

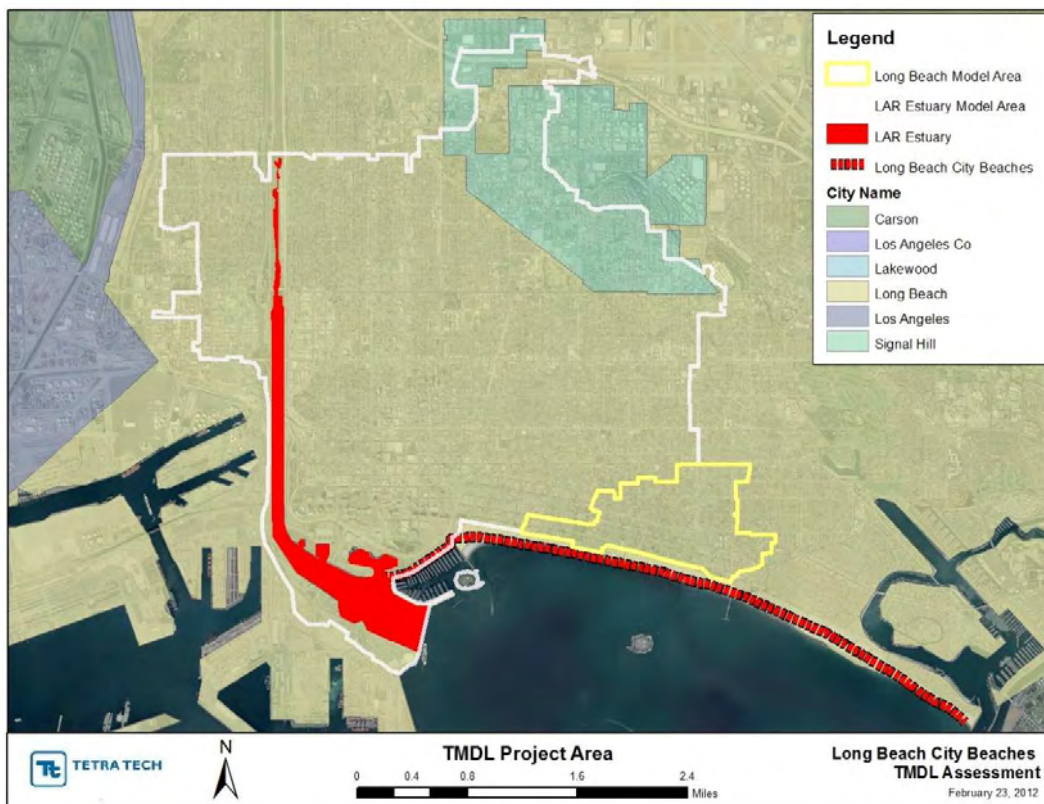
**DATE:** February 29, 2012

**TO:** Karin Graves, USEPA, Region IX

**FROM:** Amy King and Shannon Gray

**SUBJECT:** Appendix C – Dry Weather Bacteria Loads to the Long Beach City Beaches and the Los Angeles River Estuary

The Long Beach City beaches (LBC beaches) were listed as impaired by the U.S. Environmental Protection Agency (USEPA) due to elevated concentrations of indicator bacteria in 2006. This impairment stretches 4.7 miles along the coastline between the Los Angeles River (LAR) Estuary and the San Gabriel River (SGR) Estuary and Alamitos Bay. Moreover, a recent review of available bacteria data identified an impairment of the LAR Estuary from Willow Street to the mouth of the estuary (Appendix A). These impaired segments are both located in Los Angeles County in southern California (Figure 1); the general area of the beaches is further defined by hydrological unit 405.12 in the Los Angeles Regional Water Quality Control Board (Regional Board) Basin Plan. This memo presents the approach used to estimate dry weather loading from the direct drainages to the LBC beaches and LAR Estuary.



**Figure 1. Long Beach City beaches and LAR Estuary location and jurisdictions**

### Long Beach City Beaches Environmental Setting

Along the LBC beaches, impaired locations include the beach areas at: 3rd Place, 5th, 10th, 16th, 36th, 54th, 55th, 62nd, and 72nd Streets, Coronado Avenue, Granada Avenue, Molino Avenue, and Prospect Avenue. Figure 2 defines the area that drains to these beaches based on detailed subwatershed boundaries provided by the City of Long Beach. As shown in the figure, only a small area drains directly to the LBC beaches; this area is referred to as the *LBC beaches direct drainage*. In total, the LBC beaches direct drainage covers an area of approximately 505 acres, and is entirely within the jurisdiction of the City of Long Beach. Within the direct drainage, there are five sewersheds, or storm drain basins. Corresponding to discharge locations, the five storm drain basins are: Molino Avenue, Redondo Street, 9<sup>th</sup> Place, 36<sup>th</sup> Place, and West Belmont Pier. Storm water, and dry weather flows, within these basins are conveyed and discharged through storm drains to the impaired LBC beaches. Figure 2 identifies each of the five sewersheds.

