

## Water Quality Monitoring at Rancho Corral de Tierra Multi-Year Report to Golden Gate National Recreation Area

*Period covered: September 1<sup>st</sup> 2013 – June 30<sup>th</sup> 2017*

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### Background

The Golden Gate National Recreation Area (GGNRA) and the San Mateo County Resource Conservation District (RCD) entered into Task Agreement #P13AC00775 (TA) and Cooperative Agreement #P13AC00766 on September 1<sup>st</sup> 2013 for water quality monitoring at Rancho Corral de Tierra. This work included both baseline water quality monitoring on various creeks in Rancho Corral de Tierra and intensive bacteria monitoring on San Vicente Creek, in addition to providing technical assistance related to new regulations. This document is the third annual progress report for this work and provides a multi-year water quality report for all results collected to date.

### Program Summary

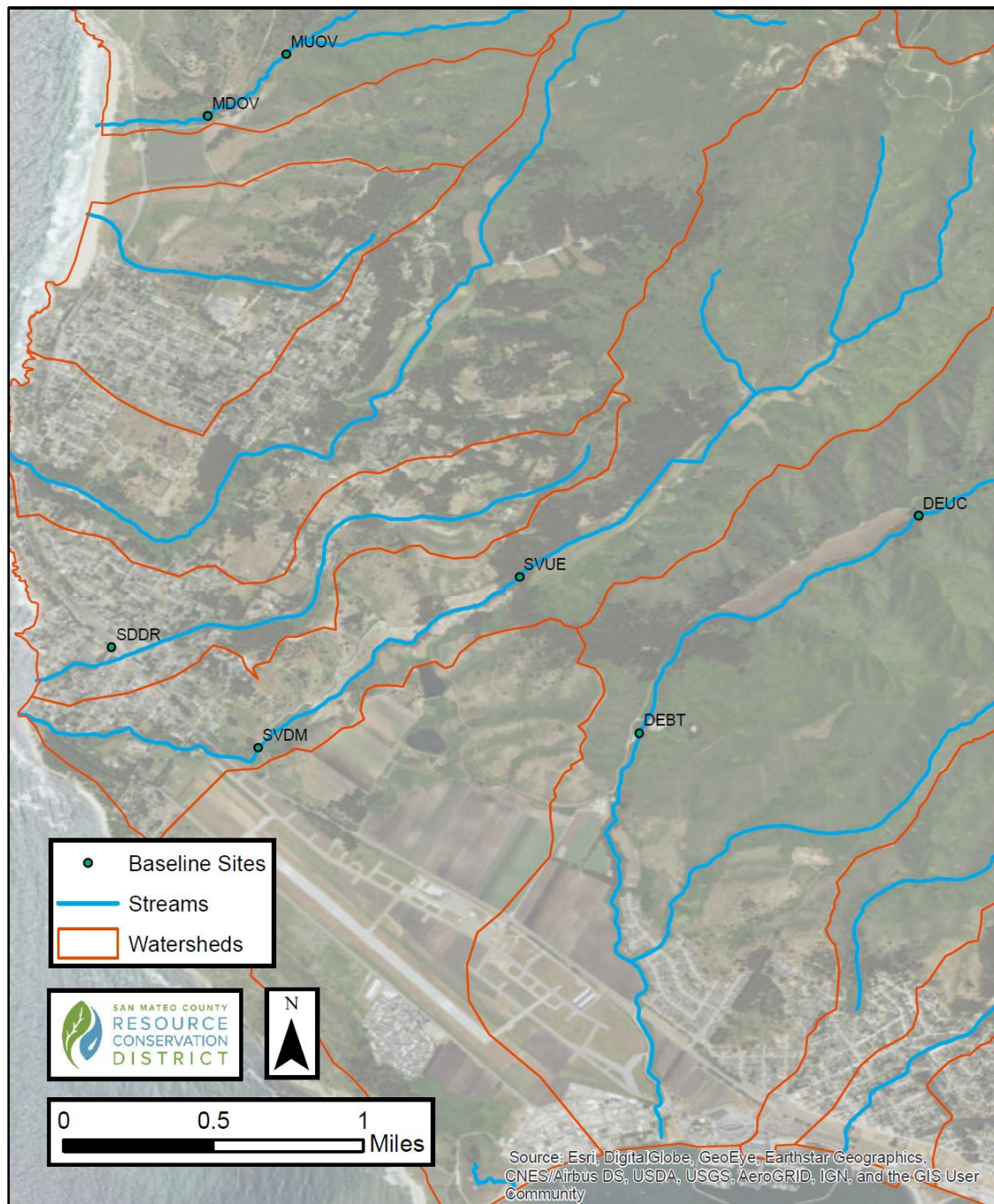
Water quality monitoring was conducted at Martini Creek, San Vicente Creek, Denniston Creek, and Sunshine/Dean Creek between November 2013 and March 2017. Baseline monitoring involved sampling fecal indicator bacteria (*E. Coli*, Total Coliforms, *Enterococcus*), ammonia, nitrate, and orthophosphate several times per year during both the wet and dry season. Copper, lead, zinc, Total Suspended Solids, and *Bacteroidales* (dog, horse, human markers) were sampled during the first big rain of the season (first flush). On Denniston, Martini and San Vicente Creeks samples were usually taken at two baseline sites (upstream and downstream of potential sources). At Sunshine/Dean Creek only one site was sampled due to lack of access further upstream. In addition to the two baseline sites on San Vicente Creek, up to five other sites were sampled at San Vicente Creek on a monthly basis for *E. Coli* and Total Coliforms.

Standard protocols were used for the collection of grab samples and samples were analyzed through ELAP certified laboratories. RCD staff measured physical parameters (temperature, pH, dissolved oxygen, specific conductivity, total dissolved solids, and salinity) and recorded observations in the field. Results were compared to water quality objectives (WQOs), or thresholds for concentrations of specific pollutants that have been established for protection of beneficial uses of waters (wildlife, agriculture, recreation etc). In order to protect beneficial uses for a given waterbody, the WQOs should not be exceeded.

