

Memorandum

Date: January 15, 2019
To: Jill Van Wie and Terri Maus-Nisich, County of Santa Barbara
From: Brandon Steets, PE and Jared Ervin, PhD, Geosyntec Consultants
Subject: Goleta Beach Bacteria Evaluation

INTRODUCTION

In early 2018, the County of Santa Barbara (County) requested that Geosyntec Consultants (Geosyntec) provide technical support in addressing elevated levels of fecal indicator bacteria (FIB) in the ocean waters at Goleta Beach. At that time, the ocean waters at Goleta Beach had been closed since January 2018 due to elevated levels of Enterococcus, measured in the surf zone, particularly at the East Buffer Zone¹ sampling location. FIB, including Enterococcus, may originate from both fecal and non-fecal sources. Fecal sources include both human and non-human wastes, and non-fecal sources include plants and soils. The County requested technical support in addressing this issue through an investigation into the source(s) and extent of bacterial contamination at Goleta Beach. The purpose of the investigation was to investigate the following questions, based on the then-existing conditions:

- a) Is beach sand/sediment at this location contributing to persistent surf zone bacteria exceedances?
- b) What is the spatial extent of elevated bacteria levels in the surf zone and sand?
- c) Is human waste a contributing source to bacteria exceedances?

To answer these questions, Geosyntec first analyzed 10 years of County bacteria monitoring data for the ocean at Goleta slough, as well as additional samples collected in 2018 at the East and West Buffer Zone sampling locations. A sampling and analysis program was then conducted in May 2018 to collect data on surf zone and sand bacteria concentrations and the presence of a human fecal DNA marker at multiple locations between the pier and the West Buffer Zone.

The County reopened the ocean waters at Goleta Beach after two consecutive samples came back under the State standards for FIB in July 2018. Since that time, the County has continued to collect weekly samples from the surf zone at the Goleta Slough (AB411) and at the East and

¹ In this document, the “West Buffer Zone” and “East Buffer Zone” sites are additional bacteriological sampling locations used by the County Public Health Department at Goleta Beach as of January 2018.

West Buffer Zones. Geosyntec has reviewed the sampling results from July to October 2018 to evaluate whether bacteria levels remain elevated relative to applicable water quality standards and historic levels at Goleta Beach.

This investigation and analysis serve to help the County better plan management actions to address any elevated bacteria levels at Goleta Beach in the future.

MAY 2018 SAMPLING AND ANALYSIS

Samples were collected near low tide each morning for four consecutive days from May 22nd to May 25th, 2018. Low tide was targeted to allow for sand samples to be collected from the intertidal zone that is exposed at low tide and submerged at high tide. Samples were collected from the surf zone (ankle to knee depth) and sand in the intertidal zone at five locations between the pier and the West Buffer Zone (Figure 1). Multiple samples were collected from each location, immediately placed on ice, and either sent by courier to Capco Analytical Services in Ventura, CA or shipped overnight to Source Molecular Laboratories in Miami, FL.

The human marker (HF183) was analyzed by Source Molecular Laboratories using methods recommended by the California Microbial Source Identification Manual². This marker represents the most sensitive and specific method for the quantification of human fecal bacteria in water and sand samples. Fecal Indicator Bacteria (FIB) including Enterococcus, Fecal Coliform, and Total Coliform, Total Suspended Solids (TSS) in water, suspendable solids in sand, and moisture content in sand were analyzed by Capco Analytical Services. For analysis of human marker, FIB, and TSS in sand samples, 10g of sand was mixed with 100mL of buffer solution, shaken to suspend bacteria and fine particles, allowed to settle, and then the water was analyzed. A summary of the number of samples analyzed for each parameter is included in Table 1.

RESULTS AND DISCUSSION

County Monitoring Data

An analysis of monitoring data collected by the County since 2010 (not shown here) was conducted to determine historical bacteria water quality at Goleta Beach. Enterococcus was selected as the primary bacteria for this analysis because Enterococcus concentrations in the surf zone were elevated from January to July 2018 and were the cause of the ocean water closure during that time. Enterococcus is also the primary fecal indicator bacteria recommended by the United States Environmental Protection Agency for monitoring marine recreational waters³.

² https://www.waterboards.ca.gov/water_issues/programs/beaches/cbi_projects/docs/sipp_manual.pdf

³ <https://www.epa.gov/wqc/2012-recreational-water-quality-criteria>

Concentrations of Enterococcus at the East Buffer Zone sampling location (GB-03, Figure 1) had been consistently high between January and July 2018. While Enterococcus at the West Buffer Zone and AB411 monitoring locations had decreased to concentrations consistently near or below the State single sample standard, the East Buffer Zone remained elevated through June 2018 (Figure 2). Concentrations of Enterococcus at the East Buffer Zone location were decreasing during that time and were expected to fall below the single sample standard in early August. However, due to the high variability in single sample bacteria results, it was expected that future temporary exceedances could still occur for a period after this.

To better assess trends in bacteria over time, a 30-day rolling geometric mean is used, which smooths single sample data variability over a 30-day period. A State geometric mean standard of 35 MPN/100mL Enterococcus is used for comparison; this is a regulatory standard used for assessment of recreational beneficial use attainment, not for beach notification programs (i.e., open/closed status). Enterococcus data for 2017 were plotted (Figure 3) to evaluate recent trends in bacteria levels prior to 2018. While geometric mean concentrations above the State standard do occur in past years, particularly during wet weather or when the slough breaches into the surf zone, concentrations of Enterococcus are generally below the State standard throughout the dry season.

By focusing on the period since February of 2018, trends in the concentration of Enterococcus at Goleta Beach could further be investigated (Figure 4). While the geometric mean concentrations at the West Buffer Zone and AB411 monitoring locations were near or below the geometric mean standard, the East Buffer Zone location remained elevated from February through June 2018. By projecting the trends at the East Buffer Zone location over this period, it was expected that the Enterococcus geometric mean concentration would fall below the geometric mean standard in late-September. This projection was based on 30-day geometric mean Enterococcus concentrations and not single sample results, which are used to determine ocean water status. However, it was expected that when geometric mean concentrations met the standard that single sample concentrations would also consistently meet the single sample standard of 104 MPN/100mL. The late-September projection was based on the 30-day geometric mean from February 1st to June 20th, 2018. This period included a rebound in the geometric mean concentration in mid-April. A review of historical weather and wave patterns in the area suggested that this rebound was likely due to an ocean swell that occurred at this time in which the height of waves and the energy associated with waves were relatively high compared to the rest of 2018. This large swell appeared to have facilitated mobilization of bacteria from sands by exposing and re-suspending new areas of the beach to water.

In general, the spring of 2018 was relatively calm in terms of ocean swell and wave height/energy in the area. These conditions likely contributed to the persistence of Enterococcus concentrations in beach sand, which may be, in part, controlled by wave action which transports

sand along the shoreline within a littoral cell. Summer and fall in the Santa Barbara area are generally calm in terms of ocean swell and waves, and therefore another rebound like that seen in April was unlikely. However, if another swell occurred, bacteria surf zone concentrations could once again rebound, which was accounted for in the beach recovery projection.

May 2018 Field Investigation

For the May 2018 investigation, sampling and analysis was conducted at Goleta Beach from May 22nd to May 25th, 2018 to evaluate current spatial variations in surf zone and sand bacteria concentrations between the pier and the County's West Buffer Zone sampling location and the degree to which human fecal contamination may exist in this area. The five sampling locations were between the County's West Buffer Zone and AB411 monitoring locations with GB-03 in the same location as the East Buffer Zone location (Figure 1). Sampling results for surf zone and sand samples are included in Table 2 and Table 3, respectively.

