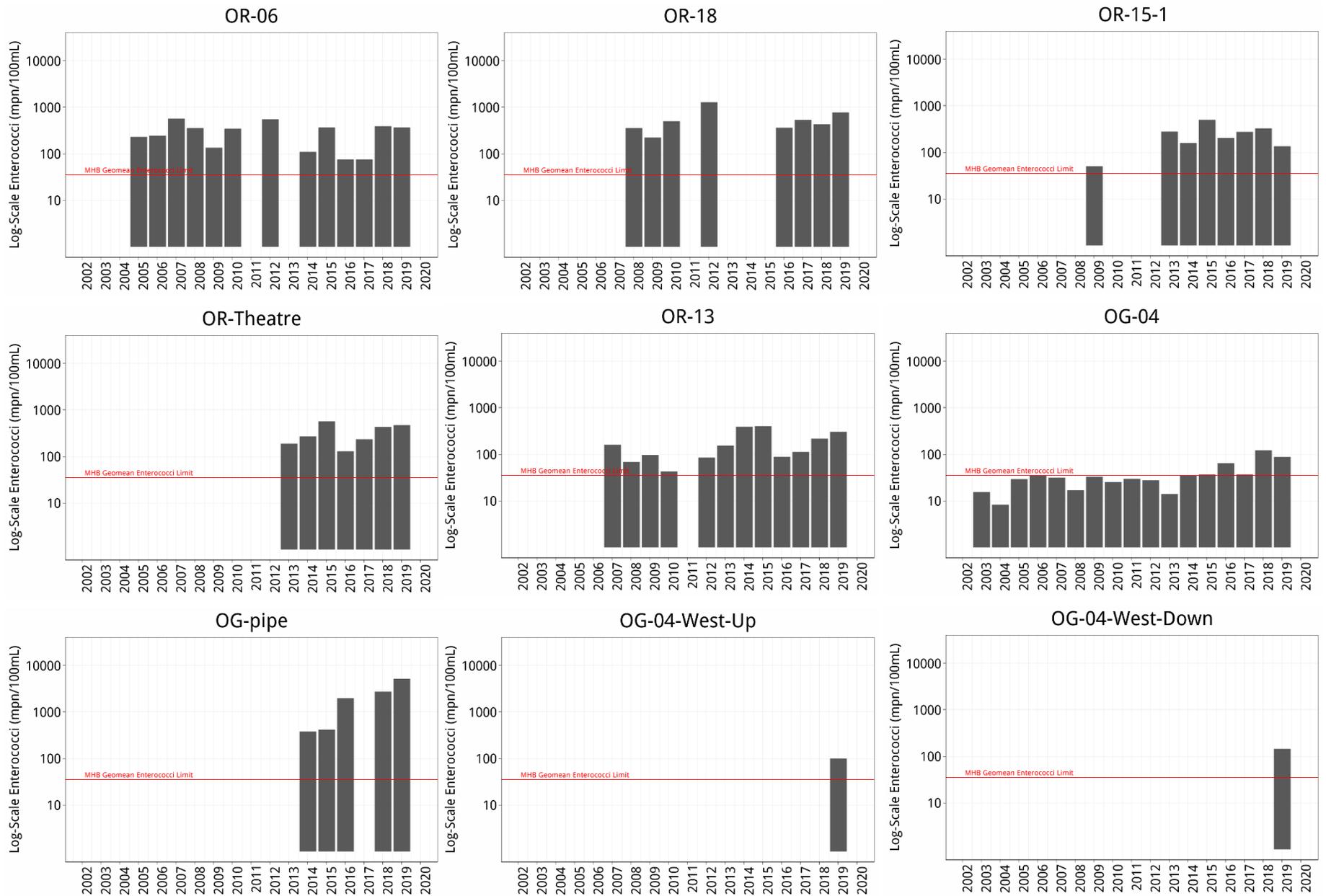


Figure 4. Annual Enterococci geomean from 2003-2019 for twelve sites in the Ogunquit River watershed. The red line represents the Maine Healthy Beaches geomean threshold of 35 mpn/100mL.

