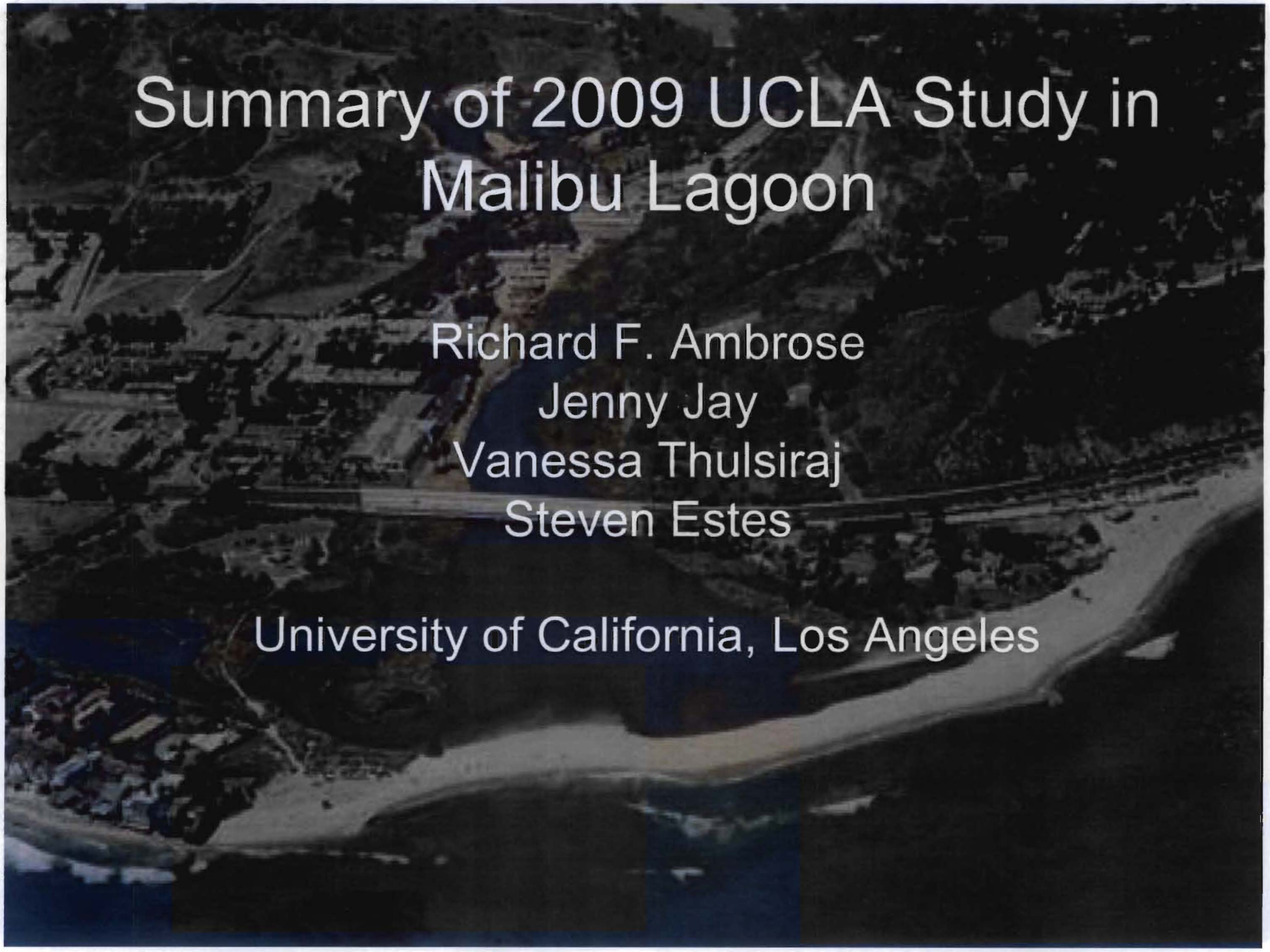

Summary of 2009 UCLA Study in Malibu Lagoon

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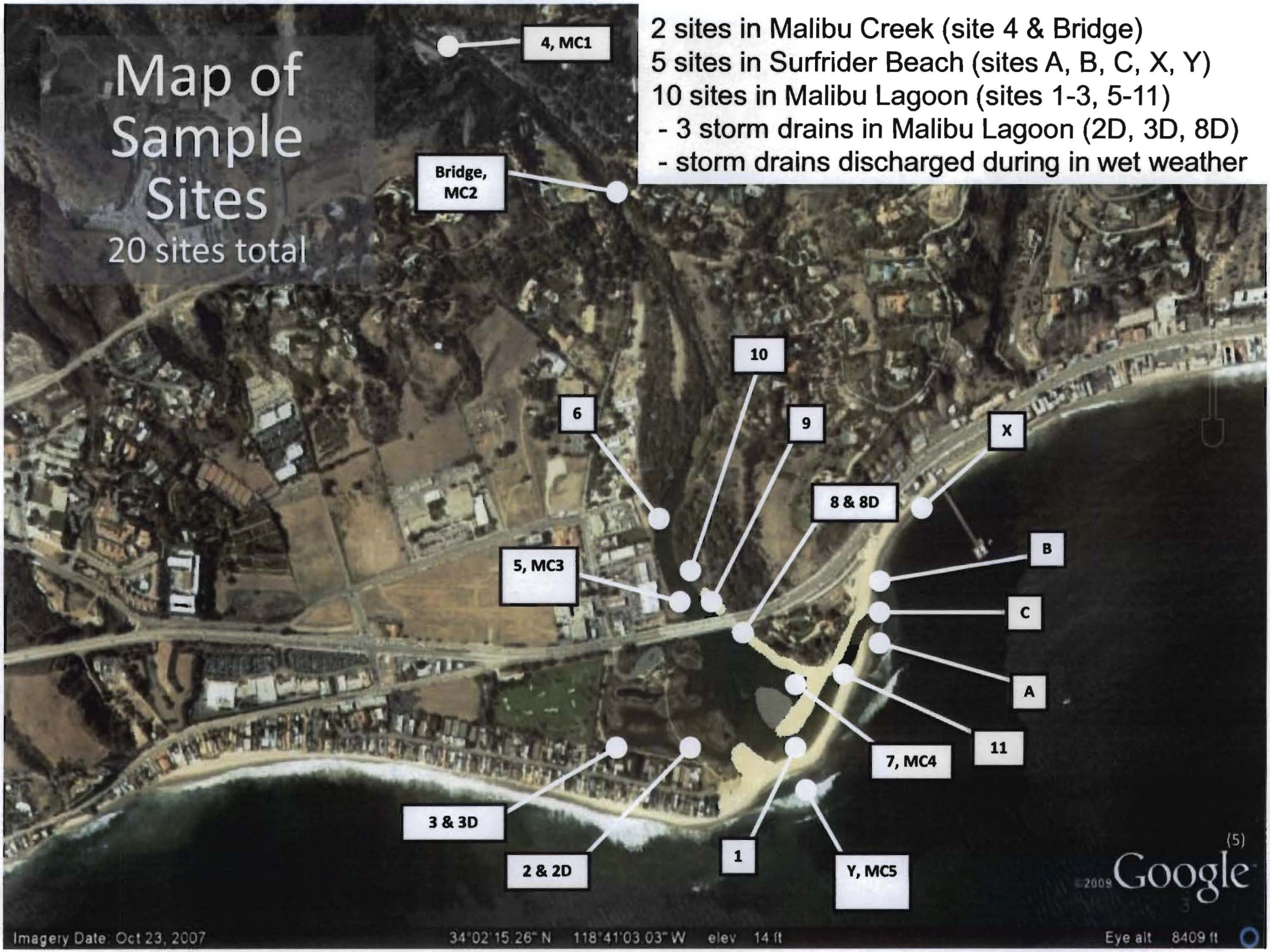
Objectives

1) Determine Fecal Indicator Bacteria (FIB) and Human-specific Bacteriodes Marker (HBM) concentrations for the following environmental conditions
    a) Wet weather, open lagoon
    b) Dry weather, open lagoon
    c) Dry weather, closed lagoon

2) Compare traditional FIB concentrations to HBM concentrations



2 sites in Malibu Creek (site 4 & Bridge)
5 sites in Surfrider Beach (sites A, B, C, X, Y)
10 sites in Malibu Lagoon (sites 1-3, 5-11)
- 3 storm drains in Malibu Lagoon (2D, 3D, 8D)
- storm drains discharged during in wet weather

Study Design

Total samples collected and analyzed for FIB and HBM (all samples were analyzed for FIB except October samples)

a) Wet weather, open lagoon
- 15 samples collected in February 16, 2009
- 14 samples analyzed for HBM (1 sample had interference)

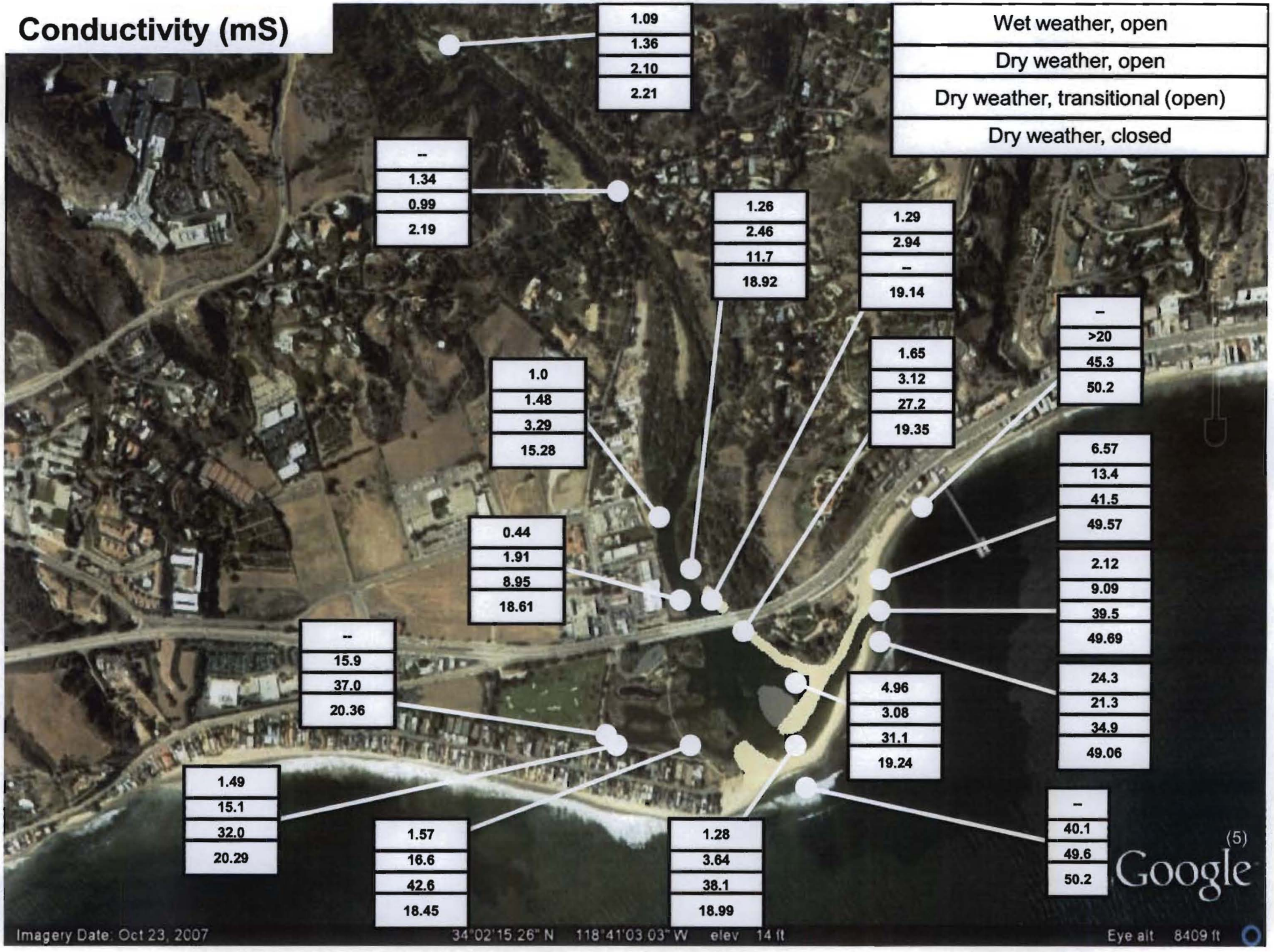
b) Dry weather, open lagoon
- 18 samples collected in March 20, 2009
- 18 samples analyzed for HBM

c) Dry weather, transitional lagoon
- 18 samples collected in May 21, 2009
- 18 samples analyzed for HBM

d) Dry weather, closed lagoon
- 19 samples collected in July 18, 2009
- 18 samples analyzed for HBM (1 sample had interference)
- 5 additional samples were collected in October 2009 and analyzed for HBM (1 sample had interference)

