Environmental and Public Health Engineering

MEMORANDUM

TO: **Allen Smith and Greg Baeza, City of Foster City**

FROM: **Bonnie de Berry, EOA, Inc.**

DATE: **September 7, 2021**

SUBJECT: **Foster City Lagoon Monitoring (March – August, 2021)**

1. INTRODUCTION

On June 30, 2020, Heal the Bay published the 2019-2020 Beach Bummer List[1], a ranking of the ten most polluted beaches in California based on levels of Fecal Indicator Bacteria (FIB). Heal the Bay's data sources include weekly data collected by the County of San Mateo (County) Division of Environmental Health Services (EHS) at public beaches in the County. Erckenbrack Park, a beach on the Foster City Lagoon, appeared on the list for the first time, at number four (4). In response to this ranking, City of Foster City (City) staff contracted with EOA, Inc. (EOA) to assist in a preliminary evaluation of potential sources of FIB to the Foster City Lagoon, with a focus on Erckenbrack Park. On February 24, 2021, EOA, in coordination with City staff, developed the Foster City Lagoon FIB Monitoring Program.

This Technical Memorandum summarizes results from the Lagoon FIB Monitoring Program for the period of March 15 – August 23, 2021. It also includes a discussion on potential FIB sources to the Lagoon and recommends mitigation measures for consideration.

2. ENVIRONMENTAL SETTING

The Foster City Lagoon is a man-made system that follows the meandering shape of a historic sough that was once present in the area (Figure 1). It is an essential component of the original 1960 Master Plan for what was to become Foster City. The Lagoon was completed in 1971 and is designed for recreational use and to serve as a drainage detention basin to capture runoff from the 100-year storm event. The water within the lagoon consists of a mixture of water from the San Francisco Bay (via Belmont Slough) and stormwater runoff from the majority of the City (2,313 acres) collected and conveyed through curb inlets, catch basins, and storm drains, i.e., the municipal separate storm sewer system (MS4).

The Lagoon holds approximately 424 million gallons of water. Its main channel is about 4.5 miles in length and ranges from 200 to 1,000 feet in width. The average maximum depth is six feet. The water level of the Lagoon is managed by the City. Water is allowed to enter the Lagoon via tidal inflows from Belmont Slough, controlled by a system of motorized slide gates located at the southwest end of the channel (Figure 1). Water levels in the Lagoon are lowered by gravity outflow and pumping to San Francisco Bay. During the winter (November 15 through March 15), water level is maintained at an elevation of 97.75 to 98.25 feet. When a major storm is predicted, water level is lowered to 97.0 feet to provide storage capacity for stormwater runoff. During the summer (March 15 through November 15),

[1] https://healthebay.org/wp-content/uploads/2020/06/Report-2020_web.pdf

water level is maintained at an elevation of approximately 99.0 feet, which provides for maximum water oriented recreational opportunities and aesthetics.

Throughout the year, Lagoon water is exchanged with Bay water on a weekly or monthly basis. The frequency of water exchange is driven by competing water quality needs. More frequent exchange allows for higher dissolved oxygen, aeration, and reduction of stagnant corners; however, the high nitrogen in Belmont Slough waters can result in increased algae production. Algae is primarily controlled by application of commercial dye, which restricts penetration of light needed for algae growth and results in a pleasing color. On rare occasions (less than one time per year), the City has also used aquatic herbicides to control algae in the Lagoon.

The Foster City Lagoon is a treasured recreational amenity where residents engage in swimming, windsurfing, paddle boarding, kayaking, and electric boating. There are seven parks along its 16.5-mile shoreline, including three with swimming beaches (Erckenbrack Park, Gull Park, and Marlin Park). The majority of the shoreline is owned by private residents and businesses, many of which have private boat docks.

3. SUMMARY OF LAGOON FIB MONITORING PROGRAM

The Lagoon FIB Monitoring Program includes collection of grab samples from the beach at Erckenbrack Park approximately every other week, and analysis of the samples for FIB and genetic markers of FIB. The primary goal of the Monitoring Program is to begin investigating sources of bacteria to the Foster City Lagoon and the seasonal variability in such sources. A secondary goal is to confirm data collected by County EHS.

