Agua Hedionda Watershed Water Quality Analysis and Recommendations Report

Prepared for:

City of Vista
California

Prepared by:

TETRA TECH, INC.
1230 Columbia Street
Suite 1000
San Diego, CA 92101

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1 Introduction

The following review of watershed and water quality data represents one of the initial components of a comprehensive effort to prepare a Watershed Management Plan (WMP) in the Agua Hedionda Watershed. This report satisfies Work Item No. 2.3.5, Water Quality and Recommendations Report per State Water Board Agreement No. 06-139-559-0. The report provides a general watershed characterization and a summary of past and current water quality conditions in the Agua Hedionda watershed. Using various regional and local datasets and previous assessment reports, this review describes both spatial and temporal trends in the watershed to evaluate current water quality conditions and provide recommendations to best meet existing and future regulatory and planning needs.

The health of the Agua Hedionda Watershed is subject to many stressors that can best be addressed through a comprehensive and strategically focused WMP. In response to the Clean Water Act Section 303(d), the San Diego Regional Water Quality Control Board (SDRWQCB) has identified waters that do not meet applicable water quality objectives including the Aqua Hedionda Lagoon, Agua Hedionda Creek, and Buena Creek (SDRWQCB, 2007). The SDRWQCB is in the process of developing Total Maximum Daily Loads (TMDLs) for Agua Hedionda Creek and Agua Hedionda Lagoon. Other important considerations for the WMP are municipal separate storm sewer systems (MS4) permit requirements for management of increases in runoff from new development and preparation of a Hydromodification Management Plan. Monitoring is required to evaluate program effectiveness under this permit. Both the stormwater permit and TMDLs play heavily in this water quality evaluation and future planning.

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2 Description of Watershed

The Agua Hedionda watershed is located in San Diego County and within the Carlsbad Hydrologic Unit. It is approximately 18,837 acres (29.4 mi^2) and is divided into two subareas: the Buena hydrologic subarea (904.32) in the upper watershed and Los Monos hydrologic subarea (904.31) in the lower watershed (Figure 1)[1]. The watershed includes portions of four municipalities, Carlsbad, Vista, Oceanside, and San Marcos, as well as area in the unincorporated portions of the County of San Diego.

The watershed contains approximately 37 linear miles of stream including Agua Hedionda, Roman, Little Encinas, La Mirada, Calavera, and Buena Creeks. It also includes three significant standing bodies of water: the Agua Hedionda Lagoon, Lake Calavera, and Squires Reservoir. Major transportation corridors include Interstate 5, State Route 78, Pacific Coast Highway, and the Santa Fe Railroad.

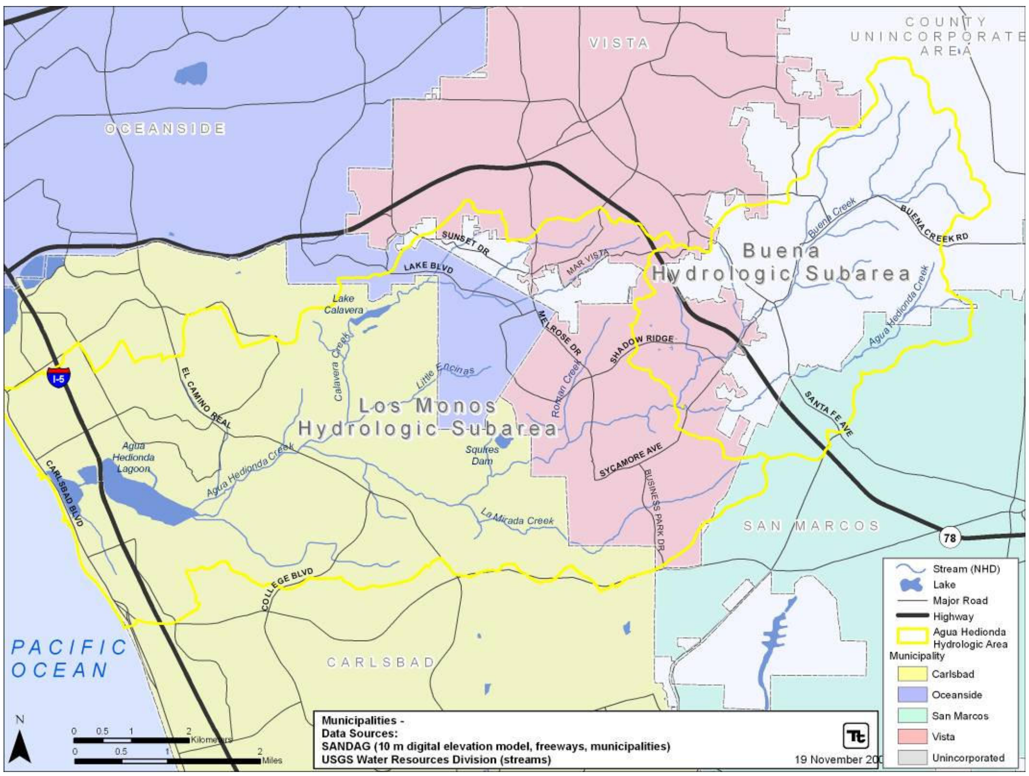

Figure 1. Agua Hedionda Watershed

[1] The watershed was delineated using a 10-m digital elevation model from the National Elevation Dataset. Boundaries were modified using the municipal storm sewer and 2-foot contour topography layers.

2.1 Physical Features

2.1.1 Geology, Soils, Topography

The watershed is comprised primarily of Mesozoic granitic rock (grMz), Eocene marine rock (E), Mesozoic volcanic rock (Mzv), and Quaternary alluvium and marine deposits (Q) (Figure 2). Table 1 provides descriptions for geological classes represented in the watershed.

Table 2 and Figure 3 present Natural Resources Conservation Service (NRCS) SSURGO soils found in the watershed. According to this dataset, there are 53 distinct soil series in the watershed. The most abundant series are Las Flores loamy fine sand, Marina loamy course sand, and Altamont clay.

The lowest elevation in the watershed is along shore adjacent to the Lagoon, which is at sea level (Figure 4). The highest elevation is in the San Marcos Mountains (1,500 ft) (KTU+A, 2002). The coastal flat area adjacent to the lagoon is dominated by Marina loamy coarse sand with 2 to 9 percent slopes (Table 2; Figure 4). Although much of the watershed is only moderately sloped, areas adjacent to Squires Dam, Lake Calavera, and the upper watershed have nearly 40 percent slopes.

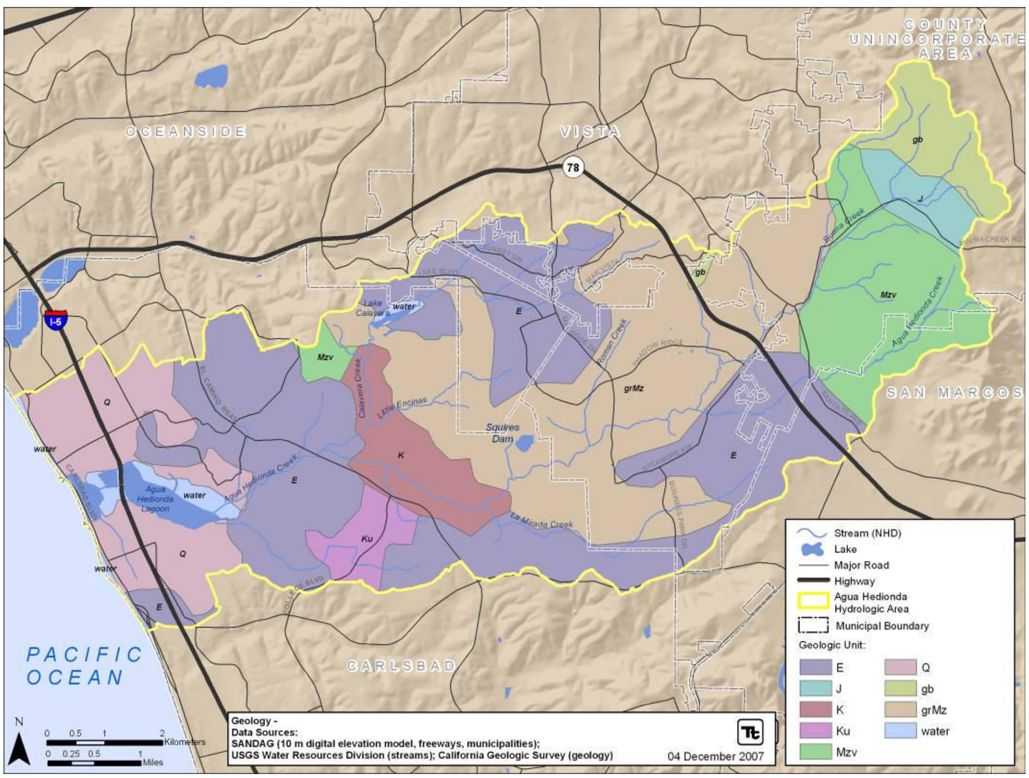

Figure 2. Geology of the Agua Hedionda Watershed

Table 1. Key to Geology within the Agua Hedionda Watershed

Label	Name	Description
E	Eocene marine rocks	Shale, sandstone, conglomerate, and minor limestone; in part Oligocene and Paleocene.
gb	Mesozoic gabbroic rocks, unit 2 (undivided)	Gabbro and dark dioritic rocks; chiefly Mesozoic
grMz	Mesozoic granitic rocks, unit 2 (Peninsular Ranges)	Mesozoic granite, quartz monzonite, granodiorite, and quartz diorite
J	Jurassic marine rocks, unit 4 (Peninsular Ranges and Western Transverse Ranges)	Shale, sandstone, minor conglomerate, chert, slate, limestone; minor pyroclastic rocks
K	Cretaceous marine rocks (in part nonmarine), unit 1 (Coast Ranges)	Undivided Cretaceous sandstone, shale, and conglomerate; minor nonmarine rocks in Peninsular Ranges
Ku	Upper Cretaceous marine rocks, unit 1 (Upper Great Valley Sequence)	Upper Cretaceous sandstone, shale, and conglomerate
Mzv	Mesozoic volcanic rocks, unit 4 (Peninsular Ranges)	Undivided Mesozoic volcanic and metavolcanic rocks. Andesite and rhyolite flow rocks, greenstone, volcanic breccia and other pyroclastic rocks; in part strongly metamorphosed. Includes volcanic rocks of Franciscan Complex: basaltic pillow lava, diabase,
Q	Quaternary alluvium and marine deposits	Alluvium, lake, playa, and terrace deposits; unconsolidated and semi-consolidated. Mostly nonmarine, but includes marine deposits near the coast.

Table 2. Most Abundant Soils Series within the Agua Hedionda Watershed

Symbol	Acreage	Description
Le	2,748	Las Flores loamy fine sand
Ml	2,000	Marina loamy coarse sand
At	1,324	Altamont clay
Cl	1,181	Cieneba coarse sandy loam
Hr	1,154	Huerhuero loam
Da	1,107	Diablo clay

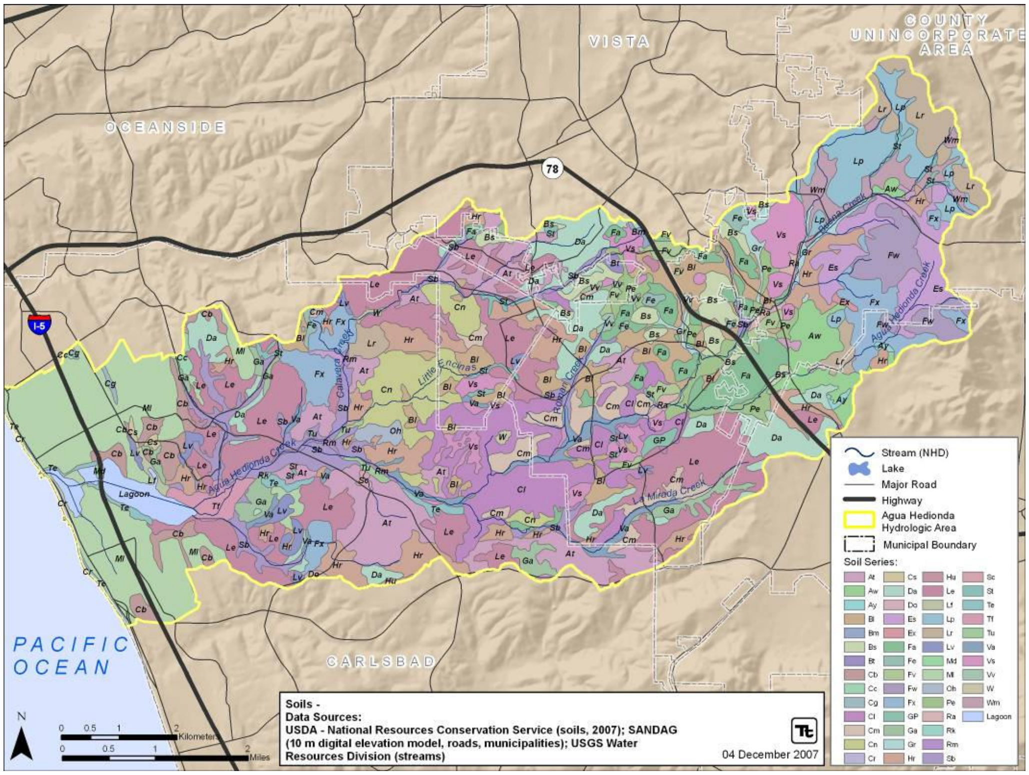

Figure 3. Soils in the Agua Hedionda Watershed

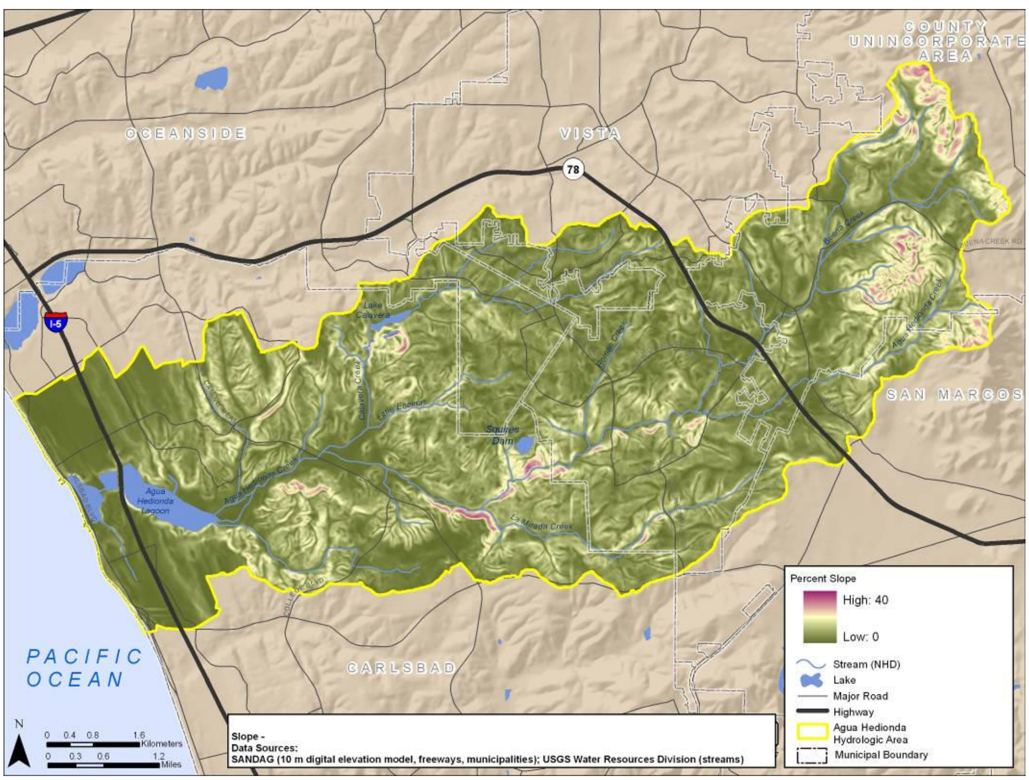

Figure 4. Slopes in the Agua Hedionda Watershed

Figure 5 presents potential erosion hazard or risk in the watershed derived by using the NRCS Soil Data Viewer based on slope and soil erosion factor from SSURGO soils data. Soil loss is caused by sheet and rill erosion where 50 to 75 percent of the surface has been exposed by disturbance. Risk is described as "slight," "moderate," "severe," or "very severe." A rating of "slight" indicates that erosion is unlikely under ordinary climatic conditions; "moderate" indicates that some erosion is likely and that erosion-control measures may be needed; "severe" indicates that erosion is very likely and that erosion-control measures, including revegetation of bare areas, are advised; and "very severe" indicates that significant erosion is expected, loss of soil productivity and offsite damage are likely, and erosion-control measures are costly and generally impractical. The majority of the watershed has a slight to moderate erosion risk if disturbed; however, there are a few areas of very severe erosion risk.

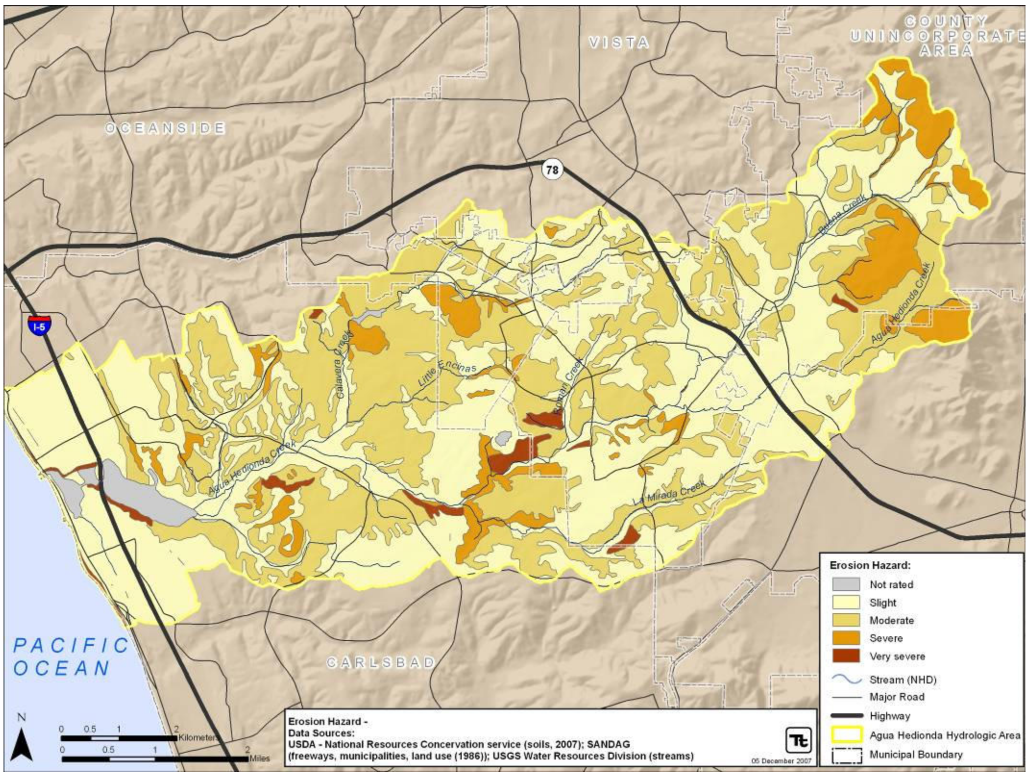

Figure 5. Erosion Risk in the Agua Hedionda Watershed

2.1.2 Hydrology

The watershed is located in a Mediterranean climate region with seasonally influenced precipitation. The vast majority of annual precipitation occurs between November and April. The average annual precipitation for the area is 15.6 inches per year and shows significant variation between years based on data from the Western Regional Climate Center.

Stormwater contributes the majority of runoff in the watershed. During non-storm periods urban runoff, agricultural runoff, and surfacing groundwater provide major sources of surface flow (IRWMP, 2007). There are limited quantities of groundwater in the regions and salinity limits its use as a potable water supply. Water for human use is predominately imported by the Water Authority from outside of the watershed (IRWMP, 2007).

Figure 6 displays the Federal Emergency Management Agency's (FEMA) Flood Zones. According to the effective FEMA Flood Insurance Study (June 19th, 1997), the current condition 100-year peak flow rate in Agua Hedionda Creek at El Camino Real is 9,850 cfs (Vol. 1, 4, Summary of Discharge). Although most of the watershed is considered outside of the 100- and 500-year floodplain, large tracts adjacent to the lagoon and along Agua Hedionda Creek are within the 100-year flood zone. Furthermore, throughout the watershed, several miles of creeks are within 100-year and 500-year flood zones.