Over a 30-day period during the fall of 2007, the City of Long Beach conducted a microbial source tracking study within the LBC beaches direct drainage. Storm drains within the direct drainage were identified as SD-1 through SD-5, but it should be noted that SD-4 had little to no flow and was, therefore, not sampled. Results from this study showed that, during dry weather, the storm drains within the direct drainage contribute considerable bacteria loads to the LBC beaches (City of Long Beach, 2009).

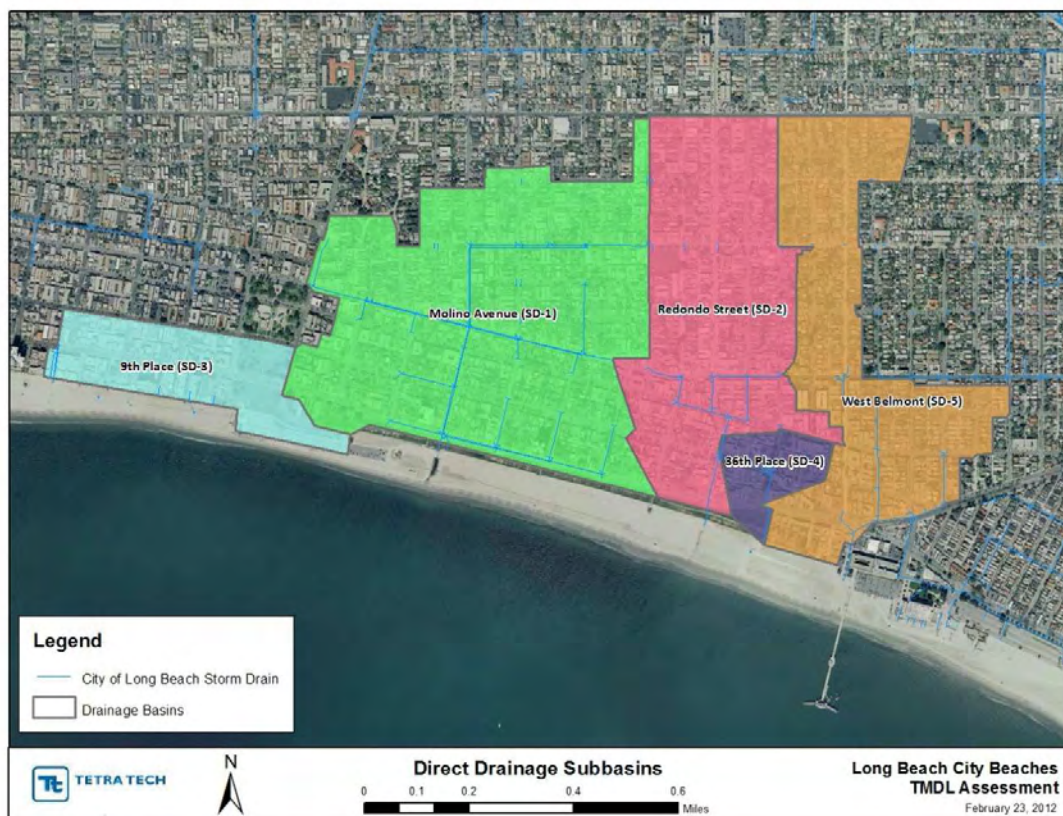


Figure 2. Direct drainage delineation of storm drain basins to the LBC beaches



### Los Angeles River Estuary Environmental Setting

The LAR Estuary connects the Los Angeles River to San Pedro Bay. It begins where the concrete-lined river ends near Willow Street and flows to Queensway Bay before entering San Pedro Bay. Receiving most of its flow from either the LAR or San Pedro Bay (during high tide), a relatively small area along either bank drains directly to the LAR Estuary. This area, referred to as the *LAR Estuary direct drainage*, is shown in Figure 3. In total, the drainage includes 6,065 acres of land, predominately draining from the east side of the estuary. Within this drainage, storm water is collected, conveyed, and discharged to the estuary through the MS4 system shown in Figure 3. MS4 jurisdictions in this area include the cities of Long Beach and Signal Hill (Figure 1).

Although a Total Maximum Daily Load (TMDL) has been developed for the LAR watershed (LARWQCB, 2010), that TMDL does not address lands draining directly to the estuary and so, unaddressed discharges to the LAR Estuary could continue to cause or contribute to impairment of the estuary itself, or the LBC beaches. For this reason, a TMDL is required to address elevated indicator bacteria (*Escherichia coli* [*E. coli*], fecal coliform, total coliform, and/or *enterococcus*) at the LBC beaches and LAR Estuary.