- **Sample Station**. The Erckenbrack Park beach monitoring station is considered representative of the types of conditions that also occur at other beaches within the Foster City Lagoon (i.e., Gull Park beach and Marlin Park beach). However, for reasons unknown, Erckenbrack beach frequently has higher bacteria levels than the other Lagoon beaches. The Lagoon and all three Lagoon beaches are shown in Figure 1.
- **Schedule**. Samples are collected approximately every other week on Monday mornings, which is when EHS collects their weekly samples that are used for beach warning notifications. City sampling commenced on March 15, 2021. Specific monitoring dates are listed in Table 1.
- **Parameters**. Samples are analyzed for FIB and genetic markers of FIB.
    - **FIB.** Samples are analyzed for enterococci using method SM9230D by Cel Analytical, Inc. (Cel Analytical), in San Francisco, CA. Enterococci is the sole indicator now used by the State Water Resources Control Board (State Water Board) for the protection of recreational uses from the effects of pathogens in brackish inland surface waters, enclosed bays, and estuaries, such as the Foster City Lagoon. For single samples, the State Water Board's water quality objective (WQO) for enterococci is 110 cfu/100 mL.[2] It should be noted that, in addition to enterococci, County EHS also analyzes samples for total coliform and *E. coli*, and bases beach notifications on these indicators. However, total coliform and *E. coli* are no longer used by the State Water Board when making decisions about Clean Water Act (CWA) Section 303(d) impaired waterbody listings or subsequent development of Total Maximum Daily Loads (TMDLs).

[2] Colony forming units (cfu)/100 mL is used interchangeably with most probable number of colonies (MPN)/100 mL.

- **Genetic Markers**. Samples collected by the City at Erckenbrack Park are analyzed by Cel Analytical for host-specific bacteroides using quantitative polymerase chain reaction (qPCR) techniques to measure DNA. All samples are analyzed for human markers (method HF183), dog markers (DogBac), and goose markers (CGOF1). A small subset of the samples are analyzed for sea gull markers. The qPCR results are provided in units of gene copies per mL (gc/mL), a unit that is not directly comparable to the enterococci results which are reported as MPN/100 mL. Table 1 lists the markers that were targeted during each monitoring event for the period of March 15 through August 23, 2021. Human sources of fecal contamination pose the greatest potential threat to recreational uses because they are more likely to contain human pathogens. Dog markers were included in the Sampling Design because, along with human sources, dog sources of bacteria are considered to be "controllable" types of sources. Goose sources of bacteria are likely in the Lagoon as goose presence at the beaches is well established. Sea gull markers were included in the Lagoon FIB Monitoring Program due to the proximity of the Lagoon to San Francisco Bay where sea gulls are commonly found.

- **Quality Assurance/Quality Control (QA/QC)**. The Lagoon FIB Monitoring Program includes QA/QC measures and Data Quality Objectives (DQOs) such that all data will be comparable with the California State Water Board Surface Water Ambient Monitoring Program (SWAMP). Field QA/QC samples include field duplicates and field blanks collected at the frequencies shown in Table 1. Field duplicates are used to estimate sampling and laboratory precision. Field blanks provide an assessment of the sample collection techniques. All samples are collected and analyzed using the methods and protocols specified by SWAMP, and are consistent with those implemented by EHS.

Table 1. Foster City Lagoon Monitoring Events and Parameters. All samples were collected at the Erckenbrack Park beach.

Monitoring Date (2021)	Analytical Parameters (method)					Field Duplicate	Field Blank
	Enterococci (SM9230D)	Human (HF183)	Dog (DogBact)	Goose (CGOF1)	Sea Gull		
Mar 15	X	X	X	X	X	X	X
Mar 29	X	X	X	X			
Apr 5	X	X	X	X			
Apr 19	X	X	X	X	X		
May 3	X	X	X	X		X	X
May 17	X	X	X	X			
Jun 7	X	X	X	X	X		
Jun 21	X	X	X	X			
Jul 12	X	X	X	X			
Jul 26	X	X	X	X	X	X	X
Aug 9	X	X	X	X			
Aug 23	X	X	X	X			

4. LAGOON MONITORING RESULTS

This section presents the Lagoon Monitoring Results. Recommendations for control of FIB in the Lagoon are presented in the next section. Analytical laboratory results from the twelve monitoring events are listed in Table 2. Table 2 also includes enterococci results for all three Lagoon beaches provided by County EHS (Erckenbrack Park, Gull Park and Marlin Park). The locations of the three parks are shown in Figure 1. Key observations noted by City staff about potential bacteria sources at the time of sample collection are shown in Table 3.