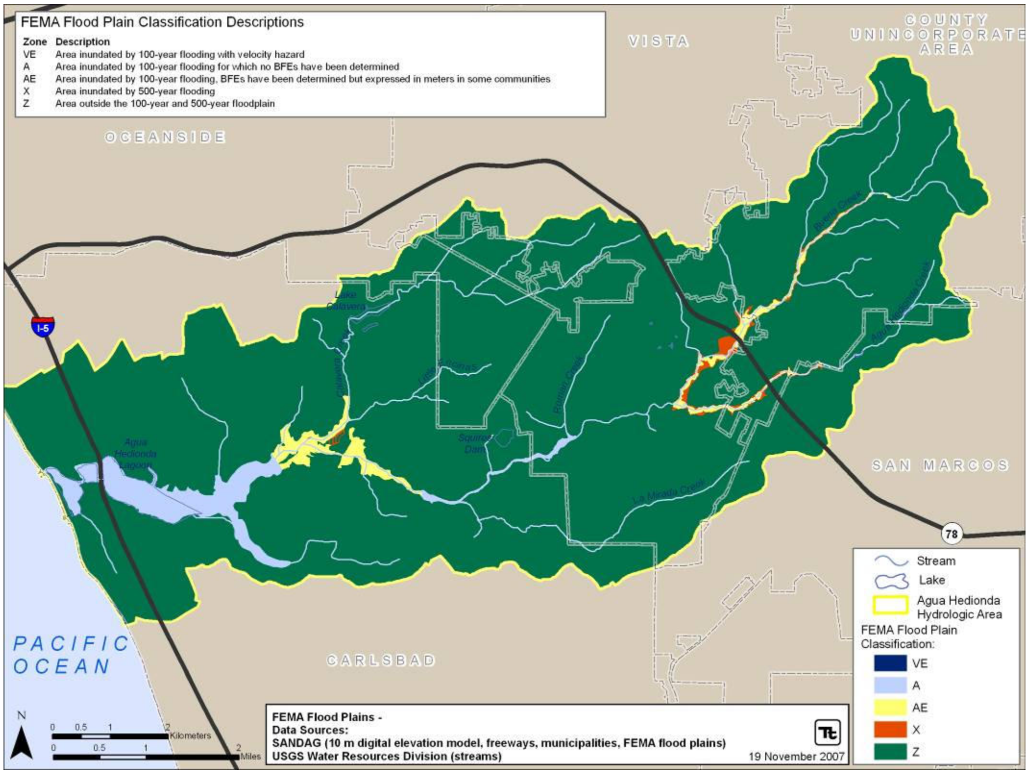

Figure 6. Federal Emergency Management Agency's (FEMA) Flood Plain Classifications for the Watershed

Flow gaging is available from one site in the watershed at the intersection of Agua Hedionda Creek and the El Camino Real. These data were provided by the San Elijo Lagoon Conservancy (SELC). Daily average discharge data are available from March of 2005 through April of 2007 (Figure 7). However, the gage was not operational between 3/6/2006 – 6/24/2006 due to city dredging operations.

There was an average daily discharge of 8.17 cubic feet per second (cfs) and median of 3.56 cfs at this gage over the monitoring period (Table 3). The minimum discharge (0.07 cfs) was measured in April 2007 while the maximum (314.21 cfs) was measured in January 2007.

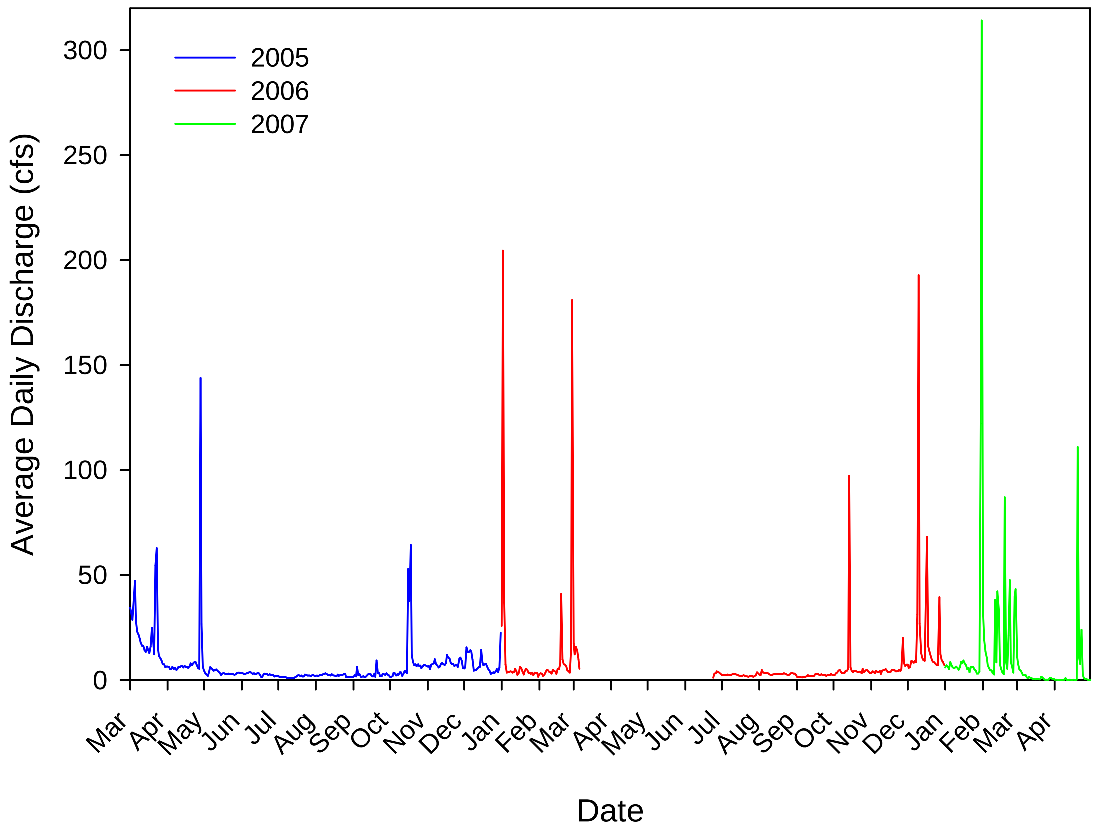

Figure 7. Average Daily Discharge at the Agua Hedionda Creek and El Camino Real Flow Gage (2005-2007)

Table 3. Average Daily Discharge (cfs) Summary Statistics at Agua Hedionda Creek and El Camino Real

Year	Number Measurements	Mean	Median	Minimum	Maximum	10th Percentile	90th Percentile
2005	306	7.08	3.54	0.91	143.91	1.65	13.80
2006	256	8.03	3.56	1.04	204.60	1.97	9.83
2007	120	11.20	3.62	0.07	314.21	0.10	23.67
Total	**682**	**8.17**	**3.56**	**0.07**	**314.21**	**1.43**	**13.28**

2.1.3 Beneficial Uses

Beneficial uses are defined as those uses of a waterbody necessary for the survival or well being of humans, plants and wildlife that promote economic, social, and environmental goals. Beneficial uses are defined for inland surface waters, coastal waters, reservoirs and lakes, and groundwater. The San Diego Basin Plan lists the beneficial uses of waters within the Agua Hedionda watershed, which determines the applicable water quality standards (SDRWQCB, 1994).

The Agua Hedionda Watershed includes several designated beneficial uses (Table 4 through Table 6). Inland surface waters, including Agua Hedionda Creek, Buena Creek, and Letterbox Canyon, are designated to provide municipal, domestic, agricultural and industrial service supplies, water recreation, and ecological habitat uses. The Agua Hedionda Lagoon is also designated for industrial service supply, recreation, and several ecological habitat uses, as well several other functions including aquaculture, fishing, shellfish and harvesting.

Table 4. Agua Hedionda Watershed Existing Beneficial Uses for Inland Surface Waters

Waterbody	Agua Hedionda Creek	Buena Creek	Agua Hedionda Creek	Letterbox Canyon
Hydrologic Unit Basin Number	4.32	4.32	4.31	4.31
Municipal and Domestic Supply (MUN)	●	●	●	●
Agricultural Supply (AGR)	●	●	●	●
Industrial Process Supply (PROC)				
Industrial Service Supply (IND)	●	●	●	●
Groundwater Recharge (GWR)				
Freshwater Replenishment (FRSH)				
Hydropower Generation (POW)				
Contact Water Recreation (REC1)	●	●	●	●
Non-contact Water Recreation (REC2)	●	●	●	●
Warm Freshwater Habitat (WARM)	●	●	●	●
Cold Freshwater Habitat (COLD)				
Wildlife Habitat (WILD)	●	●	●	●
Preservation of Biological Habitats of Special Significance (BIOL)			●	
Rare, Threatened, or Endangered Species (RARE)				
Spawning, Reproduction, and/or Early Development (SPWN)				

Table 5. Agua Hedionda Watershed Existing Beneficial Uses for Coastal Waters

Waterbody	Agua Hedionda Lagoon
Hydrologic Unit Basin Number	4.32
Industrial Service Supply (IND)	●
Navigation (NAV)	
Contact Water Recreation (REC1)	●
Non-contact Water Recreation (REC2)	●
Commercial and Sport Fishing (COMM)	●
Aquaculture (AQUA)	●
Warm Freshwater Habitat (WARM)	
Estuarine Habitat (EST)	●
Marine Habitat (MAR)	●
Wildlife Habitat (WILD)	●
Preservation of Biological Habitats of Special Significance (BIOL)	●
Rare, Threatened, or Endangered Species (RARE)	●
Migration of Aquatic Organisms (MIGR)	●
Spawning, Reproduction, and/or Early Development (SPWN)	●
Shellfish Harvesting (SHELL)	●

Table 6 reports the beneficial uses for groundwater in the Agua Hedionda Watershed. There is limited groundwater available within the Carlsbad Hydrologic Unit and salinity poses additional limitations to its use as a potable supply (IRWMP, 2007). The Basin Plan reports that only a small portion of the basin supplies appreciable quantities of groundwater due to the lack of permeable geologic formations. Most groundwater in the region is designated as municipal and domestic or agricultural supply, however, groundwater in the watershed does not provide industrial process supply, groundwater recharge, or freshwater replenishment.

Table 6. Agua Hedionda Watershed Beneficial uses for Groundwaters

Hydrologic Unit, Area, or Subarea	Los Monos (HSA)[1]	Los Monos (HSA)[2]	Los Monos (HSA)[3]	Buena (HSA)
Hydrologic Unit Basin Number	4.31	4.31	4.31	4.32
Municipal and Domestic Supply (MUN)	●	○	○	●
Agricultural Supply (AGR)	●	○	●	●
Industrial Process Supply (PROC)				
Industrial Service Supply (IND)	●	○	○	●
Groundwater Recharge (GWR)				
Freshwater Replenishment (FRSH)				

Note: Solid circles indicate existing uses; empty circles indicate potential uses.

1 These beneficial uses do not apply westerly of the easterly boundary of the right-of-way of Interstate 5 and this area is excepted from the sources of drinking water policy. Other beneficial uses for the remainder of the hydrologic area are as shown.

2 These beneficial uses designations apply to the portion of HSA 4.31 bounded on the west by the easterly boundary of Interstate Highway 5 right-of-way, on the east by the easterly boundary of El Camino Real; and on the north by a line extending along the southerly edge of Agua Hedionda Lagoon to the easterly end of the lagoon, thence in an easterly direction to Evans Point, thence easterly to El Camino Real along the ridge lines separating Letterbox Canyon and the area draining to the Marcario Canyon.

3 These beneficial uses apply to the portion of HSA 4.31 tributary to Agua Hedionda Creek downstream from the El Camino Real crossing, except lands draining to Marcario Canyon (located directly southerly of Evans Point, land directly south of Agua Hedionda Lagoon, and areas west of Interstate Highway 5.

2.1.4 Land Use and Land Cover

Land Use

Historical (1986), current (2007), and planned land use (2030) information was obtained from SANDAG. The land use layers have been updated continuously since 2000 using aerial photography, the County Assessor Master Property Records file, and other ancillary information. The planned land use data were derived from the Series 11 Regional Growth Forecast using each municipality's master development plans. Since each jurisdiction has their own individualized way of categorizing their future land use designations, an aggregate planned land use code was devised.

In 1986 the watershed was dominated by open space (37 percent), agriculture (19 percent) and single family residential (19 percent) areas (Table 7). Residential developments were centered along Highway 78 and in the northwest corner of the watershed, adjacent to Interstate 5 (Figure 8). The center and uppermost portions of the watershed were dominated by open space and agriculture.

By 2007 single family residential acreage increased to a quarter of the watershed area, while agricultural and open spaces decreased (Table 7). Residential developments spread into the central and upper watershed, bringing anthropogenic influence into closer contact with streams and displacing agriculture and open spaces (Figure 9). In fact, agricultural lands decreased 55 percent since 1986 levels. Most of the transitional areas were developed into residential and industrial spaces. Industrial and transportation lands sharply increased, especially along the southern watershed boundary. However, some of the increase in industrial and transportation acreage appears to be due to the lack of road classifications in the 1986 land use data set.

The 2030 Regional Growth Forecast for the San Diego Region was derived from local, city, and county General & Community Planning documents (SANDAG, 2005). According to this forecast, the watershed is intended to become primarily single family residential (33 percent), industrial and transportation (23 percent), and open space (18 percent) (Table 7). Nearly all current agricultural land is planned for development, while open space will be reduced 39 percent from 2007 levels (Figure 10). Although the land use plans have provided for open space buffers along much of the streams in the lower portion of the watershed, the vast majority of the upper watershed shows development adjacent to stream corridors.

Table 7. Percent of Watershed for Each Land Use Class in 1986, 2007, and 2030

Land Use Classes	Past (1986)	Current (2007)	Planned (2030)
Rural Residential	6.5	5.1	9.5
Single Family Residential	18.5	24.8	33.3
Multifamily Residential	3.5	3.9	5.7
Commercial & Institutional	2.2	4.1	5.4
Industrial & Transportation	4.2	19.6	23.1
Parks - Recreation	0.6	1.7	1.8
Open - Recreation	1.0	1.1	1.5
Agriculture	19.2	8.5	0.2
Open	36.5	29.7	18.0
Water	1.5	1.5	1.5
Transitional	6.2	0.1	0.0

Notes: The current and planned land use information was obtained from the SANDAG websites. It has been updated continuously since 2000 using aerial photography, the County Assessor Master Property Records file, and other ancillary information. The land use information was reviewed by each of the local jurisdictions and the County of San Diego to ensure its accuracy.

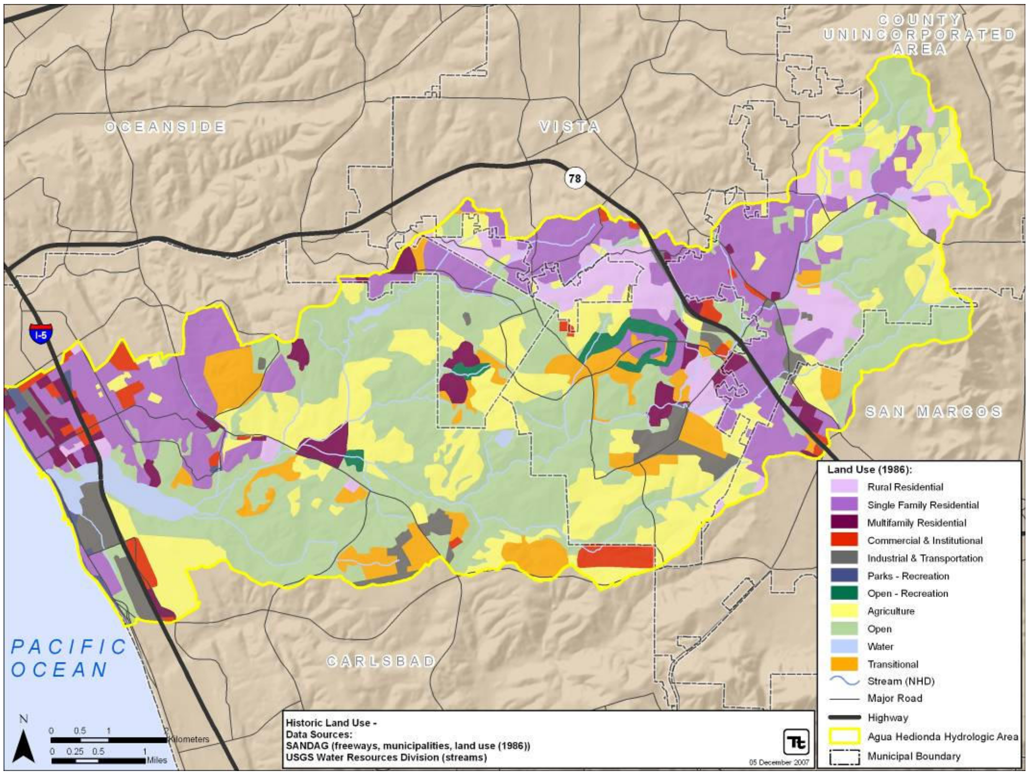

Figure 8. Past Land Use (1986) within the Agua Hedionda Watershed

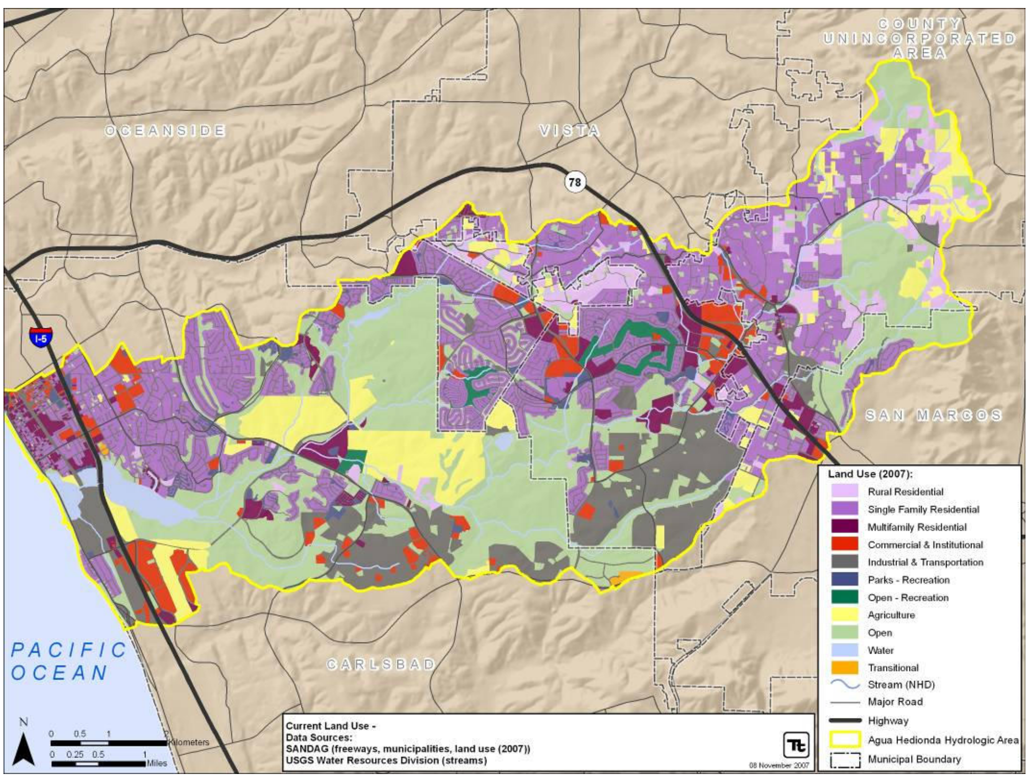

Figure 9. Current Land Use within the Agua Hedionda Watershed

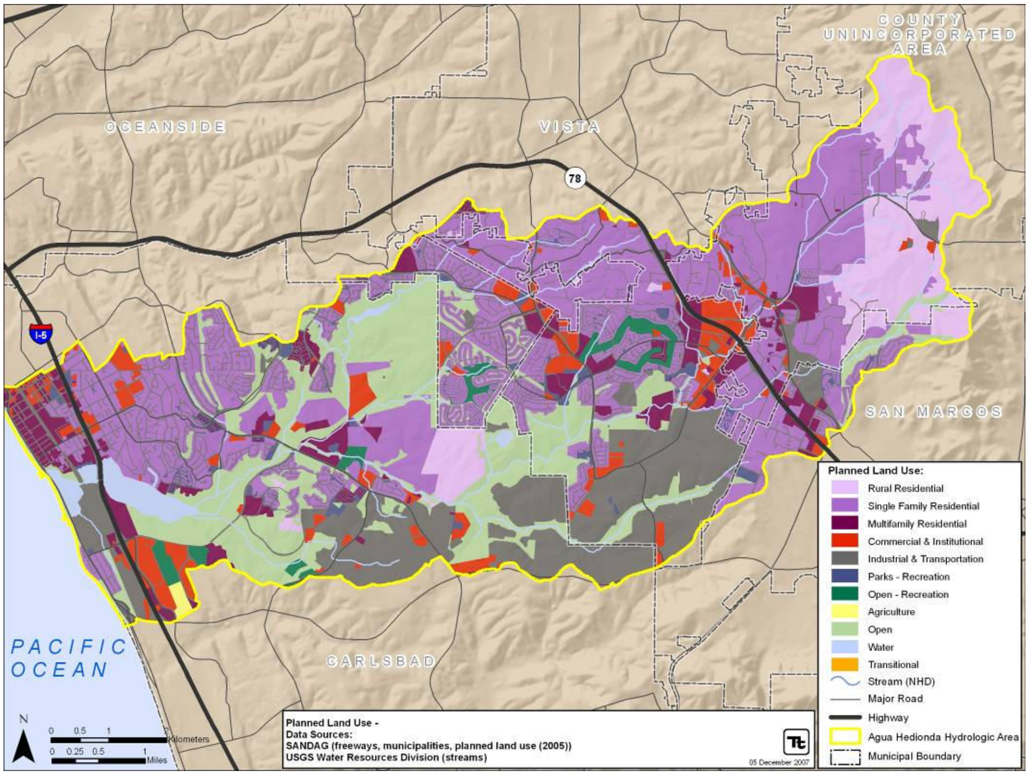

Figure 10. Planned Land Use within the Agua Hedionda Watershed (Final 2030 City/County Forecast)

Impervious Surfaces

Urbanization can have profound influences on watershed health. As land is converted to rooftops, roads, and parking lots, impervious surface area increases leading to increased storm runoff while less surface water is able to infiltrate. These increases in impervious surface lead to greater volume, frequency and magnitude of runoff within the watershed. The Impervious Cover Model (CWP, 2007) indicates that certain zones of stream quality exist, most notably at about 10 percent impervious cover, where sensitive stream elements (e.g. sensitive aquatic species, excellent habitat structure, and excellent water quality) are lost from the system. A second threshold appears to exist at around 25 to 30 percent impervious cover, where most indicators of stream quality consistently shift to a poor condition (e.g., diminished aquatic diversity, water quality, and habitat scores). However, these categories are based heavily upon mid-Atlantic and Puget Sound research and may be less applicable to Southern California watersheds.