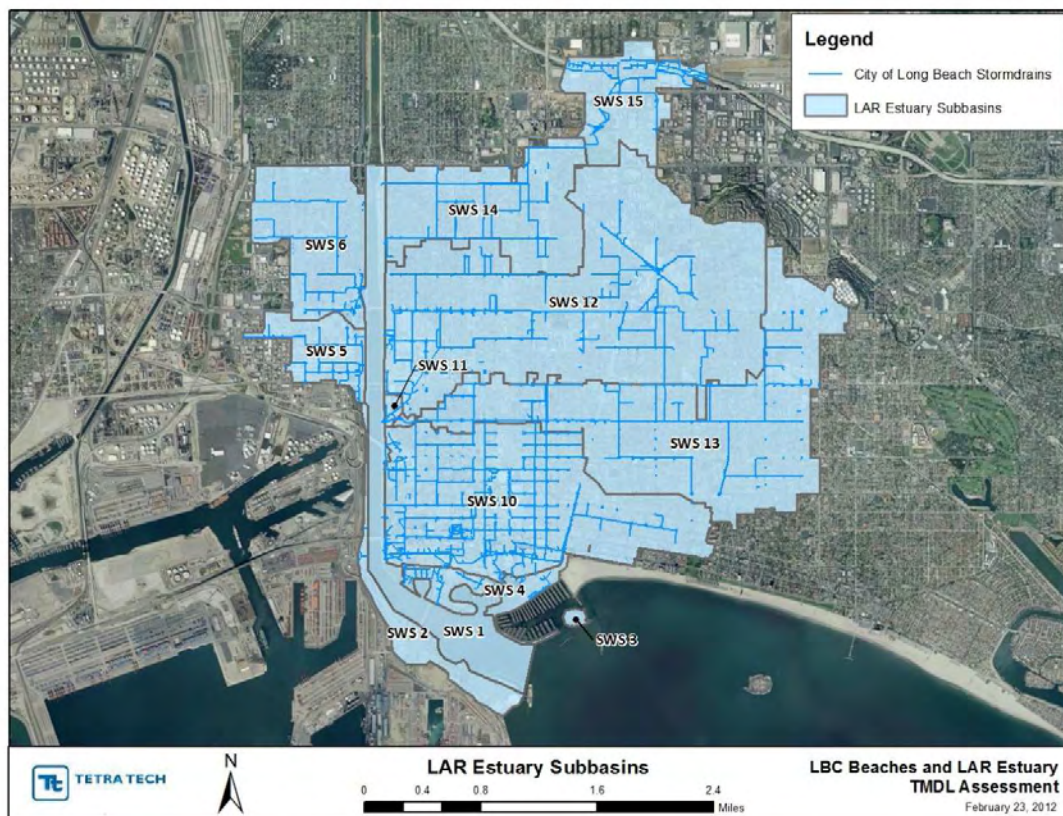


Figure 3. Direct drainage delineation of storm drain basins to the LAR Estuary

## C.1 DRY WEATHER TECHNICAL APPROACH

Although sources of bacteria are similar during wet and dry conditions, their means of transport to receiving waters vary between the conditions. To accurately address differences between weather conditions, technical approaches were developed to be consistent with our understanding of the processes for both conditions; this process is consistent with other TMDLs adopted in the Los Angeles Region (Los Angeles Regional Water Quality Control Board [LARWQCB], 2002, 2005a, 2005b, 2011). This technical memorandum provides a summary of the approach used for the estimation of bacteria (*E. coli*) loading from the direct drainages, to the LBC beaches and LAR estuary during dry weather conditions (these conditions apply to both summer dry and winter dry, as described in the TMDL report). The calculation of bacteria loads during wet weather conditions are addressed in Appendix B.

In some locations in southern California, dry weather flows can be dominated by wastewater effluent; however, no waste water reclamation plants (WWRPs) exist within the direct drainages. Therefore, based on studies across the Los Angeles region, dry weather flows to the impaired segments addressed are likely dominated by groundwater inflow and discharges to the stormwater conveyance system from illicit connections, excess irrigation, and other residential and commercial practices. Although dry-weather flows are substantially less than stormflows in the region, their long-term contribution of pollutants can be substantial (McPherson et al., 2005; Stein and Ackerman, 2007).

Flow data were non-existent at storm drains discharging to the LAR Estuary and limited at the storm drains draining to the LBC beaches. Specifically, flow was measured during the 30-day study at four of the five storm drains in the LBC beaches direct drainage (SD-4 had no data and was presumed dry during the study period). This study was performed during September 2007. Because these data covered such a brief period of time, a technical approach based on more data covering a broader time period was identified (it is also important to note that these data were not presented in the 30-day study report; therefore, it was uncertain whether final quality assurance checks had been performed on the dataset).