For surf zone samples, Fecal Coliform and Total Coliform concentrations were generally below the State single sample standards of 400 MPN/100mL and 10,000 MPN/100mL, respectively. There was only one sample measured above this concentration for Fecal Coliform at GOB-03 on May 22nd, 2018. For Enterococcus in surf zone samples, all but three samples were above the State standard of 104 MPN/100mL. Enterococcus was highest at GB-02 and GB-03, with median concentrations of over 1,500 MPN/100mL. Although concentrations decreased to the east of GB-03, surf zone concentrations were above the State standard from GB-01 to the pier at GB-05 (Figure 5). Enterococcus in sand showed a similar trend with higher concentrations at GB-02 decreasing to the east of GB-03 (Figure 6). Both surf zone and sand concentrations of Enterococcus were high at all locations sampled relative to results from samples collected during the summer of 2016 at multiple locations across Goleta Beach as part of a State Water Resources Control Board Clean Beaches Initiative grant-funded microbial source tracking study led by UCSB (Dr. Patricia Holden) and Geosyntec. This suggested that the elevated levels of Enterococcus in the surf zone and intertidal sand stretched from GB-01 to the pier.

To further investigate the impact of sand, concentrations of Enterococcus in the surf zone were normalized by surf zone TSS and concentrations of Enterococcus in sand were normalized by the mass of these solids that remained suspended in a water sample (Figure 7). This allowed for a direct comparison of the concentration of Enterococcus per mass of suspended solids in the surf zone to the concentration of Enterococcus per mass of suspendable solids in sand. The result was that there was over ten times the normalized concentration of Enterococcus in suspendable sand compared to concentrations on suspended solids in the surf zone. This suggested that the sand at Goleta Beach represented a reservoir of bacteria associated with fine particles that were being continually released to the surf zone through wave action and causing surf zone exceedances. This result was consistent with other sand and sediment studies that have found persistent bacteria associated with fines having higher organic carbon content and surface area, which

supports bacteria attachment and persistence, and where conditions are more favorable than other environments, like the surf zone, where UV attenuation is a dominant decay process.

Fecal indicator bacteria, including *Enterococcus*, may originate from both fecal and non-fecal sources. Fecal sources include both human and non-human wastes, and non-fecal sources include plants and soils. Fecal indicator bacteria standards are based on the assumption that human waste is the primary source (human waste-associated pathogens are the primary drivers for waterborne gastrointestinal illnesses, which the standards are based on); therefore, they are conservatively protective even when non-human waste sources predominate. To determine if the bacteria in the surf zone and sand at Goleta Beach were from human waste, such as sewer lines and septic systems, a human DNA marker was analyzed that is capable of detecting sewage diluted up to one million times. The human DNA marker was detected in 50% of surf zone samples collected, with no spatial trend observed, and in 30% of sand samples, with most detections on the west end of the beach (Figure 8). After adjusting these results to the higher detection and quantification limits of the UCSB lab's qPCR analytical methods, these results (both magnitudes and detection rates) were consistent with the results from UCSB researchers during their summer 2016 sampling across Goleta Beach, suggesting that current human marker levels at Goleta Beach remain very low and are similar to levels observed in previous years (i.e., there is no indication of increase). All concentrations measured in the May 2018 samples were below 100 copies/100mL for water and 50 copies/g for sand, which is consistent with results from both the 2016 sampling as well as more recent sampling conducted by UCSB in January and February of 2018. These human marker concentrations are consistent with levels expected in an urban environment such as Goleta Beach. Health relevant concentrations of the human marker used here (HF183) are estimated to be $>1,000$ copies per 100mL⁴. In other words, the marker concentration measured in water at Goleta Beach was more than ten times lower than the concentration that is expected to result in an elevated illness risk through water contact recreation. Results of sampling and analysis performed by UCSB in January and February of 2018 further supported that human waste markers (which decay in the environment) have been low throughout 2018, including when *Enterococcus* concentrations were at their highest.

UCSB also analyzed two pathogens (Human adenovirus and *Salmonella*) in surf zone and mud samples collected in January and February 2018. Pathogen analysis is the most direct measure of waterborne illness causing microorganisms (i.e., more direct than fecal indicator bacteria and human waste DNA markers). Neither pathogen was detected in any of the samples analyzed. These results combined with the previous human marker results from UCSB and the current human marker results suggested that human waste was not likely the source of bacteria at Goleta Beach and that health risks due to water contact recreation or exposure to sand at Goleta Beach were not likely elevated, despite the *Enterococcus* exceedances of the State standard.

⁴ <https://pubs.acs.org/doi/abs/10.1021/acs.estlett.5b00219>

July-October 2018 Sampling Data

After the surf zone at Goleta Beach reopened on July 6, 2018, bacteria concentrations in the majority of samples remained below the State single sample standards; however, intermittent exceedances occurred for Enterococcus and Fecal Coliform (Figure 9, Figure 10). Results from the East Buffer Zone location from July through October exceeded the standards for both Enterococcus and Fecal Coliform in 22% of samples (Table 4). At the West Buffer Zone, 4% of Enterococcus samples and 9% of Fecal Coliform samples exceeded the standards. At Goleta Slough, Fecal Coliform was the only parameter to exceed the standard (4% exceedance rate). Total Coliform concentrations remained below the single sample standard (10,000 MPN/100mL) at all three sampling locations throughout this period (Figure 11).

To evaluate how the bacteria levels in the surf zone after the beach was reopened compare to previous years during the same time period, exceedance rates from July 6, 2018 through the end of October 2018 were compared to exceedance rates from the same time period for the years 2008 to 2017 for Enterococcus and Total Coliform and 2015 to 2017 for Fecal Coliform⁵ at the Goleta Slough (AB411) location (Table 4). Because samples from previous years were only collected at the Goleta Slough location (AB411), historical concentrations of bacteria at the East Buffer Zone and West Buffer Zone are not known and thus could not be compared to historic results. At Goleta Slough, Fecal Coliform was the only parameter with a higher rate of exceedances during the July to October 2018 time period (4%) than historically (3%). However, in 2016, the same number of samples exceeded the standard as in 2018. Exceedance rates for Enterococcus and Total Coliform in 2018 were less than or equal to those observed in previous years.

The occasional single sample exceedances at the East and West Buffer Zone locations in July through October 2018 suggested that the Enterococcus and Fecal Coliform concentrations were still elevated in this localized area of the beach compared to the Goleta Slough location. However, these exceedances did not result in ocean water closures since they were opened because, as was concluded above, there was no evidence that these exceedances represented an unacceptable health risk to the recreating public through water or sand contact. Any lingering effects on bacterial water quality in the surf zone at Goleta Beach were minimal, localized near the East Buffer Zone location, and not likely to persist through the winter when beach sand and sediments are eroded and redistributed through wave action and tides.

⁵ Analysis for Fecal Coliform began in 2015. Prior to this, *E. Coli* was analyzed.

CONCLUSIONS

Based on analysis of the County's monitoring data, work performed by UCSB, and the sampling and analysis conducted in this investigation, the following conclusions were made regarding the elevated bacteria levels at Goleta Beach:

1. Bacteria concentrations, including *Enterococcus*, have continued to decrease at Goleta Beach, including at the East Buffer Zone monitoring location. Average *Enterococcus* concentrations at the East Buffer Zone fell below the State single sample standard in July 2018, slightly earlier than the initial trend analyses suggested. As expected, occasional single sample exceedances occurred during the July to October 2018 period.
2. Elevated surf zone *Enterococcus* concentrations were being caused by elevated concentrations in beach sands/sediments.
3. Surf zone and sand bacteria concentrations were elevated from the pier westward to GB-01, with the highest concentrations located near the East Buffer Zone site.
4. There was no evidence of elevated human waste contamination of beach sand or surf zone water at Goleta Beach in 2018, including when *Enterococcus* concentrations were at their highest. Elevated *Enterococcus* concentrations were therefore believed to be primarily of non-human waste origin, including environmental sources such as soil and bird waste, and beach sand conditions were likely favorable to their persistence.
5. Based on both human marker and virus sampling results, there was no evidence of an elevated health risk through water contact recreation or sand contact at Goleta Beach.

RECOMMENDATIONS

Based on best professional judgement, the County may consider two options in managing water quality at Goleta Beach if similar conditions occur in the future. One option is to remove sand from the beach and the second option is to allow bacteria concentrations to naturally decrease. These options are discussed in more detail in the following sections.

