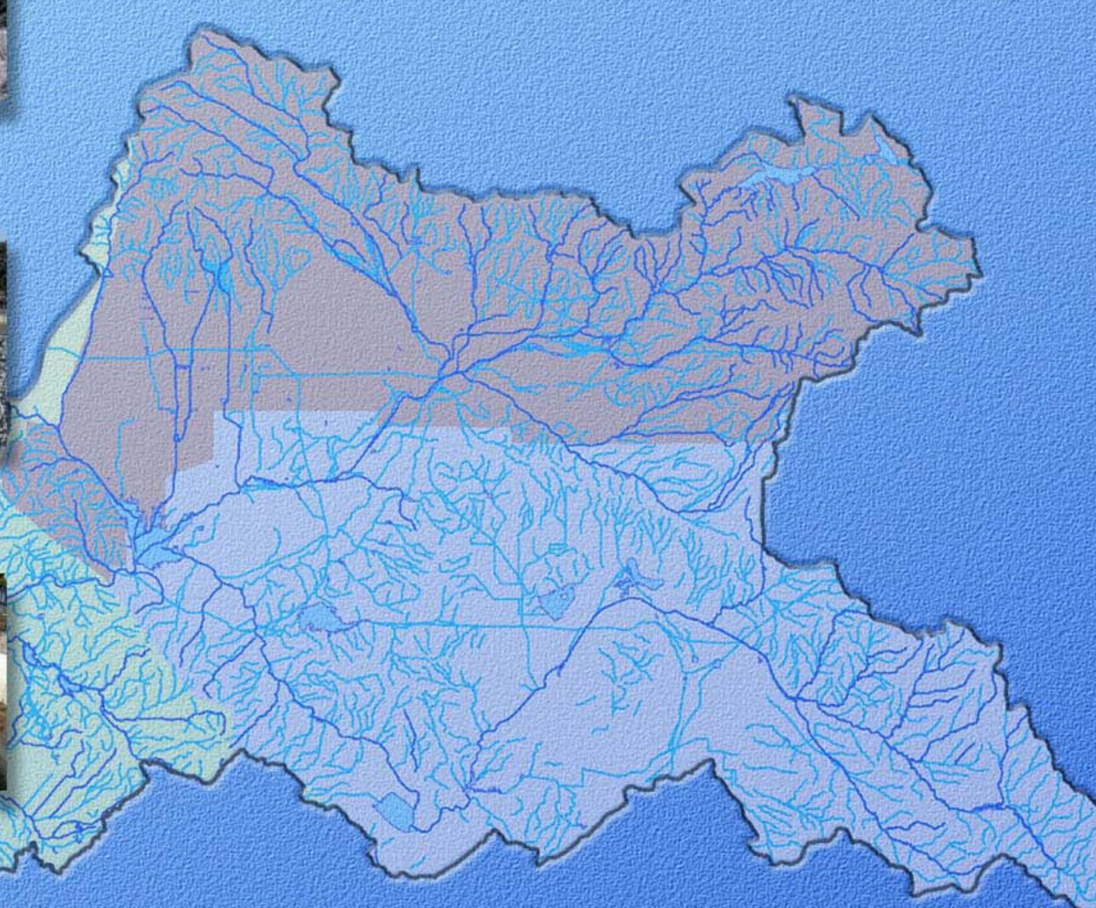
CDM

Stormwater Quality Standards Study

Phase I Study Report - Technical Memoranda

November 2004



Contents

Stormwater Quality Standards Study
Phase I Study Report – Technical Memoranda

Stormwater Quality Standards Study Technical Task Overview

Background

The Stormwater Quality Standards Study was proposed to integrate basin-wide watershed planning and water quality program management efforts with the Santa Ana Regional Water Quality Control Board (Regional Board) Triennial Review Priority List and Work Plan and rankings of priorities. The Regional Boards are required by federal law to review water quality standards, which include beneficial uses, water quality objectives, and an anti-degradation policy, on a 3-year cycle (triennial review). State law also requires periodic review and update of Basin Plans. Under the Water Quality Standards/Basin Planning activities identified in the Regional Board's Watershed Management Initiative, the Regional Board has ranked updating the bacteriological water quality objectives associated with recreational beneficial uses as one of their high priorities, in particular to respond to EPA's new national water quality criteria and AB411 Beach Standards. Another priority is to review and where appropriate, revise beneficial use designations for a number of water bodies.

The beneficial use designations were originally assigned to ocean beaches and major freshwater lakes and streams in 1975. Minor streams, including many stormwater channels, were never formally designated. The "Tributary Rule" is used to regulate small, unclassified waterbodies based on the beneficial uses and water quality objectives that occur downstream. Rapid urbanization has affected the expected beneficial uses for many designated waterbodies and unclassified tributaries throughout the Santa Ana region. For example, many previously natural drainage courses have been modified to concrete flood control facilities, including lined channel and underground pipes and culverts. As a result, generic application of the Tributary Rule may not result in the most appropriate regulatory requirements in all cases.

Stakeholders in the Santa Ana Watershed expressed strong interest in assisting the Santa Ana Regional Board in providing additional data and science to assist in the evaluation of the REC-1 beneficial use designation and associated water quality objectives. To coordinate this assistance effort, the Stormwater Quality Standards Study Task Force (Task Force) was formed. Since the Task Force and Regional Board had similar data collection needs in order to understand the fate, transport, and exposures to pollutants associated with impaired water bodies, they elected to work together on similar data collection activities that would meet both of their objectives – the Task Force's objectives of developing cost-effective practices to improve water quality, and the Regional Board's objectives of developing water quality objectives and beneficial use designations that are appropriately protective of public interests.

The foremost task at the outset of the Stormwater Quality Standards Study was to establish a Work Plan that would govern the next phases of the study process. The primary goals of the Work Plan were to recommend studies and activities that would provide support to the Regional Board to ensure that all waterbodies in the region have been properly designated with appropriate existing and probable future beneficial use classifications; to ensure that the most appropriate water quality objectives are established to protect those beneficial uses; and to ensure that implementation strategies to achieve the water quality objectives are appropriate. The final Work Plan recommended that this work be conducted in three phases:

- Phase I – Review Beneficial Use Classifications and Assess Existing Conditions
- Phase II – Review and Update Water Quality Objectives and Conduct Additional Analyses
- Phase III – Develop Permit Implementation and Monitoring Strategies

This phased process gives an opportunity for intermediate decision points and for focusing or prioritizing efforts that would be conducted under subsequent phases.

The work under Phase I was further divided into two parallel efforts:

- A regulatory review of recreation-based beneficial use classifications to more accurately reflect the true nature of recreational uses occurring throughout the watershed. This effort was led by Risk-Sciences, Inc.
- Development of technical data and scientific information required to support the regulatory review. This effort was led by CDM and is summarized in this document and presented in detail in the accompanying Technical Memoranda. Phase I objectives for the technical efforts included researching and providing a summary of available information, with limited analysis of the information pertaining to the following study topics:
- Receiving Water and Watershed Inventory Mapping
- Use Inventory
- Flow and Water Quality Data Inventory and Characterization
- Inventory and Analysis of Existing Major Control Programs and Structural Measures

A series of technical memoranda were prepared that focus on the findings within each Phase I study topic. This study overview summarizes the technical memoranda. Technical Memorandum 1 provides receiving water and watershed inventory mapping information. Technical Memorandum 2 provides existing and potential use inventory information. Technical Memorandum 3 provides flow and water quality data inventory and characterization information. Technical Memorandum 4 provides and inventory and analysis of existing major control programs and structural measures.

The information within the technical memoranda will be used to support the regulatory objectives review being performed by Risk Sciences, Inc. as part of the overall Stormwater Quality Standards Study. A separate report will be generated by Risk Sciences, Inc.

This overview memorandum provides a brief summary of the inventory and characterization efforts for existing conditions in the watershed. A brief summary of inventory and characterization findings follows, along with a brief overview of the types of information and additional analysis that might prove useful for Phase II efforts.

Summary of Phase I Findings

The Santa Ana River watershed is located in southern California, south and east of the city of Los Angeles. Approximately 2800 square miles in area, the watershed includes the northern portion of Orange County, the northwestern corner of Riverside County, the southwestern corner of San Bernardino County, and a small portion of Los Angeles County as shown in Figure 1. The river drainages generally flow from east to west. The highest elevations of the watershed occur in the San Bernardino, San Gabriel Mountains and San Jacinto Mountains. Downstream in the central part of the watershed, the Santa Ana Mountains and the Chino Hills form a topographic high before the river flows onto the Coastal Plain into the Pacific Ocean.

The drainage system within the Santa Ana River Basin is comprised of a highly variable set of natural and structurally modified channels that carry flows, and inland lakes and basins that temporarily or permanently store flows. In some cases, the physical conditions that may affect contact recreation can sometimes vary considerably within a single stream reach from a natural bank conditions to a stabilized bank condition, then to a concrete-lined condition, and in some cases back to a natural condition, along the reach. On the other hand, there are some stream/tributary systems that are fully improved, lined channels with restricted access along all or most of their length, primarily within densely developed area such as much of the Orange County coastal plain.

County agencies with jurisdiction within the Santa Ana River Basin have well-established existing GIS coverage of the drainage system, with attribute data (physical channel information) in some areas. The GIS may need field verified in some areas as conditions may have changed since GIS development, and the attribute data provided within GIS is not consistent from agency to agency. Most agency GIS differentiate the drainage system as either natural channel or modified channel, but may define these physical conditions differently. Existing GIS may not differentiate channel segments into physical attribute types to the level of detail necessary to describe a channel segment's capacity for providing safe or desirable water contact recreation. A summary of existing basin mapping is included within Technical Memorandum 1.

Water contact and non-contact recreational use is supported and encouraged at the beaches along almost the entire coastline of the watershed, as well as in several inland lakes. Both contact and non-contact recreation are identified as either existing or potential beneficial uses (in some cases intermittent) for nearly all of the other inland receiving waters and tributaries. However most of these water bodies within the urban portion of the watershed are fully or partially improved flood control facilities for which water contact uses and access to water bodies are typically actively discouraged or prohibited due to concerns for potential unsafe conditions and liability. Good information is available about the frequency and type of use at beaches and lakes, but information is very limited pertaining to actual existing or historic water contact use activities in most other waterbodies within the basin. A number of additional recreational park areas are planned within the basin for the near future but typically do not include planned beach or similar body contact recreation use areas. Additional recreational use information is available in Technical Memorandum 2.

The Santa Ana watershed is an arid region, and therefore there is little natural perennial surface water in most of the watershed. Surface waters begin primarily in the San Bernardino, San Gabriel, San Jacinto and Santa Ana Mountain ranges where flows consist mainly of snowmelt and storm runoff from the lightly developed National Forest land. This water is generally relatively high quality (low levels of indicator bacteria) leaving the mountain fronts. In the most upper reaches within the local Mountains, the Santa Ana River and other stream systems are generally confined in their lateral movement, contained by the slope in the mountainous regions. Once the stream systems reach the valley floors, the gradients flatten and the majority of systems have been partially or wholly modified to safely carry high storm event flows through the more urbanized portions of the basin. Most streams within the basin carry minimal flow throughout most of the year except in response to rainfall events, or as a result of man-made discharges such as waterwater treatment effluent or imported water releases. During the winter season, storms can bring significant rainfall resulting in high flow rates within channels.

The San Jacinto Watershed contains a separate network of tributaries in Riverside County. The watershed encompasses more than 700 square miles starting roughly in Idyllwild and ending in Lake Elsinore. The San Jacinto River is the principal river in the watershed. It originates in the San Jacinto Mountains and flows northwest for the first half of its course and then southwest, occasionally reaching Canyon Lake, and less frequently Lake Elsinore. During high precipitation years, Lake Elsinore may overflow to Temescal Wash, which is tributary to the Santa Ana River.

Flow record data is available at over 100 flow monitoring stations throughout the basin. Data from representative flow monitoring stations in most urban streams and channels (with the exception of the middle reaches of the Santa Ana River) exhibit similar typical similar patterns. Long periods of very low flow occur during the dry weather months (April through November). The flow is typically so low that channel bottom variability makes depth of flow difficult to determine but is typically a few inches in depth based on looking at data from several different focused study sites. The source of this flow is primarily "nuisance" urban runoff. There are a small number of stream segments receiving treated POTW effluent (e.g. Chino Creek, Cucamonga Creek) and occasional releases of imported water. At the other extreme, wet weather events occur typically on a long term average between 10 and 20 times per year during winter months, resulting in high flow conditions in most channels. These events tend to quickly increase flow by 1 to 2 orders of magnitude, creating potentially rapid flows and unsafe conditions. Based on an evaluation of several focused study sites, in three different urban watersheds, the flow pattern is similar: approximately 96% of the time, flow is very low and depth of flow is minimal, and 1-2% of the time depth or velocity-depth relationships exceed criteria considered safe for being in the water.

On the other hand, the Santa Ana River exhibits a much different flow pattern throughout it's length. In the upper valley of the Santa Ana River Basin drainage system, flows from the Seven Oaks dam to the city of San Bernardino consist mainly of storm flows, flows from the San Timoteo Creek, and groundwater that is rising due to local geological conditions. Below the Cities of San Bernardino and Colton to the City of Riverside, the river flows perennially, and it includes treated discharges from wastewater treatment plants. From the City of Riverside to the recharge basins below the Imperial Highway in Orange County, river flow consists of highly treated wastewater discharges, urban runoff, irrigation runoff, and groundwater forced to the surface by shallow/rising bedrock. Prado Dam captures flows from all of the upper portions of the Santa Ana River watershed in Riverside and San Bernardino Counties. The majority of base flow reaching Prado Dam from upstream is tertiary effluent from river discharging POTWs. Releases from Prado Dam are highly regulated.

Below the dam, the river cuts through the Santa Ana Mountains and the Puente-Chino Hills. Where the river flows onto the Orange County Coastal Plain; the channel lessens and the gradient decreases. In a natural environment, the river in this area would have a much wider, more meandering channel and sediment would naturally build up. However, much of the Santa Ana river channel in this area has been contained in concrete-lined channels, which modifies the flow regime and sediment deposition environment. Downstream of Imperial Highway there is a rubber dam, which is the primary diversion facility used to route water to several Orange County

Water District groundwater recharge basins located adjacent to this reach of the Santa Ana River. Based on USGS data from 1998 to 2001, baseflow in this reach ranges between 200 and 400 cfs. Through these diversion facilities and additional surface spreading in the soft channel bottom below the diversion, essentially all base flow and substantial portions of the storm flow released from Prado Dam are coveyed away from the River, and the remaining reach to the Ocean is exhibits a pattern more similar to other urban watersheds.

For additional flow data details, see Technical Memorandum 3.

While extensive bacterial water quality sampling has been performed in areas that support and encourage water contact recreation (e.g. beaches), relatively limited sampling has been performed over extended periods of time in inland waterbodies for fecal coliform and E.coli indicators. Phase I efforts focused on compiling and analyzing the sampling data within inland waterbodies. The much larger volume of beach sampling data was not inventoried, though water quality objectives in these areas were considered during Phase I efforts.

When compared to both existing fecal coliform objectives and proposed E. coli EPA criteria, most available indicator bacteria sampling from inland waterbodies potentially exceed water quality objectives. Bacteria results obtained from upstream, largely undisturbed areas are typically lower than those obtained from downstream areas affected by urbanized land uses and more frequently are below water quality objectives and proposed criteria.

The relatively limited amount and frequency of available sampling data makes temporal trending difficult. Throughout the period of available sampling data, improvements or declines in bacterial water quality could not be easily determined. For additional bacterial sampling data details, see Technical Memorandum 3.

Municipal stormwater agencies as well as industrial and construction site owners/operators throughout the basin implement source control programs directly or indirectly aimed at preventing or controlling bacteria within urban runoff. Agency stormwater or urban runoff quality programs implement best management practices for controlling potential bacteria and pathogen sources such as sanitary system overflows, portable toilets, septic tank failures, and pet waste. Stormwater management programs under NPDES permits were initiated in the early 1990s throughout the Santa Ana Watershed in all three counties and have become progressively more fully implemented and comprehensive over several permit cycles.

Stormwater and other agencies are beginning to implement structural treatment control measures that can improve the overall quality of urban runoff, including bacteria quality. These measures include:

- Low-flow diversion to sanitary sewer system

- Recharge (Infiltration) basins
- Detention basins, swales, and buffer strips
- Natural treatment wetlands/ wet ponds
- Ultraviolet disinfection and Ozone

Some of these measures can have multiple benefits and may in fact be implemented primarily for other purposes, such as capture of runoff for groundwater recharge.

All significant new development/redevelopment projects with the region must also now incorporate treatment controls into project design and construction that must take into account reducing pollutants of concern.

Current data and available control measure assessments are not sufficient to show improvements or other trends in bacterial water quality from implementation.

Publicly owned treatment works (POTW) within the basin routinely discharge year-round to the Santa Ana River and a few inland streams. The POTWs produce an effluent compliant with Title 22 requirements for filtered, disinfected effluent, resulting in discharges with bacteria levels at or below detection levels. For additional control measure details, see Technical Memorandum 4.

Data Gaps

At the onset of Phase I, certain information was viewed as necessary to support the beneficial use evaluation. After an initial inventory of available information, certain data or information gaps were noted:

- Channel attribute data is very different between Orange, Riverside, and San Bernardino County GIS. Field measurements and further research would be necessary in each county to develop a layer of open channels with complete attribute data for the Santa Ana Basin. Orange County flood control facilities are in the form of MicroStation maps and channel information is not regularly updated. Communication with County staff revealed that parts of the county maps may not have been updated over the past 20 years. Riverside County flood control maps are very detailed, but the index map does not include complete channel attribute information summarizing flood control facilities. Detailed plans for all flood control projects are numerous and include additional information that does not relate to conditions that impact recreational use in waterbodies. San Bernardino County flood control facilities are included in a GIS layer with some attribute data. Field checking and filling in missing data for channels will be necessary.

- More formal use survey information would be necessary to support study efforts if any changes in use classifications and designations are contemplated. Focusing the surveys upon specific areas of interest or types of waterbodies being considered for modified recreational use standards would be appropriate.

Depending upon the outcome and recommendations of the regulatory review effort, additional research and analysis may be desirable upon the following topics:

- Fate and transport of bacteria (e.g., resuspension from sediments)
- Sources of bacteria
- Storm and post-storm flow depths and durations
- Economic cost of compliance

Technical Memorandum 1
Receiving Water and Watershed Inventory Mapping

Inventory and mapping of available geographical data was necessary to support efforts of the Stormwater Quality Standards Study (SWQSS) Task Force. Geographical data relating to physical attributes of Santa Ana Basin waterbodies was collected from a variety of agencies to construct a Geographical Information System (GIS) for the SWQSS (Study GIS). Monitoring locations, recreational use information, and structural BMP information and associated data was also collected, as described in other Technical Memoranda and included in the Study GIS. This technical memorandum describes the geographical data collected and reviews the integration of different layers into a common Study GIS. Geographic data collected and compiled include:

- Listed waterbodies and other unnamed tributaries
- Storm drain system information
- Land use information for the years 1990, 1993, and 2000
- Publicly Owned Treatment Works (POTWs) and groundwater recharge basins
- Meteorological, climatic, hydrological, and water quality data monitoring locations
- Various base map layers

Data Collection and Integration

Geographical data layers were collected from multiple sources and compiled into a single GIS to facilitate overlay and analysis (Table 1). Many of the spatial data layers presented in this inventory are included in a base map of the Santa Ana Basin (Figure 1). A digital elevation model (DEM) of the Santa Ana Basin was provided to the Stormwater Standards Study by SAWPA. This is a raster, grid based, layer of elevation data for 10 meter squared cells for the entire Santa Ana Basin. All other GIS layers collected were vector data, points, lines, or polygons.

The data was provided in a variety of forms and therefore integration into a common GIS was necessary. ArcGIS® [ESRI, 2003], a multi-component geographical data management and analysis tool was used to integrate each layer, complete analyses, and prepare descriptive maps for technical reports. All GIS layers were converted to the same coordinate system, UTM projection NAD 1927 Zone 11N, to accurately overlay the data. In some instances, shapes were provided for the entire state of California or for all of San Bernardino, Orange, or Riverside Counties. These shapes were clipped to only include data that exists within the boundary of the Santa Ana Basin. Map layers included are listed in Table 1.

Table 1
GIS Map Layers Compiled

Layer	Source(s)	Description
Watershed	SAWPA	Boundary of Santa Ana Basin
Basin Plan Reaches	California Spatial Information Library (CaSIL) and Regional Water Quality Control Board (RWQCB)	Named inland surface streams in Basin Plan compiled from; • CaSIL - Statewide Hydrography, National Hydrography Dataset (NHD) • RWQCB - 2002 303(d) Rivers
Other Reaches	CaSIL	Streams of National Hydrography Dataset (NHD) prepared by the USGS and EPA for the Santa Ana Region
Lakes	CaSIL	Lakes and other waterbodies of NHD prepared by the USGS and EPA for the Santa Ana Region
Flow Stations	USGS, Orange County, San Bernardino County, Riverside County	Flow gauging stations within the Santa Ana Basin
Water Quality Monitoring Stations	Santa Ana Regional Water Quality Control Board, Coast Keeper, Elsinore Valley Municipal Water District, Big Bear Lake Municipal Water District, San Bernardino County Flood Control District, Orange County Health Care Agency, Riverside County Flood Control District, USGS	Bacteria sampling locations along inland surface waterbodies
County	CaSIL	County boundaries
Roads	CaSIL	Roads within the Santa Ana Basin
Land Use	Southern California Associated Governments (SCAG)	Land use areas within the Santa Ana Basin with land use type data for 1990, 1993, and 2000
Modified Channels	Orange, Riverside, and San Bernardino County Flood Control Districts	Modified channels in the parts of Riverside and San Bernardino counties that exist within the Santa Ana Basin
Rainfall Stations	National Climatic Data Center (NCDC)	Rainfall stations used to distinguish wet weather days
Wastewater Treatment Plants	SAWPA	Locations of wastewater treatment plants in Santa Ana Basin
Sawpa_dem	SAWPA	Raster elevation map of the entire Santa Ana Basin – 30 meter grid cell

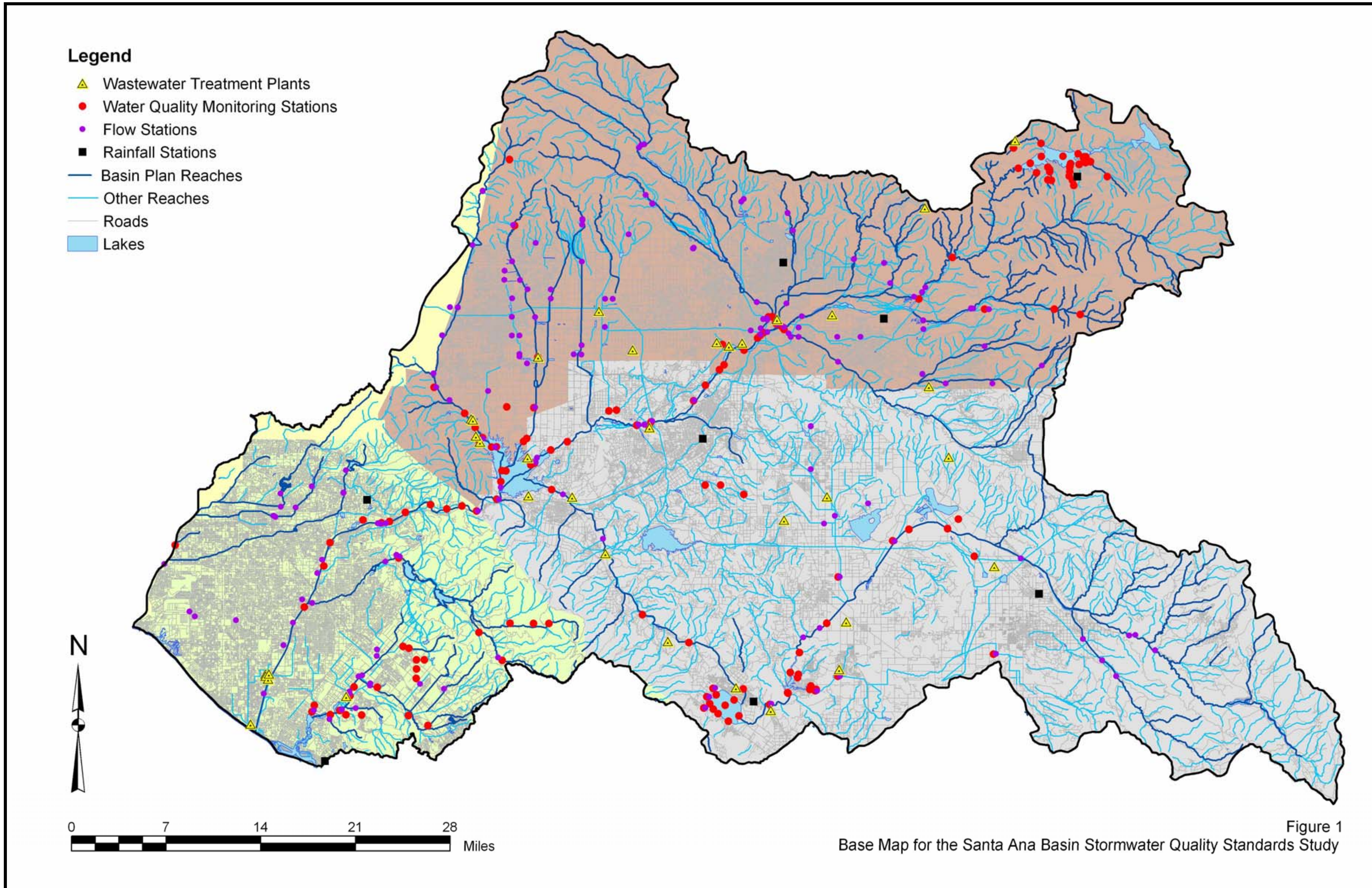


Figure 1
Base Map for the Santa Ana Basin Stormwater Quality Standards Study

Study GIS

Receiving Waterbodies

Several GIS layers were used to compile a single layer of named waterbodies with designated recreational use in Table 3-1 of the Santa Ana River Basin Water Quality Control Plan (Figure 2). The national hydrography dataset (NHD), which is a combination of USGS blue line streams digitized from topographic maps and the USEPA Reach File Version 3 (RF3) was used as well as a draft layer of all 303(d) listed waters being compiled by the Santa Ana Regional Water Quality Control Board (SARWQCB). Tributaries to the named waterbodies were equated to waters in the NHD that are unnamed, in the Basin Plan (Figure 3). Some of these waterbodies are improved engineered channels. In addition, there is an extensive network of storm drainage facilities (pipes, culverts, and channels) that are tributary to the waterbodies shown in Figure 3. The layer contains the majority, but not all small channels within the basin.

Channel Properties

Stormwater drainage facility information for Orange, Riverside, and San Bernardino counties is available in a variety of different forms. Therefore, different GIS approaches were employed to incorporate channel characteristics for each county into the Study GIS. The primary goal of a watershed wide assessment of channel properties was to extract from county facility map the open channels that have been modified or have engineered improvements.

San Bernardino County Flood Control District facility information is organized into a polyline layer with descriptive attribute data (Table 2). These attribute data are described briefly in Table 2, which summarizes a metadata file that accompanied the map layer. Features that were classified as lined or which were type C (channel) or Z (trapezoidal/rectangular) were exported to a new polyline layer of modified channels in San Bernardino County.

Table 2
Attributes of San Bernardino County Flood Control District Facilities Layer

<table>
<tr><th>Item</th><th>Description</th><th colspan="2">Values</th></tr>
<tr><td>PSIZE</td><td>Pipe Size (in)</td><td colspan="2">Diameter</td></tr>
<tr><td>BSIZE</td><td>Box Size</td><td colspan="2">Base, Height</td></tr>
<tr><td>CSIZE</td><td>Channel Size</td><td colspan="2">Base, Side Slope</td></tr>
<tr><td>TYPE</td><td>Type Code</td><td>P – pipe
B- box
C – channel
W – water course
L – levee
S – designed street</td><td>Z – trapezoidal/rectangular
T – transition
E – easement
G – curb and gutter
A – arched conduit
V – v-gutter</td></tr>
<tr><td>Lining</td><td>Channel Material</td><td colspan="2">Lined, Unlined</td></tr>
<tr><td>STATUS</td><td>Current condition</td><td colspan="2">Existing, Proposed</td></tr>
<tr><td>Owner</td><td>Jurisdiction maintaining facility</td><td colspan="2">County, Cities, Private, Other</td></tr>
</table>

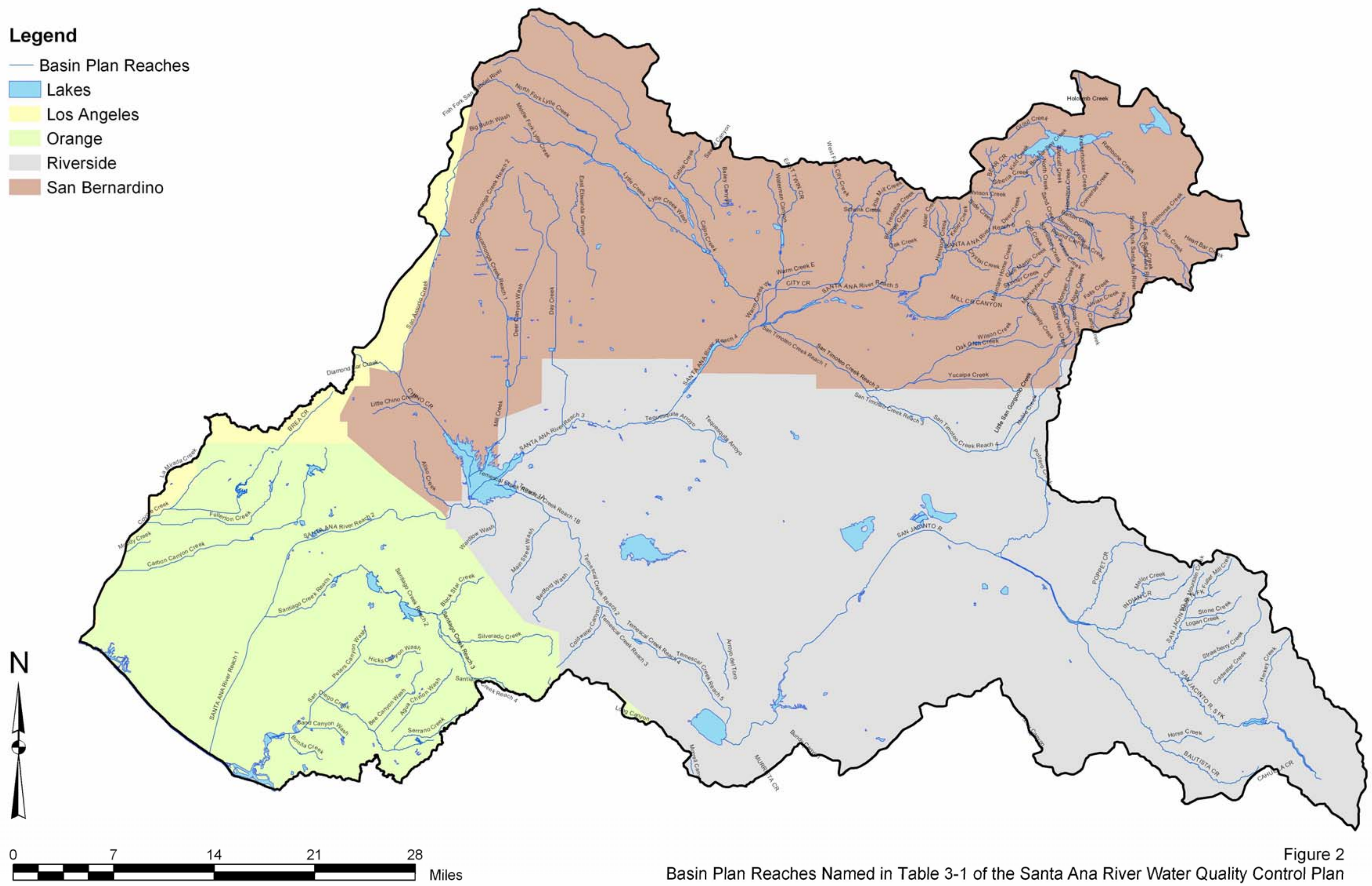


Figure 2
Basin Plan Reaches Named in Table 3-1 of the Santa Ana River Water Quality Control Plan

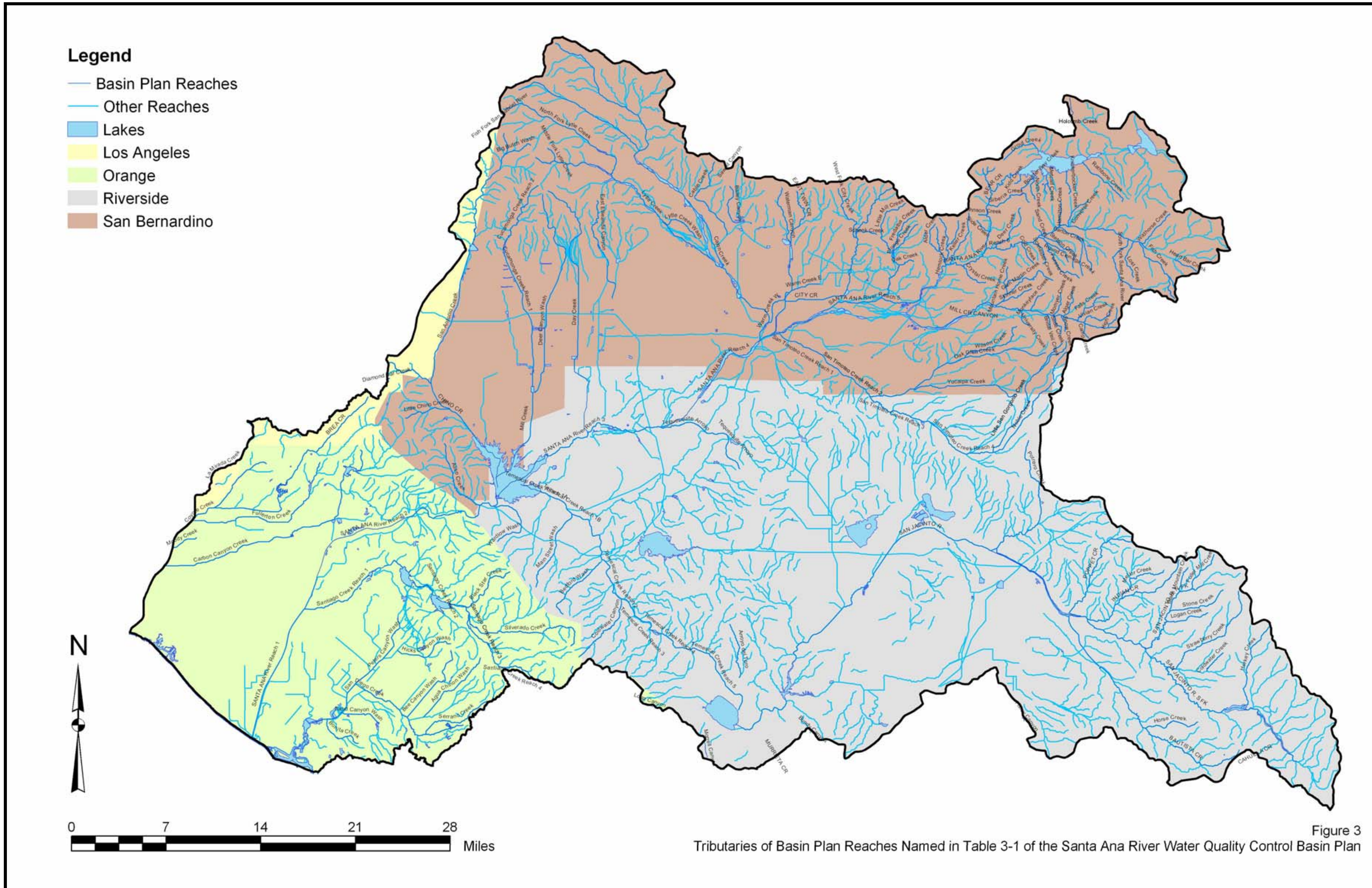


Figure 3
Tributaries of Basin Plan Reaches Named in Table 3-1 of the Santa Ana River Water Quality Control Basin Plan

Riverside County Flood Control District submitted a polyline layer of drainage projects with attribute data as shown in Table 3. Consequently, all open channels in this layer could be considered modified channels. To distinguish between open channels and closed conduits, the ORTYPES field in the attribute table was utilized. The YESORTP field included up to five different drainage types listed in order of most predominant to least. This field in the attribute table was exported to a spreadsheet and delimited to create five distinct fields representing the different drainage types. The new fields were then joined back into the polyline attribute table using the unique project number of each feature. All features which included drainage types CONC, DIKE, LVEE, RECT, ROCK, or TRAP, in either the first or second most predominant ORTYPE fields (ORTYPES and ORTYPE2) were exported to a new polyline layer of modified channels in Riverside County.

Table 3
Attributes of Riverside County Flood Control Facilities Layer

Item	Description	Values
Project identifiers	Name, Developer, NOC, ID, GDO ID, STRMDRN ID	Unique
Project location	Tract, DWG Number, ROW DWG Number	Unique
ORTYPES	Types of drainage facilities	AC, BASN, CIP, CMP, **CONC**, CP, **DIKE, EAR, LVEE**, PVC, RCB, RCP, **RECT, ROCK**, SP, **TRAP**, V

Digital drainage facilities maps provided to the Stormwater Standards Study by the Orange County RDMD were converted from Micro Station format into GIS layers to facilitate overlay. The conversion process generated four GIS layers of Orange County's drainage system; points, polylines, polygons, and annotations. Attribute tables for these layers are generated during the conversion process, however these tables do not include detailed properties of the drainage facilities. Drainage facility information describing point, polyline and polygon features are held within the annotation layer. The attribute table of the annotation layer does distinguish channel types. This facilitated the extraction of lined open channels from the polyline layer by selecting only those polylines within a small distance from annotation types identifying a channel as earth trapezoidal channel, reinforced concrete trapezoidal channel, or reinforced concrete rectangular channel.

The modified open channels that are extracted from Orange, Riverside, and San Bernardino county facility maps are then merged into a single polyline layer and clipped to include only those portions within the Santa Ana Basin (Figure 4).

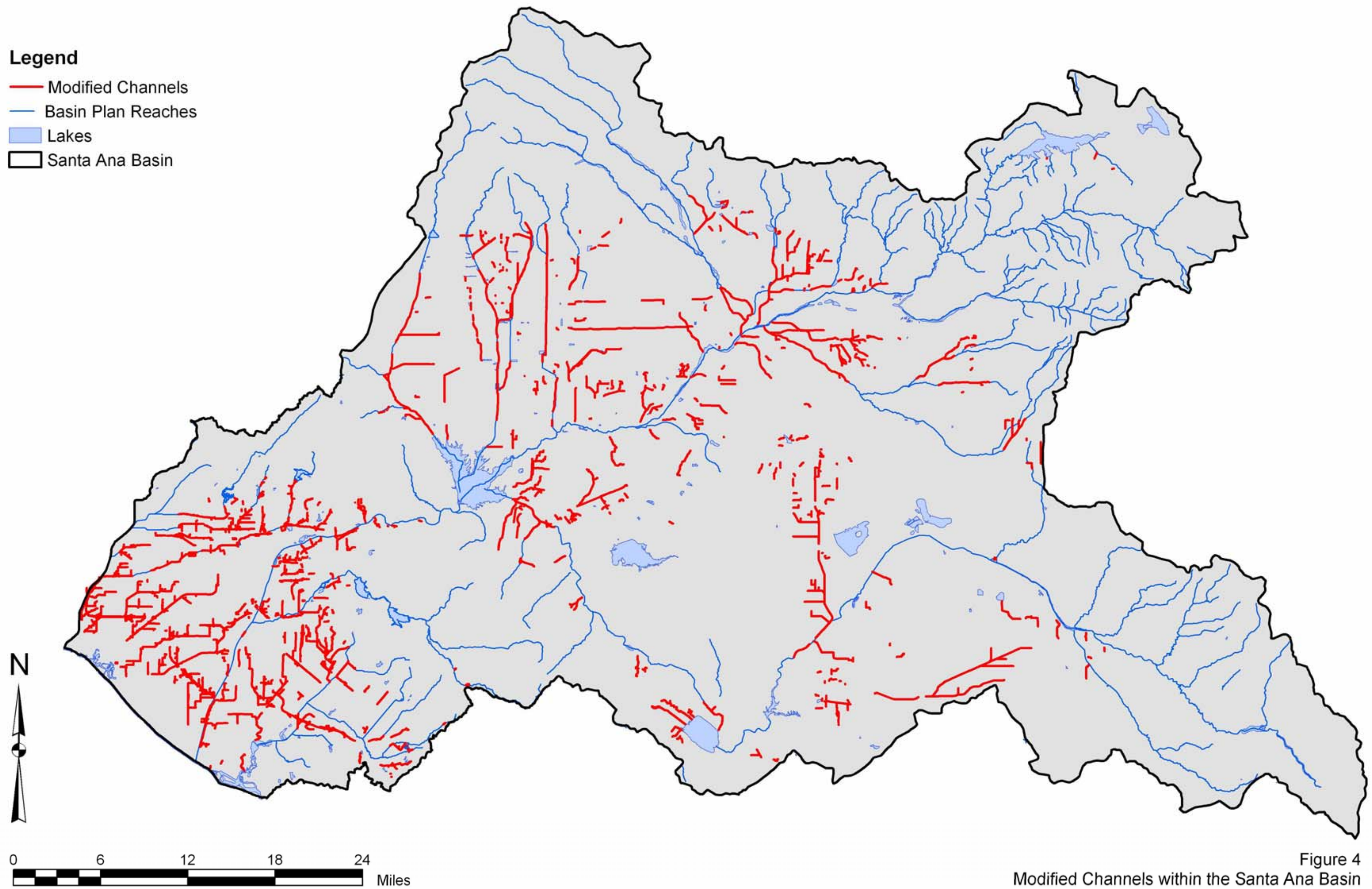


Figure 4
Modified Channels within the Santa Ana Basin

Water Quality Monitoring Stations

Bacteria data compiled from a variety of agencies included information about the location within the Santa Ana Basin where samples were collected. These locations where merged into a layer called "Water Quality Monitoring Stations" (Figure 5). The format of information includes:

- GIS layers
- GPS coordinates
- Notations on paper maps
- Descriptive location names

GIS layers of bacteria monitoring locations were integrated into the Study GIS. Bacteria monitoring locations that were provided in the form of GPS coordinates were imported into a new GIS map with the same coordinate system (typically WGS 1984 for most GPS receivers) and then converted into a GIS layer for integration into the Santa Ana Basin GIS model. Bacteria monitoring locations that were shown on a paper map were added to the GIS model by comparing surrounding features, such as specific roads or waterbodies. Lastly, bacteria monitoring locations that did not include any geographical information aside from the descriptive name were added to the Study GIS by interpreting the narrative description. This scenario often involved locations described by a cross-street or bridge overpass near the water body, (i.e., Santa Ana River (SAR) at Imperial Highway, SAR at Van Owen). Some bacteria monitoring locations were sampled by multiple entities. These bacteria monitoring locations were aggregated together in the GIS model. However, the entity or source of specific bacteria records is included as an additional field in the Stormwater Quality Standards Study database.

Flow Monitoring Stations

Flow in inland surface waterbodies is monitored by the USGS and by the counties or flood control districts of Riverside, Orange, and San Bernardino Counties. Coordinates of USGS flow monitoring stations were imported into a new GIS map with the same coordinate system (WGS 1984) and then converted into a GIS layer for integration into the Study GIS. San Bernardino County flow monitoring station coordinates were extracted from the county's Hydrology web page and integrated into the Study GIS using the same method. Flow monitoring station coordinates were provided in this same format by the Riverside County Flood Control District. These stations were integrated into the Study GIS. Flow monitoring stations in Orange County are described and mapped in the annual Resources and Development Management Department (RDMD) Hydrology Report. This map was used to locate and add the flow monitoring stations maintained by the RDMD to the Study GIS. Figure 6 shows flow monitoring stations within the Santa Ana Basin.