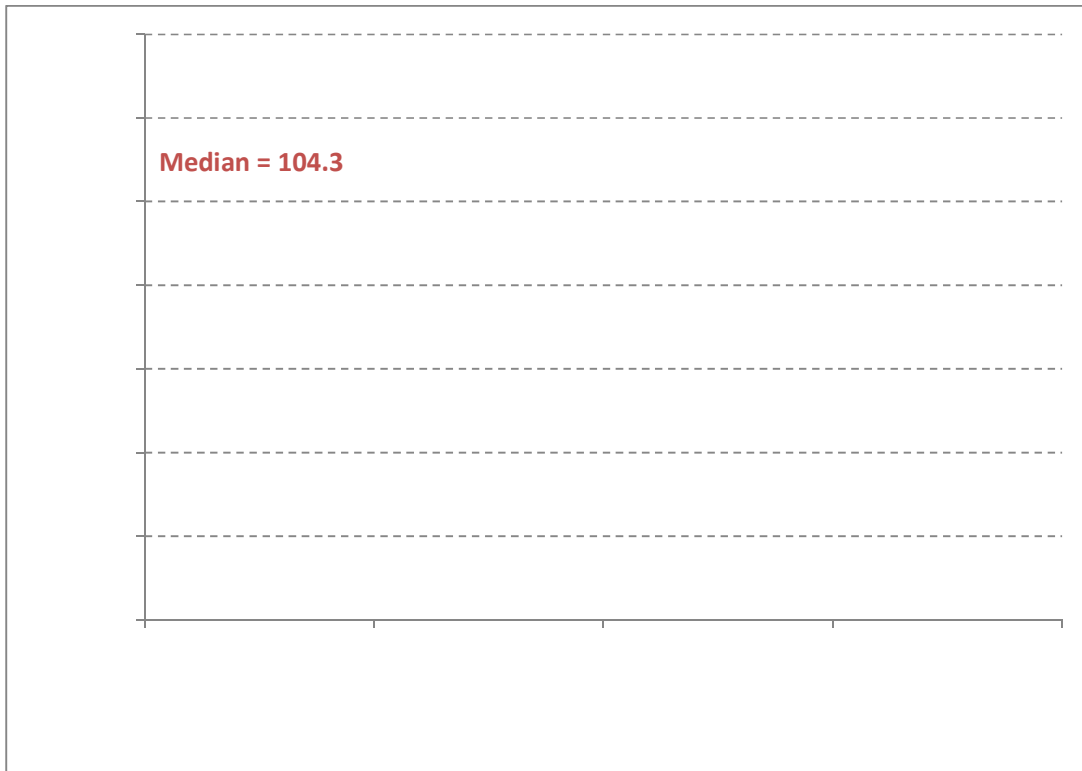
The City of Long Beach provided new data associated with dry weather flow studies to the Colorado Lagoon and Belmont Pump (City of Long Beach, 2006; Stevenson, 2012). These data were originally collected to evaluate the potential installation of dry weather flow diversions. The Colorado Lagoon and Belmont Pump drainage areas were considered similar to the LBC beaches and LAR Estuary direct drainages because the land uses and impervious cover have similar distributions and they are located in very close proximity to the direct drainages. Overall, these flows represent a combination of all dry weather runoff, baseflow, etc. that does not include WWRP contributions. The Colorado Lagoon and Belmont Pump dry weather data were collected from 2005 (Colorado Lagoon) to 2011 (Belmont Pump had data from 2009-2011), representing a total of four dry weather seasons. The 2005 data for Colorado Lagoon were based on the sum of the daily dry weather flow collected at four stations over a ~20 day period (City of Long Beach, 2006). For the Belmont Pump station, the total gallons discharged over several dry season (2009-2011) months were divided by the associated dry weather days, resulting in an average flow in gallons per day (Stevenson, 2012). Both the Colorado Lagoon and Belmont Pump data were presented on an area-weighted basis (gallons per acre per day), by dividing the average flow rates by the associated drainage areas (1,172 acres for Colorado Lagoon and 203 acres for Belmont Pump). These results are illustrated in Figure 4.

The median of these area-weighted flow rates is 104.3 gallons per acre per day. This value was used to calculate dry weather flows from each of the basins in the direct drainages. Specifically, dry-weather flows for all direct drainage areas were estimated based on the following equation (1), which uses the median area-weighted dry weather flow rate:

$$Flow = 104.3 \times (Total\ Area) \tag{1}$$

where, *Flow* is in gallons per day and *Total Area* is in acres. The total area of each subbasin is shown in Table 1 for the LBC beaches and LAR Estuary direct drainages (note: the total urban area is also shown because urban land uses likely contribute the majority of dry weather flows, but this value is not included in any calculations).

Using the equation above (1), the estimated dry weather watershed flows calculated for each of the five LBC beaches direct drainages as well as the 12 LAR Estuary subbasins are shown in Table 2 (note: these flows are presented in both gallons per acre and cubic feet per second [cfs]). Based on the area-weighted calculations, flows discharged from each outfall are relative to the corresponding total area. As an example, the largest estimated flow in the LBC beaches direct drainage is discharged from the Molino Avenue (SD-1) drainage which contains the largest total area. Likewise, the 36<sup>th</sup> Place (SD-4) drainage, with the least amount of total area, is estimated to have the lowest discharge rate. In the LAR Estuary drainage, basin 12 has the greatest amount of total area and, correspondingly, also has the greatest discharge. In contrast, basin 3 in the LAR Estuary direct drainage has the least amount of total area and lowest rate of discharge.