4.1. Enterococci

4.1.1. Data Results

Enterococci is the sole indicator bacteria now used by the State Water Board for the protection of water contact recreational uses. Three (3) of the twelve (12) samples collected by the City (April 5, June 21, and August 23) had enterococci concentrations above the WQO (i.e., 110 MPN/100 mL), and a fourth sample (March 15) had an enterococci concentration approaching the WQO. This represents an exceedance rate of 25% of the dataset. The County data for Erckenbrack Park beach, which was collected weekly and has 23 data points during the March 15 through August 23 monitoring period, has a WQO exceedance rate of 35%. The WQO exceedance rates for Gull Park and Marlin Park in the County dataset were lower, at 0% and 13% respectively. It is currently unknown why enterococci concentrations are lower at Gull Park and Marlin Park.

There were no obvious seasonal patterns in the City and County datasets for the March 15 through August 23 monitoring period. The samples with high enterococci concentrations were spread evenly throughout monitoring period in the City and County datasets. There is also a lack of an obvious seasonal pattern in enterococci concentrations in the full County dataset which began on March 6, 2017 (Figure 2). Although sampling by the City commenced during the wet season, conditions were remarkably dry throughout the monitoring period. The 2020-2021 wet season was one of the driest on record for most precipitation stations in California, including those in the Bay Area.

Field observations of potential bacteria sources, such as the presence of dogs, people, wildlife, and their feces are presented in Table 3. There is no apparent connection between the number of wildlife or feces observed and the concentration of enterococci.

Table 2. Analytical Results of Foster City Erckenbrack Park Monitoring. County EHS Beach Monitoring Data for all Lagoon beaches shown for comparison. Enterococci values above the WQO (110 MPN/100 mL) are highlighted with bold font.

	Foster City FIB Monitoring					County Beaches Monitoring			
	Erckenbrack Park					Erckenbrack		Gull Park	Marlin
	Human (HF183)	Dog (DogBact)	Goose (CGOF1)	Sea Gull (lee sea gull)	Enterococci (City)	Enterococci (County)	Relative Percent Difference (City vs. County)	Enterococci (County)	Enterococci (County)
	(gc/mL)	*(gc/mL)*	*(gc/mL)*	*(gc/mL)*	*(MPN/100 mL)*	*(MPN/100 mL)*	*(%)*	*(MPN/100 mL)*	*(MPN/100 mL)*
State Water Board Water Quality Objective (WQO):					*110*	*110*	--	*110*	*110*
3/15/2021	ND	ND	ND	**2135**	108	52	70%	10	20
3/22/2021	--	--	--	--	--	**441**	--	20	**644**
3/29/2021	ND	5.2 DBLOD	ND	--	31	20	43%	75	30
4/5/2021	ND	2 DBLOD	**19**	--	**144**	**211**	38%	10	31
4/12/2021	--	--	--	--	--	51	--	20	10
4/19/2021	ND	2 DBLOD	2 DBLOD	ND	<10	**581**	193%	20	52
4/26/2021	--	--	--	--	--	20	--	41	10
5/3/2021	ND	ND	ND	--	20	41	69%	72	**465**
5/10/2021	--	--	--	--	--	10	--	62	52
5/17/2021	ND	ND	ND	--	10	10	0%	10	31
5/24/2021	--	--	--	--	--	97	--	30	41
6/1/2021	--	--	--	--	--	**121**	--	20	31
6/7/2021	ND	ND	**2121**	ND	84	20	123%	20	52
6/14/2021	--	--	--	--	--	**275**	--	50	10
6/21/2021	ND	ND	**172**	--	**712**	95	153%	41	74
6/28/2021	--	--	--	--	--	**185**	--	97	63
7/5/2021	--	--	--	--	--	--	--	--	--
7/12/2021	ND	ND	ND	--	30	63	71%	52	52
7/19/2021	--	--	--	--	--	**299**	--	31	30
7/26/2021	ND	ND	ND	ND	20 *	52 *	89%	10	31
8/2/2021	--	--	--	--	--S	**288**	--	41	52
8/9/2021	ND	ND	ND	--	50	31	47%	20	41
8/16/2021	--	--	--	--	--	86	--	31	10
8/23/2021	ND	ND	ND	--	**121**	85	35%	<10	**241**
Percent of samples that exceed WQO (110 MPN/100 mL):					25%	35%	--	0%	13%