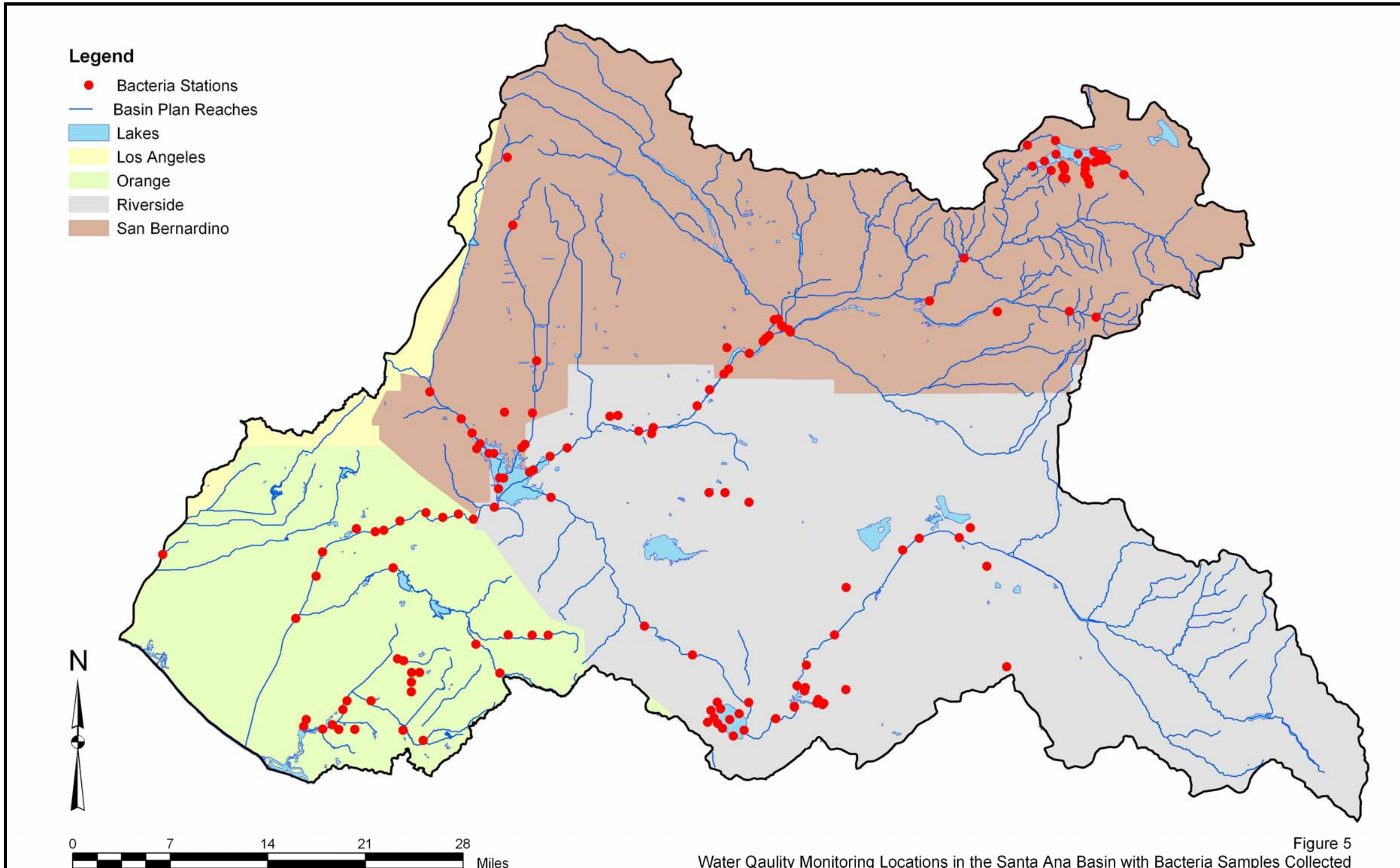


Figure 5
Water Qaulity Monitoring Locations in the Santa Ana Basin with Bacteria Samples Collected

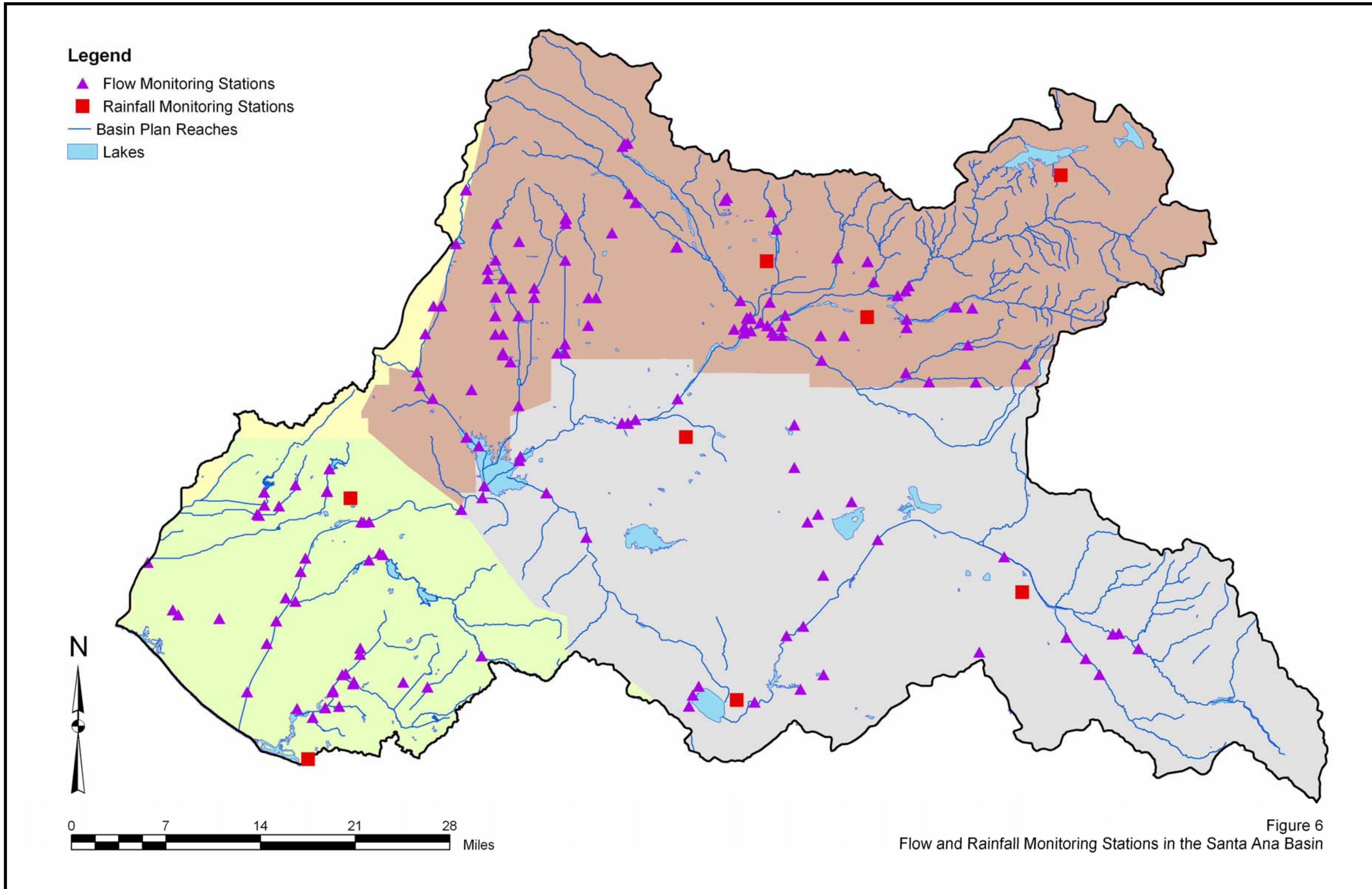


Figure 6
Flow and Rainfall Monitoring Stations in the Santa Ana Basin

Figure 6 also shows selected long term rainfall stations located within the Santa Ana Basin that can serve as a surrogate to missing or unavailable flow data or to assess wet weather conditions for regional analyses.

Land Use

Land use data of the Santa Ana Basin in 1990, 1993, and 2000 was provided by Southern California Associated Governments (SCAG). Figure 7 shows the year 2000 SCAG land use dataset, which is the most recent land use information available for the Santa Ana Basin. Land use in the immediate vicinity of Santa Ana Basin waterbodies may play a role in the likelihood of recreational use in nearby segments of the reach. Land use within small drainage areas also suggests potential sources of bacteria levels in receiving waterbodies with REC-1 use designations.

Existing Treatment and Structural Control Measures

There are numerous control and treatment measures located throughout the basin. Mapping coverage is not available for the entire magnitude of facilities that are designed and installed or have the potential to address bacteria water quality. Two types of bacteria treatment and control measures for which mapping currently exists or has been compiled for this study are publicly owned treatment works (POTW) and recharge basins.

There are 42 publicly owned treatment works (POTW) within the Santa Ana Basin that treat wastewater and either recycle the water or discharge effluent to inland surface waterbodies. POTW discharges that are released into waters with a designated recreational use are required to meet Title 22 standards for filtration and disinfection (Figure 8).

Recharge basins exist within the watershed to capture runoff by infiltration. Removal of bacteria can be achieved in such basins through groundwater infiltration/treatment. The location of these basins was provided by SAWPA (Figure 8). Attribute information for each basin is included in a GIS layer, including the monitoring agency, name of the basin, and for some basins, size and source water.

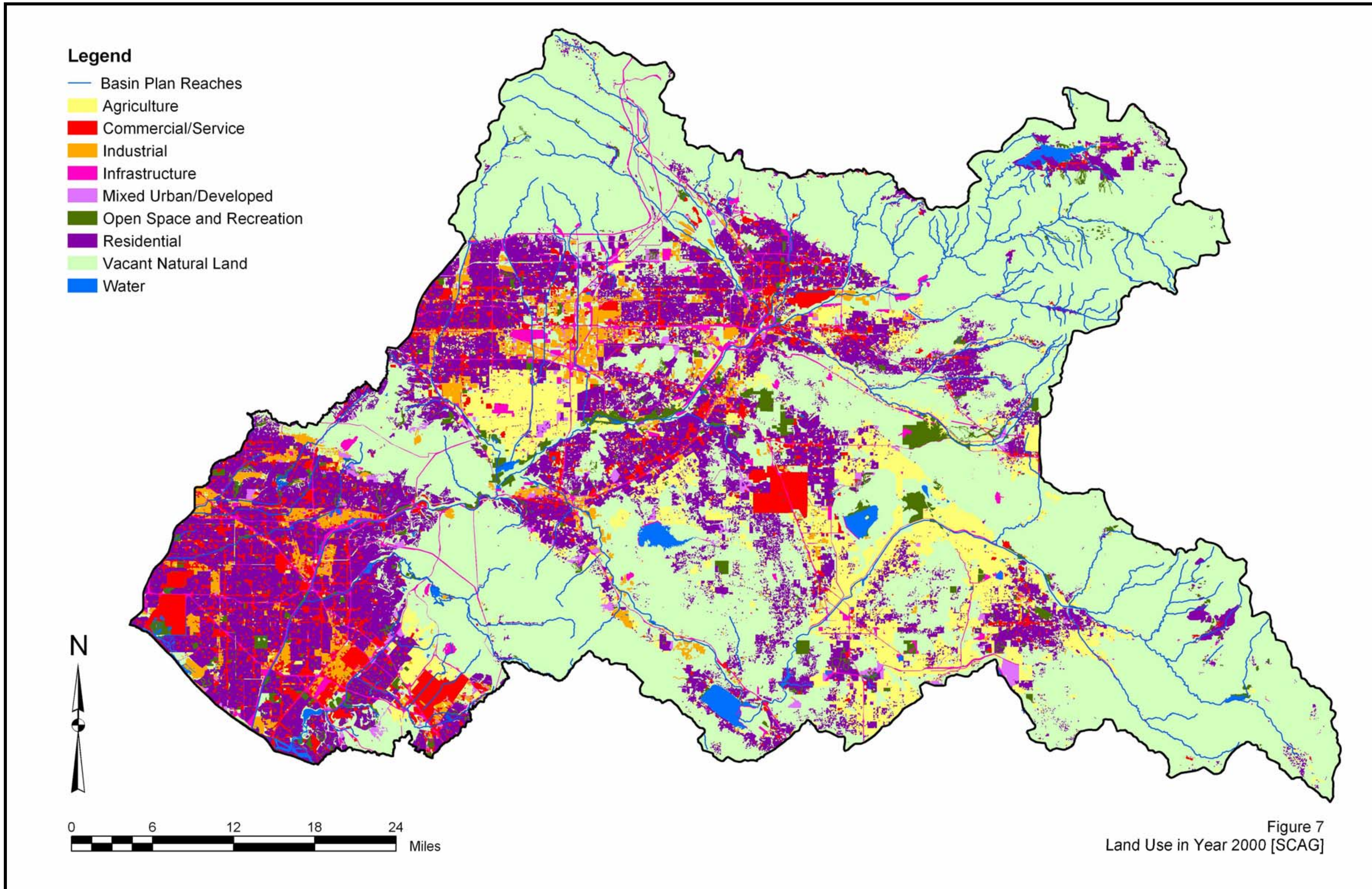


Figure 7
Land Use in Year 2000 [SCAG]

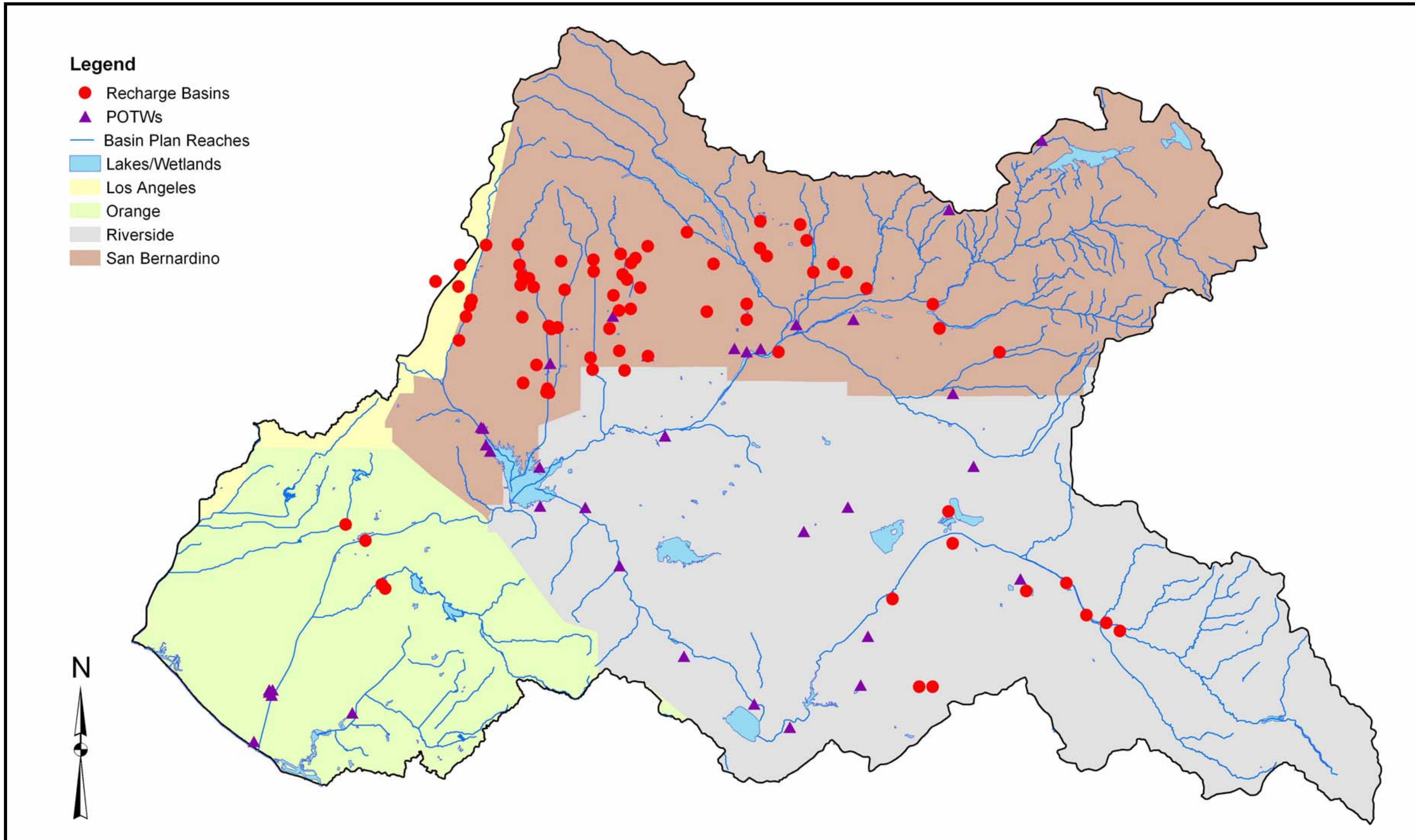


Figure 8
Surface Water Basins with Potential Bacteria Reduction and POTWs within the Santa Ana Basin

Technical Memorandum 2
Recreational Use Inventory

The Santa Ana Basin Water Quality Control Plan ("Basin Plan") (1995) designates nearly all waters and their tributaries with both water contact recreation (REC-1) and non-contact water recreation (REC2) beneficial uses. In addition, all waters not specifically listed in the Basin Plan that are tributary to waters with a REC-1 beneficial use are by default presumed to have a REC-1 use. Although the Basin Plan uses this blanket approach for protecting recreational uses in the region, little documentation exists regarding actual or existing recreational use in many of basin's waters. This lack of documentation is especially true for the undesignated tributaries, many of which are channels that were constructed for the purpose of capturing and moving stormwater flows.

With the exception of the coastal beaches, few inland waters in the Santa Ana River basin are obvious or typical water contact waterbodies, i.e., locations such as Big Bear Lake and Lake Perris which have permanent water and public facilities that support or encourage water contact recreation activity. Instead, the majority of waters that do have sufficient water to support some kind of recreational activity are posted to limit or prohibit water contact recreation, e.g., Santa Ana River.

The Stormwater Quality Standards Study Task Force is evaluating the applicability of the classification and designation of recreational beneficial uses in the Santa Ana River Watershed and documenting, to the extent practical, existing and potential recreational uses in the Santa Ana basin. To support this effort, this technical memorandum was prepared to document what is known regarding existing and potential recreational uses within the receiving waters in the watershed. The types of information gathered for this effort included:

- The Santa Ana Integrated Watershed Plan, Environmental and Wetlands Component (SAWPA 2002) regional planning document;
- Identification of known waters where water contact recreation is planned and encouraged;
- Review of recreational use surveys;
- Site-specific information from specific study sites;
- Informal observations and anecdotal reports; and
- Other regional land use plans or reports that document existing and planned recreational opportunities associated with the Santa Ana River and tributaries.

Santa Ana Watershed Recreational Use Designations

Waters in the Santa Ana Basin are protected with REC-1 and REC-2 beneficial uses. The Basin Plan defines these uses in the following manner:

- <u>Water Contact Recreational (REC-1)</u>: Waters are used for recreational activities involving body contact where ingestion of water is reasonably possible. These uses may include, but are not limited to swimming, wading, water skiing, skin and scuba diving, surfing, whitewater activities, fishing, and use of natural hot springs

- <u>Non-contact Water Recreation (REC-2)</u>: Waters are used for recreational activities involving proximity to water, but not normally involving body contact where ingestion of water would be reasonably possible. These uses may include, but are not limited to picnicking, sunbathing, hiking, beachcombing, camping, boating, tide pool and marine life study, hunting, sightseeing, and aesthetic enjoyment in conjunction with the above activities.

These definitions include the following supporting footnote:

> "The REC-1 and REC-2 beneficial use designations assigned to surface waterbodies in this Region should not be construed as encouraging recreational activities. In some cases, such as Lake Mathews and certain reaches of the Santa Ana River, access to the waterbodies is prohibited because of potentially hazardous conditions and/or because of the need to protect other uses, such as municipal supply or sensitive wildlife habitat. Where REC-1 or REC-2 is indicated as a beneficial use in Table 3-1 [of the Basin Plan], the designations are intended to indicate that the uses exist or that the water quality of the waterbody could support recreational uses."

Attachment A provides a list of the waterbodies with designated recreational uses in the Basin Plan. An "X" indicates that the waterbody has an existing or potential use. Some of the existing uses are well-established, many are not. Lakes and streams may have potential beneficial uses established because local activities or land use plans already exist to establish these uses, or because conditions (e.g., location, demand) make such future use likely. The establishment of a potential beneficial use serves to protect the quality of that water for such eventual use. An "I" in Attachment A indicates that the waterbody has an intermittent beneficial use. This may occur because water conditions do not allow the beneficial use to exist year-round, i.e., flow ephemeral or seasonally intermittent.

The listing of waters within the Basin Plan attempts to include all significant surface streams and bodies of water. Specific waters which are not listed have the same beneficial uses as the streams, lakes, or reservoirs to which they are tributary. Therefore, by this "tributary rule", the recreational uses are extended to local natural tributaries and urban storm drain channels.

Existing Recreational Uses

Established Recreational Areas

The Santa Ana Integrated Watershed Plan Environmental and Wetlands Component (SAWPA 2002) provides baseline information on existing recreational use areas in the Santa Ana River Watershed (Figure 1). This information was supplemented with anecdotal information from conversations with county officials and park rangers, information from the Parks and Open Space District, Flood Control District, Health & Sanitation Department websites, and readily accessible planning documents.

Within each of the counties there are water bodies which have recreational beaches such as the coastal beaches of Orange County, Big Bear Lake and Lake Yucaipa Regional Park in San Bernardino County, and Lake Perris in Riverside County. Recreational uses are also encouraged and supported at localized areas within the Santa Ana River Watershed. Park land within the three aforementioned counties totals 75 square miles (Santa Ana Integrated Watershed Plan Environmental and Wetlands Component).

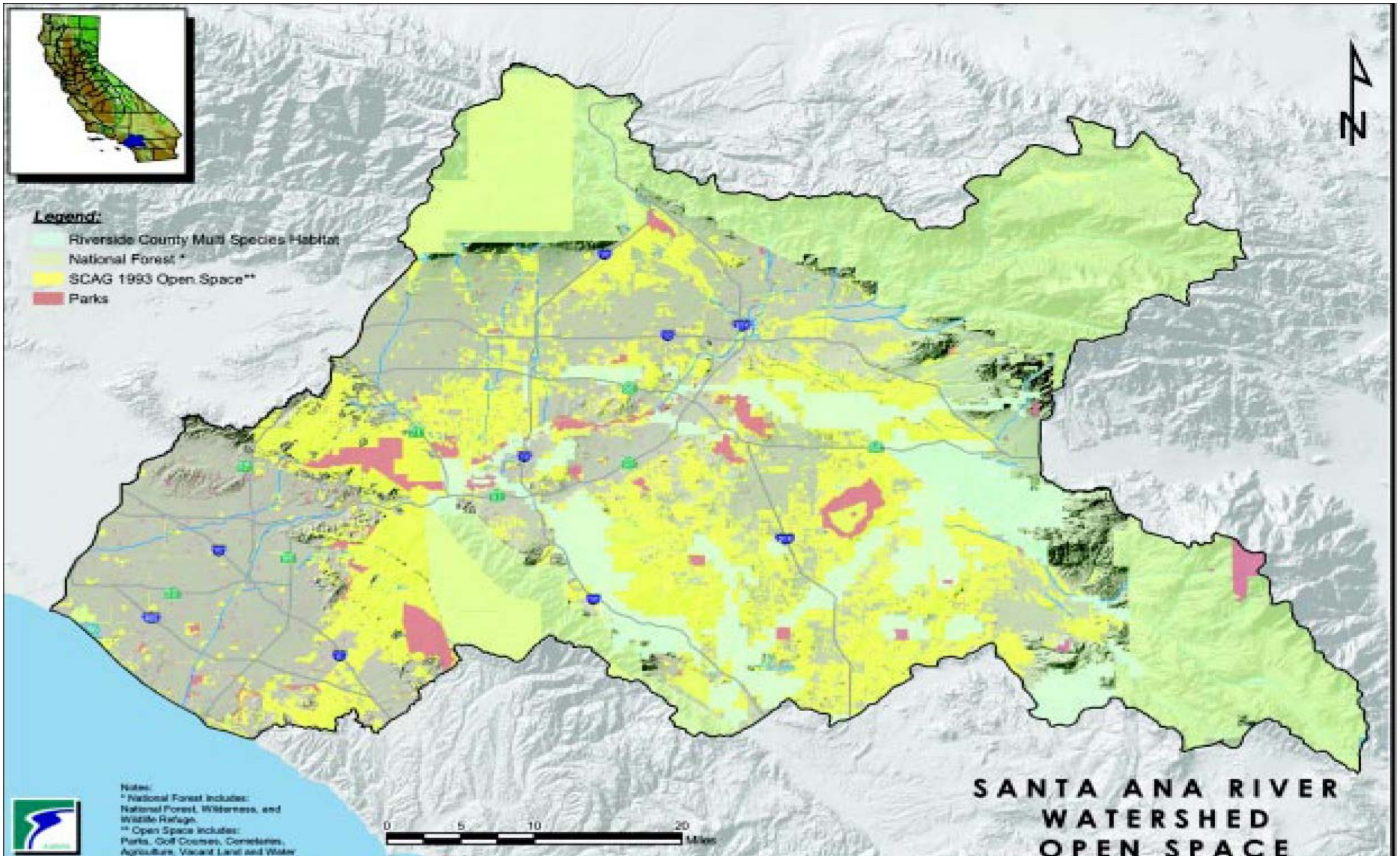
The following sections will provide a summary of existing recreational areas and ordinances applicable to recreational use.

San Bernardino County

SAWPA (2002) identifies 12 regional parks in San Bernardino County within the Santa Ana Basin (Table 1). Swimming is an allowable activity in several of these parks: Big Bear Lake, Canyon Wash, Cucamonga-Guasti Park, and Yucaipa Park. Most of these parks have lake habitats, and encourage swimming as a recreational activity.

Glen Helen encourages swimming, but this activity occurs in a swimming pool that is supplied by water from an onsite well.

Fishing is allowed in all San Bernardino Regional Parks and boating is allowed in about two-thirds of the parks. Activities that do not typically involve body immersion, e.g., fishing or boating, vary in their availability. Yucaipa Regional Park and Big Bear Lake have opportunities for a full variety of water recreational activities, including swimming, boating, and fishing.



Source: Santa Ana Integrated Watershed Plan, SAWPA (2002)

Figure 1
Parks. Open Space, Habitat, and National Forest in the Santa Ana Watershed

Table 1
San Bernardino County Recreational Use at Water Bodies and Open Space Areas within Santa Ana Basin

Name	Picnic	Habitat	Swimming	Boating	Fishing	Trails
Baldwin Lake	•	•		•	•	•
Big Bear Lake	•	•	•	•	•	•
Bear Creek	•	•			•	•
Mill Creek	•	•			•	•
Canyon Wash	•	•	•		•	•
Lytle Creek	•	•			•	•
San Timoteo Wash	•	•			•	•
Glen Helen	•	•	•	•	•	•
Yucaipa Park	•	•	•	•	•	•
Prado Park	•	•		•	•	•
Cucamonga-Guasti Park	•	•	•	•	•	•
San Bernardino National Forest	•	•		•	•	•

San Bernardino County recently opened a new 25-acre regional park named Colton Park. This park is located along the Santa Ana River and does not allow for swimming, but does provide opportunity for fishing in a 7-10 acre lake located near the Santa Ana River channel.

San Bernardino County Code Title 2 (Public Morals, Safety, and Welfare), Division 8 (Property Protection), Chapter 3 (San Bernardino County Regional Parks) establishes the allowable uses for the San Bernardino Regional Parks. Section 28.037 prohibits swimming and other recreational activities, including fishing, in any Regional Park unless specifically designated for that purpose. Interviewed park rangers indicated that they rely on posted signs to prevent park users from swimming or having any type of immersion contact with water within the posted parks.

Riverside County

SAWPA (2002) identifies 23 regional parks and waterbodies in Riverside County within the Santa Ana Basin (Table 2). Only a few parks encourage water contact recreation activities where immersion is likely, i.e. Lake Elsinore and Canyon Lake. Riverside County Regional Parks prohibit certain recreational activities, including wading or bathing, within County-owned or operated parks and recreation camps (Ordinance 328.1). In parks where swimming is prohibited, signs are posted to prohibit body contact.

Table 2
Riverside County Recreational Use at Regional Parks and Water Bodies within the Santa Ana Basin

Name	Picnic	Habitat	Swimming	Boating	Fishing	Trails
Lake Elsinore	●	●	●[1]	●	●	●
Canyon Lake	●	●	●[2]	●	●	●
Mystic Lake		●		●		●
Perris Reservoir	●	●	●	●	●	●
Lake Hemet	●	●		●		●
Railroad Canyon Reservoir						●
San Jacinto River		●				●
Bautista Creek	●	●				●
Bogart Park	●	●			●	●
Box Springs Mountain		●				●
Hidden Valley Wildlife	●	●				●
Kabian Park	●	●				●
Louis Robidoux Nature	●	●				●
Martha Mxlean-Anza	●	●				●
Narrows Park	●	●				●
Rancho Jurupa Park	●	●			●	●
Hurkey Creek Park	●	●				●
Idyllwild Park	●	●				●
idyllwild Nature Center	●	●				●
Lawler Lodge Park	●	●				●
McCall Memorial Park	●	●				●
San Gorgonio Recreation	●	●	●	●	●	●
Cleveland National Forest	●	●			●	●

1 Water skiing is advertised, but swimming is not allowed at Lake Elsinore.

2 Water skiing is advertised, but swimming is not allowed at Canyon Lake.

3 Perris Reservoir is a CA Department of Water Resources reservoir.

Orange County

Both inland park and ocean park/beach recreational opportunities are available in Orange County within the Santa Ana Basin (Table 3). Swimming is authorized at only five of the parks, all of which are associated with coastal waters: Seal Beach, Sunset Beach, Huntington Beach, Newport Beach and Newport Bay. All other county parks with water-related activities limit recreation to boating and fishing. Orange County prohibits swimming, bathing, wading or other water entry in County parks unless the waterbody is designated for such activity (Title 2, Division 5, Article 3, Section 2-5-64). Similarly, Orange County prohibits swimming, bathing or entry into ocean waters where posted (Title 2, Division 5, Article 4, Section 2-5-80).

Table 3
Orange County Recreational Use at Parks, Beaches, Water Bodies, and Open Space Areas within the Santa Ana Basin

Name	Picnic	Habitat	Swimming	Boating	Fishing
Seal Beach	●	●	●	●	●
Sunset Beach	●	●	●	●	●
Huntington Beach	●	●	●	●	●
Newport Beach	●	●	●	●	●
Fairview Park	●	●			
Canyon Lake, Costa Mesa	●	●			
Talbert Nature Preserve		●			
Bolsa Chica Wetlands	●	●		●	●
Newport Bay	●	●	●	●	●
Santiago Creek	●	●			
Villa Park Reservoir		●			
Carbon Canyon Dam		●			
Santa Ana Lakes	●	●		●	●
Arroyo Trabuco		●			
Carbon Canyon Park	●	●			●
Clark Park	●	●		●	●
Craig Park	●	●		●	●
Featherly Park	●	●			
Harriett M. Wieder Park	●	●			
Irvine Park	●	●		●	●
Laguna Niguel	●	●		●	●
Mason Park	●	●		●	●
Mile Square Park	●	●		●	●
O'Neill Park	●	●			
Peters Canyon Park	●	●			
Santiago Oaks Park	●	●			
Yorba Park	●	●		●	●

California State Parks

State-operated inland parks and beach recreational opportunities are available within the Santa Ana Basin. These recreational areas include: Lake Perris, Huntington State Beach, and Corona del Mar State Beach. Lake Perris has a wide variety of recreational use activities, including swimming, fishing, and boating. Huntington and Corona del Mar State Beaches are located on coastal waters and allow swimming.

Recreational Activity

Documented Use Surveys

Significant documented recreational use surveys were not identified for receiving waters within the Santa Ana River Watershed. SAWPA plans to initiate a limited recreational use survey in the watershed (Fall 2004). However, this data will not be available in time to include in this memorandum.

Other evidence of water contact recreation in the Santa Ana basin includes: (1) SAWPA-recorded a video during a helicopter flyover of the Santa Ana River which shows individuals swimming near the Van Buren Bridge, immediately downstream of the Metropolitan Water District crossing; and (2) SAWPA photos of children and adults wading, swimming, and picnicking near the Van Buren Bridge in the summer of 2002.

Staff from the Riverside Regional Water Quality Treatment Plant conducted informal use surveys on the Santa Ana River, Van Buren Boulevard crossing from July to October 2004 (personal communication, Rodney Cruze, City of Riverside). Two locations were surveyed: (1) The mainstem Santa Ana River below the Van Buren Boulevard bridge; and (2) the effluent channel that delivers treated effluent meeting Title 22 standards to the Santa Ana River (confluence of the effluent channel and mainstem Santa Ana River is downstream of the Van Buren Boulevard bridge). Information gathered during the informal survey included number and type of people observed (e.g., adult vs. children), number of people that were wet or in the water, and number that had no contact with the water (however; it cannot be assumed that this group did not at some time come into contact with the water). The number of people observed recreating in the effluent channel greatly exceeded the number of people observed in the Santa Ana River (Table 4). Often at least a third of the people observed were children.

Table 4
Informal Recreational Use Survey - Santa Ana Riverbed at Van Buren Boulevard Crossing

Date	Time	Effluent Channel					Santa Ana River					Temperature			Comments
		People Wet		People Dry	Total Observed	% < 10 yrs old	People Wet		People Dry	Total Observed	% < 10 yrs old				
		Hair Wet	Wet blw Waist	No Contact			Hair Wet	Wet blw Waist	No Contact			< 75^0 F	75 - 90^0 F	> 90^0 F	
7/1/2004	1406				0					0			X		Sunny - no one observed
7/2/2004	1406		2	2	4	0	3	3	1	7	30		X		Sunny
7/3/2004	1430				0					0			X		Sunny - no one observed
7/4/2004	841				0					0		X			Cloudy
7/5/2004	1240		3	6	9	10				0			X		Sunny
7/6/2004	1345				0					0				X	Sunny - no one observed
7/8/2004	830			7	7	0				0			X		Sunny
7/9/2004	1245				0					0			X		Sunny
7/9/2004	1408				0					0			X		Sunny
7/10/2004	1320				0					0			X		Sunny
7/11/2004	1210		1		1	0				0			X		Sunny
7/14/2004	1453				0					0				X	Sunny
7/15/2004	1340				0					0				X	Sunny
7/15/2004	1435				0					0				X	Sunny
7/16/2004	1440	7			7	30				0				X	Sunny - swimmers at outfall
7/17/2004	1310	9	1		10	30				0				X	Sunny
7/18/2004	1430	3	9	4	16	13				0				X	Sunny
7/20/2004	1450		2	2	4	0				0			X		Sunny
7/23/2004	1448		3		3	33				0				X	Sunny

Table 4 (continued)
Informal Recreational Use Survey – Santa Ana Riverbed at Van Buren Boulevard Crossing

Date	Time	Effluent Channel					Santa Ana River					Temperature			Comments
		People Wet		People Dry	Total Observed	% < 10 yrs old	People We		People Dry	Total Observed	% < 10 yrs old				
		Hair Wet	Wet blw Waist	No Contact			Hair Wet	Wet blw Waist	No Contact			< 75^0 F	75 - 90^0 F	> 90^0 F	
7/24/2004	1337	9	2		11	35				0				X	Sunny
7/25/2004	1215	1	1	1	3	33				0				X	Sunny
7/30/2004	1435				0					0			X		Sunny
8/1/2004	1000				0					0			X		Sunny - no one observed
8/5/2004	1500				0					0			X		Sunny
8/7/2004	1435	15		2	17	12	1			1	0			X	Sunny
8/8/2004	1430	5	6	2	13	46				0				X	Sunny
8/9/2004	1430				0					0				X	Sunny
8/14/2004	1443	6	2	2	10	0	5	9	0	14	1		X		Sunny
8/15/2004	1450	0	1	2	3	0	3	3	0	6	0			X	Sunny
8/20/2004	1455	0	0	1	1	0				0			X		Sunny w/Clouds
8/21/2004	1435				0		2	0	6	8	0		X		Sunny
8/22/2004	1450	9	4	3	16	1				0			X		Sunny
8/26/2004	1450				0		6	0	6	12	0		X		Sunny
8/27/2004	1445				0					0			X		Sunny
8/28/2004	1450	0	5	0	5	0	5	0	2	7	0		X		Sunny
8/29/2004	1506	1	1	2	4	0					0		X		Sunny
9/2/2004	1440				0					0				X	Sunny
9/3/2004	1430	1	0	3	4	0				0			X		Sunny
9/4/2004	1455	4	0	0	4	0				0				X	Sunny
9/5/2004	1440	0	0	7	7	0	0	2	0	2	0			X	Sunny

Table 4 (continued)
Informal Recreational Use Survey – Santa Ana Riverbed at Van Buren Boulevard Crossing

Date	Time	Effluent Channel					Santa Ana River					Temperature			Comments
		People Wet		People Dry	Total Observed	%<10 yrs old	People Wet		People Dry	Total Observed	%<10 yrs old				
		Wet Hair	Wet blw Waist	Not Contact			Hair Wet	Wet blw Waist	No Contact			< 75⁰ F	75 - 90⁰ F	> 90⁰ F	
9/6/2004	1430	10	5	0	15	1	10	30	3	43	1			X	Sunny
9/8/2004	1438				0					0				X	Sunny, Very Hot
9/9/2004	1444				0		1	1	0	2	0			X	Sunny, Cloudy, Hot, & Humid
9/10/2004	1440	0	0	1	1	0				0				X	Sunny, Cloudy, Hot, & Humid
9/11/2004	1450	8	2	1	11	1	14	3	0	17	1			X	Sunny, Cloudy, Hot, & Humid
9/12/2004	1440	0	0	3	3	0				0				X	Sunny
9/16/2004	1450				0					0			X		Sunny
9/19/2004	1200				0					0			X		Sunny
9/20/2004	1300				0					0			X		Sunny
9/30/2004	1455				0		0	0	1	1	0		X		Cloudy, relatively cool
10/2/2004	1444				0					0			X		Partly cloudy, warm
10/3/2004	1430				0					0			X		Sunny
10/6/2004	1442				0					0			X		Sunny, breezy
10/7/2004	1500				0					0				X	Sunny
10/9/2004	1442				0		0	0	2	2	0		X		Sunny - 2 People on horseback
10/10/2004	1450				0					0			X		Sunny
10/13/2004	1441				0					0			X		Sunny
10/14/2004	1446				0					0				X	Hot!
10/15/2004	1441				0					0			X		Breezy
10/16/2004	1436				0					0		X			Cloudy

Recreational Evaluation of Study Sites

As discussed further in Technical Memorandum 3 for this study, six study sites were selected for detailed characterization. These sites represent archetypes, or examples of differing types of waterbodies in the region, e.g., natural, partially natural but modified channel or banks, and fully concrete lined channels.

Risk Sciences, Inc. developed scoring criteria which were designed to provide a discussion tool for evaluating the recreational use potential and appeal of various waterbodies within the Santa Ana River Watershed. The following criteria were ranked from 0 (poor recreational habitat and/or appeal) to 3 (good recreational habitat and/or appeal):

- Direct Evidence of Water Contact Recreation – Direct observations of people recreating in the water (0 = no observation; 3 = people actually in the water).
- Indirect Evidence of Recreational Activity – Measures evidence that people are occasionally present at the site, e.g., graffiti, recreational trash (bottles, soda cans, etc), fishing line, and human paths to the channel; however, no evidence exists that visitors actually enter the water (0 = no evidence of recreational activity; 3 = evidence observed, e.g., fishing line, footprints, graffiti).
- Ease of Access – Measure of degree of difficulty to access the waterbody because of fencing, gates, locks, etc. (0 = inaccessible; 3 = easily accessible).
- Channel Slope – Measure of the type of slope, e.g., trapezoidal vs. rectangular (0 = box channel, 90° slopes; 3 = gentle slope)
- Channel Type – Measure of degree of naturalness, ranging from completely natural bottom and banks to completely constructed concrete channel (0 = bottom and banks are concrete; 3 = natural bank and channel bottom).
- Flow Depth & Volume – Measure of the degree that instream flow is sufficient for water contact recreation, including consideration of children (0 = minimal flow, not possible for adults or children to immerse themselves in the water; 3 = sufficient flow for immersion at least by children).
- Flow Velocity – Measure of the degree that flow velocity is dangerous for recreational activity (0 = high velocity, flow is dangerous; 3 = velocity is safe for recreational activity).
- Water Quality (Aesthetics) – Measure of how appealing the water is for recreation (0 = poor quality, e.g., lots of algae, trash; 3 = very appealing, water is an attractant).

- Vegetation Quality – Measure of quality of bank habitat for recreational activity (0 = no cover or shade for visitors; 3 = sufficient cover or shade).
- Adjacent Land Use – Measure of type of nearby land use (0 = site is adjacent to industrial parks; 3 = site is in a residential area).

Each study site was scored based upon the above criteria, and the results are shown in Table 5. The scoring was performed by consultants to the Task Force for each study site. The same criteria were used by members of the Task Force to score similar sites during field trips conducted as part of study workshops. Table 5 does not represent scoring performed during the Task Force workshop field trips.

Table 5
Evaluation of Recreational Appeal at Sites

Evaluation Criteria (Scale: Low - 0 to High - 3)	Temescal Creek at Lincoln (upstream)	Temescal Creek at Lincoln (downstream)	Santa Ana Delhi Channel	Chino Creek at Schaeffer Ave	Santa Ana River at Imperial Highway	Santa Ana River at MWD Crossing	Icehouse Canyon
Direct Evidence of Water Contact Recreation	0	1	0	0	0	0	3
Indirect Evidence of Water Contact Recreation	2	2	0	1	1	3	3
Ease of Access	2	3	0	1	1	2	3
Channel Slope	2	3	0	2	2	3	2
Natural or Concrete	1	3	0	0	0	3	3
Flow Depth & Volume	1	2	1	0	3	3	1
Flow Velocity	2	2	0	1	1	3	2
Water Quality-Aesthetics not Chemistry	1	2	0	0	2	2	3
Vegetation Quality	0	3	0	1	0	2	3
Adjacent Land Use	1	1	1	0	1	1	3

While the results of this scoring cannot be used as a substitute for an appropriately designed recreational use survey, the results do provide information on the range of actual or presumed use and recreational appeal present in different types of waters in the Santa Ana River watershed. A brief summary of the findings for each study site follows.

Temescal Creek at Lincoln Avenue
Recreational opportunity at Temescal Creek at Lincoln Avenue varied depending upon whether one visited the upstream or downstream side of Lincoln Avenue. Because of this variability, two evaluations were prepared (Table 5).

Direct evidence of water contact recreation was not observed upstream or downstream of Lincoln Avenue; limited indirect evidence of recreational activity was observed (e.g., foot trails traced to the stream). Fencing limited access from Lincoln Road, and signs prohibiting trespassing were posted near locked gates. However, both sites were easily accessible simply by walking around the fence. Channel slopes were easy to walk on and provided easy access to the stream. Natural habitat was present downstream, but a modified channel (concrete banks) was present upstream. Low flow depth and volume limit water contact recreation opportunities.

Santa Ana Delhi Channel
Direct or indirect evidence of recreational activity was not observed at the Santa Ana Delhi Channel. The site is fenced, has a locked gate and posted signs warning people to stay away from the water. The channel is boxed shape; approximately 55 feet wide. During dry weather, low flow coupled with a slow flow velocity and shallow depth conditions limited water contact recreational opportunities at this site.

Chino Creek at Schaeffer Avenue
Water contact recreation activity was not observed at the Chino Creek at Schaeffer Avenue site; however, indirect evidence of recreational activity, e.g., graffiti and human made walk paths that led to Chino Creek was observed. The channel is concrete. Normally, this site is fenced and access is severely restricted; however, at the time of the site visit, an access gate was unlocked and open. The presence of a gentle channel slope provided easy access to the stream bottom. According to County environmental health staff that collect water quality data in the Riverside area, occasional incidental water contact at Chino Creek at Schaeffer has been observed at this site from time to time. Overall, the recreational appeal was very low, primarily because of presence of trash, low flow, low depth, and odors.

Santa Ana River at Imperial Highway
The Santa Ana River at this site is entirely fenced with signs posted prohibiting access to the river. Direct evidence of water contact recreation was not observed. Indirect evidence of recreational activity in the area included footprints and trails leading to the river. Flow depth and volume were sufficient for water contact recreation to occur. In terms of aesthetics, water quality was attractive for contact recreation. The channel was modified, with a mix of natural bottom and rip-rap banks.

Santa Ana River at MWD Crossing
Direct evidence of recreational water use was not observed during this evaluation, but data from the Riverside Regional Water Quality Treatment Plant during summer 2004 indicate that this reach of the river is occasionally used for water contact recreation (this activity occurs in spite of posted bilingual signs warning the public to stay away from the water). The Santa Ana River has a natural channel in this area and under dry weather conditions flow volume and velocity are appropriate to support water contact recreational activity. In addition, water quality aesthetics and vegetation quality serve to improve the overall recreational appeal of the site.

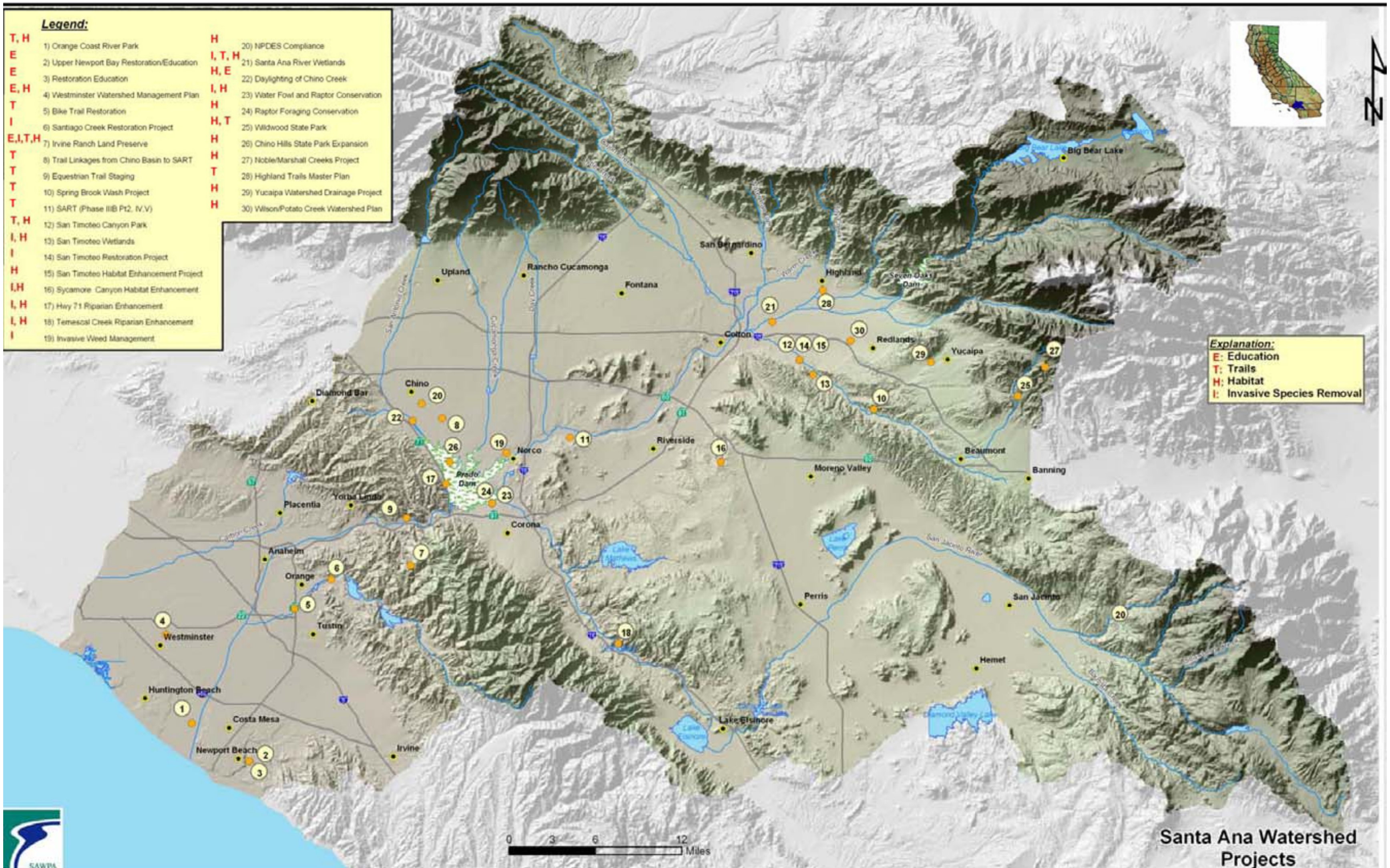
Icehouse Canyon
Icehouse Canyon Creek is located alongside a regularly utilized hiking trail in the Angeles National Forest in the upper part of the Chino Creek watershed. Direct evidence of water contact recreation was not observed, but the creek, which has a sustained baseflow throughout most years, includes several pools and other areas where visitors could likely recreate. Access to the site is easy and water quality aesthetics, vegetation, and land use have good recreational appeal.

