



OARS River Meadow Brook Bacteria Monitoring Results—2022

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Following is a summary of OARS' monitoring and source-tracking results for *E. coli* bacteria in the Lowell River Meadow Brook special study. This study was funded by the Greater Lowell Community Foundation, and it was prompted by elevated bacteria levels in our 2019 sampling in the Concord River at the Rogers Street Bridge in Lowell. We also thank our team of dedicated volunteers for helping collect the stream and river water samples.

In 2020 and 2021, our volunteers collected weekly samples for bacteria analysis at 15 sites along the Concord River and River Meadow Brook. Our initial focus in 2020 was to identify the source of bacterial pollution that we had discovered at the site next to the Concord River Rogers Street bridge. Fairly quickly, we confirmed that River Meadow Brook was the primary source of bacteria, and in 2021 we focused on sampling as widely in River Meadow Brook as possible. Based on the 2021 results, we identified four hot-spots along the brook that seemed to have separate bacteria pollution signals (see our report "OARS River Meadow Brook Bacteria Monitoring Results—2021"). In 2022, we continued monitoring for bacteria at the mouth of the brook, and we refocused our efforts to source-tracking through DNA analysis and detergent testing. Below are our 2022 results for Bacteria Monitoring, DNA Analysis, and Detergent Testing.

Bacteria Monitoring

The Lawrence Street site on River Meadow Brook (RVM-001) is 0.1 miles upstream from the confluence of the brook with the Concord River. OARS volunteers have been monitoring this site on a regular basis since 2020 (Figure 1). Monitoring results at this site document significant bacterial pollution continuously throughout this period. Almost all results from the three-year period were above the EPA's designated Beach Action Value for swimming (BAV) of 235 CFU-MPN¹ per 100ml. The geometric mean for the period was 396 CFU-MPN, as compared to Mass DEP's recreational water quality criteria of 126 CFU-MPN. And 44% of the samples exceeded the EPA's Statistical Threshold Value (STV) of 410 CFU-MPN, as compared to Mass DEP's recreational water quality criteria of 10%. An evaluation of results based on a wet and dry weather distinction shows significantly higher bacteria levels in wet weather (Figure 2), which is an indicator of stormwater runoff pollution, but dry weather bacteria levels were also well above recreational water quality criteria, indicating a potential sanitary sewer pollution source. The geometric mean of dry weather results was 349 CFU-MPN, and 35% of dry weather samples exceeded the EPA's Statistical Threshold Value.

¹ Culturable bacteria can be enumerated in either CFU/100 ml (Colony Forming Units) or MPN/100 ml (Most Probable Number) depending on the method used for analysis. The two units of measure are statistically interchangeable for bacteria monitoring purposes in surface waters.