**Figure 4. Area-weighted dry weather flows**

**Table 1. Land Use Areas within Direct Drainages to the Long Beach City Beaches and the Los Angeles River Estuary**

Land Use									
Direct Drainage (Storm Drain Outfall)	Commercial (acres)	High Density Residential (acres)	Industrial (acres)	Mixed Urban (acres)	Roads (acres)	Open (acres)	Total Area (acres)	Total Area (km <sup>2</sup> )	Total Urban Area (km <sup>2</sup> )
<b>LBC Beaches Storm Drain Subbasins</b>									
<b>9th Place (SD-3)</b>	4.4	14.5	0.7	0	13.2	13.9	46.7	0.19	0.13
<b>Molino Avenue (SD-1)</b>	11.1	119.4	1.4	0	66	4.9	202.7	0.82	0.8
<b>Redondo Street (SD-2)</b>	14.9	60.6	0.4	8.7	38.3	0.6	123.6	0.5	0.5
<b>36th Place (SD-4)</b>	0.9	9.3	0	0	6	1.6	17.8	0.07	0.07
<b>West Belmont (SD-5)</b>	7.4	68.5	0.1	1.7	35.8	0.4	113.9	0.46	0.46
<b>LBC Beaches Total</b>	38.7	272.3	2.5	10.5	159.2	21.3	504.7	2.04	1.96
<b>LAR Estuary Storm Drain Subbasins</b>									
<b>LARE-1</b>	8.2	0.1	27.1	0.0	21.1	6.3	62.8	0.25	0.23
<b>LARE-2</b>	0.0	0.0	142.7	0.0	12.2	0.6	155.5	0.63	0.63
<b>LARE-3</b>	0.0	0.0	11.0	0.0	0.0	0.0	11.0	0.04	0.04
<b>LARE-4</b>	66.6	0.5	0.0	0.0	15.0	46.6	128.6	0.52	0.33
<b>LARE-5</b>	5.5	0.0	93.2	0.0	74.3	0.9	173.9	0.70	0.70
<b>LARE-6</b>	49.8	218.4	3.1	0.0	149.9	3.2	424.4	1.72	1.71
<b>LARE-10</b>	361.4	293.7	20.2	11.0	365.1	39.0	1090.4	4.42	4.26
<b>LARE-11</b>	0.0	0.2	7.7	0.0	2.4	4.1	14.3	0.06	0.04
<b>LARE-12</b>	328.4	739.3	181.2	5.7	504.7	103.6	1862.9	7.54	7.13
<b>LARE-13</b>	220.5	614.2	45.0	11.8	355.0	13.0	1259.4	5.10	5.05
<b>LARE-14</b>	77.4	291.4	15.7	0.0	175.4	7.9	567.8	2.30	2.27
<b>LARE-15</b>	48.5	2.9	128.3	4.6	85.9	44.0	314.2	1.27	1.09
<b>LAR Estuary Total</b>	1,166.4	2,160.6	675.1	33.1	1,760.9	269.2	6,065.3	24.5	23.5

**Table 2. Calculated Direct Drainage Dry Weather Flows to the LBC Beaches and LAR Estuary**

Direct Drainage (Storm Drain Outfall)	Flow (gallons/day)	Flow (cfs)
<b>LBC Beaches</b>		
9 <sup>th</sup> Place (SD-3)	4,866	0.008
Molino Avenue (SD-1)	21,138	0.033
Redondo Street (SD-2)	12,884	0.020
36 <sup>th</sup> Place (SD-4)	1,852	0.003
West Belmont (SD-5)	11,880	0.018
<b>LAR Estuary</b>		
LARE-1	6,549	0.010
LARE-2	16,217	0.025
LARE-3	1,143	0.002
LARE-4	13,414	0.021
LARE-5	18,134	0.028
LARE-6	44,254	0.068
LARE-10	113,693	0.176
LARE-11	1,496	0.002
LARE-12	194,243	0.301
LARE-13	131,316	0.203
LARE-14	59,201	0.092
LARE-15	32,757	0.051

## C.2 DRY WEATHER BACTERIA

Additional analyses were performed to calculate existing dry weather bacteria loadings to the impaired segments using the above flow predictions (Table 2). Dry weather monitoring of the LBC beaches direct drainage storm drains was limited to samples collected during a 30-day special study conducted in during the fall of 2007 (City of Long Beach, 2009). These data were analyzed to evaluate concentrations relative to water quality standards and to estimate the existing dry weather bacteria loading from the direct drainage to the LBC beaches. Summary statistics for each of the storm drains are show in Table 3, while a detailed analysis of monitoring data is provided in Appendix A. The geometric mean concentrations of each of the storm drains monitored well exceeded the freshwater geometric mean *E. coli* water quality standard of 126 CFU per 100 mL. In addition, all samples exceeded the single sample maximum *E. coli* water quality standard of 235 CFU per 100 mL except for one sample at SD-3 and one sample at SD-5.