DBLOD = Detected Blow Limit of Detection (used for PCR analysis only), ND = Not Detected

* On 7/26/21, the City and County analyzed samples collected from the same bottle (i.e., a split sample). All other samples were collected in separate bottles.

Figure 1. Foster City Lagoon (image provided by City of Foster City with notations by EOA).

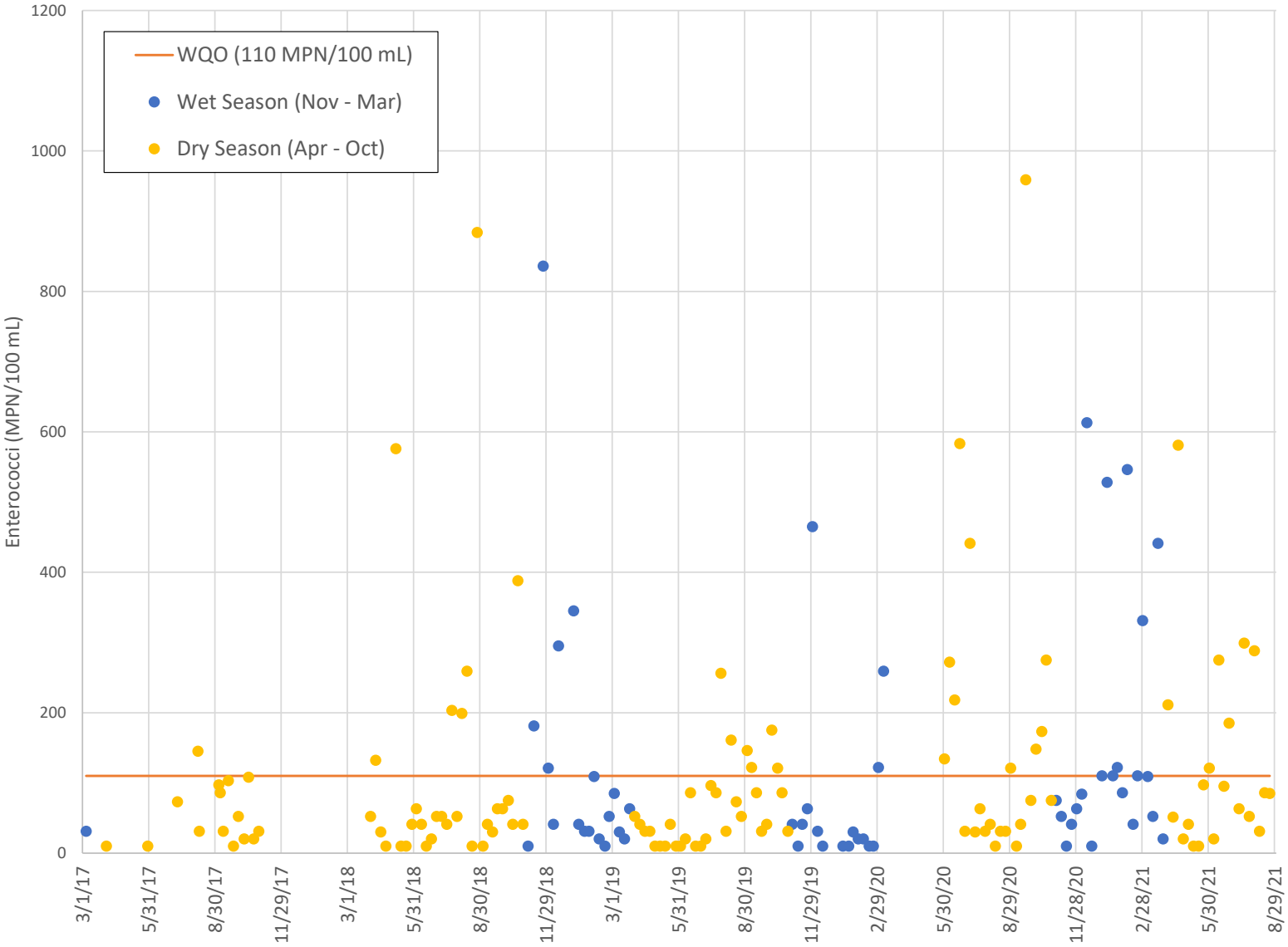

Figure 2. Enterococci Concentrations Reported by County EHS for Erckenbrack Park Beach, March 6, 2017 – August 23, 2021.