Option 1: Removal of Sand from Goleta Beach

The excavation and removal of sand high in bacteria from an impacted area at Goleta Beach has the potential to expedite a reduction in bacteria levels in the surf zone and sand. While this intervention has the potential to be effective, this option has several potential challenges:

- Excavation could result in environmental impacts including negative impacts to the food web associated with the supratidal and intertidal sands at Goleta Beach. Similar concerns have been raised over other projects involving removal and/or replacement of beach sand, as well as beach grooming and wrack removal at other beaches.
- A study would be needed to determine the extent of sand needing removal. The depth of sand impacted, the area of sand impacted, and the potential for sand in the nearshore (i.e., submerged sand, which could require dredging to remove) to also be a source are all

unknown factors that would need to be investigated to plan an effective and comprehensive excavation that minimizes environmental impacts and removal of clean material which is important for beach protection. Considerable time would be required to plan, collect, and analyze samples to answer these questions.

- Identifying a disposal site for the sand (other than a landfill) could be a potentially long process.
- Excavation and dredging activities would limit public access to Goleta Beach Park.
- Excavation would require permitting, which could be costly, a potentially long process, and delay action.
- The total cost for excavation and disposal could be high, and potentially for little public health benefit if the evidence indicated that there was no elevated illness risk.

The time necessary for a sampling study and permitting could delay any excavation long enough for any surf zone *Enterococcus* exceedances to naturally fall below State standards, making for wasted effort and the potential for unnecessary negative impacts to the environment.

Option 2: Monitored Natural Attenuation

If enterococcus concentrations were decreasing over time through natural processes, the County could use a monitored natural attenuation approach. This passive option would involve close monitoring of FIB, including *Enterococcus*, until bacteria concentrations decreased and there were no longer exceedances of the State standard.

Microbiological Monitoring Recommendations for Future Emergency Beach Operations

The results of this evaluation suggest that while bacteria levels exceeded State standards from January 2018 to July 2018, which resulted in the County's decision to close the ocean water at the beach, microbiological monitoring data were critical to support the determination that there was not an elevated health risk at Goleta Beach. Therefore, recommendations are provided for future microbiological monitoring for emergency operations at County beaches that have the potential to impact bacteria levels and where it is possible that material has been impacted by human waste (e.g., from damaged sanitary sewers and/or septic systems). Sampling locations would consist of surf zone, operational material, and sand to determine whether public health risk is elevated (i.e., whether human waste is present). If future emergency operations are necessary and materials may be impacted by human waste, sampling and analysis for FIB and the human DNA marker should begin as quickly as possible and continue at a regular frequency until pre-operation conditions are restored. If possible, for a subset of samples, it could also be valuable to conduct analysis of human pathogens (especially a virus suite representing typical drivers of waterborne illness) to more directly evaluate the health risk associated with the emergency operations.

LIMITATIONS

The professional opinions and recommendations expressed in this memo are made in accordance with generally accepted standards of practice and no other warranty is either expressed or implied. Geosyntec is responsible for the findings contained in this memo based on the data and information relating only to the specific project and location discussed herein. Geosyntec is not responsible for use of the information contained in this memo for purposes other than those expressly stated in this memo. Geosyntec is not responsible for any conclusions or recommendations made by others based upon the data or conclusions contained herein unless given the opportunity to review them and respond to them in writing.

Table 1. Summary of sampling and analysis conducted during the field investigation, numbers represent the number of samples collected and analyzed, N/A = Not Applicable.

Date	Sample Type	Human Marker	Enterococcus	Fecal Coliform	Total Coliform	TSS	Suspendable Solids	Moisture Content
5/22/2018	Water	5	5	5	5	0	N/A	N/A
	Sand	5	5	5	5	N/A	5	5
5/23/2018	Water	5	5	5	5	0	N/A	N/A
	Sand	5	5	5	5	N/A	5	5
5/24/2018	Water	5	5	5	5	5	N/A	N/A
	Sand	5	5	5	5	N/A	5	5
5/25/2018	Water	5	5	5	5	5	N/A	N/A
	Sand	5	5	5	5	N/A	5	5
Total		40	40	40	40	10	20	20

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Table 2. Laboratory results for water samples collected at Goleta Beach from 5/22 to 5/25, 2018. ND = Not Detected, DNQ = Detected but Not Quantifiable, NS = Not Sampled.

Location	Date	Human Marker (copies/100 mL)	Enterococcus (MPN/100mL)	Fecal Coliform (MPN/100mL)	Total Coliform (MPN/100mL)	TSS (mg/L)
GB-01	5/22/2018	ND	74	168	364	NS
GB-01	5/23/2018	ND	2300	20	504	NS
GB-01	5/24/2018	78.6	840	<10	504	160
GB-01	5/25/2018	68.6	51	<10	85	170
GB-02	5/22/2018	ND	320	288	620	NS
GB-02	5/23/2018	DNQ	2700	73	689	NS
GB-02	5/24/2018	ND	9200	399	682	430
GB-02	5/25/2018	61.4	315	10	272	110
GB-03	5/22/2018	44.3	462	473	631	NS
GB-03	5/23/2018	ND	2700	20	888	NS
GB-03	5/24/2018	DNQ	4400	161	544	190
GB-03	5/25/2018	ND	397	20	638	315
GB-04	5/22/2018	ND	616	145	717	NS
GB-04	5/23/2018	ND	798	10	399	NS
GB-04	5/24/2018	45.7	1800	10	315	190
GB-04	5/25/2018	80	272	<10	350	380
GB-05	5/22/2018	DNQ	85	98	388	NS
GB-05	5/23/2018	ND	155	10	52	NS
GB-05	5/24/2018	ND	730	20	345	190
GB-05	5/25/2018	75.7	631	96	391	220

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Table 3. Laboratory results for sand samples collected at Goleta Beach from 5/22 to 5/25, 2018. ND = Not Detected, DNQ = Detected but Not Quantifiable, results reported on a dry weight basis.

Location	Date	Human Marker (copies/g)	Enterococcus (MPN/g)	Fecal Coliform (MPN/g)	Total Coliform (MPN/g)	Suspendable Solids (mg/Kg)	Moisture (%)
GB-01-Sand	5/22/2018	ND	746	<124	<124	310	19.6
GB-01-Sand	5/23/2018	ND	540	<13	109	280	21.3
GB-01-Sand	5/24/2018	DNQ	1333	44	104	290	10.0
GB-01-Sand	5/25/2018	DNQ	343	<12	132	360	16.2
GB-02-Sand	5/22/2018	33.2	1061	<115	<115	230	13.3
GB-02-Sand	5/23/2018	31.3	641	12	86	480	15.0
GB-02-Sand	5/24/2018	ND	6782	25	359	550	18.9
GB-02-Sand	5/25/2018	ND	913	<11	332	570	12.4
GB-03-Sand	5/22/2018	ND	118	<118	<118	250	15.5
GB-03-Sand	5/23/2018	ND	472	12	75	345	15.9
GB-03-Sand	5/24/2018	DNQ	2051	26	187	930	22.0
GB-03-Sand	5/25/2018	ND	1116	<11	185	670	12.0
GB-04-Sand	5/22/2018	ND	654	<109	<109	280	8.3
GB-04-Sand	5/23/2018	ND	534	<12	138	330	17.6
GB-04-Sand	5/24/2018	29.4	6170	13	67	350	22.2
GB-04-Sand	5/25/2018	ND	448	13	20699	560	22.7
GB-05-Sand	5/22/2018	ND	578	<116	<116	220	13.5
GB-05-Sand	5/23/2018	ND	480	<12	96	300	16.0
GB-05-Sand	5/24/2018	ND	225	11	300	390	12.8
GB-05-Sand	5/25/2018	ND	234	81	213	210	11.2

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Table 4. Percent of samples collected between July 6 and October 31 exceeding the single sample standards of 104 MPN/100mL for Enterococcus, 400 MPN/100mL for Fecal Coliform, and 10,000 MPN/100mL for Total Coliform.

Location	Date	Enterococcus	Fecal Coliform	Total Coliform
West Buffer Zone	2018	4%	9%	0%
East Buffer Zone	2018	22%	22%	0%
AB411 at Slough	2018	0%	4%	0%
	Historical (2008-2017)*	6%	3%	0%

*Analysis for Fecal Coliform began in 2015



Figure 1. Goleta Beach sampling locations.