Ogunquit River Watershed Restoration Project 2019 Sampling Results

2019 Sampling Location & Results

Legend

- △ Dry Weather Geomean
- Wet Weather Geomean
- All Weather Geomean

Enterococci Geomean (MPN/100mL)

- 0-35
- 36-150
- 151-300
- 301+

- Stream/River
- Roads
- Waterbody

Data Source: MEGIS, ESRI, FBE
Projection: NAD 1983 UTM Zone 19N
Created by FBE, Nov. 2019



0 0.125 0.25 Miles



FIGURE 5. Ogunquit River watershed monitoring results for 2019. For each sampling site, overlaid symbols show Enterococci counts as the geomean of dry weather samples (triangles), wet weather samples (circles), and all (wet and dry) samples (squares).

TARGETED FECAL SOURCE TRACKING

In previous years, bracketed sampling of an unnamed tributary flowing between OR-18 (downstream) and OR-18-1 (upstream near Route 1) suggested that fecal contamination to **OR-18** is sourced from the adjacent land or from incoming estuarine waters. In 2019, FBE conducted a groundwater testing study along both sides of the unnamed tributary on 8/29/2019 (Figure 6). Along the southern edge of the tributary lies Littlefield Village. Littlefield Village is serviced by sewer and was identified as a potential source of fecal contamination to the Ogunquit River. Generally, sewer related risks include leaking infrastructure (pipes, pump stations, etc.) due to undersized infrastructure, blockages, or excessive infiltration of groundwater or rainwater into pipes, exceeding system capacity. The Great Works Regional Land Trust facility is located north of the unnamed tributary and is serviced by an on-site wastewater disposal system (septic system), which was identified as a potential source. In general, septic systems can malfunction due to improper maintenance, leach field erosion, or excessively wet conditions.

METHODS

Following a moderate storm event (1.04 inches over 9 hours), FBE collected 12 groundwater samples and 3 surface water samples along the marsh fringe bordering buildings belonging to the Great Works Regional Land Trust and Littlefield Village on 8/29/2019 for a total of 15 samples (Figure 6). Samples were analyzed for Enterococci, ammonia, dissolved organic carbon (DOC), total dissolved nitrogen (TDN), nitrate-nitrite, orthophosphate, and optical brighteners. These parameters are used as co-indicators of fecal contamination, which is suspected to be from malfunctioning septic and/or sewer systems in the study area. Surface water sampling followed methods previously mentioned for the annual baseline water quality monitoring. Groundwater samples were collected 1-2 feet below the marsh surface using a 36-inch MHE PushPoint $\frac{1}{4}$ " diameter field investigation sampler, equipped with syringe assembly. The syringe and sampler were each rinsed three times with distilled water after each site.

Optical brighteners are fluorescent whitening agents which can be found in soaps, detergents, and bathroom paper. A fluorometer was used to detect the presence of optical brighteners in each sample at the end of the sampling day. This procedure first measures the amount of light emitted from a water sample. Each sample was run in triplicates to ensure accurate results. After the initial fluorometer reading, if elevated, the samples are incubated under a UV light and then read again using the fluorometer. The measurement recorded shows the amount of emitted light which degraded as a result of the UV light incubation because optical brighteners rapidly degrade under these conditions. If there was an intermediate level of decrease (between the definitive thresholds for “presence” or “absence” of optical brighteners) in the fluorescence of the sample, then the samples are placed under the UV light again for a second incubation.

RESULTS

Four (4) of the 15 sites exceeded the instantaneous threshold of 104 mpn/100mL (OR-18-1, OR-GW-03, OR-GW-12, and OR-18). OR-18-1 and OR-18 are both surface water sites serving as the main inlet and outlet sampling locations respectively within the study area. OR-18-1 (upstream) had considerably higher fecal indicator bacteria counts compared to OR-18 (downstream), a pattern consistent with historical observations and suggesting that source inputs occur somewhere between the two sites or from incoming estuarine waters.