Potential Recreational Uses

Orange, Riverside, and San Bernardino Counties have designated parks, open space, habitat, and recreational amenities (i.e., designated bikeways, walking, hiking, equestrian trails) within their General Plans and other adopted land use planning documents. There are a number of recreational use areas planned for development within the Santa Ana Watershed. The Santa Ana Integrated Watershed Plan Environmental and Wetlands Component (SAWPA 2002) provides baseline information on other recreational use areas in the Santa Ana River Watershed (Figure 2). The following inventory does not attempt to describe all of the planned recreational use areas, but rather, provide highlights of potential key projects in the watershed.

Natural Wetlands Restoration – Regional planners have been working towards restoring natural wetlands to provide high value habitat, recreation, and educational opportunities (SAWPA 2002). Examples of potential projects include:

- Bolsa Chica Wetlands Restoration
- Chino Creek Treatment Wetlands
- River Road Treatment Wetlands; and
- Lake Elsinore Aeration and Fisheries Restoration



Source: Santa Ana Integrated Watershed Plan, SAWPA (2002)

Figure 2
Other Recreational Opportunities within the Santa Ana River Watershed

Santa Ana River Trail – Regional recreation development efforts are focused on the Santa Ana River Trail. First conceived over a century ago and formally proposed in 1955, the Santa Ana River Trail is a much-anticipated project with watershed-wide support. Watershed planning participants agree that the trail should provide access for a wide variety of users, including walkers, hikers, joggers, bicyclists and horseback riders. While the 110-mile trail is far from complete, several segments, totaling approximately 40 miles, have been constructed. Plans are almost complete for the remaining 70 miles (as well as a number of feeder trails and connections), and full funding has been secured for some segments.

San Timoteo State Park - Riverside Lands Conservancy with the support of other organizations is developing a plan to create a new State park centered in the San Timoteo Creek Watershed. The park will provide a number of linkages with other recreational areas in Riverside County, and create, restore, and protect wetlands in the floodplains of the canyon and its major tributaries from Loma Linda to I-10.

Orange Coast River Park - The Friends of Harbors, Beaches, and Parks, with cooperation from many partners, including local cities, Orange County nonprofit organizations, and private entities, have proposed a large park at the mouth of the Santa Ana River. The Orange Coast River Park, which may include Banning Ranch, would link several existing parks, incorporating ponds, boardwalks, and habitat restoration.

"String of Pearls" (a series of parks along Santiago Creek) - Local cities and organizations are acquiring land to add a series of new parks along Santiago Creek ("string of pearls"), a major tributary in the lower Santa Ana watershed. These parks would provide recreational and educational benefits, in addition to habitat and water quality benefits. The City of Orange has recently acquired eight acres of land to be included in the 42-acre Grijalva Park on Santiago Creek. The City also owns Yorba Park that borders the Santiago Creek just south of Chapman Avenue and Hart Park, which includes several acres of unimproved land in the creek. The County of Orange and City of Santa Ana incorporate additional parks upstream and downstream from the City of Orange. These public entities, along with the City of Villa Park, are working to connect these parks with a contiguous recreational trail system.

Chino Creek Park - The Inland Empire Utilities Agency, Orange County Water District, and the Wildlands Conservancy are developing an integrated recreational plan that will link Prado Basin with the Santa Ana River Trail System providing habitat, recreational and educational opportunities. Plans include an educational center at Chino Creek Park and a nursery designed specifically to grow native plants for restoration projects. A Prado Basin interpretative center and youth camp for inner-city children will be developed where a gun club is currently located.

Attachment A
Recreational Beneficial Uses in Santa Ana River Basin

Ocean Waters	Designation	
	REC-1	**REC-2**
Nearshore Zone		
San Gabriel River to Poppy Street in Corona del Mar	X	X
Poppy Street to Southeast Regional Boundary	X	X
Offshore Zone		
Waters between Nearshore Zone and Limit of State Waters	X	X
Bays, Estuaries, and Tidal Prisms	**Designation**	
	REC-1	**REC-2**
Anaheim Bay – Outer Bay	X	X
Anaheim Bay – Seal Beach National Wildlife Refuge	X[1]	X
Sunset Bay – Huntington Harbour	X	X
Bolsa Bay	X	X
Bolsa Chica Ecological Reserve	X	X
Lower Newport Beach	X	X
Upper Newport Beach	X	X
Santa Ana River Salt Marsh	X	X
Tidal Prism of Santa Ana River (to within 1000' of Victoria Street) and Newport Slough	X	X
Tidal Prism of San Gabriel River – River Mouth to Marina Drive	X	X
Tidal Prisms of Flood Control Channels Discharging to Coastal or Bay Waters	X	X

Attachment A (continued)
Recreational Beneficial Uses in Santa Ana River Basin

Surface Stream	Designation	
	REC-1	REC-2
Lower Santa Ana River		
Santa Ana River		
Reach 1-Tidal Prism to 17th Street	X[2]	X
Reach 2-17th Street to Prado	X	X
Aliso Creek	X	X
Carbon Canyon Creek	X	X
Santiago Creek		
Reach 1-Below Irvine Lake	X[2]	X
Reach 2-Irvine Lake	X	X
Reach 3-Irvine Lake to Modjeska Canyon	I	I
Reach 4-Modjeska Canyon	X	X
Silverado Creek	X	X
Black Star Creek	I	I
Ladd Creek	I	I
San Diego Creek		
Reach 1-Below Jeffrey Road	X[2]	X
Reach 2-Above Jeffrey Road	I	I
Other Tributaries: Bonita Creek, Serrano Creek, Peters Canyon Wash, Hicks Canyon Wash, Bee Canyon Wash, Borrego Canyon Wash, Agua Chinon Wash, Laguna Canyon Wash, Rattlesnake Canyon Wash, Sand Canyon Wash, and other tributaries to these Creeks	I	I
San Gabriel River		
Coyote Creek within SA Regional Boundary	X	X

Attachment A (continued) Recreational Beneficial Uses in Santa Ana River Basin		
Lakes and Reservoirs		
Anaheim Lake	X	X
Irvine Lake (Santiago Reservoir)	X	X
Laguna, Lambert, Peters Canyon, Rattlesnake, Sand Canyon, and Siphon Reservoirs	X[7]	X
Upper Santa Ana River		
Santa Ana River		
Reach 3-Prado Dam to Mission Blvd. in Riverside	X	X
Reach 4-Mission Blvd to San Jacinto Fault in San Bernardino	X[3]	X
Reach 5-San Jacinto Fault to Seven Oaks Dam	X[3]	X
Reach 6-Seven Oaks Dam to Headwaters	X	X
Mills Creek		
Reach 1-Confluence w/ SAR to Bridge Crossing Route 38	I	I
Reach 2-Bridge Crossing Route 38 to Headwaters	X	X
Mountain Home Creek	X	X
Mountain Home Creek, East Fork	X	X
Monkey Face Creek	X	X
Alger Creek	X	X
Vivian Creek	X	X
High Creek	X	X
Other Tributaries: Lost, Oak Cove, Green, Skinner, Momyer, Glen Martin, Camp, Hatchery, Rattlesnake, Slide Snow, Bridal Veil, and Oak Creeks and other Tributaries to these Creeks	I	I
Bear Creek		
Bear Creek	X	X
Siberia Creek	X	X

Attachment A (continued) Recreational Beneficial Uses in Santa Ana River Basin		
Slide Creek	I	I
All other tributaries to these Creeks	I	I
Big Bear Lake Tributaries		
North Creek	X	X
Metcalf Creek	X	X
Grout Creek	X	X
Rathbone Creek	X	X
Meadow Creek	X	X
Summit Creek	I	I
Other Tributaries ot Big Bear Lake: Knickerbocker, Johnson, Minnelusa, Polique, and Red Ant Creeks and other Tributaries to these Creeks	I	I
Baldwin Lake Drainage		
Shay Creek	X	X
Other Tributaries to Baldwin Lake: Wawmill, Green, and Caribou Canyons, and other Tributaries to these Creeks	I	I
Other Streams Draining to SAR		
Canjon Creek	X	X
City Creek	X	X
Devil Canyon Creek	X	X
Eash Twin and Strawberry Creeks	X	X
Waterman Canyon Creek	X	X
Fish Creek	X	X
Forsee Creek	X	X
Plunge Creek	X	X
Barton Creek	X	X

Attachment A (continued) Recreational Beneficial Uses in Santa Ana River Basin		
Bailey Canyon Creek	I	I
Kimbark Canyon, East Fork Kimbark Canyon, Ames Canyon, and West Fork Cable Canyon Creeks	X	X
Valley Reaches of Above Streams	I	I
Other Tributaries: Alder, Badger Canyon, Bledsoe Gulch, Borea Canyon, Breakneck, Cable Canyon, Cienega Seca, Cold, Converse, Coon, Crystal, Deer, Elder, Fredalba, Frog, Government, Hamilton, Heart Bar, Hemlock, Keller, Kilpecker, Little, Mill, Little Sand Canyon, Lost, Meyer Canyon, Mile, Monroe, Canyon, Oak, Rattlesnake, Round Cienega, Sand, Schneider, Staircase, Warm Springs Canyon, and Wild Horse Creeks and other Tributaries to these Creeks	I	I
San Gabriel Mountain Streams		
San Antonio Creek	X	X
Lytle Creek and Coldwater Canyon Creek	X	X
Day Creek	X	X
East Etiwanda Creek	X	X
Valley Reaches of Above Streams	I	I
Cucamonga Creek		
Reach 1-Confluence w/Mill Creek	X[3]	X
Reach 2-Upland to headwaters	X	X
Mills Creek (Prado Area)	X	X
Other Tributaries: Cajon Canyon, San Sevaine, Deer, Duncan Canyon, Henderson Canyon, Bull, Fan, Demens, Thorpe, Angalls, Telegraph Canyon, Stoddard Canyon, Icehouse Canyon, Cascade Canyon, Cedar, Falling Rock, Kerkhoff, and Cherry Creeks and other Tributaries to these Creeks	I	I
San Timoteo Creek		
Reach 1-SAR confluence to gage at San Timoteo Canyon Rd	I[3]	I
Reach 2-Gage at Canyon Rd to Confluence w/ Yucaipa Creek	X	X
Reach 3-Confluence w/ Yucaipa Creek to Bunker Hill II	X	X
Reach 4-Bunker Hill II to Confluence w/Little San Gorgonio and Noble Creeks	X	X

Attachment A (continued) Recreational Beneficial Uses in Santa Ana River Basin		
Oak Glen, Potato Canyon, and Birch Creeks	X	X
Little San Gorgonio Creek	X	X
Yucaipa Creek	I	I
Other Tributaries to these Creeks Valley Reaches	I	I
Other Tributaries to these Creeks Mountain Reaches	I	I
Anza Park Drain	X	X
Sunnyslope Channel	X	X
Tequesquite Arroyo (Sycamore Creek)	X	X
Chino Creek		
Reach 1-SAR confluence to beginning of concrete-lined channel south of Los Serranos Rd.	X	X
Reach 2-Beginning of concrete lined channel south of Los Serranos Rd. to Confluence with San Antonio Creek	X[3]	X
Temescal Creek		
Reach 1A-SAR confluence w/ Lincoln Ave	X[4]	X
Reach 1B-Lincoln Ave. to Riverside Canal	X[4]	X
Reach 2- Riverside Canal to Lee Lake	I	I
Reach 3- Lee Lake	X	X
Reach 4-Lee Lake to Mid Section Line of Section 17	I	I
Reach 5- Mid Section Line of Section 17 To Elsinore Groundwater	X	X
Reach 6- Elsinore Groundwater to Lake Elsinore Outlet	I	I
Coldwater Canyon Creek	X	X
Bedford Canyon Creek	I	I
Dawson Canyon Creek	I	I
Other Tributaries to these Creeks	I	I

Attachment A (continued) Recreational Beneficial Uses in Santa Ana River Basin		
Lakes and Reservoirs		
Baldwin Lake	I	I
Big Bear Lake	X	X
Erwin Lake	X	X
Evans Lake	X	X
Jenks Lake	X	X
Mathews Lake	X[5]	X
Mockingbird Reservoir	X[6]	X
Norconian Lake	X	X
San Jacinto River Basin		
Reach 1-Lake Elsinore to Canyon Lake	I	I
Reach 2- Canyon Lake	I	I
Reach 3- Canyon Lake to Nuevo Road	I	I
Reach 4- Nuevo Road to North-South Mid Section Line	I	I
Reach 5-North-South Mid Section Line to Confluence w/ Popppet Creek	I	I
Reach 6- Popppet Creek to Cranston Bridge	I	I
Reach 7- Cranston Bridge to Lake Hemet	X	X
Bautista Creek-Headwater to Debris Dam	X	X
Strawberry Creek and San Jacinto River, North Fork	X	X
Fuller Mill Creek	X	X
Stone Creek	X	X
Salt Creek	I	I
Other Tributaries: Logan, Black Mountain, Juaro Canyon, Indian, Hurkey, Poppet, and Protrero Creeks and other Tributaries to these Creeks	I	I

Attachment A (continued) Recreational Beneficial Uses in Santa Ana River Basin		
Lakes and Reservoirs		
Canyon Lake	X	X
Elsinore Lake	X	X
Fulmor Lake	X	X
Hemet Lake	X	X
Perris Lake	X	X
Wetlands		
San Joaquin Freshwater Marsh	X	X
Shay Meadows	I	I
Stanfield Marsh	X	X
Prado Flood Control Basin	X	X
San Jacinto Wildlife Preserve	X	X
Glen Helen	X	X

I Intermittent Beneficial Use
X Present or Potential Beneficial Use
1 No access per agency with jurisdiction (U.S. Navy)
2 Access prohibited in all or part by Orange County Resources Development Management Department (RDMD)
3 Access prohibited in some portions by San Bernardino County Flood Control
4 Access prohibited in some portions by Riverside County Flood Control
5 Access prohibited by the Metropolitan Water District
6 Access prohibited by the Gage Canal Company (owner-Operator)
7 Access prohibited by Irvine Ranch Company

Technical Memorandum 3
Flow and Water Quality Data Inventory and Characterization

Data Inventory

Flow Data Inventory

Numerous flow monitoring stations are operated by several agencies throughout the Santa Ana River Watershed. The location of each station was mapped and described within the Receiving Water and Watershed Inventory Mapping technical memorandum. The data record available at each location varies in length of time, and interval of measurement (daily readings vs. hourly readings). Some flow gauging stations were operational for very short periods, such as for a targeted wet season and then removed. Many of the currently operating flow gauging stations implemented smaller interval (15 or 30 minute) flow measurement in the late 1980s or early 1990s. Mean daily flow records are available for longer periods of record at these and other sites, generally dating back to the 1960s and 1970s.

The US Geological Survey (USGS) has flow records for 140 gauging stations within the Santa Ana River Watershed. Many of these stations have been removed or were passed on to local flood control districts and therefore are no longer operated by the USGS. Some of these USGS flow gauging stations monitor effluent channels, power plant outtakes, and other diversions of runoff. There are also many USGS flow gauging stations that record runoff rates in inland surface waters. The Riverside County Flood Control District is operating 4 flow gauging stations within the Santa Ana River Watershed. These stations began recording in the beginning of 2001. The San Bernardino County Flood Control District has flow records for 40 gauges within the Santa Ana River Watershed, 31 of which are located in the Chino basin. Few flow gauging stations are operated along mountain streams in the San Bernardino National Forest or along tributaries to Big Bear Lake. The Orange County Resource and Development Management Department (RDMD) is currently operating 13 flow gauging stations in the Santa Ana River Watershed. These stations are primarily along channels that have been modified or engineered to facilitate urban flood hazard protection.

Bacteriological Data Inventory

Available indicator bacteriological water quality data collected from receiving waters within the Santa Ana River Watershed during dry weather and wet weather seasonal sampling was requested from Storm Water Quality Task Force members as well as participants from other agencies. This request was made specifically with the County of Orange, County of Riverside, County of San Bernardino, Santa Ana Watershed Protection Authority (SAWPA), and the Regional Water Quality Control Board (RWQCB) - Region 8. Each agency responded to these requests as part of its participation on the Task Force. Requests of, and responses from these and other agencies are summarized below.

The Orange County Health Care Agency (OCHCA) conducts the Bacteriological Monitoring Program for the County of Orange. OCHCA provided a list of inland receiving water sampling locations within Orange County. Of those locations, two sampling locations lie within the Santa Ana River Watershed and also are upstream of tidal influence. The remaining sample locations are either beach sampling locations or located within tidal influence.

The Orange County Water District (OCWD) also provided bacteria sampling data for a sampling period between 1958 and 2004. The majority of the data is from the OCWD internal water quality database, while additional data for a period from 1999 to 2004, was extracted from the OCWD Santa Ana River Water Quality and Health (SARWQH) Study. The SARWQH Study was finalized Summer 2004.

The RWQCB provided data for sampling efforts for Chino Basin, Big Bear Lake, Santa Ana River, Lake Elsinore, Moro Canyon, San Jacinto River, and Canyon Lake. The majority of the data is from sampling efforts conducted by the RWQCB staff. The RWQCB also provided additional data not specifically collected by RWQCB staff. This particular data included bacteriological results for Big Bear Lake and Canyon Lake which were collected by Big Bear Municipal Water District (BBMWD) and Elsinore Valley Municipal Water District (EVMWD) staff, respectively.

The San Bernardino County Flood Control District (SBCFCD) represented the County of San Bernardino in providing bacteria data collected for the urbanized area NPDES stormwater program between 2000 and 2003.

The Riverside County Flood Control District (RCFCD) represented the County of Riverside in providing bacteria data. The RCFCD provided a set of bacteriological data for locations along the Santa Ana River. The data includes bacteriological data from samples collected not only by the Riverside County Health Department (1981 to 1991) but also bacteriological results from sampling along the Santa Ana River conducted by the OCHCA (1981 to 1993).

Additionally, bacteriological data was obtained from the Riverside County Health Care Department for bacteria data collected in 1985.

Additional data was obtained from agencies or organizations such as the United States Geologic Survey (USGS), Orange County Coastkeeper, and United States Environmental Protection Agency (USEPA) via its STORET Legacy Data Center.

Table 1 further describes the water quality data received from the source agencies and describes the data format, sampling dates, and agency contact information.

Data Management

Flow Data Management

For this study, available flow record data was not compiled into a single study database. Due to the ease of accessibility of flow data records, data was retrieved for each flow monitoring station as needed. Additionally, compiling a single database given the number of flow monitoring stations and the lengthy data record maintained for each station would require considerable effort.

Bacteria Data Management

Water quality data was submitted in varying formats and levels of detail. Data was provided in either hard copy format only or in electronic format from the source agencies. The data received from the source agencies all included a sampling location name, sample date, and bacteriological results. Some data, particularly samples collected more recently was provided in electronic format and included additional information such as sample time, analytical method, and sample location coordinates, etc.

Data Entry

For older sets of data, only hard copy documents were provided by the source agency. Data entry procedures and quality assurance checks were established and implemented for these datasets. These datasets included that which was provided by the RCFCD and Riverside County Health Department. Another source of data which required data entry was the Santa Ana Use Attainability study dataset obtained by Risk Sciences, Inc.

Table 1
Storm Water Quality Standards Study
Data Source Summary

Title/File Name	Description	Date	Agency From Which CDM Received Data
County of Orange			
Handout3.xls	Table showing sampling locations for OCHCA and OCSD	Jun 2004	Orange County Health Care Agency/ Monica Mazur
Bacteriological Data downloaded via the www.ocbeachinfo.com website	Sampling locations include: San Diego Creek/Campus Dr. (1994 to 2004); Santa Ana Delhi Channel (1986 to 2004)	Various	Orange County Health Care Agency/ www.ocbeachinfo.com
BacterialData_Database.xls	From OCWD water quality database	Various	Orange County Water District/ Nira Yamachika
MicrobialData_OCWD_CDM.xls	From OCSD SAR Water Quality and Health (SARWQH) Study	1999-2004	Orange County Water District/ Nira Yamachika
Feb03_BactiData.xls	Mill Creek and SAR at Imperial Highway	Feb 2004	Orange County Water District/ Nira Yamachika
Regional Water Quality Control Board (RWQCB) - Region 8			
Chino Basin			
Chino_TMDL_JanFeb04.xls	Data for Chino Basin TMDL	Jan - Feb 2004	Santa Ana RWQCB/ David Woelfel/ Bill Rice
Chino_TMDL_FebMar04.xls	Data for Chino Basin TMDL	Feb - Mar 2004	Santa Ana RWQCB/ David Woelfel/ Bill Rice
Chino_TMDL_MarApr04.xls	Data for Chino Basin TMDL	Mar - April 2004	RWQCB/ David Woelfel; Bill Rice
Big Bear Lake			
SARWQCB Knickerbocker Results_totals.xls	Knickerbocker Creek as part of pathogen TMDL	June 2003- April 2003	RWQCB/ Heather Boyd
Path_bbl.xls	RWQCB data collected in 1985, 1992, 1993, 1994, 1998; Big Bear Municipal Water District (BBMWD) data in 1994 & 1996	Various	RWQCB/ Heather Boyd

Table 1 (continued)
Storm Water Quality Standards Study
Data Source Summary

Title/ Electronic File Name	Description	Date	Agency From Which CDM Received Data
Santa Ana River			
SARBact 84.xls	Santa Ana River data collected from 1984	1984	RWQCB/ David Woelfel
SARBact 85.xls	Santa Ana River data collected from 1985	1985	RWQCB/ David Woelfel
85associatedlab.pdf	RWQCB sampling effort from 1985; Analyzed by Associated Labs	August 1985	RWQCB/ David Woelfel
Lake Elsinore			
LakeElsinoreStudy_MaySept03.xls	Lake Elsinore Bacteriology Results	May - Sept 2003	RWQCB/ Vitale Pavlova
San Jacinto River			
Lab Data For San Jacinto River Watershed	San Jacinto River data	Feb 2003; Feb 2004	RWQCB/ Cindy Li
Canyon Lake			
CL Bacterial 90-02.xls	Canyon Lake sampling data from Elsinore Valley Municipal Water District (EVMWD)	2002	RWQCB/ Cindy Li
CL Dock Sites 03-04 received 05-25-04.xls	Data from RWQCB and EVMWD	2003	RWQCB/ Cindy Li; Original data source: EVMWD/ Chantel Stapleton provided additional information for sample site locations
Santa Ana Watershed Project Authority (SAWPA)			
Summary WQ data Chino TMDL.xls	Water quality bacteria data summarizing sampling for Chino Basin TMDL	2002-2003	SAWPA/ Rick Whetsel
County of San Bernardino			
Bacteria sampling results (hard copy)	Hard copy report of laboratory results from E.S. Babcock Lab	2000 -2003	San Bernardino County Flood Control District/ Janet Dietzman

Table 1 (continued)
Storm Water Quality Standards Study
Data Source Summary

Title/File Name	Description	Date	Agency From Which CDM Received Data
County of Riverside			
Handwritten table of bacteria data – Total Coliform, Fecal Coliform, Enterococcus, E.coli	Handwritten table of data from 1985	1985	Riverside County Health Care Department/ Damian Meins
PDF files on CD	CD contains PDF of hard copy handwritten sampling results from Santa Ana River locations. Sampling was conducted originally by the Orange County Health Care Agency and the Riverside County Health Department.	1981 - 1994	Riverside County Flood Control District / Tom Rheiner
USEPA			
STORET Data	Pre-1999 data downloaded from USEPA website; No matches for post-1999 data	Various	Data downloaded from USEPA STORET Legacy Data Center website. Original data source: Orange County Environmental Management Agency & California Department of Water Resources
USGS			
USGS_SantaAna11074000.txt USGS_SantaAna11075600.txt	USGS Sampling stations: Prado Dam and Santa Ana River at Imperial Highway	2000 - 2001	Downloaded from USGS website
Additional Sources			
Bacteria Monitoring Results (hard copy)	Report: "Santa Ana Use Attainability Analysis Water Quality," Section 4 - Relationship to the Use-Attainability Analysis; contains bacteria data from 1991	May 1992	Report Prepared by: Regulatory Management, Inc./ Copy of data provided by Tim Moore
Citizen Monitoring Database (Access)	MS Access database of monitoring data	2002 - 2004	Orange County Coastkeeper/ Mina Danieli

Duplicate Data by Source

Data was checked to ensure it was not duplicate data submitted by differing agencies. Queries were performed on the database based on sample location, sample date, parameter and analytical results value to verify that data was not appended to the database in a duplicative manner. The potential for duplicate data may have occurred in situations in which the originating sampling agency (e.g., County) provided sampling data which was also submitted by the RWQCB. An example of this occurrence involves the electronic data provided by the RWQCB for sampling conducted along the Santa Ana River in 1985. The same data was also provided by the Riverside County Health Department in a hard copy format.

Duplicate Sampling Data

Queries were performed based on sample location, sample date, parameter, and sampling time (if available) to determine cases where duplicate samples were collected. In many cases multiple samples were collected but analyzed under different analytical testing methods. These samples were treated as distinct sample results and not averaged.

Database Development

Data was provided in various formats (electronic and hard copy) and was compiled and integrated into one overall database. Each sample result and its related information such as date, sample location, and bacteriological result was established as a data field as part of a distinct data record. Table 2 lists the relevant fields included in the database.

Table 2
Database Fields

Field Name	Description
DB_ID	Database record number – this number is unique to the each record of the database
Location_ID	Sample Location Name (see Table 2-3)
Bacteria_ID	Constituent Analyzed – Total Coliform, Fecal Coliform, E.Coli, or Enterococcus
Date	Date (month, day, and year)
Time	Sampling time (very limited data records include time)
Result	MPN /100 ml
Qualifier	Data Qualifiers
Source_ID	Source agency that provided the bacteria data.
Comments	Any relevant information provided by the source agency
Analytical Method	Analytical Method

Database Identification Number (DB_ID)
A numbering system was established to differentiate between individual records. This number is unique to each water quality sample and allows for establishing the order in which data was incorporated into the database.

Sample Location Identification (Location_ID)
Each source of data included locations at which samples were collected. Samples often were collected at the same locations or general vicinity by various agencies. Table 3 lists the data sources, sampling locations, and the number of samples collected at each sample location.

From examining the overall data set, common sampling locations were identified among the various data sources. After integrating the numerous datasets, queries were conducted to determine the number of samples collected for each sampling location.

For instance, sampling locations were often described by a cross-street or bridge overpass near the water body, (i.e, Santa Ana River (SAR) at Imperial Highway, SAR at Van Owen). In order to analyze data, sampling locations were mapped in GIS Arcview. In cases where GPS coordinates were not available or recorded, mapping of sampling locations was determined by any additional location information provided by the data source. For purposes of data analyses, sampling locations in the same location also were identified under one common name.

Bacteria Result (Bacteria_ID)
The bacteriological parameters analyzed for in the various datasets included:

- Total Coliform
- Fecal Coliform
- E. coli
- Enterococcus
- Fecal Streptococcus

Date
The date of sample collection is included in this data field.

Time
The recorded time of sample collection is included where available.

Result
The bacteriological results are listed in MPN/100ML units.

Table 3
List of Sampling Locations and Number of Samples by Source

Data Source	E. Coli	Enterococci	Fecal Colif.	Fecal Strep.	Total Colif.
Big Bear Municipal Water District					
200' Downstream from MWDC9	2	2	2		
At Forest Road 2N08			1		
At Forest Road 2N08 at Hairpin	2	2	2		1
Big Bear Lake – Center			3		2
Big Bear Lake - East Area			1		2
Big Bear Lake - Near Dam			3		3
Big Bear Lake - West Area			1		1
Big Bear Lake - West Center			3		2
Knickerbocker Creek at Big Bear Lake	19	18	20		11
Metcalf Creek at Big Bear Lake			1		1
Rathbun at Big Bear Lake			1		1
Elsinore Valley Municipal Water District					
East Bay	37	22	7		40
Indian Beach	37	22	7		42
Intakes	40	22	7		45
North Causeway	38	22	7		41
Sierra Park	37	22	7		40
Orange County Coastkeeper					
133 Freeway	29				30
Bake Parkway	15				15
Civic Center	31				30
Gold Star 2	28				30
Gold Star 3	25		1		28
Gold Star Creek 1	28		1		29
Katella	12				13
Lakeview	30				30
Lincoln	28				30
Maple Springs	18				18
Michelson	28				30
Mill Creek 1	22				24
Mill Creek 3	24				25
Modjeska Canyon	23				23
Sand Canyon	20				21
Santiago Oaks Park	22				26
SAR at Green River Rd	30				31
SAR at Gypsum Canyon Rd	26				31
Slide Zone	24				27
Smisek	22				24
Temescal Creek 1	25		1		29
Temescal Creek 2	29				31
Temescal Creek at Lincoln Ave	27		1		29
Woodbridge	28				29
Yorba Linda Regional Park	29				30
Featherly Park East			102		103
Featherly Park West			108		107
San Diego Creek at Campus Dr		274	421		430

Table 3 (continued)
List of Sampling Locations and Samples by Source

Data Source	E. Coli	Enterococci	Fecal Colif.	Fecal Strep.	Total Colif.
Orange County Health Care Agency					
Santa Ana Delhi Channel/Back Bay		274	695		679
SAR at Green River Rd			416		420
SAR at Gypsum Canyon Rd			105		107
SAR at Imperial Highway			416		423
SAR at Lincoln Ave			174		174
Orange County Water District					
Chino Creek at Euclid Ave			3		3
Chino Creek at Prado GC			1		1
Inlet to OCWD wetlands; east side of service road	56	61	40		63
Knickerbocker Creek at Hwy 18	1	1	6	4	2
OC Wetlands Effluent	49	57	39		59
Rathbun at Big Bear Lake			2		2
SAR at Imperial Highway	71	66	56		92
SAR at La Palma Ave			1		1
SAR at Prado Dam	63	60	63		126
SAR at River Rd	1		5		4
Slide Zone	1				
Temescal Creek at Lincoln Ave			1		1
Riverside County Flood Control District					
Fair Weather Dr. storm drain in Canyon Lake			2	2	2
Salt Creek at Murrieta Rd			1	1	1
SAR at Market St			26	23	26
SAR at Mission Blvd			1	1	1
SAR at Norco Bluffs			1	1	1
SAR at Pueblo St			24	22	24
SAR at River Rd			25	21	25
SAR at Van Buren			2	1	2
Sierra Park			2	2	2
Riverside County Health Department					
Chino Regional WRP #1	10	10	7		10
Chino Regional WRP #2	10	10	10		10
Colton STP	7	7	6		7
Riverside STP	9	9	7		9
San Bernardino STP	9	9	7		9
SAR at Green River Rd	12	12	64		63
SAR at Imperial Highway	12	11			2
SAR at La Cadena Dr	12	12	12		12
SAR at Mission Blvd	12	12	76		78
SAR at MWD Crossing	12	10			1
SAR at North Main/Hamner	12	12	103		79
SAR at Prado Dam	12	12	14		15
SAR at River Rd	12	11	76		81
SAR at Riverside Ave	12	10	46		80
SAR at Van Buren			74		77

Table 3 (continued)
List of Sampling Locations and Samples by Source

Data Source	E. Coli	Enterococci	Fecal Colif.	Fecal Strep.	Total Colif.
County of San Bernardino					
Cucamonga Canyon	10	10	11	8	10
Cucamonga Creek at Hellman Ave	1	1	1	1	1
Forest Falls	11	11	11	10	11
Seven Oaks Dam	10	10	11	8	10
Santa Ana Regional Water Quality Control Board					
Big Bear Lake – East End			1		1
Big Bear Lake - Near Dam				1	1
Big Bear Lake at Pine Knot Landing					1
Bon View at Merrill	13	13	13		13
Boulder Bay Creek at Hwy 18			1	1	
Center of Lake Elsinore		19	19		19
Chino Creek Above Wetlands	30	30	30		30
Chino Creek at Central	15	15	15		15
Chino Creek at Prado Golf Course	15	15	15		15
Chino Creek at Schaeffer Ave	45	45	45		45
Chino Creek Below Wetlands	17	17	17		17
Colton STP			3		3
Cucamonga Creek at Merrill Ave	43	43	43		43
Elm Grove		19	19		19
Elsinore West Marina		19	19		18
Fair Weather Dr storm drain in Canyon Lake	2	2	2	2	2
Four Corners		19	19		19
Grout Creek Headwaters	1	1	1		1
Hemet Channel at Sanderson Ave	2	2		2	2
Icehouse Canyon	43	43	43		43
Inlet Area		19	19		19
Knickerbocker Creek at Hwy 18	2	2	2		2
Knickerbocker Creek at Stocker Rd		19	19		19
Lake Elsinore Outlet Channel in Elsinore		19	19		19
Lakeland Park		19	19		18
Meadow Creek at Bike Trail			1	4	1
Metcalf Bay				1	1
Metcalf Creek at Hwy 18	1	1	5	4	2
Metcalf Creek, East Fork (.3 mi from West Fork and Cedar Lake Camp Rd.)	1	1	1		1
Metcalf Creek, West Fork Cedar Lake Camp Rd.	1	1	1		1
Mill Creek at Chino Corona Rd	45	45	45		45
Mill Creek at Chino Creek	45	45	45		45
N Side Ramona Expressway at Warren Rd	1	1	1		1
OC Wetlands Effluent	30	30	30		30

Table 3 (continued)
List of Sampling Locations and Samples by Source

Data Source	E. Coli	Enterococci	Fecal Colif.	Fecal Strep.	Total Colif.
Perris Valley Storm Drain at Nuevo	1	1	1		1
Playland Park		19	19		19
Prado Park Outlet at Chino Creek	42	42	42		42
Rathbun - Below Zoo			4		4
Rathbun Creek at Swan Dr.			1	1	
Rialto STP at Divers			2		2
Salt Creek at Murrieta Rd	3	3	2	2	3
San Bernardino STP			3		3
San Jacinto River at Bridge St	1	1	1		1
SAR at Etiwanda Channel	15	15	15		15
SAR at Green River Rd	12	12	12		12
SAR at Greenspot Rd			2		2
SAR at Gypsum Canyon Rd		1	2	1	2
SAR at I-10			3		3
SAR at Imperial Highway	12	12	12		12
SAR at Mission Blvd	12	13	15		16
SAR at Mt Vernon Ave			3		3
SAR at MWD Crossing	56	57	59	1	59
SAR at North Main/Hamner	12	13	14	1	14
SAR at Prado Dam	58	57	57		57
SAR at River Rd	12	13	14	1	14
SAR at Riverside Ave	12	13	15	1	16
SAR at Van Buren		1	1		1
SAR at Warm Creek East			4		2
SAR at Waterman			1	1	1
Sierra Park Drain in Canyon Lake	3	2	3	2	3
State Park		19	19		19
Summit Creek at Mouth			2	2	
Warm Creek at “F” St			2		2
Warm Creek at STP			1		1
Warm Lytle Creek Confluence			1		1
Weekend Paradise		19	19		19
Santa Ana Use Attainability Analysis Report					
Center of Lake Elsinore			2	2	2
Chino Regional WRP #1			2	2	2
Chino Regional WRP #2			2	2	2
Colton STP			2	2	2
Mill Creek at Chino Creek			2	2	2
Rialto STP at Divers			2	2	2
Riverside STP			2	2	2
San Bernardino STP			2	2	2
SAR at Gypsum Canyon Rd			2	2	2
SAR at Gypsum Canyon Rd			2	2	2
SAR at La Cadena Dr			1	1	1
SAR at Mission Blvd			2	2	2
SAR at MWD Crossing			2	2	2
SAR at Prado Dam			2	2	2
SAR at River Rd			1	1	1

Table 3 (continued)
List of Sampling Locations and Samples by Source

Data Source	E. Coli	Enterococci	Fecal Colif.	Fecal Strep.	Total Colif.
USEPA - STORET					
Hicks Canyon Wash at Culver Blvd			21	5	23
Peters Canyon Wash at Irvine Blvd			16	2	16
Peters Canyon Wash East Side of Jeffrey Rd			7		7
Peters Canyon Wash NE Santa Ana Fwy			36	3	36
Rattlesnake Canyon Wash at Jeffrey Rd			20	3	26
San Diego Creek at Campus Dr Bridge			25	23	166
San Timoteo Creek at Waterman Ave.			2		3
Santa Ana Delhi Channel at Irvine Ave			25	22	168
Santa Ana River Basin at Jamboree, North of Main					9
Santiago Creek at Santiago Canyon Rd Bridge					11
SAR Basin at Jeffrey Rd at Hines Nursery			20		26
SAR Basin at San Diego Creek Confluence					10
SAR Basin Culver at University, Irvine					13
SAR at Prado Dam			10		12
USGS					
SAR at Imperial Highway	65	65	14		14
SAR at Prado Dam			144	148	

Qualifier
In cases where the bacteriological result is qualified, this field includes symbols such as <, >, ≤, and ≥ to denote cases in which data is qualified.

Source_ID
The source of the data is an important data field included in the database. This information is valuable in order contact the source if questions arise related to the sample water quality data.

Comments
Any relevant information describing the data record is included in this field.

Analytical Methods
The vast majority of data received did not include the analytical methods conducted to perform the analyses. Phase II of the Water Quality Standards Study should further investigate and research the types of analytical methods performed in the course of analyses.

Table 4 lists the specific analytical methods applied by each agency, where provided, in its analyses of the samples collected from specific water bodies.

Table 4
Analytical Methods

Water Body	Total Coli form	Fecal Coli form	E.Coli	Enterococci
Santa Ana Regional Water Quality Control Board				
Lake Elsinore/ Canyon Lake	SM9221B	SM9221C	SM9221F	SM9230C
Chino Basin	SM9222B [1]	SM9222D [1]	Modified E.Coli (USEPA 1998)	SM9230B [1]
Orange County Coastkeeper				
Various OC Locations	Colilert 18 /24 IDEXX	NA	Colilert 18 / 24 IDEXX	NA

(1) Standard Methods 20th Edition

Data Characterization

Flow Data Characterization

Data from flow gauging stations along inland surface waters within the Santa Ana River Watershed show some similarities in the pattern of average annual hydrographs. Long periods of generally persistent low flow occur during dry weather months (April through November) and dry periods during winter months in many surface waters. The source of this flow is POTW effluent in a few locations, nuisance urban runoff (irrigation, car washing, etc.), and groundwater seepage in mountain streams. On average, wet weather induced high flow events occur between 10-20 times during the winter months, rapidly increasing flow by 1 to 2 orders of magnitude. Following individual wet weather events, urban streams tend to return to a level very close to summer dry weather flow. Conversely, inland surface waters with drainage areas in the San Bernardino and Angeles National Forests or Santa Ana Mountains tend to have a slower recession of high flow resulting from wet weather events. Snowmelt tends to occur soon after wet weather, thus maintaining a higher flow rate in these waters.

There are also a number of dam releases, flow diversions, and water importing that influence flow in certain inland surface waters. There are 85 dams and other runoff impoundments that control runoff within the Santa Ana River Watershed. Response to wet weather of inland surface waters downstream of these impoundments is attenuated, with a more steady flow regime that is controlled by dam operators. Also, the effort to recharge groundwater by facilitating infiltration of surface water runoff reduces runoff in receiving waters by diversion and spreading of runoff in basins with high infiltration capacity. Imported water used to recharge groundwater can increase dry weather flow upstream of these basins.

Flow within the main stem of the Santa Ana River is influenced at different times and locations from urban runoff, POTW effluent discharges, dam releases, and groundwater recharge diversions.

Receiving waters either receiving or downstream of area POTW discharges include Reach 3 of the Santa Ana River, Prado Lake, Chino Creek, and Cucamonga Creek. Reaches downstream of major controlled dam releases include the Santa Ana River, receiving releases from Prado Dam, and Chino Creek, receiving releases from the San Antonio Dam. Releases of imported water occur within Chino Creek.

Bacteria Data Characterization

Different data was compiled from many discrete locations into a study GIS database. Watershed wide analyses were developed to guide the Stormwater Standards Task Force by portraying water quality within channels. The resulting spatial representation of water quality facilitates a basin wide understanding of existing or potential recreational uses and compliance with water quality objectives in these waterbodies.

Methods

Queries of the study database were performed to compare data with existing fecal coliform water quality objectives in sampled inland surface waterbodies and also with proposed E. coli objectives based upon current EPA guidance criteria.

Existing Bacteria Water Quality Objectives

The following water quality objectives for fecal coliform have been established for the protection of recreational uses in freshwaters within the Santa Ana Region:

REC-1 - *Fecal coliform: log mean less than 200 organisms/100 mL based on five or more samples/30 day period, and not more than 10% of the samples exceed 400 organisms/100 mL for any 30-day period.*

REC-2 *Fecal coliform: average less than 2000 organisms/100 mL and not more than 10% of samples exceed 4000 organisms/100 mL for any 30-day period*

Ocean Beaches - Coastal areas of California are currently subject to bacteria water quality objectives established by the California Department of Health Services (DHS). The objectives to protect ocean waters at beaches are:

Geometric Mean Limits

a. Total coliform density shall not exceed 1,000/100 ml.
b. Fecal coliform density shall not exceed 200/100 ml.
c. Enterococcus density shall not exceed 35/100 ml.

Single Sample Limits

a. Total coliform density shall not exceed 10,000/100 ml.
b. Fecal coliform density shall not exceed 400/100 ml.
c. Enterococcus density shall not exceed 104/100 ml.
d. Total coliform density shall not exceed 1,000/100 ml, if the ratio of fecal-to-total coliform exceeds 0.1.

Potential Future Bacteria Water Quality Objectives

The EPA published new bacteria guidance in 1986, which advised states to change their bacteria criteria from fecal coliform for fresh and marine waters to *Escherichia coli* (*E. coli*) for freshwaters and *Enterococcus* for marine waters. The basis for this change was new data which showed that increased *E. coli* (a subset of fecal coliforms) and *Enterococcus* concentrations showed a better correlation with an increased frequency of gastroenteritis than increased concentrations of fecal coliforms. *E. coli* and *Enterococcus* serve as pathogen indicators meaning that when concentrations of these bacteria are elevated there is an increased likelihood that many other potential human pathogens, e.g., viruses and protozoans such as *Giardia* and *Cryptosporidium*, are also elevated to unsafe levels.

The *E. coli* and *Enterococcus* objectives are based on studies conducted by EPA in the early 1980's. These studies were conducted at three marine and two freshwater locations over several years. Information on the frequency of gastroenteritis and related water quality were obtained by conducting surveys of individual swimmers and non-swimmers while at the same time collecting water quality data from the selected study sites. The resulting data, average illness rate and geometric mean of water quality, were used to calculate risk-based levels of protection for locations where primary contact recreation occurred, e.g., swimming.

EPA guidance is based on acceptable levels of protection for freshwaters of 8 to 10 swimmers per 1000 and for marine waters of 8 to19 swimmers per 1000 getting gastroenteritis as a result of swimming activities. For each level of protection, the EPA provides recommended geometric mean criteria and corresponding statistically derived single sample limits based on varying upper percentile values (75^{th} to 95^{th} percentile) of allowable densities. For freshwaters, Table 5 lists recommended criteria for risk levels ranging from 8 to 10 swimmers/1000 are as follows:

Table 5					
Risk Level (% of swimmers)	**Geometric Mean Density** (per 100 ml)	**Upper Percentile Value Allowable Density (per 100 ml)**			
		75th Percentile	**82nd Percentile**	**90th Percentile**	**95th Percentile**
0.8	126	236	299	409	576
0.9	161	301	382	523	736
1.0	206	385	489	668	940

For example, for *E. coli* if the acceptable geometric mean value is 126, the corresponding single sample value using the 75th percentile of the data distribution of all values is 236. If a 95th percentile is acceptable, then the corresponding single sample value would be 576.

REC-1 use bacteria objectives for basin plan waterbodies are based upon a 30-day rolling set of data. In order to develop complex queries for all locations where bacteria data was historically collected, calendar months are used as a surrogate to the rolling 30-day time period. Actual rolling 30-day compliance criteria are assessed at six study sites and are presented in the Detailed Study Site Characterization section of this technical memorandum.

Results from queries of the database are joined to the GIS layer of "Bacteria Stations" using a reference location identification number. New fields in the point attribute table of this layer, resulting from the join are then used to symbolize sampling locations in the GIS model. The points on these maps are symbolized by two attributes, the 1) fraction of non-compliant calendar months and 2) number of non-compliant calendar months when sufficient data was present to determine compliance. These attributes are depicted as varying intervals of color and size of points, respectively. Several different queries are used to assess the relationship between compliance with REC-1 bacteria standards and flow condition, season, and time period.