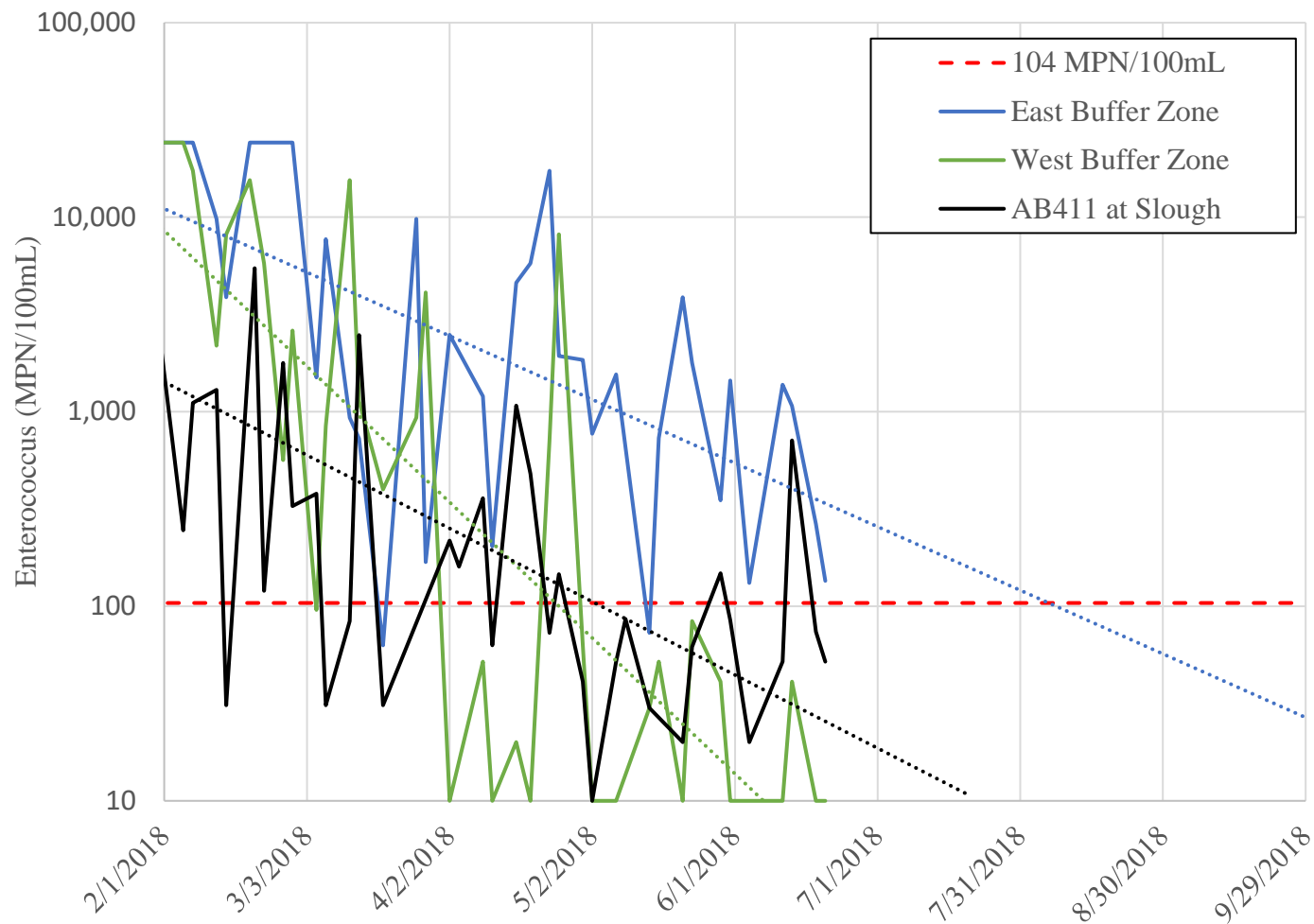


Figure 2. Single sample Enterococcus concentrations at Goleta Beach monitoring locations, for February – June 2018 relative to the 104 MPN/100mL single sample standard.

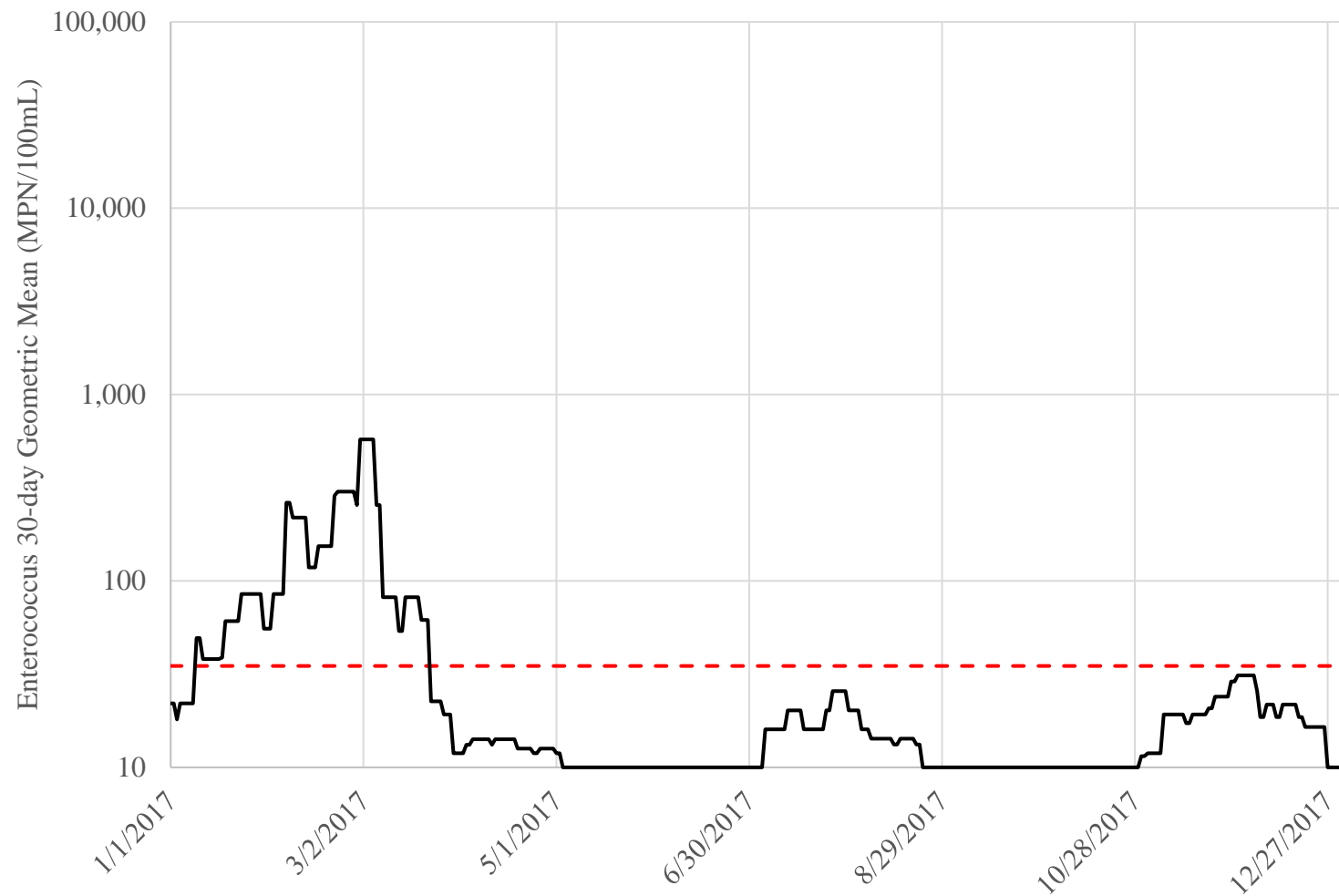


Figure 3. 30-day rolling geometric mean Enterococcus concentrations at Goleta Beach monitoring locations for 2017 relative to the 35 MPN/100mL geometric mean standard.