Since specific data were not available for either the 36<sup>th</sup> Place storm drain (SD-4) or the storm drains in the LAR Estuary direct drainage, the geometric mean of all samples collected in the LBC beaches direct drainage was used to estimate likely bacteria concentrations from unmonitored storm drains. This method was determined sufficient since the available data represented conditions similar to those present in the unmonitored storm drains. It should also be noted, that this method was used only to estimate annual existing watershed loadings. The TMDL itself is based on an exceedance day reference system/ antidegradation approach in the receiving waters.

**Table 3. Summary Statistics for Dry Weather *E. coli* Sampled at Storm Drains within the Direct Drainages**

Direct Drainage (Storm Drain Outfall)	Number of Samples	Minimum of Result (CFU/100 mL)	Maximum of Result (CFU/100 mL)	Geomean (CFU/100 mL)
<b>LBC Beaches</b>				
Molino Avenue Storm Drain (SD-1)	30	281	29,090	4,507
Redondo Street Storm Drain (SD-2)	2	1,198	1,445	1,316
9 <sup>th</sup> Place Storm Drain (SD-3)	21	10	325,500	8,947
36 <sup>th</sup> Place Storm Drain (SD-4)	NS	NS	NS	6,680 <sup>a</sup>
West Belmont Pier Drain (SD-5)	29	10	198,630	9,085
<b>LAR Estuary</b>				
LARE-1	NS	NS	NS	6,680 <sup>a</sup>
LARE-2	NS	NS	NS	6,680 <sup>a</sup>
LARE-3	NS	NS	NS	6,680 <sup>a</sup>
LARE-4	NS	NS	NS	6,680 <sup>a</sup>
LARE-5	NS	NS	NS	6,680 <sup>a</sup>
LARE-6	NS	NS	NS	6,680 <sup>a</sup>
LARE-10	NS	NS	NS	6,680 <sup>a</sup>
LARE-11	NS	NS	NS	6,680 <sup>a</sup>
LARE-12	NS	NS	NS	6,680 <sup>a</sup>
LARE-13	NS	NS	NS	6,680 <sup>a</sup>
LARE-14	NS	NS	NS	6,680 <sup>a</sup>
LARE-15	NS	NS	NS	6,680 <sup>a</sup>
NS: Not sampled.				
<sup>a</sup> Geometric mean of all storm drain data used as geometric mean for SD4 and LARE 1-15.				
Source for LBC Beaches: City of Long Beach, 2009				

Existing average daily loads from each storm drain (shown in Table 4) were calculated by multiplying bacteria concentrations by their respective dry weather flows, estimated above, and a conversion factor. The equation used is shown below (2):

$$\text{Bacteria concentration} \times \text{Flow (cfs)} \times \text{Conversion factor} = \text{Load (CFU) per day} \quad (2)$$

Where, the *bacteria concentration* equals the observed geometric mean (in CFU/100 mL) (Table 3), the *Flow* (in cfs) is derived from the area-weighted calculation above (Table 2), and the *conversion factor* below (3) is used to convert the product of these values to CFU/day:

$$24,465,888 = \text{Conversion Factor} \quad (3)$$

For comparison purposes only, allowable dry weather loads were also calculated using the equations above (2 and 3). The bacteria concentrations were represented by the WQS of 126 CFU/100 mL (note: the geometric mean WQS was used as a conservative assumption because dry weather loading is assumed to be relatively constant). *Flow* remained equal to respective dry weather storm drain flow, in cubic feet per second (Table 2), and the conversion factor did not change. This step was completed to evaluate the potential for storm drains to cause or contribute to dry weather exceedances in the impaired waterbodies. As shown in Table 4, existing dry weather bacteria loads exceeded the dry weather allowable loads by



one to two orders of magnitude, indicating that dry weather loads from the direct drainages are of concern (percent reductions ranged from 90.4% to 98.6%; note the percent reductions for the LAR Estuary are constant because the existing concentration applied was the same in all basins). These loads are for each individual drainage area based on the land area in that basin and not cumulative loads.