Example of a groundwater sample extraction along a marsh.

Two (2) groundwater samples collected along the north side of the tributary (downhill from the Great Works Regional Land Trust) exceeded the Enterococci instantaneous threshold of 104 mpn/100mL (OR-GW-03 at 1,250 mpn/100mL and OR-GW-12 at 1,270 mpn/100mL). OR-GW-03 also had elevated nitrate-nitrite concentrations at 0.28 mg N/L but neither of these two sites had elevated ammonia concentrations. Further downstream along the north bank at OR-GW-01, nitrate-nitrite concentrations were still higher at 0.57 mg N/L (though no other indicator parameters were elevated). The highest ammonia concentrations were observed on the south bank at OR-GW-10.

Though fecal indicator bacteria in groundwater samples along the south side of the tributary were generally low, sites extending from OR-GW-08 to OR-GW-11 had elevated nitrate and/or ammonia concentrations above natural background levels that may signify some sewer line leaks.

DOC was elevated in the surface water samples at OR-18-1 and OR-18 and in groundwater at OR-GW-11 on the north bank. Surface water samples at OR-18-2 had elevated TDN (1.85 mg N/L) and nitrate-nitrite (1.88 mg N/L) compared to all other sites, which ranged from 0.19–0.68 mg N/L and 0.05–0.66 mg N/L, respectively. OR-18-2 drains runoff from Route 1 and may reflect the accumulation of atmospheric nitrogen deposition and car exhaust pollution. Orthophosphate ranged from <1–21 $\mu\text{g P/L}$ and was generally low with no distinct spatial patterns. Optical brighteners were not found in any of the 15 samples collected in or along the tributary. All water quality results for targeted fecal source tracking can be found in Appendix A, Table A3.



View of the riparian zone along the unnamed tributary north of Littlefield Village, where groundwater samples were collected from the upland area adjacent to the stream.

Unnamed Tributary Groundwater Sampling Results

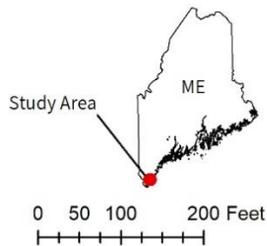
Sampling Locations

Enterococci (mpn/100mL)

- 5 - 104
- 105 - 1000
- 1001 - 3450

Results below RL labeled as 1/2 RL.

OR-18, OR-18-1, and OR-18-2 are surface water samples, not groundwater samples.



Data Source: MEGIS, ESRI, FBE
 Projection: NAD 1983 UTM Zone 19N
 Created by FBE, Nov. 2019



FIGURE 6. Unnamed tributary sampling results for fecal indicator bacteria (Enterococci) collected on 8/29/2019. Green circles mark sites whose Enterococci results were below the instantaneous threshold of 104 mpn/100mL. Yellow and red circles indicate sites with results over the threshold. Sites OR-18, OR-18-1, and OR-18-2 are surface water samples.

CONCLUSIONS AND NEXT STEPS

Fecal indicator bacteria monitoring in the Ogunquit River watershed in 2019 demonstrated that fecal contamination remains persistent in the known “hotspot” areas, particularly during and immediately after wet weather. This pattern suggests that stormwater sources, likely from a combination of wildlife and dog waste (as demonstrated by DNA analyses in previous monitoring years), may be the dominant source of fecal contamination to the Ogunquit River. As in 2018, the Leavitt Stream subwatershed from OR-15-1 to the outlet at OR-13 (covering the Village Highlands neighborhood) and Littlefield Village area upstream of OR-18 remain a concern, especially for dog waste in stormwater runoff and human waste in groundwater. Fecal source tracking samples also indicate potential septic and sewer issues on either side of the unnamed tributary.