Limited instances of concurrent flow data for all inland surface waterbodies where bacteria samples were collected over the past 30+ years resulted in a decision to use data from a set of daily rainfall stations rather than flow records to assess the presence or absence of wet weather conditions. Eight rainfall stations were used to represent rainfall across the basin (Figure 1). Although the distribution of stations was relatively course, it was suitable for purposes of this analysis, considering the flow condition only requires a distinction between wet and dry weather. Samples collected on days when there was greater than or equal to 0.1 inches of rainfall, as measured at the nearest reference rainfall station, were considered wet weather samples.

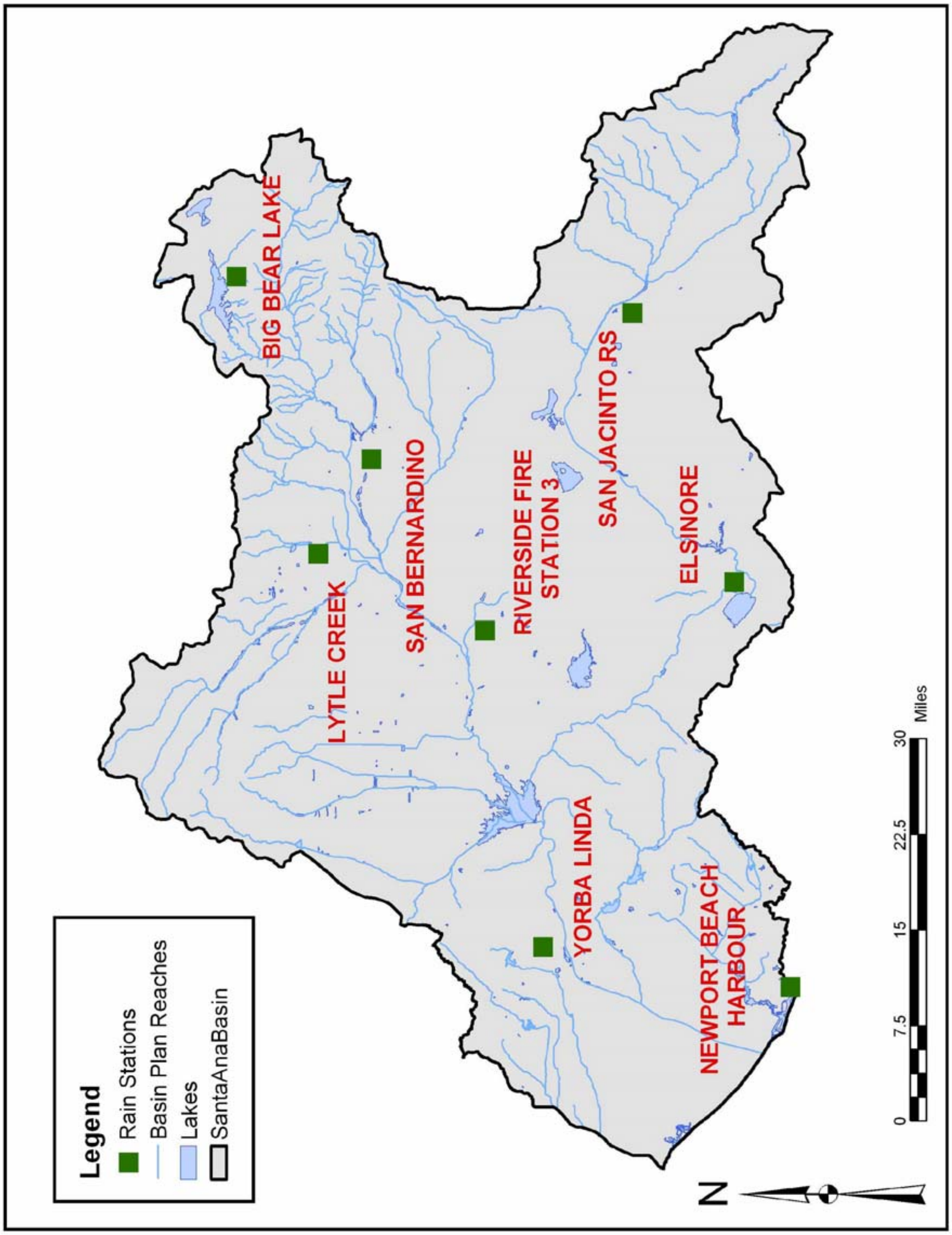


Figure 1
Rainfall Stations Used to Identify Wet/Dry Days for Nearby Bacteria Stations

The relationship between the layers "Bacteria Stations" and "Rainfall Stations" was developed by using the ESRI Spatial Analyst extension for ArcGIS 8.3®. The straight line allocation function was employed to create a raster dataset of nearest rainfall station. The raster data conversion function of Spatial Analyst was then used to convert the grid of the nearest rain station to a polygon layer of distinct rainfall regions. Lastly, a spatial join was used to assign rainfall stations to the bacteria stations that fell within each respective region. The updated point attribute table resulting from the spatial join was exported as a database file and imported to the Stormwater Standards Study database to support the creation of wet weather and dry weather queries.

Dry weather samples, on days without rain or when less than 0.1 inches was recorded, were further distinguished between winter and summer dry weather flows. Bacteria samples collected between April 1 and October 31 were categorized as summer dry weather samples and those collected between November 1 and March 31 were categorized as winter dry weather samples.

Lastly, fecal coliform and E. coli bacteria water quality data was assessed for three different time periods. November 28, 1975 and January 1, 1996 are delineators of critical events that may impact actual bacteria counts or reach-specific recreational use designation in waterbodies of the Santa Ana Basin. November 28, 1975 marks the date when the Clean Water Act's antidegradation laws were implemented, disallowing any reduction in water quality in surface waters of the United States. The second date is an approximate estimate of when most POTW effluent discharges in the Santa Ana Basin met Title 22 tertiary treatment requirements, although some began adding tertiary treatment beginning in the late 1970's.

All Samples

Figures 2 through Figure 5 show Santa Ana Basin maps with the results of each of the bacteria data queries performed upon the entire dataset. The maps generated using all samples provide a comparison to REC-1 use bacteria objectives in the Santa Ana Basin. The percentage of calendar months with sample results potentially exceeding objectives and the size of the bacteria record at each location improve our current understanding of water quality associated with recreational use in Santa Ana Basin surface waterbodies.

Table 6 provides the number of sampling locations with sufficient data to compare to water quality objectives and proposed criteria.

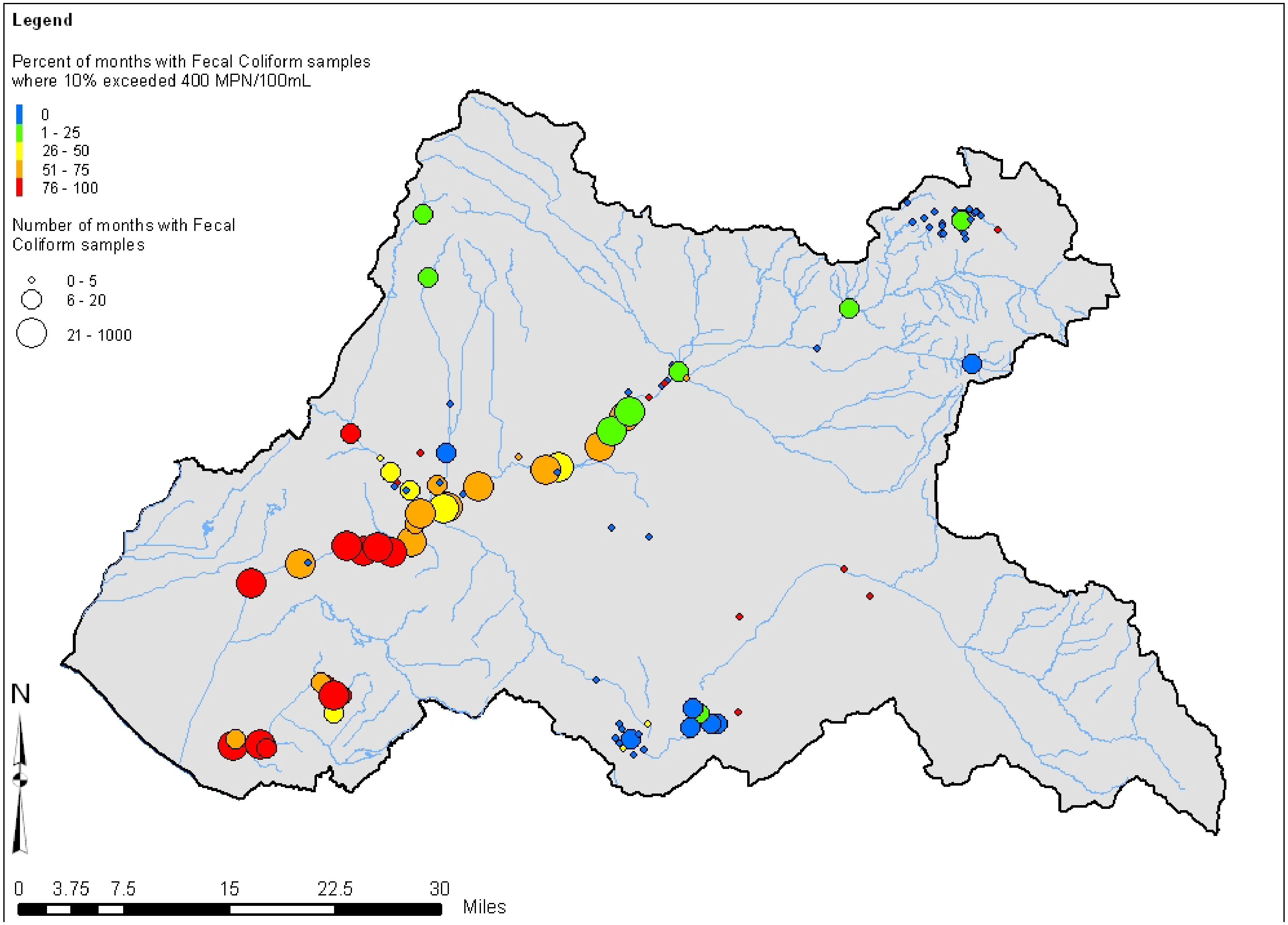


Figure 2
Fecal Coliform Analysis 10% of Samples Exceedence Criteria

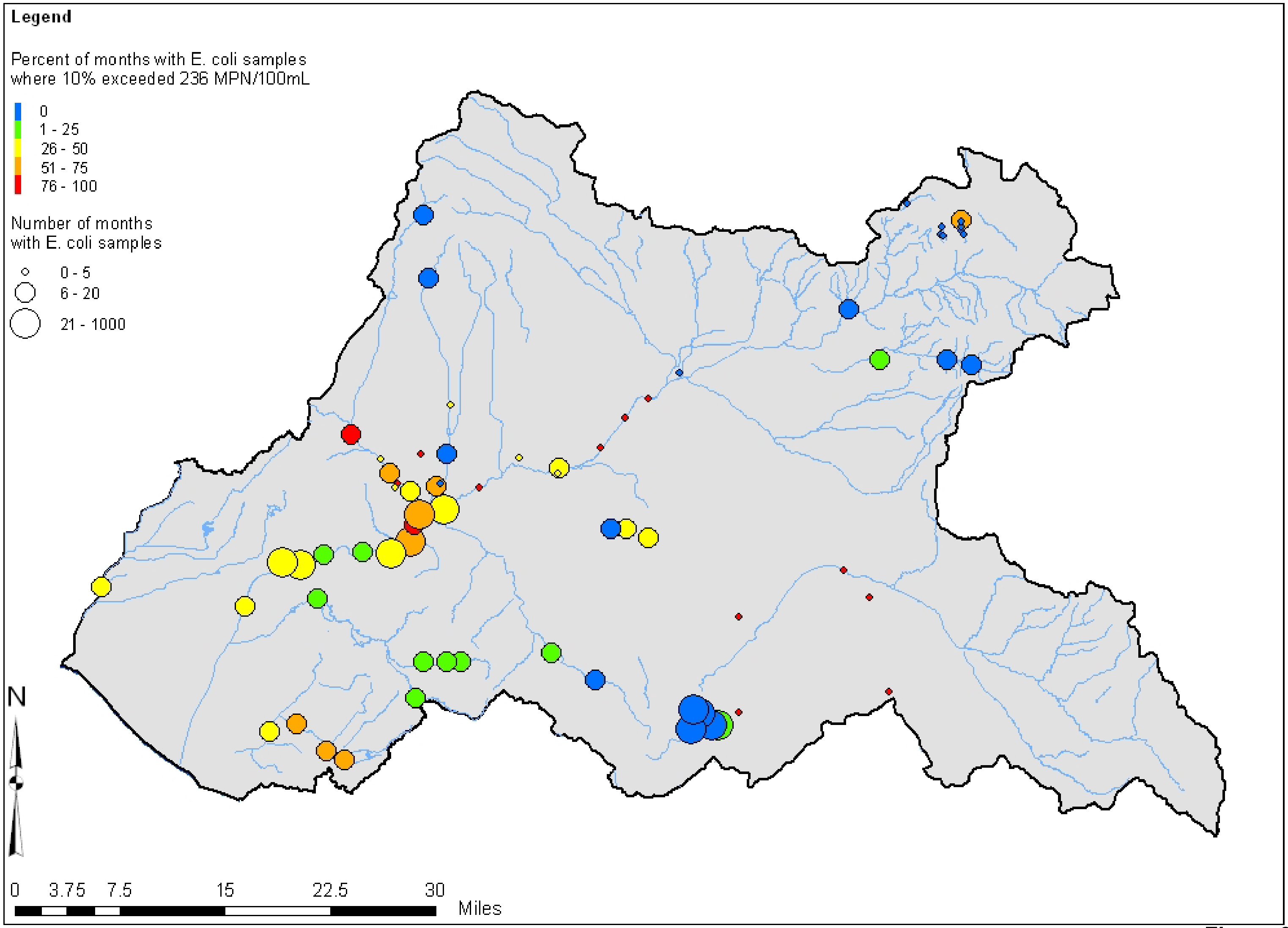


Figure 3
E. coli Analysis 10% of Samples Exceedence Criteria

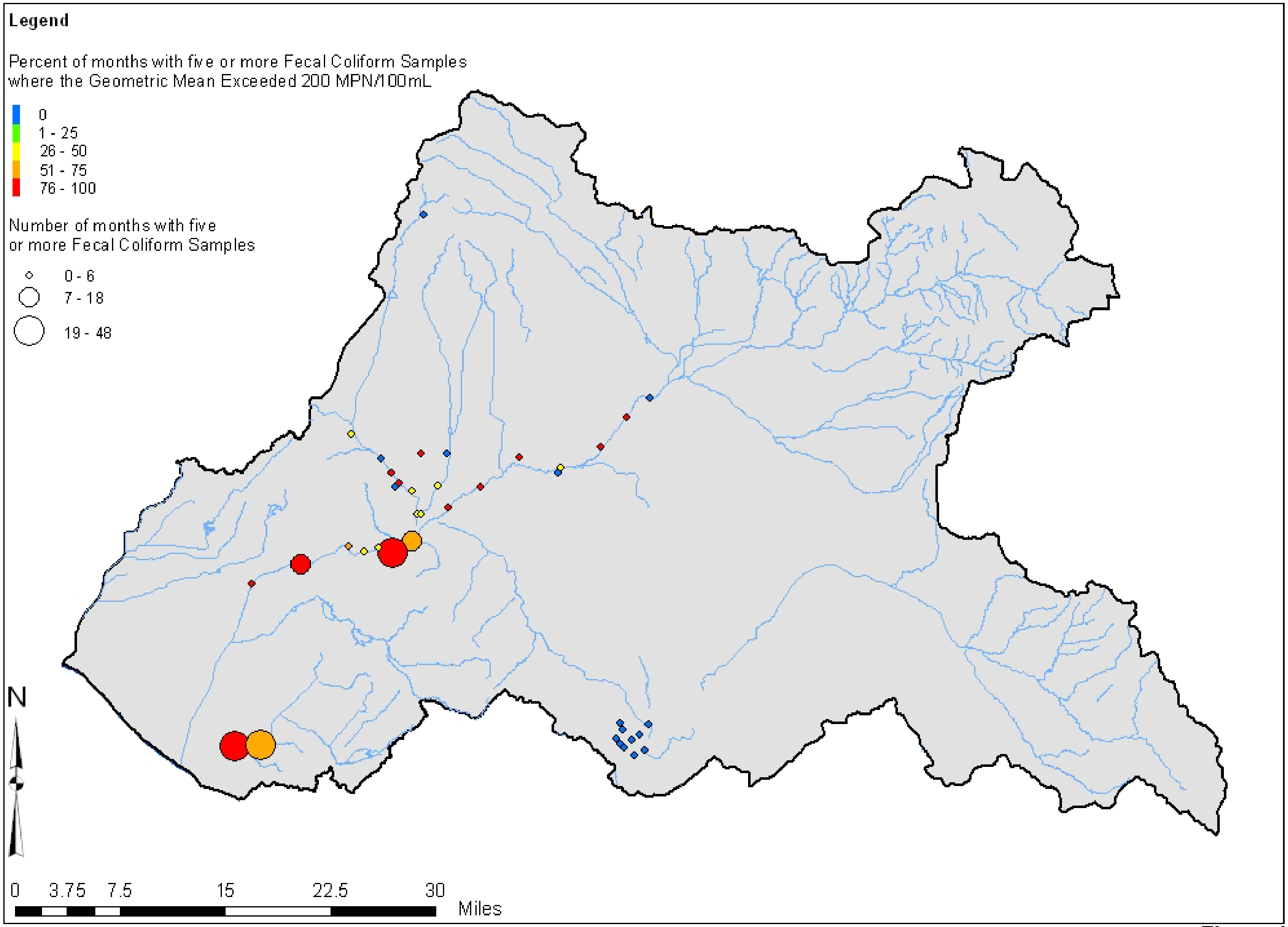


Figure 4
Fecal Coliform Analysis Geometric Mean Criteria

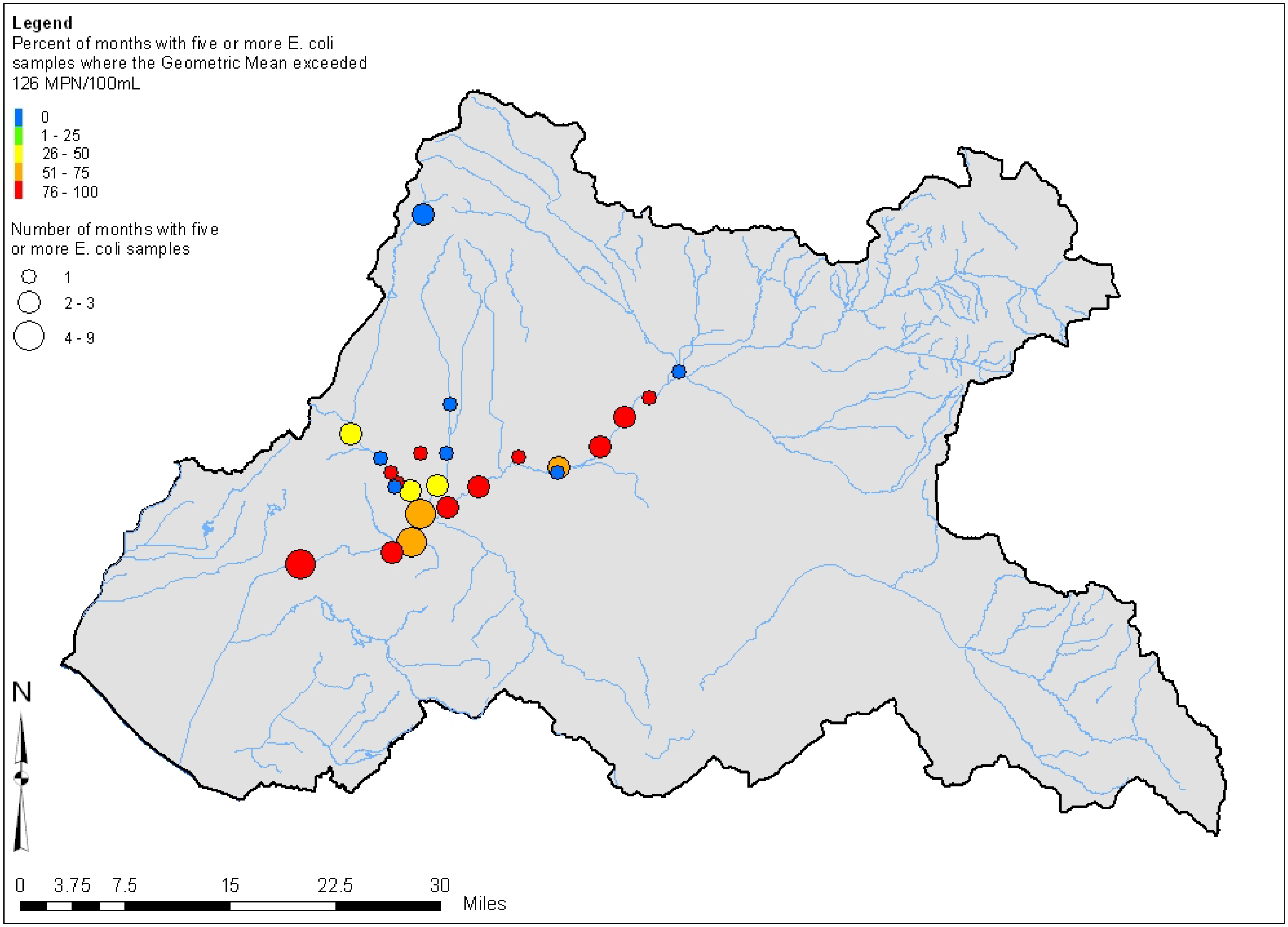


Figure 5
E. coli Analysis Geometric Mean Criteria
Stormwater Quality Standards Study
November 2004

Table 6
Number of Sampling Locations Compared to Objectives/Criteria

Criteria	All Samples	Wet Weather	Summer Months, Dry Weather	Winter Months, Dry Weather
Fecal Coliform: 10% of Samples Collected within a 30 days	110	44	94	68
Fecal Coliform: Geometric Mean of 30-day Periods with 5 or More Samples	39	0	28	22
E. coli: 10% of Samples Collected within 30 days	77	45	69	54
E. coli: Geometric Mean of 30-day Periods with 5 or More Samples	25	1	14	15

Potential exceedences of REC-1 bacteria objectives were observed at most Basin Plan reaches with sample results, including high order rivers such as the Santa Ana, medium sized inland surface streams such as Chino Creek, small urban channels such as Salt Creek near Lake Elsinore, and mountain streams such as Knickerbocker Creek in Big Bear Lake. There is more sampling data available from more urbanized areas of the basin than areas less impacted by urbanization.

When comparing available fecal coliform data to the 10% exceedence criteria (Figure 2), the data query shows that sampling performed upon the Santa Ana River and other waterbodies heavily influenced by urbanization may exceed water quality objectives in all months sampled. Querying results from less urbanized areas, especially around inland lake areas, available data shows several locations that may meet objectives, however some less urbanized areas have months where objectives may be exceeded.

When comparing available E. coli data to the 10% exceedence criteria (Figure 3), the data query shows similar results to the fecal coliform analysis, however most locations have fewer months exceeding proposed E. coli objectives than fecal coliform objectives, and more locations may meet proposed E. coli objectives.

When comparing available fecal coliform data to the geometric mean exceedence criteria (Figure 4), the data query shows that fewer locations have sufficient data to perform the comparison. For the locations with enough sampling to perform the comparison, again sampling performed upon waterbodies heavily influenced by urbanization may exceed water quality objectives in all months sampled. Less urbanized areas may meet the objective, though the amount of data is limited in order to support.

When comparing available E. coli data to the geometric mean exceedence criteria (Figure 5), the data query shows a larger number of months with enough data for comparison, with most locations potentially exceeding proposed E. coli objectives, and some less urbanized locations potentially able to meet proposed objectives.

Wet Weather

There were relatively few wet weather samples collected by the various agencies over the period of record (1958-2004). Wet weather samples were collected at select locations, primarily along the Santa Ana River. Figure 6 and Figure 7 present a summary of wet weather fecal coliform and E. coli data, respectively. The charts represent each sample result and the median of wet weather sampling performed at locations where more than one wet weather sample was collected. In almost all cases, median values at each of the locations may exceed objectives. The limited number of wet weather samples resulted in a small number of sites where the data could be compared to objectives.

When comparing available wet weather fecal coliform data to the 10% exceedence criteria (Figure 8), the data query shows similar results as to the all samples query, waterbodies heavily influenced by urbanization may exceed water quality objectives in all months sampled, with some exceptions in less urbanized areas.

When comparing available wet weather E. coli data to the 10% exceedence criteria (Figure 9), more locations have enough sampling to perform a comparison to objectives. Per this query, more locations may exceed proposed E. coli objectives in all months sampled as compared to fecal coliform data.

When comparing available wet weather fecal coliform data to the geometric mean criteria, there were no calendar months with five or more wet weather samples collected at any bacteria monitoring location within the available data.

When comparing available wet weather E. coli data to the geometric mean (Figure 10), five or more E. coli samples were collected during three wet weather events at the Santa Ana at Imperial Highway monitoring station. Proposed objectives were exceeded in each month. The pattern of bacteria results in relation to storm hydrographs is shown later in this technical memorandum, within the Detailed Study Site Characterization section.

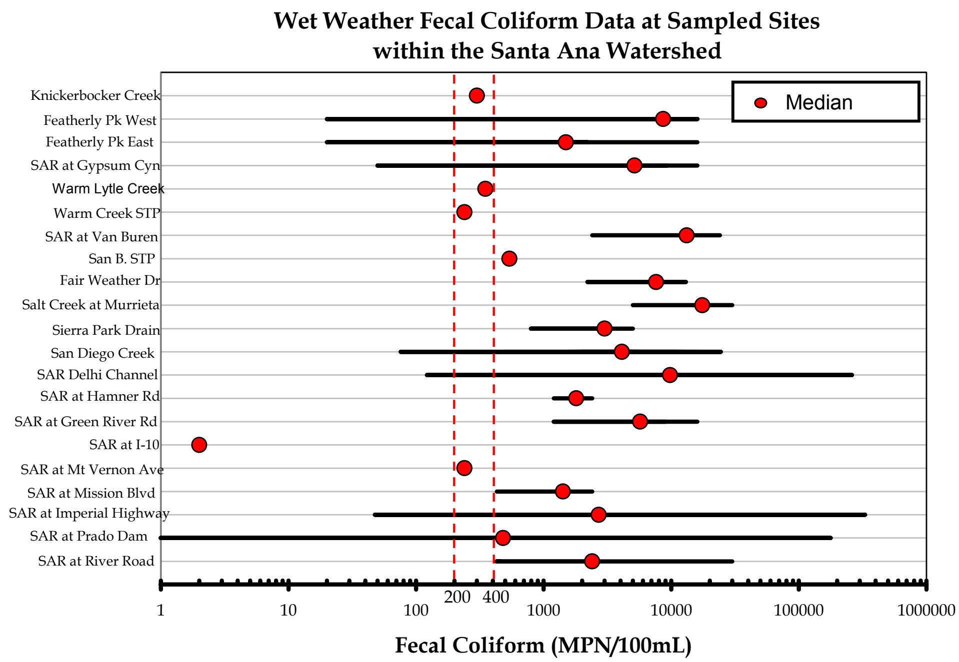


Figure 6
Fecal Coliform in Samples Collected During Wet Weather Days

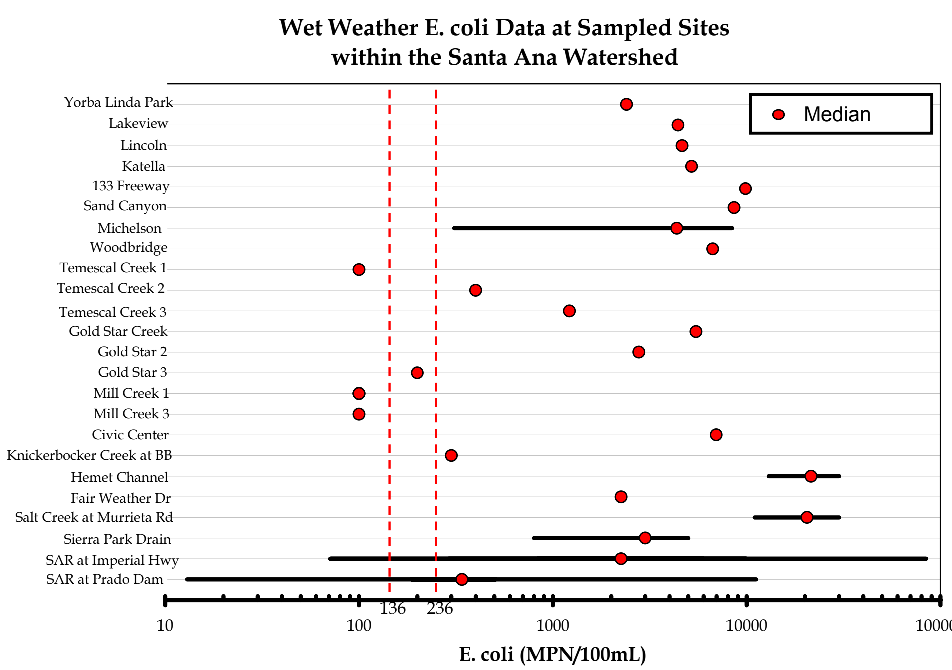


Figure 7
E. coli in Samples Collected During Wet Weather Days

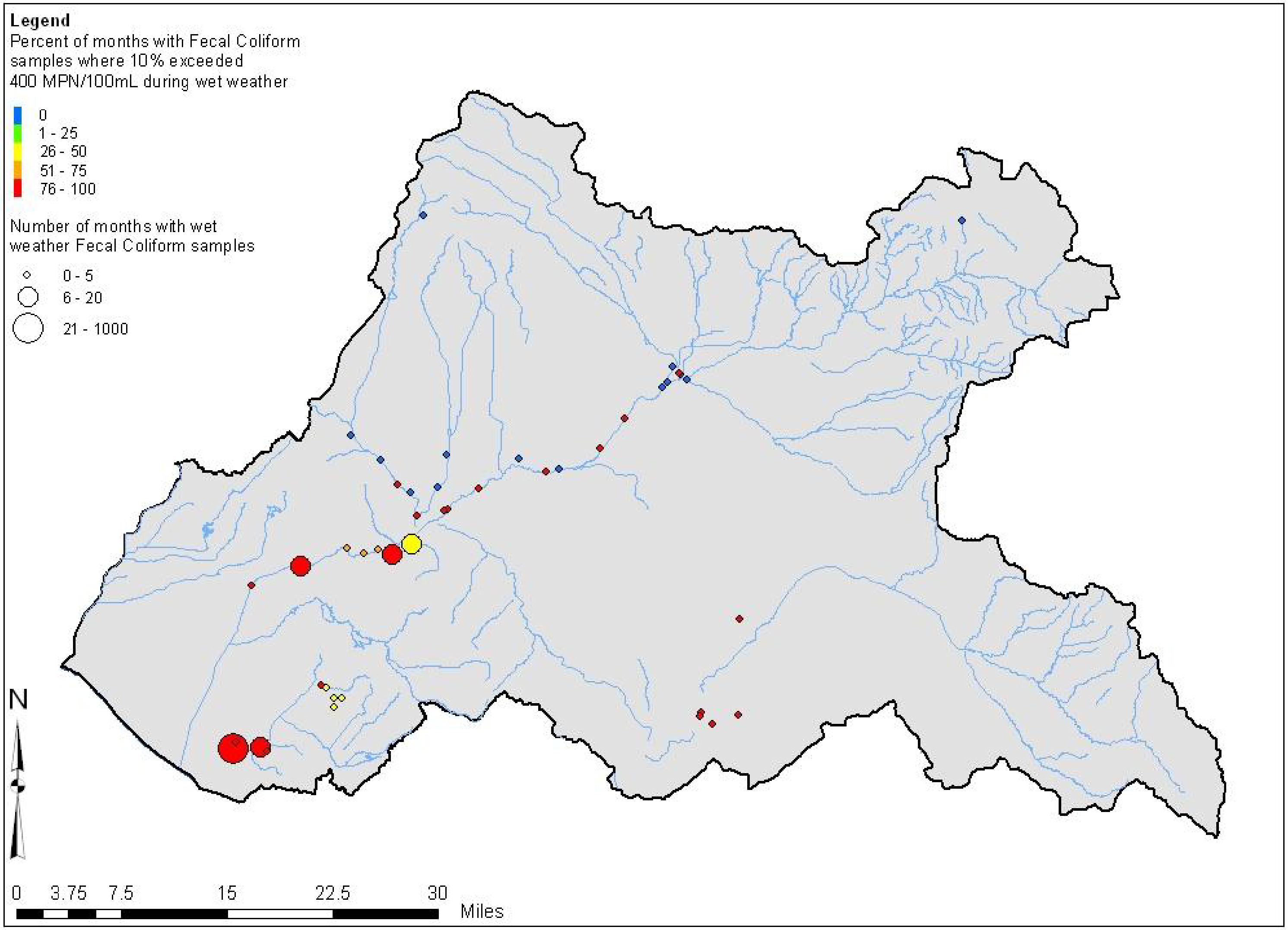


Figure 8
Fecal Coliform Analysis 10% of Samples Exceedence Criteria-Wet Weather

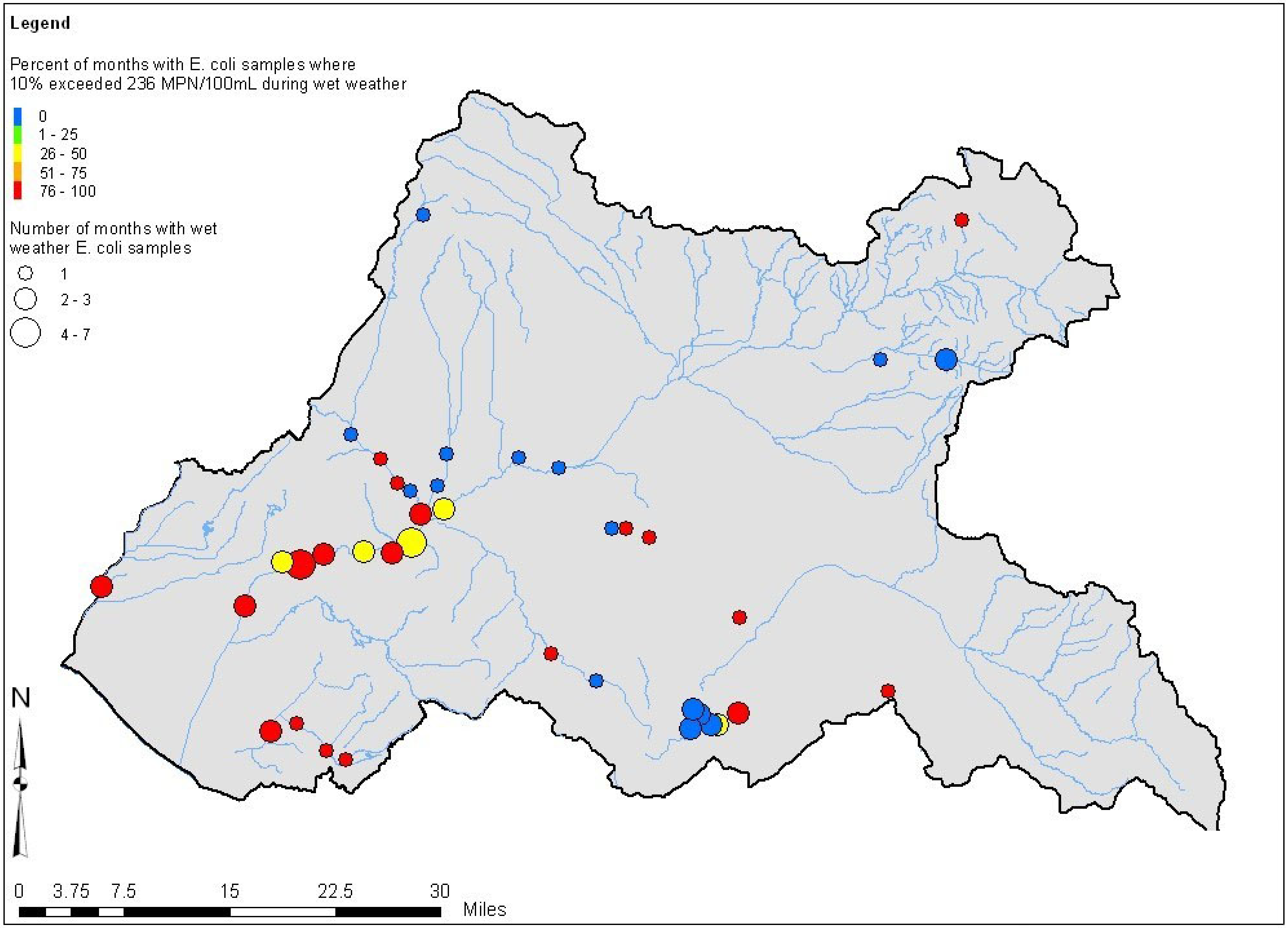


Figure 9
E. coli Analysis 10% of Samples Exceedence Criteria - Wet Weather

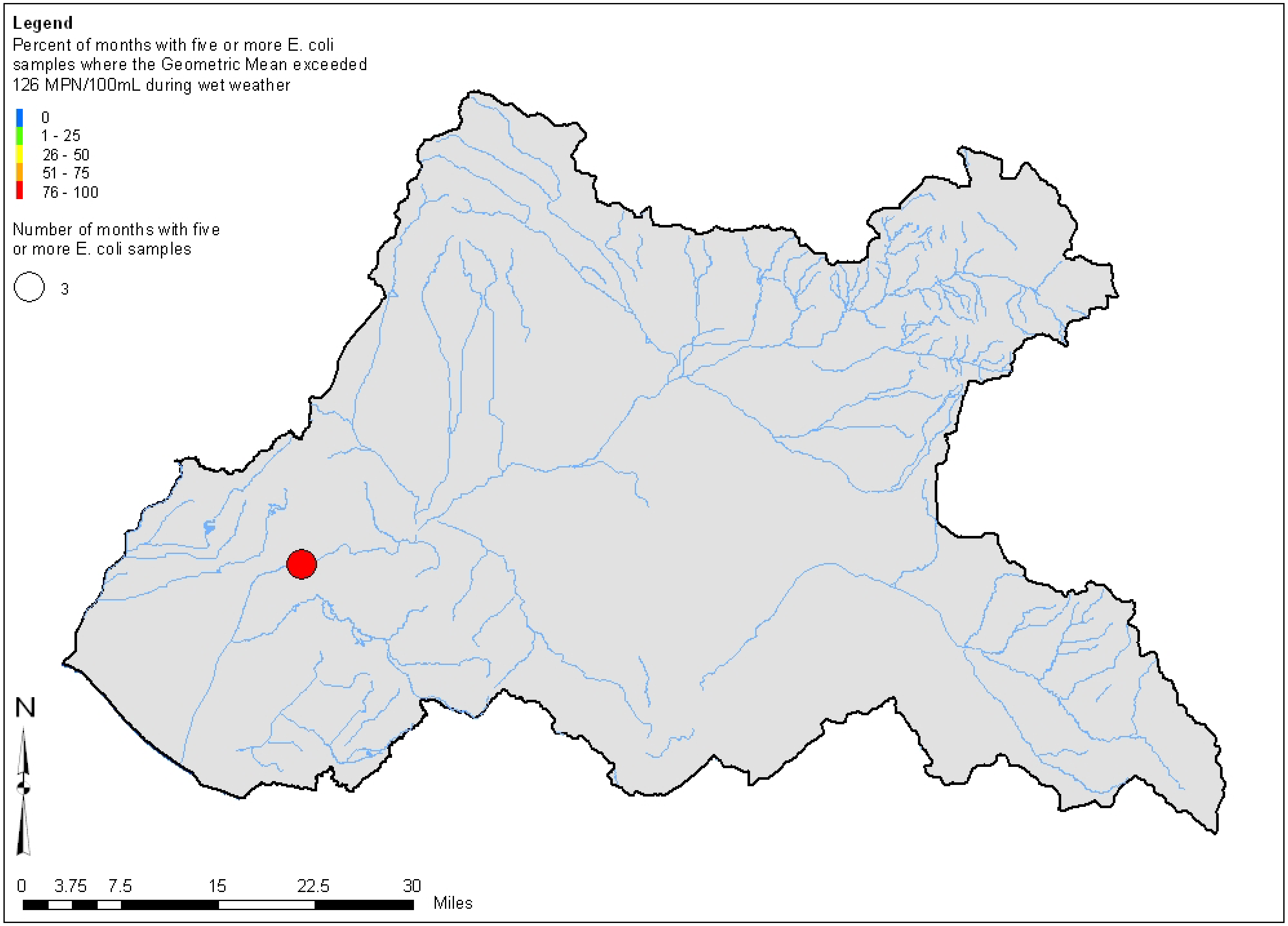


Figure 10
E. coli Analysis Geometric Mean Criteria - Wet Weather

Dry Weather

To analyze data from dry weather periods, the available sample database was divided into summer dry weather (April through November) and winter dry weather (December through March) periods based upon flow records. Figures 11 through 18 present the results from several dry weather data queries. As most available samples within the database were collected during dry weather periods, queries that compare only summer dry weather data to water quality objectives look very similar to comparisons of the entire database of sample results (Figures 11 through 14).

When comparing available winter dry weather fecal coliform data to the 10% exceedence criteria (Figure 15), the data query shows that comparatively more locations in urbanized areas may meet objectives during winter dry weather periods. More locations may meet the proposed 10% exceedence criteria for E. coli during winter dry weather periods as well (Figure 16).

When comparing available winter dry weather fecal coliform and E.coli data to the geometric mean exceedence criteria (Figures 17 & 18), query results follow the results found for all samples waterbodies heavily influenced by urbanization may exceed water quality objectives in all months sampled, and results from less urbanized areas may meet objectives, though the data set is limited.

Detailed Study Site Characterization

Data availability varies significantly among sample locations within the Santa Ana basin. As a consequence, performing a detailed characterization of water quality and waterbody conditions, and comparing the data with waterbody characteristics at every location where bacteria samples have been collected would be extremely resource intensive. As an alternative for study purposes, study sites were selected to serve as surrogates for different types of waterbodies. At each study site, site-specific water quality and site characteristics were documented to characterize recreational quality.