Based on 2001 National Land Cover Data (30 m resolution), the upper portion of the watershed generally has a lower percentage of impervious surfaces than the lower watershed. Pockets of low imperviousness are present in the central watershed, especially along Little Encinas Creek (Figure 11). However, conditions within a stream segment are influenced by the entire upstream contributing area. When upstream impervious influences are taken into account, the whole lower watershed is characterized as having greater than second impervious cover threshold contained in the Impervious Cover Model (Figure 12).

Unlike Figure 11, which represents the imperviousness within each individual subbasin, the cumulative percent impervious calculations in Figure 12 take into account upstream imperviousness. This is a useful measure of the potential impact on the mainstem reach in each subbasin. This was determined by taking the average of all cumulative areas upstream of each subbasin. For example, the uppermost subbasin has a 9.1 percent imperviousness value. To calculate the percent imperviousness for the next subbasin downstream, the combined area of these two subbasins is taken into account. The bottom-most basin (along the beach) represents an average imperviousness of the whole watershed (32.8 percent).

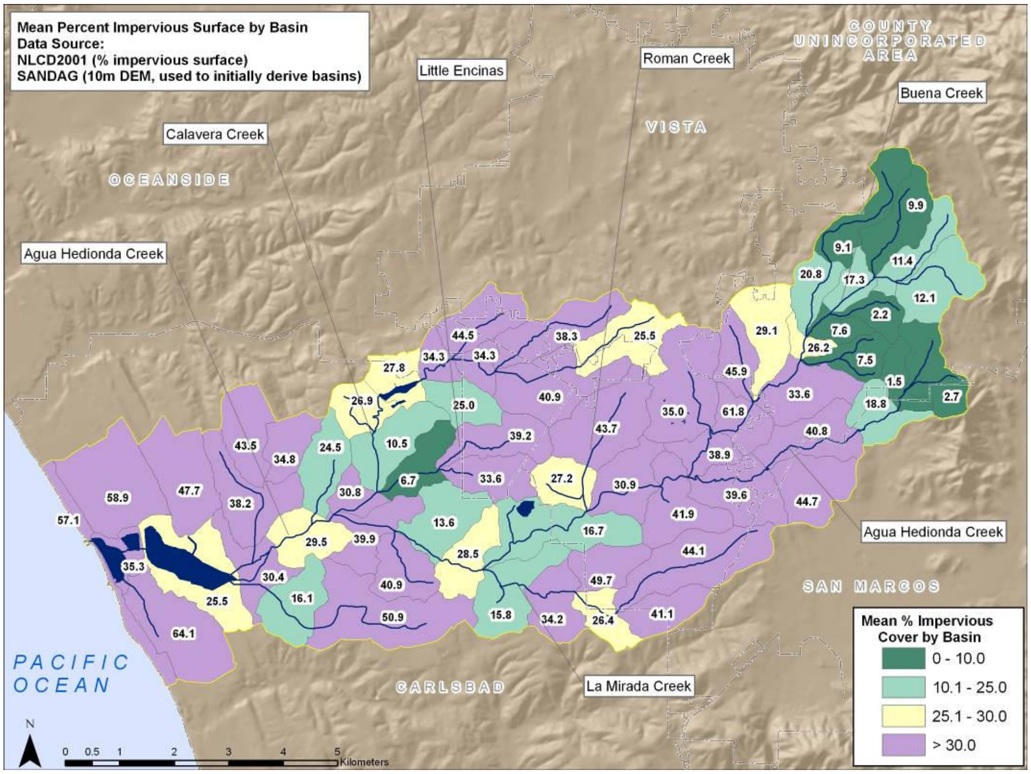

Figure 11. Percent Impervious Surface Cover by Subbasins

Plant Communities

Figure 13 displays the distribution of major Holland vegetation classification system categories within the watershed (SANDAG, 1995). Although most of the watershed is classified as non-native/unvegetated habitat and developed lands, significant areas of scrub/chaparral and herbaceous communities are present (Table 8). Riparian and bottomland habitat is located adjacent to the creek corridors, while bog/marsh and estuary habitat is represented adjacent to the lagoon.

Many of the natural vegetation communities are fragmented due to roads, agriculture, and residential and commercial development. As natural vegetation communities are divided into smaller and smaller parcels, native plant and animal species may be threatened due to reduced mobility. Meanwhile, invasive species often thrive in fragmented habitats. Disturbed wetland communities may be prime candidates for restoration activities.

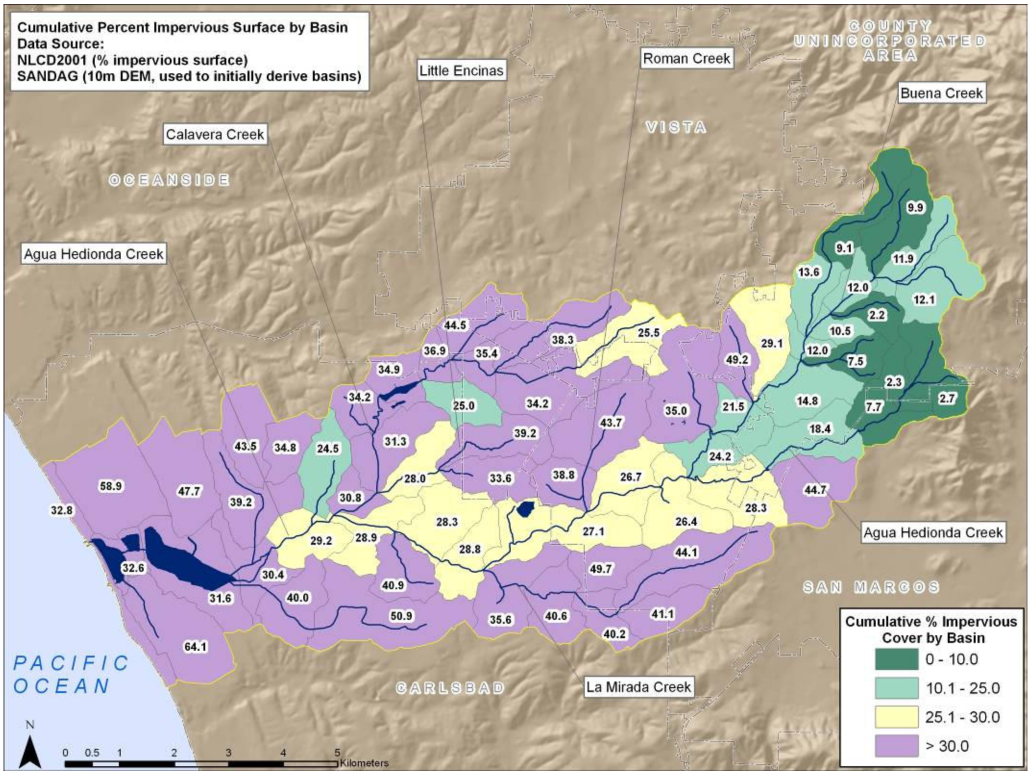

Figure 12. Cumulative Upstream Percent Impervious Surface Cover by Subbasin

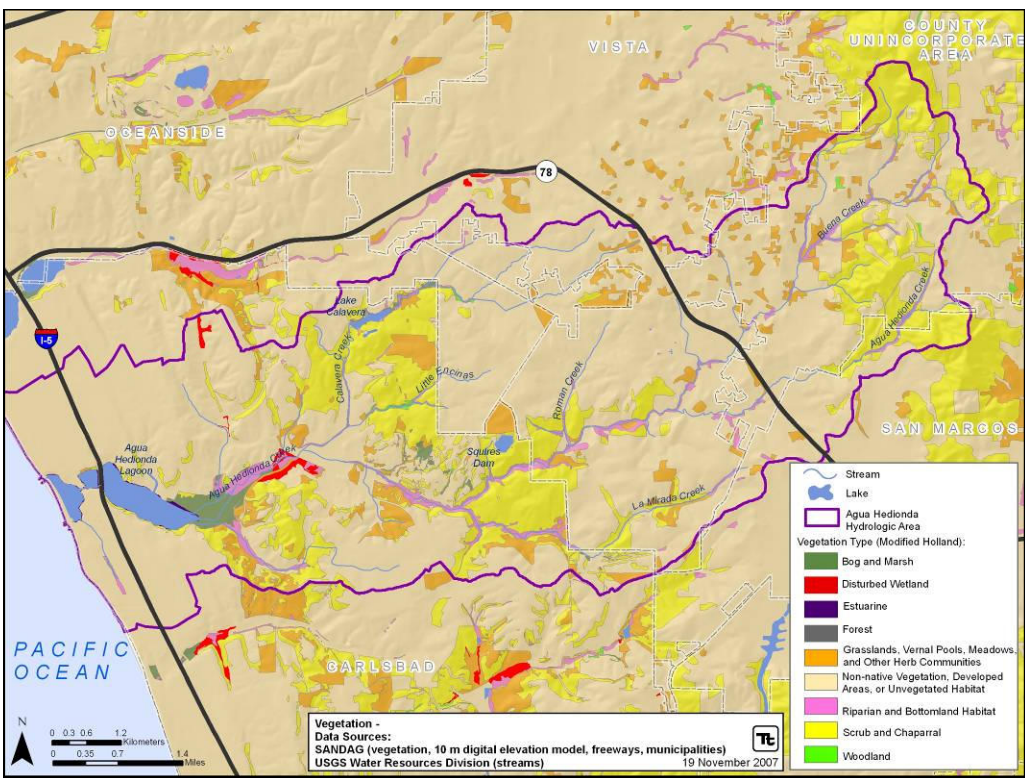

Figure 13. Vegetation Communities Available in the Watershed

Table 8. Vegetation Community Types in Agua Hedionda Watershed

Vegetation Community	Acreage
Non-native Vegetation, Developed Areas, or Unvegetated Habitat	14,087.3
Scrub and Chaparral	3,812.6
Grasslands, Vernal Pools, Meadows, and Other Herb Communities	1,189.9
Riparian and Bottomland Habitat	542.2
Estuarine	272.3
Bog and Marsh	191.9
Disturbed Wetland	52.9
Woodland	26.4
Forest	0.1

Populations of invasive plant species can dominate a plant community by out-competing native species, increasing soil erosion, and altering fire regimes, nutrient cycling, and hydrology. Invasive species data were collected by the SELC (2007) as part of their recent study of restoration of riparian/wetlands habitat in the Carlsbad Hydrologic Unit. They found pampas grass (*Cortaderia selloana*) and giant reed (*Arundo donax*) to be the most dominant invasive species within the Agua Hedionda Watershed (Table 9; Figure 14). However, the presence of periwinkle (*Vinca major*), salt cedar (*Tamarix sp.*), castor bean (*Ricinus communis*), artichoke thistle (*Cynara cardunculus)*, palms (*Washingtonia robusta* or *Phoenix canariensis)*, and pepperweed (*Lepidium latifolium)* are also a concern.

Table 9. Acreage of Invasive Plant Species Present in the Agua Hedionda Watershed (SELC)

Common Name	Scientific Name	Acreage
Pampas grass	*Cortaderia selloana*	98.4
Giant reed	*Arundo donax*	22.9
Periwinkle	*Vinca major*	6.9
Salt cedar	*Tamarix sp.*	4.4
Castor bean	*Ricinus communi*	4.3
Artichoke thistle	*Cynara cardunculus*	3.6
Palms	*Washingtonia robusta* or *Phoenix canariensis*	2.7
Pepperweed	*Lepidium latifolium*	0.01
Total		**143.1**

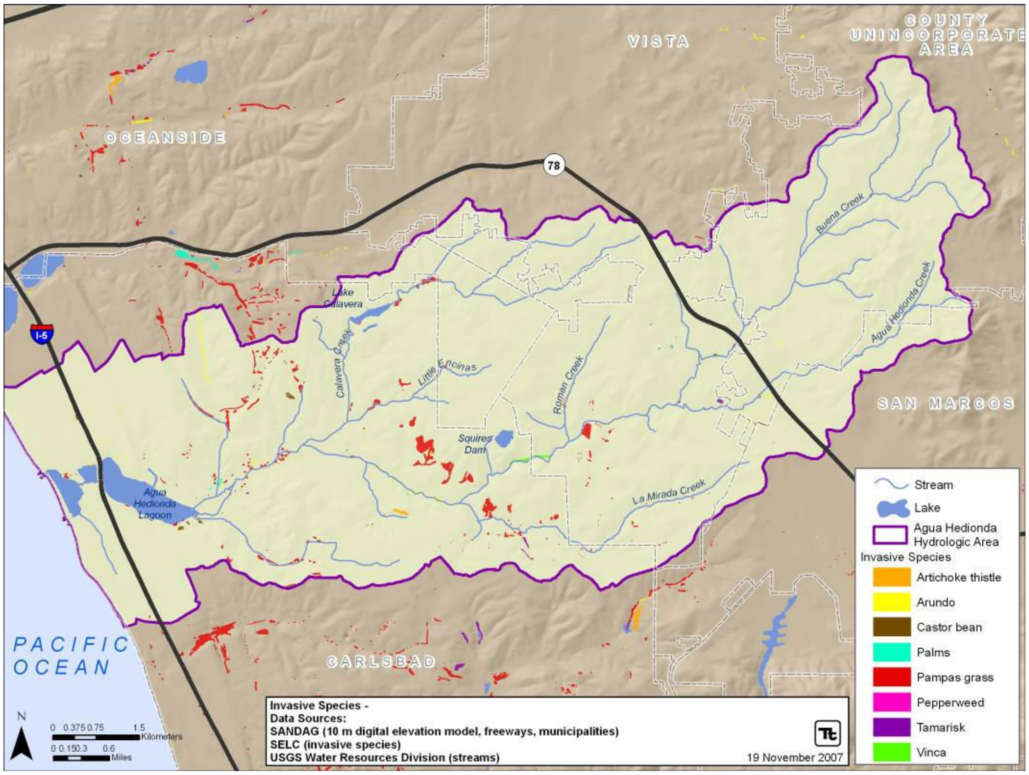

Figure 14. Invasive Plant Species Present in the Watershed

Public Land and Open Space

Several categories of open space are represented in the watershed, including undeveloped natural areas, parks, preserves, and passive beaches. Although the majority of open space is privately owned, there are large tracts of publicly owned open space - especially in the lower half of the watershed. Publicly owned open space may provide prime opportunities for restoration and protection of open space.

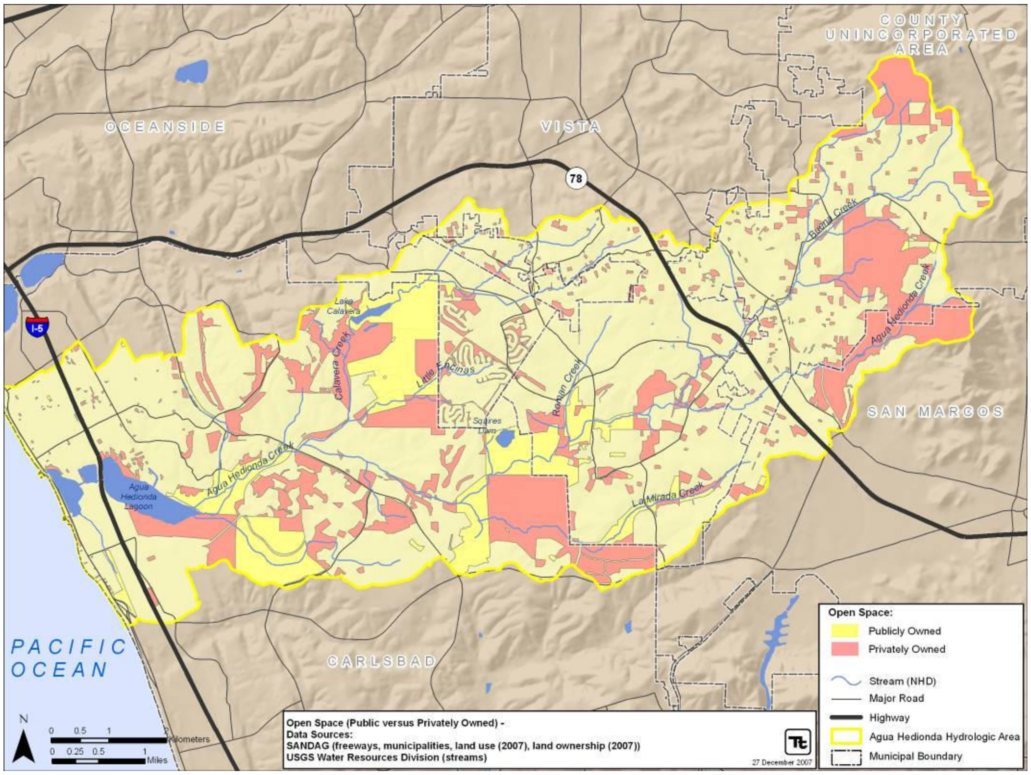

Figure 15. Public and Private Open Space Distribution, 2007

2.2 HUMAN ENVIRONMENT

2.2.1 Point Sources

There are no direct point source discharges from wastewater treatment plants (WWTPs) to waterbodies in the watershed. WWTPs are active in the watersheds; however, all effluent from these facilities is discharged from offshore ocean outfalls. Pollutants are periodically discharged into the water courses as a result of sewage spills.

Other potential sources of pollutants throughout the watershed can be associated with specific facilities if they are not properly managed. Figure 16 shows the distribution of the primary potential sources throughout the watershed according to the Baseline Long Term Effectiveness Report (Weston and others, 2005). This report identifies animal facilities, food facilities, nurseries and water/wastewater publicly owned treatment works (POTWs) to be likely or unknown sources of bacteria and sediment pollution in the watershed. The POTWs are actually lift stations, a potential source of sewage spills due to accidental overflow.

Certain sources of stormwater are also considered point sources. In 1990 USEPA developed rules establishing Phase I of the NPDES stormwater program, designed to prevent harmful pollutants from being washed by stormwater runoff into MS4s (or from being dumped directly into the MS4s) and then discharged from the MS4 into local waterbodies. Phase I of the program required operators of medium and large MS4s (those generally serving populations of 100,000 or more) to implement a stormwater management program as a means to control polluted discharges from MS4s. Phase II of the rule extended coverage of the NPDES stormwater program to certain small municipalities with a population of at least 10,000 and/or a population density of more than 1,000 people per square mile. For the San Diego region, all discharges of urban runoff are covered by MS4 permits. For the watersheds of San Diego County, the incorporated cities of San Diego County (18 cities), the Airport Authority, and the San Diego Unified Port District, NPDES No. CAS0108758 (referred to in this document as the Municipal NPDES Permit) defines the waste discharge requirements for MS4s. Urban runoff discharges from MS4s contain pollutants that contribute to water quality impairments in the watershed (SDRWQCB, 2007).

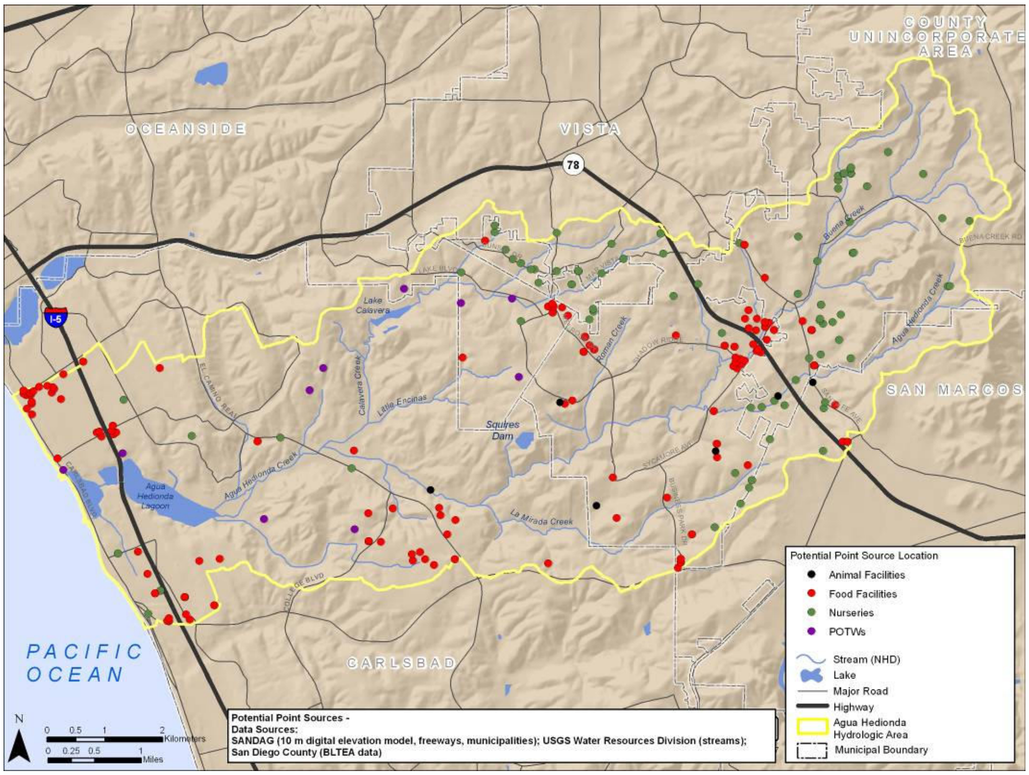

Figure 16. Potential Sources of Pollutants

2.2.2 Sewered/Unsewered Areas

Figure 17 presents data currently available[2] for the distribution of stormwater and sewer lines throughout the watershed. Although the majority of the watershed is on a sanitary sewer system, some portions of developed lands use septic systems (Figure 18). Figure 18 is based on an analysis of developed parcels with apparent sewer service (i.e., parcels located within 200 ft of the available sewer). Specifically, portions of the upper watershed that are currently low density residential are not on the sewer system.