### Baseline Monitoring Results

Seven sites on Denniston, Martini, San Vicente, and Sunshine/Dean Creeks (Figure 1 and Table 1) were tested several times per year for fecal indicator bacteria (FIB) and nutrients (nitrate, ammonia, orthophosphate) between November 2013 and February 2017 to establish baseline conditions. Out

of 404 samples collected, 76 samples exceeded the water quality objectives at the baseline sites. Fecal indicator bacteria (FIB) exceeded the objective much more than nutrients with a ~33% exceedance rate, while nutrients only had a ~5% exceedance rate. San Vicente Creek had the most exceedances of FIB with an overall exceedance rate of 62%, followed by Martini Creek with 23%, and Denniston Creek with 21%. Results from baseline data collection are shown in Tables 2 and 3.



**Figure 1.** Baseline water quality sampling sites on Martini, Sunshine/Dean, San Vicente, and Denniston Creeks sampled between November 2013 and February 2017.

**Table 1.** Site names, current and past GGNRA site IDs, and locations for baseline monitoring sites.

| Site Name                                        | Site ID | Previous Site ID | Coordinates            |
|--------------------------------------------------|---------|------------------|------------------------|
| San Vicente Creek Downstream of Moss Beach Ranch | SVDM    | SV-4             | 37.522611, -122.506417 |
| San Vicente Creek Upstream of Ember Ridge        | SVUE    | SV-1             | 37.530880, -122.493836 |
| Martini Creek Downstream of Ocean View Farms     | MDOV    | MAR-2            | 37.553068, -122.508797 |
| Martini Creek Upstream of Ocean View Farms       | MUOV    | MAR-1            | 37.556072, -122.505079 |
| Sunshine/Dean Creek Downstream of Renegade Ranch | SDDR    | RR-2             | 37.527469, -122.513477 |
| Denniston Creek Below Treatment Infrastructure   | DEBT    | DN-2             | 37.523355, -122.488006 |
| Denniston Creek Upstream Cabrillo Farms          | DEUC    | DN-1             | 37.533854, -122.474562 |

All types of FIB had about the same number of exceedances. Most exceedances for *Enterococcus* occurred at the upstream San Vicente Creek site, some of which were during the dry season. Exceedances of the *E. Coli* WQO occurred mainly at sites on San Vicente and Martini Creeks, with some occurring during the dry season. Overall, San Vicente Creek and Martini Creek exceeded objectives during both the wet and dry season while Denniston Creek typically only had exceedances during wet weather events.

The upstream sites at Denniston and Martini Creeks exceeded WQOs periodically, but only about half the number of times as the downstream sites. The upstream site at San Vicente Creek exceeded the WQOs for FIB more often than the San Vicente Creek downstream site. The downstream site was not sampled as often due to lack of flowing water, but the upstream site still had a higher exceedance rate (63%) than the downstream site (60%).

Overall, nutrient objectives were exceeded far less than FIB but almost all were orthophosphate exceedances. The ammonia objective was never exceeded and the nitrate objective was only exceeded at Sunshine/Dean Creek during the one event it was sampled. Each site exceeded the orthophosphate objective at least once, but the highest exceedance rate was at the downstream San Vicente Creek site (~17%), followed by the downstream site at Denniston Creek (~14%).

The First Flush 2015 event was sampled at the downstream sites on Martini and Denniston Creek and the upstream site on San Vicente Creek, as the downstream site had no water. None of the additional pollutants monitored (copper, zinc, lead, Total Suspended Solids) exceeded water quality objectives.

Microbial source tracking of bacteria (MST) only detected trace levels of the dog marker at the downstream Denniston site, while horse and human markers were not detected (Table 4).

**Table 2.** Baseline monitoring results for FIB with exceedances of WQOs shown in red. NW=No Water, ND=Non-Detect, NA=Not Applicable/No Sample Taken.

