

2018 FINAL PROJECT REPORT

Microbial Source Tracking and Virginia's Beach Monitoring Program

MEMORANDUM OF AGREEMENT: HRSDMST617FY18

between

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and

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Introduction:

Forty-six public beaches are monitored by the Virginia Department of Health (VDH) for fecal indicator bacteria through the Virginia beach monitoring program. The presence of elevated fecal indicator bacteria, like enterococci, indicate that waterborne pathogens may be present. Unfortunately, fecal indicator bacteria measure total fecal bacteria. They do not provide evidence to the source of elevated bacteria since they originate from human, animal, and environmental sources. For the 2018 beach swimming season Hampton Roads Sanitation District (HRSD) used the human-associated Microbial Source Tracking (MST) marker, HF183, on VDH health districts water samples that exceeded the recreational water quality standard.

The HF183 molecular marker is associated with recent human fecal contamination and is the most frequently used DNA-based marker to identify human sewage pollution in surface waters (Griffith et al., 2013; Ahmed et al., 2016). An unofficial action threshold of 1000 gene copies/100 mL has been used to differentiate significant marker detections in surface waters. Recently Boehm et al. (2015) suggested a HF183 threshold of 4200 copies/100 mL to represent the benchmark illness rate of 30 gastrointestinal illnesses per 1000 swimmers (the current recreational acceptable risk level). However, for the purposes of detecting the potential presence of human fecal contamination, any significant positive detection defines the susceptibility of a water body to contamination. For reference HF183 is found in the range of $10^7 - 10^8$ copies/100 mL in Hampton Roads raw sewage, but can be lower in sewer collection systems.

Approach:

Water samples collected by health districts were chosen for MST analyses at VDH's discretion when regulatory exceedances of enterococci concentrations occurred. Samples were collected from contract laboratories used for enterococci quantification then brought to HRSD's Central Environmental Laboratory. Upon receipt, 50 – 200 mL of sample were immediately filtered to collect total DNA then stored in a -80°C freezer until downstream molecular processing within the week. Salmon testes DNA was spiked into samples and controls prior to DNA extraction to gauge matrix inhibition according to methods described in Gonzalez et al. (submitted). Extraction of samples was completed with an automated total nucleic acid extraction system (bioMerieux NucliSENS easyMag) per the manufacturer's protocol. The HF183 molecular marker was quantified using droplet digital PCR according to the protocol in Cao et al. (2015). Concentrations are reported as gene copies per 100 mL. For simplicity positive results were anything quantifiable above the assay limit of detection, while negative results were below limit of detection. Limits of detection are shown in table 1 with the associated sample volumes.

Results:

One hundred samples were processed by HRSD—44 samples from Norfolk Health District, 35 from the Peninsula Health District, 12 from Hampton Health District, 7 samples from Virginia Beach Health District, 1 sample from the Eastern Shore Health District, and 1 sample from Three Rivers. This is double the sample number processed for the 2017 beach season. Raw results can be seen in Table 1.

Human Fecal Contamination Marker

The human-associated HF183 marker was detected in 9% (9/100) samples (see Figure 1). Hilton Beach had 1 (of 13 samples submitted) positive detection, King-Lincoln Park had 1 (of 7 submitted), 10th View had 1 (of 7 submitted), 27th Bay had 1 (of 4 submitted), Captains Quarters had 1 (of 5 samples submitted), Sarah Constant Park had 2 (of 5 samples submitted), Lesner Bridge East had 1 (of 3 samples submitted), and Cape Charles had 1 (of 1 sample submitted). Of the 9 positive detections only one sample—Sarah Constant Park—was greater than the unofficial action value of 1000, but it did not exceed the published 4200 gene copies/100 mL ‘recreational’ threshold. Sarah Constant Park was also the only site to have more than one exceedance, however 2 exceedances for the entire beach season is far from chronic detection. It should be noted that the 9% of samples were on a subset of samples that had elevated bacteria. The true positive percentage of samples over the entire beach season would be much less.

Caution should be taken when interpreting positive (or negative) detections at recreational beaches. Samples collected are taken at recreational water bodies that can dilute positive signals and are at risk of signal degradation by environmental factors (e.g. UV inactivation). Beaches with strong evidence of chronic contamination should undergo surveys that screen potential contaminant inputs (e.g. stormwater inputs) using human-associated markers. Overall there is not evidence at these beaches of chronic issues—these sporadic human detections could be due to capacity related issues or isolated events.