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[2] City of Vista data is draft for the stormwater system. Also, City of Oceanside data is not available for the watershed.

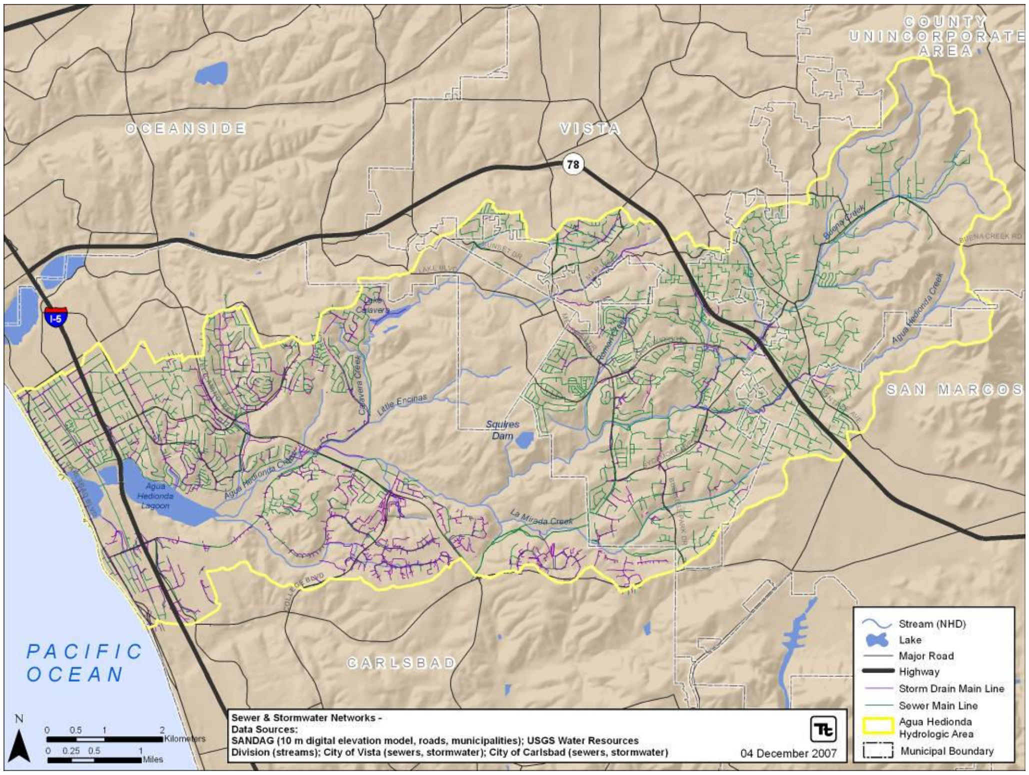

Figure 17. Stormwater and Sewer Line Distribution in the Agua Hedionda Watershed

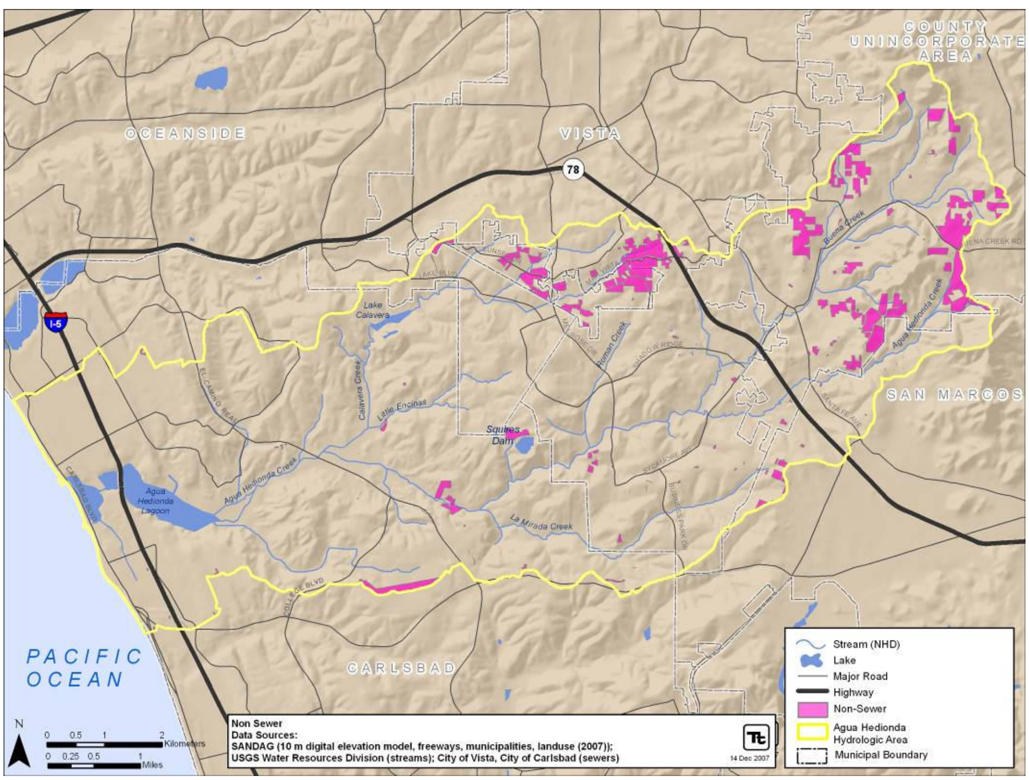

Figure 18. Non-Sewered Development in the Agua Hedionda Watershed

2.2.3 Agriculture

Figure 19 displays agricultural lands within the watershed in three categories: intensive agriculture, field crops, and vineyards/orchards. Field crops, including pasture land, are the most abundant followed by intensive agriculture and vineyards/orchards.

The Agua Hedionda Lagoon also serves as an agricultural environment. The Carlsbad Aguafarm produces scallops, mussels, clams, and oysters. It also raises seahorses, seaweed and octopuses for aquariums. A 22,000 square foot fish hatchery which focuses on white seabass is also located within the lagoon.

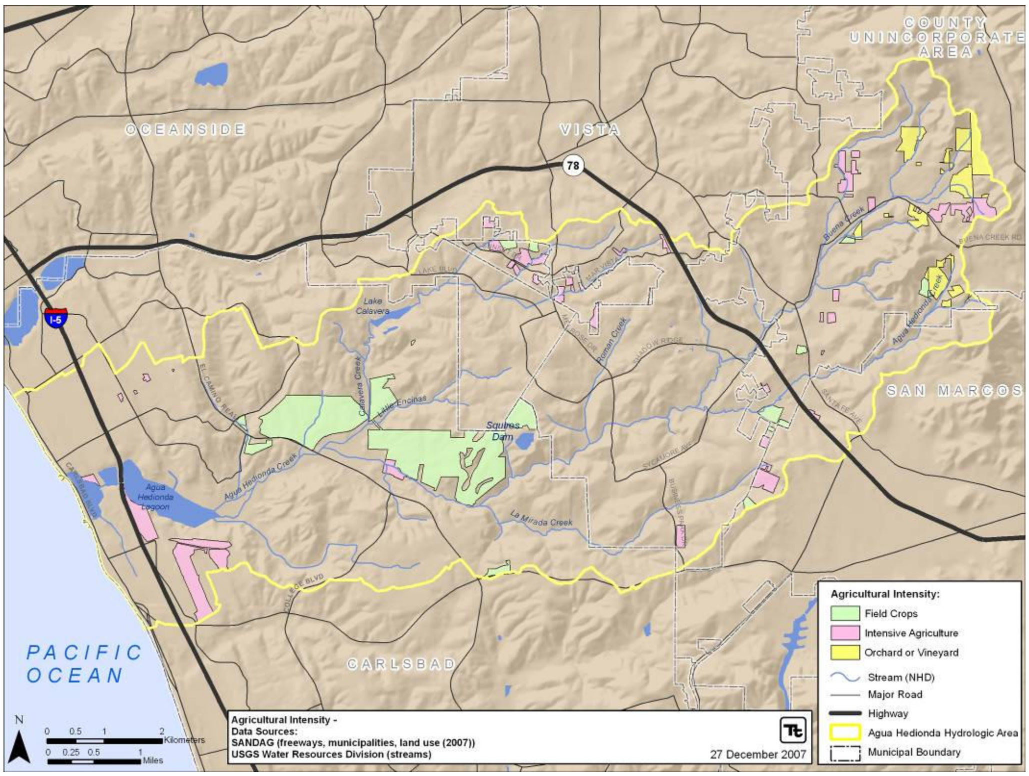

Figure 19. Classification of Agricultural Land Use Intensity in the Agua Hedionda Watershed (SANDAG)

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3 Water Quality Assessment

The following assessment of water quality in the Agua Hedionda Watershed focuses on both impaired and non-impaired waterbodies. Data sets from multiple sources have been used to evaluate existing threats to beneficial uses. In addition, a discussion of trends in pollutant concentrations is presented.

3.1 IMPAIRED WATERS

Section 303(d) of the Clean Water Act requires the Regional Board and State Board to identity waters that do not meet applicable water quality objectives. Those waters not meeting these standards are considered impaired. In the 2006 list of impaired waters, Agua Hedionda Creek is listed as impaired by manganese, selenium, sulfates, and total dissolved solids (TDS) impairment (Table 10). Buena Creek is listed for the pesticide DDT, nitrate and nitrite, and phosphate impairment. The Agua Hedionda Lagoon is listed due to elevated bacteria and sedimentation/siltation. The SDRWQCB is in the process of developing Total Maximum Daily Loads (TMDLs) for Agua Hedionda Creek and Lagoon, supported by ongoing co-permittee monitoring.

Table 10. San Diego Regional Board 2006 Clean Water Act Section 303d List of Water Quality Limited Segments for the Agua Hedionda Watershed[3]

Waterbody Type	Name	Pollutant/Stressor
Rivers/Stream	Agua Hedionda Creek	Manganese
		Selenium
		Sulfates
		Total Dissolved Solids
Rivers/Stream	Buena Creek	DDT
		Nitrate and Nitrite
		Phosphate
Estuarine	Agua Hedionda Lagoon	Indicator bacteria
		Sedimentation/Siltation

The source for manganese, selenium, and sulfate impairment in Agua Hedionda Creek is unknown according to the 303(d) list for 2006. Likewise, impairments in Buena Creek are attributed to unknown sources. Bacterial and sediment-related impairments have been attributed to urban runoff, storm sewers, and other nonpoint sources.

3.2 LAGOON MONITORING

3.2.1 Lagoon Sediment Monitoring

The Ambient Bay and Lagoon Monitoring (ABLM) program began collecting sediment samples, which included the Agua Hedionda lagoon, as part of the San Diego County Co-permittees' Urban Runoff

[3] http://www.waterboards.ca.gov/tmdl/303d_lists2006.html

Monitoring program in 2003. Weston (2007b) examined the program to determine if any linkage was observed between sediment conditions in monitored bays and lagoons and freshwater conditions at upstream mass loading stations (MLS), as stated in the Report of Waste Discharge, County of San Diego Co-permittees. The three years of data are compared to the corresponding three years of wet weather mass loading station (MLS) data from upstream runoff sources.

Results of the ABLM program indicate that the sediment within Agua Hedionda lagoon is relatively healthy. Sediment metals chemistry and mean ERM-Q (Effects Ranged Median-Quotient) values were low. In addition, the levels of pesticides and organics were not detectable in the sediments during any sampling year. Toxicity test results also indicate low toxicity of sediment in 2004 and 2005 and low toxicity of water in all years. Benthic infaunal health was measured by two indices for estuarine conditions (RBI and BRI) and these indices indicated good to fair results. Use of a freshwater index (IBI) resulted in poor scores.

An evaluation of mass loading on Agua Hedionda Creek (monitored just upstream of the lagoon) found high total suspended solids in all three years. On one of three dates in 2003, copper was above the criteria continuous concentrations (CCC) water quality guidelines based on hardness. All other metals were below CCC.

The report concluded that conditions in the lagoon have not changed appreciably over the 3-year study period. The pattern between sediment conditions observed in the lagoon monitoring and upstream stormwater monitoring (at mass loading station) for the 3-year study period is unclear. The report recommends that co-permittees take part in the Bight program, which allows for periodic (5-year) monitoring of sediments within the lagoons.

Sediment samples were collected in Agua Hedionda Lagoon in 2003 to evaluate grain size (MEC, 2004). Sediments in the outer Lagoon consisted primarily of sand (95.1 percent to 96.2 percent) and had a much lower TOC content (0.05 percent to 0.10 percent) than sites in the middle and inner Lagoon. Sediments in the inner Lagoon had a much smaller median grain size consisting primarily of clay, and a higher TOC content than the other sites in the Lagoon.

3.2.2 Co-permittees' Coastal Storm Drain Monitoring

The Co-permittees' Coastal Storm Drain Monitoring (CSDM) program was designed to meet the Municipal NPDES Permit requirements by monitoring bacteria levels in urban runoff from coastal and lagoon outfalls, and evaluating the relationship between storm drain discharges and exceedances of bacteriological water quality standards in the coastal receiving waters. This program included sampling of both storm drains and adjacent receiving waters at coastal beaches and in lagoons. Out of 18 samples collected at site AH-006, four exceeded fecal coliform and enteroccocus receiving water standards (one exceeded the total coliform standard) during 2005-2006.

The CSDM Program has been modified (effective in October of 2007) to address new Municipal NPDES Permit requirements (San Diego Co-permittees, 2007). The modifications to the program include a sampling frequency reduction from every other week during the summer months to a monthly frequency year-round. In addition Co-permittees must collect a storm drain outfall sample even when it is not directly discharging to the receiving water. Finally, the program was also modified to increase follow-up sampling based on exceedances of water quality objectives for both receiving water and storm drain samples.

3.3 Existing Watershed Monitoring Data

Water quality data have been collected by many organizations (Figure 20; Table 11). Sources include the Co-permittees, San Elijo Lagoon Conservancy, Surface Water Ambient Monitoring Program (SWAMP), and the Citizen's Biomonitoring Program and are summarized below.

3.3.1 Data Sources

Co-permittee Dry Weather Monitoring

Co-permittee dry weather monitoring has been performed in the watershed annually between May 1st and September 30th since 2002 (WURMP, 2003-2007). Data are collected in ambient streams and in storm drains in an effort to identify possible illicit connections and illegal discharges. A total of 61 Co-permittee dry weather data stations have been established, including 10 ambient and 51 storm drain sites.

Co-permittee Wet Weather Monitoring

The Co-permittee wet weather data has been collected since the 1998-1999 storm season (MEC, 2004; MEC, 2005; Weston, 2005; Weston, 2007a). This dataset represents one sample station located at the intersection of Agua Hedionda Creek and the El Camino Real. This site is located downstream of the confluence of Agua Hedionda Creek and Buena Creek. The following parameters have been collected at this site:

- Inorganic Chemicals - Ammonia, Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Total and Dissolved Phosphorus, Nitrate, Nitrite, total hardness, Total Kjedahl Nitrogen (TKN), Total Dissolved Solids (TDS), Total Suspended Solids (TSS), turbidity, and detergents (MBAS).
- Metals (Total and Dissolved) - Antimony, arsenic, cadmium, chromium, copper, lead, nickel, selenium, and zinc.
- Organophosphate Pesticides - Diazinon and chlorphyrifos
- Toxicity Testing - Using *Ceriodaphnia dubia*, *Selenastrum capticornutum*, and *Hyalella azteca*.

In this review, a large focus is on water quality data from the Co-permittee wet weather station. We are able to explore temporal trends because data have been collected for nearly 10 years. It also represents the only wet weather data for this water quality analysis. Furthermore, its location, downstream in the watershed at the confluence of several creeks, provides an integrator site for the majority of the watershed.

Co-Permittee Bioassessment

There are 20 Co-permittee bioassessment monitoring sites throughout San Diego County (Weston, 2007a). However, only two of these sites are located within the Agua Hedionda Watershed. Benthic macroinvertebrate data have been collected at these sites since 2001.

San Elijo Lagoon Conservancy

The San Elijo Lagoon Conservancy (SELC), on behalf of the Carlsbad Watershed Network, received a grant funded by a Proposition 13 Watershed Protection Program Grant from the California State Water Resources Control Board (Grant Agreement Number 04-083-559-0) for the restoration of riparian and wetland habitat in the Carlsbad Hydrologic Unit (SELC, 2007). As part of this study, SELC collected physical habitat, water quality, and benthic macroinvertebrate data between 2004 and 2006. Four sites, located along Agua Hedionda Creek, were monitored as part of this project.

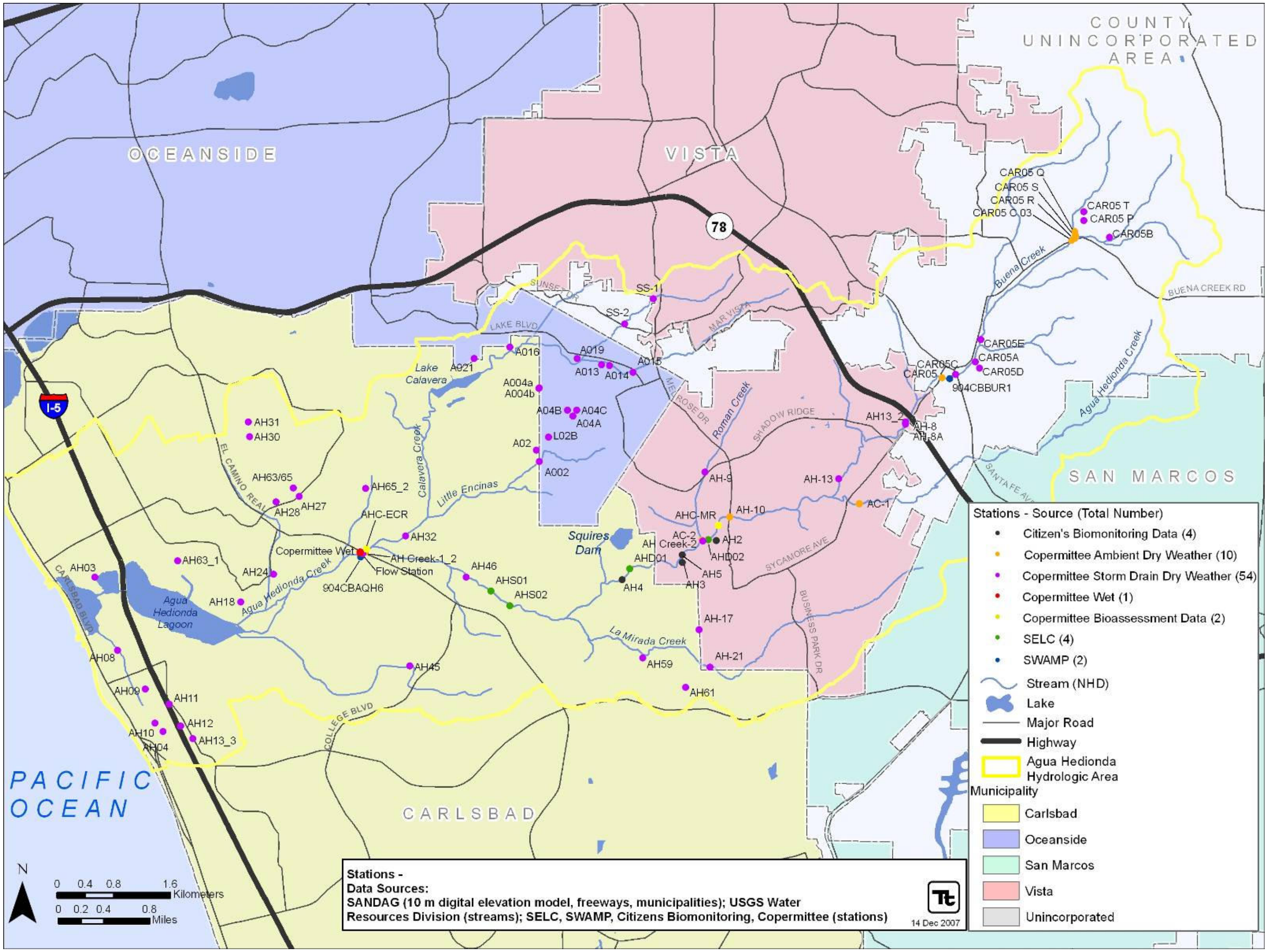

Figure 20. Monitoring Stations in the Agua Hedionda Watershed

Table 11. Summary of Existing Watershed Monitoring

Agency/Organization	Sites	Years Covered	Water Quality	Water Chemistry	Bacteriological	BMI	Toxicity	Physical Habitat	Rain Gauge	Discharge
Co-permittee Dry Weather (ambient & storm drain)	61	2002-2007	X	X	X					
Co-permittee Wet Weather	1	1998 - 2007	X	X	X		X		X	
Co-permittee Bioassessment	2	2002 - 2006		X		X		X		
Citizen's Biomonitoring	4	2001, 2002, 2003, 2005, 2007		X		X		X		
San Elijo Lagoon Conservancy	4	2004 - 2006	X	X	X	X		X		X
SWAMP	2	2002	X	X			X	X		

Surface Water Ambient Monitoring Program (SWAMP)

Data were collected at two stations in the Agua Hedionda Watershed as part of the SWAMP. Water quality, water chemistry, toxicity, and physical habitat data were collected at these sites in 2002.