| Parameters & WQOs                     | Sample Date             | Sample Site ID |       |       |       |       |       |       |
|---------------------------------------|-------------------------|----------------|-------|-------|-------|-------|-------|-------|
|                                       |                         | MUOV           | MDOV  | SVUE  | SVDM  | DEUC  | DEBT  | SDDR  |
| E. coli:<br><406 MPN/100mL            | November 2013           | 10             | 10    | 3873  | 148   | 20    | 20    | NW    |
|                                       | February 2014*          | 10             | 41    | 269   | 11199 | 31    | 86    | 24196 |
|                                       | May 2014                | 10             | 75    | 41    | 908   | 97    | 52    | NW    |
|                                       | August 2014             | 657            | 96    | 1376  | NW    | 41    | 30    | NW    |
|                                       | First Flush (10/31/14)* | 727            | 9804  | 3076  | NW    | 512   | 187   | NW    |
|                                       | November 2014           | 10             | 75    | 86    | 794   | 173   | 132   | NA    |
|                                       | February 2015           | 10             | 20    | 85    | 218   | 20    | 10    | NA    |
|                                       | May 2015                | 10             | 203   | 428   | 145   | 63    | 228   | NA    |
|                                       | August 2015             | 813            | 1017  | 1500  | NW    | 63    | 134   | NA    |
|                                       | First Flush (11/2/15)*  | NA             | 2143  | 17329 | NW    | NA    | 1198  | NA    |
|                                       | February 2016*          | 75             | 457   | 172   | 24196 | 295   | 471   | NA    |
|                                       | August 2016             | 20             | 63    | 327   | 1664  | NA    | 75    | NA    |
|                                       | FF 2016^ *              | NA             | 240   | NA    | 5172  | NA    | 134   | NA    |
| Total Coliforms:<br><10,000 MPN/100mL | February 2017*          | 20             | 246   | 3654  | 4611  | 201   | 171   | NA    |
|                                       | November 2013           | 823            | 452   | 17329 | 1301  | 323   | 408   | NW    |
|                                       | February 2014*          | 5794           | 5794  | 14136 | 24196 | 882   | 24196 | 24196 |
|                                       | May 2014                | 1106           | 1201  | 3654  | 2382  | 880   | 934   | NW    |
|                                       | August 2014             | 1483           | 1860  | 6131  | NW    | 2489  | 2310  | NW    |
|                                       | First Flush (10/31/14)* | 24196          | 24196 | 24196 | NW    | 15531 | 19863 | NW    |
|                                       | November 2014           | 1782           | 1376  | 3282  | 12033 | 909   | 1467  | NA    |
|                                       | February 2015           | 2382           | 2755  | 2187  | 4352  | 657   | 703   | NA    |
|                                       | May 2015                | 2142           | 1850  | 3448  | 9208  | 3130  | 2098  | NA    |
|                                       | August 2015             | 2924           | 6131  | 15531 | NW    | 3130  | 4611  | NA    |
|                                       | First Flush (11/2/15)*  | NA             | 17329 | 24196 | NW    | NA    | 24196 | NA    |
|                                       | February 2016*          | 4721           | 15531 | 24196 | 24196 | 24196 | 24196 | NA    |
|                                       | August 2016             | 464            | 122   | 580   | 50    | NA    | 75    | NA    |
| Enterococcus:<br><104 MPN/100mL       | FF 2016^ *              | NA             | 2400  | NA    | 17329 | NA    | 2187  | NA    |
|                                       | February 2017*          | NA             | NA    | NA    | NA    | NA    | NA    | NA    |
|                                       | November 2013           | 30             | 52    | 960   | 84    | 41    | 10    | NW    |
|                                       | February 2014*          | 41             | 20    | 3255  | 24196 | 31    | 121   | 24196 |
|                                       | May 2014                | 10             | 108   | 110   | 2046  | 146   | 41    | NW    |
|                                       | August 2014             | 52             | 135   | 221   | NW    | 20    | 52    | NW    |
|                                       | First Flush (10/31/14)* | 5172           | 6131  | 5172  | NW    | 691   | 520   | NW    |
|                                       | November 2014           | 20             | 10    | 135   | 132   | 10    | 10    | NA    |
|                                       | February 2015           | 10             | 10    | 20    | 109   | 10    | 10    | NA    |
|                                       | May 2015                | 20             | 97    | 243   | 20    | 63    | 63    | NA    |
|                                       | August 2015             | 74             | 63    | 759   | NW    | 86    | 63    | NA    |
|                                       | First Flush (11/2/15)*  | NA             | 3076  | 17329 | NW    | NA    | 3654  | NA    |
|                                       | February 2016*          | NA             | NA    | NA    | NA    | NA    | NA    | NA    |
|                                       | August 2016             | NA             | NA    | NA    | NA    | NA    | NA    | NA    |
|                                       | FF 2016*                | NA             | NA    | NA    | NA    | NA    | NA    | NA    |
|                                       | February 2017*          | NA             | NA    | NA    | NA    | NA    | NA    | NA    |

\*= precipitation event, ^= Assumed that data could be expressed an order of magnitude lower than lab results due to varying lab procedures. Note that 24,196 is the maximum detection limit so values could actually be higher.

**Table 3.** Baseline monitoring results for nutrients with exceedances of WQOs shown in red. NW=No Water, ND=Non-Detect, NA=Not Applicable/No Sample Taken, \*=Precipitation Event.