Many municipalities are already collaborating with HRSD on targeted microbial source tracking projects that are using the HF183 and other human-associated markers in collection systems. This approach avoids dilution and degradation of molecular markers. Beaches with chronic enterococci exceedances or beaches that have had positive MST markers in past beach seasons should consider working on more targeted approaches with local partners.

Recommendations:

- Follow up on beaches that have had positive human-associated marker detections in the past with targeted investigations (e.g. beach sanitary surveys)
- Coordinate with HRSD and appropriate stakeholders for a more intensive and comprehensive screening of potential sewage delivery conduits (e.g. stormwater outfalls)
- Investigate the feasibility of an adaptive monitoring program that takes into account wet weather
- Investigate the appropriateness of novel fecal indicators in comparison to the currently used indicators

Tables/Figures:

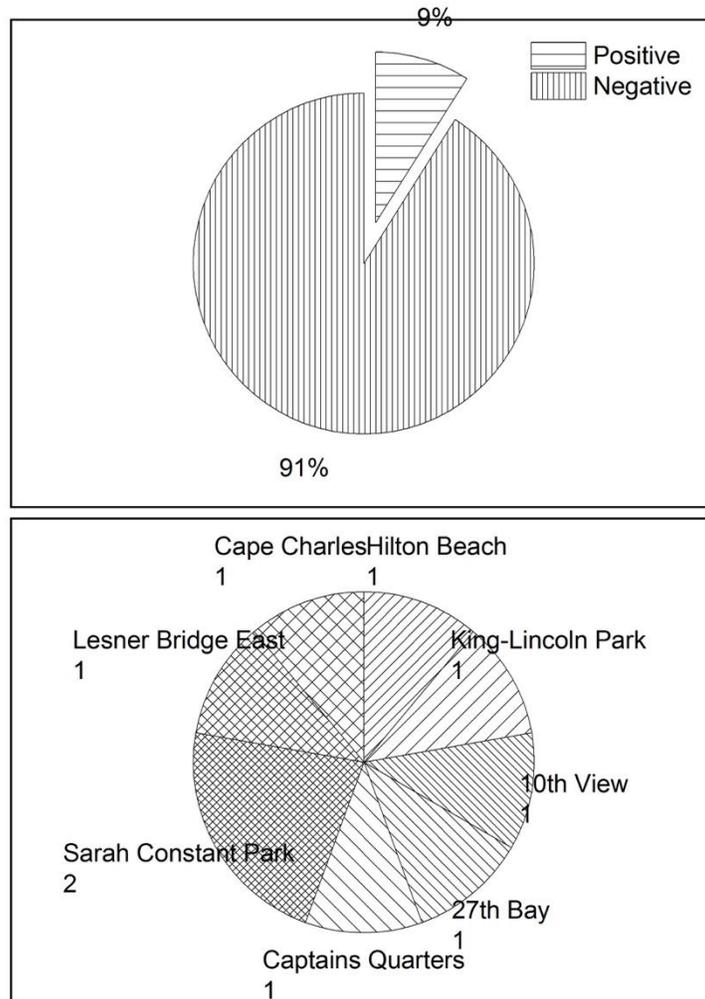
Table 1. Dates, locations, volumes, and results for HRSD processed samples. Positive samples are those greater than the detection limit.

Date	Location	Sample Volume (mL)	HF183 gene copies/100 mL	Outcome
5/29/18	Anderson	100	<168	Negative
5/29/18	Buckroe South	200	<84	Negative
5/29/18	King-Lincoln Park	200	<84	Negative
5/29/18	Croatan	74	<227	Negative
5/29/18	Lesner Bridge E	83	<202	Negative
5/29/18	Chesapeake Bch	50	<336	Negative
5/29/18	Captains Qrts	83	<202	Negative
6/4/18	27th Bay	93	<181	Negative
6/4/18	21st Bay	95	<177	Negative
6/4/18	5th Bay	93	<181	Negative
6/4/18	Capeview Ave	92	<183	Negative
6/4/18	North Comm Bch	91	<185	Negative
6/4/18	Ocean View Park	90	<187	Negative
6/4/18	Sarah Constant	92	<183	Negative
6/4/18	10thView	94	<179	Negative
6/4/18	13thView	97	<173	Negative
6/4/18	Captains Qrts	90	<187	Negative
6/5/18	27th Bay	100	<168	Negative
6/5/18	21st Bay	100	<168	Negative
6/5/18	5th Bay	100	<168	Negative
6/5/18	Capeview Ave	100	<168	Negative
6/5/18	North Comm Bch	100	<168	Negative
6/5/18	Ocean View Park	100	<168	Negative
6/5/18	Sarah Constant	100	<168	Negative
6/5/18	10thView	100	<168	Negative
6/5/18	13thView	100	<168	Negative
6/12/18	Ft._Monroe	98	<171	Negative
5/29/18	Yorktown_1	100	<168	Negative
6/25/18	10 th View	100	<168	Negative
6/25/18	North Comm	100	<168	Negative
6/26/18	10thView	100	<168	Negative
6/26/18	North Comm	100	<168	Negative
6/26/18	King Lincoln	100	<168	Negative
6/27/18	King Lincoln	100	<168	Negative
7/2/18	Buckroe South	100	<168	Negative
7/3/18	Buckroe South	100	<168	Negative