**Table 4. Existing Dry Weather *E. coli* Loads from Storm Drains in the Direct Drainages**

Direct Drainage (Storm Drain Outfall)	Geomean (CFU/100 mL)	Existing Load (CFU/day) <sup>a</sup>	Allowable Load (CFU/day) <sup>b</sup>	Percent Reduction
<b>LBC Beaches</b>				
Molino Avenue Storm Drain (SD-1)	4,507	3.61E+09	1.01E+08	97.2%
Redondo Street Storm Drain (SD-2)	1,316	6.42E+08	6.15E+07	90.4%
9 <sup>th</sup> Place Storm Drain (SD-3)	8,947	1.65E+09	2.32E+07	98.6%
36 <sup>th</sup> Place Storm Drain (SD-4)	6,680 <sup>c</sup>	4.68E+08	8.83E+06	98.1%
West Belmont Pier Drain (SD-5)	9,085	4.09E+09	5.67E+07	98.6%
<b>LBC Beaches Direct Drainage Total</b>		<b>1.04E+10</b>	<b>2.51E+08</b>	<b>97.6%</b>
<b>LAR Estuary</b>				
LARE-1	6,680 <sup>c</sup>	1.66E+09	3.12E+07	98.1%
LARE-2	6,680 <sup>c</sup>	4.10E+09	7.74E+07	98.1%
LARE-3	6,680 <sup>c</sup>	2.89E+08	5.45E+06	98.1%
LARE-4	6,680 <sup>c</sup>	3.39E+09	6.40E+07	98.1%
LARE-5	6,680 <sup>c</sup>	4.59E+09	8.65E+07	98.1%
LARE-6	6,680 <sup>c</sup>	1.12E+10	2.11E+08	98.1%
LARE-10	6,680 <sup>c</sup>	2.87E+10	5.42E+08	98.1%
LARE-11	6,680 <sup>c</sup>	3.78E+08	7.13E+06	98.1%
LARE-12	6,680 <sup>c</sup>	4.91E+10	9.26E+08	98.1%
LARE-13	6,680 <sup>c</sup>	3.32E+10	6.26E+08	98.1%
LARE-14	6,680 <sup>c</sup>	1.50E+10	2.82E+08	98.1%
LARE-15	6,680 <sup>c</sup>	8.28E+09	1.56E+08	98.1%
<b>LAR Estuary Direct Drainage Total</b>		<b>1.60E+11</b>	<b>3.02E+09</b>	<b>98.1%</b>

<sup>a</sup> Existing load calculated with geometric mean (Table 3) and corresponding flow (Table 2).  
<sup>b</sup> Allowable load calculated with WQS of 126 CFU/100 mL paired with outfall flow presented in Table 2.  
<sup>c</sup> Geometric mean of all available storm drain data (at four sampled locations) used to represent existing concentrations at SD-4 and LARE 1-15.

### C.3 SUMMARY

Dry-weather bacteria loading from the direct drainages were calculated through the analyses described above. These loads incorporate all sources in the direct drainages to the receiving waterbodies (see Section 5 in the TMDL Staff Report for presentation on the TMDLs including dry weather loads during the critical period). The average daily loads presented above represent the average during dry conditions, while separate loads were developed to represent wet-weather conditions (discussed in more detail in Appendix B).

The analysis discussed above was used to estimate dry weather loading from each of the five subbasins within the LBC beaches direct drainage and the 12 subbasins in the LAR Estuary direct drainage. A gradient per storm drain basin within the direct drainages are shown in Figure 5 and Figure 6, with the highest dry weather loading shown in dark red. Of concern in the LBC beaches direct drainage, despite not having the largest flow, the West Belmont Pier drainage is estimated to discharge the greatest dry weather load due to its high geometric mean concentration. That location is followed closely, in terms of dry weather loading, by the Molino Avenue drainage. Since dry weather loading from the West Belmont Pier does not relate to flow as well as the loadings from other subbasins do, it is likely that other localized sources of bacteria exist within this drainage (e.g., dog parks, cross connections, etc.).

No monitoring data were available for the LAR Estuary subbasins; therefore, the loading potential is directly related to total land area. For this reason, the largest subbasins resulted in the greatest dry weather loading. As an example, subbasin 12 has the largest total area, and therefore, had the greatest discharge of both flow and bacteria loading. Subbasins with the greatest loading potential are shown in dark red in Figure 6. It is important to note that the loading presented in this map is cumulative (while the loads presented in Table 4 are not), so the load associated with a downstream subbasin includes the loading from all upstream subbasins.