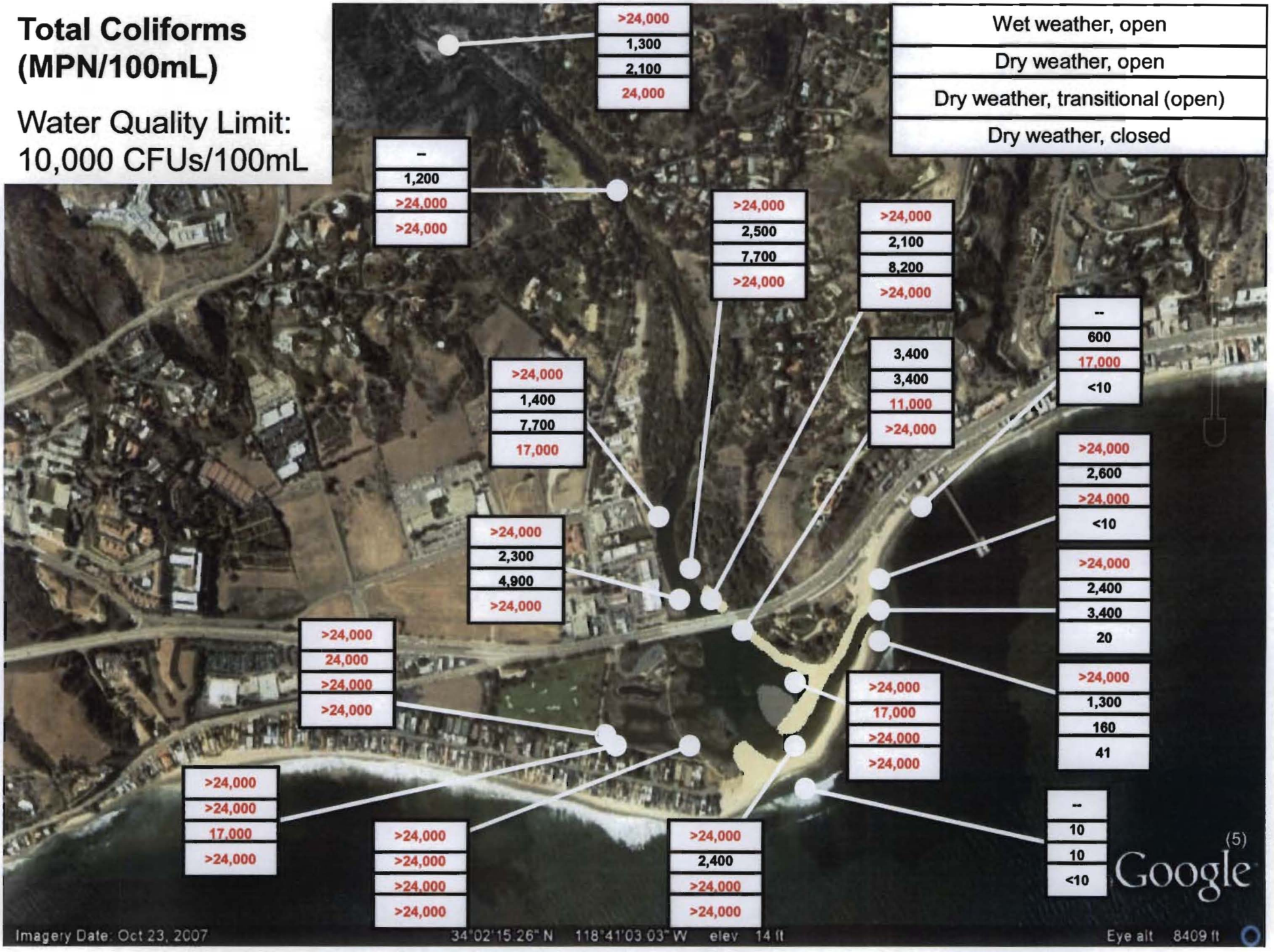
Additional City of Malibu Study

- 2 week study conducted in Malibu Creek and Lagoon
- 5 sample locations (MC1 – MC5) were further analyzed for presence of HBM
  - MC1 – MC4 sampled on 4/29
  - MC5 samples on 4/29, 4/30, 5/5, 5/7
  - No detection of HBM in any samples taken during this time (April/May)


Conductivity (mS)
Wet weather, open
Dry weather, open
Dry weather, transitional (open)
Dry weather, closed
1.09
1.36
2.10
2.21
--
1.34
0.99
2.19
1.26
2.46
11.7
18.92
1.29
2.94
--
19.14
--
>20
45.3
50.2
1.65
3.12
27.2
19.35
1.0
1.48
3.29
15.28
6.57
13.4
41.5
49.57
0.44
1.91
8.95
18.61
2.12
9.09
39.5
49.69
--
15.9
37.0
20.36
4.96
3.08
31.1
19.24
24.3
21.3
34.9
49.06
1.49
15.1
32.0
20.29
1.57
16.6
42.6
18.45
1.28
3.64
38.1
18.99
--
40.1
49.6
50.2
Google
(5)
Imagery Date: Oct 23, 2007
34°02'15.26" N 118°41'03.03" W elev 14 ft
Eye alt 8409 ft

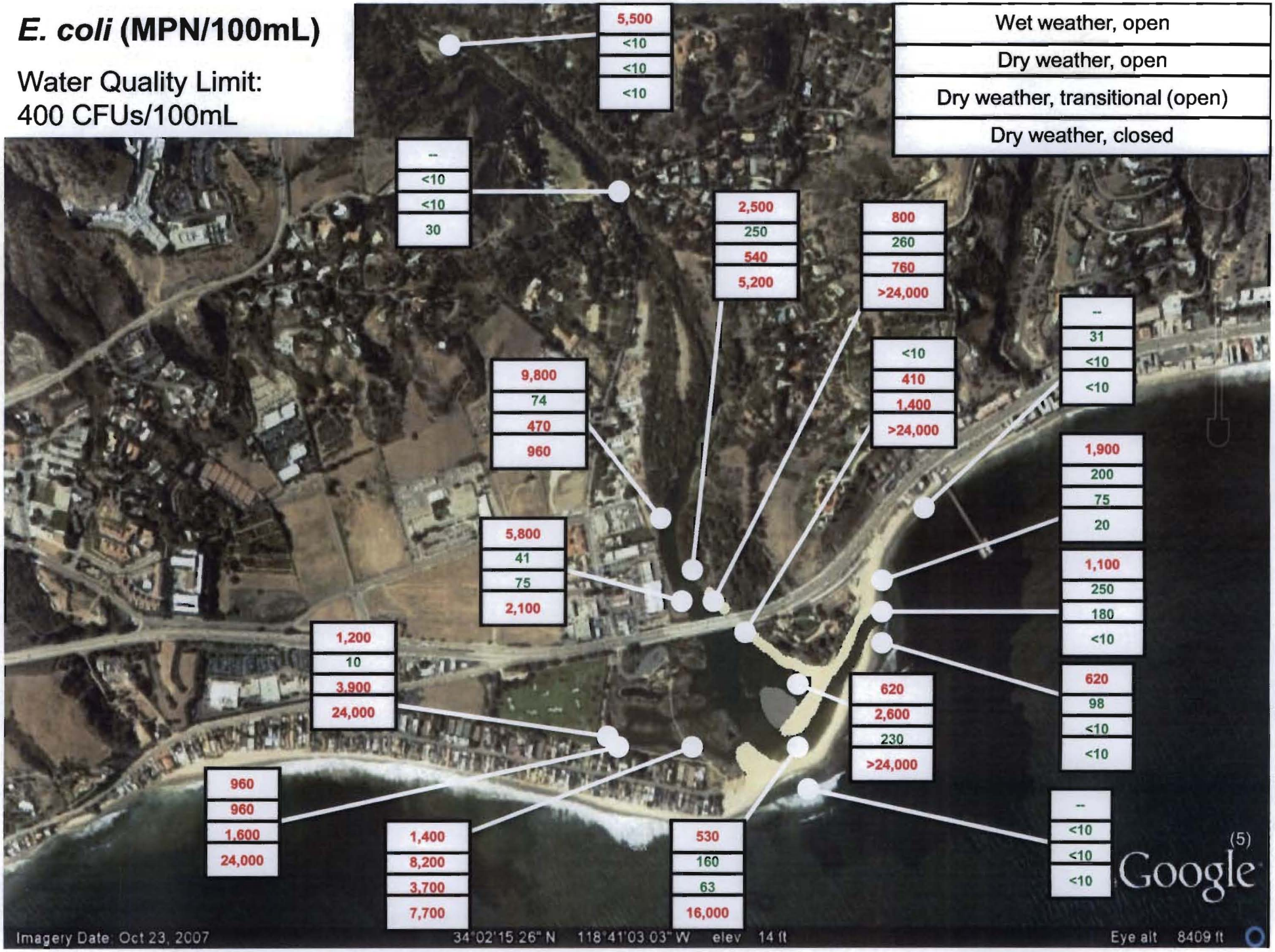
Total Coliforms (MPN/100mL)