RECOMMENDATIONS

- Continue to monitor fecal indicator bacteria levels annually within the Ogunquit River watershed, targeting sites in areas where outreach and/or implementation occurred under previous and current phases (I-III) of the Maine DEP/USEPA 319 Watershed Assistance Grant. Assess whether these initiatives helped to improve water quality.
- Follow up on the elevated fecal indicator bacteria counts found in groundwater samples along the Great Works Regional Land Trust property and investigate the state of the septic system present.
- Follow up on the elevated groundwater nitrogen concentrations found in groundwater samples along the Littlefield Village properties and investigate the state of the sewer lines present.
- Investigate the source of excess algae growing above OR-13 by testing for both phosphorus (typically the limiting nutrient to growth in freshwater systems) and nitrogen.
- Continue to conduct outreach on river- and beach-friendly home practices to property owners adjacent to the river and its tributaries, especially the Leavitt Stream.
- Install pet waste signage in the Littlefield Village community.

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APPENDIX A: Additional Data Tables

TABLE A1. Enterococci (mpn/100mL) results for all sampling locations within the Ogunquit River watershed from June-October 2019. Sites are ordered from upstream to downstream. Red text indicates an exceedance of the Maine Healthy Beaches water quality threshold for Enterococci of 104 mpn/100mL for a single grab sample.

Site	Location	6/20/2019	6/25/2019	7/23/2019	7/25/2019	8/29/2019	9/6/2019	10/4/2019
		Dry	Dry	Wet	Dry	Wet	Dry	Wet
OR-06	Main Stem	-	110	4,352	-	1,840	62	121
OR-18	Tributary to Main Stem	-	295	4,884	74	3,130	670	932
OR-15-1	Leavitt Stream	-	20	-	171	1,010	30	428
OR-Theatre	Leavitt Stream	-	41	2,105	161	5,170	280	571
OR-13	Leavitt Stream	-	31	2,755	41	13,000	63	279
OG-04	Main Stem	-	10	3,784	10	6,130	5	41
OG-Pipe	Stormwater Pipe to Main Stem	-	-	5,172	-	-	-	-
OG-Seep	Beach Seep to Main Stem	-	-	-	-	-	-	-
OG-04-West-Up	Main Stem	-	-	2,382	-	-	10	41
OG-04-West-Down	Main Stem	-	-	4,884	-	-	20	31

TABLE A2. Summary of average water quality data from 2019 for sampling locations within the Ogunquit River watershed. Dissolved oxygen (DO) in parts per million (ppm) was corrected in all cases where salinity was >9 ppt (using <http://water.usgs.gov/software/DOTABLES/>). Sites are ordered from upstream to downstream.

Site	Location	Water Temp (°C)	DO (ppm)	Salinity (ppt)	Spec. Cond. (µS/cm)	pH
OR-06	Main Stem	17.0	8.1	0.1	216	7.4
OR-18	Tributary to Main Stem	18.5	8.6	3.7	9,031	7.1
OR-15-1	Leavitt Stream	15.8	8.0	0.1	259	7.0
OR-Theatre	Leavitt Stream	15.2	9.1	0.2	319	7.3
OR-13	Leavitt Stream	16.1	8.9	0.6	2,021	7.2
OG-04	Main Stem	17.4	8.5	20.2	37,889	7.5
OG-Pipe	Stormwater Pipe to Main Stem	19.4	4.7	-	277	-
OG-Seep	Beach Seep to Main Stem	-	-	-	-	-
OG-04-West-Up	Main Stem	16.2	8.9	16.3	42,563	7.5
OG-04-West-Down	Main Stem	16.1	9.0	16.7	44,093	7.6

TABLE A3. Water quality results for targeted fecal source tracking samples collected along the unnamed tributary north of Littlefield Village on 8/29/2019. Sites are organized by sample type (surface water and groundwater) and ordered upstream to downstream along the north side of the tributary and south side of the tributary (Refer to Figure 6). Values in yellow indicate measurements that are elevated. Water quality criteria do not exist for these parameters in this project, but 0.5 ppm NH₃ is used as an indicator for fecal contamination by the EPA Illicit Discharge Detection and Elimination program, and 0.1 ppm NO₃+NO₂ typically indicates background conditions and higher values suggest human-derived bacteria sources.