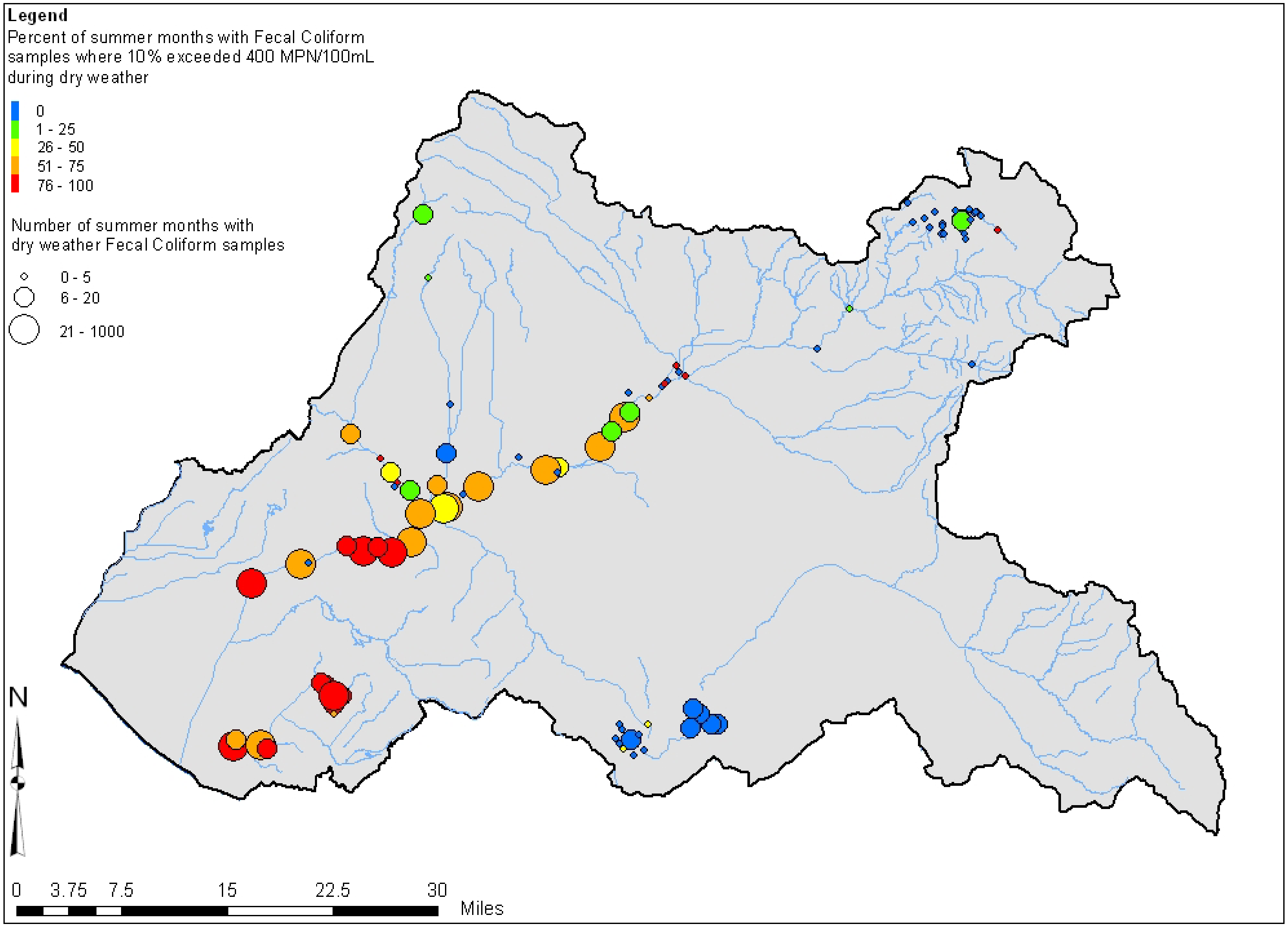


Figure 11
Fecal Coliform Analysis 10% of Samples Exceedence Criteria - Dry Weather – April through November

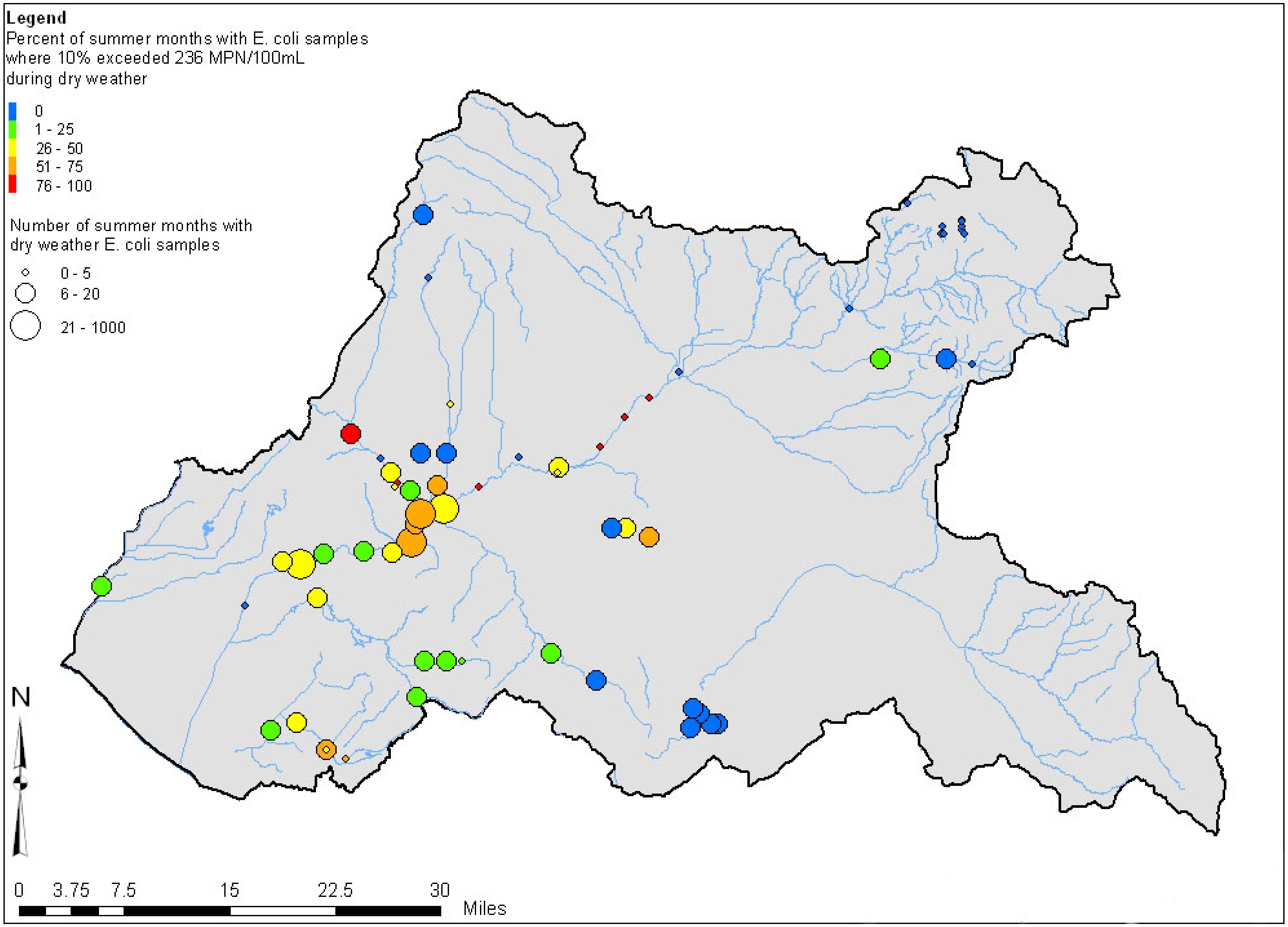


Figure 12
E. coli Analysis 10% of Samples Exceedence Criteria - Dry Weather – April through November

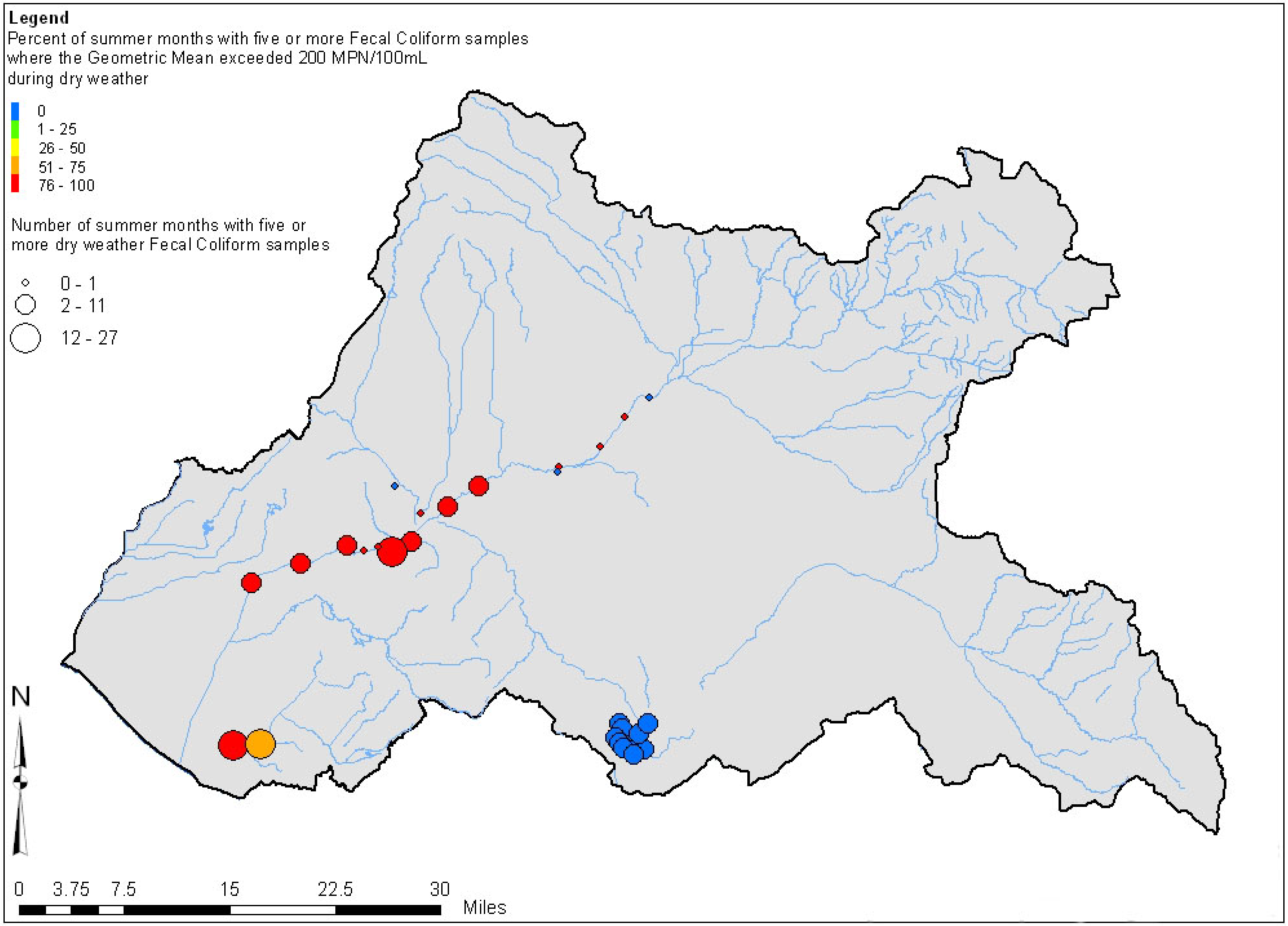


Figure 13
Fecal Coliform Analysis Geometric Mean Criteria - Dry Weather – April through November

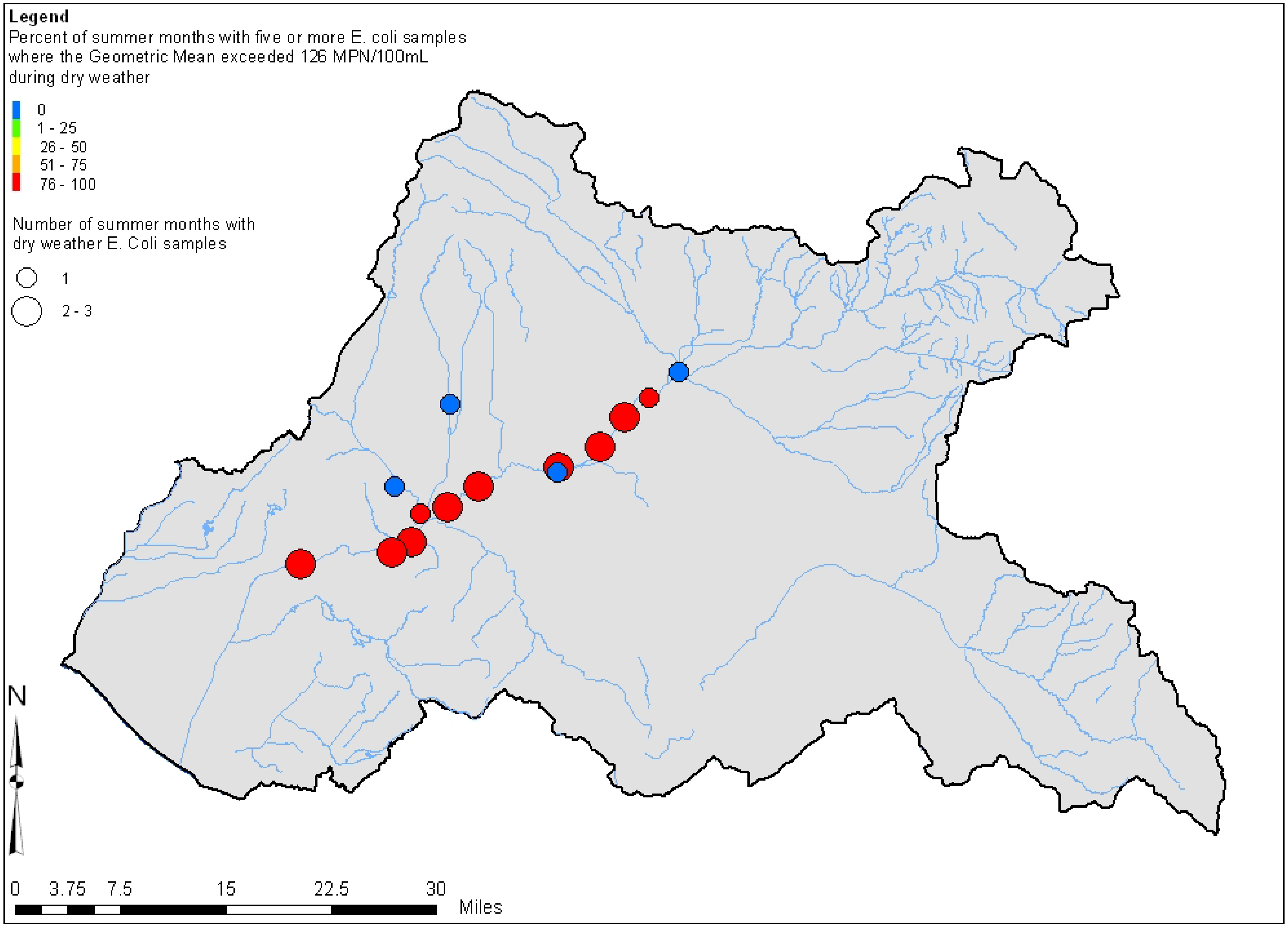


Figure 14
E. coli Analysis Geometric Mean Criteria - Dry Weather – April through November

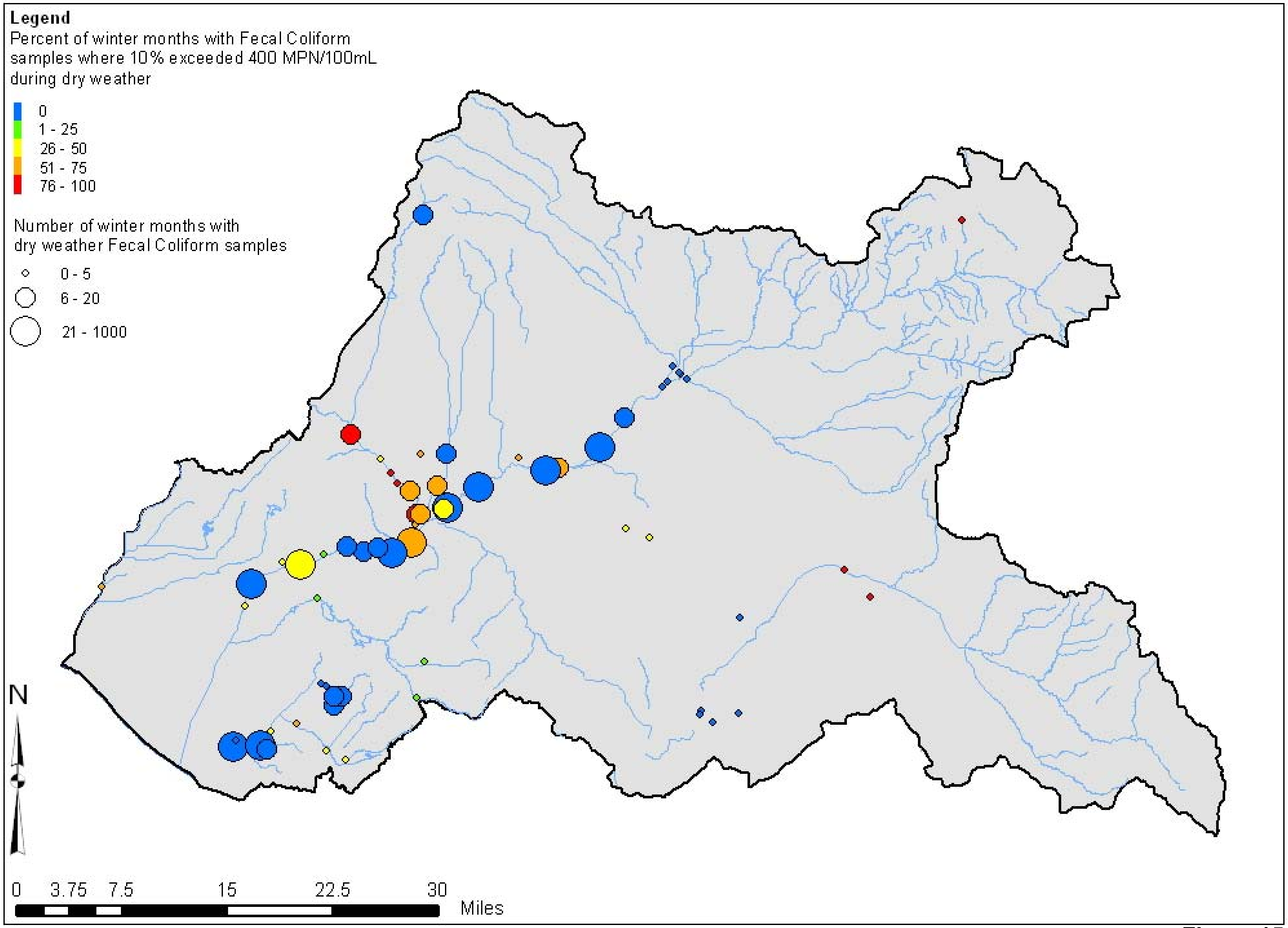


Figure 15
Fecal Coliform Analysis 10% of Samples Exceedence Criteria - Dry Weather – December through March

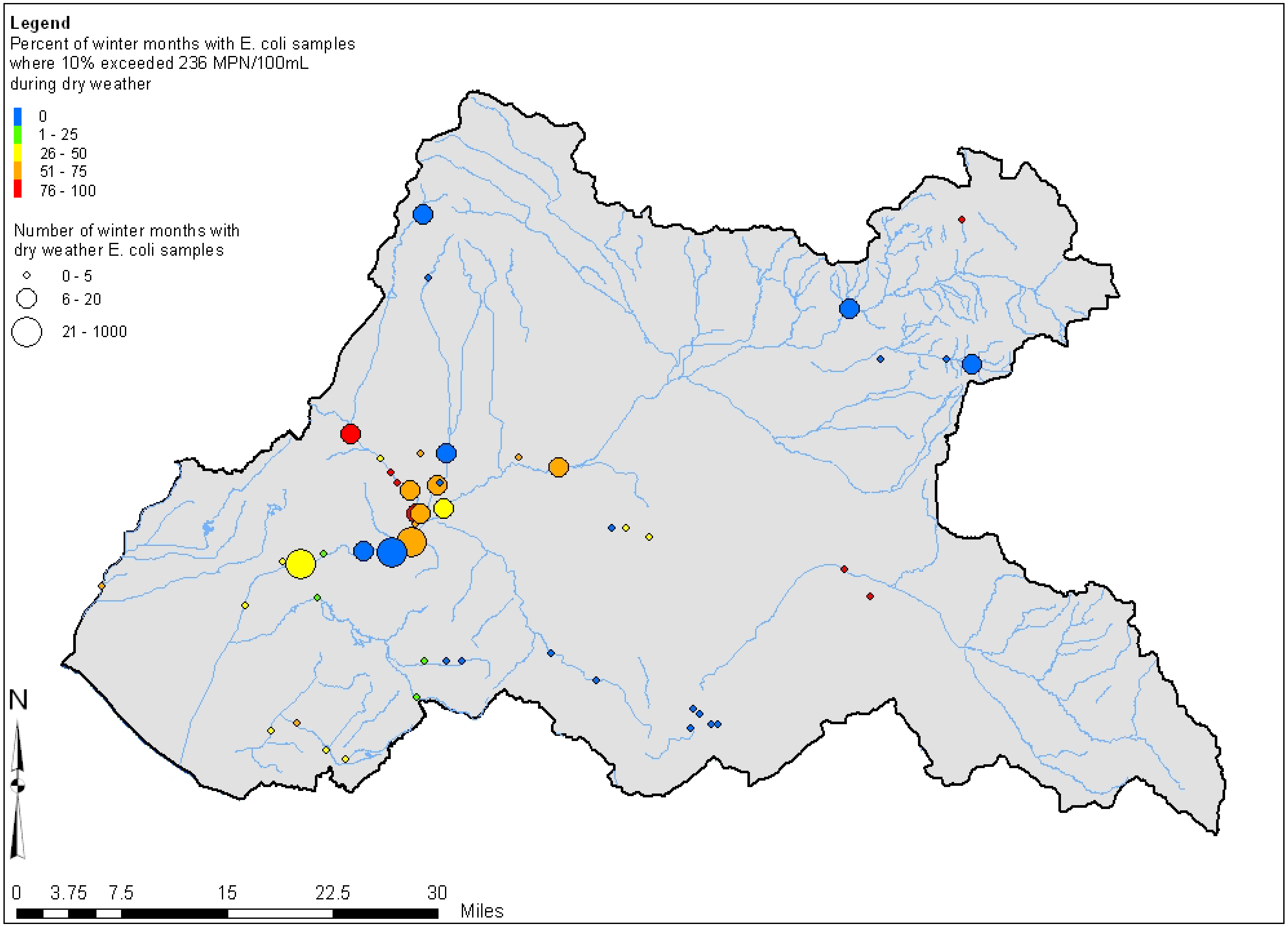


Figure 16
E. coli Analysis 10% of Samples Exceedence Criteria - Dry Weather – December through March

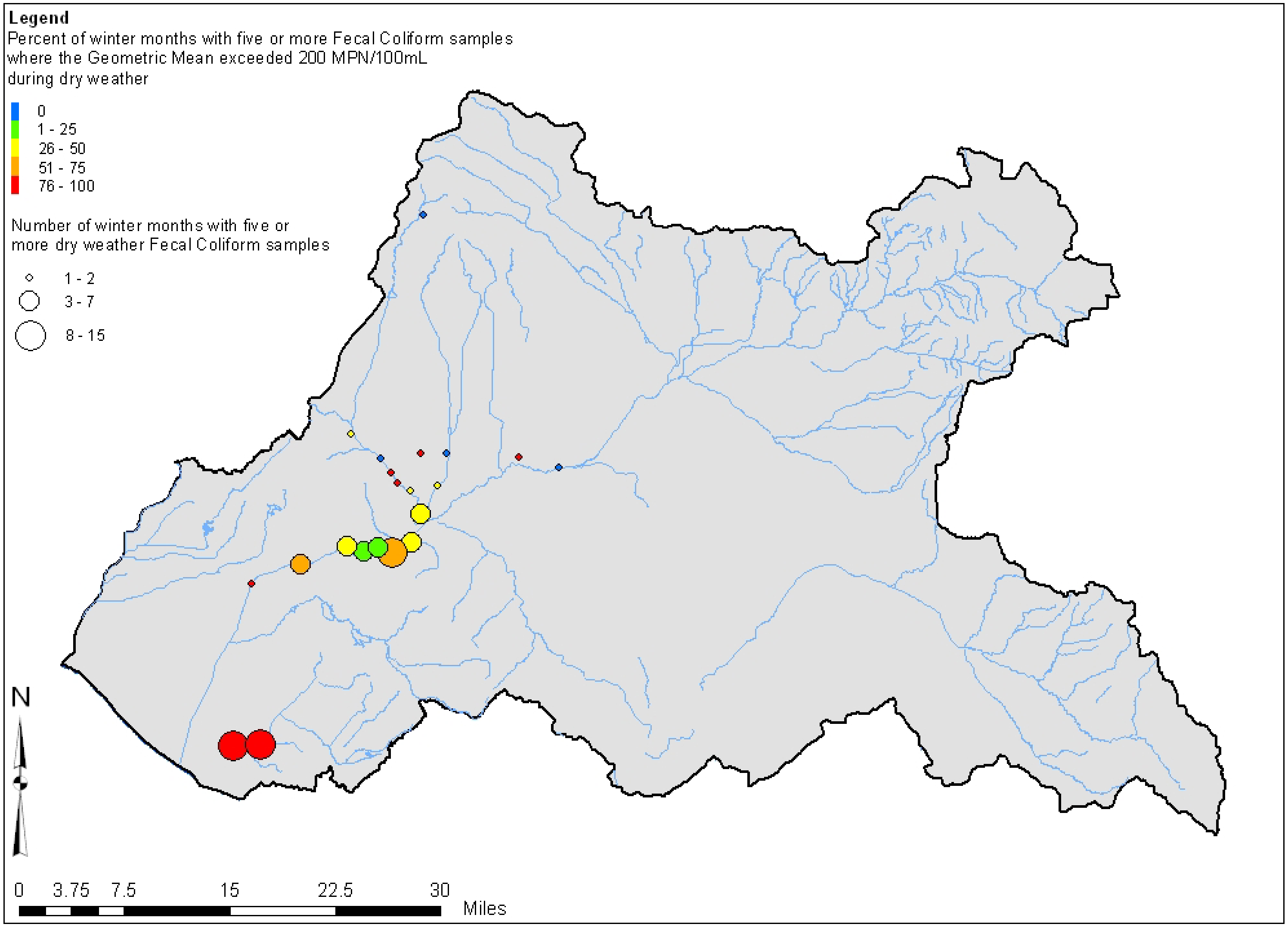


Figure 17
Fecal Coliform Analysis Geometric Mean Criteria - Dry Weather – December through March

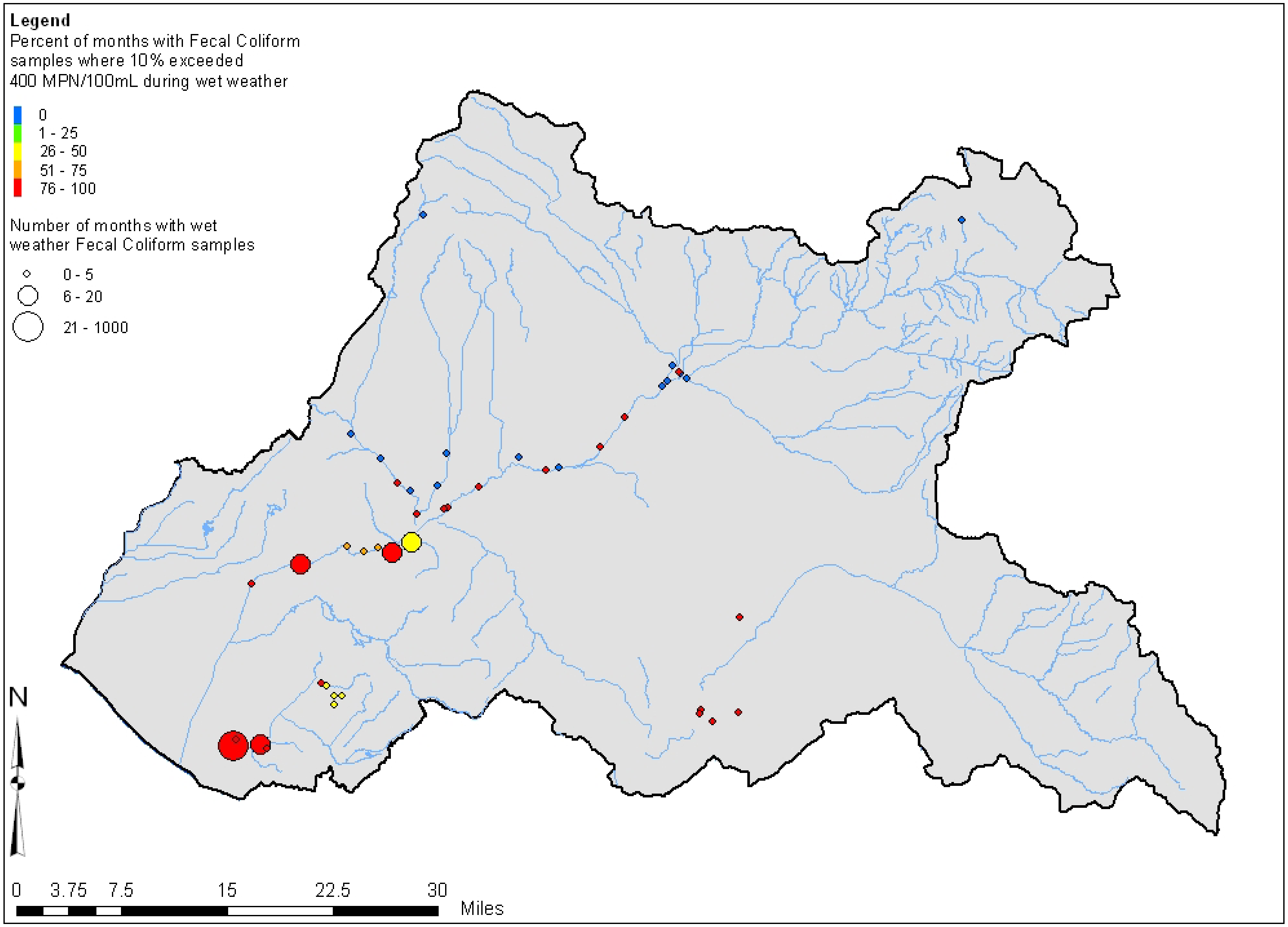


Figure 18
E. coli Analysis Geometric Mean Criteria - Dry Weather – December through March

Methods

Selection of Study Sites

Study sites were selected to facilitate detailed analysis of varying channel types and conditions in the Santa Ana basin, including natural channels, channels with both natural and modified portions (e.g., natural bottom, but concrete or rip-rap banks), and channels completely constructed with concrete. The availability of flow and bacteria data at the potential sites representing these various channel conditions was assessed. Based on this evaluation, the following five study sites were recommended to the Stormwater Standards Task Force:

- Chino Creek at Schaeffer Avenue (100% concrete channel in mixed land use area)
- Santa Ana Delhi Channel (100% concrete in highly urbanized area)
- Temescal Creek at Lincoln Avenue (mixed concrete/rip-rap; natural channel)
- Santa Ana River at Imperial Highway (mixed concrete/rip-rap; natural channel)
- Santa Ana River at MWD Crossing (natural channel in urbanized area)

The Task Force supported these recommendations, but also recommended the inclusion of Icehouse Canyon as a site to provide information at and above which no urbanization has occurred (Figure 19).

Channel and Stream Attributes

Attributes of channels at each study site were identified by reviewing collected GIS layers and verifying this information during field visits. Lack of published data for channel dimensions along the Santa Ana River at some study sites led to the use of high resolution aerial photography or distance meters to estimate channel widths. Channel slopes at study sites more estimated in the field to estimate cross-sectional area. In generally natural reaches, where the channel was wide, the channel slope did not significantly impact cross sectional area

Channel attributes that could affect recreational appeal were evaluated for each of the study sites. Photographs were taken of direct and indirect evidence of recreational use and of conditions that could affect recreational use. These study site attributes were summarized in a checklist, prepared by Risk Sciences, Inc, discussed within Technical Memorandum 2

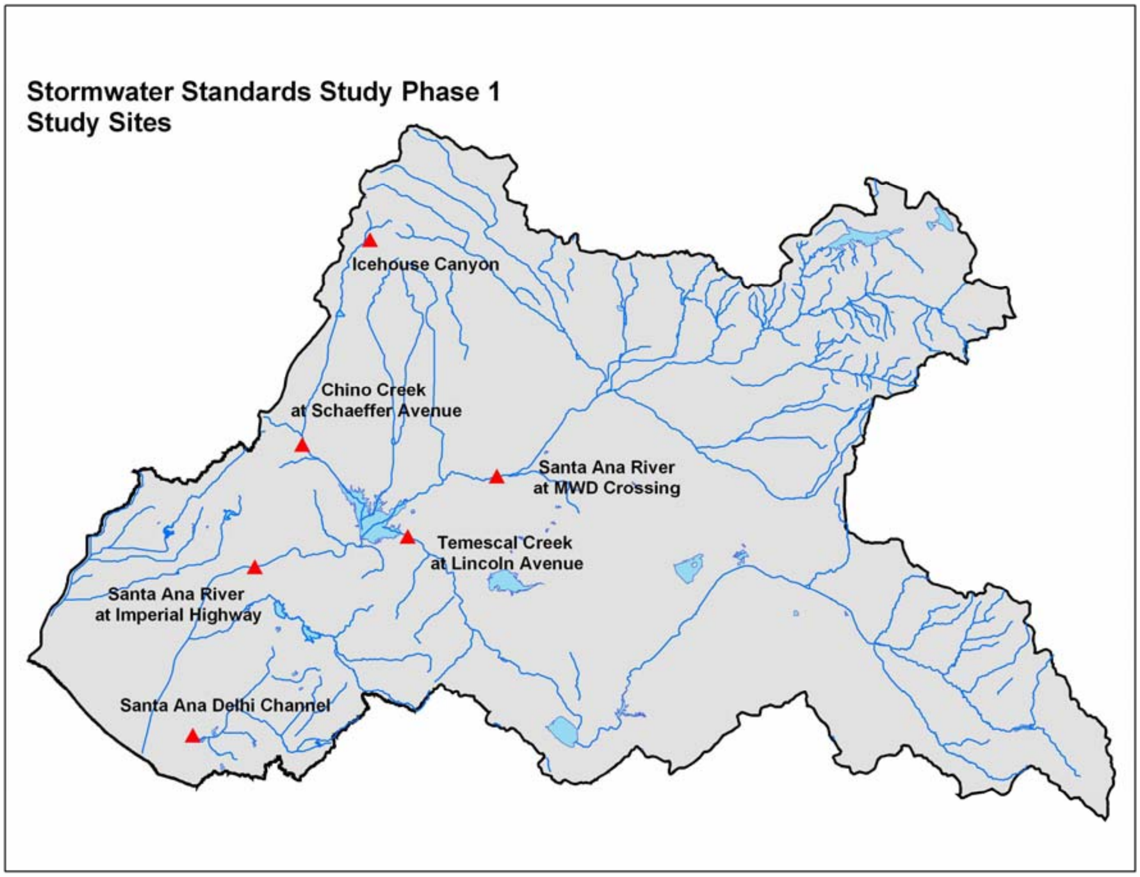


Figure 19
Study Sites Selected for Detailed Analysis

Drainage Area Characteristics & Land Use

To characterize land use adjacent to and in the tributary watershed to the study sites, the drainage areas of three study sites were determined using a digital elevation model (DEM) of the Santa Ana basin provided by SAWPA. Arc Hydro, a tool created for ESRI ArcGIS 8.3® documented in Maidment [2002], was used to delineate the drainage area of each study site. This tool "burns" the section of channel onto the DEM and through a series of pre- and post-conditioning processes, determines cells, i.e., small areas that will drain to the reach based solely upon topography. In urbanized areas where drainage network information was available, flow path alterations resulting from urban development were accounted for by manually editing the Arc Hydro derived polygons.

Following drainage area delineation, land use layers of the Santa Ana basin from 1990, 1993, and 2000 provided by Southern California Area Governments (SCAG) were clipped to the watershed areas. The attributes of the clipped land use layers were summarized to create land use distributions.

Recreational Appeal

The recreational appeal of each study site was evaluated with a field observation checklist prepared by Risk Sciences, Inc, discussed within Technical Memorandum 2. This checklist evaluates factors that may influence the potential for a site to be used for recreational activity. All criteria were ranked from 0 (poor recreational habitat and/or appeal) to 3 (good recreational habitat and/or appeal):

- Direct Evidence of Water Contact Recreation – Direct observations of people recreating in the water (0 = no observation; 3 = people actually in the water).

- Indirect Evidence of Recreational Activity – Measures evidence that people are occasionally present at the site, e.g., graffiti, recreational trash (beer bottles, sodas, etc), fishing line, and human paths to the channel; however, no evidence exists that visitors actually enter the water (0 = no evidence of recreational activity; 3 = evidence observed, e.g., fishing line, footprints, graffiti).

- Ease of Access – Measure of degree of difficulty to access the waterbody because of fencing, gates, locks, etc. (0 = inaccessible; 3 = easily accessible).

- Channel Slope – Measure of the type of slope, e.g., trapezoidal vs. rectangular (0 = box channel, 90° slopes; 3 = gentle slope)

- Channel Type – Measure of degree of naturalness, ranging from completely natural bottom and banks to completely constructed concrete channel (0 = bottom and banks are concrete; 3 = natural bank and channel bottom).

- Flow Depth & Volume – Measure of the degree that instream flow is sufficient for water contact recreation, including consideration of children (0 = minimal flow, not possible for adults or children to immerse themselves in the water; 3 = sufficient flow for immersion at least by children).

- Flow Velocity – Measure of the degree that flow velocity is dangerous for recreational activity (0 = high velocity, flow is dangerous; 3 = velocity is safe for recreational activity).

- Water Quality (Aesthetics) – Measure of how appealing the water is for recreation (0 = poor quality, e.g., lots of algae, trash; 3 = very appealing, water is an attractant).

- Vegetation Quality – Measure of quality of bank habitat for recreational activity (0 = no cover or shade for visitors; 3 = sufficient cover or shade).
- Adjacent Land Use – Measure of type of nearby land use (0 = site is adjacent to industrial parks; 3 = site is in a residential area).

Flow Data

Available flow data at each study site were collected and processed to facilitate time series plotting and frequency distribution analyses. In general, the collected data included mean daily flow for the entire period of record and, where appropriate, 15 or 30 minute interval flow data for a subset of the data record. Observations of the flow record at each site led to more detailed investigation of the sources of flow. Frequency distributions of flow rates, depths, and velocities were generated at each study site to assess the likelihood of the occurrence of certain flow conditions within the channel. The smaller interval of measurements relative to mean daily flow provided a more accurate analysis of instantaneous flow in the channel.

The Stormwater Standards Task Force is evaluating the appropriateness of establishing a high flow suspension of REC-1 water quality standards when the beneficial use is not attainable due to dangerous flow conditions. To identify potentially dangerous flow conditions at each site, two criteria, which have been used to define flow conditions where recreational activities are dangerous, were evaluated: (1) flow velocities greater than 8 ft/sec [Helsinki University of Technology, "The Use of Physical Models in Dam-Break Flood Analysis", RESCDAM, 2000]; and (2) a 10 ft^2/sec threshold depth-velocity product, above which wading is considered unsafe [USGS, Book 9 of the National Field Manual for the Collection of Water Quality Data, 2004]. Cumulative frequency curves of flow velocities and depth-velocity products were generated at each study site to determine the likelihood of occurrence of these potentially dangerous flow conditions.

Bacteria Data

Bacteria data collected at each of the study sites differed with regard to the length of record, frequency of sampling, constituents that were measured, and availability of concurrent flow data. Consequently, analyses of bacteria data were tailored as needed for each study site based on data availability. In general, the following methods were applied to when bacteria data were available:

- Time series plots of bacteria counts and flow were generated for the entire period of record at each study site to illustrate the relationship between bacteria concentrations and REC-1 standards and to identify any general trends. Where appropriate, these time series plots were related to flow data to evaluate the relationship between bacteria concentrations and wet or dry weather.

- Evaluation of changes in bacteria concentrations over the course of a specific storm.

- Bivariate plots of fecal coliform and E. coli were created for each study site to evaluate the relationship between bacteria types.

- Analysis of compliance with existing REC-1 fecal coliform water quality objectives and potential E. coli water quality objectives based on draft EPA guidance [USEPA, Implementation Guidance for Ambient Water Quality Criteria for Bacteria, November 2003 Draft]:

  - Fecal coliform: log or geometric mean less than 200 organisms/100 mL based on five or more samples/30 day period, and not more than 10% of the samples exceed 400 organisms/100 mL for any 30-day period

  - E.coli: log or geometric mean less than 126 organisms/100 mL based on five or more samples/30 day period, and a single sample maximum of 235 organisms/100 mL.

Bacteria concentrations under both dry and wet weather conditions were analyzed. Wet weather conditions were determined according to the method described previously within this memorandum. For this analysis, calendar months were used as a surrogate for the rolling 30-day period that is part of the existing fecal coliform water quality objectives. Thus, geometric means were calculated for calendar months in which there were 5 or more samples, and the 10% exceedance threshold was calculated on samples collected during a single calendar month.

Results

Chino Creek at Schaeffer Avenue

Channel Section

The Chino Creek at Schaeffer Avenue study site is located where California State Route 71 crosses Chino Creek (Figure 20 and Figure 21). The study reach consists of a trapezoidal concrete-lined channel with 2.25:1 side slopes and a bottom width of 60 feet. The bed slope of the channel at this site is 3 percent. Flow is recorded in this section of Chino Creek by the US Geological Survey [USGS Gage 11073360] (Figure 22).

Figure 20
Aerial Photograph of the Chino Creek at Schaeffer Avenue Study Site

Figure 21
Chino Creek Looking Upstream from USGS Flow Gage

Figure 22
USGS Flow Gage for the Chino Creek at Schaeffer Avenue Study Site

Drainage Area Characteristics

Land use in this watershed is predominantly residential, natural/vacant land, and commercial (Figure 23**)**. A portion of the drainage area, which lies upstream of San Antonio Dam, is comprised almost entirely of natural/vacant land in the San Gabriel Mountains. The drainage area below the dam is a mixed land use region which is primarily residential. Growth in residential and commercial land use in the area was observed between the years 1990 and 2000; however these changes have been minor (Figure 24). Runoff from the mountains that reaches the San Antonio Dam is diverted into the San Antonio Spreading Grounds (SASG) for recharge of the Six Basin Groundwater Management Area. The Pomona Valley Protective Association, owner of the SASG, spreads most of the runoff from above the dam during years with average runoff and the majority of flows from above average rainfall years. Occasional bypass of the spreading grounds, which routes excess runoff to San Antonio Creek, a major tributary of Chino Creek, occurs in high rainfall years. If the natural/vacant land upstream of San Antonio Dam is excluded from the analysis, residential is the primary land use in the primary contributing watershed to the Chino Creek at Schaeffer Avenue site (Figure 25**).**

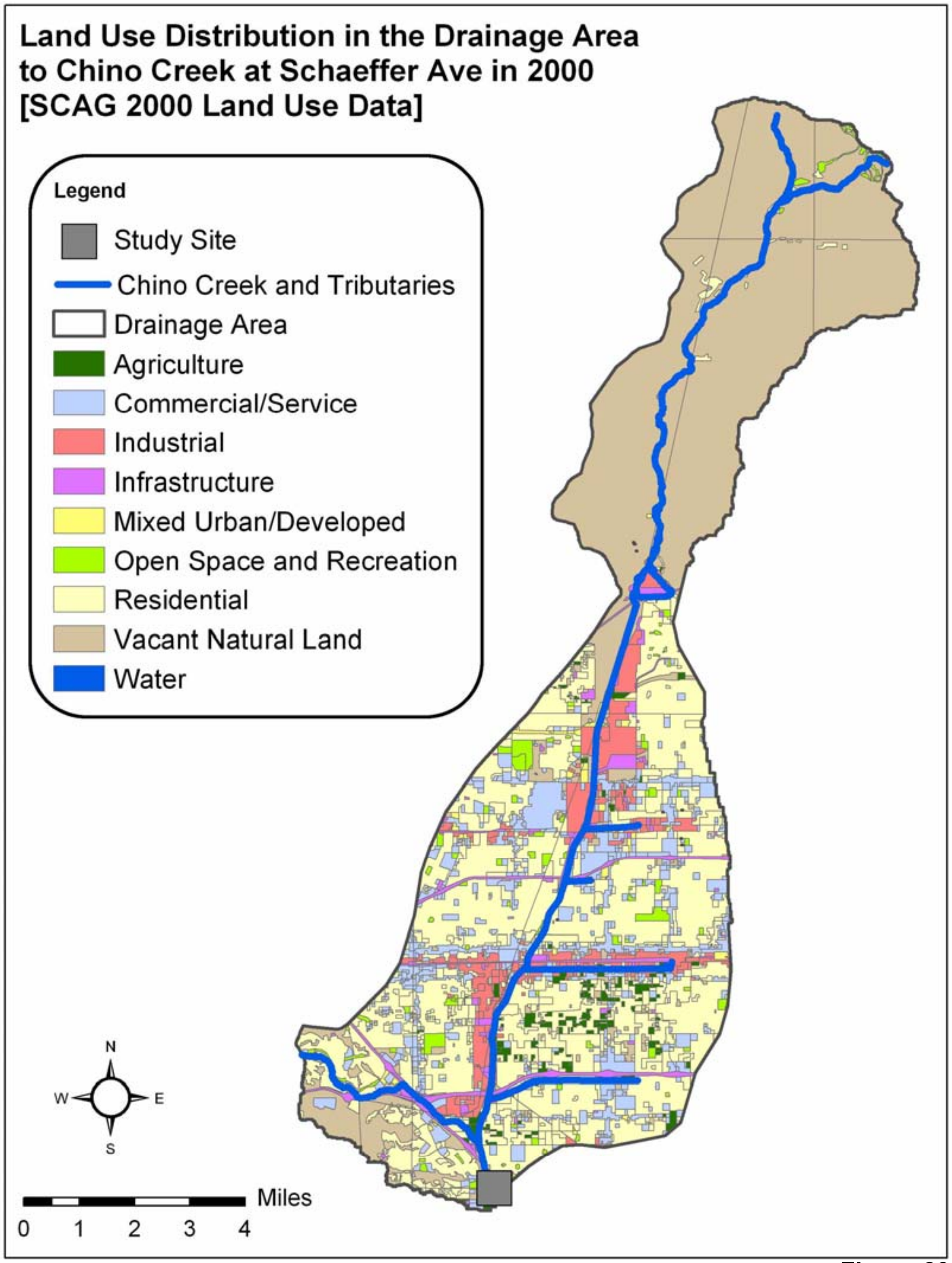


Figure 23
Land Use within Drainage Area to Chino Creek at Schaeffer Avenue Study Site

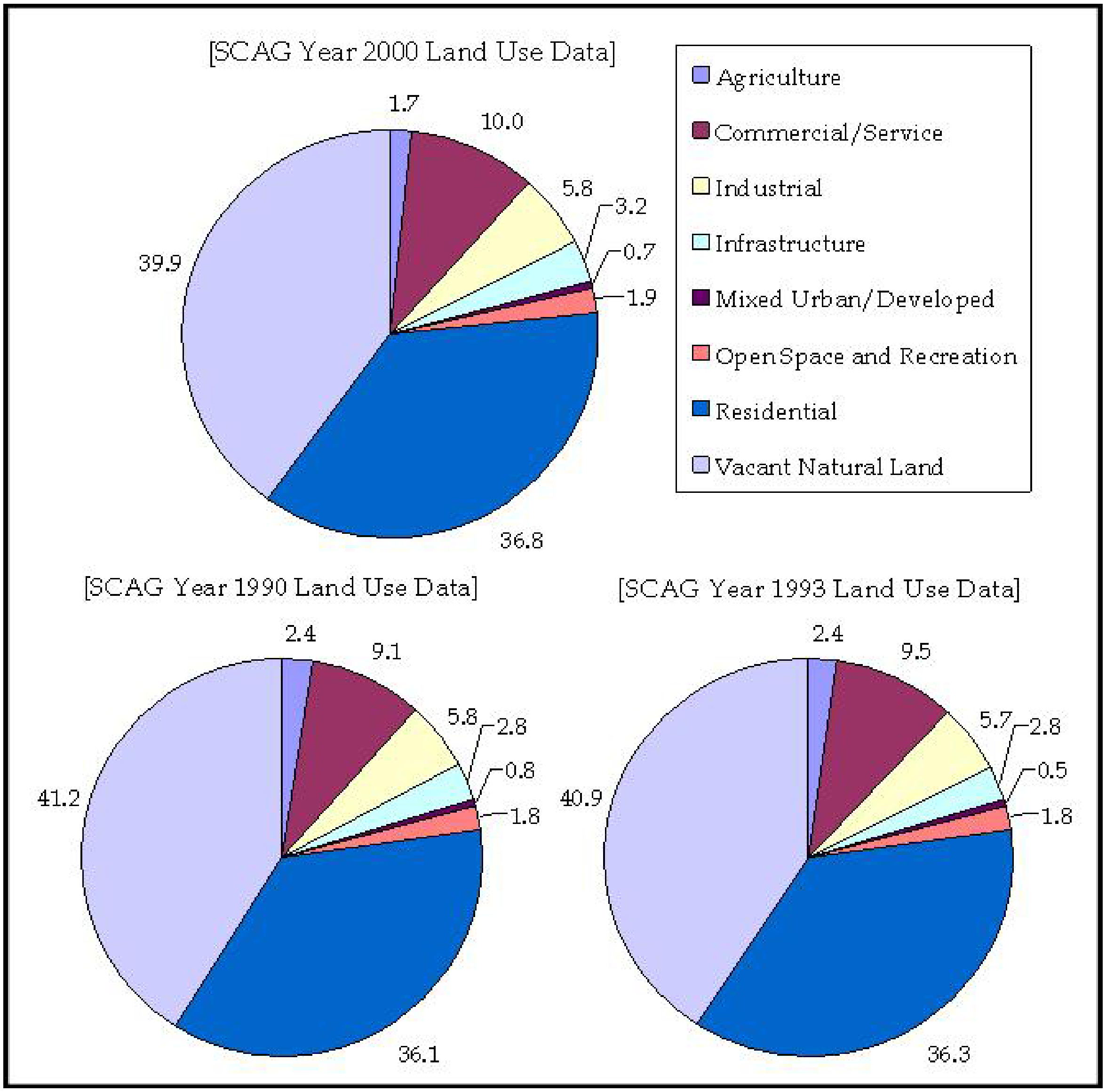


Figure 24
Relative Distribution (%) of Land Use Types in Chino Creek at Schaeffer Avenue Watershed, 1990, 1993, and 2000

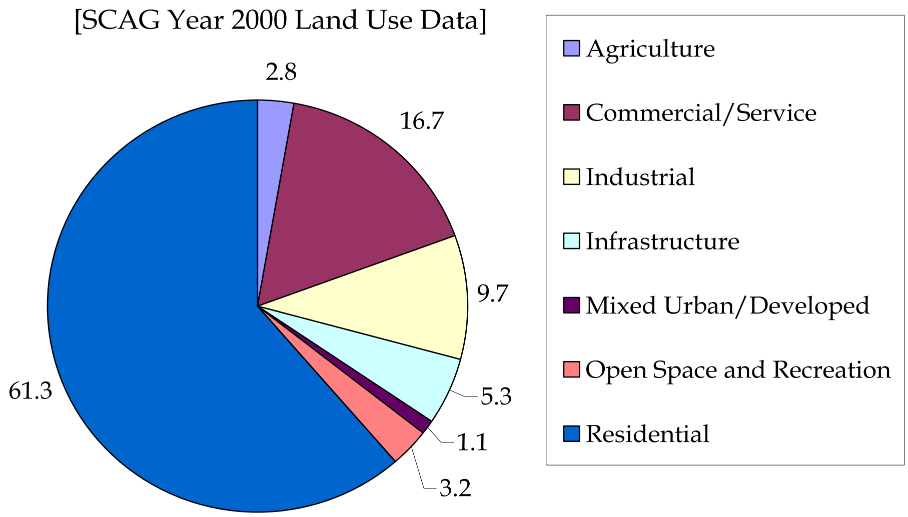


Figure 25
Relevant Distribution (%) of Land Use Types in Chino Creek at Schaeffer Avenue Watershed, Downstream of San Antonio Dam

Evidence of Recreational Activity
During the CDM site visit, the channel access gate was unlocked allowing easy access to the water. The gentle side slope of the channel would enable visitors to easily walk to the stream; and in fact the presence of graffiti and trash provided evidence that people had recently accessed this section of Chino Creek (Figure 26). This section of Chino Creek is located within a highly developed area of the city of Chino, with State Route 71 on the left bank and a shopping plaza on the right bank (Figure 27). With regards to the sites recreational appeal, the site generally received low scores (Figure 28).