Water Quality Limit:
10,000 CFUs/100mL



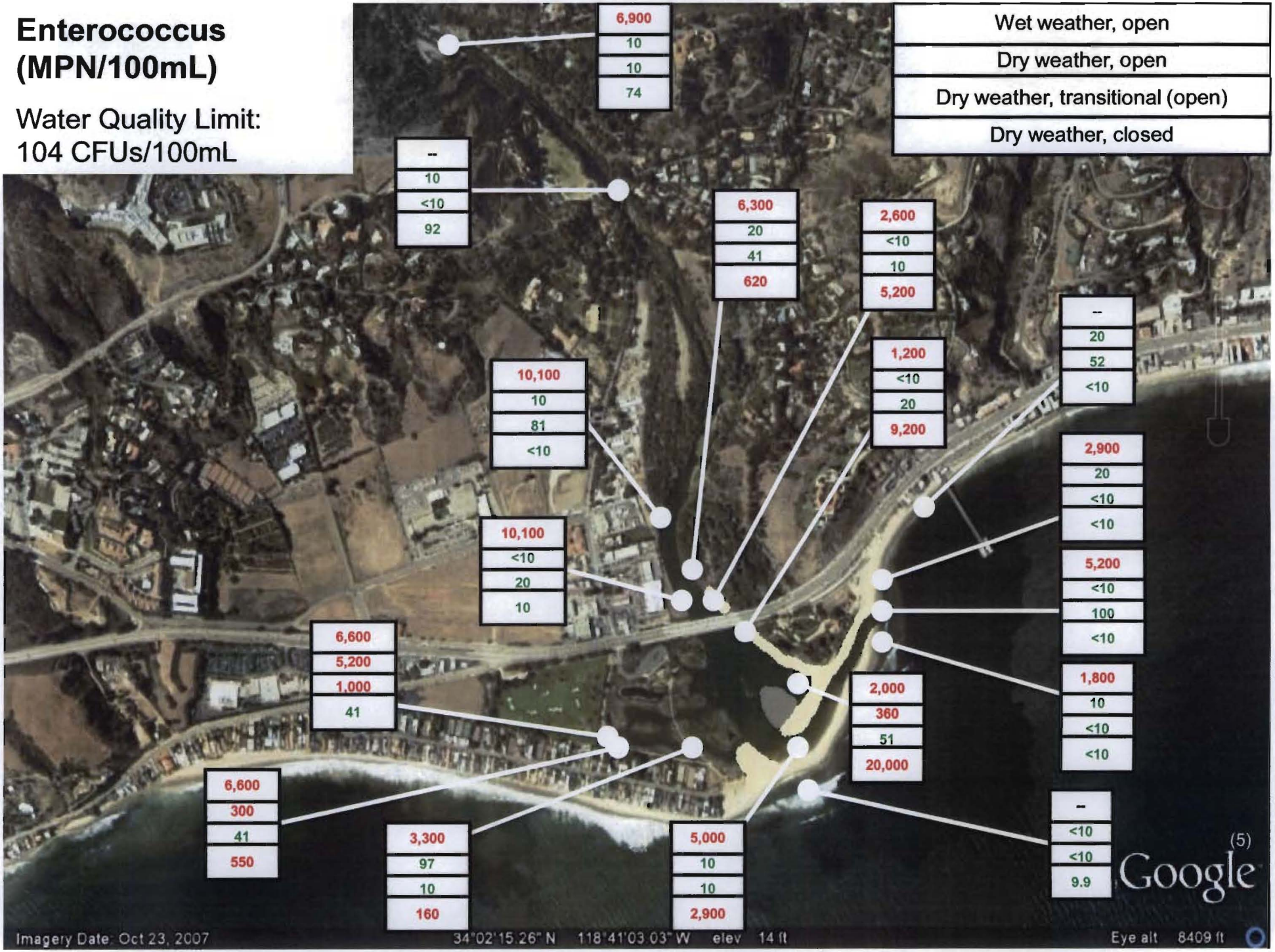
E. coli (MPN/100mL)

Water Quality Limit:
400 CFUs/100mL

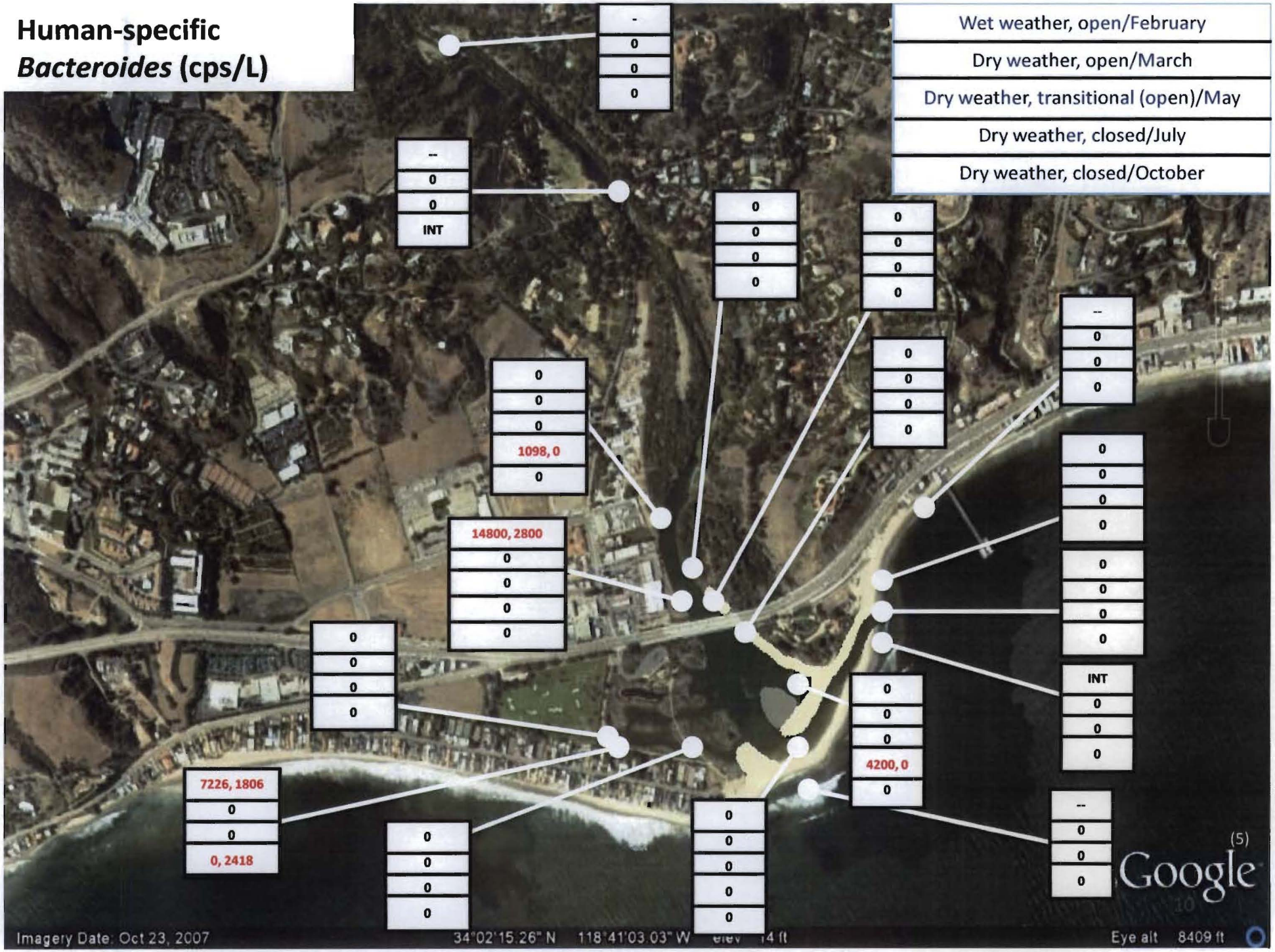


Enterococcus (MPN/100mL)

Water Quality Limit:
104 CFUs/100mL



Human-specific *Bacteroides* (cps/L)

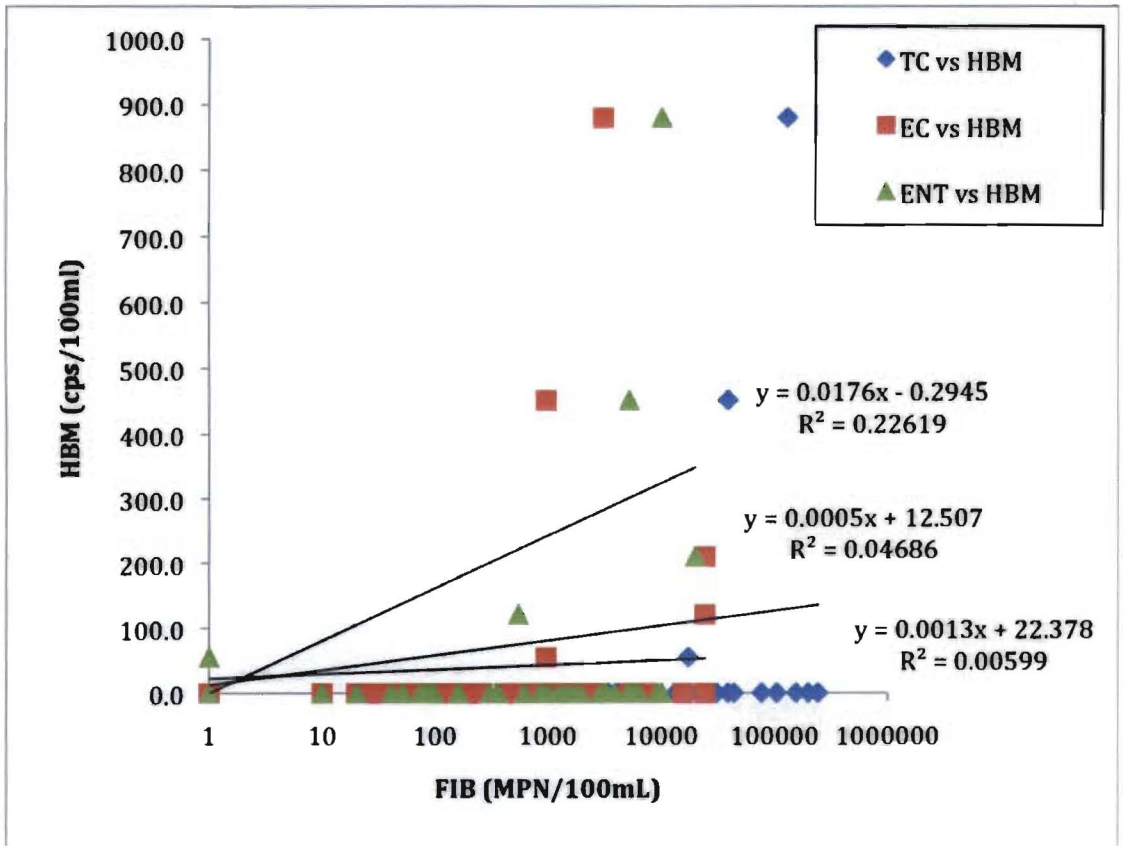


Malibu Creek, Malibu Lagoon and Surfrider Beach 2009 Human Specific Bacteriodales

Site	2/16/09 Wet-Open	3/20/09 Dry-Open	4/29 & 4/30/09 Dry - Open	5/5 & 5/7/09 Dry-Open	5/21/09 Dry-Transitional Open	7/18/09 Dry-Closed	10/30/09 Dry-Closed	Total Samples
1	N	N	-		N	N	N	5
2	N	N	-		N	N	-	4
2D[1]	N	-	-		-	N	-	2
3	Y	N	-		N	Y	I	4
3D[1]	N	N	-		N	N	-	4
4 (MC1)	-	N	N		N	N	-	4
5 (MC3)	Y	N	N		N	N	N	6
6	N	N	-		N	Y	N	5
7 (MC4)	N	N	N		N	Y	N	6
8	N	N	-		N	N	-	4
8D[1]	N	N	-		-	-	-	2
9	N	N	-		N	N	-	4
10	N	N	-		N	N	-	4
11	-	-	-		N	N	-	2
A	I	N	-		N	N	-	3
B	N	N	-		N	N	-	4
C	N	N	-		N	N	-	4
Y (MC5)	-	N	NN	NN	N	N	-	7
X	-	N	-		N	N	-	3
Bridge (MC2)	-	N	N		N	I	-	3
	2 of 14	**0 of 18**	**0 of 6**	**0 of 2**	**0 of 18**	**3 of 18**	**0 of 4**	**5 of 80**

[1] No samples taken in dry weather from drains at 2 D, 3D or 8 D because there were – no dry weather discharges from drains. (*Although Ssamples at these sites were taken from where drains would outfall within the Lagoon if there had been discharge., no discharge was collected. Therefore these samples could be counted as duplicates samples of 3, 2 and 8 during dry weather. Samples were collected at 3D and 8D in March; 3D in May; and 2D and 3D in July.*