Citizen's Biomonitoring

Biomonitoring was conducted by the Watershed Stewards Training for Citizens Monitoring, the Agua Hedionda Lagoon Foundation, and the Carlsbad Watershed Network (Agua Hedionda Lagoon Foundation, 2007). This dataset included four sites located along Agua Hedionda Creek (Table 11). Water chemistry, benthic macroinvertebrate, and physical habitat data were collected at these sites several years between 2002 and 2007.

3.3.2 Water Quality Parameter Summaries

Water quality standards have been established at the federal, state, regional levels. Standards are primarily based on the California Toxic Rule (40 CFR 131 – 65FR 31682, May 18, 2000) and the San Diego Basin Plan (September 8, 1994). The most localized standard available should be used, such that Regional Board standards take precedence over state and federal standards. The San Diego Basin Plan (1994) defines water quality objectives (WQO) for the majority of these parameters. These standards have been established to protect beneficial uses of water and prevent nuisances within a specific area. Each WQO is designated by waterbody type (ocean waters, inland surface waters, enclosed bays and estuaries, coastal lagoons and groundwaters). All data summarized in this section represent inland surface waters.

Data from the sources discussed above were combined by data type (i.e., wet weather, ambient dry, or storm drain) for evaluation. General water quality, chemistry, bacteriological, and pesticide data collected at wet weather, ambient dry weather, and storm drain sites are summarized in Table 12–Table

14 below. Values reported as non-detect were converted to one-half the detection limit for summary purposes. Discussions of individual parameters are provided afterward.

Table 12. Wet Weather Water Quality Summary Statistics

Parameter	Units	WQO	Min	Mean	Max	Count	DL	ND
General								
Electrical Conductivity	umhos/cm	NA	502.00	1,431.85	3,180.00	27	-	0
Oil And Grease	mg/L	15 (a)	0.25	1.16	3.54	27	0.5-5.0	19
pH	pH Units	6.5-8.5 (b)	6.70	7.60	8.22	17	-	0
Chemistry								
Ammonia As Nitrogen	mg/L	NA	0.05	0.38	0.91	27	0.1	3
Un-ionized Ammonia as N	µg/L	25 (b)	0.21	5.31	17.34	15	-	0
Biochemical Oxygen Demand	mg/L	30 (a)	1.00	11.24	49.40	27	2-3	2
Chemical Oxygen Demand	mg/L	120 (a)	2.50	99.13	552.00	27	5	1
Dissolved Organic Carbon	mg/L	NA	7.20	15.24	32.90	15	-	0
Dissolved Phosphorus	mg/L	0.1 (b)	0.03	0.29	1.10	27	0.05-0.1	2
Nitrate As N	mg/L	10 (b)	0.03	1.48	3.20	27	0.05	1
Nitrite As N	mg/L	1 (b)	0.03	0.03	0.09	27	0.05	23
Surfactants (MBAS)	mg/L	0.5 (b)	0.03	0.21	0.33	27	0.05-0.5	22
Total Dissolved Solids	mg/L	500 (b)	10.00	780.00	1,611.00	26	20	1
Total Kjeldahl Nitrogen	mg/L	NA	0.44	3.58	14.10	26	-	0
Total Organic Carbon	mg/L	NA	5.21	22.05	47.50	15	-	0
Total Phosphorus	mg/L	0.1 (b)	0.11	0.67	2.28	27	-	0
Total Suspended Solids	mg/L	100 (a)	5.00	434.42	2,210.00	26	20	2
Turbidity	NTU	20 (b)	6.40	157.14	825.00	26	-	0
Bacteria and Pesticides								
Enterococcus	MPN/100 ml	151 (b)	3,000	56,238	500,000	21	-	0
Fecal Coliform	MPN/100 ml	400 (b)	1	9,787	50,000	27	2	1
Total Coliform	MPN/100 ml	NA	300	58,416	300,000	27	-	0
Chlorpyrifos	µg/L	0.02 (c)	0.001	0.019	0.121	26	0.002-0.5	13
Diazinon	µg/L	0.08 (c)	0.002	0.185	0.464	27	0.004-0.5	11
Malathion	µg/L	0.43 (c)	0.005	0.191	0.622	15	0.01	2

(a) USEPA National Pollutant Discharge Elimination System (NPDES) Storm Water Multi-Sector General Permit for Industrial Activities, 65 Federal Register (FR) 64746 (only used as a benchmark; does not apply to ambient samples); **(b)** Water Quality Control Plan for the San Diego Basin; **(c)** Siepmann and Finlayson. 2000.
; NTU is nephelometric turbidity units; MPN is most probable number

Table 13. Ambient Dry Weather Water Quality Summary Statistics

Parameter	Units	WQO	Minimum	Mean	Maximum	Count	DL	ND
General								
Electrical Connectivity	mS/cm	NA	2.08	2.19	2.33	7	-	0
Specific Conductance	µS/cm	NA	1126	2,3622	5,310	67	-	0
Oil & Grease	mg/L	15 (a)	0.50	3.09	11.00	21	1-5	8
pH	pH Units	6.5-8.5 (b)	6.59	7.94	8.60	70	-	0
Temperature	℃	NA	9.40	17.58	22.70	61	-	0
MBAS	mg/L	0.5 (b)	0.03	0.27	0.50	27	0.05-0.5	7
Chemistry								
Ammonia as N	mg/L	NA	0.05	0.64	8.00	39	0.05-0.1	6
Nitrate as N	mg/L	10 (b)	0.025	5.41	32.96	56	0.05-1.35	1
Nitrate as NO3	mg/L	45 (b)	1.33	13.11	40.30	32	-	0
Nitrite + Nitrate	mg/L	10 (b)	0.48	8.23	19.40	8	-	0
Nitrite as N	mg/L	1 (b)	0.005	0.03	0.19	24	0.01	15
Total Kjeldahl Nitrogen	mg/L	NA	0.05	0.45	1.63	40	0.1-0.5	6
OrthoPhosphate as P	mg/L	NA	0.005	0.20	0.70	58	0.01-0.1	5
Dissolved Oxygen	mg/L	> 5.0 (b)	4.86	8.75	11.26	36	-	0
Phosphate as P	mg/L	0.1 (b)	0.03	0.30	1.62	36	0.06	1
Phosphorus as P	mg/L	0.1 (b)	0.025	0.11	0.20	16	0.02-0.05	2
Salinity	ppt	NA	0.10	0.10	0.11	7	-	0
Sulfate	mg/L	250 (b)	280.00	402.63	522.00	8	-	0
Turbidity	NTU	20 (b)	0.01	6.79	43.00	39	-	0
Bacteria and Pesticides								
Enterococcus	MPN/100 ml	151 (b)	0	463	5,000	54	10-20	5
Fecal Coliform	MPN/100 ml	400 (b)	4	3502	80,000	56	-	0
Total Coliform	MPN/100 ml	NA	50	64,971	3,000,000	56	-	0
Chlorpyrifos	µg/L	0.02 (c)	0.025	0.055	0.500	27	0.05-1	18
Diazinon	µg/L	0.08 (c)	0.010	0.053	0.500	27	0.02-1	17
Malathion	µg/L	0.43 (c)	0.025	0.027	0.050	15	0.05	15

(a) USEPA National Pollutant Discharge Elimination System (NPDES) Storm Water Multi-Sector General Permit for Industrial Activities, 65 Federal Register (FR) 64746 (only used as a benchmark; does not apply to ambient samples);
(b) Water Quality Control Plan for the San Diego Basin; **(c)** Siepmann and Finlayson. 2000;
NTU is nephelometric turbidity units; MPN is most probable number

Table 14. Storm Drain Dry Weather Water Quality Summary Statistics

Parameter	Units	WQO	Minimum	Mean	Maximum	Count	DL	ND
General								
Conductivity	µS/cm	NA	0.80	2,199.56	13,000.00	163	-	0
Dissolved Oxygen	mg/L	> 5.0 (b)	0.79	7.18	14.77	24	-	0
Electrical Connectivity	mS/cm	NA	1.67	2.18	2.68	2	-	0
MBAS	mg/L	0.5 (b)	0.03	0.39	5.00	135	0.050.5	34
Oil & Grease	mg/L	15 (a)	0.50	27.62	530.00	62	1-5	27
Temperature	℃	NA	16.00	24.31	220.60	120	-	0
pH	pH Units	6.5-8.5 (b)	5.70	7.71	9.80	166	-	0
Chemistry								
Ammonia as N	mg/L	NA	0.03	0.78	7.65	156	0.05-0.1	1
Nitrate-N	mg/L	10 (b)	0.03	8.56	75.00	142	0.05-1.35	2
OrthoPhosphate	mg/L	NA	0.02	0.81	5.50	109	-	0
Phosphorus	mg/L	0.1 (b)	0.01	0.24	0.98	34	0.02	3
Salinity	ppt	NA	0.07	0.19	0.32	27	-	0
Turbidity	NTU	20 (b)	0.00	13.03	308.00	140	-	0
Bacteriological								
Enterococcus	MPN/100 ml	151 (b)	10	9,545	16,0000	68	-	0
Fecal Coliform	MPN/100 ml	400 (b)	20	22,115	300,000	66	-	0
Total Coliform	MPN/100 ml	NA	20	15,5156	1,600,000	67	-	0
Pesticides								
Chlorpyrifos	µg/L	0.02 (c)	0.025	0.124	1.500	57	0.05-3	39
Diazinon	µg/L	0.08 (c)	0.025	0.179	3.000	57	0.05-6	40
Malathion	µg/L	0.43 (c)	0.020	0.047	0.330	15	0.04-0.05	13

(a) USEPA National Pollutant Discharge Elimination System (NPDES) Storm Water Multi-Sector General Permit for Industrial Activities, 65 Federal Register (FR) 64746 (only used as a benchmark; does not apply to ambient samples); **(b)** Water Quality Control Plan for the San Diego Basin; **(c)** Siepmann and Finlayson. 2000;
NTU is nephelometric turbidity units; MPN is most probable number

pH

Hydrogen ion activity, or pH, is a measure of the acidity/alkalinity of water. The pH scale ranges from 0 to 14, with 7 indicating neutral conditions. The Basin Plan requires that pH levels are maintained between 6.5 and 8.5 in inland surface waters. Storm drain data expressed the greatest range of pH values (5.7 to 9.8) and periodically exceeded both the upper and lower bounds of the WQO. The extremes of the ambient dry weather data did exceed the upper bounds of this standard. Wet weather samples met this WQO, ranging from 6.70 to 8.22.

Figure 21 presents the distribution of pH measurements collected as part of the Co-permittee storm drain monitoring. Values represent means over all sampling events. Those points exceeding the lower WQO are located in the upper watershed, while those exceeding the upper WQO bounds are located at the base of the watershed. There appears to be a general spatial trend in the watershed: the upper watershed is more acidic than the lower watershed.

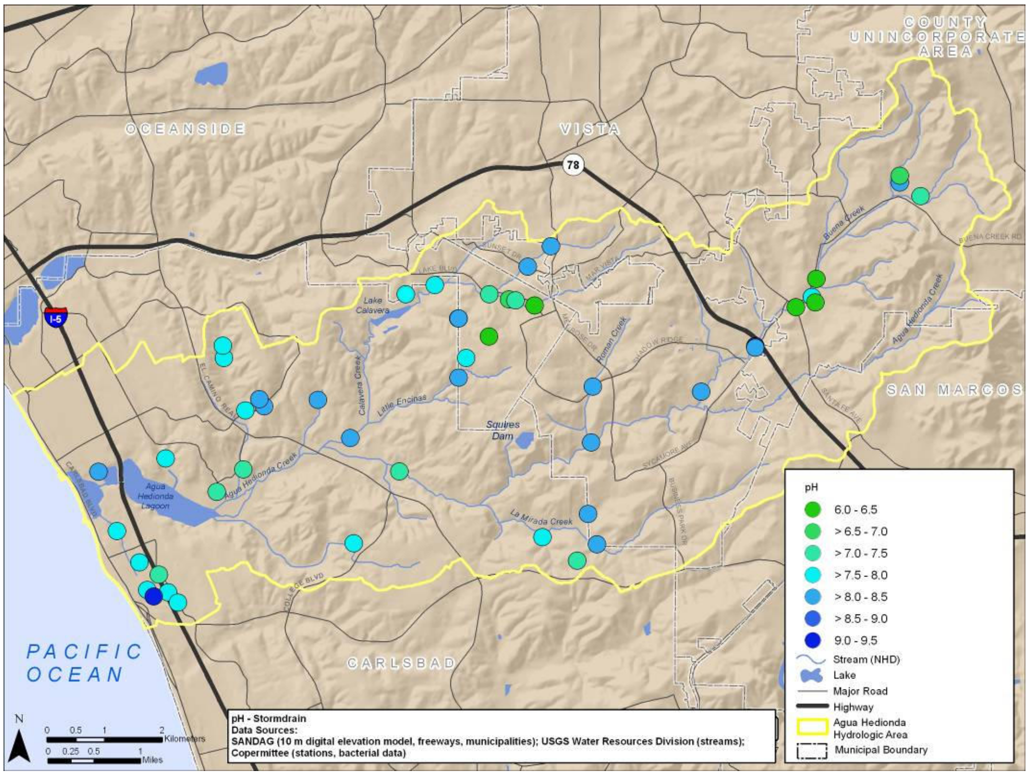

Figure 21. Distribution of pH Measurement Collected as Part of the Co-permittee Dry Weather Storm Drain Monitoring

Turbidity

Turbidity is a measure of light scattering in water or "cloudiness" and is most often a result of suspended fine sediment. It normally increases after heavy rains, as runoff transports increased sediment loads into streams. These increased turbidity levels can harm aquatic life by limiting light penetration.

The Basin Plan lists the water quality objectives for turbidity as not to exceed 20 NTU in inland surface waters. The majority of wet weather samples surpassed this standard and the five samples that did meet this goal were collected prior to 2003 (Figure 22). Wet weather turbidity measured the highest (157 mean) and with the greatest range (6.4 – 825.0) (Table 15).

Twenty-three of the 140 storm drain measurements taken during dry weather (or 16 percent) exceeded the WQO. Similar to the effects of heavy rainfall, these high levels result from increased runoff transporting sediments into the storm drains.

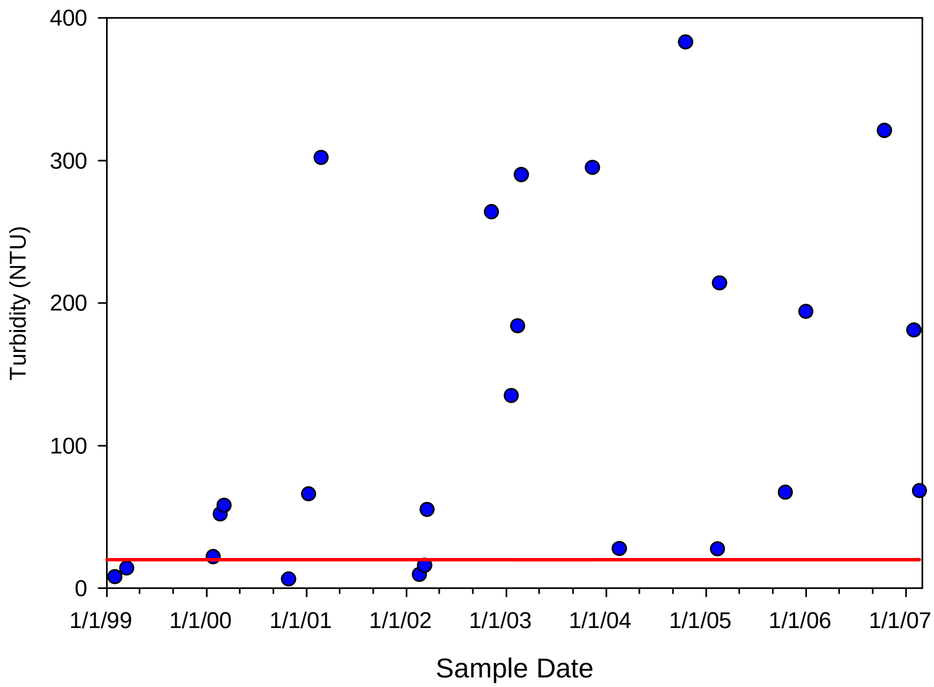

Figure 22. Turbidity Measurements Taken at the Co-permittee Wet Weather Site Between 1999 and 2007 (Line Represents WQO of 20 NTU)

Table 15. Turbidity Measurements (in NTU) Taken at Wet Weather, Ambient, and Storm Drain Sites

Data Type	Minimum	Mean	Maximum	Count
Wet Weather	6.40	157.14	825.00	26
Ambient	0.01	6.79	43.00	39
Storm Drain	0.00	13.03	308.00	140

Total Suspended Solids

Total suspended solids (TSS) can include both organic and inorganic materials including sediments, decaying plant and animal matter, industrial waste, and sewage. Sediment can increase turbidity, clog fish gills, reduce spawning habitat, lower young aquatic organism survival rates, smother bottom-dwelling organisms, and suppress aquatic vegetation growth.

TSS data were only available for the Co-permittee wet weather sample station. Figure 23 presents TSS measurements at this site between 1999 and 2007. Though there is no ambient water quality standard for TSS, 100 mg/L is used as a benchmark (USEPA Multi-Sector General Permit for Industrial Activities). Only seven samples were lower than this benchmark. After 2003 all samples exceeded the benchmark.

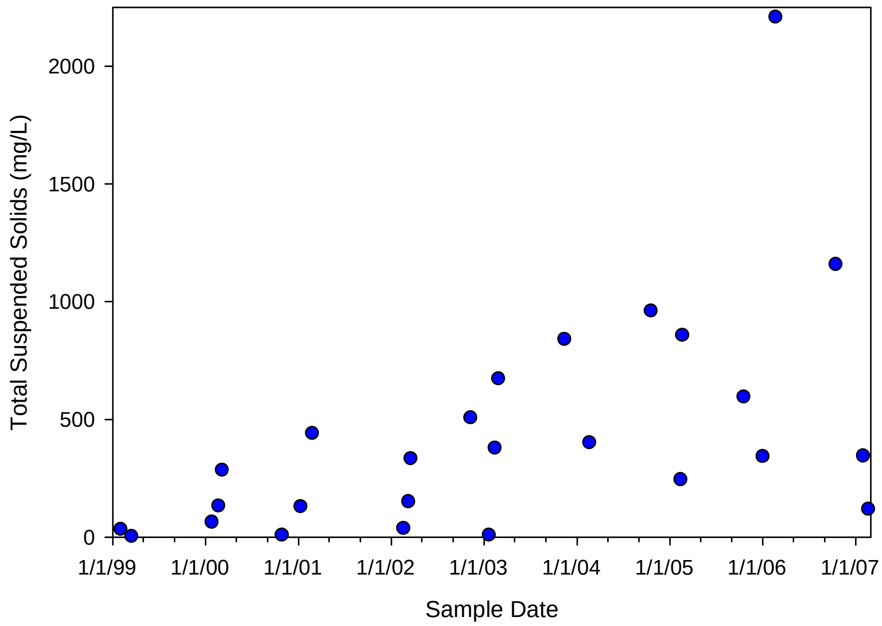

Figure 23. Total Suspended Solids at the Co-permittee Wet Weather Site between 1998 and 2007

Salinity and Total Dissolved Solids

Salinity is a measure of dissolved mineral constituents. Increased salinity can adversely impact aquatic and wildlife habitat and the usability of water for municipal and irrigation supply. Dry weather ambient salinity averaged 0.10 parts per thousand (ppt), while storm drain samples had an average salinity of 0.19 percent. Figure 24 presents the distribution of salinity concentrations throughout the watershed. The central portion of the watershed along the northern boundary represent areas of elevated salinity. In California, elevated salinity often occurs as a result of native geology.

Agua Hedionda Creek was been 303(d) listed for total dissolved solids (TDS) impairment in 2006. TDS is a measure of inorganic salts and small amounts of organic matter present in solution in water. This principally includes calcium, magnesium, sodium, and potassium cations and carbonate, hydrogencarbonate, chloride, sulfate, and nitrate anions along with dissolved organics. Because TDS and salinity measures similar constituents, they are closely related.

According to the Basin Plan, the water quality objective for TDS is 500 mg/L based on beneficial use for municipal and domestic water supply. Nineteen of the 26 wet weather TDS data collected between 1999 and 2007 (or 73 percent) have exceeded this objective (Figure 25). The figure suggests a decrease in TDS concentrations over this time period.

Composition of TDS has not been analyzed in these samples. However, it is not unusual for coastal streams in southern California to exhibit elevated TDS due to mineral soils and geology.