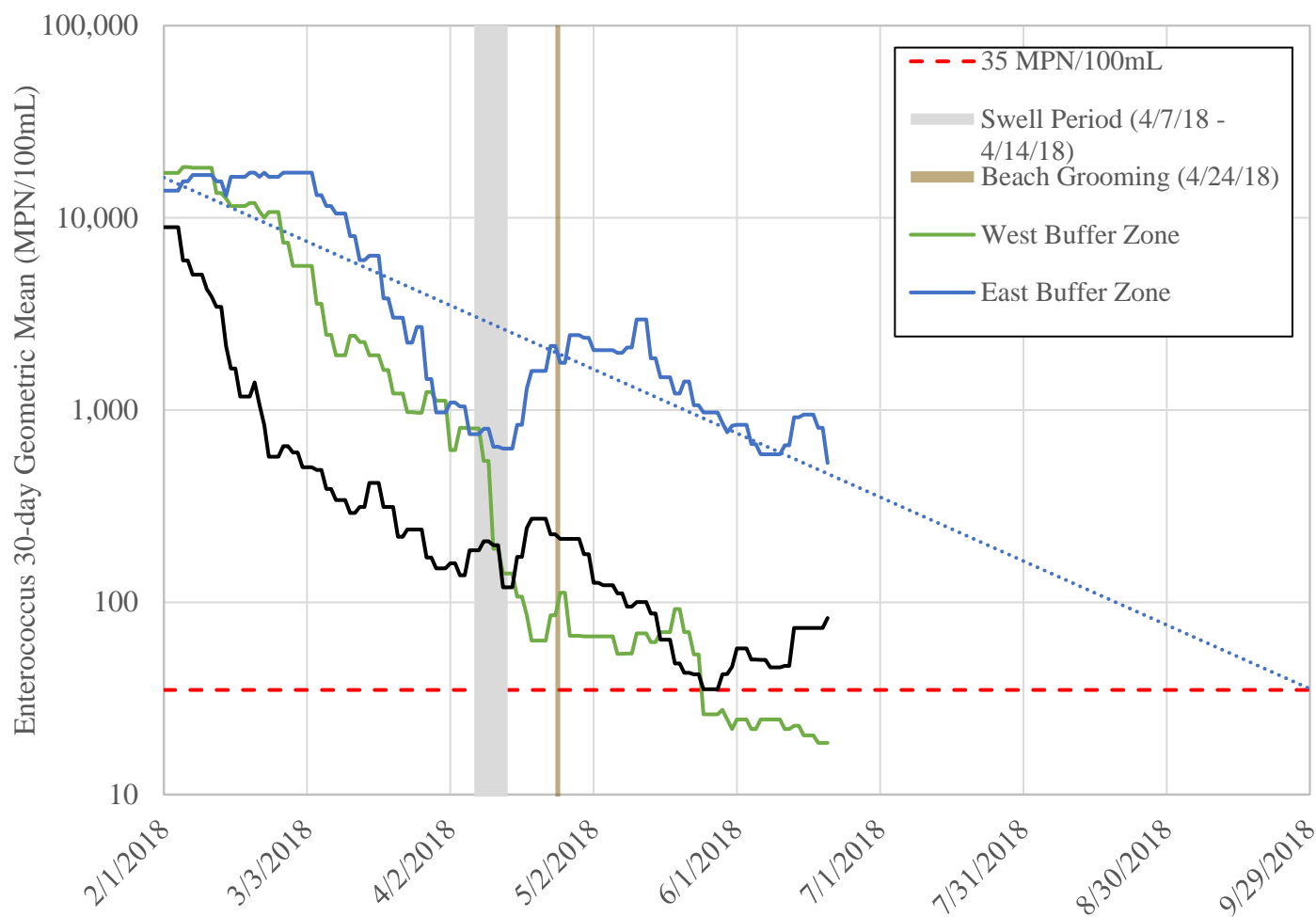


Figure 4. 30-day rolling geometric mean Enterococcus concentrations at Goleta Beach monitoring locations for February – June 2018 relative to the 35 MPN/100mL geometric mean standard.

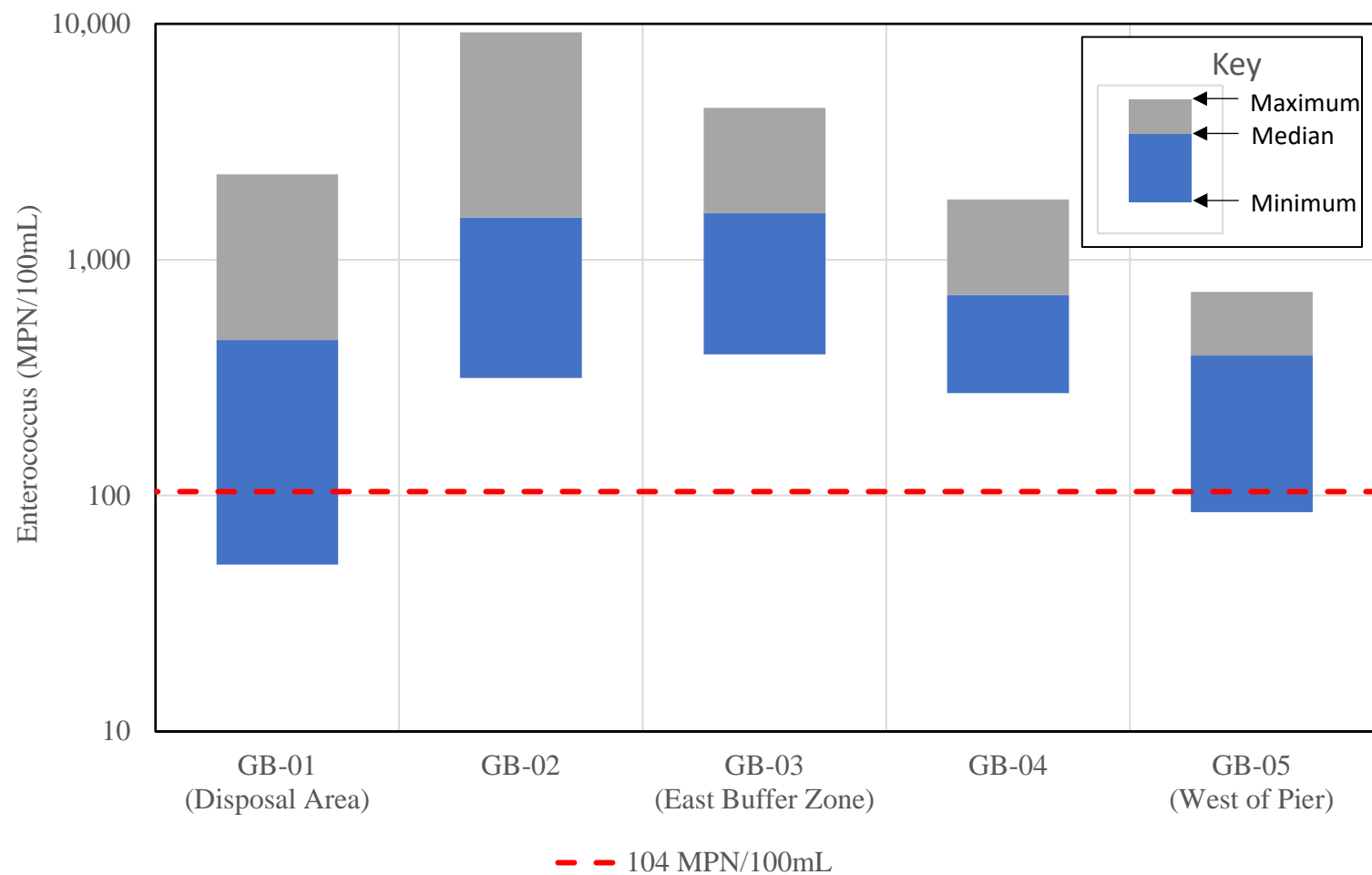


Figure 5. Enterococcus concentrations for surf zone samples collected from May 22nd to May 25th, 2018 (n = 4 samples per location) relative to the 104 MPN/100mL single sample standard.