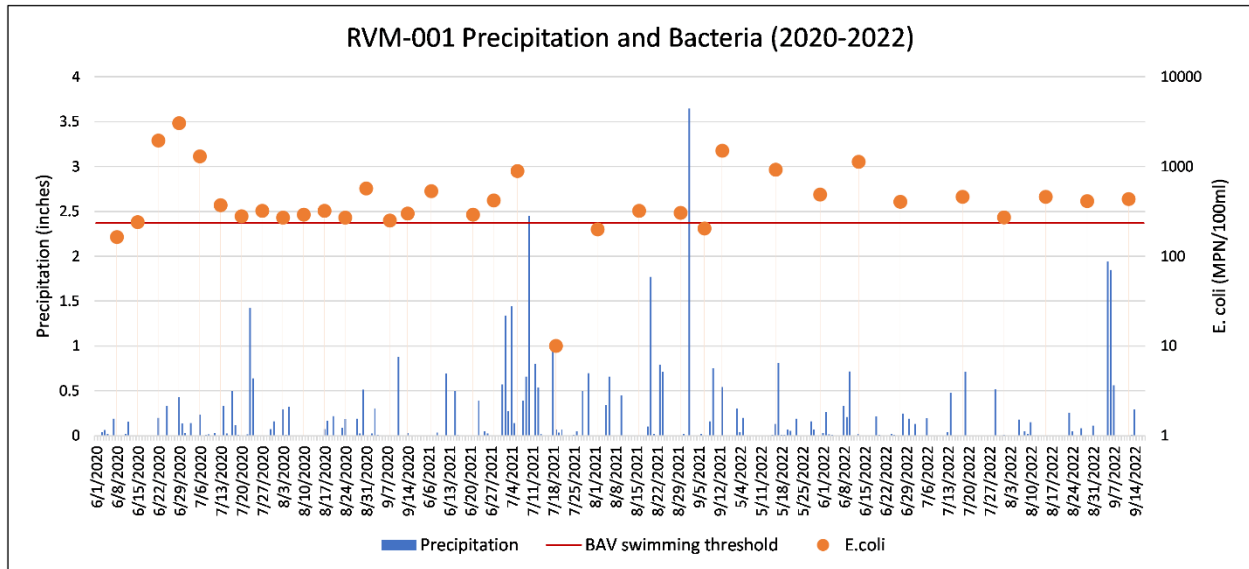


Figure 1: Precipitation and Bacteria results for site RVM-001, near the confluence of River Meadow Brook and the Concord River. Graph shows data for each of three years for the sampling season of May–Sept.

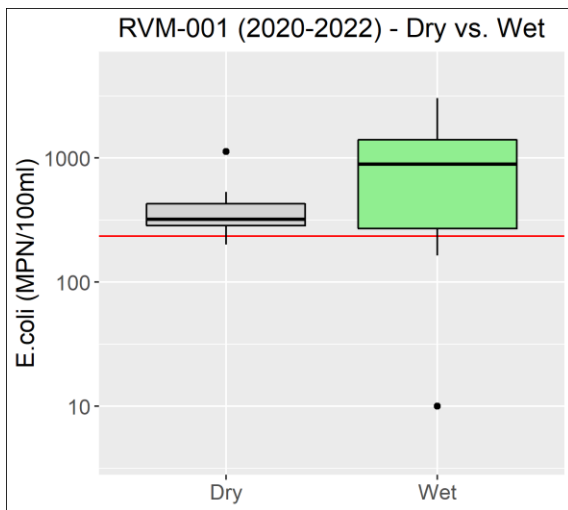


Figure 2: RVM-001 E. coli results plotted by wet and dry conditions. Wet weather is defined as days when the previous 48-hour rainfall is greater than or equal to 0.1 inches. The red line shows the EPA BAV threshold of 235 CFU/100 ml.

DNA Analysis

OARS analyzed two separate water samples for DNA at two different times and with two different methods. Both samples were collected from the RVM-001 site. Both samples confirmed human contamination of the water.

The first sample was analyzed by EMSL Analytical, Inc., who used qPCR technology to detect *Bacteroides* species, distinguishing human *Bacteroides* from total *Bacteroides* with the HF183 genetic marker. The test results returned a cell count for human *Bacteroides* of 1,250 Cell Equivalents/100 ml (Table 1), which was 1% of the total *Bacteroides* cell count. This result is hard to interpret because we only sampled one site and we don't have any reference for comparison. However, when compared to results from other studies, this cell count is considered significant and to be indicative of human sewage contamination.

Sauer, et al.² concluded that cell counts of 1,000-5,000 CEs/100 ml represent moderate sewage contamination. They also calculated that the human Bacteroides proportion for undiluted raw sewage is only about 5%, and they concluded that 0.5%-1.5% human Bacteroides in an outfall was a high enough percentage to suggest that human sources are the predominant source of fecal pollution. Therefore, we believe it is safe to conclude that this result does indicate significant human sewage contamination at RVM-001.

Table 1: First sample, analyzed by EMSL Analytical, Inc.

	RVM-001 8/29/22 7:05 AM	
Total Bacteroides by qPCR	123,593	Cell Equivalents/100 ml
Human Bacteroides by qPCR	1,250	Cell Equivalents/100 ml
E.coli Bacteria by Collilert-18	411	MPN/100 ml
Notes	Very low water, low flow, 0.1" rain 3 days prior	

The second sample was analyzed by Jonah Ventures, who used qPCR technology to measure the number of DNA replicates found in the water sample for four different species: human, beaver, goose, and dog. This allowed us to check whether other species might be drivers of the bacterial pollution. The test results returned DNA copy counts of 271 for human, 131 for beaver, 45 for goose, and 5 for dog. These results confirmed that the dominant pollution source at RVM-001 is most likely human sewage. The beaver results are interesting because the closest sign of beaver activity is 1.7 miles upstream.