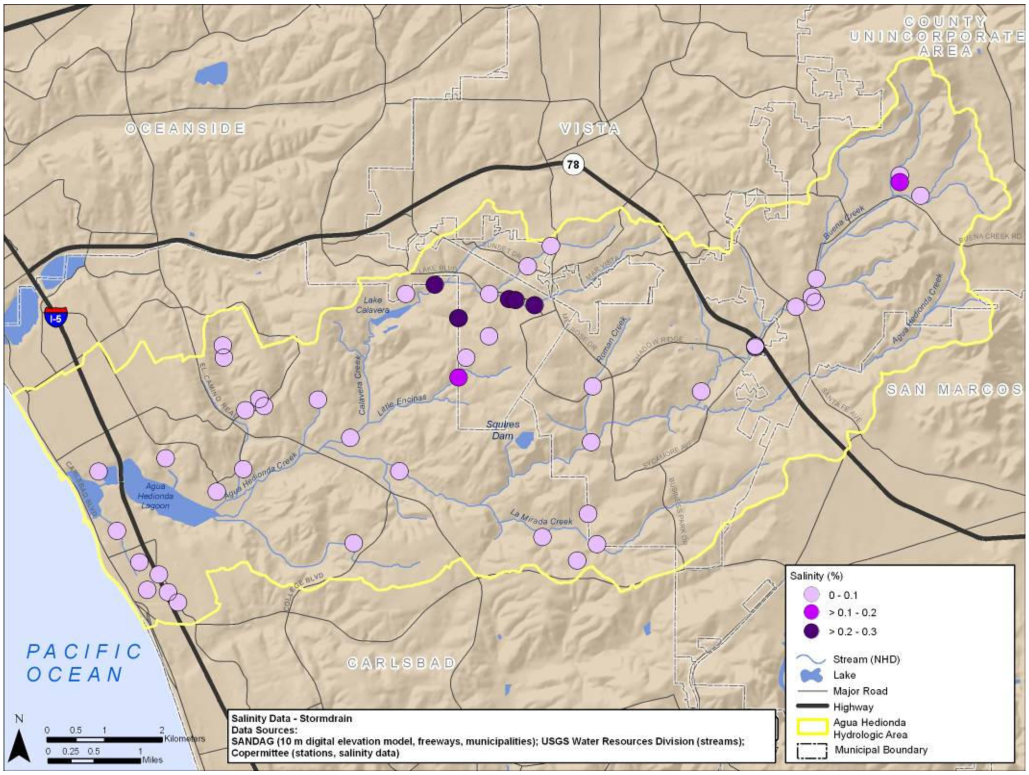

Figure 24. Distribution of Salinity Measurements (ppt) Collected As Part of the Co-permittee Dry Weather Storm Drain Monitoring

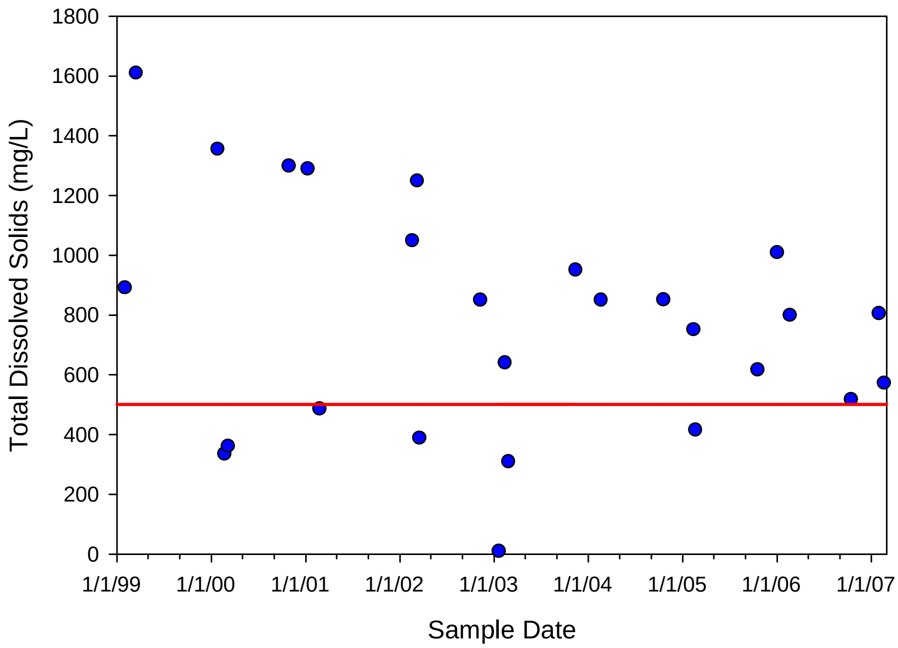

Figure 25. Total Dissolved Solids at the Co-permittee Wet Weather Site (1998-2007) (Line Represents WQO)

Nutrients

Elevated concentrations of nutrients may promote algal blooms and overgrowth of emergent and sub-emergent vegetation, which in turn may cause daily swings in dissolved oxygen (DO) and pH that can harm other aquatic life. Excess plant growth may reduce dissolved oxygen in the water, either on a diurnal basis as a result of night-time algal respiration or on an episodic basis as a result of algal death. Un-ionized ammonia, and perhaps nitrate and nitrite, may also cause direct toxic effects on aquatic life.

Phosphorus, because of its tendency to sorb to soil particles and organic matter, is primarily transported in surface runoff with eroded sediments. Inorganic nitrogen, on the other hand, does not sorb as strongly and can be transported in both particulate and dissolved phases in surface runoff. Dissolved inorganic nitrogen also can be transported through the unsaturated zone (interflow) and ground water. Further, both phosphorus and nitrogen can enter natural waters by both dry fallout and rainfall.

The Basin Plan specifies nitrogen related WQO for un-ionized ammonia (25µg/L), nitrate (10 mg/L), and nitrite (1 mg/L); however, these general criteria were developed for protection of human health and aquatic from direct toxicity and were not developed to control excess algal/plant growth. Wet weather data did not exceed WQO for any of these parameters. Wet weather total nitrogen values were calculated using TKN, nitrate as N, and nitrite as N (Table 16). Figure 26 presents the total nitrogen data. There is some indication of an increasing trend in total nitrogen over these sampling events. This is primarily a result of particularly high samples collected between 2003 and 2005.

Table 16. Wet Weather Nitrogen Summary Statistics

Parameter	Units	WQO	Min	Mean	Max	Count	DL	ND
Ammonia As Nitrogen	mg/L	NA	0.05	0.38	0.91	27	0.1	3
Un-ionized Ammonia as N	µg/L	25 (a)	0.21	5.31	17.34	15	-	0
Nitrate As N	mg/L	10	0.03	1.48	3.20	27	0.05	2
Nitrite As N	mg/L	1	0.03	0.03	0.09	27	0.05	26
Total Kjeldahl Nitrogen	mg/L	NA	0.44	3.58	14.10	26	-	0

(a) Un-ionized Ammonia is a calculated value, non-detectable values calculated at the detection limit. Basin Plan WQO is 0.025 mg/L; values shown here have been converted to µg/L.

Buena Creek is listed on the 2006 303(d) list for nitrate and nitrite. Dry weather samples were high in nitrate. At CAR05 (Figure 20), the mean for 10 samples was almost 12 mg/L.

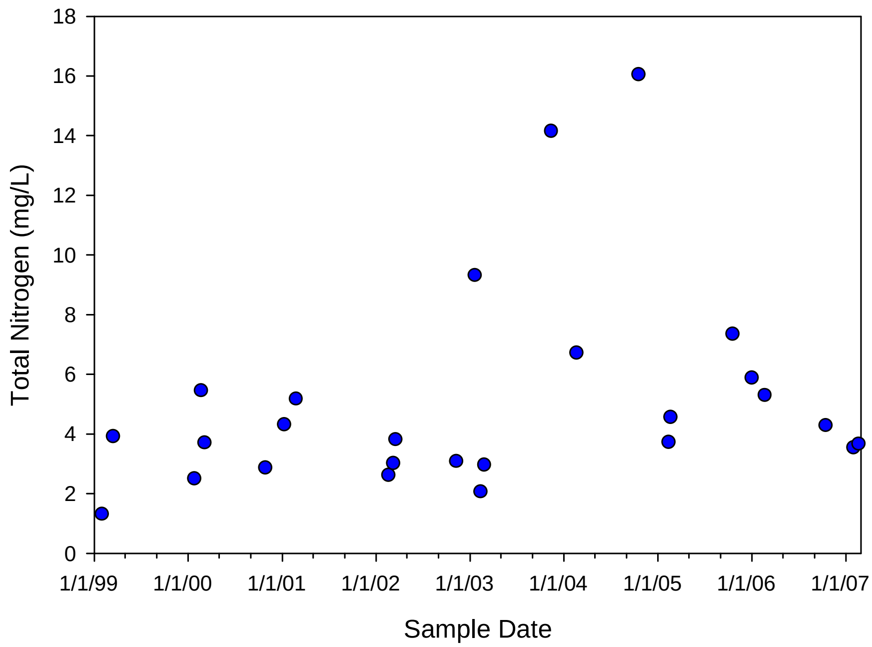

Figure 26. Total Nitrogen Data Collected at the Co-permittee Wet Weather Site (1999-2007)

Phosphorus is often (though not always) the controlling nutrient for algal growth in freshwater systems. The Basin Plan lists the total phosphorus WQO as 0.1 mg/L. The wet weather mean was several times the WQO (Table 17). All wet weather and 50 percent of storm drain phosphorus measurements exceeded this standard (Figure 27).

Table 17. Wet Weather Phosphorus Summary Statistics

Parameter	Units	WQO	Min	Mean	Max	Count	DL	ND
Total Phosphorus	mg/L	0.1	0.11	0.67	2.28	27	-	0
Dissolved Phosphorus	mg/L	NA	0.03	0.29	1.10	27	0.05-0.1	2

Buena Creek was 303(d) listed for phosphorus impairment in 2006. Ambient dry weather phosphate data were available for this watershed. The orthophosphate data averaged 0.16 mg/L.

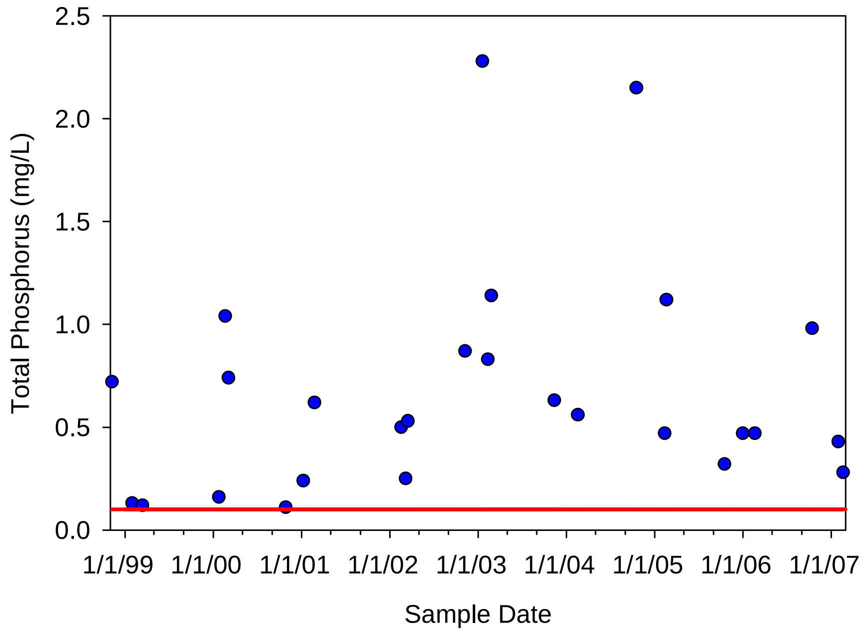

Figure 27. Total Phosphorus Data from the Co-permittee Wet Weather Site Collected Between 1998 and 2007 (Line Represents WQO 0.1 mg/L)

3.3.3 Metals

Although metals occur naturally in the environment, human activity may alter their distribution. Metals can be a significant source of toxicity to aquatic life. Metals criteria vary with hardness, thus each individual sample may have a different concentration objective. The significance of metals can be screened by converting to toxicity units (TU) – the ratio of concentration to the criterion calculated at ambient hardness. A TU > 1 indicates a potential risk of adverse impacts on aquatic life.

Metals criteria are expressed in terms of the dissolved metal concentration as this is the bioactive fraction. However, the rules also provide default equations for converting between dissolved and total recoverable fractions. Both total and dissolved metals (wet weather data) have been converted to toxic units using the California Toxics Rule standards (USEPA Federal Register Doc. 40 CFR Part 131, May 18, 2000). We evaluated metals relative to both acute and chronic aquatic life criteria. Toxicity is a function of the dissolved constituent. The analysis shows that only copper, lead, and zinc may present potential threats to aquatic life (Table 18). However, none exceed 1 TU for the measured dissolved fraction under the acute criteria. Thus, there is little evidence to suggest that ambient metal concentrations present a major risk to aquatic life in the Agua Hedionda Watershed.

Table 18. Criteria Exceedances for Co-Permittee Wet Weather Metals

	Total Metals (Acute Criteria)	Total Metals (Chronic Criteria)	Dissolved Metals (Acute Criteria)	Dissolved Metals (Chronic Criteria)
Arsenic	0.00%	0.00%	0.00%	0.00%
Cadmium	0.00%	0.00%	0.00%	0.00%
Copper	16.70%	34.10%	0.00%	2.70%
Lead	0.00%	8.20%	0.00%	0.00%
Nickel	0.00%	0.00%	0.00%	0.00%
Zinc	0.20%	0.20%	0.00%	0.00%
Chromium	0.00%	0.00%	0.00%	0.00%

Note: table compares metals data with criteria, both in toxicity units

3.3.4 Bacteria

Table 19 through Table 21 provide wet weather, ambient dry weather, and storm drain summary statistics for indicator bacteria. High bacterial concentrations usually result from the presence of animal or human fecal wastes, and may impair aquatic habitat, threaten human health, and promote undesirable organism growth. Total coliform measures include both fecal and non-fecal coliform concentrations. The presence of fecal bacteria, in particular, is an indicator of pollution. Therefore, separate fecal coliform measurements are also reported.

Table 19. Total Coliform (MPN/100ml) Summary Statistics for Wet Weather, Ambient, and Storm Drain Data

Data Type	Min	Mean	Max	Count [1]	DL	ND
Wet Weather	300	58,416	300,000	27	-	0
Ambient Dry Weather	50	64,971	3,000,000	56	-	0
Storm Drain	20	155,156	1,600,000	67	-	0

1 Refers to number of samples.

Table 20. Fecal Coliform (MPN/100ml) Summary Statistics for Wet Weather, Ambient, and Storm Drain Data.

Data Type	Min	Mean	Max	Count [1]	DL	ND
Wet Weather	1	9,787	50,000	27	2	1
Ambient Dry Weather	4	3,502	80,000	56	-	0
Storm Drain	20	22,115	300,000	66	-	0

1 Refers to number of samples.

Total coliform concentrations were lowest in the wet weather measurements. However, fecal coliform concentrations were lowest in the ambient dry weather samples. Total and fecal coliform concentrations were highest in storm drain samples.

Table 21. Enterococcus (MPN/100ml) Summary Statistics for Wet Weather, Ambient, and Storm Drain Data.

Data Type	Min	Mean	Max	Count [1]	DL	ND
Wet Weather	3,000	56,238	500,000	21	-	0
Ambient Dry Weather	0	463	5,000	54	10-20	5
Storm Drain	10	9,545	160,000	68	-	0

1 Refers to number of samples.

In waters designated for contact recreation (REC-1), the fecal coliform concentration based on a minimum of not less than five samples for any 30-day period, shall not exceed a log mean of 200 MPN/100 ml, nor shall more than 10 percent of total samples during any 30-day period exceed 400 MPN/100 ml (SDRWQCB, 2006). The fecal coliform WQO used for comparison of individual samples is 400 MPN/100 ml. The Basin Plan cites USEPA criteria for enterococci WQOs. For waters designated for contact recreation, the freshwater maximum for infrequently used areas is 151 MPN/100 ml.

Figure 28 presents wet and dry weather fecal coliform measurements collected at the Co-permittee wet weather site. Both ambient dry weather samples were below 400 MPN/100 ml, while only two of the wet weather samples met this objective. All wet weather samples collected after 2001 exceeded this value. Figure 29 presents enterococcus data collected from the Agua Hedionda Creek and El Camino Real station between 2000 and 2007. Wet weather samples were consistently greater than those collected in dry weather. The data suggest an increasing bacteria trend in wet weather data.

Figure 30 presents the spatial distribution of fecal coliform concentrations collected as part of the ambient dry weather sampling efforts. The highest mean concentration occurs in Agua Hedionda Creek, just upstream of its confluence with Buena Creek and adjacent to commercial and industrial parcels. The next highest mean fecal coliform concentrations were located in Buena Creek adjacent to single family residential and industrial lands, and in Agua Hedionda Creek downstream of large residential and industrial areas. Enterococcus data exhibited similar patterns.

Figure 31 presents the spatial distribution of dry weather storm drain enterococcus data. Storm drain concentrations were greatest at two stations near the lagoon, several stations in the upper portions of Calavera Creek, and in La Mirada Creek. That pattern was similar in fecal coliform data (not shown). Some of the lowest enterococcus storm drain measurements were located in the upper watershed along Buena Creek, although fecal coliform data (not shown) were high at some stations just above Hwy 78.

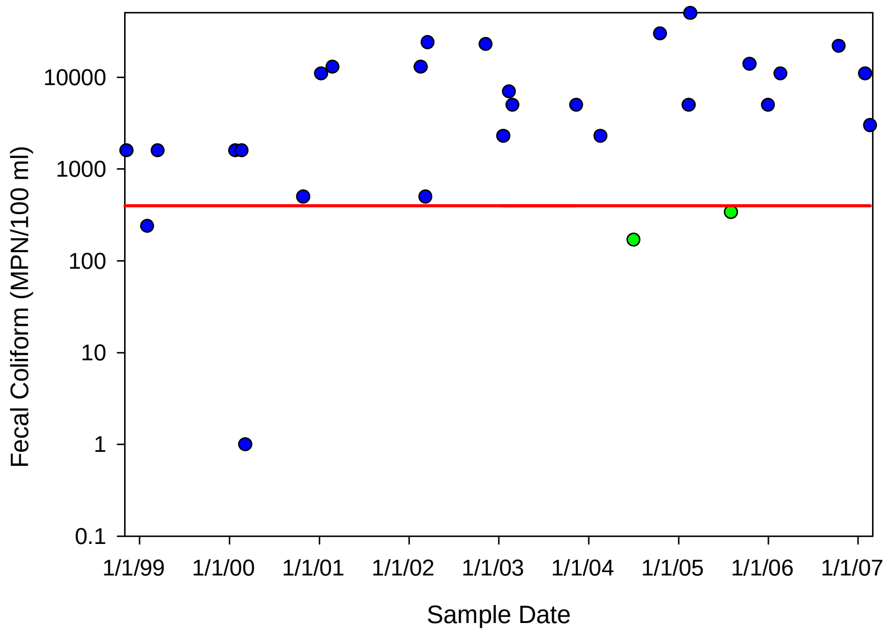

Figure 28. Fecal Coliform Wet (Dark Blue) and Dry (Light Green) Data Collected from Agua Hedionda Creek at the Co-permittee Wet Weather Site (Line Represents WQO)

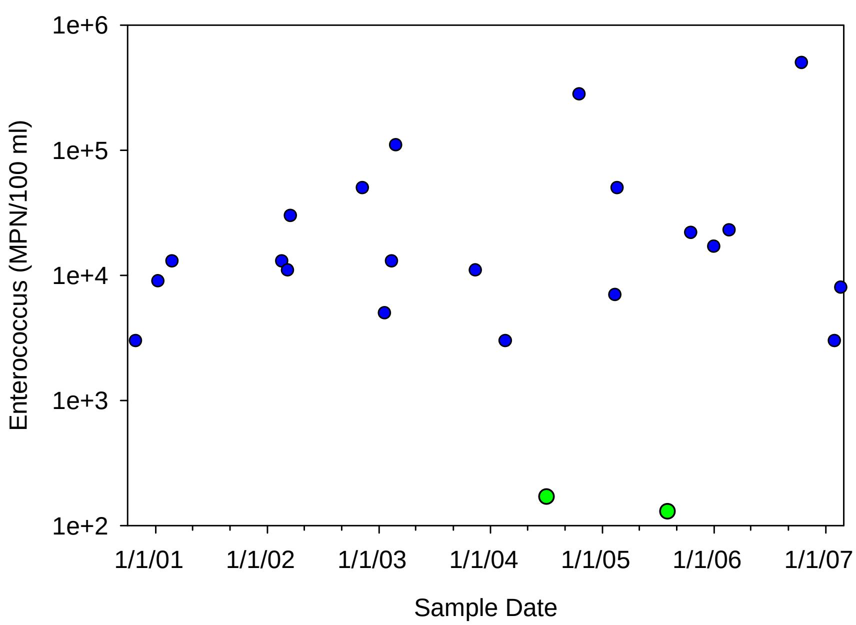

Figure 29. Enterococcus Wet (Dark Blue) and Dry (Light Green) Data Collected from the Agua Hedionda Creek at the Co-permittee Wet Weather Site