Table 3. Field Observations of Potential Bacteria Sources during Monitoring Events at Erckenbrack Park Beach. Dates with enterococci WQO exceedances are highlighted. Dates with detections of species-specific markers of goose, dog, and sea gull are highlighted in the relevant cells. No human markers were detected in this study.

	Potential Bacteria Sources							
Date (2021)	**Geese Present (Individuals)**	**Goose Feces Present on Beach**	**Goose Feces Present in Water**	**Goose Feces Level of Contamination**	**Dogs Present (Individuals)**	**Dog Feces Present (# of Waste Piles)**	**People Present (Individuals)**	**Other Animals Present**
Mar 15	5-20	Yes	Yes	Light	No	None	None	Ducks, 15 Seagull, 15
Mar 29	1-5	Yes	No	NR	Yes, 1	None	1-5	Ducks
Apr 5	None	No	No	No Visible Feces	No	None	1-5	None
Apr 19	None	No	No	No Visible Feces	No	None	None	None
May 3	5-20	Yes	No	NR	No	1-5	1-5	Seagulls, 2
May 17	None	No	No	No Visible Feces	No	None	1-5	None
Jun 7	5-20	Yes	Yes	Light	No	None	1-5	Ducks, Crows
Jun 21	>20	Yes	No	Light	No	None	None	Ducks, 5
Jul 12	None	Yes	No	No Visible Feces	No	None	1-5	None
Jul 26	5-20	Yes	No	Light	Yes, 2	NR	1-5	NR
Aug 9	None	Yes	No	Light	No	None	None	Duck, 5-10
Aug 23	None	Yes	No	Moderate	No	None	None	Ducks, Crows

NR = Not Reported (the field sheet was left blank for this parameter)

4.1.2. City County Comparison

Sample results by the City and County were compared by calculating the Relative Percent Difference (RPD)[3]. For the Lagoon FIB Monitoring Program an RPD of 100 percent is considered acceptable.

In June 2021, a preliminary review of the data suggested that there was sometimes poor alignment between the enterococci results from City samples and enterococci results at Erckenbrack Park from County samples. In particular, on April 19, the City sample had an enterococci concentration of <10 MPN/100 mL (i.e., the result was below the detection limit); whereas the County reported an enterococci concentration of 581 MPN/100 mL (Table 2). City staff confirmed that all samples were collected in close geographic proximity and near in time to those collected by the County, and the City's contract laboratory, Cel Analytical, confirmed that both laboratories use the same analytical method (SM9230D). As should be standard with microbial samples collected from brackish water, both laboratories dilute the samples by a factor of ten (10) to reduce potential interference in the analysis caused by high salinity.

In order to investigate whether the differences were caused by laboratory error, the City and Cel Analytical coordinated a split sampling event with the County field crew on July 26, 2021. The split

[3] The RPD is calculated by dividing the difference between the two samples by the average of the two samples.

sampling protocol involved collecting a single sample in the field and pouring that sample into two separate bottles for analysis by each lab. The enterococci results for the July 26 split sample were 20 MPN/100 mL and 52 MPN/100 mL for the City and County laboratories, respectively. The enterococci RPD on July 26 was 89%, which is within the expected range for natural variability in the enterococci method.

The RPD between the City and County samples is shown for the full dataset in Table 2. These overall RPD results combined with the findings from the July 26 split sample event highlight the high variability in FIB common to surface waters. In general, large sites, such as Erckenbrack Beach or the Lagoon, should be characterized using the geometric mean of several discrete samples collected at multiple locations (USEPA 2010). However, both the City and County monitoring programs are constrained by limited resources. Bacterial autoaggregation, or the formation of suspended bacterial clumps in the Lagoon, could also help explain the differences between City and County results (Trunk and others 2018). With the exception of the July 26 sample, the City and County collected separate samples from the Lagoon, albeit close in time and proximity. It is possible that clumps of bacteria were present in the Lagoon and were captured in one sample but not the other.