| Parameters & WQOs                                         | Sample Date             | Sample Site ID |       |       |       |       |       |       |
|-----------------------------------------------------------|-------------------------|----------------|-------|-------|-------|-------|-------|-------|
|                                                           |                         | MUOV           | MDOV  | SVUE  | SVDM  | DEUC  | DEBT  | SDDR  |
| Nitrate (NO <sub>3</sub> -N):<br><1.0 mg/L                | November 2013           | 0.17           | 0.14  | ND    | 0.13  | ND    | ND    | NW    |
|                                                           | February 2014*          | 0.11           | 0.01  | 0.10  | 0.87  | 0.01  | 0.13  | 2.6   |
|                                                           | May 2014                | ND             | ND    | ND    | 0.16  | ND    | 0.10  | NW    |
|                                                           | August 2014             | ND             | ND    | ND    | NW    | ND    | ND    | NW    |
|                                                           | First Flush (10/31/14)* | 0.35           | ND    | 0.12  | NW    | ND    | ND    | NW    |
|                                                           | November 2014           | ND             | ND    | ND    | ND    | ND    | ND    | NA    |
|                                                           | February 2015           | 0.13           | 0.14  | ND    | 0.49  | ND    | 0.24  | NA    |
|                                                           | May 2015                | ND             | 0.12  | ND    | ND    | ND    | ND    | NA    |
|                                                           | August 2015             | ND             | ND    | ND    | NW    | ND    | ND    | NA    |
|                                                           | First Flush (11/2/15)*  | NA             | 0.2   | 0.4   | NW    | NA    | 0.1   | NA    |
|                                                           | February 2016*          | 0.19           | 0.15  | 0.11  | 0.85  | 0.06  | 0.54  | NA    |
|                                                           | August 2016             | 0.07           | 0.05  | ND    | ND    | NA    | ND    | NA    |
|                                                           | FF 2016*                | NA             | 0.20  | NA    | 0.80  | NA    | 0.20  | NA    |
|                                                           | February 2017*          | 0.45           | 0.22  | 0.04  | 0.62  | 0.27  | 0.26  | NA    |
| Orthophosphate<br>(PO <sub>4</sub> -P) <0.12 mg/L         | November 2013           | ND             | ND    | ND    | ND    | ND    | ND    | NW    |
|                                                           | February 2014*          | 0.03           | 0.03  | 0.09  | 0.14  | 0.04  | 0.05  | 2.7   |
|                                                           | May 2014                | 0.02           | 0.03  | 0.06  | 0.05  | 0.03  | 0.06  | NW    |
|                                                           | August 2014             | 0.01           | 0.01  | 0.08  | NW    | 0.03  | 0.04  | NW    |
|                                                           | First Flush (10/31/14)* | 0.26           | 0.22  | 0.46  | NW    | 0.12  | 0.12  | NW    |
|                                                           | November 2014           | 0.03           | 0.03  | 0.06  | 0.07  | 0.03  | 0.04  | NA    |
|                                                           | February 2015           | 0.02           | 0.01  | 0.03  | 0.01  | 0.02  | 0.03  | NA    |
|                                                           | May 2015                | 0.02           | 0.03  | 0.05  | 0.02  | 0.02  | 0.04  | NA    |
|                                                           | August 2015             | ND             | 0.01  | 0.07  | NW    | 0.02  | 0.03  | NA    |
|                                                           | First Flush (11/2/15)*  | NA             | ND    | ND    | NW    | NA    | 0.30  | NA    |
|                                                           | February 2016*          | 0.05           | 0.05  | 0.10  | 0.07  | 0.06  | 0.09  | NA    |
|                                                           | August 2016             | 0.08           | 0.09  | 0.02  | 0.02  | NA    | 0.03  | NA    |
|                                                           | FF 2016*                | NA             | 0.02  | NA    | 0.01  | NA    | 0.02  | NA    |
|                                                           | February 2017*          | 0.06           | 0.07  | 0.09  | 0.16  | 0.08  | 0.08  | NA    |
| Unionized Ammonia<br>(NH <sub>3</sub> -N):<br><0.025 mg/L | November 2013           | ND             | ND    | ND    | ND    | 0.001 | ND    | NW    |
|                                                           | February 2014           | 0.003          | 0.002 | ND    | 0.003 | 0.001 | ND    | 0.012 |
|                                                           | May 2014                | ND             | ND    | ND    | ND    | ND    | 0.001 | NW    |
|                                                           | August 2014             | 0.008          | 0.001 | 0.001 | NW    | 0.001 | 0.002 | NW    |
|                                                           | First Flush (10/31/14)* | 0.008          | 0.004 | 0.004 | ND    | 0.003 | 0.002 | NW    |
|                                                           | November 2014           | 0.001          | 0.001 | 0.001 | ND    | 0.001 | ND    | NA    |
|                                                           | February 2015           | ND             | ND    | ND    | ND    | ND    | ND    | NA    |
|                                                           | May 2015                | ND             | 0.001 | 0.001 | ND    | 0.001 | 0.001 | NA    |
|                                                           | August 2015             | 0.002          | 0.002 | 0.001 | NW    | 0.003 | 0.002 | NA    |
|                                                           | First Flush (11/2/15)*  | NA             | NA    | NA    | NA    | NA    | NA    | NA    |
|                                                           | February 2016*          | NA             | NA    | NA    | NA    | NA    | NA    | NA    |
|                                                           | August 2016             | NA             | NA    | NA    | NA    | NA    | NA    | NA    |
|                                                           | FF 2016*                | NA             | NA    | NA    | NA    | NA    | NA    | NA    |
|                                                           | February 2017*          | NA             | NA    | NA    | NA    | NA    | NA    | NA    |

**Table 4.** Monitoring results from the First Flush 2015 sampling event. ND indicates Non-Detect.

|                                            | Bacteroidales<br>Human Marker | Bacteroidales<br>Horse Marker | Bacteroidales<br>Dog Marker | Dissolved<br>Copper <13<br>(µg/L) | Dissolved<br>Lead <65<br>(µg/L) | Dissolved<br>Zinc <120<br>(µg/L) | Total Suspended<br>Solids <500 mg/L |
|--------------------------------------------|-------------------------------|-------------------------------|-----------------------------|-----------------------------------|---------------------------------|----------------------------------|-------------------------------------|
| Martini Downstream of<br>Ocean View (MDOV) | ND                            | ND                            | ND                          | ND                                | ND                              | ND                               | 68                                  |
| San Vicente Upstream of<br>Ember (SVUE)    | ND                            | ND                            | ND                          | ND                                | ND                              | ND                               | 384                                 |
| Denniston Below<br>Treatment (DEBT)        | ND                            | ND                            | Trace Levels                | ND                                | ND                              | ND                               | 213                                 |

## San Vicente Creek Bacteria Monitoring Results

In addition to the baseline monitoring at San Vicente Creek, monthly monitoring for *E. Coli* and Total Coliform was conducted at various locations between the upstream and downstream sites on San Vicente Creek from February 2016 to March 2017 (Figure 2 and Table 5). There were a total of 128 exceedances of FIB water quality objectives out of 210 samples collected for an exceedance rate of 61% on San Vicente Creek (includes baseline data). WQOs were exceeded at all sites, and wet season samples generally had higher FIB counts than dry season samples. During the 14 monthly sampling events, the site above both equestrian facilities (SVUE) never exceeded the WQO for *E. Coli*, while during 12 of 14 events the WQO was exceeded at one or more sites at Ember Ridge Equestrian (SVEA, SVME, SVER, SVDE). See Table 6 for results of bacteria monitoring on San Vicente Creek.

Sites on San Vicente Creek were sampled at various times of year and at different frequencies, so the rate of exceedance of WQOs was calculated (Table 7). San Vicente Creek upstream of Moss Beach Ranch (SVUM) had the highest exceedance rates followed by San Vicente Creek at Moss Beach Ranch (SVMB). The sites with the lowest rates of exceedance were the three sites furthest upstream (SVUE, SVEA, SVME).