Relationship between FIB and HBM

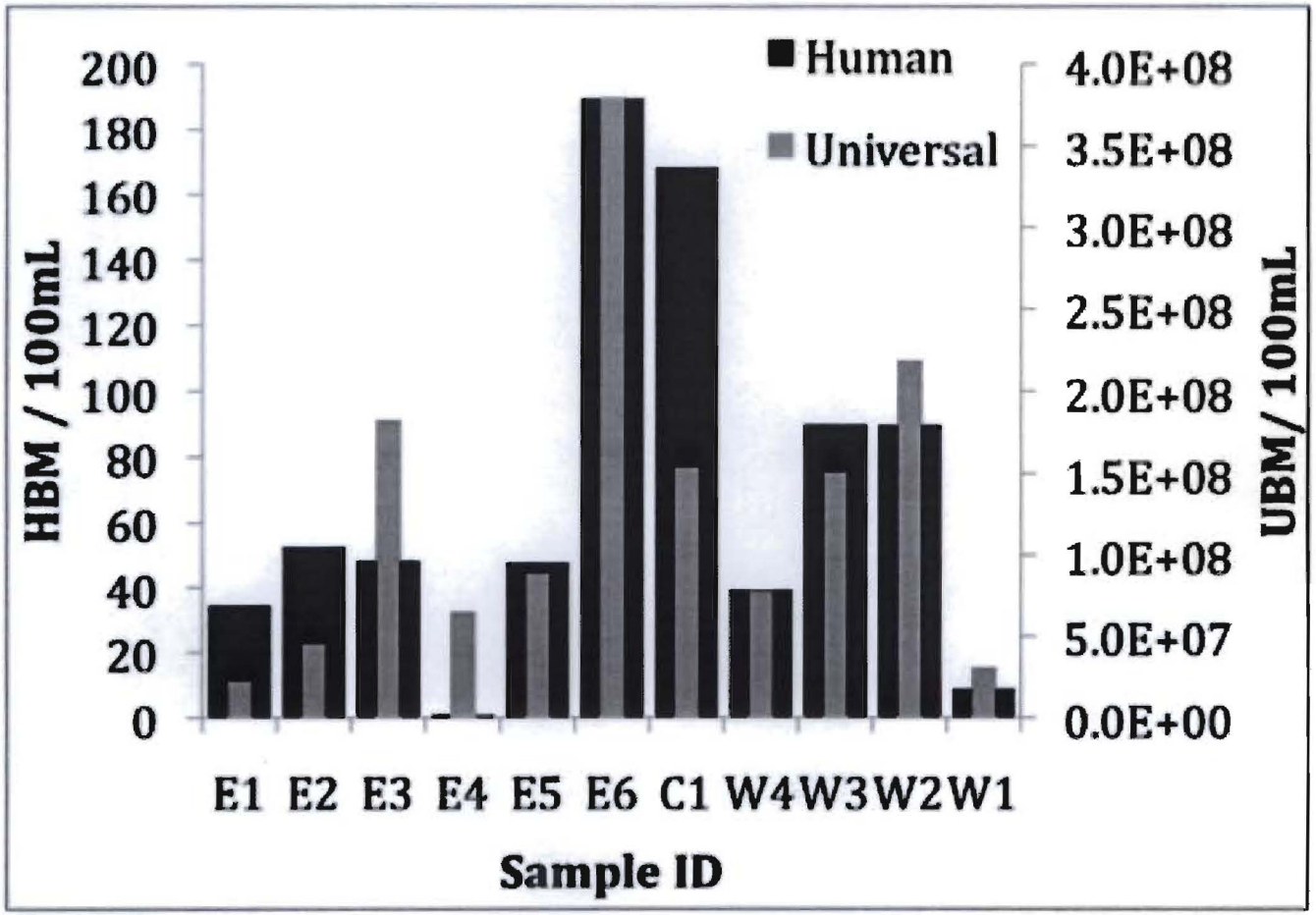


- Samples positive for HBM occurred only when FIB was high
- High FIB observed in absence of HBM

Other work by Jay Lab in Santa Monica Canyon (SMC)

- SMC carries runoff from residential areas and natural mountain watersheds to the ocean.
- In this watershed, HBM was quantifiable in more than 60% of samples in the channel draining the less urbanized subwatershed, and 35% of samples in the channel draining the more urbanized subwatershed.
- After rain events, FIB levels would increase by a factor of 2-18, while *Bacteroidales* was not observed to increase more than a factor of 2 at any location.
- Very little correlation was observed between human-specific or universal *Bacteroidales* and traditional FIB in the Santa Monica Canyon watershed($R^2<0.05$).

Universal (UBM) and human-specific *Bacteroidales* (HBM) along Santa Monica Canyon



Samples W1-W4 are from the less urbanized channel. A storm drain located at E6 flowed regularly during sampling events.

Conclusions

- FIB concentrations were high throughout stream, lagoon and ocean after rainfall
  - Only time of high FIB upstream and in ocean
- FIB concentrations generally low when lagoon was open
  - Specific hot spot areas
- FIB concentrations were high throughout lagoon when lagoon closed
- Human-specific bacteroides marker (HBM) detected in 5 out of 80 samples
  - Only detected in Lagoon samples
  - Very weak relationship between FIB and HBM

Malibu Lagoon Bacteria Study
Synopsis with Preliminary Results
4-25-09

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Monique Myers
Steve Estes
University of California, Los Angeles

1. Introduction

The purpose of the current UCLA study in Malibu Lagoon is generally to increase our understanding of the dynamics of bacteria in the Lagoon and adjacent ocean waters. We are interested in spatial and temporal patterns of bacteria concentrations as well as the bacteria sources. For this study, we are focusing on water samples only (not sediments).

2. Methods

To understand the spatial pattern of bacteria concentrations, samples are being collected from 18 sites in and around the Lagoon, including one site upstream of all development in Serra Retreat, four sites in the restored salt marsh, and five sites along the beach in or near the mouth of the Lagoon (Figure 1). The furthest upstream site provides information about bacteria entering the Lagoon from the upstream Malibu Creek watershed. The Lagoon samples include samples on the east and west banks of the main lagoon as well as samples from the restored wetland area (taken near outlets draining into that area). The beach samples include a sample where the lagoon water meets the ocean (when the lagoon is open) and two samples east and two samples west of this location. These samples represent exposure to ocean users. In addition to collecting water samples for bacteria, we are measuring other water quality parameters, particularly conductivity (salinity), which provides a useful indicator of how much mixing there has been between freshwater and ocean water at each site when we sample it.

To understand the temporal pattern of bacteria concentrations, samples are being collected at times that represent different important phases of Lagoon dynamics. Our first sample was during a major rainstorm (February 16, 2009) when the Lagoon was open to the ocean and dominated by fluvial (stream) processes. More than 1.5" of rain had fallen in the upper watershed when sampling occurred, with a total of about 2.3" for the storm. Although we call the February 16 sample a "wet weather" sample, it really represents storm conditions in the lagoon with significant runoff from upstream and the areas around the lagoon.

Our second sample (March 20, 2009) occurred while the lagoon was still open, but more than three weeks after a significant rain. Although the lagoon was open to the ocean, the

outlet was near the downcoast (closer to the pier) limit of its normal migration as the lagoon closes. Interestingly, this was also the outlet location during the February 16 sampling despite the heavy rainfall.

We plan on sampling at least one more time, when the Lagoon is closed.

To understand the sources of bacteria in the Lagoon, we are analyzing our samples for human-specific and universal bacteroides as well as the traditional fecal indicator bacteria. The results of these analyses will provide an indication of how much of the indicator bacteria may be due to human sources. We will also look at markers for other sources (e.g. birds, dogs) if feasible. Although bacteroides samples were taken February 16 and March 20, those data are not yet available.

3. Preliminary Results

No attempt is made to provide a detailed description of the results in this preliminary report, but a general summary of results is given below. The presentation of the results follows a consistent approach for each parameter: First we present a map with parameter values for the February 16 sampling event, then we present a map with parameter values for the March 20 sampling event, and finally we present a map with values from both sampling periods on the same map.

The data for total coliform bacteria are shown in Figure 2, Figure 3 and Figure 4.

The data for *E. coli* are shown in Figure 5, Figure 6 and Figure 7.

The data for enterococcus are shown in Figure 8, Figure 9 and Figure 10.

For all indicator bacteria, nearly all stations had concentrations above water quality standards during the wet weather sampling event. The samples were taken after 1.5" of rain had fallen in the upper watershed and water flow rates were very high. The uppermost sample, taken a day later by Heal the Bay, still had high FIB concentrations. The one exception to sample exceedances was the station on the east side of the lagoon near the Pacific Coast Highway, which had concentrations of total coliforms and *E. coli* that were below the water quality standard. Interestingly, the enterococcus concentration at this station did exceed the water quality standard. All other stations exceeded the standards, but some stations had exceptionally high values. Three stations north of the PCH bridge and the westernmost station in the restored salt marsh (where the sample was taken from a running drain) had total coliform values >100,000 MPN/100 ml. The same three stations north of PCH had *E. coli* concentrations >2,300 MPN/100 ml. Two stations in the restored salt marsh and two ocean stations near the lagoon mouth had *E. coli* concentrations >1,000 MPN/100 ml. The same three stations north of PCH and two stations in the westernmost area of the restored salt marsh had enterococcus concentrations >6,000 MPN/100 ml.

The February 16 values reflected runoff with high FIB concentrations entering the lagoon from a number of different locations, including upstream from Malibu Creek, outlets draining into the restored marsh, and perhaps inputs into the main lagoon north of PCH. Runoff into the lagoon resulted in high FIB values throughout the lagoon and in the adjacent coastal water.

In contrast to the February 16 storm sampling event, when the lagoon was open during dry weather nearly all stations had FIB concentrations below the water quality standards. There were two exceptions. (1) Two or three stations in the restored salt marsh exceeded the standards for all three indicators. These samples were taken near culverts that drain into the marsh. (2) In addition, the station in the southeast portion of the main lagoon exceeded water quality standards for all three indicators. This station is adjacent to the Adamson house property, near the exposed shoals that routinely serve as a roosting area for hundreds of birds, and is isolated from the main water flow in and out of the lagoon because of the configuration of the lagoon outlet.

The March 20 sampling event identified two "hotspots" of high FIB concentrations in the lagoon. In the restored salt marsh, it seems likely that the sources of FIB are the pipes that drain into the sampled tidal creek. However, we do not know if the high values are due to continued input or FIB regrowth or survival in that area of the lagoon. The high FIB concentrations in the SE corner of the main lagoon may be due to the high concentrations of birds in that area coupled with relatively poor circulation, but we cannot conclude this definitively. The bacteroides results may help clarify the possible FIB sources in these two hotspots.

The conductivity data (Figure 11, Figure 12,and Figure 13) provide an indication of the amount of freshwater influence at the different stations. During the February 16 sampling event, the entire lagoon system was dominated by freshwater runoff. The only station that showed even moderate salinity was an ocean station by the lagoon mouth (although the other two ocean stations were largely freshwater). During the March 20 sampling event, most stations were still dominated by freshwater even though the lagoon was open to the ocean. This is not too surprising because we sampled around low tide, when the lagoon would be least influenced by ocean water. The ocean stations, of course, had higher salinities, although the stations near the outlet were much lower than full seawater and even the station near Malibu Pier was much lower than full seawater. The stations in the restored wetland, in contrast to all other lagoon stations, showed significant influence of seawater.

Figure 1. Location of Malibu Lagoon sampling sites.

The two farthest upstream sites (one upstream of Serra Retreat and one at Cross Creek Road) and the easternmost and westernmost beach samples were not included in the first sampling period.