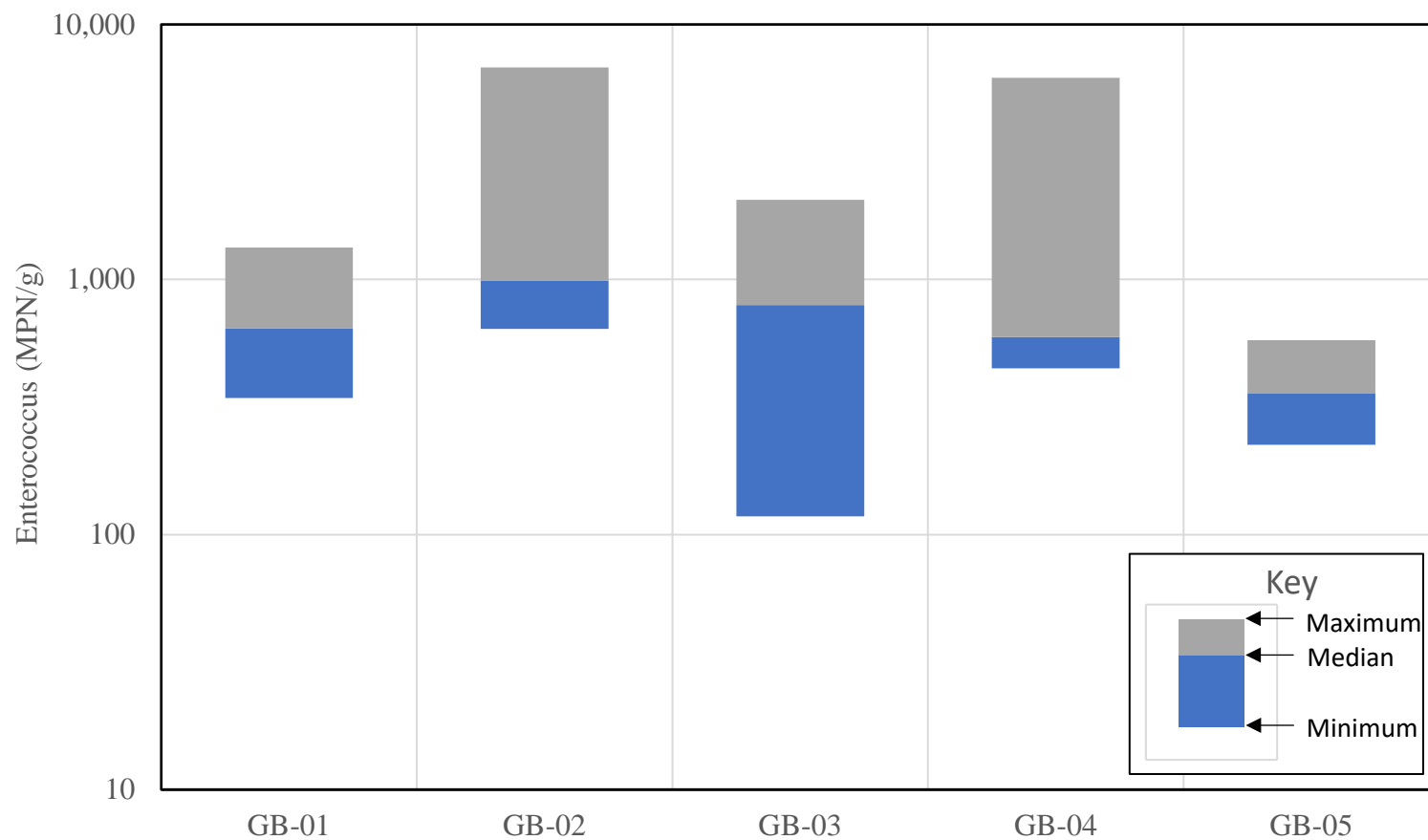


Figure 6. Enterococcus concentrations for sand samples collected from May 22nd to May 25th, 2018 (n = 4 samples per location), concentrations are on a dry weight basis.

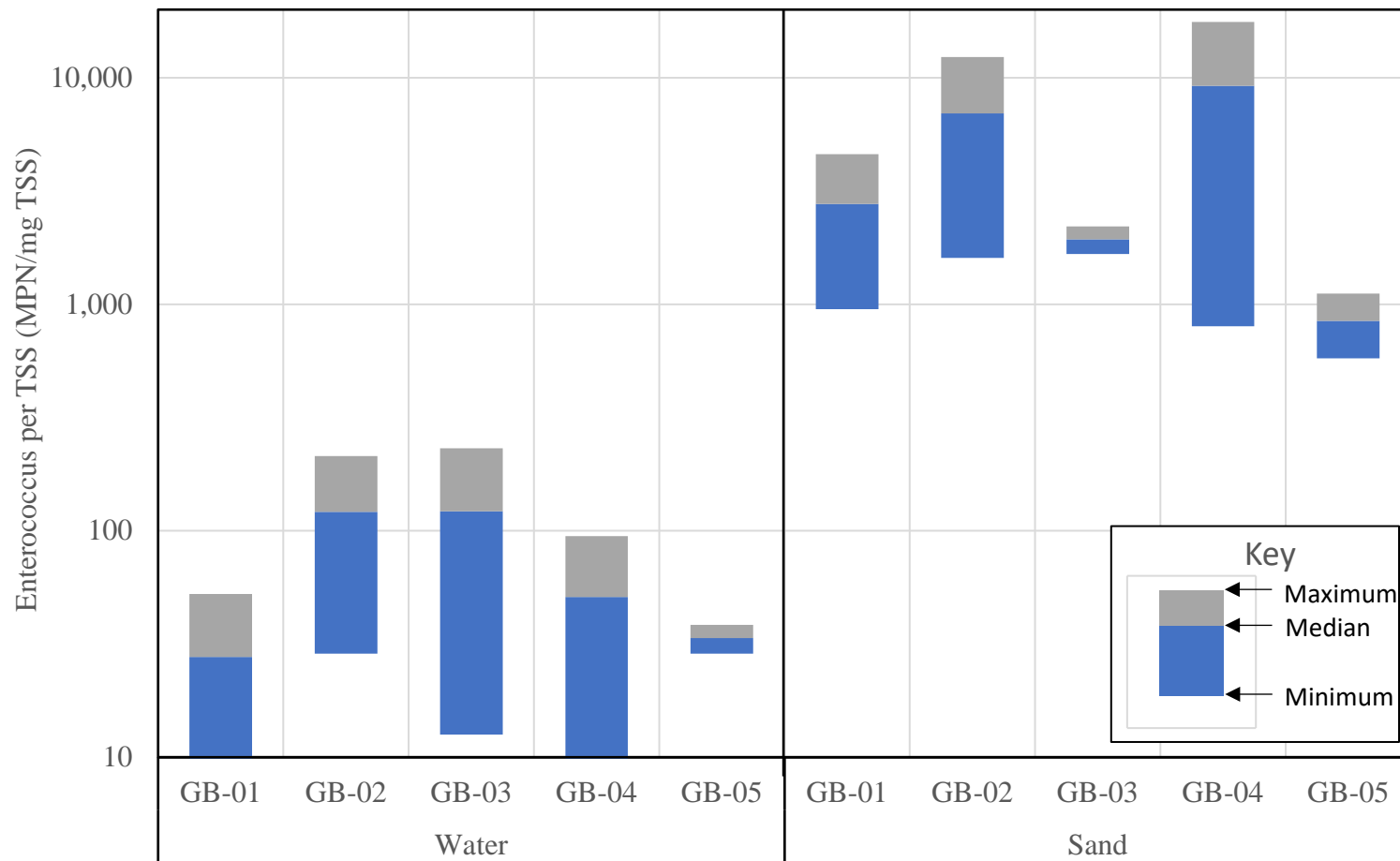


Figure 7. Enterococcus concentration in surf zone and sand samples collected on May 24th and May 25th (n = 2 samples per location) normalized by total suspended solids concentration (TSS) for water and suspendable solids for sand.