Figure 26
Graffiti in bottom of Chino Creek

Figure 27
Surrounding area along Chino Creek near the Schaeffer Avenue Study Site

Evaluation Criteria (Scale = Low - 0 to High - 3)	Chino Creek at Schaeffer Avenue
Direct Evidence of Water Contact Recreation	0
Indirect Evidence of Recreational Activity	1
Ease of Access	1
Channel Slope	2
Concrete to Natural	0
Flow Depth and Volume	0
Flow Velocity	1
Water Quality Aesthetics	0
Vegetation Quality	1
Adjacent Land Use	0

Figure 28
Field Observation Checklist for the Chino Creek at Schaeffer Avenue Study Site

Flow

The USGS mean daily flow record from 1969 through 2004 was used to plot a time series of flow at this site and to compare flow in the channel to other measured parameters, including rainfall and bacteria (Figure 29). Flow in Chino Creek is primarily urban dry weather. As observed, the channel experiences predominantly low flows much of the year, typically averaging about 5 cfs, and periodic elevated flow typically correlated with rainfall event runoff.

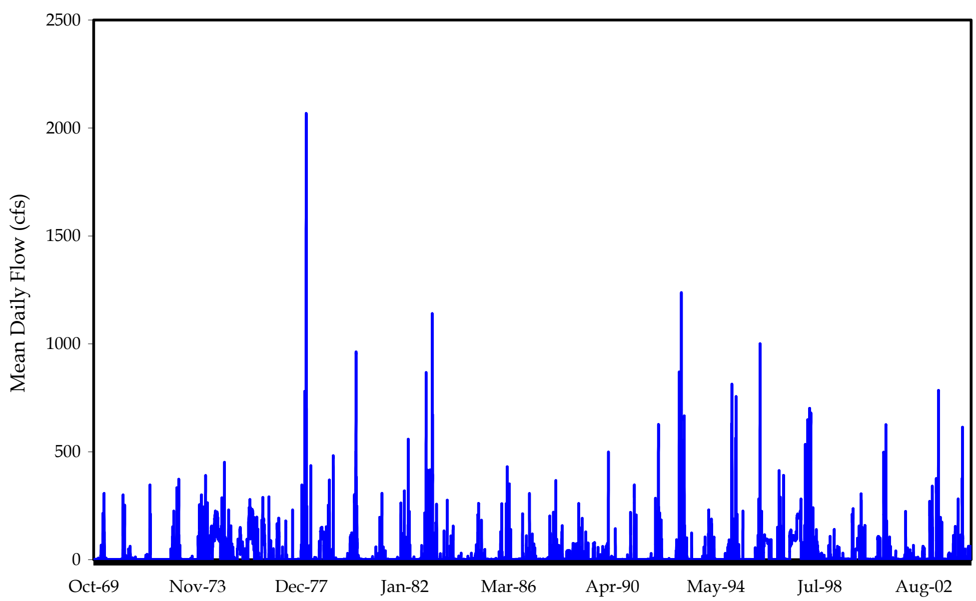


Figure 29
Mean Daily Flow in Chino Creek at Schaeffer Avenue between 1969 and 2004

However several instances of elevated flow occur without a corresponding rainfall event. During such periods, measured flow is elevated from typical dry weather baseflow (1 to 5 cfs) by one order of magnitude for about 30 days. Consultation with Orange County Water District (OCWD) indicated that these prolonged non-rainfall high flow events are the result of a water purchase from the State Water Project (SWP) or conveyed via Chino Creek to increase groundwater recharge downstream of Prado Dam in Orange County. A subset of the mean daily flow record provides an example of one of these water purchase events in August 2002 (Figure 30).

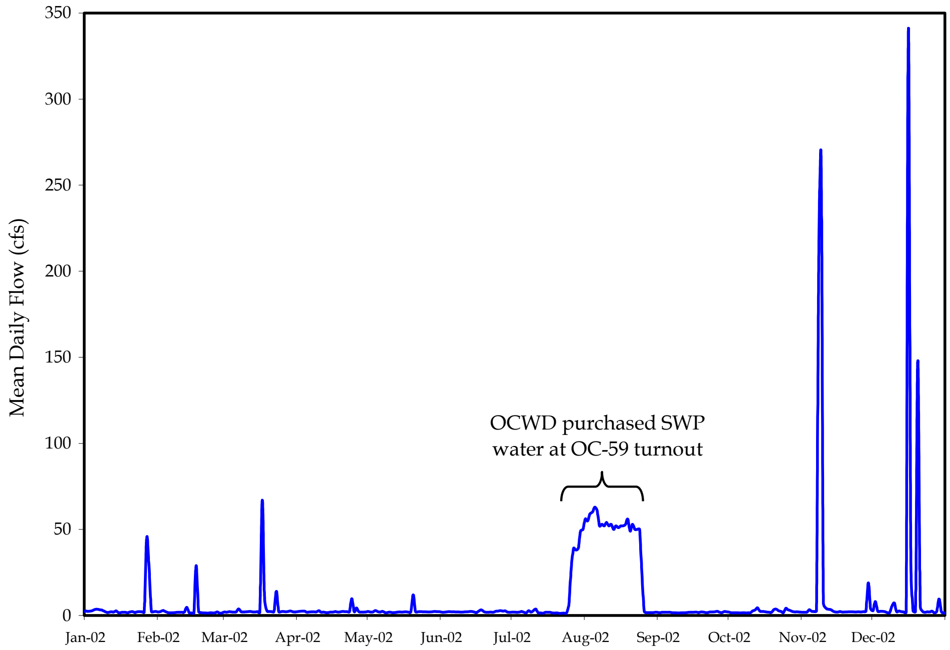


Figure 30
Mean Daily Flow in Chino Creek at Schaeffer Avenue during 2002

Flow data was recorded in 15 minute intervals by the USGS in Chino Creek at Schaeffer Avenue between 1988 and 2004. These data were used to develop a frequency distribution of flow rate and depth in the channel (Figure 31 and Figure 32), as well as flow velocity and the depth-velocity product. Both Figures 31 & 32 provide an illustration of the complete distribution, and the top 10th percentile of flow rate and depth.

To estimate the frequency of potentially dangerous flows at this site, cumulative frequency curves of flow velocities and depth-velocity products were developed. Figure 33 shows that an 8 ft/sec velocity is exceeded about 2.5% of the time, and Figure 34 shows that the depth-velocity product exceeds 10 ft^2/sec about 0.5% of the time.

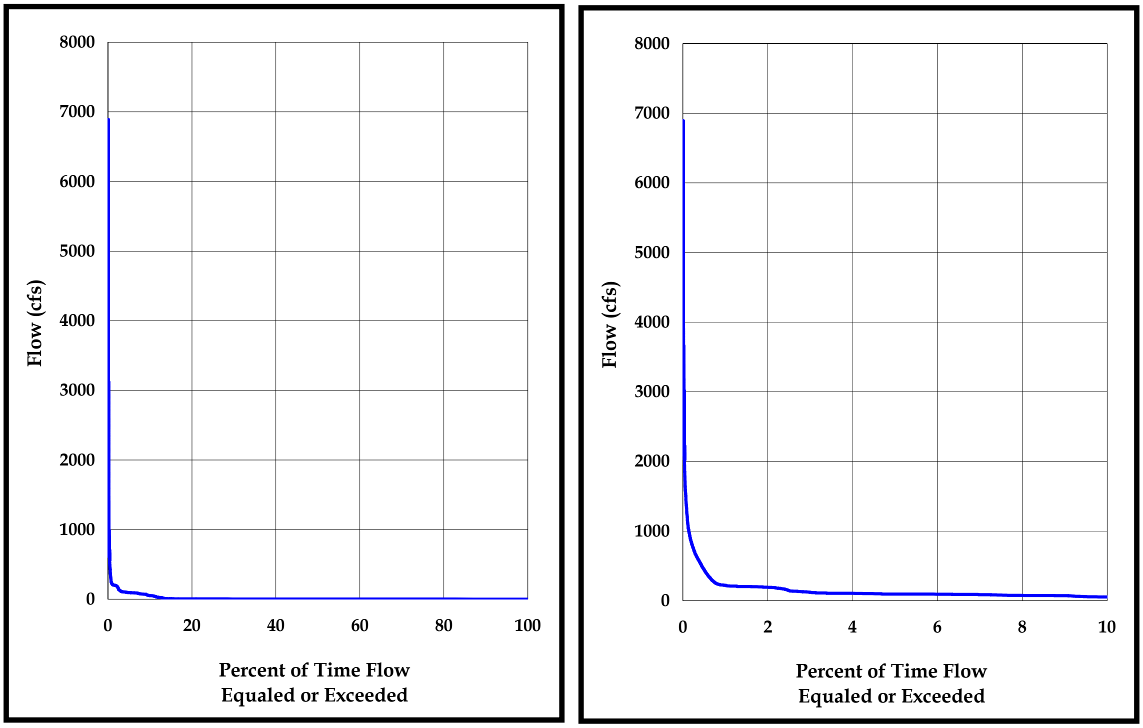


Figure 31
Channel Flow Curves for Chino Creek at Schaeffer Avenue (1988 – 2004)

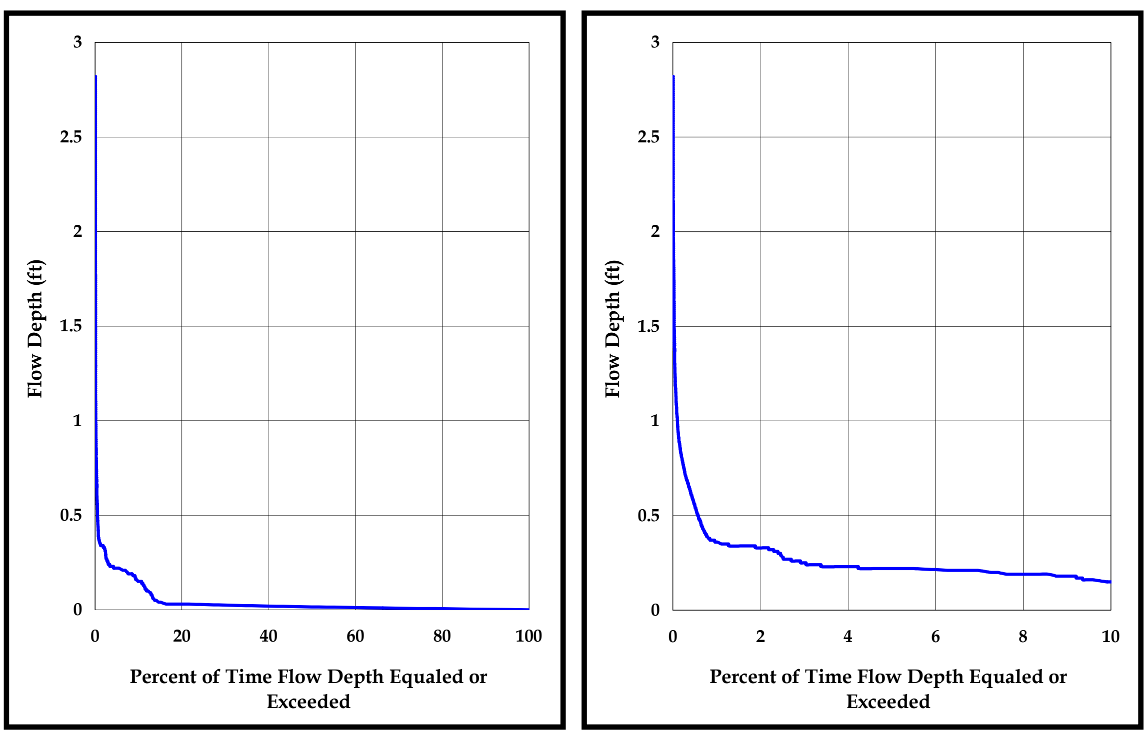


Figure 32
Channel Depth Curve for Chino Creek at Schaeffer Avenue (1988 – 2004)

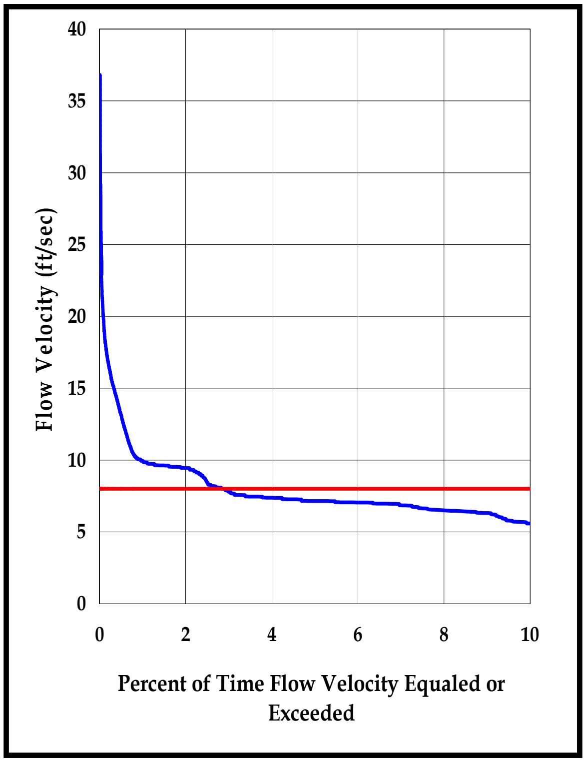


Figure 33
Channel Velocity Curve for Chino Creek at Schaeffer Ave (1988-2004)

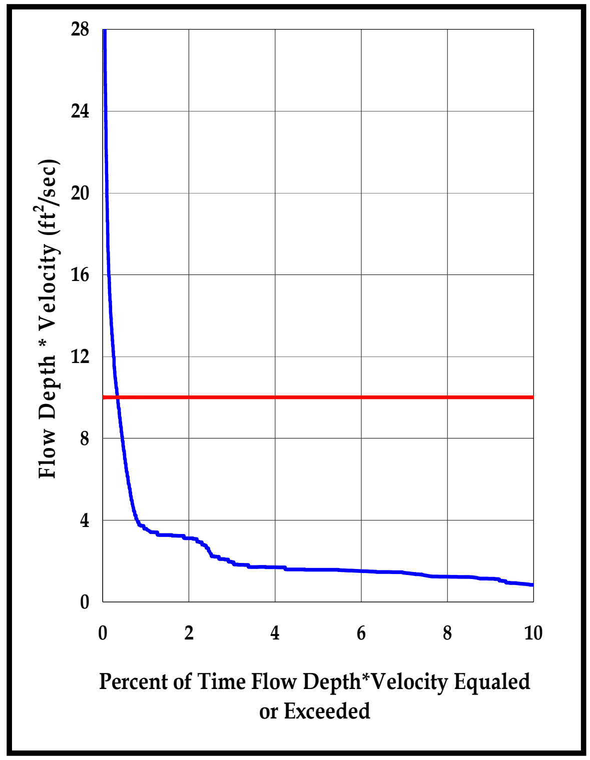


Figure 34
Channel Depth*Velocity Curve for Chino Creek at Schaeffer Ave (1988-2004)

Analysis of Bacteria Data

Fecal coliform and E. coli bacteria samples were collected in Chino Creek at Schaeffer Avenue as part of the Chino Basin TMDL monitoring program. Weekly bacteria samples were collected at this site during wet weather months from February 2002 to present. Weekly samples were also collected during the summer of 2002.

Bacteria Trends

Between 2002 and 2004, both fecal coliform and E. coli concentrations frequently exceed the 10% exceedance thresholds of 400 and the EPA proposed criteria of 236 MPN/100 mL, respectively (Figure 35). The data also suggest that high flow events are not correlated with high bacterial counts.

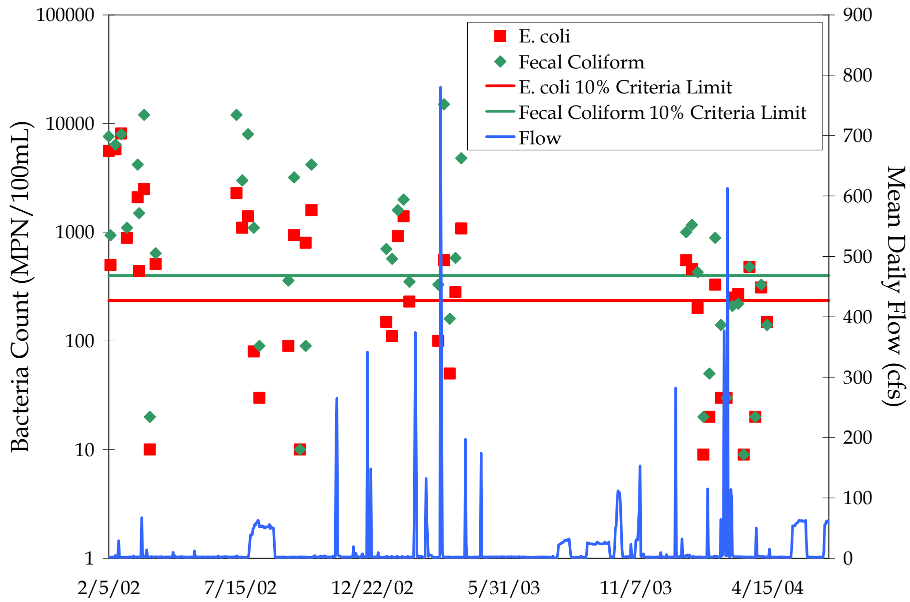


Figure 35
Time Series of Bacteria Counts and Flow at the Chino Creek at Schaeffer Avenue Study Site

Table 7 summarizes geometric means of fecal coliform and E. coli bacteria sample results for all calendar months (Note: in some cases the number of samples/month was less than five; however, geometric means were still calculated to provide a method to evaluate any trends in mean bacteria concentrations. Both fecal coliform and E. coli bacteria concentrations generally exceed existing and or anticipated geometric mean water quality objectives, assuming 5 or more samples were collected in a given month (Figure 36). The data also suggest that monthly geometric means decreased gradually between 2002 and 2004. The strong correlation between fecal coliform and E. coli concentrations in Chino Creek at the Schaeffer Avenue study site indicate that regardless of the pathogen indicator used, exceedences of water quality objectives would have occurred (Figure 37**).**

Table 7
Monthly Fecal Coliform and E. coli Concentrations (Geometric Mean) in Chino Creek at Schaeffer Avenue

Month	E. coli Geometric Mean	Fecal Coliform Geometric Mean	Sample Size
Feb-02	2592	3318	5
Mar-02	390	1109	4
Apr-02	510	640	1
Jul-02	730	4219	4
Aug-02	30	90	1
Sep-02	95	226	3
Oct-02	1131	615	2
Jan-03	382	1063	4
Feb-03	230	350	1
Mar-03	140	925	3
Apr-03	550	1669	2
Jan-04	94	216	3
Feb-04	49	117	4
Mar-04	90	83	5
Apr-04	216	215	2

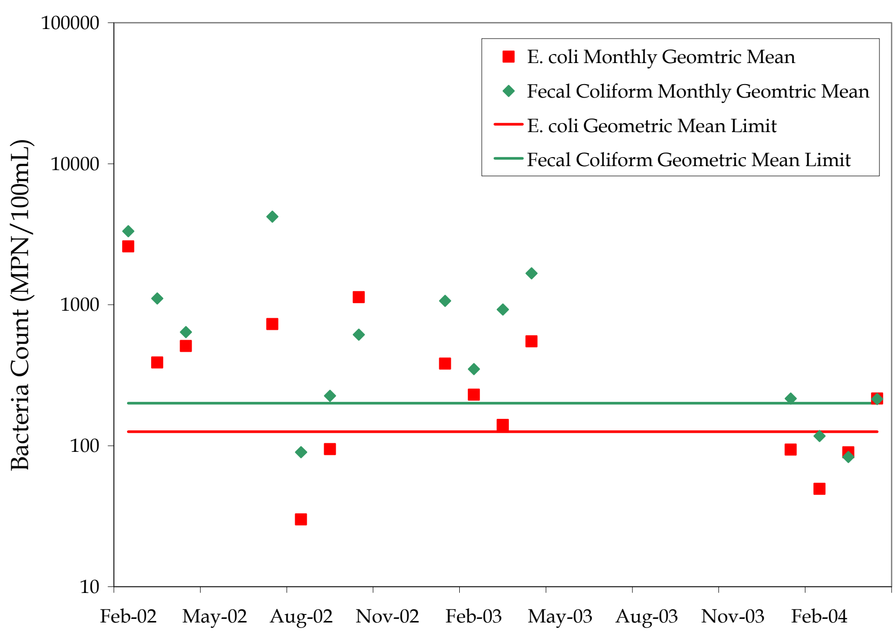


Figure 36
Monthly Bacteria Geometric Mean Concentrations at Chino Creek at Schaeffer Avenue

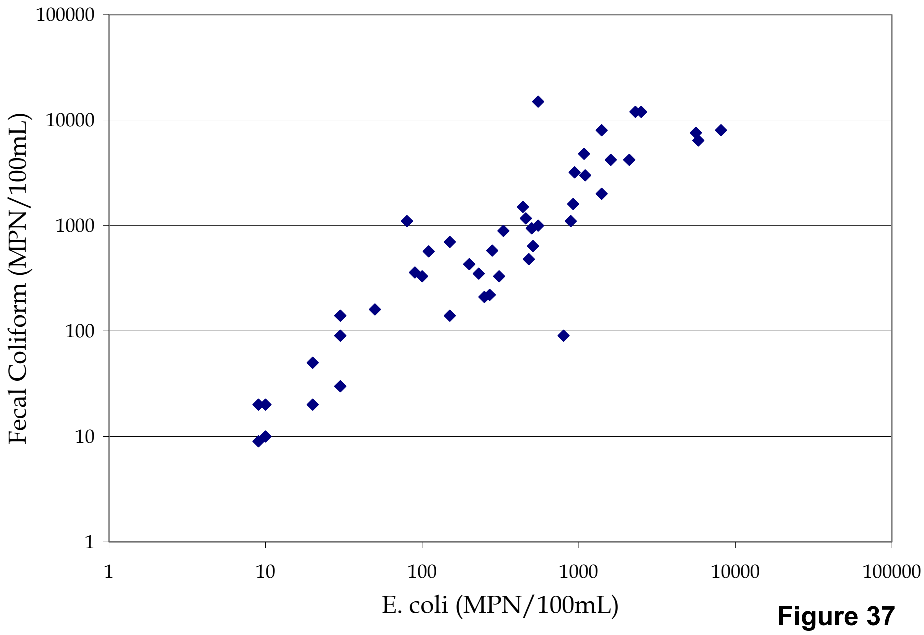


Figure 37
Relationship between E. coli and Fecal Coliform concentrations at Chino Creek at Schaeffer Avenue

Bacteria Water Quality Objectives Compliance

Analysis of bacteria compliance showed that exceedences of water quality objectives may occur during dry weather flows during both summer and winter months (Figure 38). This figure shows the number of calendar months when sufficient water quality data was available to be compared to objectives (number at the end of each bar) and the percent of those calendar months that may have exceeded water quality objectives. In contrast, of the two wet weather samples collected in February 2004 during two separate rainfall events, neither sample exceeded bacteria water quality objectives.

Santa Ana Delhi Channel

Channel Section

The Santa Ana Delhi Channel (Figure 39) extends from the city of Santa Ana to Upper Newport Bay. At Irvine Avenue, the conveyance is a concrete lined rectangular channel with a 55 ft bottom width (Figure 40 and Figure 41). Channel attribute information was provided by Orange County Flood Control District and field verified during a site visit. The bed slope of the channel at this site is 2.5 percent.

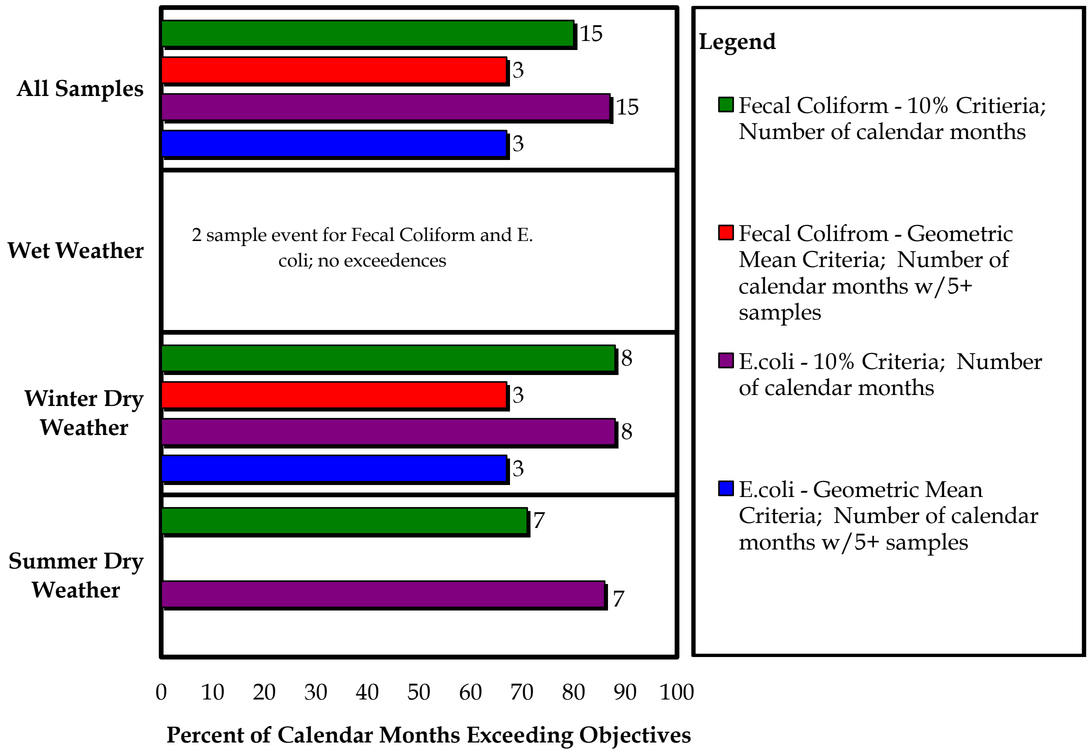


Figure 38
Comparison with Existing and Potential Bacteria Water Quality Objectives

Figure 39
Aerial Photograph of the Santa Ana Delhi Channel Study Site

Figure 40
Santa Ana Delhi Channel Downstream from Irvine Avenue

Figure 41
USGS Flow Gage at Newport Beach Golf Course Upstream of Irvine Avenue

Drainage Area Characteristics
The channel and its tributaries are primarily engineered flood control facilities that capture urban stormwater and dry weather runoff from commercial and residential land uses (Figure 42). The watershed is primarily comprised of an older urbanized part of Orange County, which has not undergone significant land use change between 1990 and 2000 (Figure 43).

Evidence of Recreational Activity
Direct or indirect evidence of recreational use of the Santa Ana Delhi Channel was not observed during site visits and, accordingly, the site was scored low in terms of recreational appeal (Figure 44).

The steep side slopes, fencing, and restrictive signs minimize the likelihood of recreational use at this study site (Figure 45 and Figure 46). Although recreational use is not likely to occur within the Santa Ana Delhi Channel itself, the site is immediately upstream of Upper Newport Bay, an inland surface water that supports a diversity of REC-1 uses (Figure 47).

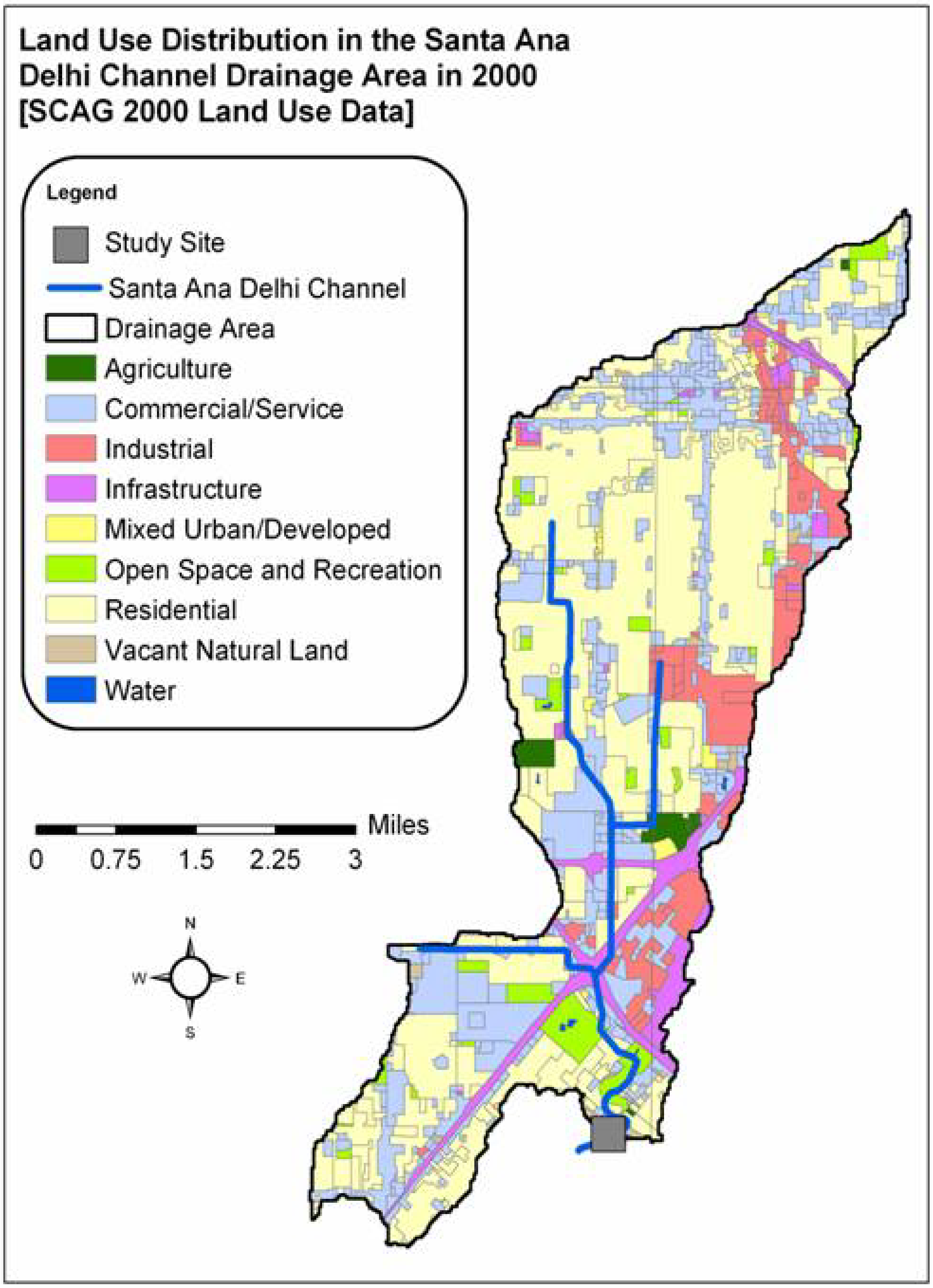


Figure 42
Land Use within Drainage Area to Santa Ana Delhi Channel Study Site

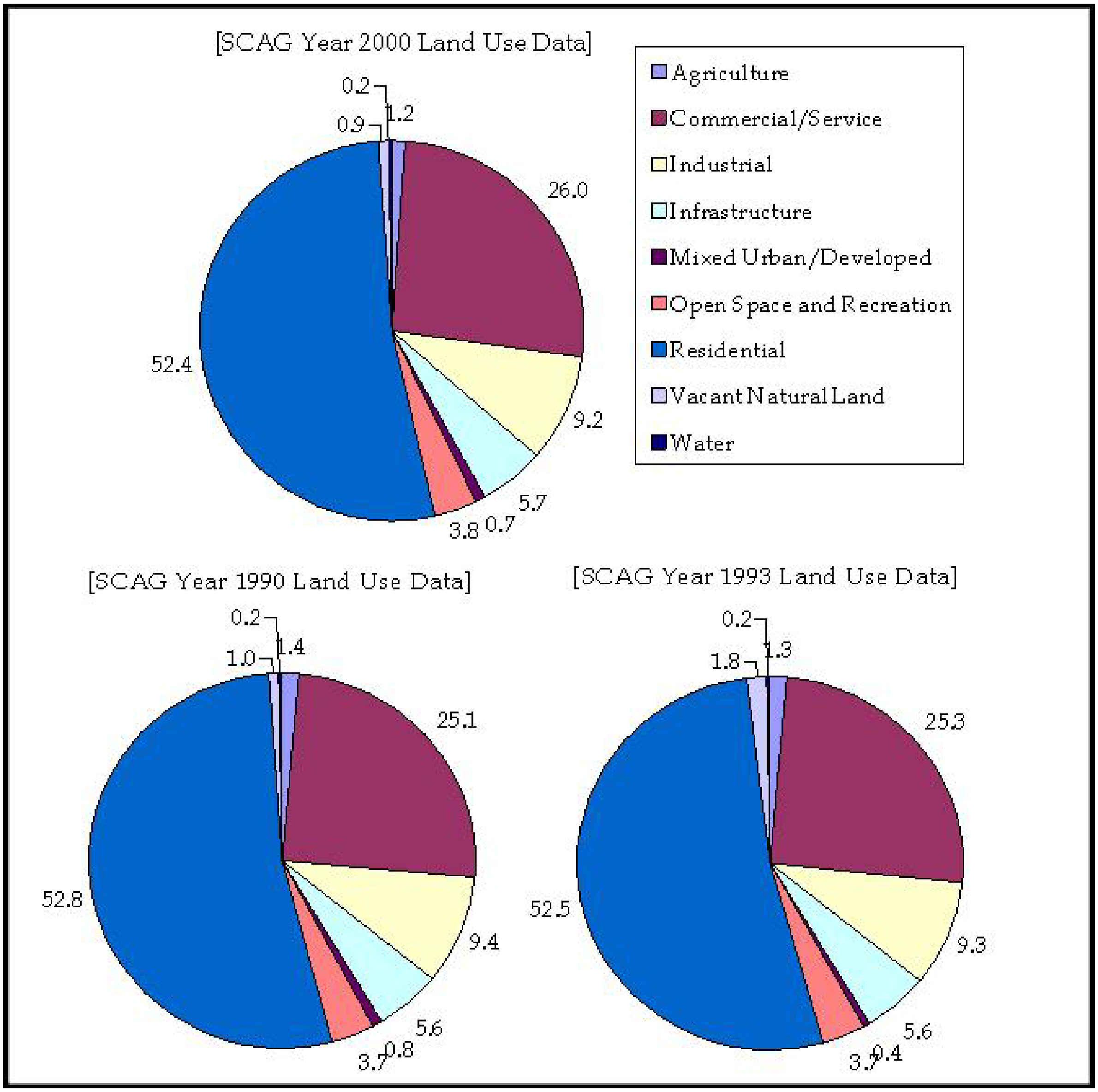


Figure 43
Relative Distribution (%) of Land Use Types in the Santa Ana Delhi Channel Watershed during 1990, 1993, and 2000

Evaluation Criteria (Scale = Low - 0 to High - 3)	Santa Delhi Channel at Irvine Ave.
Direct Evidence of Water Contact Recreation	0
Indirect Evidence of Recreational Activity	0
Ease of Access	0
Channel Slope	0
Concrete to Natural	0
Flow Depth and Volume	0
Flow Velocity	1
Water Quality Aesthetics	0
Vegetation Quality	0
Adjacent Land Use	1

Figure 44
Field Observation Checklist for the Santa Ana Delhi Channel Study Site

Figure 45
Fencing around Santa Ana Delhi Channel Prevents Access to Waterbody

Figure 46
Restrictive Signs around Santa Ana Delhi Channel

Figure 47
Upper Newport Bay near Santa Ana Delhi Channel Outfall

Flow

The Orange County Public Facilities and Resources Department (PFRD) records flow at 30-minute intervals in the Santa Ana Delhi Channel at a gage located upstream of the Irvine Avenue bridge (Figure 39). Flow records were available for the period between 1992 and 2004. Figure 48 illustrates a subset of the flow record to provide a better picture of flow during a typical year. Flow during dry weather periods typically is comprised of residential/commercial irrigation overflow, car washing, and other nuisance flow sources.

Cumulative frequency curves of the top 10^{th} percentile of flow rate and depth were generated from the 30-minute interval flow data (Figure 49 and Figure 50). Cumulative frequency curves of flow and velocities and depth-velocity products, which occurred in the Santa Ana Delhi Channel between 1992 and 2004, are shown in Figure 51 and Figure 52. Between 1992 and 2004, flow velocity in the Santa Ana Delhi Channel exceeds 8 ft/sec about 1.5 % of the time and the depth-velocity product exceeds 10 ft^2/sec about 1.0% of the time. These statistics are relatively similar to those observed at the Chino Creek study site.

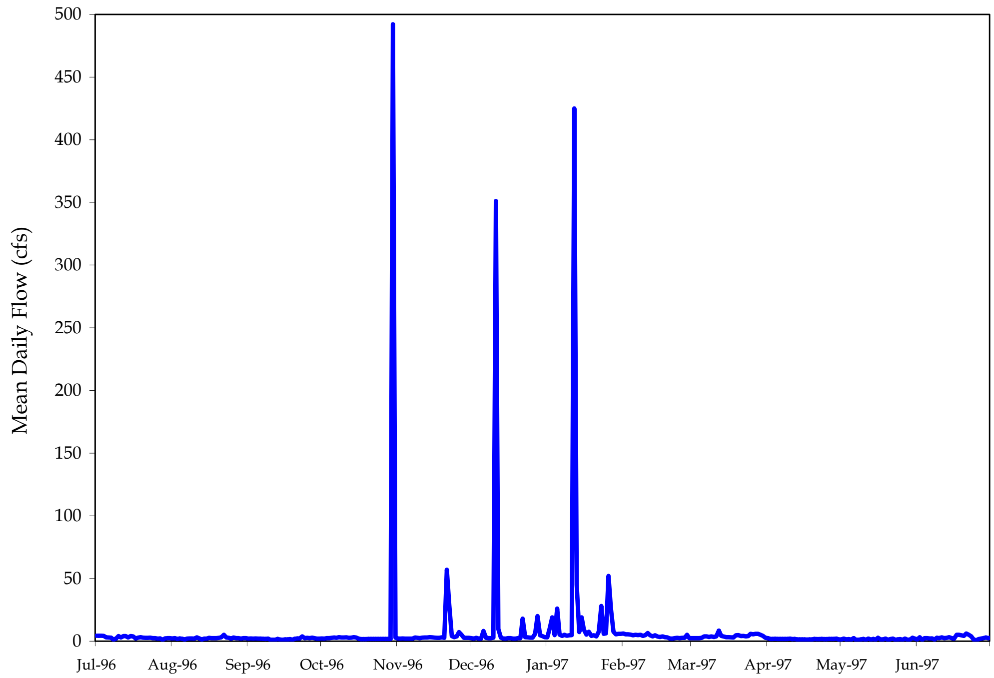


Figure 48
Mean Daily Flow in Santa Ana Delhi Channel during 1996-1997

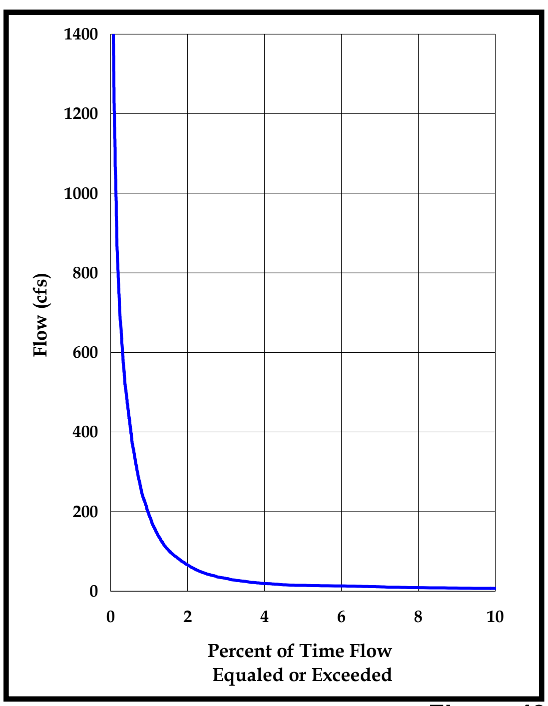


Figure 49
Channel Flow Duration Curve for Santa Ana Delhi Channel near Irvine Avenue (1992-2004)

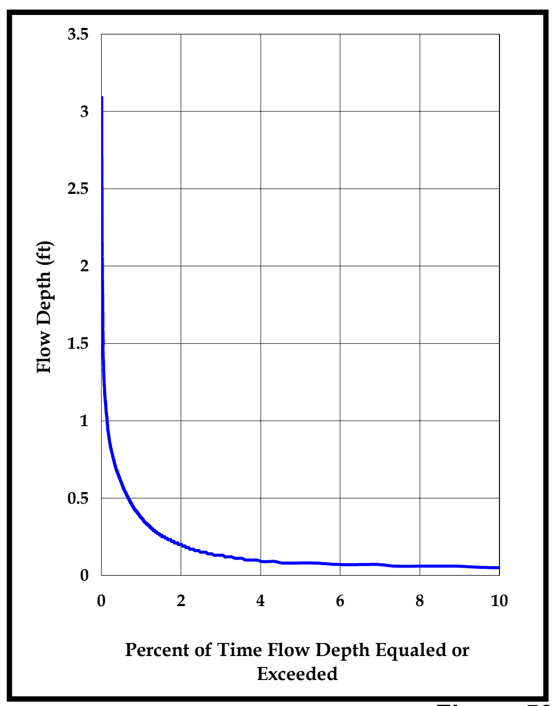


Figure 50
Channel Depth Curve for Santa Ana Delhi Channel near Irvine Avenue (1992-2004)

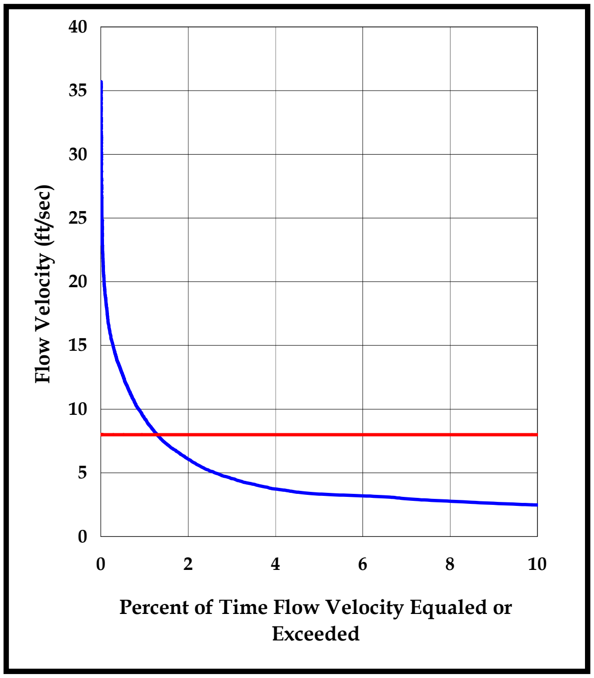


Figure 51
Channel Velocity Curve for Santa Ana Delhi Channel near Irvine Avenue (1992-2004). Red line denotes potentially dangerous condition

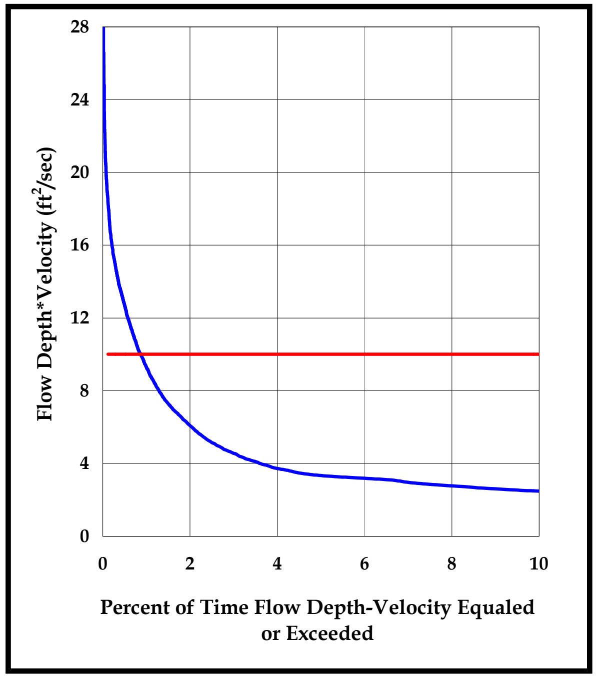


Figure 52
Channel Depth-Velocity Curve for Santa Ana Delhi Channel near Irvine Avenue (1992-2004) Red line denotes potentially dangerous condition

Bacteria Trends

Bacteria samples have been collected in two locations near this study site: at the Irvine Avenue Bridge and about ¾ mile downstream where the rectangular channel transitions to a natural wetlands area (Santa Ana Channel – Backbay). Fecal coliform samples collected between 1973 and 1976 were taken at the Irvine Avenue Bridge. Samples gathered between 1985 and 2004 were collected at the Santa Ana Delhi Channel - Backbay.