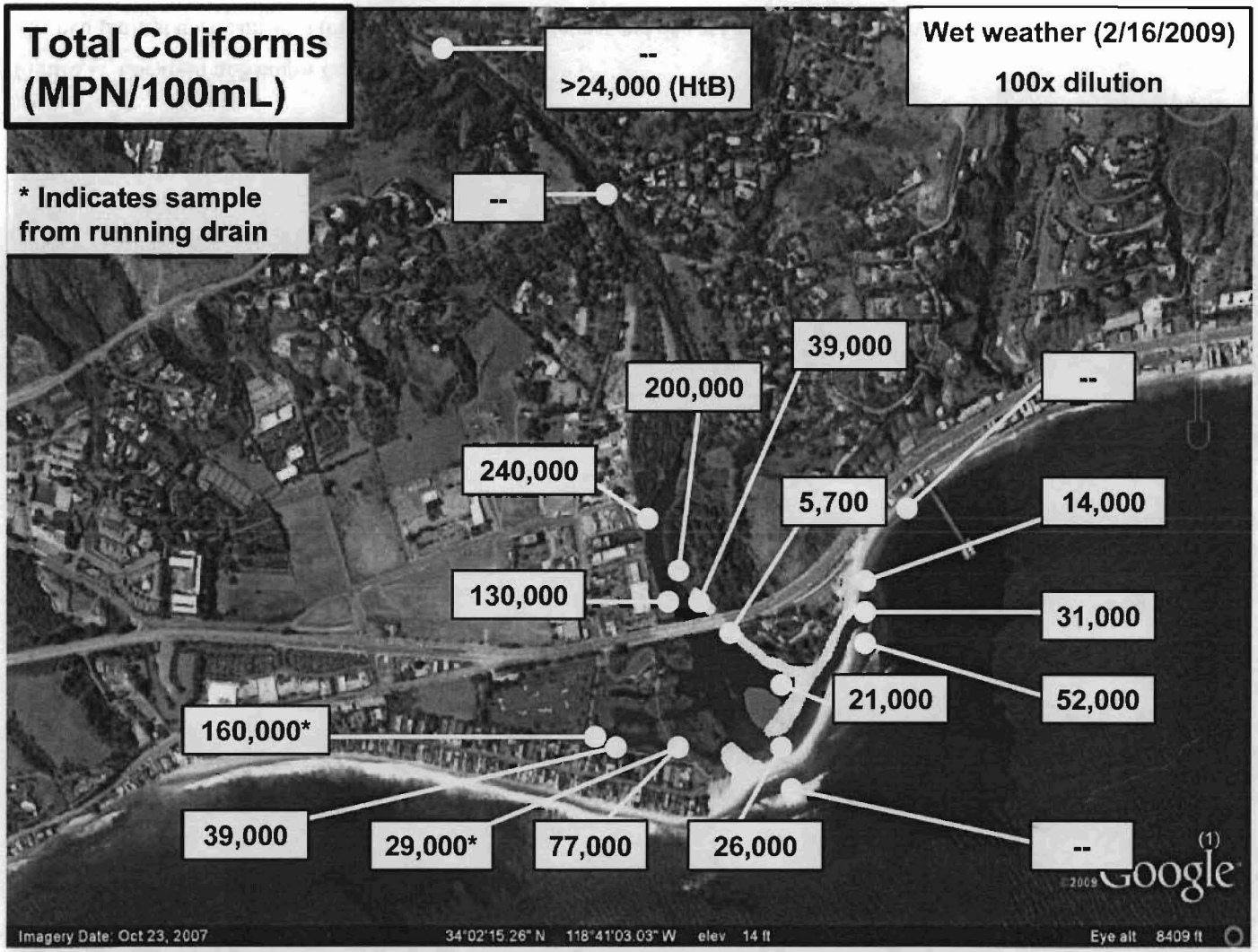

Figure 2. Total coliform concentrations during wet weather sampling period.

The single-sample water quality standard is 10,000 CFU/100 ml. The two upstream sites were not sampled, but data collected nearby by Heal the Bay one day after our samples were collected are shown.

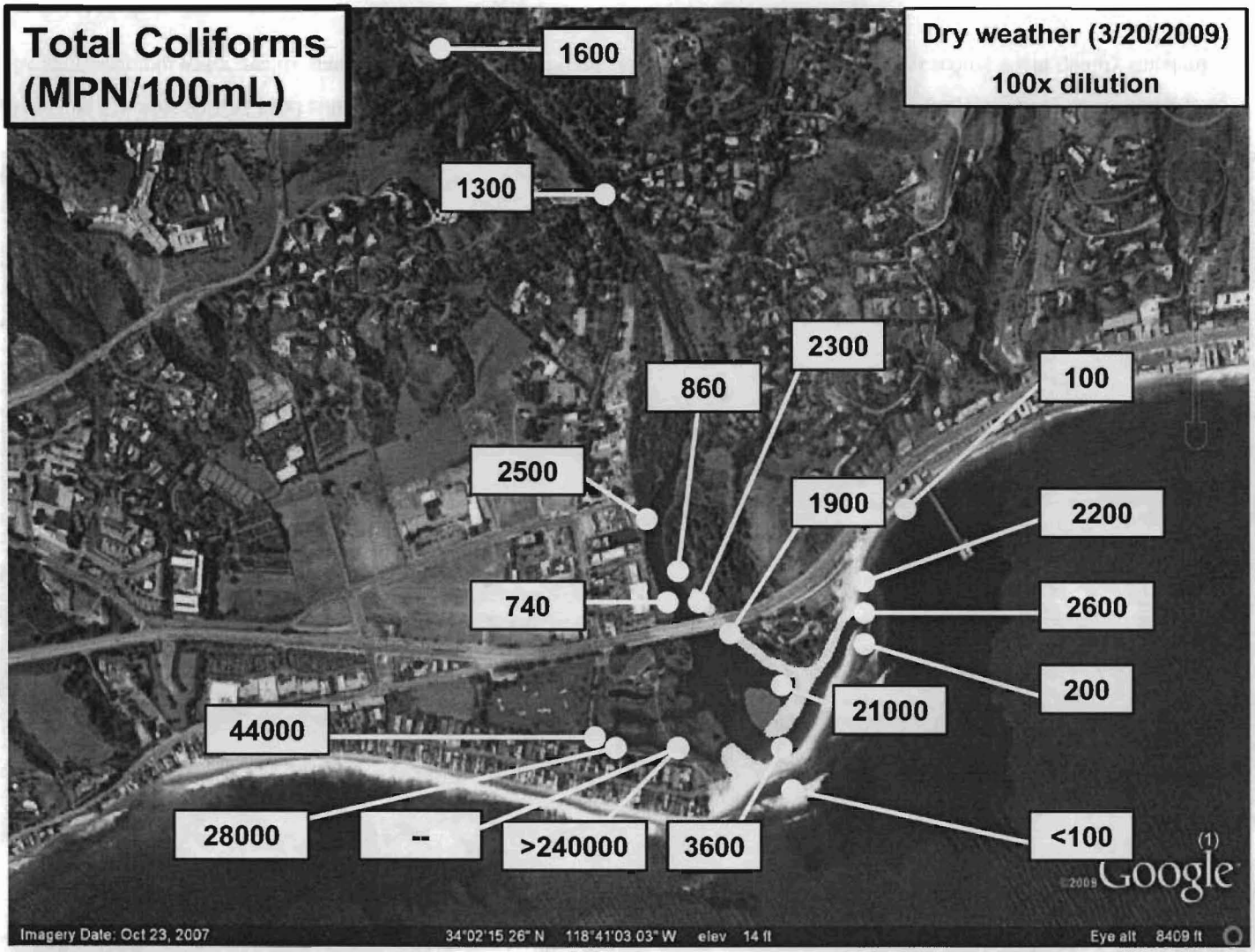

Figure 3. Total coliform concentrations during dry weather (lagoon open) sampling period.

The single-sample water quality standard is 10,000 CFU/100 ml.

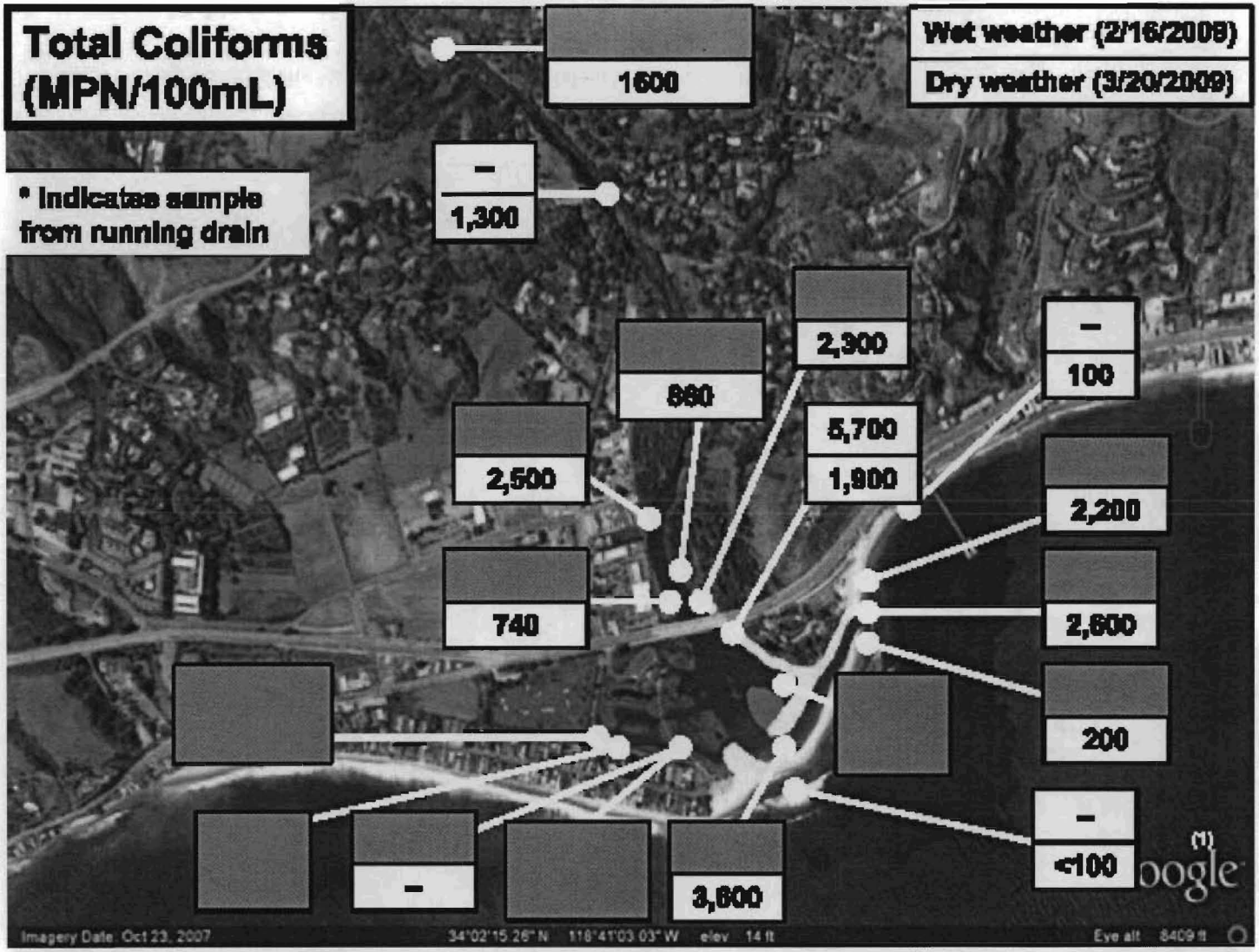

Figure 4. Comparison of total coliform concentrations during wet weather and dry weather (lagoon open) conditions.

The single-sample water quality standard is 10,000 CFU/100 ml. Red shading indicates values exceeding water quality standard.