Table 2: Second sample, analyzed by Jonah Ventures. Results are averages based on three replicates. All replicates had similar detection levels, except for dog which was only detected in 2 out of 3 replicates.

	RVM-001 10/13/22 9:07 AM	
Human DNA by qPCR	271	Copies/100 ml
Beaver DNA by qPCR	131	Copies/100 ml
Canadian Goose DNA by qPCR	45	Copies/100 ml
Dog DNA by qPCR	5	Copies/100 ml
E.coli Bacteria by Collilert-18	>2420	MPN/100 ml
Notes	Mid-low flow, dry weather, 7 days since significant rain	

Detergent Monitoring

With the help of one of our intrepid volunteers, OARS conducted a survey of all of the outfall pipes draining into River Meadow Brook between RVM-001 (furthest downstream site) and RVM-027 (2.7 miles upstream at Glen Avenue). We walked the brook on 10/13/22 and tested for detergents, using a Chemets K-9400 test kit, in each pipe that had flowing water. Most of the pipes along the brook did not have any flow at the time of the survey, which probably makes it safe to exclude them as dry-weather sanitary sewage sources. Of the pipes that were tested, most did not show any noteworthy results, but three pipes at miles 1.15, 2.21, and 2.22 did show elevated levels (Figure 3). The two pipes at miles 2.21

² Sauer E., et al., 2011, "Detection of the human specific Bacteroides genetic marker provides evidence of widespread sewage contamination of stormwater in the urban environment", Water Research, 45 (2011) 4081-4091.

and 2.22 had very high levels. These two pipes empty into the brook next to the Crosspoint Tower complex on Industrial Ave (Figure 4). The location of these two pipes is particularly interesting because the same location exhibited elevated levels of bacteria in some of our 2021 testing. We originally assumed the bacteria was from the geese that are often present on the Crosspoint Tower parking lot. But these new results raise the possibility that these pipes could actually be the source of the bacteria. The only other pipe in our survey that was concerning was the pipe at mile 1.15, which is a very large storm sewer on the west side of the brook 50 feet downstream from the Lincoln St. bridge. This pipe had no visible flow, but the sample was taken from the pool that the pipe discharges into.

This detergent survey clearly identified three pipes that need to be addressed. The two at Crosspoint Tower should be very easy to resolve. The Lincoln St. pipe will need more detailed catchment surveys by the Lowell Wastewater Utility. Note that there were a few locations along the brook that we were not able to access, such as underneath the industrial building on Crosby St., between Gorham St. and Howard St., and between Lincoln St. and Plain St. These sections will also need to be surveyed by the Lowell Wastewater Utility.

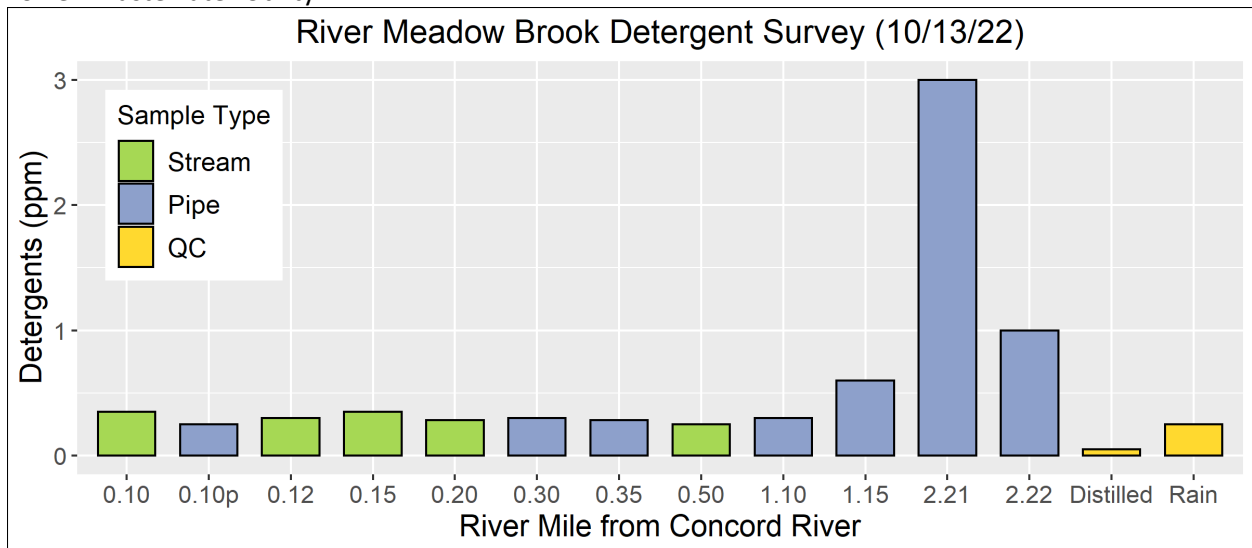


Figure 3: River Meadow Brook detergent survey 10/13/22. Samples listed by river mile of outfall pipe. Each bar represents one sample.