**Table 5.** Site names, current and past GGNRA site IDs, and locations for bacteria monitoring sites.

| Site Name                                          | Site ID | Previous Site ID | Coordinates            |
|----------------------------------------------------|---------|------------------|------------------------|
| San Vicente Creek Upstream of Ember Ridge          | SVUE    | SV-1             | 37.530843, -122.493788 |
| San Vicente Creek Ember Ridge Arenas               | SVEA    | SV-Arena         | 37.529404, -122.496001 |
| San Vicente Creek Middle of Ember Ridge            | SVME    | SV-Shed          | 37.529303, -122.496358 |
| San Vicente Creek at Ember Ridge                   | SVER    | SV-Wash          | 37.528851, -122.497666 |
| San Vicente Creek Downstream of Ember Ridge        | SVDE    | SV-2 Ember       | 37.528648, -122.498035 |
| San Vicente Creek Upstream of Moss Beach Ranch     | SVUM    | SV-2             | 37.528145, -122.498449 |
| San Vicente Creek at Moss Beach Ranch              | SVMB    | SV-3             | 37.524414, -122.503712 |
| San Vicente Creek at Moss Beach Ranch Manure Ditch | SVMD    | SV-3 Ditch       | 37.524671, -122.503912 |
| San Vicente Creek Downstream of Moss Beach Ranch   | SVDM    | SV-4             | 37.522611, -122.506417 |





**Figure 2.** San Vicente Creek monthly bacteria monitoring sites (February 2016 to March 2017).

**Table 6.** Bacteria monitoring results for San Vicente Creek with exceedances of WQOs shown in red. NW = No Water, NA = Not Applicable/No Sample Taken

| Parameters and WQOs                   | Sample Date                | SVUE   | SVEA | SVME | SVER  | SVDE   | SVUM   | SVMB   | SVMD   | SVDM   |
|---------------------------------------|----------------------------|--------|------|------|-------|--------|--------|--------|--------|--------|
| E. coli:<br><406 MPN/100mL            | 11/4/2013                  | 3,873  | NA   | NA   | NA    | NA     | NA     | NA     | NA     | 148    |
|                                       | 2/28/2014*                 | 269    | NA   | NA   | NA    | NA     | NA     | NA     | NA     | 11,199 |
|                                       | 5/21/2014                  | 41     | NA   | NA   | NA    | NA     | NA     | NA     | NA     | 908    |
|                                       | 8/26/2014                  | 1376   | NA   | NA   | NA    | NA     | NA     | NA     | NA     | NW     |
|                                       | First Flush (10/31/14)*    | 3076   | NA   | NA   | NA    | NA     | NA     | NA     | NA     | NW     |
|                                       | 11/24/2014                 | 86     | NA   | NA   | NA    | NA     | NA     | NA     | NA     | 794    |
|                                       | 2/24/2015                  | 85     | NA   | NA   | NA    | NA     | NA     | NA     | NA     | 218    |
|                                       | 5/27/2015                  | 428    | NA   | NA   | NA    | NA     | NA     | NA     | NA     | 145    |
|                                       | 8/26/2015                  | 1500   | NA   | NA   | NA    | NA     | NA     | NA     | NA     | NW     |
|                                       | First Flush (11/2/2015)*   | 17329  | NA   | NA   | NA    | NA     | NA     | NA     | NA     | NW     |
|                                       | 2/18/2016*                 | 172    | NA   | NA   | NA    | 24,196 | 24,196 | 24196  | 24,196 | 24,196 |
|                                       | 3/7/2016*                  | 161    | NA   | NA   | NA    | 408    | 1178   | 908    | 3255   | 959    |
|                                       | 4/14/2016                  | 122    | NA   | NA   | NA    | 1119   | 1607   | 1658   | 19863  | 3,448  |
|                                       | 5/23/2016                  | 158    | NA   | NA   | NA    | 4611   | 8164   | 5794   | NW     | 12033  |
|                                       | 6/15/2016                  | 185    | NA   | NA   | NA    | 11199  | 8664   | 2909   | NW     | 1439   |
|                                       | 7/20/2016                  | 404    | NA   | NA   | NA    | 4884   | 5475   | NW     | NW     | 63     |
|                                       | 8/30/2016                  | 327    | NA   | NA   | NA    | 2489   | 2089   | 1,501  | NW     | 1664   |
|                                       | 9/13/2016                  | 259    | NA   | NA   | NA    | 11,199 | 12,033 | 5,475  | NW     | 4352   |
|                                       | First Flush (10/14/2016)^* | NA     | NA   | NA   | NA    | NA     | NA     | NA     | NA     | 5172   |
|                                       | 10/18/2016*                | 160    | 471  | 906  | 959   | 1,039  | NA     | 7,701  | NA     | 2098   |
|                                       | 11/22/2016                 | 199    | 1112 | 1153 | 1515  | 1,112  | NA     | 2,755  | NA     | 2613   |
|                                       | 12/8/2016*                 | 160    | 420  | 457  | 1017  | 1,259  | NA     | 6,488  | NA     | 5475   |
|                                       | 1/24/2017                  | 97     | 98   | 63   | 98    | 98     | NA     | 185    | NA     | 86     |
|                                       | 2/9/2017*                  | 3654   | NA   | NA   | NA    | NA     | NA     | NA     | NA     | 4611   |
|                                       | 2/16/2017                  | 109    | 148  | 97   | 246   | 110    | NA     | 410    | NA     | 480    |
|                                       | 3/22/2017                  | 233    | 496  | 488  | 1309  | 488    | NA     | 2,427  | NA     | 5475   |
| Total Coliforms:<br><10,000 MPN/100mL | 11/4/2013                  | 17,329 | NA   | NA   | NA    | NA     | NA     | NA     | NA     | 1301   |
|                                       | 2/28/2014*                 | 14,136 | NA   | NA   | NA    | NA     | NA     | NA     | NA     | 24,196 |
|                                       | 5/21/2014                  | 3654   | NA   | NA   | NA    | NA     | NA     | NA     | NA     | 2382   |
|                                       | 8/26/2014                  | 6131   | NA   | NA   | NA    | NA     | NA     | NA     | NA     | NW     |
|                                       | First Flush (10/31/14)*    | 24196  | NA   | NA   | NA    | NA     | NA     | NA     | NA     | NW     |
|                                       | 11/24/2014                 | 3282   | NA   | NA   | NA    | NA     | NA     | NA     | NA     | 12033  |
|                                       | 2/24/2015                  | 2187   | NA   | NA   | NA    | NA     | NA     | NA     | NA     | 4352   |
|                                       | 5/27/2015                  | 3448   | NA   | NA   | NA    | NA     | NA     | NA     | NA     | 9208   |
|                                       | 8/26/2015                  | 15531  | NA   | NA   | NA    | NA     | NA     | NA     | NA     | NW     |
|                                       | First Flush (11/2/2015)*   | 24196  | NA   | NA   | NA    | NA     | NA     | NA     | NA     | NW     |
|                                       | 2/18/2016*                 | 24196  | NA   | NA   | NA    | 24196  | 24196  | 24196  | 24196  | 24196  |
|                                       | 3/7/2016*                  | 6488   | NA   | NA   | NA    | 24196  | 24196  | 24196  | 24196  | 24196  |
|                                       | 4/14/2016                  | 9804   | NA   | NA   | NA    | 19863  | 14136  | 10462  | 24196  | 15531  |
|                                       | 5/23/2016                  | 6867   | NA   | NA   | NA    | 17329  | 24196  | 14136  | NW     | 3873   |
|                                       | 6/15/2016                  | 8164   | NA   | NA   | NA    | 19863  | 17329  | 9208   | NW     | 4884   |
|                                       | 7/20/2016                  | 7270   | NA   | NA   | NA    | 19863  | 24196  | NW     | NW     | 1664   |
|                                       | 8/30/2016                  | 580    | NA   | NA   | NA    | 121    | 340    | 235    | NW     | 50     |
|                                       | 9/13/2016                  | 7701   | NA   | NA   | NA    | 1723   | 1664   | 14,136 | NW     | 14,136 |
|                                       | First Flush (10/14/2016)^* | NA     | NA   | NA   | NA    | NA     | NA     | NA     | NA     | 17,329 |
|                                       | 10/18/2016*                | 7701   | 8664 | 8664 | 10462 | 9208   | NA     | >24196 | NA     | 11,199 |
|                                       | 11/22/2016                 | 8164   | 9208 | 8164 | 11199 | 14136  | NA     | 12,033 | NA     | 8,164  |
|                                       | 12/8/2016*                 | 4352   | 7270 | 5247 | 10462 | 8664   | NA     | 19,863 | NA     | 12,997 |
|                                       | 1/24/2017                  | 2613   | 5475 | 5475 | 5475  | 5794   | NA     | 6,488  | NA     | 3,448  |
|                                       | 2/9/2017*                  | NA     | NA   | NA   | NA    | NA     | NA     | NA     | NA     | NA     |
|                                       | 2/16/2017                  | 4352   | 4611 | 7701 | 9208  | 11199  | NA     | 19,863 | NA     | >24196 |
|                                       | 3/22/2017                  | NA     | NA   | NA   | NA    | NA     | NA     | NA     | NA     | NA     |