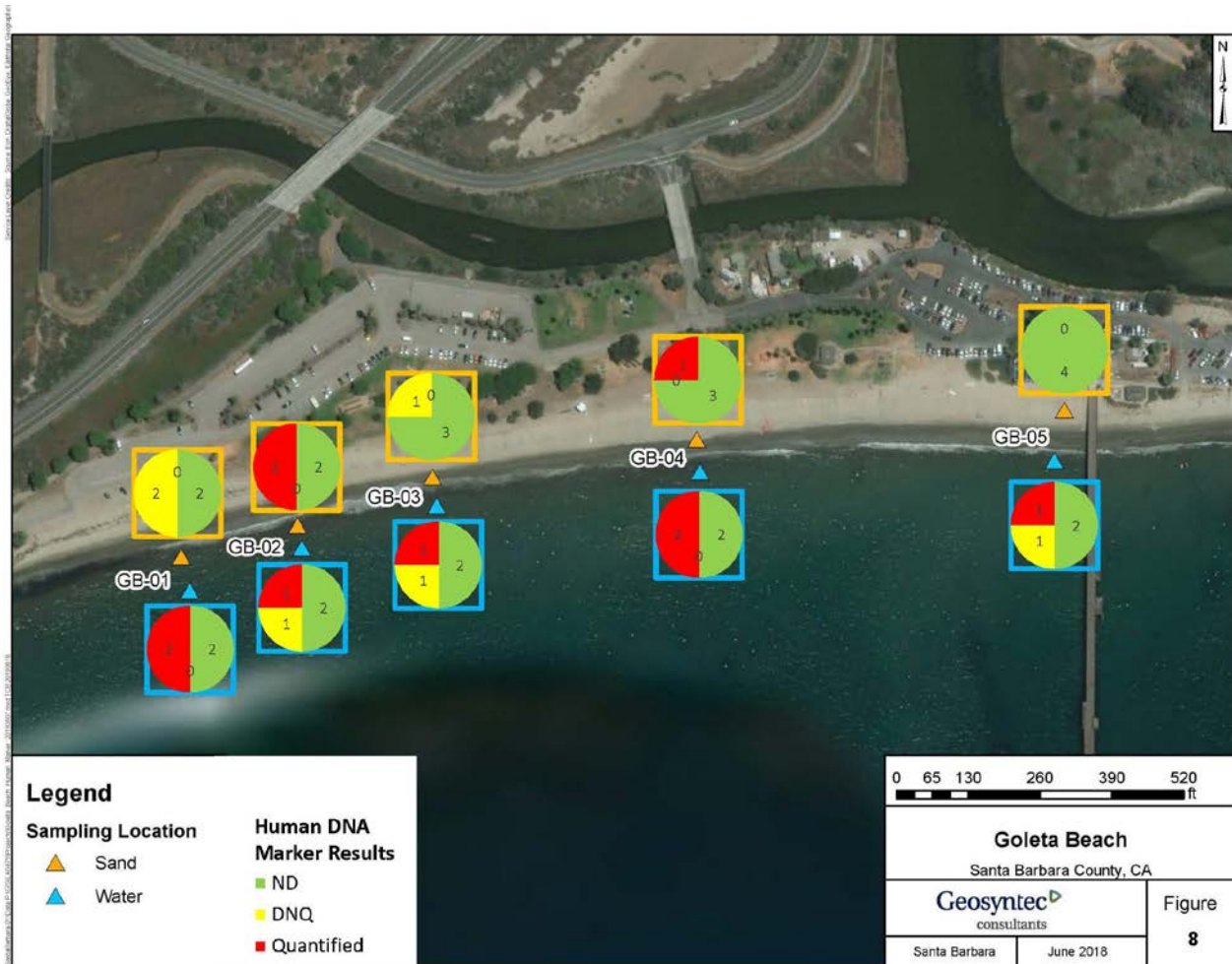


Figure 8. Human DNA marker results for surf zone and sand samples collected from May 22nd to May 25th at Goleta Beach (n = 4 samples per location), ND = Not Detected, DNQ = Detected but Not Quantifiable.

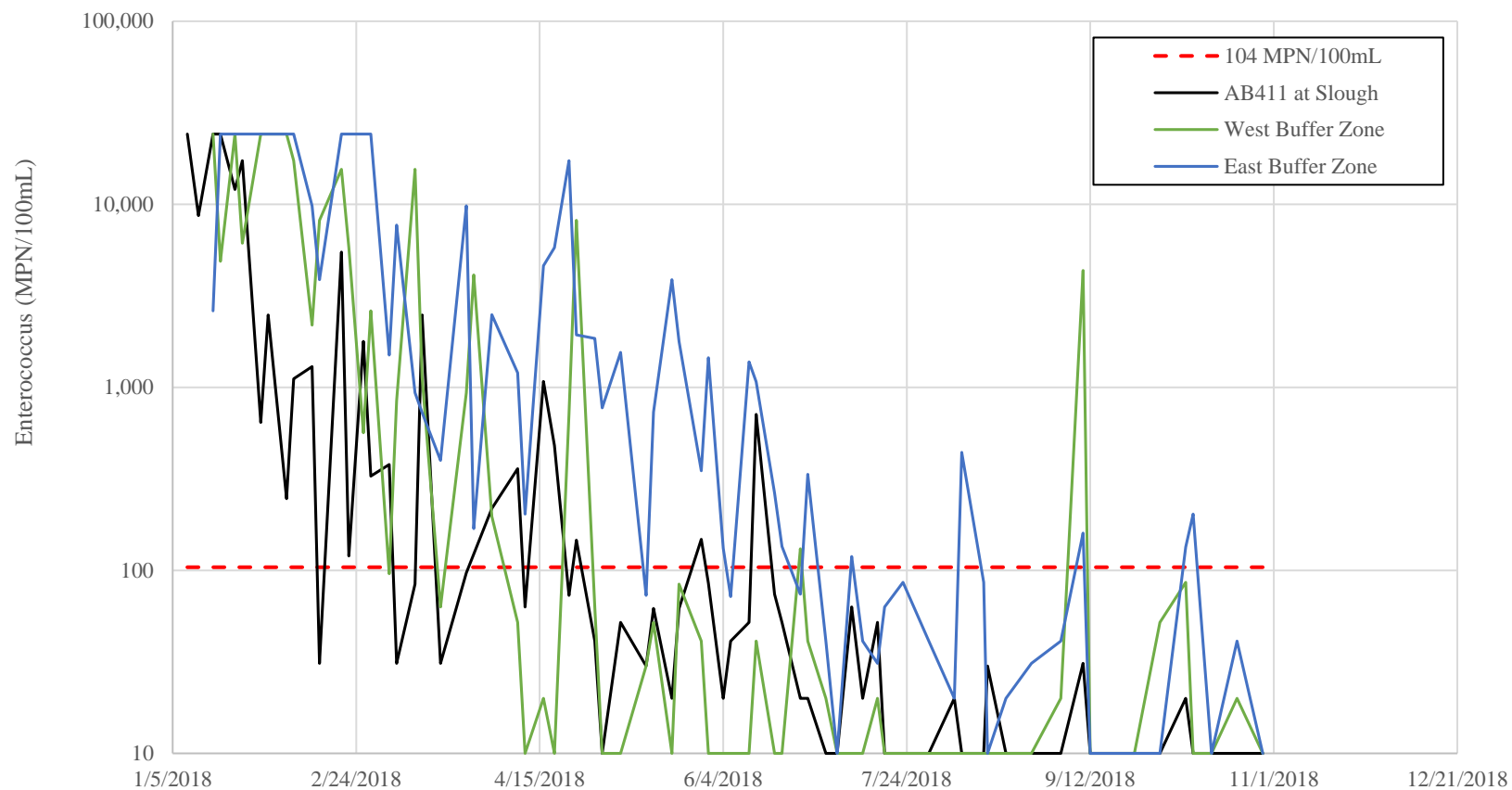


Figure 9. Single sample Enterococcus concentrations at Goleta Beach monitoring locations, for January-October 2018 relative to the 104 MPN/100mL single sample standard.