Fecal coliform concentrations have remained generally the same in the Santa Ana Delhi Channel - Backbay between 1991 and 2004 (Figure 53). By looking at a subset of this record, it is also evident that the bacteria limit for 10% of samples per 30-day period is regularly exceeded and there is no obvious connection between bacteria concentrations and wet weather events (Figure 54).

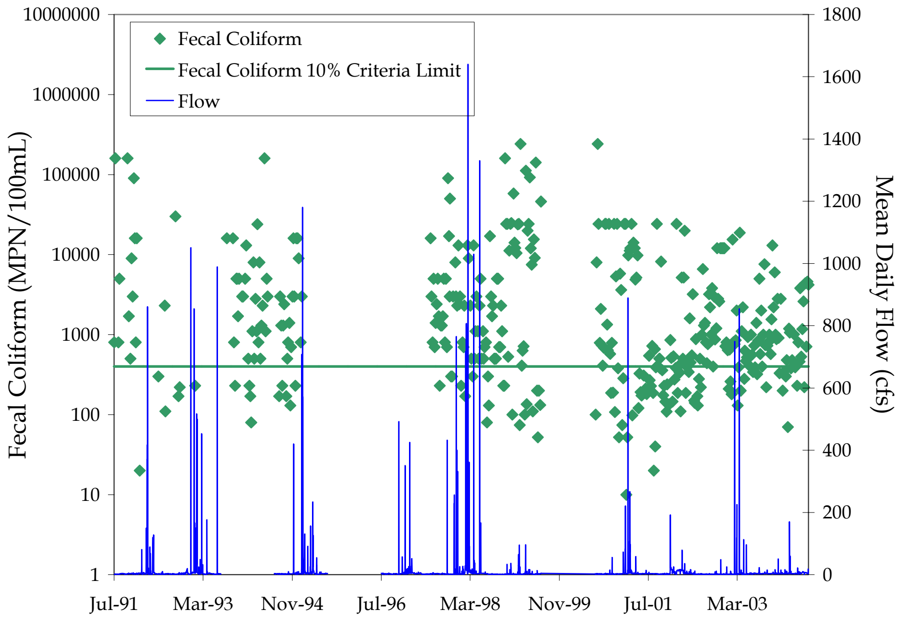


Figure 53
Time Series of Bacteria Concentrations and Flow in the Santa Ana Delhi Channel - Backbay

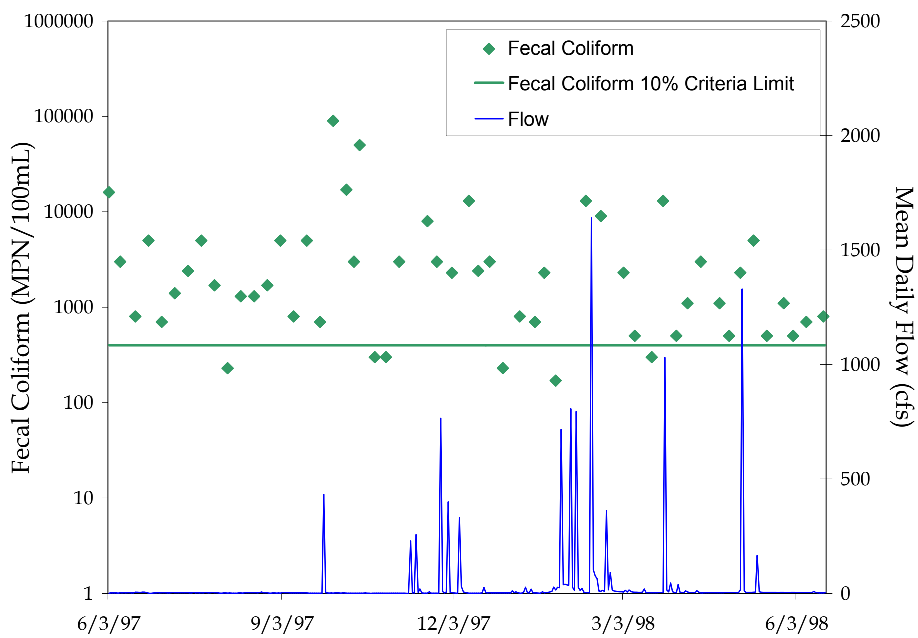


Figure 54
Time Series of Bacteria Concentrations and Flow in the Santa Ana Delhi Channel – Backbay between 1997and 1998

Annual geometric means of bacterial data at both sites in the Santa Ana Delhi Channel were calculated and are listed with the sample size in Table 8 and shown graphically in Figure 55. The geometric means exceeds the fecal coliform water quality objective (200 MPN/100mL) for every year for which data was available. Monthly geometric means for the more recent time period from January 2000 to June 2004 were also calculated (Table 9) (note: geomtric means were calculated for each month regardless of whether the five sample threshold was reached). While the majority of monthly geometric means exceed the fecal coliform geometric mean water quality objective, bacteria concentrations tend to be lower during late spring (Figure 56).

Table 8
Annual Geometric Means Santa Ana Delhi Channel

Year	Fecal Coliform Geometric Mean at Irvine Ave	Fecal Coliform Geometric Mean at Back Bay	Sample Size
1973	3715		1
1974	258		9
1975	798		13
1976	460		1
1985		700	1
1986		1654	51
1987		543	50
1988		651	46
1989		5251	41
1990		1403	44
1991		2329	26
1992		663	6
1993		2961	13
1994		1469	39
1995		3000	1
1997		2515	31
1998		1722	50
1999		2561	52
2000		560	52
2001		1141	52
2002		900	52
2003		676	49
2004		275	23

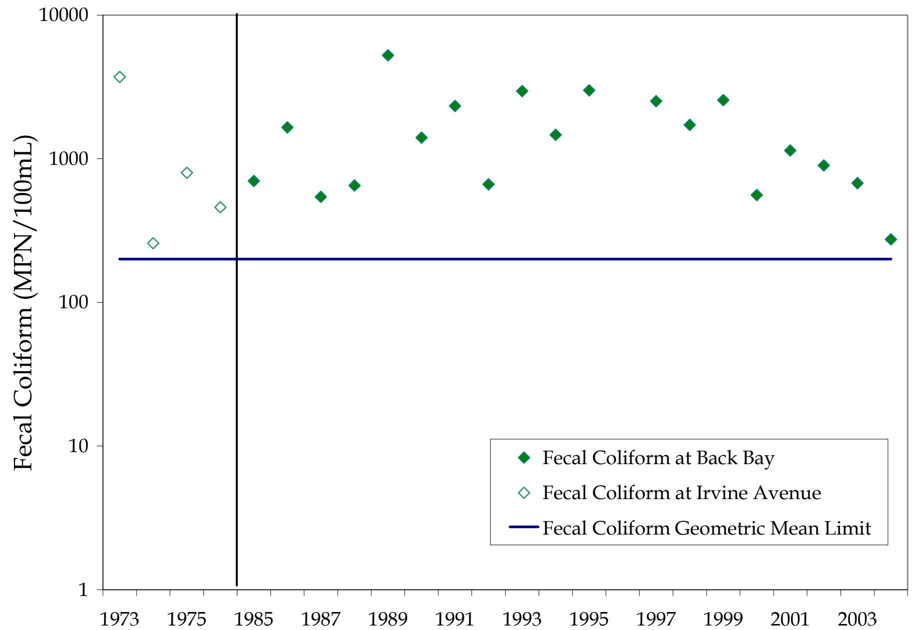


Figure 55
Annual Geometric Means of Fecal Coliform in the Santa Ana Delhi Channel

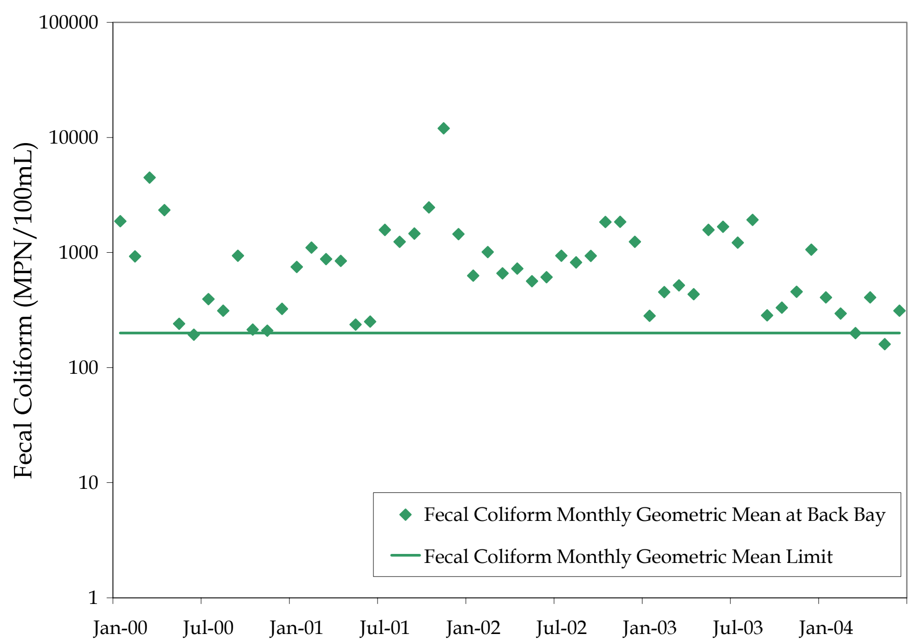


Figure 56
Monthly Geometric Means of Fecal Coliform in the Santa Ana Delhi Channel

Table 9
Monthly Geometric Means Santa Ana Delhi Channel

Month	Fecal Coliform Geometric Mean at Back Bay	Sample Size	Month	Fecal Coliform Geometric Mean at Back Bay	Sample Size
Jan-00	1874	4	Apr-02	725	5
Feb-00	928	5	May-02	563	4
Mar-00	4481	4	Jun-02	611	4
Apr-00	2340	4	Jul-02	940	5
May-00	240	4	Aug-02	822	4
Jun-00	194	4	Sep-02	937	5
Jul-00	394	4	Oct-02	1841	4
Aug-00	312	6	Nov-02	1846	4
Sep-00	938	4	Dec-02	1239	4
Oct-00	214	4	Jan-03	282	4
Nov-00	210	5	Feb-03	454	4
Dec-00	324	4	Mar-03	518	4
Jan-01	751	5	Apr-03	434	4
Feb-01	1101	4	May-03	1573	4
Mar-01	878	4	Jun-03	1677	5
Apr-01	845	5	Jul-03	1220	4
May-01	237	4	Aug-03	1924	4
Jun-01	252	4	Sep-03	284	5
Jul-01	1572	5	Oct-03	332	4
Aug-01	1239	4	Nov-03	456	3
Sep-01	1461	4	Dec-03	1058	4
Oct-01	2466	5	Jan-04	407	4
Nov-01	12000	4	Feb-04	295	4
Dec-01	1447	4	Mar-04	199	4
Jan-02	629	5	Apr-04	408	4
Feb-02	1011	4	May-04	160	4
Mar-02	661	4	Jun-04	312	2

Figure 57 shows the number of calendar months when sufficient water quality data was available to be compared to objectives (number at the end of each bar) and the percent of those calendar months that may have exceeded water quality objectives. This may occur regularly regardless of flow conditions in the Santa Ana Delhi Channel.

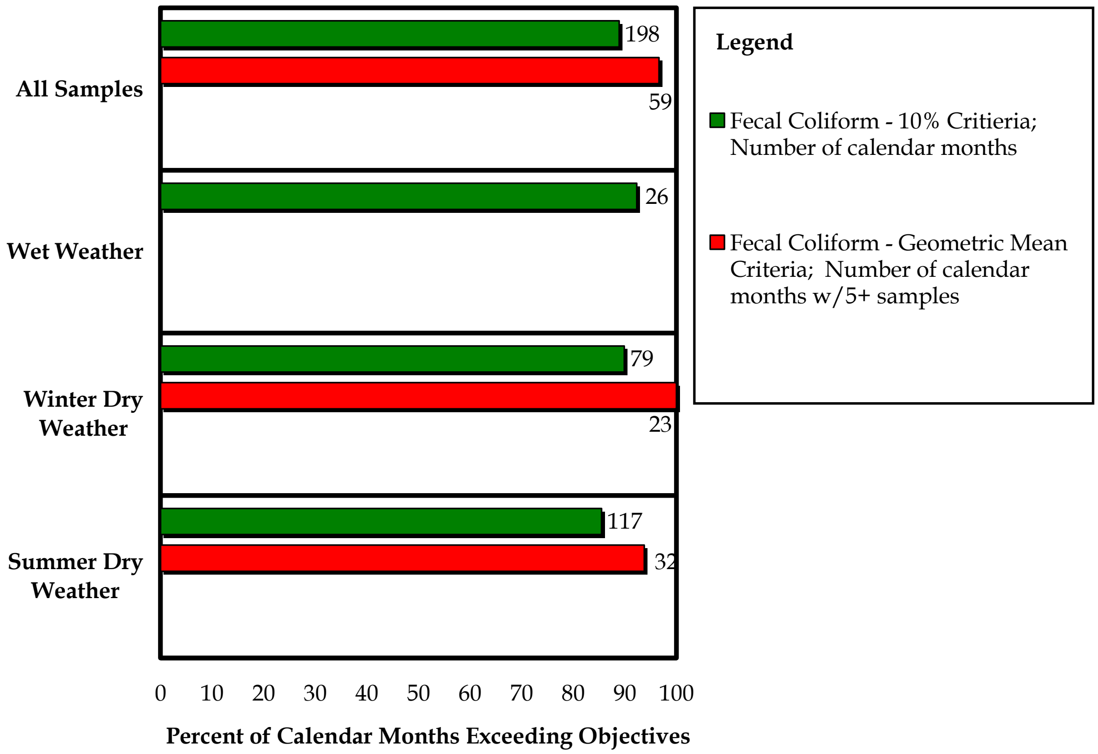


Figure 57
Comparison with Existing and Potential Bacteria Water Quality Objectives

Temescal Creek at Lincoln Avenue

Channel Section

Temescal Creek is a concrete lined trapezoidal channel upstream of Lincoln Avenue. Downstream of Lincoln Avenue the channel transitions from concrete lined to a more natural channel (Figure 58 through Figure 60). The concrete trapezoidal channel section has a 60 ft bottom width and 1.5:1 side slopes; the channel bed slope is 2.0 %. Flow is monitored in Temescal Creek near Main Street, approximately 1 mile upstream of the bacteria sampling location.

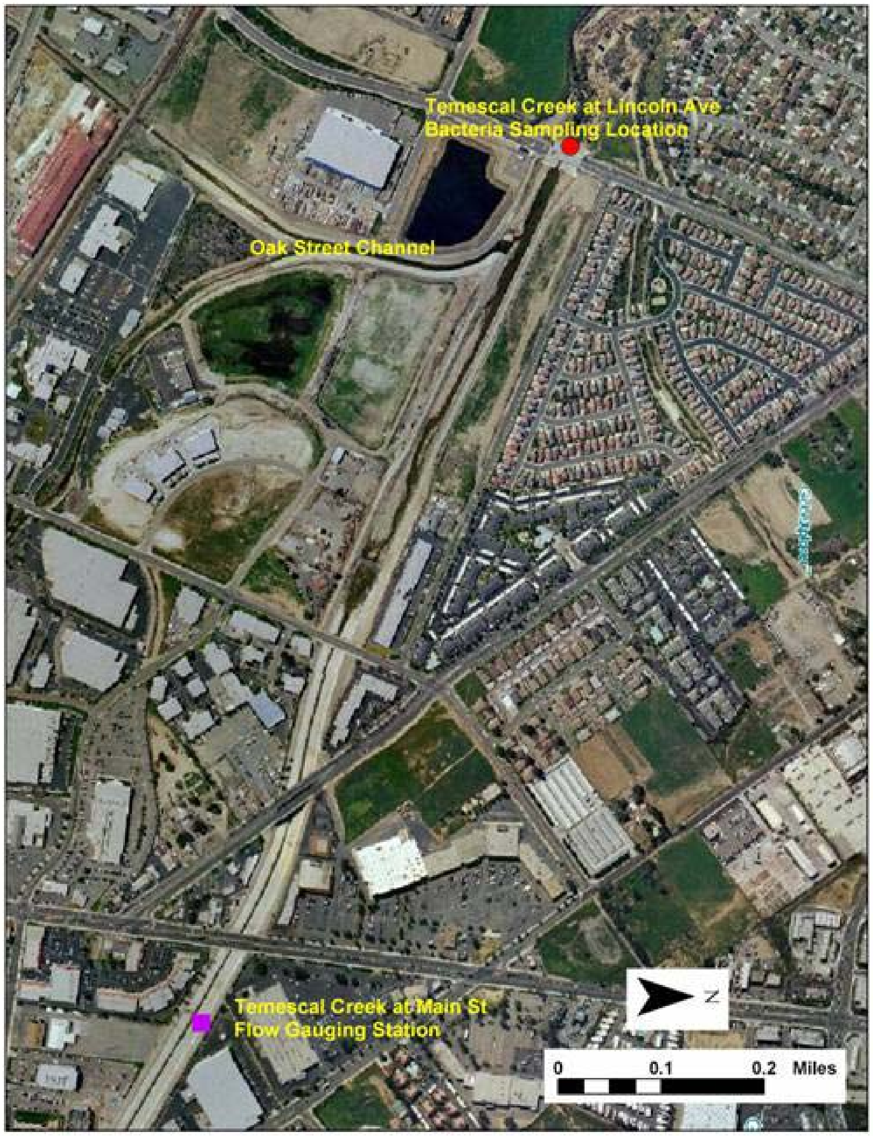


Figure 58
Aerial Photograph of the Temescal Creek at Lincoln Avenue Study Site

Figure 59
Temescal Creek transitions from concrete lined to natural below Lincoln Avenue Bridge

Figure 60
Temescal Creek downstream of Lincoln Avenue bridge, looking upstream

Drainage Area Characteristics

The Temescal Creek watershed is very large and includes both the Lake Elsinore and Lake Matthews subwatersheds. However, for the purpose of this analysis both of these subwatersheds were excluded. Lake Mathews is a terminal reservoir for storage of imported Colorado River water supply and outflow from Lake Matthews is routed into the water supply system and not into Temescal Creek. Lake Elsinore and its contributing area were also excluded from the Temescal Creek study site drainage area. The outlet of Lake Elsinore does not overflow in most years, due to high evaporation losses in the lake, low inflow volume due to channel bottom infiltration of flows in the San Jacinto River and its tributaries, and the objective to manage high lake levels to maintain recreational use and prevent algal blooms.

Because a large portion of the upper watershed of Temescal Creek is undeveloped, the dominant land use in the Temescal Creek watershed is vacant or natural land (Figure 61). The majority of the vacant/natural land is within the Cleveland National Forest and Lake Matthews Estelle Mountain Reserve. From 1990 to 2000 agricultural land use has declined while residential land use has increased (Figure 62). The Temescal Creek drainage area will likely continue to develop as space for new development in more accessible areas of the Santa Ana basin decreases.

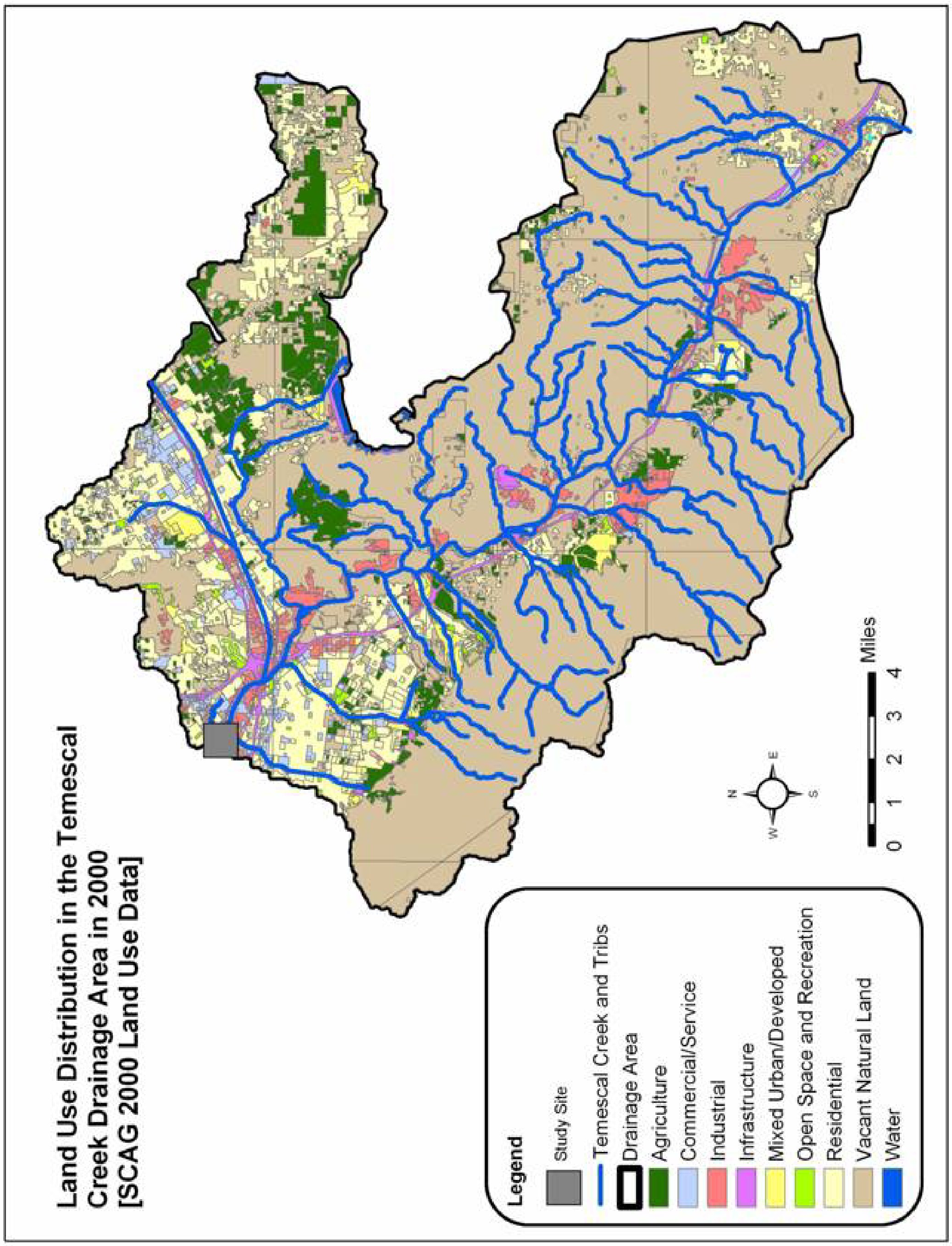


Figure 61
Land Use within Drainage Area to Temescal Creek Study Site

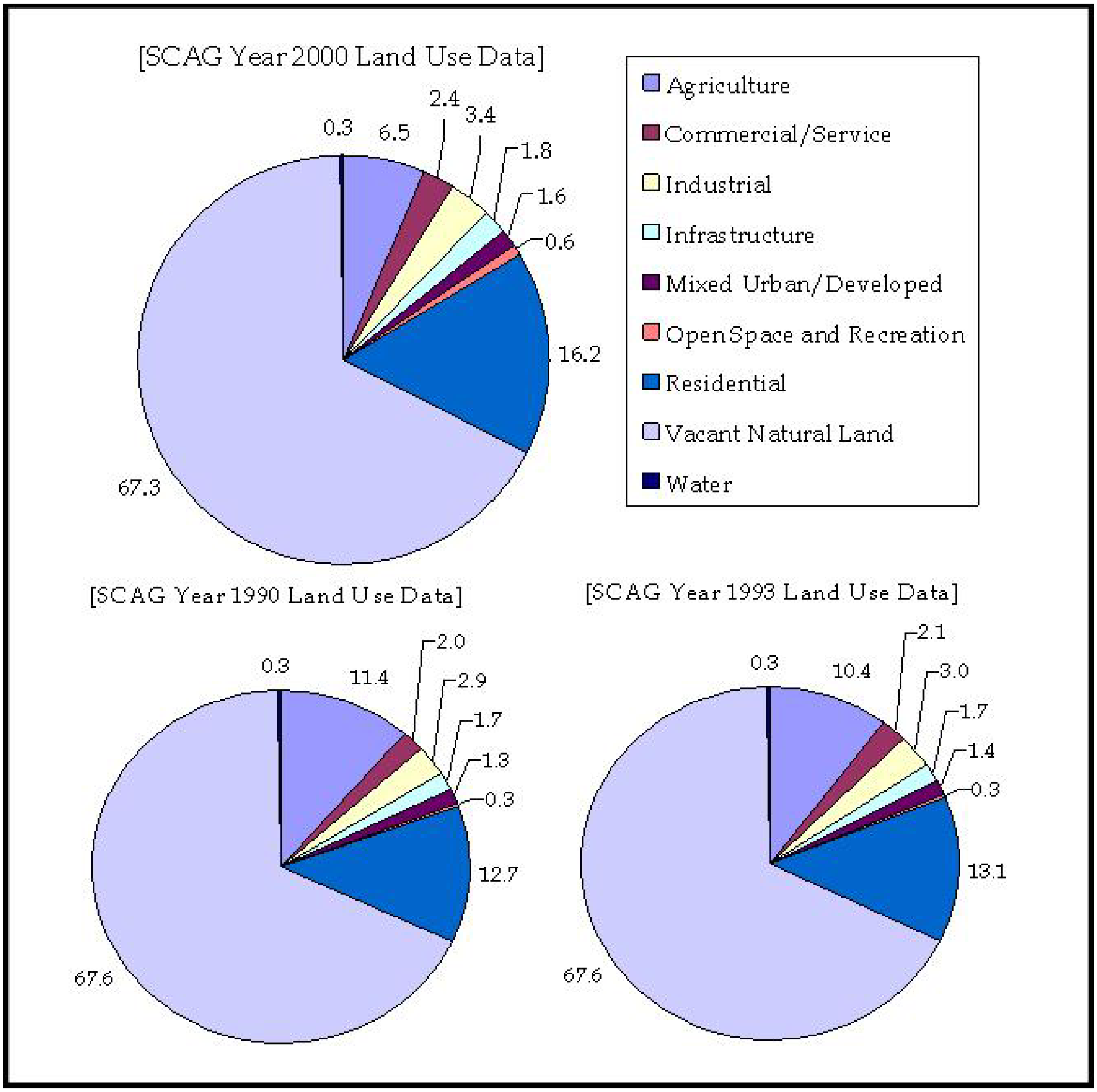


Figure 62
Relative Distribution (%) of Land Use Types in the Temescal Creek Watershed during 1990, 1993, and 2000

Evidence of Recreational Activity

Two locations were evaluated for recreational appeal at the Temescal Creek study site, upstream and downstream of the Lincoln Avenue Bridge (Figure 63). At the Lincoln Avenue bridge, the site was fenced and signs were posted prohibiting trespassing; however, the fence could be easily bypassed (Figure 64). Upstream of the Lincoln Avenue Bridge, where Temescal Creek is concrete lined, no direct and little indirect evidence of recreation activity was observed. In the natural channel section downstream of the Lincoln Avenue Bridge, trails with recent footprints led from the road to the stream, indicating that people do access this reach of Temescal Creek (Figure 65). Upstream and downstream of Lincoln Avenue, the channel side slopes are gradual enough to provide easy access to the stream.

Flow

Flow in Temescal Creek is recorded by the USGS approximately 1 mile upstream of the Lincoln Avenue Bridge, where Temescal Creek passes under Main Street in Corona [USGS Gage 11072100] (Figure 66). Additional ungauged flow enters Temescal Creek from the Oak Street channel, between the USGS gage and bacteria monitoring locations. Flow in these tributaries is relatively small compared to Temescal Creek, but must be considered when relating bacteria to flow for the study site.

Evaluation Criteria (Scale = Low - 0 to High - 3)	**Temescal Creek at Lincoln Ave.**	**Temescal Creek Natural Channel Section**
Direct Evidence of Water Contact Recreation	0	1
Indirect Evidence of Recreational Activity	2	2
Ease of Access	2	3
Channel Slope	2	3
Concrete to Natural	1	3
Flow Depth and Volume	1	2
Flow Velocity	2	2
Water Quality Aesthetics	1	2
Vegetation Quality	0	3
Adjacent Land Use	1	1

Figure 63
Field Observation Checklist for the Temescal Creek Study Site

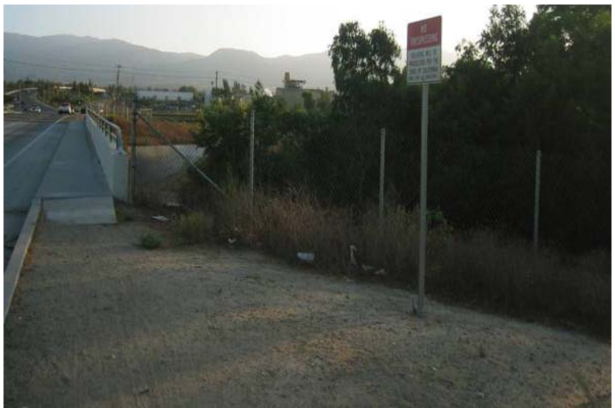


Figure 64
Fencing and signs prohibiting access to Temescal Creek from the Lincoln Avenue Bridge

Figure 65
Trash and other indirect evidence of recreational activity along Temescal Creek, downstream of Lincoln Avenue

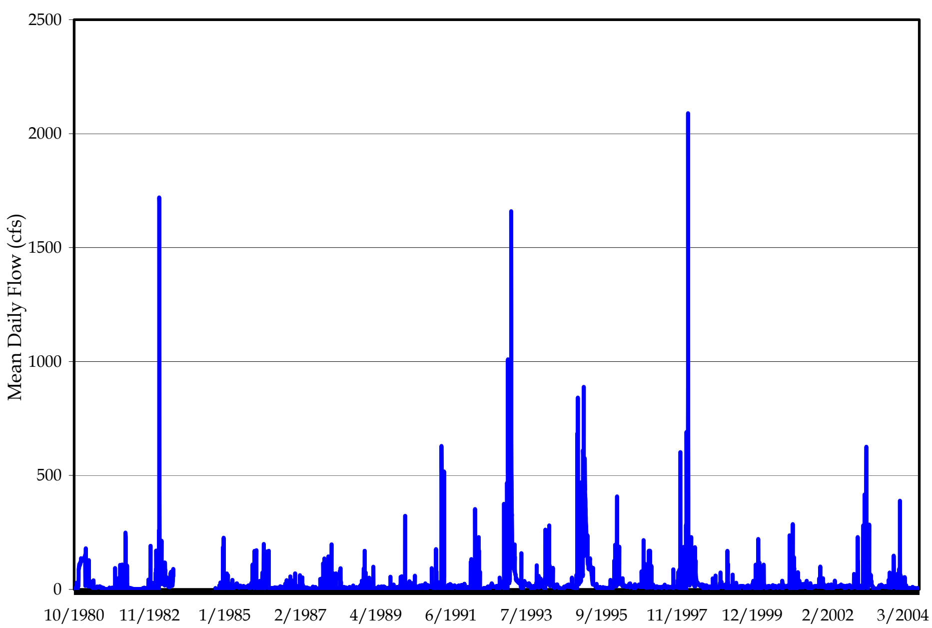


Figure 66
Mean Daily Flow in Temescal Creek at Main Street between 1980 and 2004

Figure 67 shows flow in Temescal Creek during a high rainfall year (7/1/92 through 6/30/93). High flows in Temescal Creek include both urban stormwater runoff and runoff from upstream mountain canyons. Spring-fed flow from canyons of the Santa Ana Mountains along the western boundary of the Temescal Creek watershed is more pronounced in the flow record following rainy seasons with greater than average precipitation, as was the case in the spring of 1993 (Figure 67). Runoff in Temescal Creek during summer months is typically dry weather runoff from residential/commercial areas and agricultural irrigation

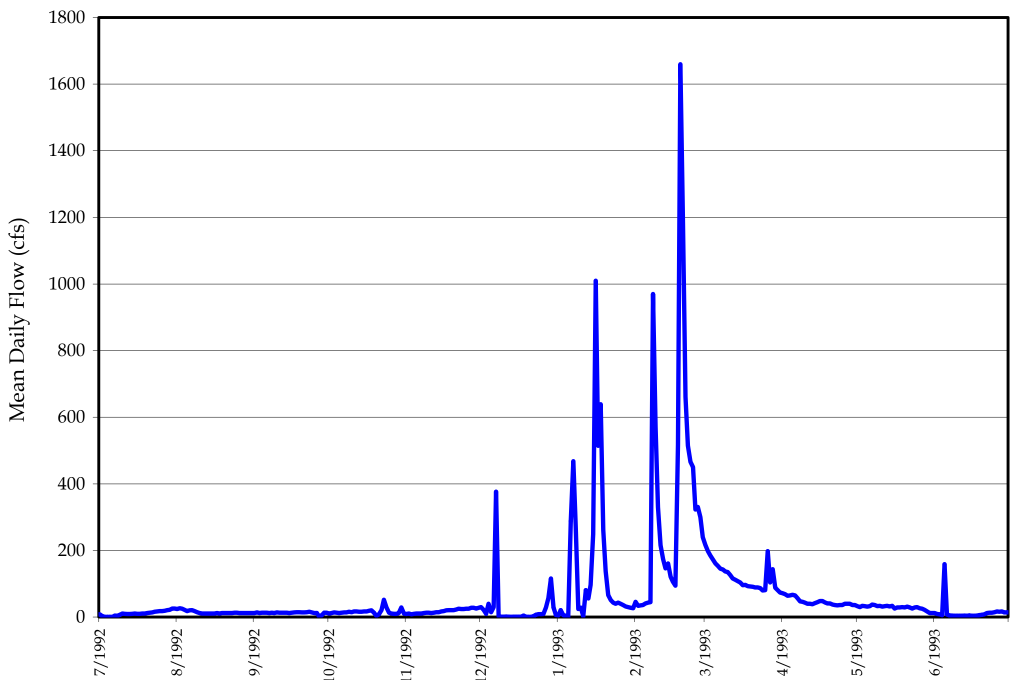


Figure 67
Mean Daily Flow in Temescal Creek at Main Street during the 1992-1993 Water Year

overflow.

Cumulative frequency curves of the top 10th percentile of flow rate and depth were generated from 15-minute interval flow USGS data (Figure 68 and Figure 69). Cumulative frequency curves of flow velocities and depth-velocity products are used to assess the likelihood of occurrence of dangerous flow conditions. Between 1988 and 2004, flow velocities in Temescal Creek at the Main Street Bridge exceed 8 ft/sec about 2.0 % of the time and the depth-velocity product exceeds 10 ft^2/sec about 0.8% of the time (Figure 70 and Figure 71), again, similar frequencies to the other two urban channel study sites.

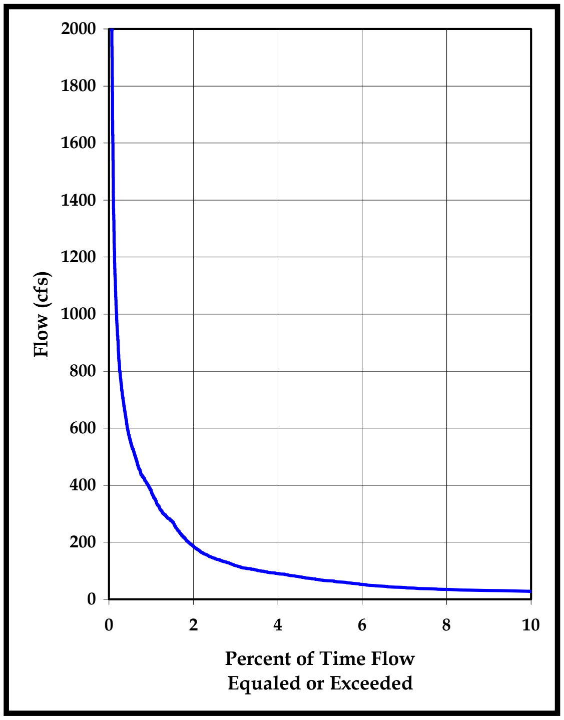


Figure 68
Channel Flow Duration Curve for Temescal Creek at Main Street (1988-2004)

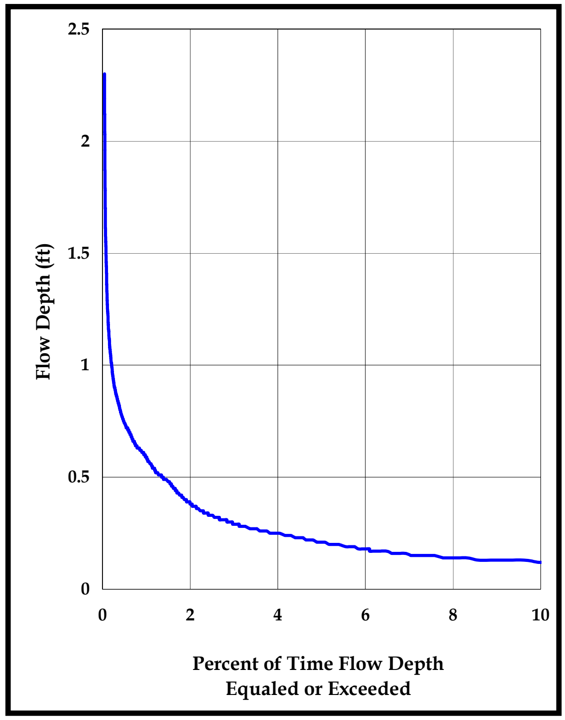


Figure 69
Channel Depth Curve for Temescal Creek at Main Street (1988-2004)

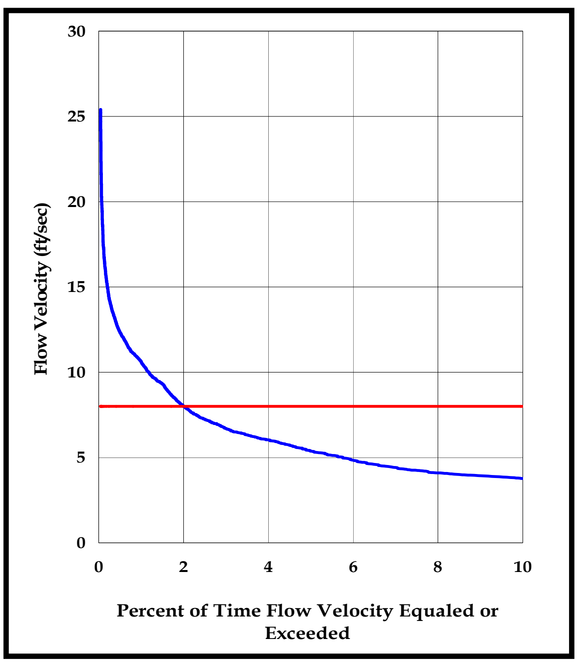


Figure 70
Channel Velocity Curve for Temescal Creek at Main Street (1988-2004)

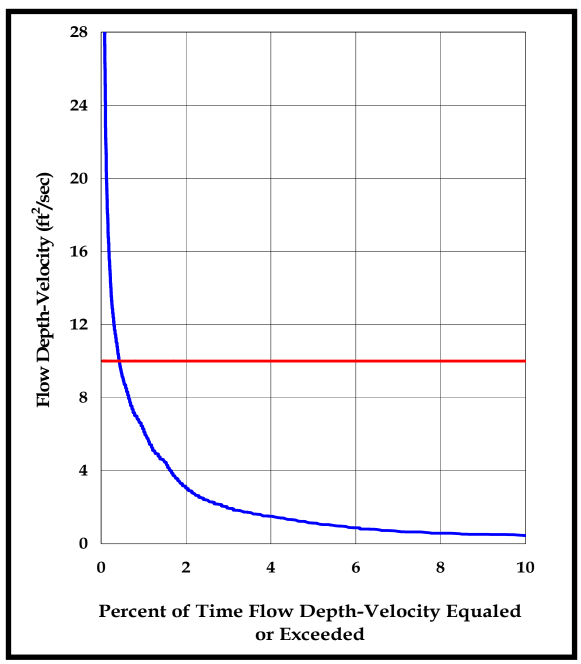


Figure 71
Channel Depth*Velocity Curve for Temescal Creek at Main Street (1988-2004)

Analysis of Bacteria Data
E. coli bacteria samples were collected from Temescal Creek at the Lincoln Avenue Bridge by Orange County Coastkeeper approximately once each month between 2002 and 2004. Fecal coliform was measured twice; 100 MPN/100mL on 1/26/1993 (OCWD) and 900 MPN/100mL on 3/24/03 (Orange County Coastkeeper).

Bacteria Trends
No obvious increasing or decreasing trend in E. coli bacteria concentrations occurred between 2002 and 2004 (Figure 72). E. coli concentrations increased during the winter months of 2002 - 2003 and concentrations regularly exceeded the potential single sample water quality objective for E. coli (236 MPN/100 mL). It is unclear whether this increase in E. coli concentration is directly related to wet weather events. With the exception of a few months, the monthly sample result or geometric mean of the sample result exceeded the anticipated 30-day geometric mean water quality objective of 126 MPN/100mL (Table 10/ Figure 73).