\*= precipitation event, ^= Assumed that data could be expressed an order of magnitude lower than lab results due to varying lab procedures. Note that 24,196 is the maximum detection limit so values could actually be higher.

**Table 7.** Exceedance rates of WQOs for E. Coli and all types of FIB (E. Coli, Enterococcus, Total Coliform) for each site on San Vicente Creek.



| Site ID (Upstream to Downstream) | <i>E. Coli</i> Exceedance Rate | All FIB Exceedance Rate |
|----------------------------------|--------------------------------|-------------------------|
| SVUE                             | 28%                            | 37%                     |
| SVEA                             | 67%                            | 36%                     |
| SVME                             | 67%                            | 36%                     |
| SVER                             | 67%                            | 64%                     |
| SVDE                             | 86%                            | 78%                     |
| SVUM                             | 100%                           | 94%                     |
| SVMB                             | 92%                            | 84%                     |
| SVDM                             | 80%                            | 60%                     |

## Discussion

Overall, results of water quality monitoring at Rancho Corral de Tierra indicated that FIB is the highest pollutant of concern in all waterbodies sampled, particularly at San Vicente Creek. According to the EPA, a waterbody is generally considered to be impaired for a specific pollutant if the exceedance rate is greater than about 15%. Therefore results indicate potential FIB impairment at all creeks sampled, in addition to potential orthophosphate impairment at San Vicente Creek and Denniston Creek.

Monitoring also indicated that nitrate, ammonia, copper, lead, zinc, and Total Suspended Solids are not currently pollutants of concern as they were either not detected or occurred in very low concentrations. Nitrate was sampled over 10 times from 2013 to 2017 so there is a high amount of certainty that nitrate is not a pollutant of concern. Ammonia was sampled during nine sampling events between 2013 and 2015 using both a certified laboratory as well as a multi-parameter water quality probe. Both methods indicated very low concentrations of ammonia but there may have been errors with probe calibration and conversions of ammonia. The new Regional Water Quality Control Board (RWQCB) Waste Discharge Requirements for Confined Animal Facilities (WDR) requires that ammonia be sampled on San Vicente Creek so it will be assessed further in future. All other parameters listed were only sampled one time and in 2015, so this data only provides a snapshot.

Orthophosphate samples were collected during 14 sampling events between 2013 and 2017 at the baseline monitoring sites. All exceedances occurred during rain events which indicate build-up on the landscape of this pollutant during the dry season. The only exceedances at Martini Creek were during the First Flush event in 2014, while the only exceedances at Denniston creek were during the 2014 and 2015 First Flush events. However, at San Vicente Creek there were two exceedances at the downstream baseline site (SVDM) when there were no exceedances at the sampling site furthest upstream (SVUE), indicating a potential source between the two sites where the equestrian facilities are located. The RCD has proposed monitoring of orthophosphate in future monitoring work to further visualize trends and understand potential inputs.