Sample Type	Location	Site	Enterococci (mpn/100mL)	NH ₃ (ppm)	DOC (mg C/L)	TDN (mg N/L)	NO ₃ +NO ₂ (mg N/L)	PO ₄ (µg P/L)	Optical Brighteners
Surface Water	North	OR-18-2	41	0.0	2.36	1.85	1.88	8	Negative
	South	OR-18-1	130	0.25	5.48	0.52	0.13	3	Negative
		OR-18	3,450	0.25	4.39	0.39	0.14	5	Negative
Groundwater	North	OR-GW-03	1,250	0.25	2.07	0.36	0.28	4	Negative
		OR-GW-12	1,270	0.0	3.78	0.28	0.06	7	Negative
		OR-GW-01	10	0.25	1.91	0.68	0.57	2	Negative
	South	OR-GW-11	41	0.25	5.36	0.64	0.46	21	Negative
		OR-GW-10	30	1.0	1.97	0.62	0.05	23	Negative
		OR-GW-09	10	0.5	2.00	0.33	0.06	20	Negative
		OR-GW-08	10	0.5	1.72	0.55	0.66	3	Negative
		OR-GW-07	20	0.0	1.68	0.27	0.13	2	Negative
		OR-GW-06	41	0.25	3.22	0.32	0.05	3	Negative
		OR-GW-05	<10	0.25	2.07	0.19	0.05	10	Negative
		OR-GW-04	63	0.25	3.66	0.33	0.08	9	Negative
OR-GW-02	<10	0.0	2.44	0.19	0.07	1	Negative		

APPENDIX B: QAPP QA/QC Protocol Review

Fecal indicator bacteria samples were collected in 2019 by FBE staff and analyzed by Nelson Analytical Laboratory in accordance with the specific Standard Operating Procedures (SOPs) outlined in the Ogunquit River Watershed-Scale Bacteria Monitoring Quality Assurance Project Plan (QAPP), with any deviations described below (FBE, 2016). These deviations were minor and did not impact the quality of results.

- 1) OG-Seep was monitored over the sampling season, but no samples were collected due to low-flow conditions. No samples were collected at OG-Pipe on all but one round of sampling (7/23/2019) due to no flow conditions. No sample was collected at OR-15-1 on 7/23/2019 due to sampling error. No sample was collected at OR-06 on 7/25/2019 due to site access constraints. Per QAPP data completeness guidelines, >90% of proposed data were collected.
- 2) One field duplicate sample should be collected for every 10 samples. Out of a total of 41 samples over six sampling dates, 5 field duplicate samples were collected.
- 3) Field duplicates for bacteria should attempt to yield a relative percent difference (RPD) of <20%; 3 out of 5 duplicate samples resulted in RPD >20% (Table B1). RPD >20% can be deemed acceptable given the inherent variability of collecting and measuring biological communities. Typically, higher bacteria counts will be less variable than lower bacteria counts of <200 mpn/100mL. As such, 2019 RPDs ranging from 0-100% were acceptable and reflect a consistent field sampling procedure by personnel. One elevated RPD at 147% for OR-15-1 on 9/6/2019 was flagged but was accepted assuming environmental factors may have changed the fecal count within the parcel of sampled water coming downstream due to the high variability of sources activated during wet weather. Discussions with field personnel immediately following sample collection determined that there were no concerns for sampler-caused contamination.

TABLE B1. Summary of relative percent difference (RPD) between duplicate field samples. One duplicate field sample was taken on five of the six sampling dates.