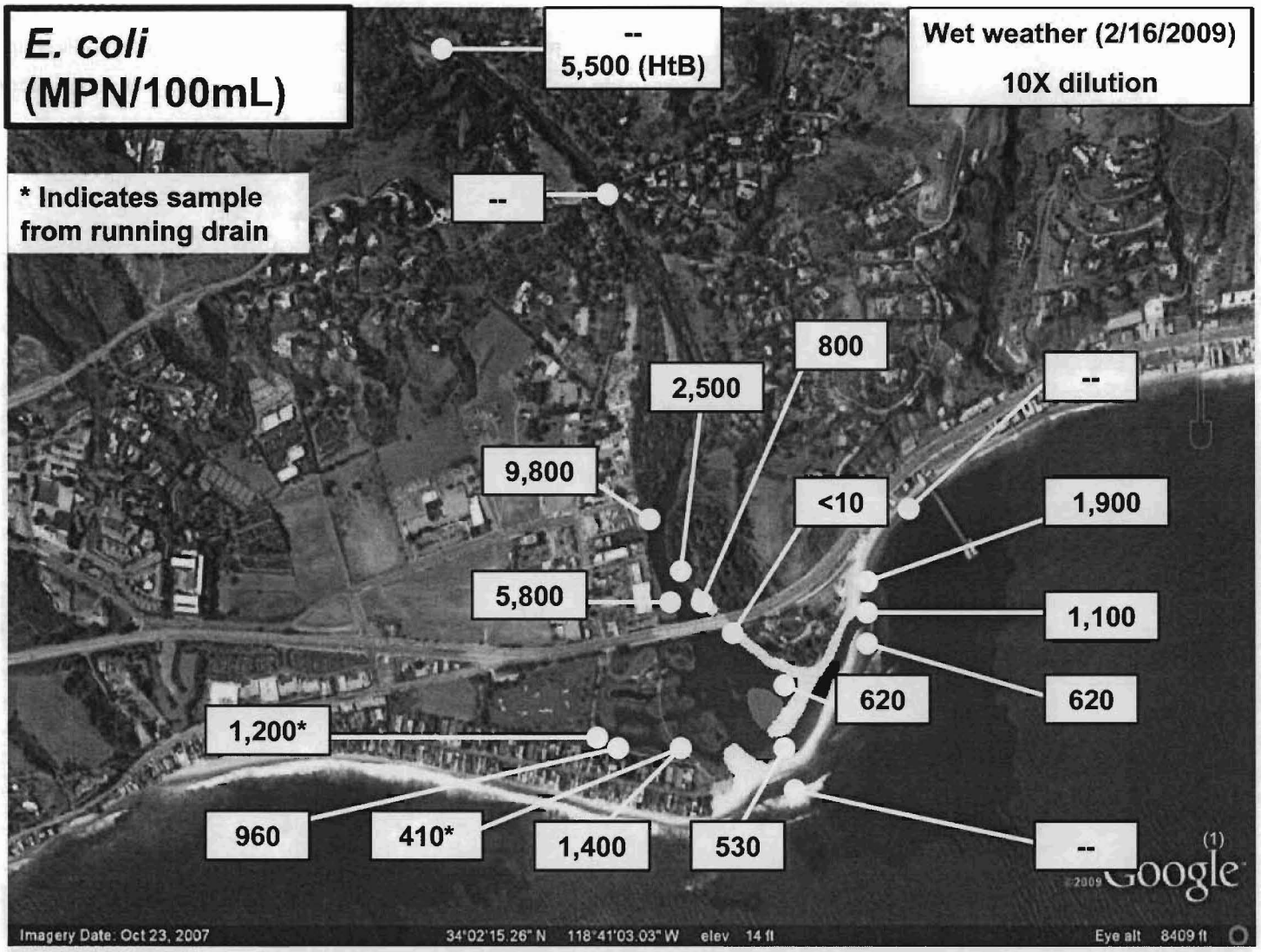

Figure 5. *E. coli* concentrations during wet weather sampling period.

The single-sample water quality standard is 400 CFU/100 ml. The two upstream sites were not sampled, but data collected nearby by Heal the Bay one day after our samples were collected are shown.

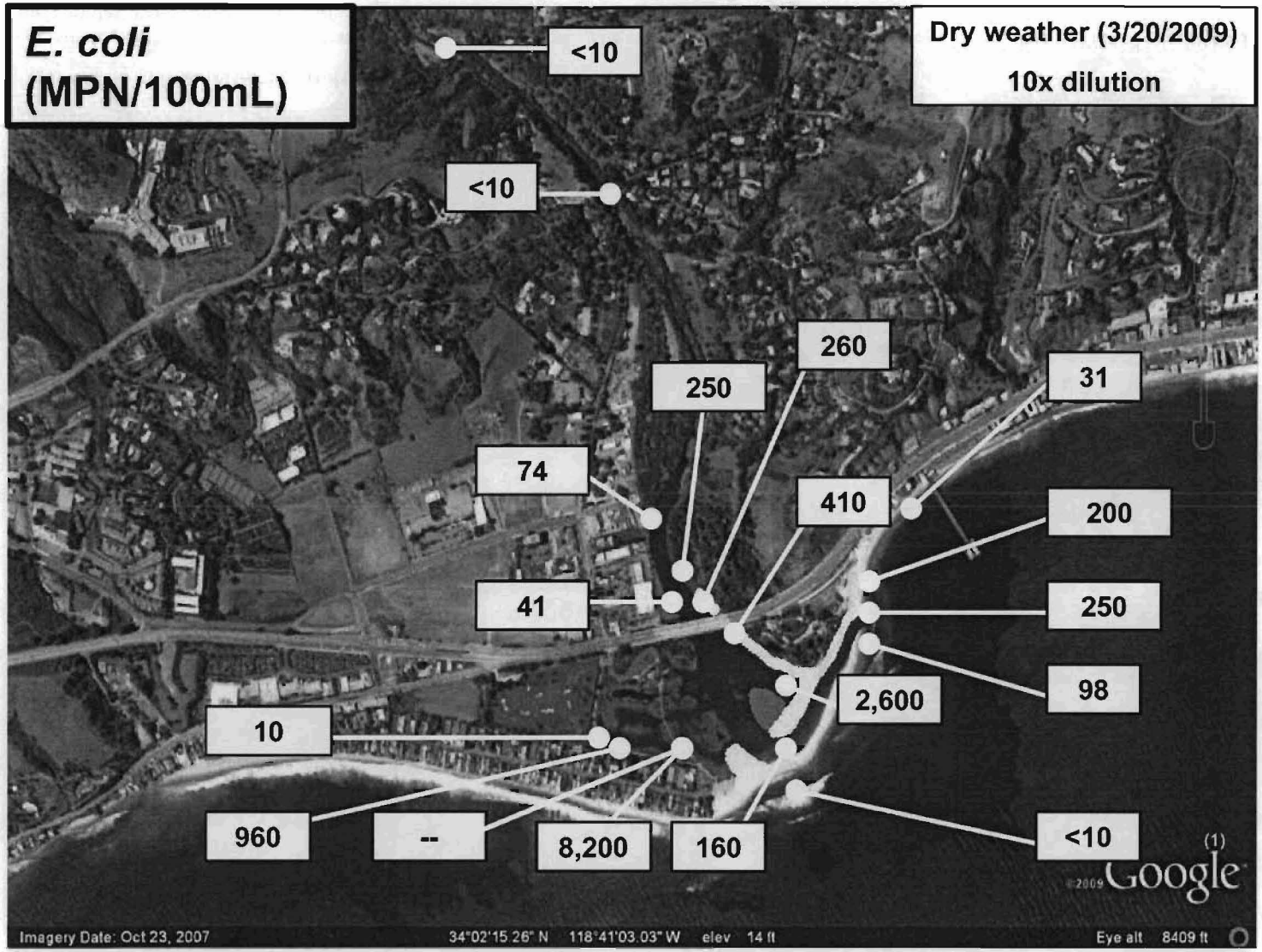

Figure 6. *E. coli* concentrations during dry weather (lagoon open) sampling period.

The single-sample water quality standard is 400 CFU/100 ml.

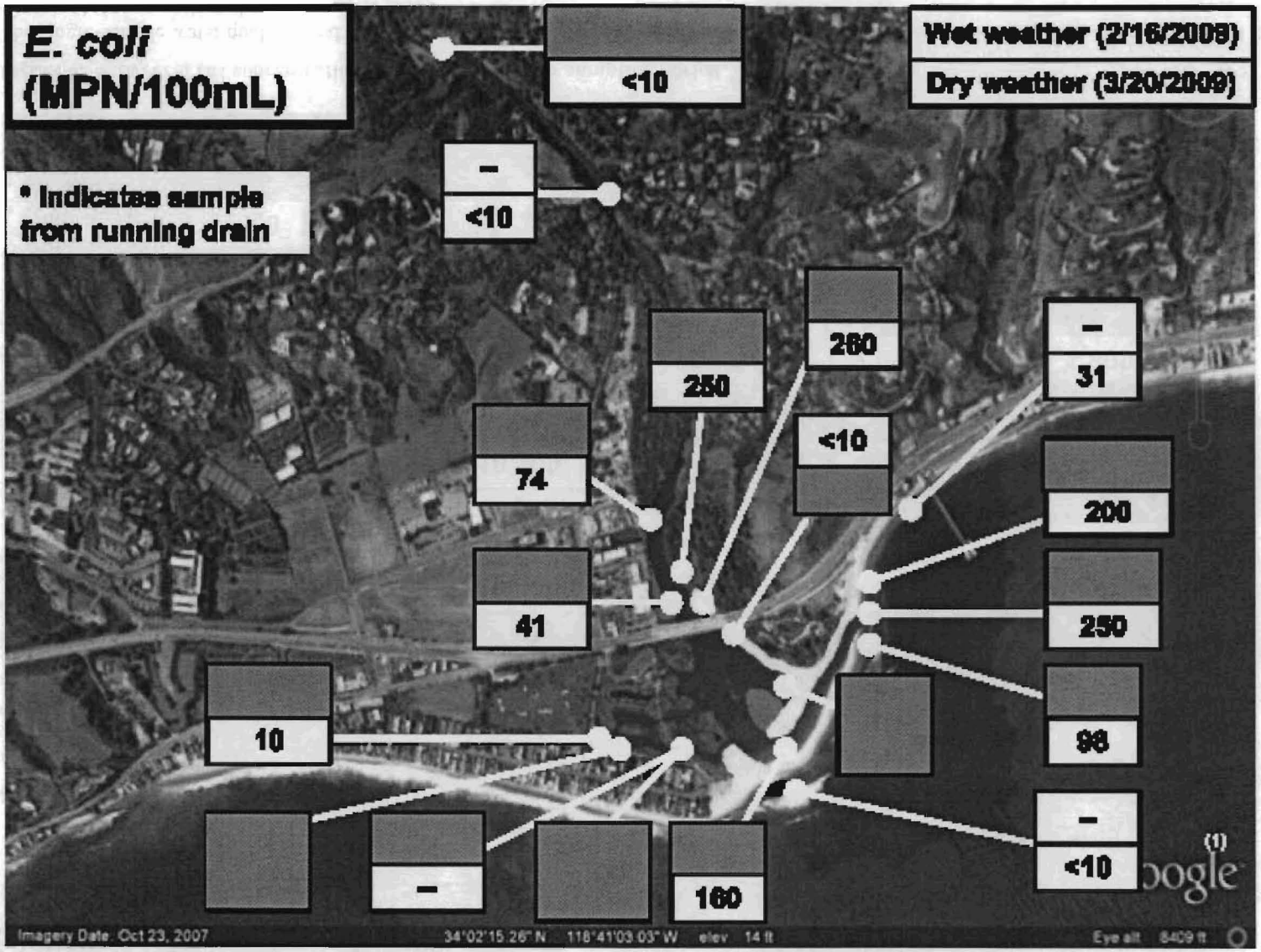

Figure 7. Comparison of *E. coli* concentrations during wet weather and dry weather (lagoon open) sampling periods.

The single-sample water quality standard is 400 CFU/100 ml. Red shading indicates values exceeding water quality standard.