MST samples taken during the 2015 First Flush event only detected trace levels of the dog marker, which was surprising as human and horse markers were also tested. One explanation could be contribution of FIB from sources that were not tested such as wildlife (deer, pigs, birds etc) or other

animals located on the ranches/farms (chickens, ruminants etc). Alternately, the results could be false negatives, which are considered to be the most prominent limitation to current MST technologies. "Absence of detection" is not the same as "detection of absence". It only takes several samples with detection of a certain source to indicate presence, while it would take many samples for absence to be proven. Therefore, results of MST do not indicate that there are no human or horse sources of FIB at Martini, Denniston, and San Vicente Creeks. Additional MST testing in Rancho Corral de Tierra is not recommended at this time.

Baseline FIB results at Martini Creek and Denniston Creek indicated that WQOs were exceeded 23% and 21% of the time respectively, with over 30 FIB samples collected at each site over 3+ years. There were generally higher levels of FIB at downstream sites than at the corresponding upstream sites, so it is likely that there are inputs between the sites and opportunities for management improvements. Ocean View Farms is between the upstream and downstream sites on Martini Creek and Cabrillo Farms is between the upstream and downstream sites on Denniston Creek. The RCD has proposed monitoring of *E. Coli* at Denniston and Martini Creeks (including a new site on each creek) for future monitoring work to further visualize trends. Note that sampling on Sunshine/Dean Creek was removed from the program due to lack of access and flowing water, but this may no longer be the case and this can be explored further if requested.

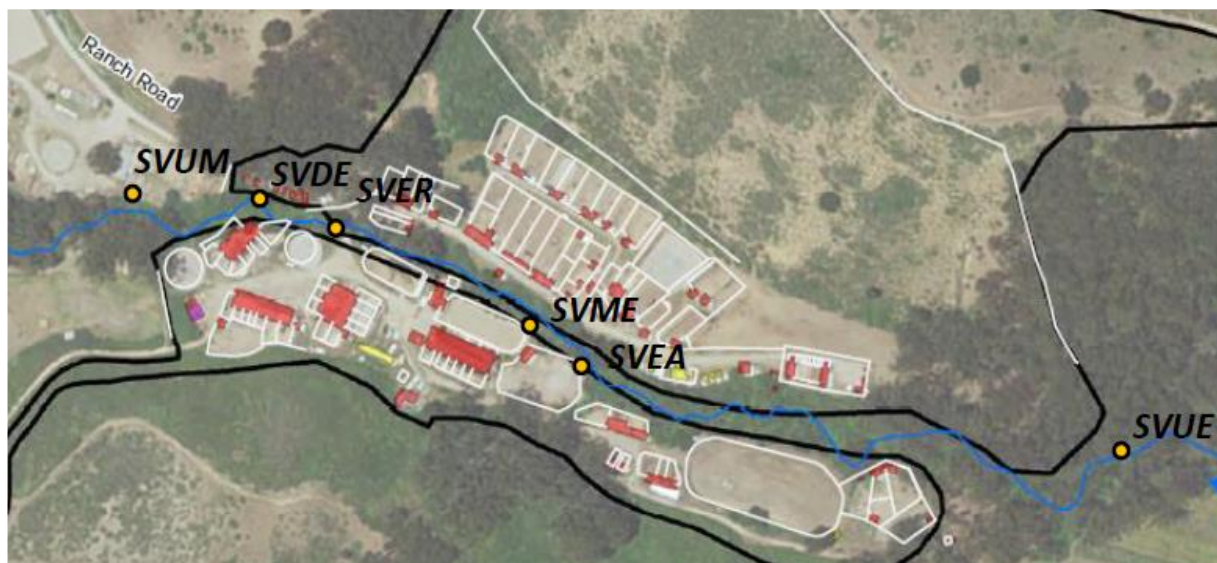
Analysis of baseline and monthly FIB results for San Vicente Creek demonstrated several key trends. Note that the baseline sites (SVUE and SVDM) had a higher sample size and were sampled over a longer period of time than the monthly sites. The sampling site just upstream of Ember Ridge Equestrian (SVUE) had considerable amounts of FIB especially between 2013 and 2015. This was particularly apparent when results were compared to the upstream baseline sites on Denniston and Martini Creek and given that the FIB exceedance rate for this site was 37% over the course of several years. However, one of the most important trends at this site was that FIB levels decreased dramatically between 2016 and 2017 and there was only one exceedance during this time.

These results indicate that there are, or were, sources of FIB upstream of SVUE which is largely private property including fallowed farm fields and various residential structures. Potential sources of FIB could be anthropogenic and related to this property and/or stem from wildlife. The RCD will continue to reach out to the property owner and explore the significance of any sources above the horse facilities.

The next sites sampled downstream of SVUE (in order) were SVEA, SVME, SVER, and SVDE (Figure 3). SVDE is the most downstream site and is located between the trailers at the entrance of the Ember Ridge Equestrian and captures virtually all runoff from this facility. During 12 of 14 sampling events, SVDE exceeded the *E. Coli* WQO, while the site upstream of Ember Ridge (SVUE) did not. At the beginning of monthly sampling, there were large increases in *E. Coli* between these two sites but for the latter half of the program (October 2016- March 2017) *E. Coli* levels were much lower.

Sampling at the sites between these two locations did not occur until the latter half of the program once this trend was identified. Two sites were selected in the middle of Ember Ridge that capture the upper half of the facility (SVEA and SVME) and another site (SVER) was selected at the bridge near the downstream end of the facility. Results indicated that when WQOs were exceeded downstream of SVUE, it occurred as far upstream as SVEA. As stated previously, FIB levels at Ember

Ridge during this period (October 2016 – March 2017) were lower than previously indicated. This was evident at SVEA as most values were just slightly over the WQO and as there were only small increases at each of the sites downstream (SVME, SVER, SVDE). Therefore, no specific hot spot areas were identified at Ember Ridge but it is recommended that some of these sites continue to be sampled in the dry season to help pinpoint FIB inputs to the creek.