Date	Wet/Dry	Sample ID	Enterococci (mpn/100ml)	RPD
6/25/2019	Dry	OG-04	10 20	100%
7/25/2019	Dry	OR-Theatre	161 120	25%
8/29/2019	Wet	OR-18	3,130 3,130	0%
9/6/2019	Dry	OR-15-1	30 74	147%
10/4/2019	Wet	OR-06	121 145	20%

- 4) Laboratory duplicates should also attempt to yield an RPD <20%; results for 2019 fecal indicator bacteria yielded RPDs ranging from 0-24% (Table B2). This also reflects a consistent laboratory analysis procedure by laboratory staff, with greater RPDs generally associated with lower bacteria counts and vice versa. This pattern is to be expected when measuring biological communities and the data are acceptable.

TABLE B2. Summary of relative percent difference (RPD) between field sample and laboratory duplicate results in 2019.

Date	Wet/Dry	Sample ID	Enterococci (mpn/100ml)	RPD
6/25/2019	Dry	OR-13	31 31	0%
7/23/2019	Wet	OG-04	3,784 4611	22%
7/25/2019	Dry	OR-Theatre	161 122	24%
8/29/2019	Wet	OR-13	13,000 11,200	14%
9/6/2019	Dry	OG-04	10 10	0%
10/4/2019	Wet	OG-04-West-Down	31 31	0%

- 5) Fecal indicator bacteria samples were collected from tidal sites (OG-04, OG-Seep, OR-06, OR-13, and OR-18) within a rough window of ±2 hours around dead low tide; the sample collected at OR-13 at 12:30 on 7/23/2019 was 13 minutes over 2 hours but was deemed acceptable because OR-13 is located within the tidal area but is a culvert draining a freshwater system (Table B3). All samples were delivered to the laboratory well within the 6-hour holding time limit (Table B3).
- 6) All but one of the six sampling events was collected within the designated timeframe of May 15 – September 30. September 2019 was an exceptionally dry month receiving a total of only 0.65 inches of precipitation. With no qualifying wet weather event in September of 2019, FBE staff completed the third and final wet weather sampling event on 10/4/2019 – only four days outside the designated window.
- 7) Samples collected on 7/23/2019 and 8/29/2019 were delivered to the laboratory at 12.9°C and 11.5°C, respectively (Table B3). The goal is for the samples to reach 10°C to reduce any potential growth of bacterial communities within the sample after collection. These samples were accepted because although above 10°C, they had decreased greatly in temperature from the initial time of collection (Table B3).
- 8) All COC forms were complete. Written field sheets were not completed. FBE used tablets with Fulcrum field forms to complete in the field.

TABLE B3. Summary of QAPP protocol results for 2019 fecal indicator bacteria sampling.

Date	Precip 24 hrs prior (in)	Precip 48 hrs prior (in)	Precip 96 hrs prior (in)	Time of First Sample	Time of First Tidal Sample	Time of Last Tidal Sample	Time of Low Tide	Time Delivered to Lab	Temp Received (°C)
6/25/2019	0.00	0.00	0.00	10:42	10:42	12:00	11:47	12:50	7.8
7/23/2019	1.34	1.34	1.34	11:00	11:00	12:30	10:17	13:51	12.9
7/25/2019	0.00	0.09	1.43	11:05	11:19	12:44	11:44	12:56	8.9
8/29/2019	1.04	1.04	1.04	5:47	5:47	6:14	4:33	7:45	11.5
9/6/2019	0	0.02	0.02	9:40	9:40	11:30	11:36	12:00	7.3
10/4/2019	0.07	0.2	0.2	7:26	8:16	9:01	10:09	9:33	6.7

Date	Time Diff. First Sample	Time Diff. Last Sample	Time Diff. to Lab
6/25/2019	1:05	0:13	2:08
7/23/2019	0:43	2:13	2:51
7/25/2019	0:25	1:00	1:51
8/29/2019	1:14	1:41	1:58
9/6/2019	1:56	0:06	2:20
10/4/2019	1:53	1:08	2:07