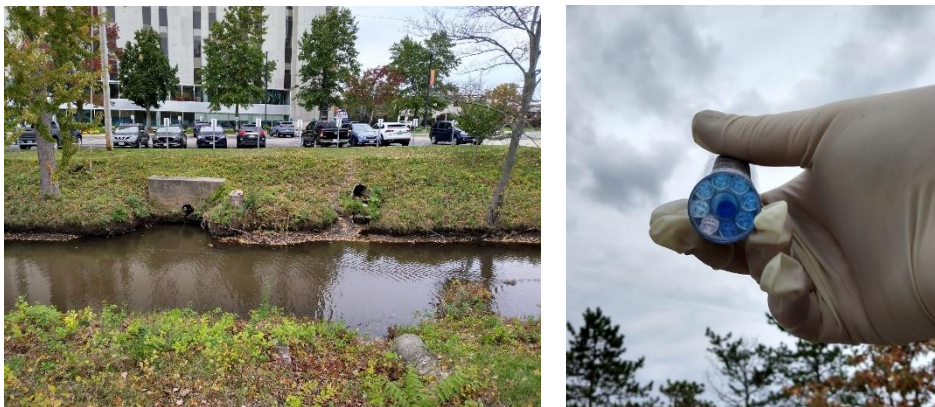
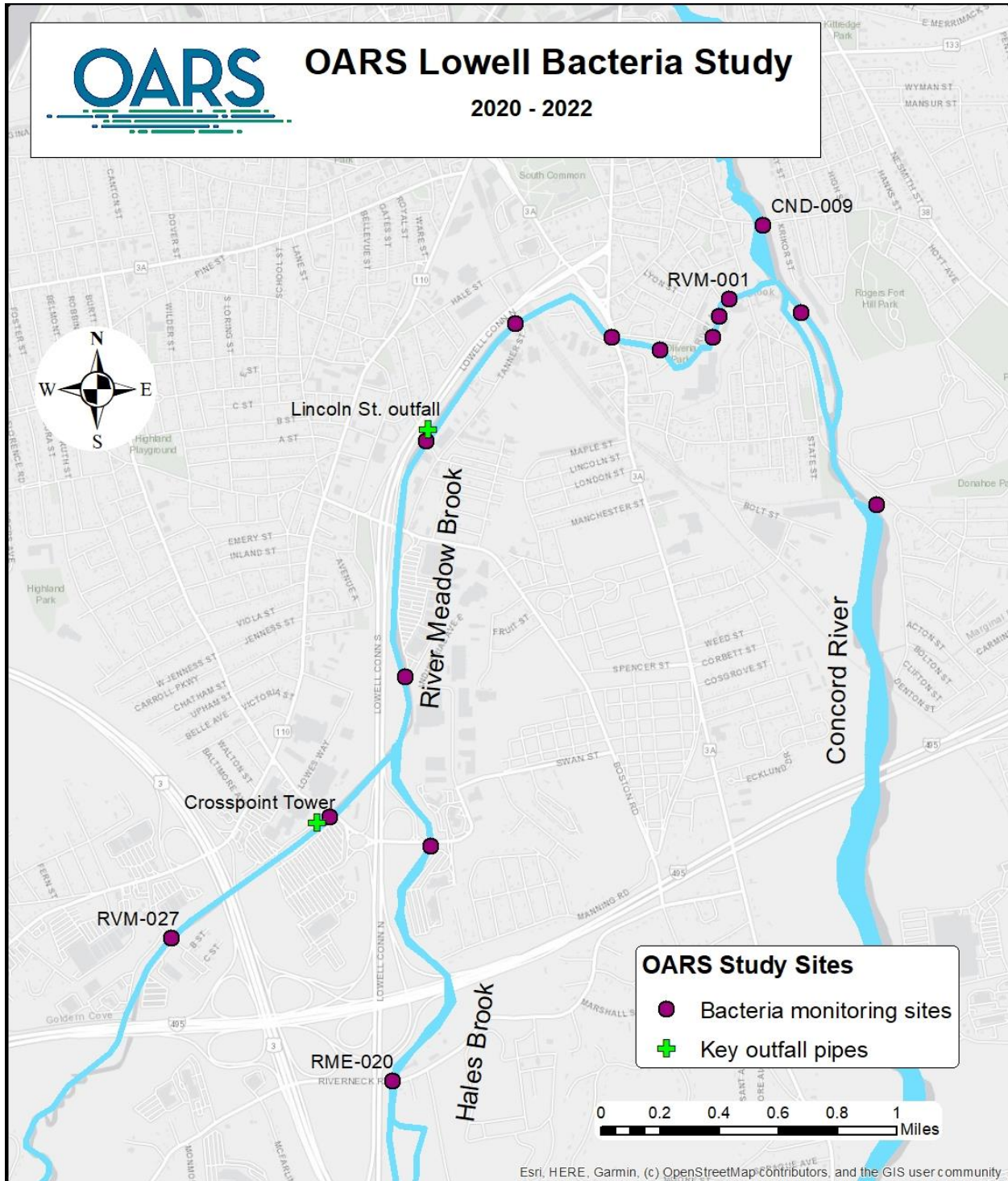