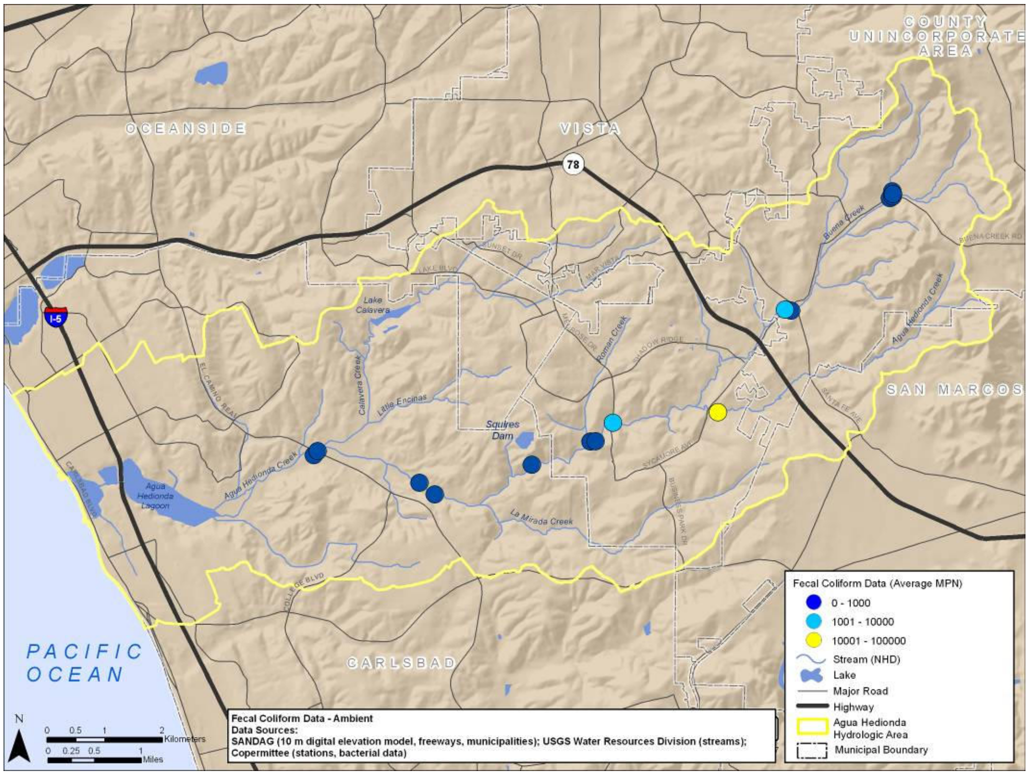

Figure 30. Fecal Coliform Spatial Distribution of Ambient Dry Weather Data (Co-permittee/SELC)

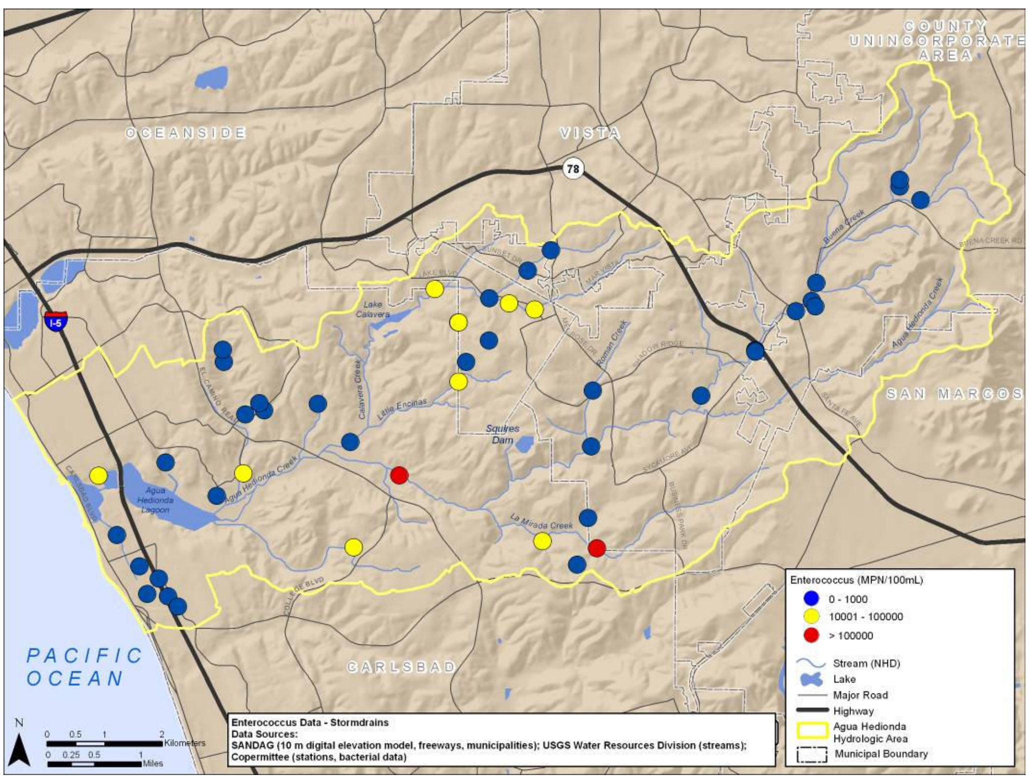

Figure 31. Enterococcus Spatial Distribution of Co-permittee Dry Weather Storm Drain Data (mean values)

3.3.5 Pesticides

Pesticides are synthetic chemicals that are developed to control insect and plants. After application, pesticides can disperse into the environment and contaminate surface and groundwaters. Pesticides are of particular concern because some can persist in an aquatic ecosystem for years and bioaccumulate in aquatic food chains.

Summaries of wet weather, ambient, and storm drain chlorpyrifos, diazinon, and malathion data are provided in Table 22-Table 24. Many of these data were non-detect. However, all three datasets experienced exceedances of these pesticides in comparison to WQOs developed by the California Department of Fish and Game (Table 25). Only the ambient dry and storm drain dry data for malathion did not exceed this WQO in any of its samples. Storm drain samples had the greatest concentrations of all three pesticides. A large number of chlorpyrifos and diazinon samples had detection limits that were greater than the WQOs.

Table 22. Co-permittee Wet Weather Pesticide Summary Statistics

Parameter	Units	WQO	Min[1]	Mean	Max	Count	DL	ND
Chlorpyrifos	µg/L	0.02	0.001	0.019	0.121	26	0.002-0.5	24
Diazinon	µg/L	0.08	0.002	0.185	0.464	27	0.004-0.5	9
Malathion	µg/L	0.43	0.005	0.191	0.622	15	0.01	2

[1]minimum levels represent half the lowest detection limit

Table 23. Ambient Dry Weather Pesticide Summary Statistics

Parameter	Units	WQO	Min[1]	Mean	Max	Count	DL	ND
Chlorpyrifos	µg/L	0.02	0.025	0.055	0.500	27	0.05-1	18
Diazinon	µg/L	0.08	0.010	0.053	0.500	27	0.02-1	17
Malathion	µg/L	0.43	0.025	0.027	0.050	15	0.05	15

[1]minimum levels represent half the lowest detection limit

Table 24. Storm Drain Dry Weather Pesticide Summary Statistics

Parameter	Units	WQO	Min[1]	Mean	Max	Count	DL	ND
Chlorpyrifos	µg/L	0.02	0.025	0.124	1.500	57	0.05-3	39
Diazinon	µg/L	0.08	0.025	0.179	3.000	57	0.05-6	40
Malathion	µg/L	0.43	0.020	0.047	0.330	15	0.04-0.05	13

[1]minimum levels represent half the lowest detection limit

Buena Creek has been added to the 303(d) list for DDT. Of the dataset reviewed for this report, only the SWAMP dataset provided DDT data, which was collected in 2002. DDT was detected in half of the samples. However, the SWAMP dataset did have one aquatic life exceedance for the pesticide Endrin.

3.3.6 Toxicity

Meeting specified criteria for individual chemicals does not guarantee an absence of risks. Multiple chemicals may interact, and unmonitored chemicals (such as polyaromatic hydrocarbons or PAHs) can significantly impact biota. Toxicity tests using well-studied organisms can be used to evaluate the toxicity of a water or sediment sample directly.

Co-permittee Data

Toxicity data have been collected at the mass loading station on Agua Hedionda Creek from 2001 through 2006. While evidence to suggest toxicity was present, there was no evidence of persistent toxicity (Table 25). Persistent toxicity occurs when more than 50 percent of tests have a No Observed Effect Concentration (NOEC) or NOEC of less than 100 percent of the ambient concentration as evaluated through a dilution series.

Table 25. Co-permittee Wet Weather Toxicity Summary Statistics

Parameter	Units	WQO (%)	Percent Below WQO
Ceriodaphnia 96-hr	LC50 (%)	100	7
Ceriodaphnia 7-day Survival	NOEC (%)	100	20
Ceriodaphnia 7-day Reproduction	NOEC (%)	100	13
Hyalella 96-hr	NOEC (%)	100	47
Selenastrum 96-hr	NOEC (%)	100	0

SWAMP Data

SCCWRP (2007) conducted toxicity tests at one site on Agua Hedionda Creek and at one site on Buena Creek under the SWAMP program between 2002 and 2003 (Mazor and Schiff, 2007). Water toxicity was evaluated with 7-day exposures on the water flea, *Ceriodaphnia dubia*, and 96-hour exposures to the alga *Selenastrum capricornutum*. Sediment toxicity was evaluated with 10-day exposures on the amphipod *Hyallela azteca*. Tests showed no toxicity using the *Ceriodaphnia*. Tests using *Selenastrum* and *Hyallela* indicated toxicity 100 percent and 25 percent of the time, respectively.

Buena Creek is on the 303(d) list of impaired waterbodies, which identifies DDT, nitrate and nitrite, and phosphate as known stressors. Although several endpoints indicated toxicity, one sampling date (April 23, 2002) accounted for 75 percent of the toxic hits at this site. Half the sampling dates were not toxic to any endpoint, suggesting that toxicity was not persistent.

3.3.7 Benthic Macroinvertebrates

The Agua Hedionda Lagoon Foundation (AHLF) (2007) sponsored macroinvertebrate bioassessment of the Agua Hedionda Creek at sites located below South Melrose on the border of the cities of Vista and Carlsbad, in the Dawson Reserve located in the city of Vista and through Sunny Creek segment of the creek, and at the wet-weather station near El Camino Real. The protocols for sampling were those specified in the California Department of Fish and Game’s, California Stream Bioassesssment Procedure.

The AHLF compared data collected to assessments by the San Diego County Municipal Co-permittees Urban Runoff Monitoring Program and the San Elijo Lagoon Conservancy. Index of Biotic Integrity

(IBI) scores for these surveys are presented in Table 26. The IBI scores from all three efforts are considered Poor to Very Poor.

Table 26. Index of Biotic Integrity Scores for Agua Hedionda Monitoring Sites (table taken from AHLF report)

Program	Site ID	2001		2002		2003		2004		2005		2006
		Spring	Fall	Spring	Fall	Spring	Fall	Spring	Fall	Spring	Fall	Spring
AHLF	AH2		14			3						
	AH3					8						
	AH4			10,8*	7	12						
SELC	AHS01									11	16	15
	AHS02									11	14	9
	AHD01									6	11	3
	AHD02									7	3	6
SD County	AHC-ECR	12	13	3	9	12	21	2	10	12		
	AHC-MR	5	13	2	20	12	12	4	13	5		

*AH4 was sampled in January and June, 2002

3.4 SUMMARY OF WATER QUALITY DATA

The data review suggests that sediment (TSS and turbidity) and bacteria (coliforms and enteroccocus) are the greatest threats to watershed function in the Agua Hedionda watershed. Concentrations of these constituents exceed water quality objectives the majority of the time. Moreover, reports of significant upward trends in TSS, turbidity, and fecal coliform at the wet weather monitoring station suggest the problem is getting worse (Weston, 2007a). Turbidity was higher in the receiving water samples, an expected pattern based on the storm-driven nature of this parameter. Impairment from bacteria is, however, both a dry and wet weather problem in the watershed.

While the lack of wet weather sites inhibits the evaluation of spatial patterns, samples collected as part of the dry weather monitoring (storm drains and instream) show particularly high bacteria levels in La Mirada Creek, which drains commercial development, as well as Calavera Creek upstream of Lake Calavera. High salinity (a parameter closely related to TDS) is also found along Calavera Creek in areas draining residential development, suggesting an anthropogenic source though groundwater is likely the chief contributor to TDS levels throughout the watershed.

While nitrogen does not appear to be a significant threat in most of the watershed, the impairment of Buena Creek combined with the significant upward trend of nitrate (Weston, 2007a) suggest that it could become a problem in the future in the watershed. Phosphorus levels in the watershed are a concern: concentrations exceed the Basin Plan WQO and Buena Creek is 303(d)-listed for phosphate.

There is some evidence to suggest that pesticides are a threat in the watershed; however, toxicity tests have not borne out a persistent impact on the biological community. In addition, Weston (2007a) observed that the number of pesticide exceedances have decreased since 2002. There is also little indication that metals present a significant problem for aquatic life in the watershed based on an evaluation of metals toxicity.

Given the lack of evidence for widespread and severe toxicity in the watershed, the poor biological community as seen in biotic integrity indices can likely be attributed to habitat degradation from scour during storms and sediment transport from both upland and instream sources.

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4 Future Monitoring Recommendations

Monitoring has been conducted by multiple organizations in the Agua Hedionda Watershed. Each have their own objectives. The Co-permittees have monitoring requirements for their Municipal NPDES Permit to evaluate program effectiveness. Monitoring to support source assessments and linkage analyses for TMDL development for sediment (TSS and turbidity) and bacterial constituents are ongoing. Progress in meeting the TMDL objectives and to address the remaining impairments will require monitoring in the future in the lagoon and its tributaries. To the extent feasible, monitoring plans should be coordinated to address current as well as anticipated multiple future objectives of the Co-permittees in the Agua Hedionda Watershed and the SDRWQCB.

Given the need to address existing impairments, meet permit requirements, and address other water resource concerns, a comprehensive, watershed-based implementation framework should guide future monitoring efforts. Therefore, the final WMP developed for the Agua Hedionda Watershed will be critical. The goals, objectives, and selected indicators of the final plan should drive future monitoring in the watershed. A comprehensive implementation framework incorporating all of these concerns would result in more efficient and effective management of water resources and increase public support, thereby improving the likelihood of more-successful and rapid overall restoration of beneficial uses.

Many of the sources of the existing and multiple impairments are likely shared. For example, urban stormwater MS4 runoff associated with urban-based activities is a significant source of pollutants in the watershed. Where non-MS4 sources may ultimately also be found to be significant, non-municipal partners can be drawn into the solution development process.

Since stormwater and urban runoff are recognized as a significant contributor to impairments and since both sampling design and sample collection (especially for wet weather) are challenging and labor-intensive activities, efforts to monitor and manage these flows should consider all pollutants of concern. Wet weather monitoring should be extended to additional sites within the watershed to better understand sources and areas requiring treatment. Furthermore, additional monitoring in the lagoon should be conducted.

A more specific monitoring plan should be developed in conjunction with the completion of the WMP and consistent with the final WMP goals and objectives.

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Appendix A. Physicochemical Data

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Table A-1. Ambient Dry Weather Water Chemistry Summary Statistics

Sample Location		Conductivity	Dissolved Oxygen	Electrical Connectivity	MBAS	Oil & Grease	Salinity	Temp	Turbidity	pH
	Units	µS/cm	mg/L	mS/cm	mg/L	mg/L	%	℃	NTU	
	DL	-	-	-	0.05-0.5	1-5	-	-	-	-
	Min	1,667.0			0.3	2.5		16.0	3.1	7.3
	Mean	3,703.4			0.3	5.8		19.7	13.2	7.9
	Max	5,310.0			0.5	11.0		22.7	26.0	8.4
	Count	5.0	0.0	0.0	7.0	5.0	0.0	3.0	5.0	5.0
AC-1	ND	0.0	0.0	0.0	2.0	1.0	0.0	0.0	0.0	0.0
	Min	1,760.0			0.3	0.5		18.4	0.0	7.6
	Mean	1,960.5			0.3	2.0		20.1	1.3	8.0
	Max	2,300.0			0.5	2.5		21.7	2.0	8.5
	Count	4.0	0.0	0.0	5.0	4.0	0.0	2.0	4.0	4.0
AC-2	ND	0.0	0.0	0.0	1.0	2.0	0.0	0.0	0.0	0.0
	Min	2,510.0			0.3	0.5			1.9	8.2
	Mean	2,605.0			0.3	1.5			1.9	8.3
	Max	2,700.0			0.3	2.5			1.9	8.3
	Count	2.0	0.0	0.0	2.0	2.0	0.0	0.0	2.0	2.0
AH Creek-1_2	ND	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Min	1,790.0			0.3	0.5		18.1	0.4	7.6
	Mean	2,126.3			0.3	2.7		19.6	9.6	8.1
	Max	2,630.0			0.5	5.4		21.0	43.0	8.4
	Count	6.0	0.0	0.0	9.0	6.0	0.0	4.0	6.0	6.0
AH-10	ND	0.0	0.0	0.0	3.0	3.0	0.0	0.0	0.0	0.0

Sample Location		Conductivity	Dissolved Oxygen	Electrical Connectivity	MBAS	Oil & Grease	Salinity	Temp	Turbidity	pH
	Units	**µS/cm**	**mg/L**	**mS/cm**	**mg/L**	**mg/L**	**%**	**°C**	**NTU**	
	DL	**-**	**-**	**-**	**0.05-0.5**	**1-5**	**-**	**-**	**-**	**-**
	Min	1,300.0	6.2	2.1	0.0	0.5	0.1	13.5	2.0	7.9
	Mean	1,953.8	7.9	2.1	0.1	2.1	0.1	20.0	8.4	8.1
	Max	2,160.0	9.6	2.1	0.3	5.0	0.1	22.4	17.0	8.3
	Count	8.0	3.0	3.0	4.0	4.0	3.0	8.0	10.0	11.0
CAR05	ND	0.0	0.0	0.0	1.0	2.0	0.0	0.0	0.0	0.0
	Min		7.3	2.3			0.1	14.7	1.0	7.4
	Mean		7.3	2.3			0.1	14.7	1.0	7.4
	Max		7.3	2.3			0.1	14.7	1.0	7.4
	Count	0.0	1.0	1.0	0.0	0.0	1.0	1.0	1.0	1.0
CAR05 C 03	ND	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Min			2.3			0.1	19.0	1.0	7.2
	Mean			2.3			0.1	19.0	1.0	7.2
	Max			2.3			0.1	19.0	1.0	7.2
	Count	0.0	0.0	1.0	0.0	0.0	1.0	1.0	1.0	1.0
CAR05 Q	ND	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Min			2.3			0.1	20.1	5.0	7.4
	Mean			2.3			0.1	20.1	5.0	7.4
	Max			2.3			0.1	20.1	5.0	7.4
	Count	0.0	0.0	1.0	0.0	0.0	1.0	1.0	1.0	1.0
CAR05 R	ND	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Sample Location		Conductivity	Dissolved Oxygen	Electrical Connectivity	MBAS	Oil & Grease	Salinity	Temp	Turbidity	pH
	Units	µS/cm	mg/L	mS/cm	mg/L	mg/L	%	℃	NTU	
	DL	-	-	-	0.05-0.5	1-5	-	-	-	-
	Min			2.2			0.1	22.0	21.0	7.0
	Mean			2.2			0.1	22.0	21.0	7.0
	Max			2.2			0.1	22.0	21.0	7.0
	Count	0.0	0.0	1.0	0.0	0.0	1.0	1.0	1.0	1.0
CAR05 S	ND	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Min	1,627						15.41	0.54	6.59
	Mean	1,839						17.71	1.88	7.5575
	Max	1,961						19.19	3.5	8.15
	Count	4						4	3	4
904CBBUR1	ND	0						0	0	0
	Min	2,707						14.44	0.24	7.52
	Mean	2,822.75						17.3375	0.79	7.8125
	Max	3,008						20.65	1.4	8.15
	Count	4						4	4	4
904CBAQH6	ND	0						0	0	0
	Min	1,541.33	4.86					10.00		7.43
	Mean	2,051.38	7.94					16.76		7.65
	Max	2,257.00	9.22					20.60		8.17
	Count	8.00	8.00					8.00		7.00
AHD02	ND	0	0					0		0

Sample Location		Conductivity	Dissolved Oxygen	Electrical Connectivity	MBAS	Oil & Grease	Salinity	Temp	Turbidity	pH
	Units	**µS/cm**	**mg/L**	**mS/cm**	**mg/L**	**mg/L**	**%**	**°C**	**NTU**	
	DL	**-**	**-**	**-**	**0.05-0.5**	**1-5**	**-**	**-**	**-**	**-**
	Min	1,408.33	5.12					9.40		7.80
	Mean	1,971.83	8.51					15.90		7.96
	Max	2,139.67	9.92					19.37		8.20
	Count	8.00	8.00					8.00		7.00
AHD01	ND	0	0					0		0
	Min	1,980.67	8.22					9.60		7.87
	Mean	2,521.33	9.64					15.74		8.15
	Max	2,751.67	11.26					19.60		8.60
	Count	8.00	8.00					8.00		8.00
AHS01	ND	0	0					0		0
	Min	1,126.33	7.52					9.70		7.77
	Mean	2,394.58	9.43					16.48		8.15
	Max	2,726.00	10.68					20.70		8.50
	Count	8.00	8.00					8.00		8.00
AHS02	ND	0	0					0		0
	Min	1,946	9.7					21		7.7
	Mean	1,946	9.7					21		7.7
	Max	19,46	9.7					21		7.7
	Count	1	1					1		1
AH2	ND	0	0					0		0