4.2. Human Sources of Bacteria

Human sources of bacteria represent the greatest threat to water contact recreation in the Lagoon because human fecal matter contains a greater number of human pathogens than other fecal sources. In addition, human sources of FIB (e.g., leakage from the private or municipal sanitary sewer system, discharge from recreational vehicles (RVs), homeless encampments, recreators defecating in the Lagoon, seepage from dumpsters containing human waste) are more controllable than many other FIB sources, such as wildlife, and therefore represent a potential opportunity for FIB reduction in the Lagoon. For this reason, the Lagoon Monitoring Program emphasizes the investigation of human sources of FIB by analyzing all samples for human-specific markers using the HF183 method.

Table 2 shows the results of the human marker analyses. None (0) of the twelve (12) samples collected by the City during the March 15 through August 23 monitoring period had detectable concentrations of human markers. These findings suggest that there were are no sources of human waste present at Erckenbrack Park beach during the monitoring events. Exceedances of the enterococci WQOs in the City and County datasets are likely caused by other sources of FIB.

4.3. Dog Sources of Bacteria

Dog (or canine) sources of bacteria in the Lagoon include wash-off of dog waste from upland areas to the Lagoon or MS4, dogs defecating in the Lagoon, and seepage from dumpsters containing dog waste. These sources of FIB are generally considered controllable because pet owners could be educated on proper pet waste management and encouraged to do so through incentive programs. All twelve (12) samples were analyzed for dog-specific markers.

Table 2 shows the results of the dog marker analyses. None (0) of the twelve (12) samples had concentrations of the dog marker above the method detection limit (MDL). However, three (3) samples collected early in the monitoring period (March 29, April 5, April 19) had detectable dog marker concentrations below the MDL. These concentrations are flagged in the dataset with “DBLOD” (Detected Below Limit of Dection), a qualifier that is used for PCR analysis only. The flagged results should be interpreted with caution because they are below the threshold that signifies confidence in the data. Nevertheless, it possible that there was a weak dog waste signal during the March 29, April 5, and April 19 monitoring events. On one of these days, March 29, the City field crew observed one (1) dog at Erckenbrack beach (Table 3). Two (2) dogs were observed on the morning of July 26 and a small number of dog waste piles (i.e., 1 to 5) were observed on May 3; no dog markers were detected on these dates.

Neither dogs nor dog waste piles were observed during any other monitoring events; however, monitoring occurred on Monday mornings and it is possible that dogs were brought to the beach at other times.

These findings suggest that there is opportunity for the City to control dog waste and potentially reduce the concentration of FIB in the Lagoon. However, full control of dog waste will likely not result in reductions of enterococci in Lagoon beach waters to below the WQO of 110 MPN/100 mL, as evidenced by enterococci WQO exceedances in samples collected by the City on two (2) days when no dog markers were detected.

4.4. Goose Sources of Bacteria

The presence of geese at the Foster City Lagoon beaches, and at other parks in the region, is a well-known problem that occurs year-round. As a result, the City has coordinated with the nearby Cities of Belmont, San Mateo, and Redwood City for the past seven (7) years to cooperatively track and attempt to control the goose population. Despite measures such as dog hazing, strobe lights, and egg addling, the Foster City goose population during the June 2021 census was 323 individual birds, almost double the count from June 2020, and well above the highest number that was observed over the last four (4) years of census records (Hall 2021). The entire region is experiencing growth in the goose population for unknown reasons.

Geese were present during six (6) of the twelve (12) Monday morning monitoring events (Table 3). Goose feces were observed on the beach at Erckenbrack Park during nine (9) monitoring events and in the water during two (2) events. These observations from the Lagoon Monitoring Program confirm that geese remain an issue at Erckenbrack Park. Furthermore, goose-specific genetic markers were detected in four (4) of the twelve (12) samples (Table 2). Although there was no obvious relationship between goose individual/feces observations and the enterococci concentrations or goose marker detections, these overall findings still suggest that goose waste is an ongoing contributor to FIB in the Lagoon. It is possible that control of goose waste could result in reductions of enterococci in beach waters to below the WQO of 110 MPN/100 mL.