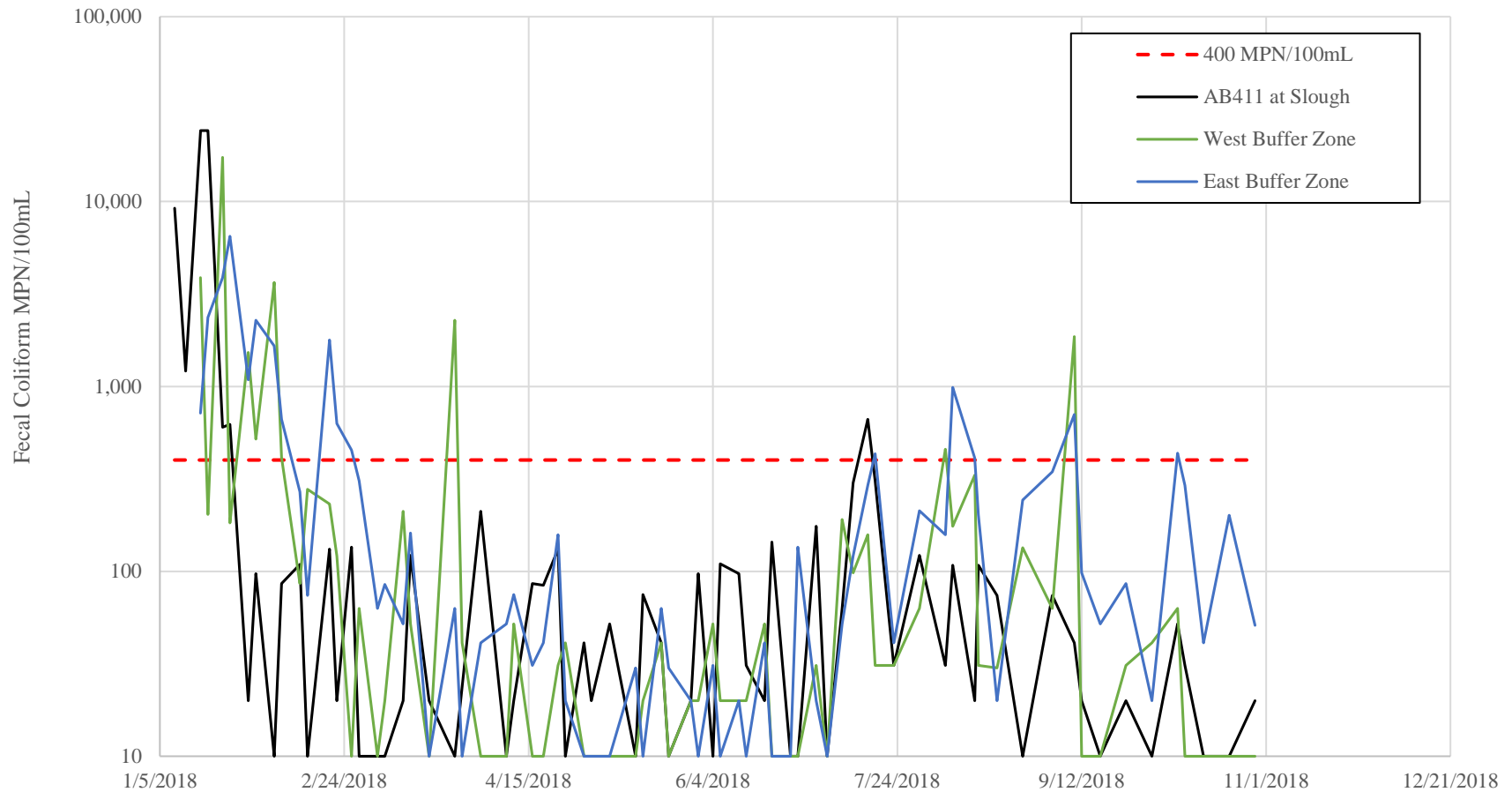


Figure 10. Single sample Fecal Coliform concentrations at Goleta Beach monitoring locations, for January-October 2018 relative to the 400 MPN/100mL single sample standard.

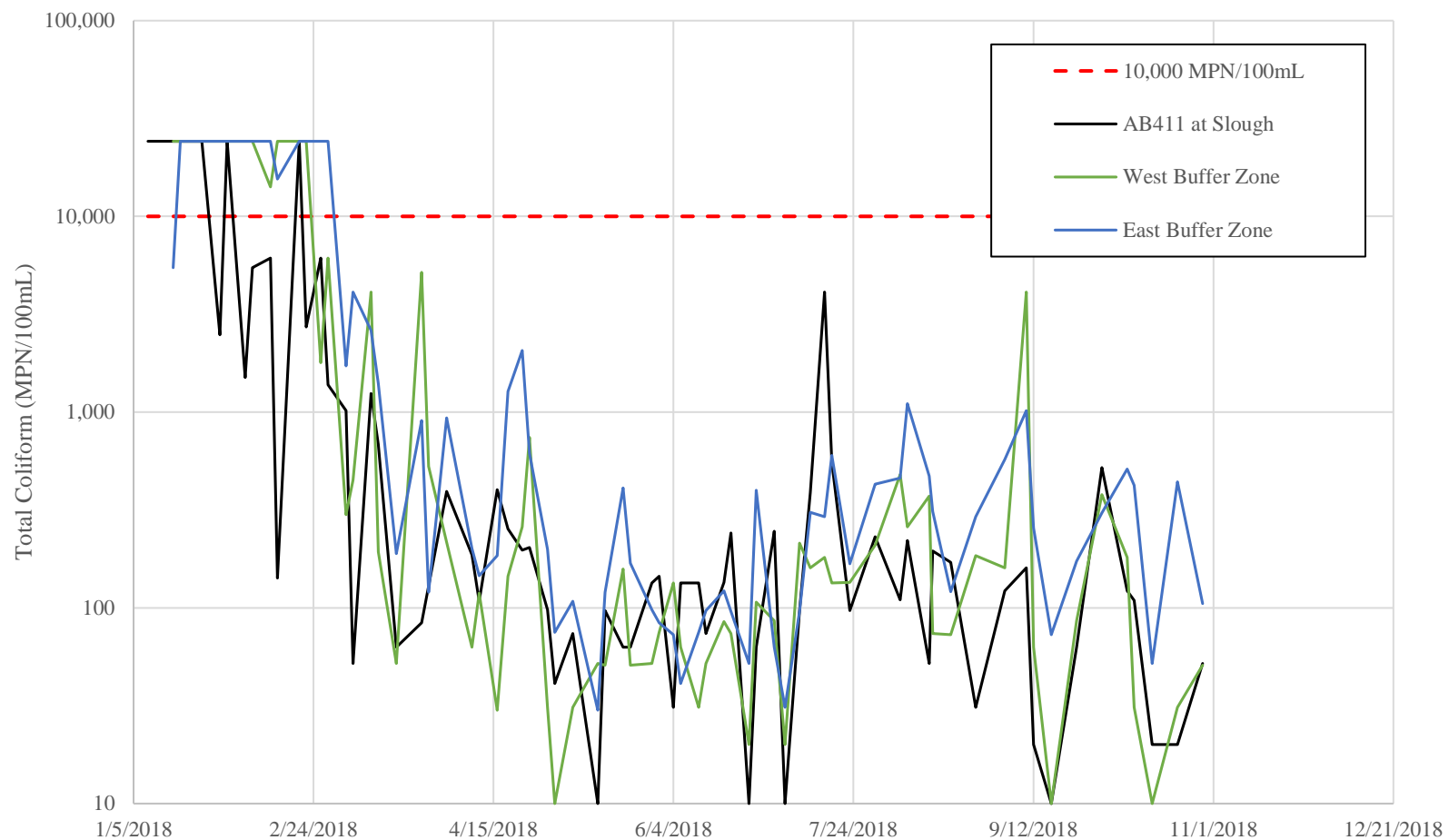


Figure 11. Single sample Total Coliform concentrations at Goleta Beach monitoring locations, for January-October 2018 relative to the 10,000 MPN/100mL single sample standard.