Sample Location		Conductivity	Dissolved Oxygen	Electrical Connectivity	MBAS	Oil & Grease	Salinity	Temp	Turbidity	pH
	Units	**µS/cm**	**mg/L**	**mS/cm**	**mg/L**	**mg/L**	**%**	**°C**	**NTU**	
	DL	**-**	**-**	**-**	**0.05-0.5**	**1-5**	**-**	**-**	**-**	**-**
	Min	1,933	8					18.5		7.7
	Mean	1,933	8					19.25		7.8
	Max	1,933	8					20		7.9
	Count	1	1					2		2
AH3	ND	0	0					0		0
	Min	848	7					13.1		8
	Mean	12,41.5	8.5					15.45		8.05
	Max	1,635	9.5					17.8		8.1
	Count	2	3					2		2
AH4	ND	0	0					0		0

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Appendix B. Nutrient Data

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Table B-1. Ambient Dry Weather Nutrient Summary Statistics

Sample Location		Ammonia as N	Nitrate as N	Nitrate as NO3	Nitrite	Nitrite + Nitrate	TKN	Orthophosphate	Phosphate as P	Phosphorus
	Units	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
	DL	0.05-0.1	0.05-1.35	-	0.01	0.01	0.1-0.5	0.01-0.1	0.06	0.02-0.05
AC-1	Min	0.40	0.10					0.10		0.07
	Mean	2.75	0.52					0.25		0.07
	Max	8.00	1.00					0.40		0.07
	Count	7.00	5.00	0.00	0.00	0.00	0.00	4.00	0.00	1.00
	ND	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
AC-2	Min	0.10	0.30					0.07		
	Mean	0.20	3.26					0.41		
	Max	0.30	7.50					0.70		
	Count	5.00	5.00	0.00	0.00	0.00	0.00	5.00	0.00	0.00
	ND	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
AH Creek-1_2	Min	0.10	1.25					0.03		
	Mean	0.20	1.25					0.03		
	Max	0.30	1.25					0.03		
	Count	2.00	2.00	0.00	0.00	0.00	0.00	2.00	0.00	0.00
	ND	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
AH-10	Min	0.05	0.03					0.07		0.07
	Mean	0.19	3.25					0.32		0.11
	Max	0.30	7.50					0.60		0.16
	Count	6.00	6.00	0.00	0.00	0.00	0.00	4.00	0.00	2.00
	ND	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Sample Location		Ammonia as N	Nitrate as N	Nitrate as NO3	Nitrite	Nitrite + Nitrate	TKN	Orthophosphate	Phosphate as P	Phosphorus
	Units	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**
	DL	**0.05-0.1**	**0.05-1.35**	**-**	**0.01**	**0.01**	**0.1-0.5**	**0.01-0.1**	**0.06**	**0.02-0.05**
CAR05	Min	0.10	8.13					0.16	0.15	0.15
	Mean	0.21	11.65					0.18	0.16	0.18
	Max	0.40	16.03					0.23	0.16	0.23
	Count	10.00	10.00	0.00	0.00	0.00	0.00	3.00	3.00	4.00
	ND	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CAR05 C 03	Min	0.30	32.96						0.15	
	Mean	0.30	32.96						0.15	
	Max	0.30	32.96						0.15	
	Count	1.00	1.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00
	ND	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CAR05 Q	Min		11.74							
	Mean		11.74							
	Max		11.74							
	Count	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	ND	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CAR05 R	Min		15.58							
	Mean		15.58							
	Max		15.58							
	Count	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	ND	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Sample Location		Ammonia as N	Nitrate as N	Nitrate as NO3	Nitrite	Nitrite + Nitrate	TKN	Orthophosphate	Phosphate as P	Phosphorus
	Units	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
	DL	0.05-0.1	0.05-1.35	-	0.01	0.01	0.1-0.5	0.01-0.1	0.06	0.02-0.05
CAR05 S	Min		27.09							
	Mean		27.09							
	Max		27.09							
	Count	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	ND	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
904CBBUR1	Min	0.05				10.10	0.25	0.13		0.12
	Mean	0.13				15.38	0.55	0.15		0.15
	Max	0.38				19.40	1.44	0.17		0.18
	Count	4.00				4.00	4.00	4.00		4.00
	ND	3.00				0.00	3.00	0.00		0.00
904CBAQH6	Min	0.05				0.48	0.25	0.01		0.03
	Mean	0.07				1.09	0.32	0.03		0.07
	Max	0.13				1.36	0.52	0.05		0.14
	Count	4.00				4.00	4.00	4.00		6.00
	ND	3.00				0.00	3.00	1.00		2.00
AHD02	Min		1.38	6.11	0.01		0.10	0.08	0.15	
	Mean		4.63	22.78	0.07		0.62	0.30	0.51	
	Max		9.00	40.30	0.13		1.63	0.49	1.62	
	Count		6.00	8.00	6.00		8.00	8.00	8.00	
	ND		0.00	0.00	1.00		0.00	0.00	0.00	

Sample Location		Ammonia as N	Nitrate as N	Nitrate as NO3	Nitrite	Nitrite + Nitrate	TKN	Orthophosphate	Phosphate as P	Phosphorus
	Units	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
	DL	0.05-0.1	0.05-1.35	-	0.01	0.01	0.1-0.5	0.01-0.1	0.06	0.02-0.05
AHD01	Min		0.48	2.12	0.01		0.05	0.09	0.16	
	Mean		2.55	13.64	0.01		0.44	0.24	0.41	
	Max		5.60	32.40	0.03		0.76	0.47	1.14	
	Count		6.00	8.00	6.00		8.00	8.00	8.00	
	ND		0.00	0.00	4.00		1.00	0.00	0.00	
AHS01	Min		0.30	1.33	0.01		0.05	0.01	0.08	
	Mean		1.26	7.73	0.04		0.39	0.11	0.18	
	Max		2.50	23.80	0.19		0.73	0.24	0.43	
	Count		6.00	8.00	6.00		8.00	8.00	8.00	
	ND		0.00	0.00	5.00		2.00	1.00	0.00	
AHS02	Min		0.37	1.64	0.01		0.05	0.01	0.03	
	Mean		1.29	8.29	0.01		0.38	0.12	0.18	
	Max		2.50	27.60	0.01		0.77	0.27	0.46	
	Count		6.00	8.00	6.00		8.00	8.00	8.00	
	ND		0.00	0.00	5.00		1.00	3.00	1.00	

Appendix C. Bacterial Data

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Table C-1. Ambient Dry Weather Bacteriology Data

		Enterococcus	Fecal Coliform	Total Coliform
	Units	MPN/100 ml	MPN/100 ml	MPN/100 ml
Sample Location	DL	10-20	-	-
AC-1	Min	110	1300	50000
	Mean	2,947.25	2,7140	65,8000
	Max	5,000	80,000	300,0000
	Count	4	5	5
	ND	0	0	0
AC-2	Min	110	40	700
	Mean	173.33	116.67	1166.67
	Max	300	170	1700
	Count	3	3	3
	ND	0	0	0
AH Creek-1_2	Min	130	170	14,000
	Mean	150	255	32,000
	Max	170	340	50,000
	Count	2	2	2
	ND	0	0	0
AH-10	Min	62	170	1,600
	Mean	458.4	1,134	3,960
	Max	800	3,000	8,000
	Count	5	5	5
	ND	0	0	0
CAR05	Min	25	555	3,000
	Mean	840.63	4,472.78	16,262.78
	Max	1,300	13,000	40,005
	Count	8	9	9
	ND	0	0	0
AHD02	Min	2.00	8.00	50.00
	Mean	125.36	472.25	3,743.75
	Max	669.90	1,600.00	16,000.00
	Count	8.00	8.00	8.00
	ND	1	0	0

Sample Location		Enterococcus	Fecal Coliform	Total Coliform
	Units	**MPN/100 ml**	**MPN/100 ml**	**MPN/100 ml**
	DL	**10-20**	**-**	**-**
AHD01	Min	0.00	4.00	50.00
	Mean	114.19	459.25	4,543.75
	Max	685.50	1,700.00	16,000.00
	Count	8.00	8.00	8.00
	ND	1	0	0
AHS01	Min	5.00	13.00	500.00
	Mean	112.23	424.13	3,612.50
	Max	552.00	1,400.00	16,000.00
	Count	8.00	8.00	8.00
	ND	2	0	1
AHS02	Min	5.00	8.00	800.00
	Mean	70.84	351.00	2,237.50
	Max	298.00	1,700.00	5,000.00
	Count	8.00	8.00	8.00
	ND	0	0	1

Table C-2. Co-permittee Dry Weather Storm Drain Bacteria Summary Statistics

		Enterococcus	Fecal Coliform	Total Coliform
	Units	MPN/100 ml	MPN/100 ml	MPN/100 ml
Sample Location	DL	10-200	20-200	20-2000
	Min	10	230	3,000
	Mean	2,620.5	1,182.5	67,000
	Max	9,520	2,300	240,000
	Count	4	4	4
A002	ND	0	0	0
	Min	1,300	5,000	300,000
	Mean	55427.2	122400	600,000
	Max	160,000	300,000	1,600,000
	Count	5	5	5
A004a	ND	1	1	0
	Min	52	40	17000
	Mean	1,920.5	1,685	56,250
	Max	6,130	5,000	110,000
	Count	4	4	4
A004b	ND	0	0	0
	Min	74	110	2,800
	Mean	8,366	6202.5	128,200
	Max	30,000	22,000	240,000
	Count	4	4	4
A013	ND	0	0	0
	Min	41	5,000	23,000
	Mean	1,810.25	10,500	50,750
	Max	2,800	24,000	80,000
	Count	4	4	4
A015	ND	0	0	0
	Min	1,133	300	50,000
	Mean	2,053.25	12,325	495,000
	Max	3,080	24,000	900,000
	Count	4	4	4
A016	ND	0	0	0

		Enterococcus	Fecal Coliform	Total Coliform
	Units	**MPN/100 ml**	**MPN/100 ml**	**MPN/100 ml**
Sample Location	**DL**	**10-200**	**20-200**	**20-2000**
	Min	516	500	16,000
	Mean	516	500	16,000
	Max	516	500	16,000
	Count	1	1	1
A04C	ND	0	0	0
	Min	170	5,000	8,000
	Mean	170	5,000	8,000
	Max	170	5,000	8,000
	Count	1	1	1
AH Creek-2	ND	0	0	0
	Min	40	500	7,000
	Mean	3,968	11,360	61,600
	Max	9,000	50,000	170,000
	Count	5	5	5
AH03	ND	0	0	0
	Min	70	300	1300
	Mean	246	13,868	38,860
	Max	500	50,000	90,000
	Count	5	5	5
AH08	ND	0	0	0
	Min	80	110	800
	Mean	320	9,777.5	202,200
	Max	800	23,000	50,0000
	Count	4	4	4
AH10	ND	0	0	0
	Min	40	20	230
	Mean	16,089.5	35,764	42,926
	Max	50,000	160,000	160,000
	Count	6	5	5
AH-21	ND	0	0	0

Sample Location		Enterococcus	Fecal Coliform	Total Coliform
	Units	MPN/100 ml	MPN/100 ml	MPN/100 ml
	DL	10-200	20-200	20-2000
AH24	Min	230	70	8,000
	Mean	1,632.5	2,192.5	16,2750
	Max	5,000	5,000	500,000
	Count	4	4	4
	ND	0	0	0
AH28	Min	170		20
	Mean	170		20
	Max	170		20
	Count	1	0	1
	ND	0	0	0
AH32	Min	170	1,300	2,400
	Mean	170	1,300	2,400
	Max	170	1,300	2,400
	Count	1	1	1
	ND	0	0	0
AH45	Min	1,300	3,000	50,000
	Mean	3,400	43,250	202,500
	Max	8,000	160,000	300,000
	Count	4	4	4
	ND	0	0	0
AH46	Min	10	270	22,000
	Mean	40,282.5	41,317.5	285,500
	Max	160,000	130,000	900,000
	Count	4	4	4
	ND	1	0	0
AH59	Min	1,300	220	386
	Mean	1,300	220	386
	Max	1,300	220	386
	Count	1	1	1
	ND	0	0	0

Sample Location		Enterococcus	Fecal Coliform	Total Coliform
	Units	**MPN/100 ml**	**MPN/100 ml**	**MPN/100 ml**
	DL	**10-200**	**20-200**	**20-2000**
CAR05A	Min	300	3,000	5,000
	Mean	300	3,000	5,000
	Max	300	3,000	5,000
	Count	1	1	1
	ND	0	0	0
CAR05B	Min	340	1,400	2,800
	Mean	340	1,400	2,800
	Max	340	1,400	2,800
	Count	1	1	1
	ND	0	0	0
CAR05C	Min	270	800	1,300
	Mean	270	800	1,300
	Max	270	800	1,300
	Count	1	1	1
	ND	0	0	0
CAR05D	Min	300	3,000	7,000
	Mean	300	3,000	7,000
	Max	300	3,000	7,000
	Count	1	1	1
	ND	0	0	0
CAR05E	Min	800	13,000	24,000
	Mean	800	13,000	24,000
	Max	800	13,000	24,000
	Count	1	1	1
	ND	0	0	0
L02B	Min	388	700	11,000
	Mean	388	700	11,000
	Max	388	700	11,000
	Count	1	1	1
	ND	0	0	0

Appendix D. Pesticide Data

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Table D-1. Co-permittee Dry Weather Ambient Pesticide Summary Data

Sample Location		Chlorpyrifos	Diazinon	Malathion
	Units	µg/L	µg/L	µg/L
	DL	0.05-1	0.02-1	0.05
AC-1	Min	0.025	0.025	0.025
	Mean	0.025	0.025	0.025
	Max	0.025	0.025	0.025
	Count	5	5	2
	ND	3	3	2
AC-2	Min	0.025	0.025	0.025
	Mean	0.025	0.04125	0.025
	Max	0.025	0.09	0.025
	Count	4	4	2
	ND	2	2	2
AH Creek-1_2	Min	0.025	0.025	
	Mean	0.025	0.025	
	Max	0.025	0.025	
	Count	2	2	0
	ND	0	0	0
AH-10	Min	0.025	0.025	0.025
	Mean	0.12	0.12	0.025
	Max	0.5	0.5	0.025
	Count	5	5	2
	ND	3	3	2
CAR05	Min	0.025	0.025	0.05
	Mean	0.108333333	0.108333333	0.05
	Max	0.25	0.25	0.05
	Count	3	3	1
	ND	2	2	1
904CBBUR1	Min	0.025	0.01	0.025
	Mean	0.025	0.01	0.025
	Max	0.025	0.01	0.025
	Count	4	4	4
	ND	4	4	4

Sample Location		**Chlorpyrifos**	**Diazinon**	**Malathion**
	Units	**µg/L**	**µg/L**	**µg/L**
	DL	**0.05-1**	**0.02-1**	**0.05**
904CBAQH6	Min	0.025	0.01	0.025
	Mean	0.025	0.0155	0.025
	Max	0.025	0.032	0.025
	Count	4	4	4
	ND	4	3	4

Table D-2. Co-permittee Dry Weather Storm Drain Pesticide Summary Data

Sample Location		Chlorpyrifos	Diazinon	Malathion
	Units	µg/L	µg/L	µg/L
	DL	0.05-3	0.05-6	0.04-0.05
A002	Min	0.025	0.025	0.020
	Mean	0.025	0.173	0.023
	Max	0.025	0.470	0.025
	Count	3	3	2
	ND	2	2	2
A004a	Min	0.025	0.025	0.025
	Mean	0.170	0.063	0.038
	Max	0.460	0.140	0.050
	Count	3	3	2
	ND	1	2	1
A004b	Min	0.025	0.025	0.025
	Mean	0.025	0.025	0.025
	Max	0.025	0.025	0.025
	Count	3	3	2
	ND	2	2	2
A013	Min	0.025	0.025	0.025
	Mean	0.025	0.025	0.178
	Max	0.025	0.025	0.330
	Count	2	2	2
	ND	2	2	1
A015	Min	0.025	0.025	0.025
	Mean	0.025	0.025	0.025
	Max	0.025	0.025	0.025
	Count	2	2	2
	ND	2	2	2
A016	Min	0.025	0.025	0.025
	Mean	0.025	0.025	0.025
	Max	0.025	0.025	0.025
	Count	3	3	3
	ND	3	3	3

Sample Location		Chlorpyrifos	Diazinon	Malathion
	Units	μg/L	μg/L	μg/L
	DL	0.05-3	0.05-6	0.04-0.05
A02	Min	0.250	0.250	
	Mean	0.250	0.250	
	Max	0.250	0.250	
	Count	1	1	0
	ND	1	1	0
A04A	Min	1.500	3.000	
	Mean	1.500	3.000	
	Max	1.500	3.000	
	Count	1	1	0
	ND	1	1	0
A04B	Min	1.500	3.000	
	Mean	1.500	3.000	
	Max	1.500	3.000	
	Count	1	1	0
	ND	1	1	0
A04C	Min	0.250	0.250	
	Mean	0.250	0.250	
	Max	0.250	0.250	
	Count	1	1	0
	ND	1	1	0
AH Creek-2	Min	0.025	0.025	
	Mean	0.025	0.025	
	Max	0.025	0.025	
	Count	1	1	0
	ND	1	1	0
AH03	Min	0.025	0.025	
	Mean	0.070	0.070	
	Max	0.250	0.250	
	Count	5	5	0
	ND	3	3	0

Sample Location		Chlorpyrifos	Diazinon	Malathion
	Units	µg/L	µg/L	µg/L
	DL	0.05-3	0.05-6	0.04-0.05
AH08	Min	0.025	0.025	
	Mean	0.070	0.070	
	Max	0.250	0.250	
	Count	5	5	0
	ND	3	3	0
AH10	Min	0.025	0.025	
	Mean	0.081	0.081	
	Max	0.250	0.250	
	Count	4	4	0
	ND	3	3	0
AH-21	Min	0.025	0.025	0.025
	Mean	0.104	0.104	0.025
	Max	0.500	0.500	0.025
	Count	6	6	2
	ND	4	4	2
AH24	Min	0.025	0.025	
	Mean	0.025	0.025	
	Max	0.025	0.025	
	Count	4	4	0
	ND	2	2	0
AH28	Min	0.250	0.250	
	Mean	0.250	0.250	
	Max	0.250	0.250	
	Count	1	1	0
	ND	1	1	0
AH32	Min	0.250	0.250	
	Mean	0.250	0.250	
	Max	0.250	0.250	
	Count	1	1	0
	ND	1	1	0

Sample Location		Chlorpyrifos	Diazinon	Malathion
	Units	µg/L	µg/L	µg/L
	DL	0.05-3	0.05-6	0.04-0.05
AH45	Min	0.025	0.025	
	Mean	0.025	0.025	
	Max	0.025	0.025	
	Count	4	4	0
	ND	2	2	0
AH46	Min	0.025	0.025	
	Mean	0.025	0.025	
	Max	0.025	0.025	
	Count	4	4	0
	ND	2	2	0
AH59	Min	0.250	0.250	
	Mean	0.250	0.250	
	Max	0.250	0.250	
	Count	1	1	0
	ND	1	1	0
L02B	Min	0.025	0.025	
	Mean	0.025	0.025	
	Max	0.025	0.025	
	Count	1	1	0
	ND	0	0	0

Appendix E. Metals Data

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Table E-1. Co-permittee Wet Weather Metals Summary Data

Parameter	Units	Min	Mean	Max	Count	DL	ND
Hardness							
Total Hardness	mg CaCO3/L	35.3	395	680	27	-	0
Total Metals							
Antimony	mg/L	7.50E-04	1.59E-03	3.00E-03	26	0.0015-0.006	21
Arsenic	mg/L	1.47E-06	1.91E-05	5.29E-05	26	0.001-0.002	4
Cadmium	mg/L	1.20E-05	9.92E-05	3.38E-04	26	0.0003-0.001	21
Chromium	mg/L	2.88E-07	2.13E-06	1.60E-05	26	0.005	15
Copper	mg/L	2.93E-05	6.38E-04	3.81E-03	26	0.005	4
Lead	mg/L	1.07E-06	1.66E-05	1.15E-04	26	0.001-0.005	7
Nickel	mg/L	1.78E-06	9.84E-06	7.36E-05	26	0.005	3
Selenium	mg/L	5.00E-04	2.00E-03	6.00E-03	26	0.001-0.005	22
Zinc	mg/L	1.64E-05	2.58E-04	1.01E-03	26	0.02	3
Dissolved Metals							
Antimony	mg/L	1.00E-03	2.44E-03	7.50E-03	24	0.0015-0.006	21
Arsenic	mg/L	1.47E-06	6.31E-06	3.24E-05	24	0.001-0.002	10
Cadmium	mg/L	5.16E-05	1.01E-04	1.79E-04	24	0.00025-0.001	24
Chromium	mg/L	9.13E-07	2.12E-06	1.03E-05	24	0.005	24
Copper	mg/L	3.06E-05	1.52E-04	8.89E-04	24	0.005	12
Lead	mg/L	1.70E-06	4.86E-06	2.45E-05	24	0.001-0.002	24
Nickel	mg/L	8.68E-07	3.02E-06	1.29E-05	24	0.002-0.005	4
Selenium	mg/L	5.00E-04	2.13E-03	1.00E-02	24	0.001-0.02	23
Zinc	mg/L	2.94E-06	7.39E-05	8.20E-04	24	0.001-0.02	19