7/5/18	Buckroe South	100	<168	Negative
7/23/18	Sarah Const	100	1170	Positive
7/23/18	Captains Qrts	100	<168	Negative
7/24/18	Sarah Const	100	183	Positive
7/24/18	Captains Qrts	100	<168	Negative
7/24/18	King Lincoln	100	400	Positive
7/24/18	Anderson	100	<168	Negative
7/24/18	Buckroe South	100	<168	Negative
7/24/18	15th	81	<207	Negative
7/24/18	Lesner BRDG	80	208	Positive
7/25/18	Buckroe South	100	<168	Negative
7/25/18	Anderson	100	<168	Negative
7/25/18	Huntington	100	<168	Negative
7/25/18	15th	100	<168	Negative
7/25/18	Lesner BRDG	100	<168	Negative
7/26/18	Anderson	100	<168	Negative
7/26/18	Buckroe South	100	<168	Negative
7/26/18	Buckroe M	100	<168	Negative
8/1/18	Anderson	100	<168	Negative
7/31/18	Cape Charles	100	300	Positive
8/2/18	Anderson	100	<168	Negative
8/2/18	Huntington	86	<195	Negative
8/2/18	Yorktown_1	100	<168	Negative
8/7/18	Anderson	100	<168	Negative
8/7/18	Festival Beach	100	<168	Negative
8/13/18	10 th View	86	<195	Negative
8/14/18	10 th View	100	567	Positive
8/14/18	Anderson	100	<168	Negative
8/14/18	Huntington	100	<168	Negative
8/14/18	King Lincoln	100	<168	Negative
8/14/18	Buckroe S	100	<168	Negative
8/15/18	Anderson	100	<168	Negative
8/15/18	Huntington	100	<168	Negative
8/15/18	King Lincoln	100	<168	Negative
8/20/18	27 th Bay	96	<175	Negative
8/20/18	5 th Bay	94	<179	Negative
8/20/18	Capeview Ave	100	<168	Negative
8/20/18	North Comm	96	<175	Negative
8/21/18	27 th Bay	100	167	Positive
8/21/18	5 th Bay	100	<168	Negative
8/21/18	Capeview Ave	100	<168	Negative
8/21/18	North Comm	100	<168	Negative
8/21/18	King Lincoln	100	<168	Negative

8/21/18	Buckroe S	100	<168	Negative
8/28/18	Buckroe S	100	<168	Negative
9/10/18	North Comm	100	<168	Negative
9/10/18	10 th View	100	<168	Negative
9/10/18	Sarah Coast	100	<168	Negative
9/10/18	Captains Qrts	99	202	Positive
9/10/18	13 th View	100	<168	Negative
9/10/18	Ocean View	100	<168	Negative
8/28/18	Hilton Beach	200	<84	Negative
8/22/18	Hilton Beach	200	<84	Negative
8/21/18	Hilton Beach	200	<84	Negative
8/8/18	Hilton Beach	200	<84	Negative
8/7/18	Hilton Beach	200	<84	Negative
8/2/18	Hilton Beach	200	<84	Negative
8/1/18	Hilton Beach	200	<84	Negative
7/26/18	Hilton Beach	200	22	Positive
7/25/18	Hilton Beach	200	<84	Negative
7/24/18	Hilton Beach	200	<84	Negative
7/17/18	Hilton Beach	200	<84	Negative
6/5/18	Hilton Beach	200	<84	Negative
5/29/18	Hilton Beach	200	<84	Negative

Figure 1. Top panel: overall percentage of HF183 positive samples for the samples submitted. Bottom panel: beach locations that were positive for the human-associated marker.



References:

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Gonzalez, D.J., Curtis, M.K., Denby, J. M., Thompson, H. B., Larson, A.R., Worley-Morse, T.O., Wilson, C. A., and R.A. (2018) Gonzalez. Intra-daily Variability of Fecal Indicators and Enteric Pathogens in Water Resource Recovery Facilities. Submitted.

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