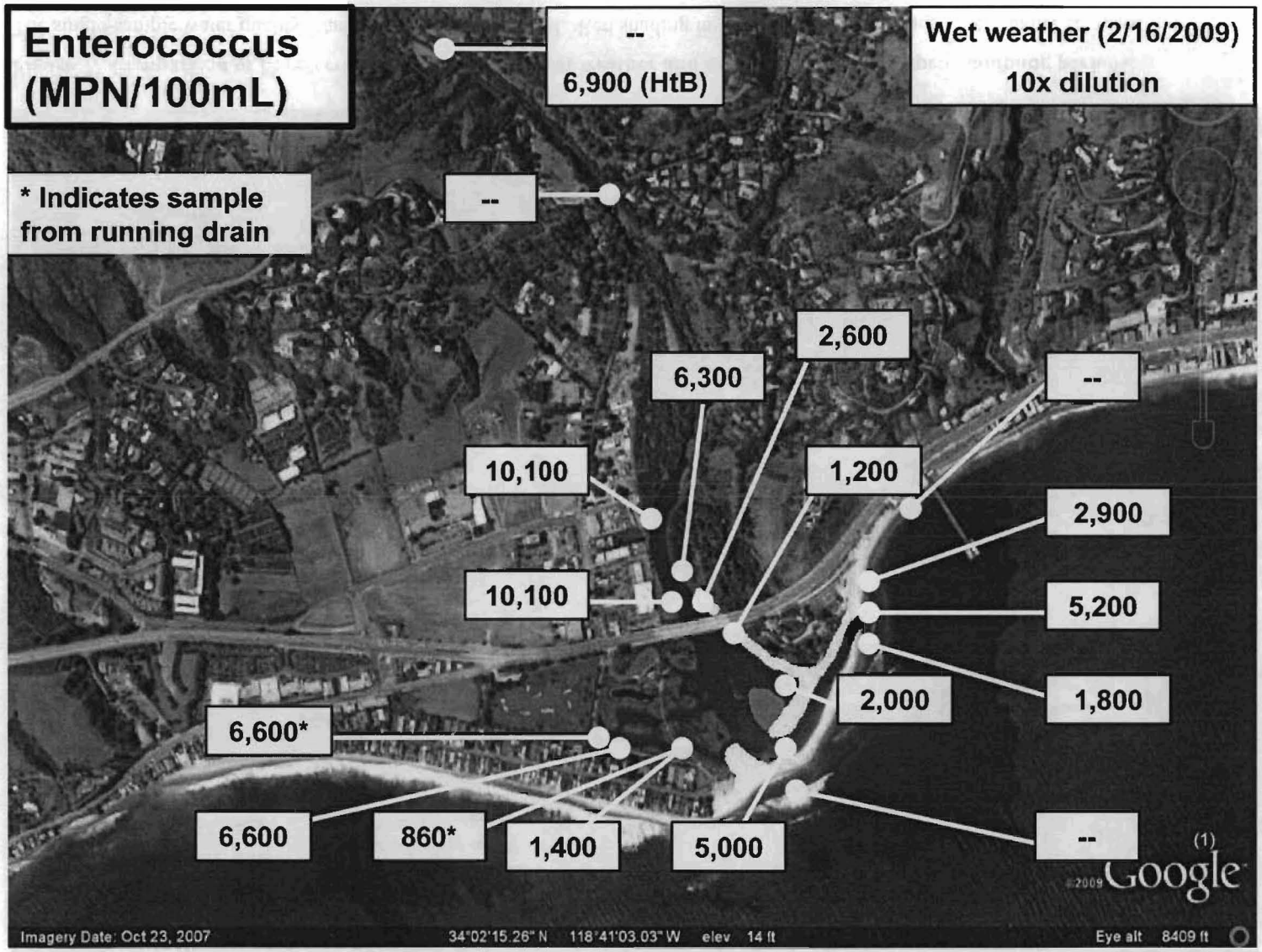

Figure 8. Enterococcus concentrations during wet weather sampling period.

The single-sample water quality standard is 104 CFU/100 ml. The two upstream sites were not sampled, but data collected nearby by Heal the Bay one day after our samples were collected are shown.

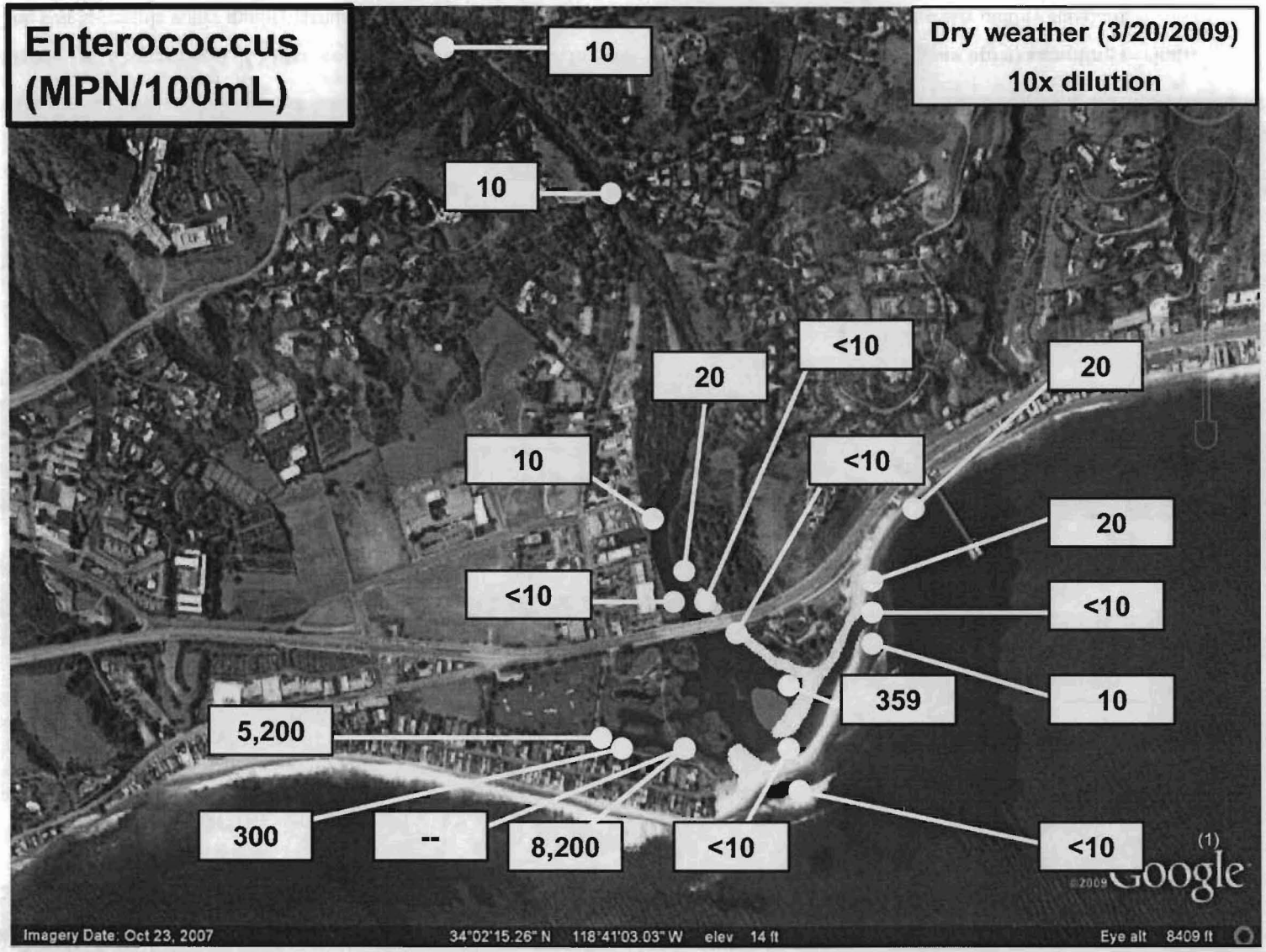

Figure 9. Enterococcus concentrations during dry weather (lagoon open) sampling period.

The single-sample water quality standard is 104 CFU/100 ml.

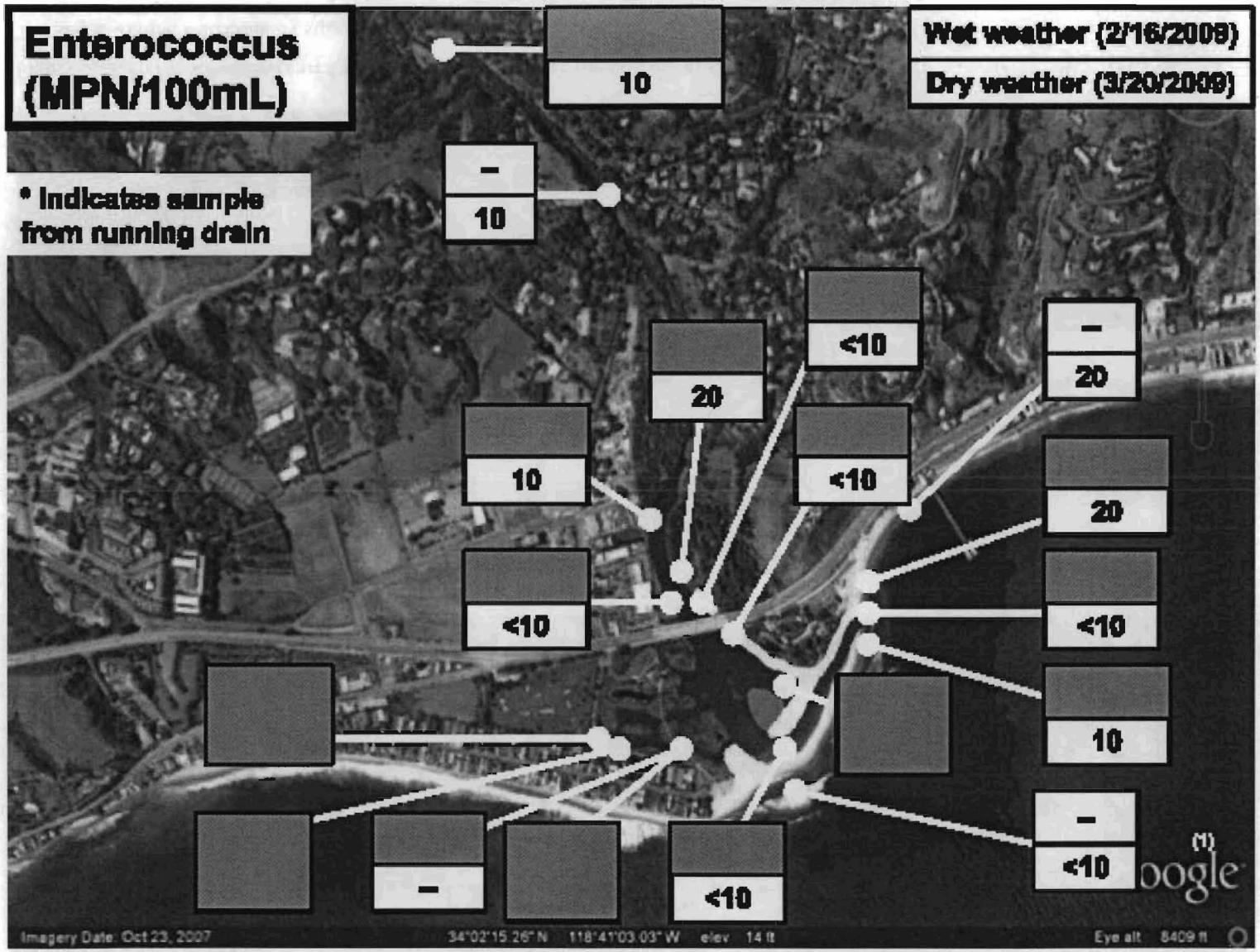

Figure 10. Comparison of Enterococcus concentrations during wet weather and dry weather (lagoon open) sampling periods.

The single-sample water quality standard is 104 CFU/100 ml. Red shading indicates values exceeding water quality standard.