4.5. Sea Gull Sources of Bacteria

Sea gulls are frequent visitors to the Lagoon and invariably contribute to FIB in the Lagoon and to the presence generic bird waste found all around the Lagoon. Although the City is not involved in actions to control sea gull or other non-goose avian/waterfowl populations, they occasionally implement bird waste clean-up actions. For example, on July 19, 2021, the City removed approximately 250 gallons of bird waste from the Lagoon abutment below Shell Bridge. City staff are careful to prevent discharge of bird waste to the Lagoon during these types of clean-up activities. Sea gull markers were included in the Lagoon Monitoring Program due to the proximity of the Lagoon to San Francisco Bay where sea gulls are commonly found and the availability of laboratory methods to detect the marker; however, due to resource limitations, only four (4) of the twelve (12) samples were analyzed for the sea gull marker.

Table 2 shows that sea gull markers were detected in one (1) (March 15) of the four (4) samples analyzed for this constituent. Table 3 shows that sea gull individuals were observed during two (2) of the twelve (12) Monday morning monitoring events, with the most individuals observed on March 15 when the sea gull marker was detected. These findings suggest that sea gull and other avian species (e.g., ducks, crows) contribute FIB to Erckenbrack Park beach. However, unlike geese, these avian wildlife species have not been identified as a nuisance at Lagoon parks, and options for control are likely limited.

5. SUMMARY AND RECOMMENDATIONS

5.1. Summary

The City of Foster City implemented a Lagoon FIB Monitoring Program from March 15 through August 23, 2021. Twelve (12) water samples were collected from the beach at Erckenbrack Park approximately every other week and analyzed for enterococci and several species-specific genetic markers (human, dog, goose, sea gull).

- Enterococci concentrations continue to be of concern in the Lagoon with exceedances of the WQO (i.e., 110 MPN/100 mL) at a rate of 25% in samples collected by the City. More frequent samples collected by County EHS (i.e., weekly) had a WQO exceedance rate of 35% during the monitoring period.
- Human sources of FIB, which would represent the highest threat to recreational use in the Lagoon, are unlikely based on the monitoring results. None (0) of the twelve (12) samples collected by the City had detections of human genetic markers. This finding supports what is already known about potential human FIB sources in the City. There is not a presence of unhoused people in the City. Furthermore, it is nearly impossible for the municipal sanitary sewer system (SSS) to leak into the MS4 because the SSS is below the ground water table.
- While human waste could contribute enterococci and other FIB to the Lagoon, there are many other sources of FIB, including wildlife and pets. These other sources of fecal material generally pose less of a threat to the health of swimmers compared to human waste because human viruses are generally unlikely to occur in animal feces (USEPA 2012).
    - Dog waste occasionally contributes to FIB in the Lagoon and represents a potential opportunity for control. Even a small amount of dog waste can contribute a large amount of enterococci to the environment. The USEPA estimates that the average dog produces about 0.75 pound (340 grams) of waste per day (USEPA 2001). Wright et al. (2009) estimates that each gram of dog waste contains approximately 3.9×10^7 colony forming units of enterococci (i.e., 39 million cfu; cfu is used interchangeably with MPN). Therefore, one dog could introduce about 13 billion cfu of enterococci to the Lagoon over the course of one day, which could easily result in an exceedance of the WQO of 110 cfu/100 mL in a localized area.
    - The primary source of FIB in the Lagoon appears to be wildlife (i.e., waterfowl such as geese, sea gulls, and ducks). Wright et al. (2009) estimates that bird waste contains approximately 3.3×10^5 cfu per gram (i.e., 330,000 cfu/g).

5.2. Recommendations

In order to reduce the amount of dog waste reaching the Lagoon, the City should review their current public outreach program for opportunities to improve messaging to pet owners. Other pet waste management opportunities include installation of dog waste cleanup stations at parks and along dog-walking trails throughout the City, a “pin-the-poo” program that targets repeat offenders, implementation of a pet waste pledge program with incentives, and direct mailers or emails to pet owners.