Figure 4: Crosspoint Tower pipes (2.22 on left upstream, 2.21 on right downstream). The right-hand image shows sample 2.21 in the test kit comparator. The sample is in the middle surrounded by a circle of reference tubes.

Conclusion:

OARS' monitoring over the last three years has repeatedly confirmed that there is persistent bacterial pollution in River Meadow Brook. Bacteria levels are consistently well above Mass DEP and EPA recreational water criteria. It is clear that until River Meadow Brook is cleaned up, the Concord River at the Rogers St. Bridge will also continue to exceed recreational water criteria (see our report "OARS Bacteria Monitoring Results—2022"). Our research this year has confirmed the bacterial pollution in the brook and provided more information about the source of the pollution. The DNA analysis of water samples at our downstream site confirmed that the dominant source of pollution in the downstream section of the brook is human sourced, most-likely sanitary sewer leakage. The analysis also shows that neither dogs nor geese are significant sources of bacterial pollution in these locations. The detergent testing of outfall pipes identified three specific pipes that the Lowell Wastewater Utility can follow up on directly. However, these are likely not the only sources, so more detailed surveys are still needed.

Appendix A: Map of River Meadow Brook Study Area



Appendix B: OARS site list with coordinates

Site #	DESCRIPTION	TOWN	WATERBODY	LATITUDE	LONGITUDE
CND-009	Rogers Street bridge	Lowell	Concord River	42.635950	-71.301487
CND-012	Centennial Island East	Lowell	Concord River	42.632793	-71.299590
CND-017	Muldoon Park	Lowell	Concord River	42.625878	-71.295905
RVM-001	649 Lawrence St.	Lowell	River Meadow	42.633278	-71.303113
RVM-0015	UMACO	Lowell	River Meadow	42.632741	-71.303577
RVM-002	Industrial Tool	Lowell	River Meadow	42.631878	-71.303969
RVM-004	Newhall St.	Lowell	River Meadow	42.631250	-71.306048
RVM-005	Gorham/Chambers St.	Lowell	River Meadow	42.631908	-71.308884
RVM-008	Howard St.	Lowell	River Meadow	42.632453	-71.313522
RVM-012	Lincoln St.	Lowell	River Meadow	42.628175	-71.317949
RVM-014	Plain St.	Lowell	River Meadow	42.625100	-71.319213
RVM-018	Industrial Ave. behind Marshalls	Lowell	River Meadow	42.619696	-71.318965
RVM-022	Industrial Ave. at Crosspoint Tower	Lowell	River Meadow	42.614641	-71.322688
RVM-027	Glen Ave.	Chelmsford	River Meadow	42.610395	-71.330474
RME-003	Industrial Ave. East	Chelmsford	River Meadow East	42.613599	-71.317732
RME-020	Riverneck Rd.	Chelmsford	River Meadow East	42.605154	-71.319594