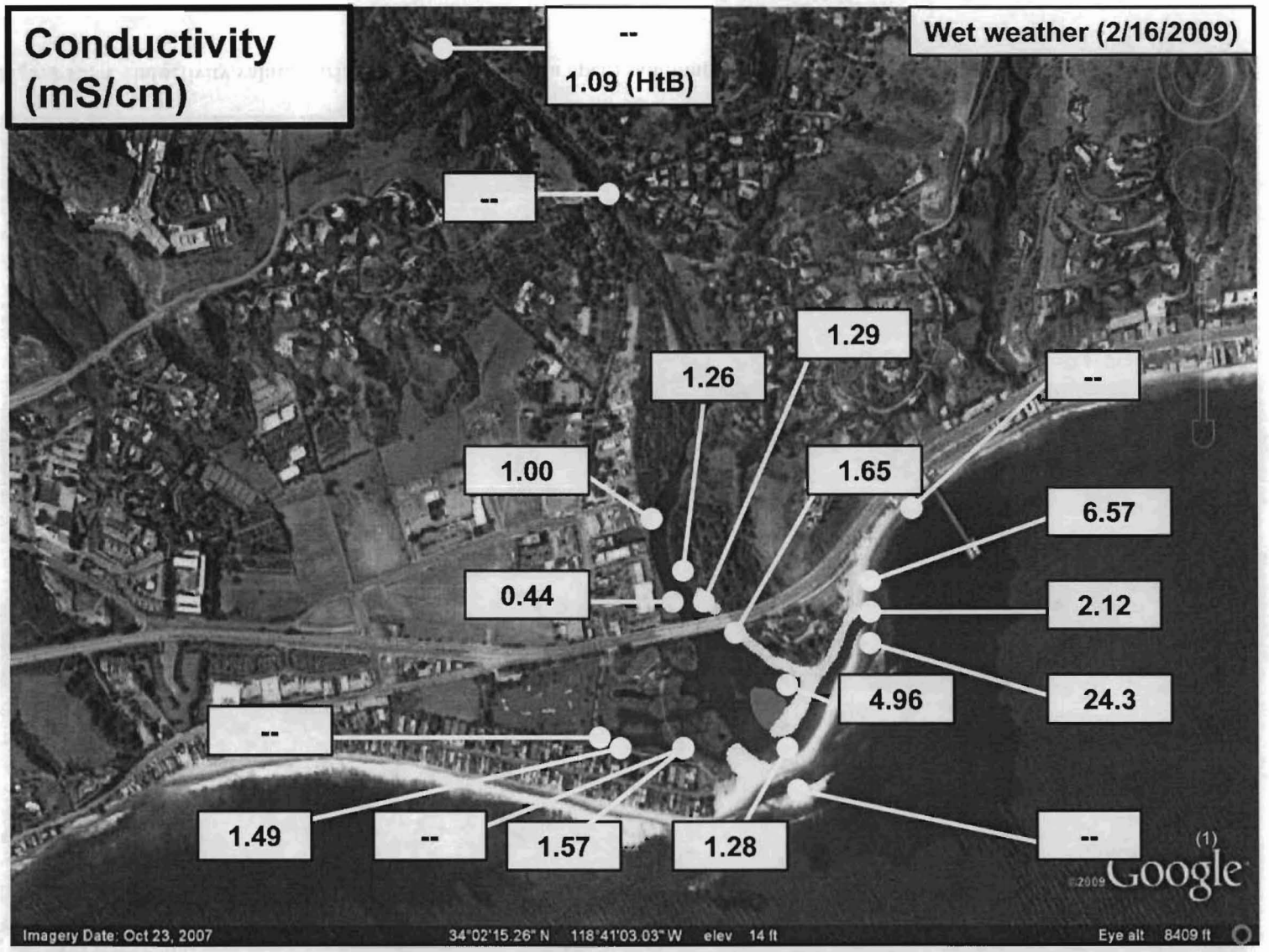

Figure 11. Conductivity values during wet weather sampling period.

The two upstream sites were not sampled, but data collected nearby by Heal the Bay one day after our samples were collected are shown.

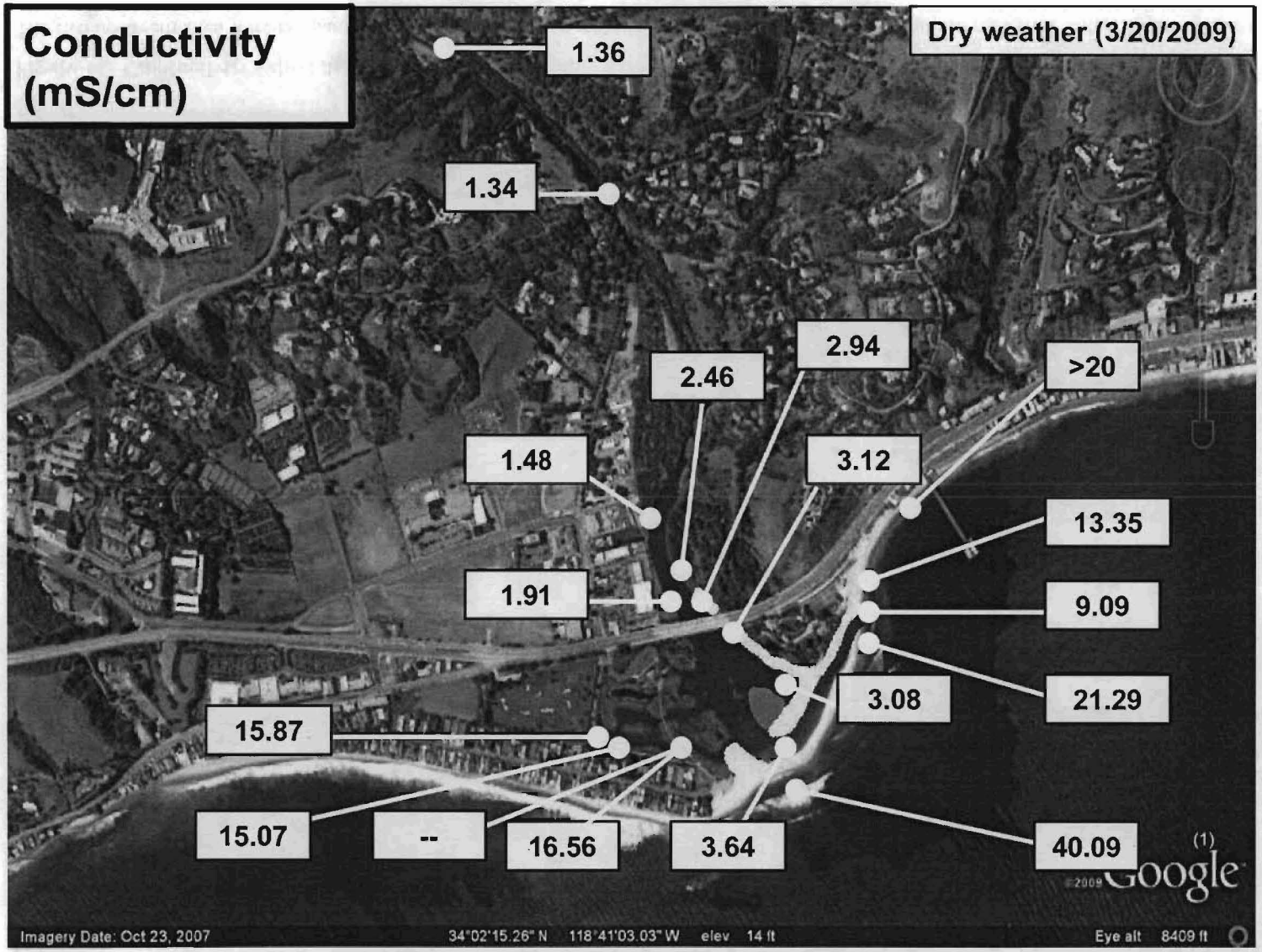

Figure 12. Conductivity values during dry weather (lagoon open) sampling period.

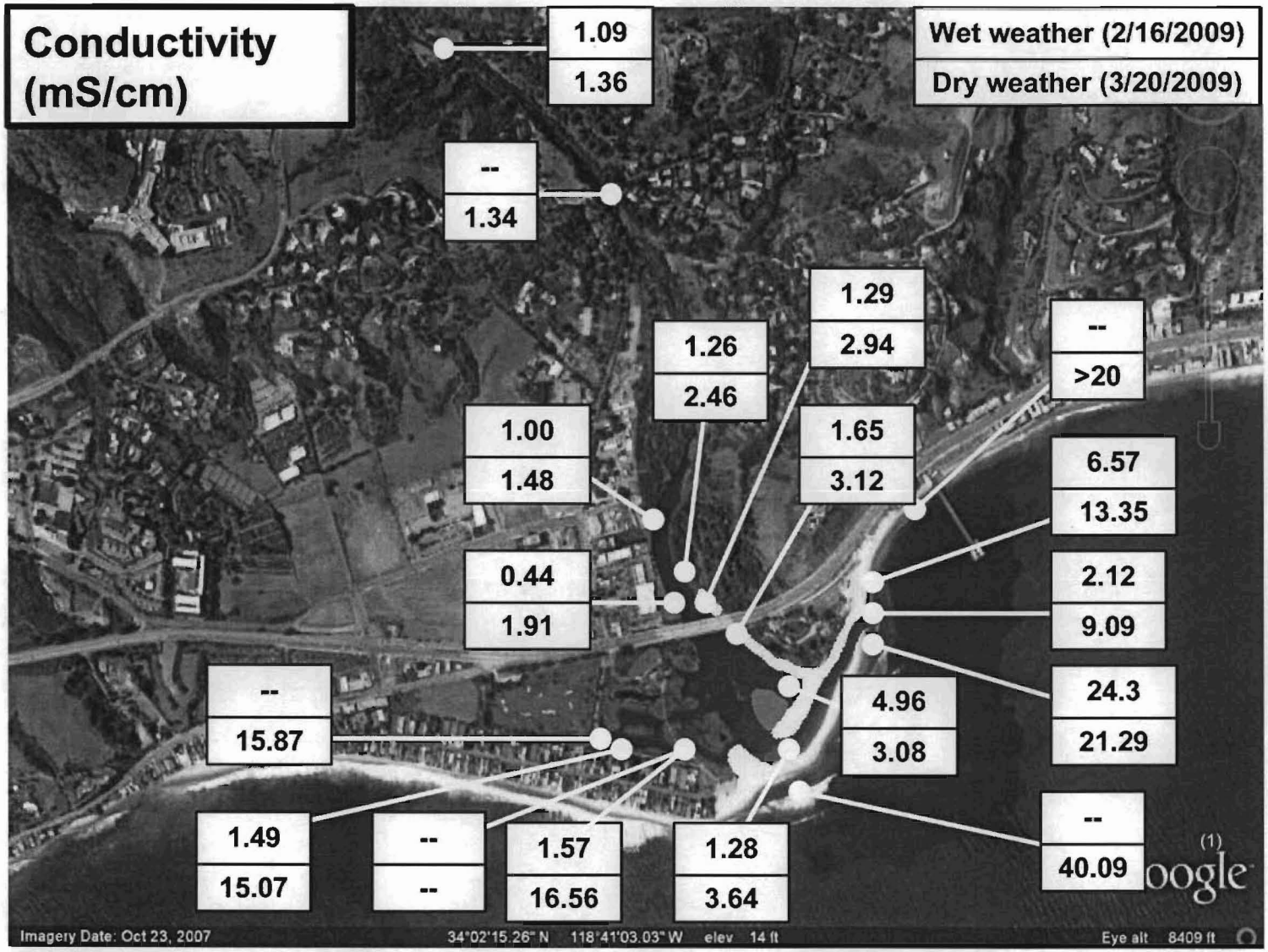

Figure 13. Conductivity values during wet weather and dry weather (lagoon open) sampling periods.