**Figure 3.** Aerial of sampling sites near Ember Ridge Equestrian with property boundaries shown in black, fences/walls in white, barns/sheds in red, coops/hutches in yellow, and other structures in purple. Basemap derived from Geosyntec Memo to GGNRA dated March 16<sup>th</sup> 2017.

These results indicate that between the site upstream of Ember Ridge Equestrian (SVUE) and the site at the downstream end of Ember Ridge Equestrian (SVDE), San Vicente Creek goes from a state of non-impairment to impairment as indicated by consistent exceedance of WQOs at various locations. However, it is important to consider that prior to 2016 there was also impairment of the creek above Ember Ridge Equestrian. And in recent months, FIB levels at the Ember Ridge Equestrian sampling sites have decreased considerably.

The sites downstream of Ember Ridge Equestrian are SVUM, SVMB, SVMD and SVDM (Figure 4). SVUM is located at the upstream end of Moss Beach Ranch and captures all of Ember Ridge Equestrian and a small part of Moss Beach Ranch. All samples at SVUM, exceeded WQOs for *E. Coli* and in six of eight samples, levels were higher than at SVDE indicating there may have been a contribution between the two sites. The next site downstream of SVUM is at the downstream end of Moss Beach Ranch (SVMB). There were both increases and decreases in *E. Coli* levels throughout the monthly sampling program between SVUM (or SVDE if SVUM not sampled) and SVMB. This indicates that there could be some filtration and improvement in the water quality from the upstream end of Moss Beach Ranch to the downstream end and few sources or inputs. However, in the latter half of monthly sampling (October 2016 to March 2017) when *E. Coli* levels at Ember Ridge were lower, there were large increases in *E. Coli* between the downstream end of Ember Ridge Equestrian (SVDE) and the downstream end of Moss Beach Ranch (SVMB) indicating some sources of FIB at Moss Beach Ranch during this time. Sampling was also conducted at a drainage

ditch (SVMD) near San Vicente Creek on Moss Beach Ranch to gauge potential effects of a manure stockpile. This site was only sampled during several wet season events in 2016 but all samples exceeded WQOs. SVDM is the furthest downstream site on the creek and is located at Ethledore Bridge below both ranches near Highway 1. There were both increases and decreases in FIB between SVMB and SVDM but overall SVDM had fewer exceedances. This indicates that there are likely few sources between these two sites and that there could be natural filtration taking place through the riparian area.



**Figure 4.** Aerial of sampling sites near Moss Beach Ranch with property boundaries shown in black, fences/walls in white, barns/sheds in red, coops/hutches in yellow, and other structures in purple. Basemap derived from Geosyntec Memo to GGNRA dated March 16th 2017.

Overall, the FIB data for San Vicente Creek indicate that there could be substantial sources of FIB above the equestrian facilities. However, FIB levels increased consistently between the furthest upstream site and the furthest downstream site (28% *E. Coli* exceedance rate compared to 80%). Hot spot areas varied over time, but it is clear that when there were no exceedances upstream of the facilities, there were often high levels of FIB at the next site downstream at Ember Ridge Equestrian. The highest and most consistent levels of FIB occurred both at the downstream end of Ember Ridge Equestrian and the downstream end of Moss Beach Ranch indicating that both facilities are likely contributing FIB.

Potential sources of FIB at Ember Ridge Equestrian and Moss Beach Ranch include waste from horses, dogs, chickens, wildlife, and humans (trailers, porta potties, septic). Based on observations in the field, the most likely source and mechanism of FIB is by means of surface water drainage through areas with horse and chicken waste. There are prominent drainage channels from the paddocks, coops, arenas, and other areas that flow to the creek, especially at Ember Ridge Equestrian. There are also several areas where manure is not stored properly (on bare soil, uncovered, near creek etc) as seen at Moss Beach Ranch and the drainage ditch that was polluted with FIB. In the future, water should be prevented from coming into contact with animal waste in any way possible (ex: installing barriers). And water that does come into contact with waste should be prevented from flowing to the creek in any way possible (ex: redirecting runoff to vegetated areas).

The RCD has communicated results and recommendations to the operators of the equestrian facilities to facilitate remediation of water quality on San Vicente Creek. The RCD plans to provide further assistance to these ranchers to help meet the requirements of the RWQCB WDR. Both equestrian facilities have historically worked in partnership with the RCD and others to implement best management practices (BMPs) to prevent bacterial pollution to San Vicente Creek. However, in recent years voluntary conservation efforts have severely curtailed due to challenges associated with GGNRA's leasing policies and the BMP approval process. It is recommended that GGNRA explore opportunities to allow more flexibility and adaptive management wherever possible and consider strategies such as programmatic permitting to facilitate efforts to protect water quality on San Vicente Creek.

### **Next Steps**

The RCD has proposed two programs to GGNRA to continue addressing water quality issues in Rancho Corral de Tierra starting July 1<sup>st</sup> 2017. One is the Rancho Corral de Tierra Monitoring and Technical Assistance Program which includes continuing monitoring on Denniston and Martini Creeks for *E. Coli* and orthophosphate. GGNRA and San Mateo County (SMC) are also required to address bacterial pollution on San Vicente Creek based on the RWRCB Water Quality Improvement Plan. The RCD developed the San Vicente Creek Bacteria Monitoring Program to cover the monitoring requirements specified in this plan. Both of these programs will allow for further assessment of water quality and sources of pollution within Rancho Corral de Tierra as well as for recommendations and implementation of best management practices to repair water quality conditions on San Vicente Creek. Both programs can be implemented under the current task agreement between GGNRA and the RCD, but a new agreement will be required by September 1<sup>st</sup> 2018 in order to continue this work.

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