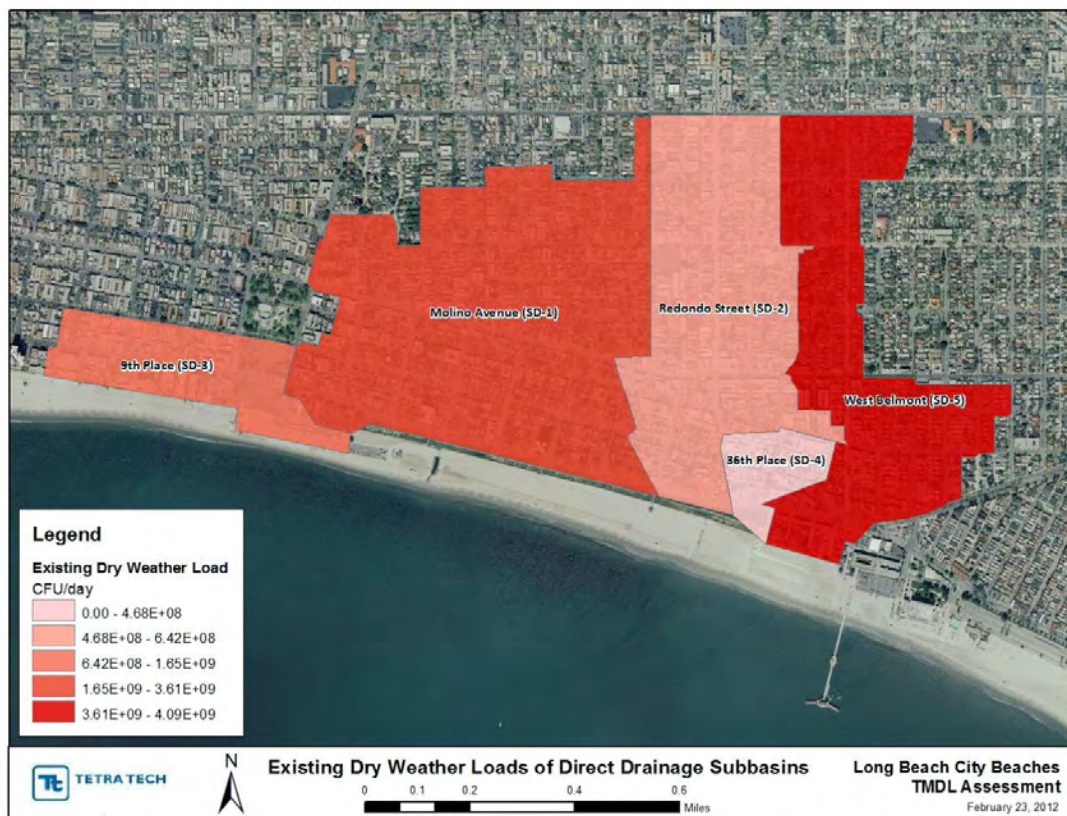


Figure 5. LBC beaches direct drainage dry weather loading

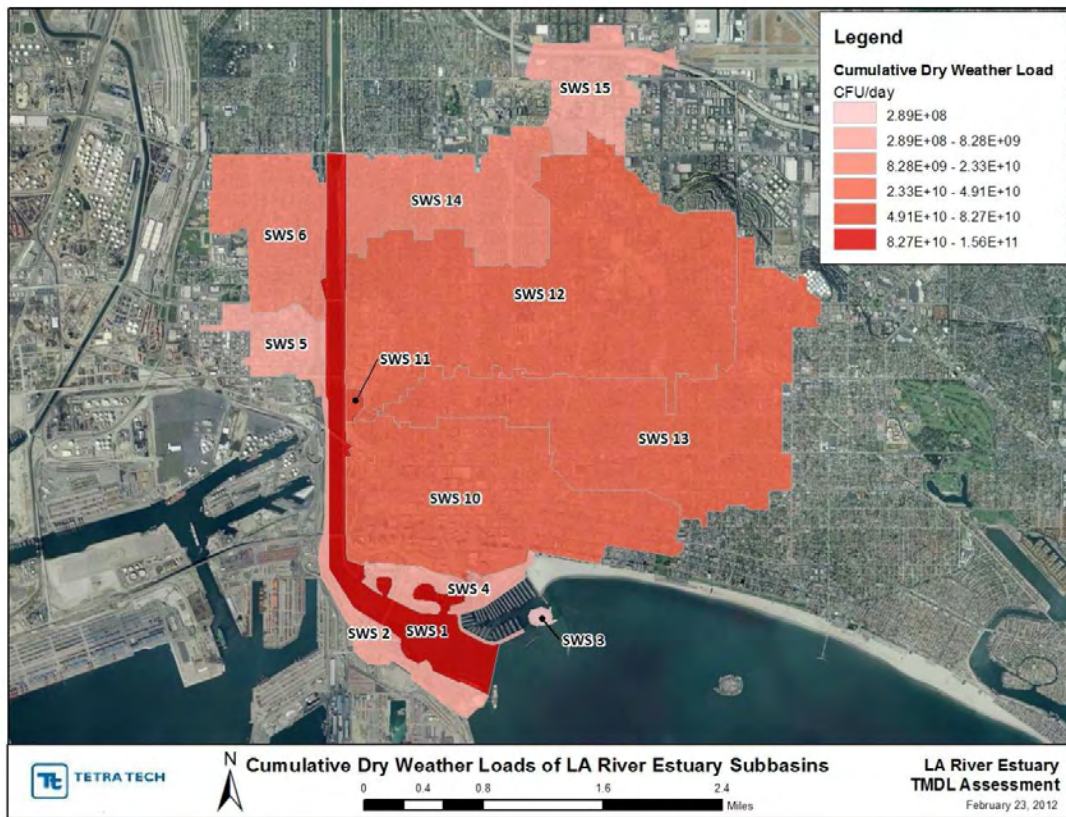


Figure 6. LAR Estuary direct drainage dry weather loading

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