The City should continue to work with the nearby Cities of Belmont, Redwood City, and San Mateo to implement and improve the ongoing goose population control measures and goose waste cleanup activities.

5.3. Lagoon Management Considerations

Because FIB in the Lagoon appears to be caused primarily by wildlife populations that are difficult to control, the City should consider Lagoon management actions that create conditions that are favorable to bacteria die-off and/or eliminate/reduce conditions that are favorable to bacteria growth.

Bacteria that enter the Lagoon can continue to grow and increase in concentration through the formation of biofilms. Biofilms form on surfaces such as organic matter (i.e., leaves), structures, and sediments. Biofilms containing enterococci are likely to be found in the sediments on the bottom of the lagoon, in stagnant "corners" of the Lagoon, and on pipe walls in submerged sections of the MS4. Providing more water movement in the Lagoon through more frequent water exchange with Belmont Slough and San Francisco Bay could reduce the formation and growth of biofilms. However, as mentioned above, Belmont slough is relatively high in nutrients; therefore, this measure could result in increased algae growth. It is also possible that inflows from Belmont Slough contain enterococci concentrations above the WQO. Another method of increasing water movement in the Lagoon is the operation of fountains and/or aeration systems. If this measure is adopted, the City should avoid actions that disturb bottom sediments, which could result in resuspension of bacteria.

The City may also want to consider a commercial products advertised for the control of bacteria in lakes and ponds. For example, the City has already met with representatives from Earth Science Laboratories, Inc. to learn about their product, EarthTec, which is a highly biologically active form of copper ion (Cu^{2+}). EarthTec is registered by the USEPA as an algaecide and bactericide for use in lakes, ponds, reservoirs, sedimentation basins, and treatment lagoons. Representatives report that it can control of *E. coli* in laboratory studies within one to 8 hours of application depending on the amount used; however, it may be less effective at control of enterococci. It is possible that such a product could help keep enterococci concentrations at Lagoon beaches below the WQO of 110 MPN/100 mL.

Prior to use of a copper-containing chemical, the City should ensure that they are following required regulatory procedures. For example, all requirements in the State General Permit for the Discharge of Aquatic Pesticides (Order No. 2013-0002-DWQ as amended by Orders 2014-0078-DWQ, 2015-0029-DWQ and 2016-0073-EXEC) must be followed, including development and implementation of an Aquatic Pesticide Application Plan (APAP), compliance with applicable receiving water limitations (including those related to copper), and compliance with monitoring and reporting requirements. Adherence to this General Permit may require that the City request a short-term or seasonal exception from meeting copper receiving water limitations.

The copper receiving water limitations in the Aquatic Pesticides General Permit (Order No. 2013-0002-DWQ) are currently based on the California Toxics Rule. The copper limitation is expressed in dissolved concentration. For freshwater (salinity equal to or less than 1 part per thousand (ppt) 95% or more of the time) the copper limitation is dependent on the hardness of the receiving waters. For waters in which the salinity is equal to or greater than 10 ppt 95% or more of the time, the copper limitation is 3.1 ug/L. For waters in which the salinity is between 1 and 10 ppt, the more stringent limitation applies.

Isolation of the Lagoon from Belmont Slough and San Francisco Bay, which is the standard Lagoon condition when water exchange activities are not occurring, may be necessary during and after application, until copper concentrations have dropped below the Aquatic Pesticides General Permit copper limitations and/or the copper WQOs for San Francisco Bay. Copper WQOs in the segment of San Francisco Bay to which the Lagoon discharges are 6.0 ug/L (4-day average) and 9.4 ug/L (1-hour average) (SFBRWQCB 2017). Lagoon water containing copper concentrations above the copper WQOs should not be discharged to San Francisco Bay. This could impact the timing of the City's controlled water exchanges between the Lagoon and the Bay.

If the City decides to conduct a bacteria control pilot study with EarthTec (or a similar product) and/or if they install an aeration device, they should consider monitoring for enterococci at multiple locations in the Lagoon to assess the effectiveness of the treatment.

5.4. Next Steps

The City is continuing to collect samples approximately every other week through September and October. It is recommended that the City continue to implement the Lagoon Monitoring Program through March 2022 with the goal of generating a full year of MST data, including the wet season when stormwater runoff to the Lagoon is likely to occur.

6. REFERENCES

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