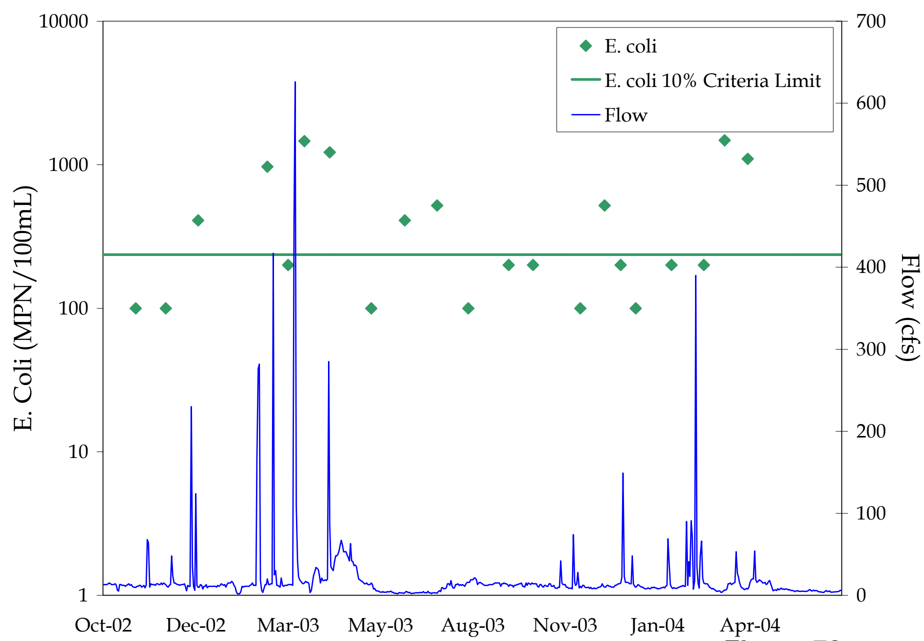


Figure 72
Time Series of Bacteria Concentrations and Flow in Temescal Creek from October 2002 to April 2004

Table 10 Monthly E. coli Geometric Means at Temescal Creek		
Year	**E. coli Concentration (Monthly Single Sample or Geometric Mean)**	**Sample Size**
Oct-02	100	1
Nov-02	100	1
Dec-02	410	1
Feb-03	970	1
Mar-03	540	2
Apr-03	1220	1
May-03	100	1
Jun-03	410	1
Jul-03	520	1
Aug-03	100	1
Sep-03	200	1
Oct-03	200	1
Nov-03	100	1
Dec-03	322	2
Jan-04	100	2
Feb-04	200	1
Mar-04	544	2
Apr-04	1100	1

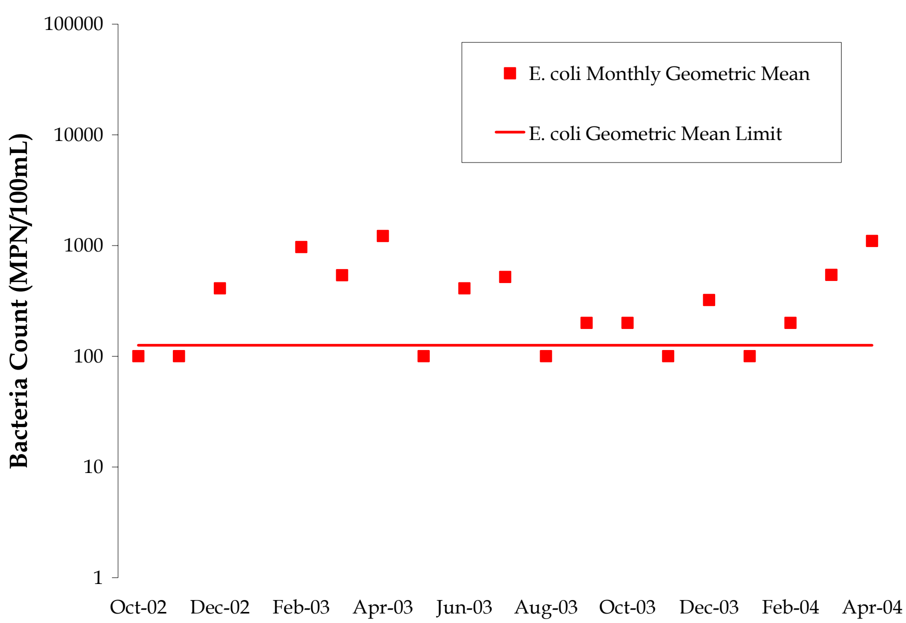


Figure 73
Monthly Single Sample Result or Geometric Mean of Sample Results for E. coli in Temescal Creek from October 2002 to April 2004

Figure 74 shows the percentage of calendar months when available fecal coliform and E. coli bacteria counts may have exceeded water quality objectives. This figure shows the number of calendar months when sufficient water quality data was available to be compared to objectives (number at the end of each bar) and the percent of those calendar months that may have exceeded water quality objectives. Results of this comparison show potential exceedences of the fecal coliform water quality objectives in one of two winter months when fecal coliform was sampled. E. coli was sampled more frequently at this study site and potential exceedences were observed in approximately 50% of dry weather samples during both summer and winter months. One wet weather sample was collected on April 15, 2003, following a wet weather event the preceding day. The E. coli bacteria concentration during the recession of the high flow was 1,220 MPN/100mL.

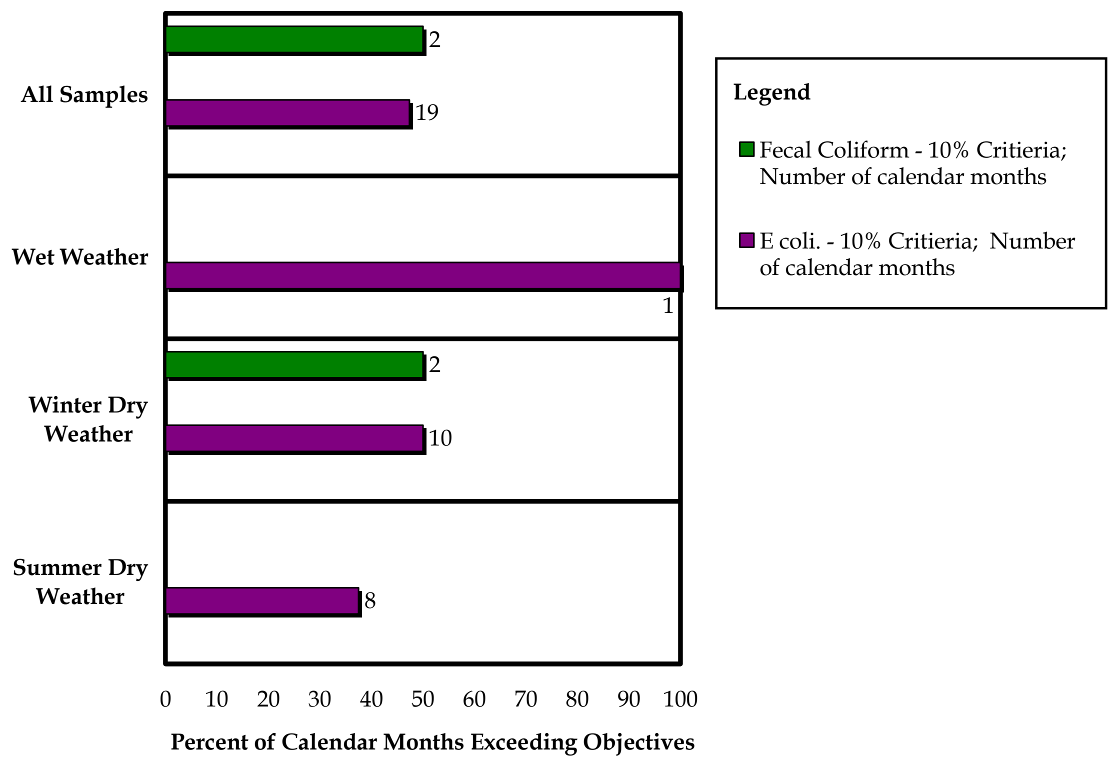


Figure 74
Comparison with Existing and Potential Bacteria Water Quality Objectives

Santa Ana River at Imperial Highway

Channel Section

This reach of the Santa Ana River at Imperial Highway has a natural bottom and is about 200 ft wide (Figure 75 and Figure 76). The river banks, which have an approximately 1:1 side slope, are reinforced with riprap in some locations (Figure 77). The bed slope of the channel is 2.0 %.

Figure 75
Aerial Photograph of the Santa Ana River at Imperial Highway Study Site

Figure 76
Santa Ana River downstream of Imperial Highway

Figure 77
Side Slopes of Santa Ana River downstream of Imperial Highway

Drainage Area Characteristics
Imperial Highway crosses Reach 2 of the Santa Ana River downstream of Prado Dam. There is also some local drainage within Santa Ana Canyon that enters the river in this reach. Prado Dam captures flows from all of the upper portions of the Santa Ana River watershed in Riverside and San Bernardino Counties. The majority of base flow reaching Prado Dam from upstream is tertiary effluent from river discharging POTWs. Releases from Prado Dam are highly regulated, and make up the majority of flow tributary to Imperial Highway. Accordingly, any potential relationship between land use in the watershed and bacteria concentrations in the Imperial Highway reach of the Santa Ana River are likely masked by the interception of flows by Prado Dam.

Recreational Use
Evidence of the potential for recreational activity in the Santa Ana River at the Imperial Highway crossing was assessed during a site visit (Figure 78). This site was entirely fenced, and posted signs prohibited entrance to the river (Figure 79). Regardless, indirect evidence of recreational activity was observed, e.g., human footprints, trails that were traced to the waters edge, and trampled vegetation. In this reach, water depths were much greater than what was observed at most other sites due to continued releases from Prado Dam(Figure 80).

Evaluation Criteria (Scale = Low - 0 to High - 3)	Santa Ana River at Imperial Highway
Direct Evidence of Water Contact Recreation	1
Indirect Evidence of Recreational Activity	3
Ease of Access	3
Channel Slope	2
Concrete to Natural	3
Flow Depth and Volume	3
Flow Velocity	3
Water Quality Aesthetics	3
Vegetation Quality	3
Adjacent Land Use	3

Figure 78
Field Observation Checklist for the Santa Ana River at Imperial Highway Study Site

Figure 79
Signs prohibiting entrance into Santa Ana River at the Imperial Highway

Figure 80
Flow in the Santa Ana River at the Imperial Highway

Flow
Flow in the Santa Ana River at Imperial Highway study site is largely comprised of outflow from Prado Dam, but also includes some stormwater runoff and dry weather flow from small tributaries in northeastern Orange County. Downstream of this reach there is a rubber dam, which is the primary diversion facility used to route water to several Orange County Water District groundwater recharge basins located adjacent to this reach of the Santa Ana River. Based on USGS data from 1998 to 2001, baseflow in this reach ranges between 200 and 400 cfs (USGS Gage 11075610) (Figure 81).

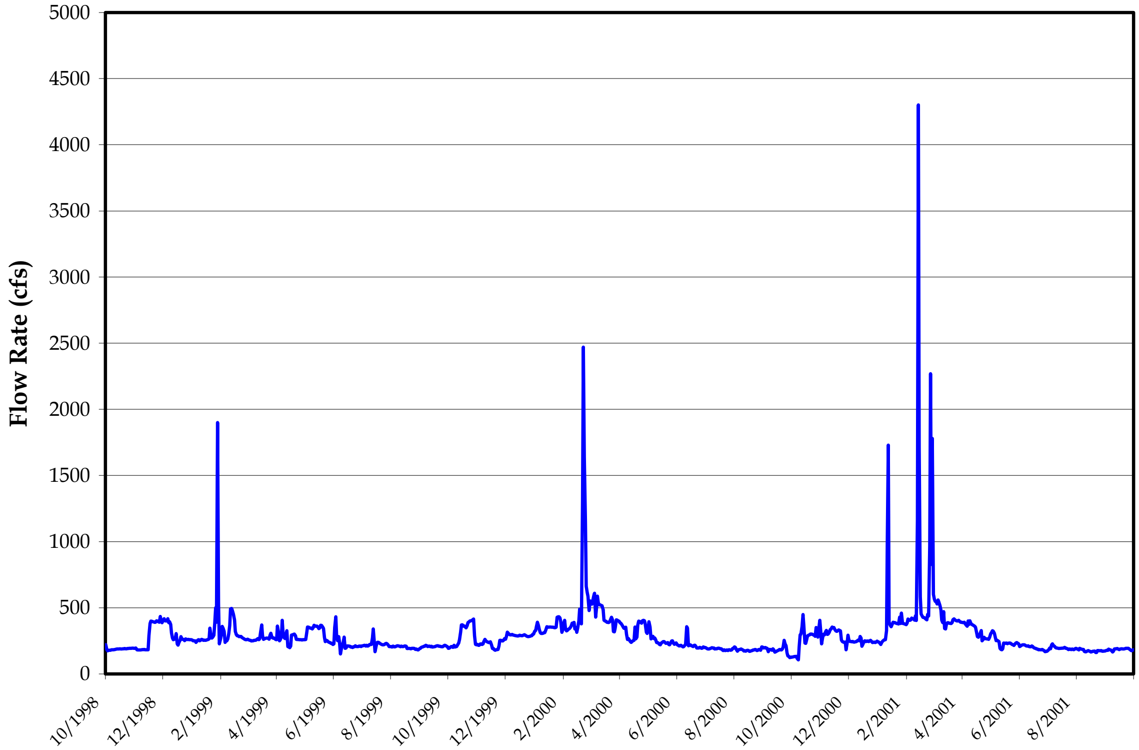


Figure 81
Mean Daily Flow in the Santa Ana River at the Imperial Highway Study Site (10/1998 to 9/2001)

Bacteria Trends

Fecal coliform samples were collected at the Imperial Highway location between 1981 and 1994, and again between 1998 and 2004. E. coli samples were collected in 1985 and between the years of 1998 and 2004. Figure 82 provides a time series plot of bacteria concentrations over the entire bacteria sampling record. Figure 83 provides a time series plot of bacteria data collected during the period when flow records are available.

Most sample results from 1981 to 1994 exceed bacteria objectives, while most results from 1998 to the present fall at or below bacteria objectives, possibly indicating improvement in bacteria quality over the period of record.

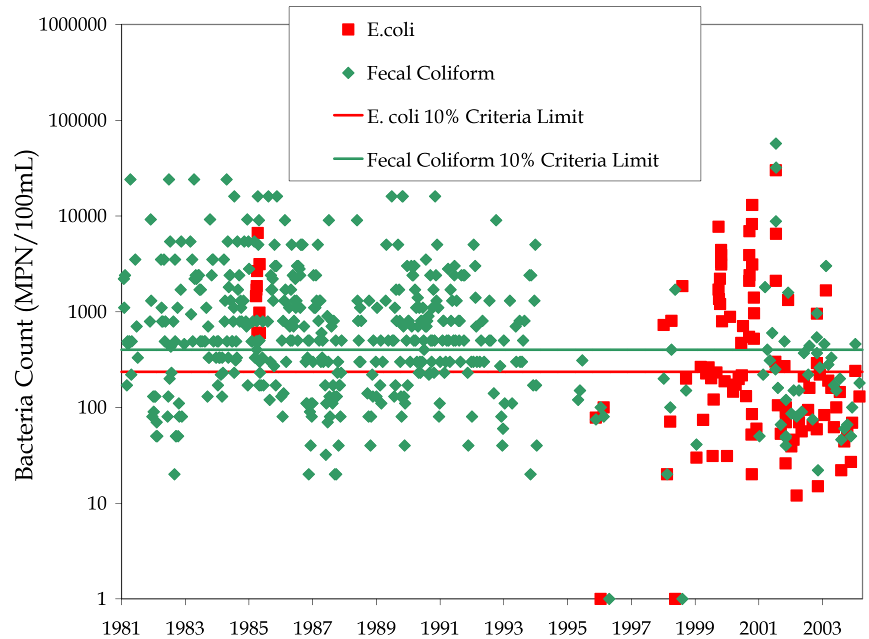


Figure 82
Time Series of Bacteria Concentrations for the Entire Period of Record in the Santa Ana River at the Imperial Highway Study Site

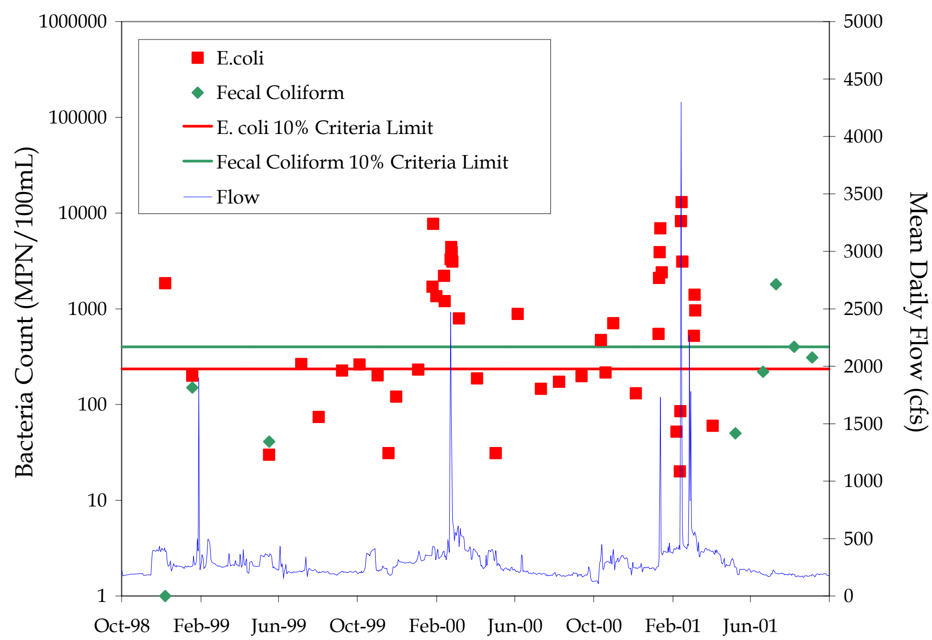


Figure 83
Time Series of Bacteria Concentrations and Flow in the Santa Ana River at the Imperial Highway Study Site

Two separate high flow events (January 2001 & February 2001) were further analyzed with E. coli data to describe the relationship between wet weather flow and bacteria concentrations. Figure 84 and Figure 85 indicate that E. coli concentrations increased during the high flow event and then remained high for one to two days after the high flow event had ended. A recently completed study that characterized bacteria concentrations in the lower Santa Ana River during stormwater runoff events also observed this same pattern (Izbicki et al. 2004). Izbicki speculated that the elevated bacteria concentrations that persist for a few days after a wet weather event result from the re-suspension of bacteria in sediments.

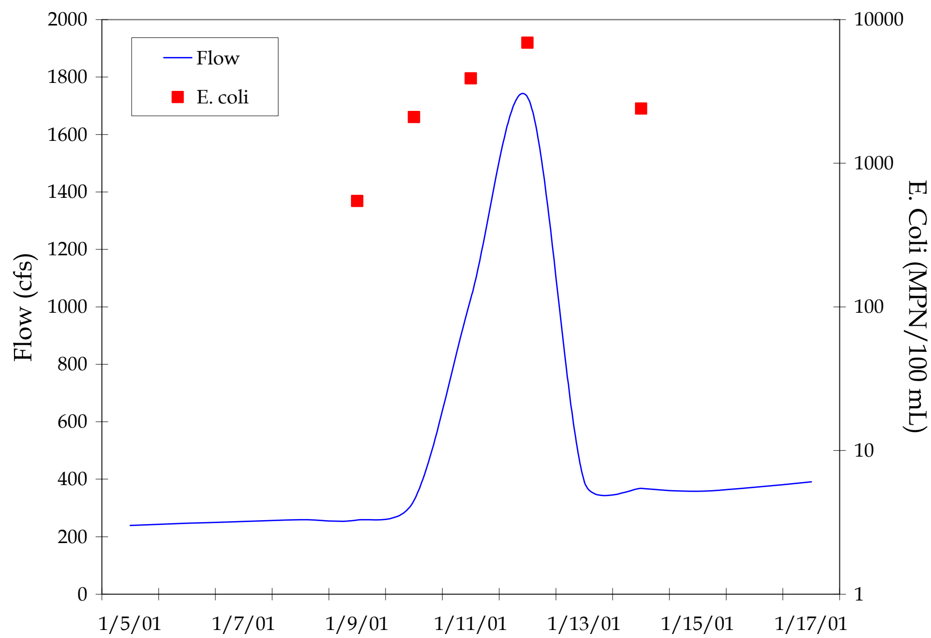


Figure 84
January 2001 Wet Weather E. coli Sampling Event

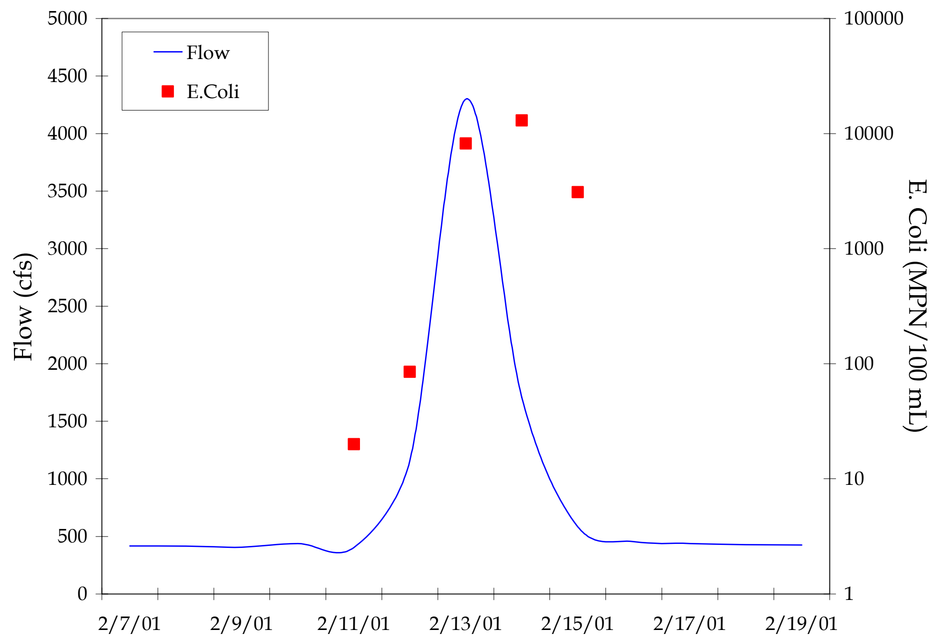


Figure 85
February 2001 Wet Weather E. coli Sampling Event

Monthly geometric means of bacteria counts measured in the Santa Ana River at the Imperial Highway study site were calculated and are shown in Figure 86. The figure potentially indicates a slight improving trend in sample results over time.

The strong correlation between fecal coliform and E. coli concentrations at the Santa Ana River at Imperial Highway study site indicates that regardless of the pathogen indicator used, exceedences of water quality objectives would have occurred (Figure 87).

Figure 88 shows the percentage of calendar months when available fecal coliform and E. coli bacteria counts may have exceeded water quality objectives. This figure shows the number of calendar months when sufficient water quality data was available to be compared to objectives (number at the end of each bar) and the percent of those calendar months that may have exceeded water quality objectives. Potential exceedences of fecal coliform and potential E. coli water quality objectives occurred during all flow conditions.

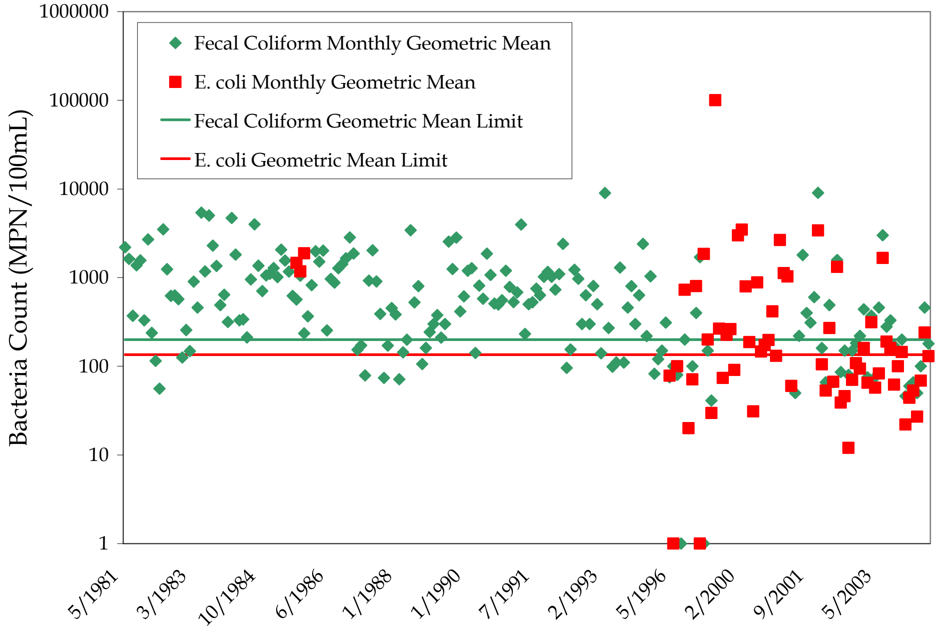


Figure 86
Monthly Single Sample Result or Geometric Mean of Sample Results for Fecal Coliform and E. coli in the Santa Ana River at the Imperial Highway Study Site

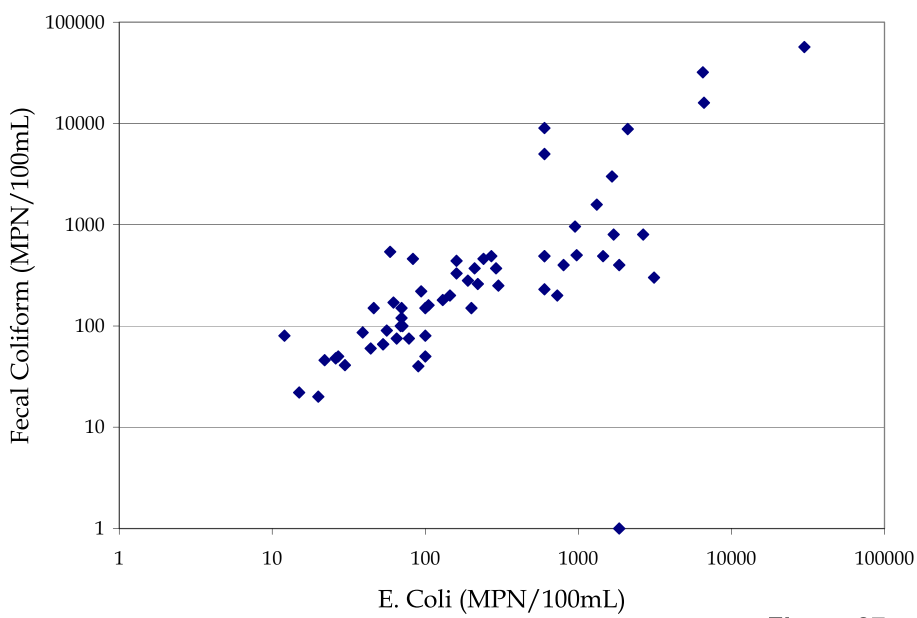


Figure 87
Bivariate Plot of Fecal Coliform and E. coli for samples collected in the Santa Ana River at the Imperial Highway Study Site

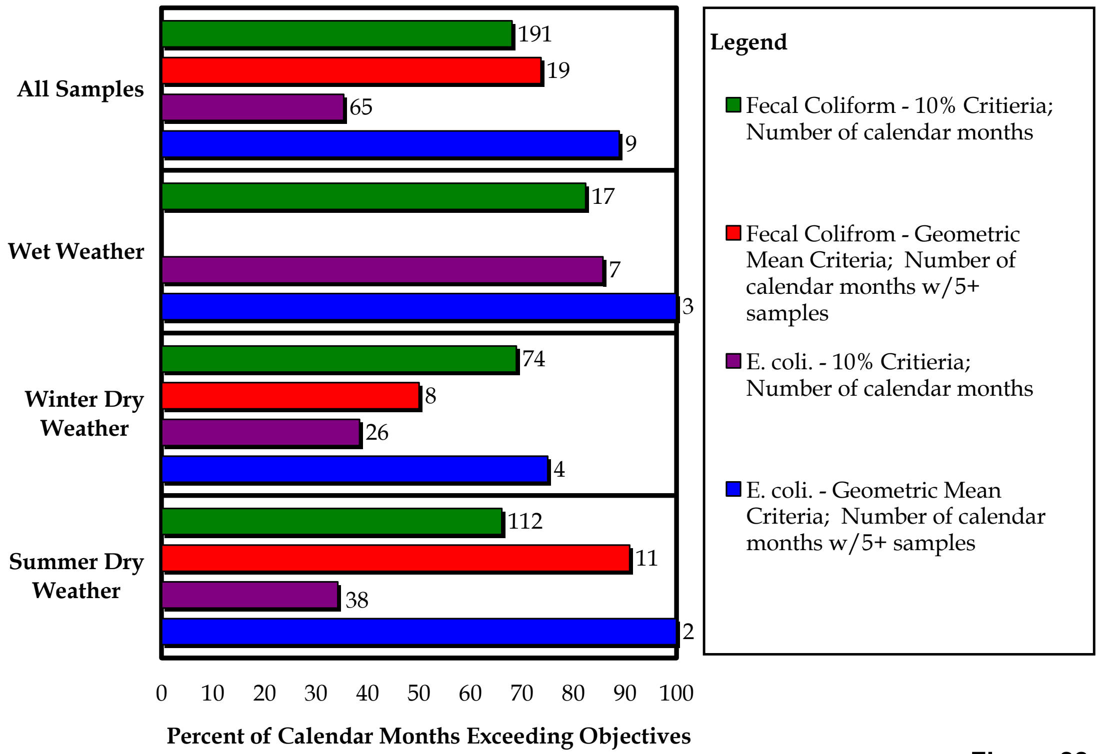


Figure 88
Comparison with Existing and Potential Bacteria Water Quality Objectives

Santa Ana River at MWD Crossing

Channel Section

This reach of the Santa Ana River exists within a predominantly naturally carved floodplain (Figure 89). Based on aerial photography it was estimated that the bankfull width of the Santa Ana River at MWD crossing is approximately 150 feet. Side slopes of 1:1 were estimated from field observations of the channel. The bed slope of the channel at this site is 2.0%. The study site is located upstream of the City of Riverside waste water treatment plant (WWTP) effluent channel (Figure 90)

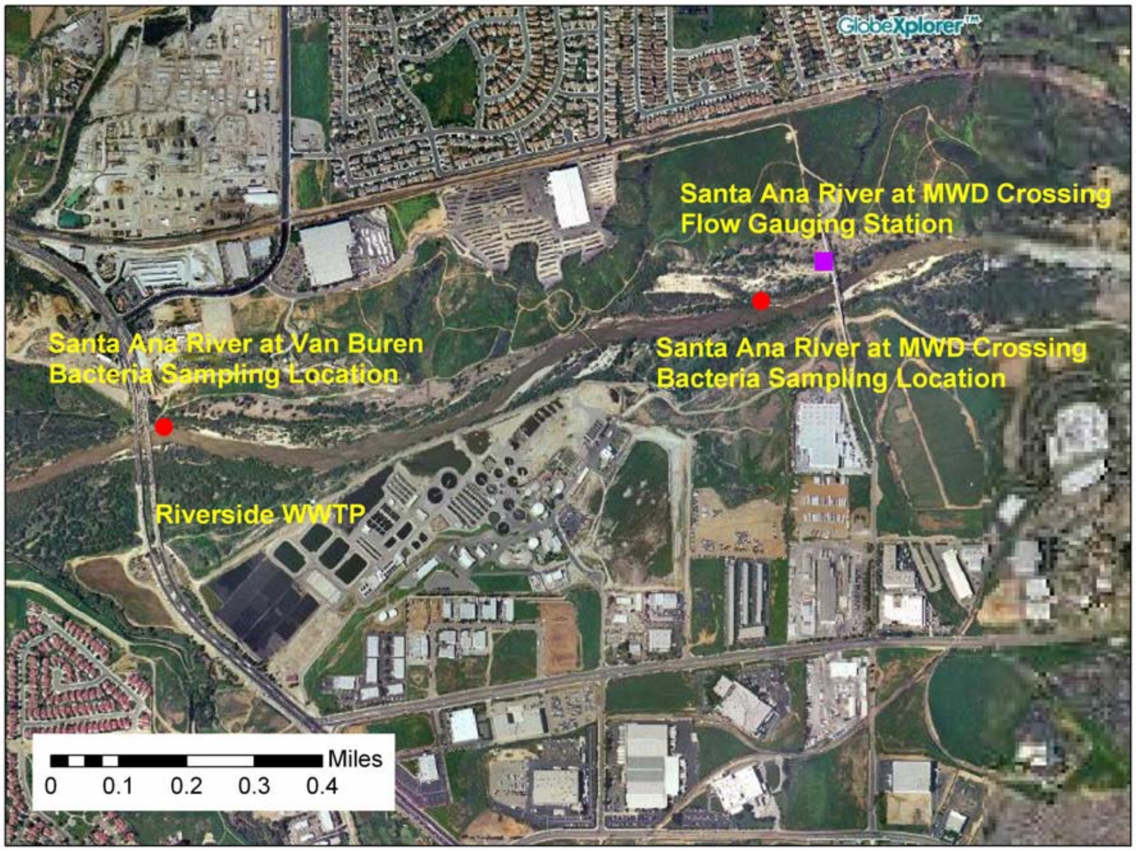


Figure 89
Aerial Photograph of the Santa Ana River at MWD Crossing Study Site

Figure 90
City of Riverside WWTP Effluent Channel

Drainage Area Characteristics

The watershed above the Santa Ana River at MWD Crossing is large and land use is diverse. The lower part of the watershed is a combination of commercial, residential, industrial, and agricultural lands. The upper part of the watershed includes natural undeveloped lands. Runoff from the San Bernardino National Forest enters the Santa Ana River upstream of the MWD crossing study site. Runoff from agricultural lands is routed to the Santa Ana River from areas south of the river. Runoff from industrial areas is routed to the river from the cities of San Bernardino, Colton, Rialto, Fontana, and Riverside. Residential land is dispersed throughout the contributing area.

Evidence of Recreational Activity

No direct evidence of recreational use was observed during the field visit. However, this site is a known recreational area for nearby communities, in spite of warnings in the form of international signs and newspaper announcements to not swim or bath in this section of the Santa Ana River. A limited use survey conducted from July to October 2004 occasionally observed swimmers in the area – either in the Santa Ana River or in an adjacent channel that carries treated effluent from the Riverside Regional Water Quality Treatment Plant to the Santa Ana River. In addition, a helicopter flyover video of the middle portion of the Santa Ana River showed people bathing in this reach of the river.

The recreational appeal of this site was evaluated during a site visit (Figure 91). There is plenty of space to park and the stream is easily accessible. Although no one was observed recreating in the water during this visit, the site scored relatively high in terms of recreational appeal.

Flow

The USGS mean daily flow record [USGS Gage 11066460] from 1970 through 2004 was used to plot a time series of flow at this site. Sources of water to this reach are varied. Streams such as Mill Creek and Lytle Creek route snowmelt from the San Bernardino Mountains to the Santa Ana River, although much of this runoff is captured for recharge within the San Bernardino groundwater basin. Effluent from WWTPs enters the Santa Ana River upstream of the MWD crossing in Colton and Rialto. These sources of water, in addition to urban dry weather flows and rising ground waters at Riverside Narrows, result in a year-round baseflow of 50-100 cfs in the river at the MWD crossing study site (Figure 92). Stormwater runoff from urban and mountain watersheds creates sharp increases in flow, as shown in the winter months of 1993-1994 (Figure 93).

Flow data was recorded in 15 minute intervals by the USGS at the Santa Ana River at MWD Crossing gauging station between 1988 and 2004. These data were used to develop frequency distributions of flow rate and depth in the channel (Figure 94 and Figure 95). Over the 15 year period, flow rates exceeded 1,000 cfs 1.5% of the time and flow depths exceeded 5 feet 2 % of the time.

Evaluation Criteria (Scale = Low - 0 to High - 3)	**Santa Ana River at Van Buren Blvd.**
Direct Evidence of Water Contact Recreation	0
Indirect Evidence of Recreational Activity	3
Ease of Access	2
Channel Slope	3
Concrete to Natural	3
Flow Depth and Volume	3
Flow Velocity	3
Water Quality Aesthetics	2
Vegetation Quality	2
Adjacent Land Use	1

Figure 91
Field Observation Checklist for the Santa Ana River at MWD Crossing Study Site

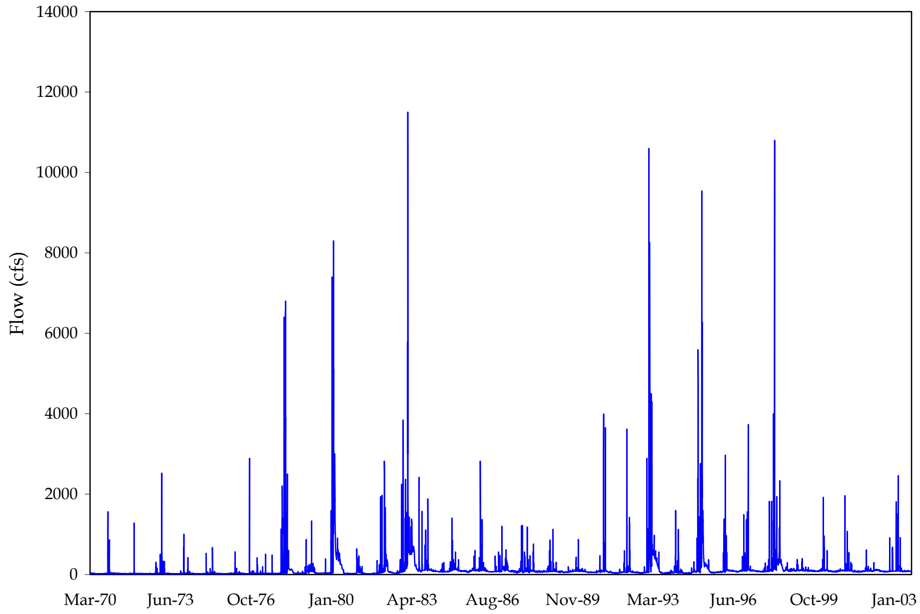


Figure 92
Mean Daily Flow in the Santa Ana River at MWD Crossing Study Site between 1969 and 2003

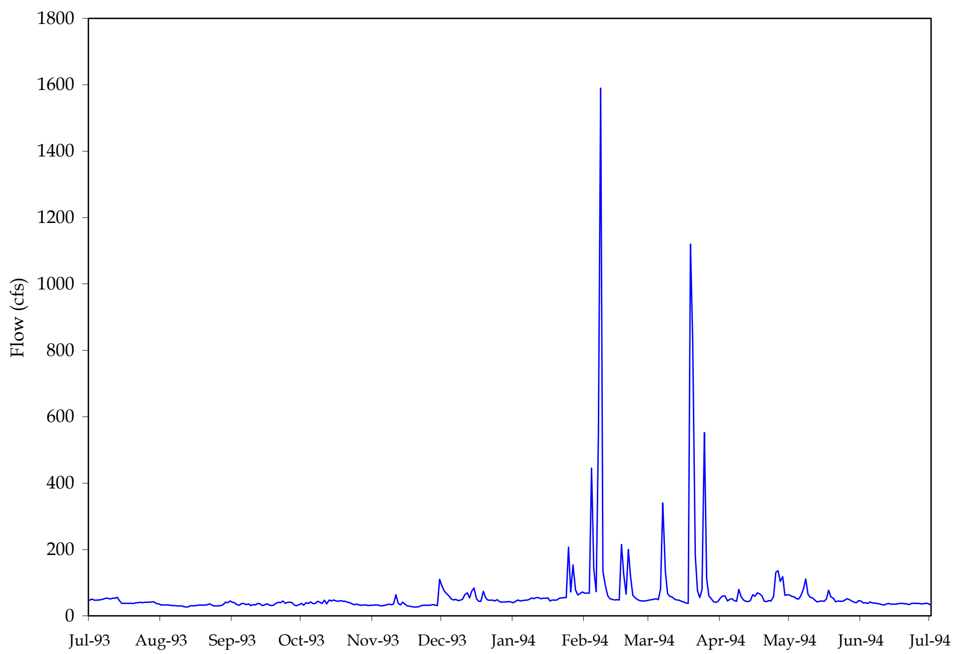


Figure 93
Mean Daily Flow in the Santa Ana River at MWD Crossing Study Site (7/1993 to 7/1994)

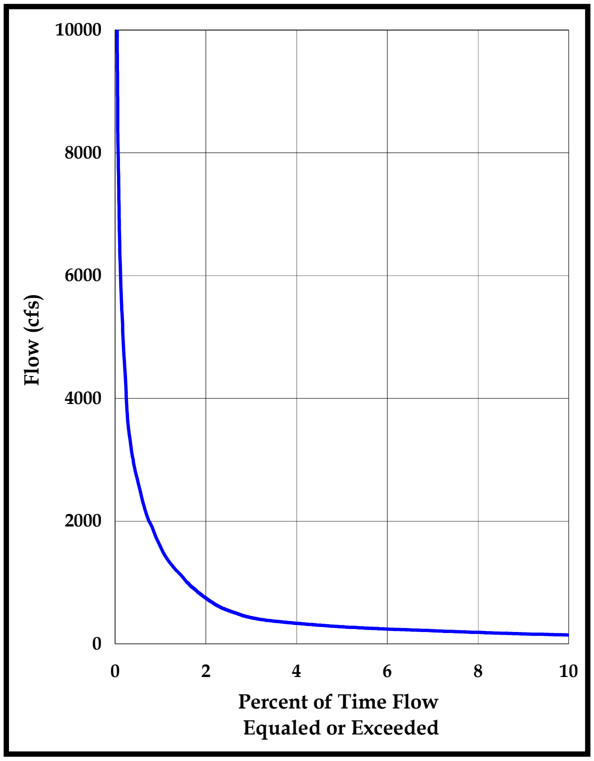


Figure 94
Channel Flow Curve for Santa Ana River at MWD Crossing (1988 – 2004)

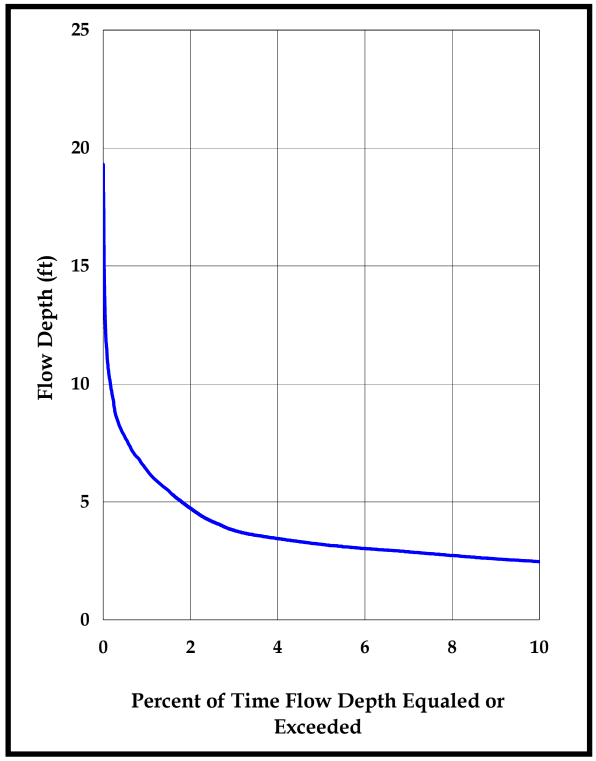


Figure 95
Channel Depth Curve for Santa Ana River at MWD Crossing (1988 – 2004)

Cumulative frequency curves of flow velocity and depth-velocity product between 1988 and 2004, are shown in Figure 96 and Figure 97. Between 1988 and 2004, flow velocities in the Santa Ana River at the MWD crossing study site exceeded 8 ft/sec for 0.5 % of the time and the depth-velocity product exceeded 10 ft^2/sec for 1% of the time.

Analysis of Bacteria Data

Fecal coliform and E. coli bacteria samples were collected from the Santa Ana River at the MWD crossing study site by the Riverside County Health Department and the Santa Ana Regional Water Quality Control Board between 1984 and 2004. Sampling occurred 3 times in 1984, weekly during the summer of 1985, twice during the summer of 1991 (as part of the Santa Ana Use Attainability Analysis Study), and about weekly since February of 2002.

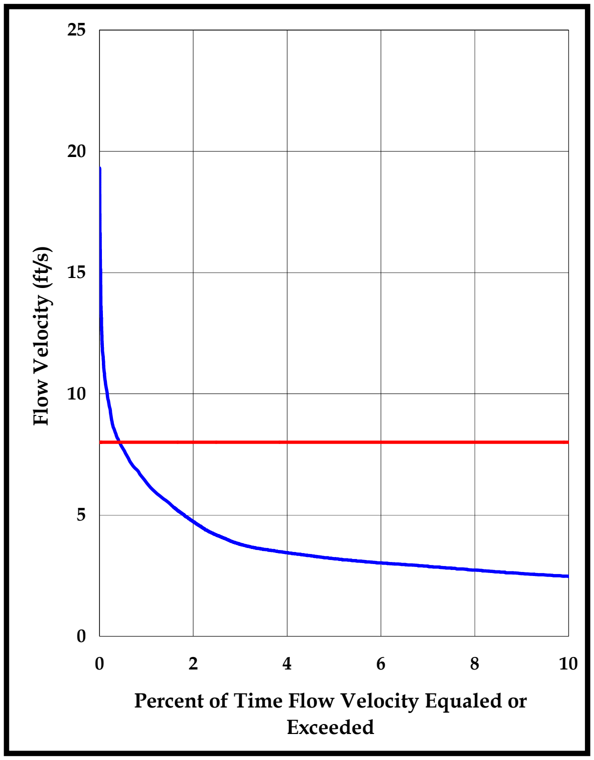


Figure 96
Channel Velocity Curve for the Santa Ana River at MWD Crossing Study Site (1988-2004)

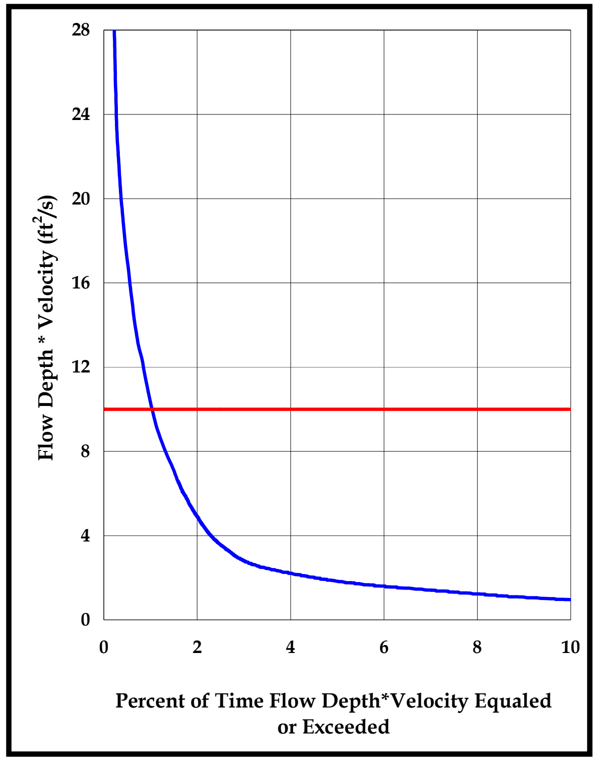


Figure 97
Channel Depth*Velocity Curve for the Santa Ana River at MWD Crossing Study Site (1988-2004)

Bacteria Trends

Figure 98 and Figure 99 provide time series plots of fecal coliform and E. coli bacteria concentrations and flow recorded in the Santa Ana River during summer 1985 and between December 2001 and June 2004, respectively. During summer 1985, fecal coliform and E. coli concentrations were regularly higher than the 10% of samples exceedance objective of 400 and 236 MPN/100mL, respectively. However, in recent years, fecal coliform and E. coli concentrations have only occasionally exceeded the 10% of samples exceedance threshold of 400 and 236 MPN/100mL, respectively. Both time series plots suggest that high flow events are not necessarily correlated with high bacteria counts.

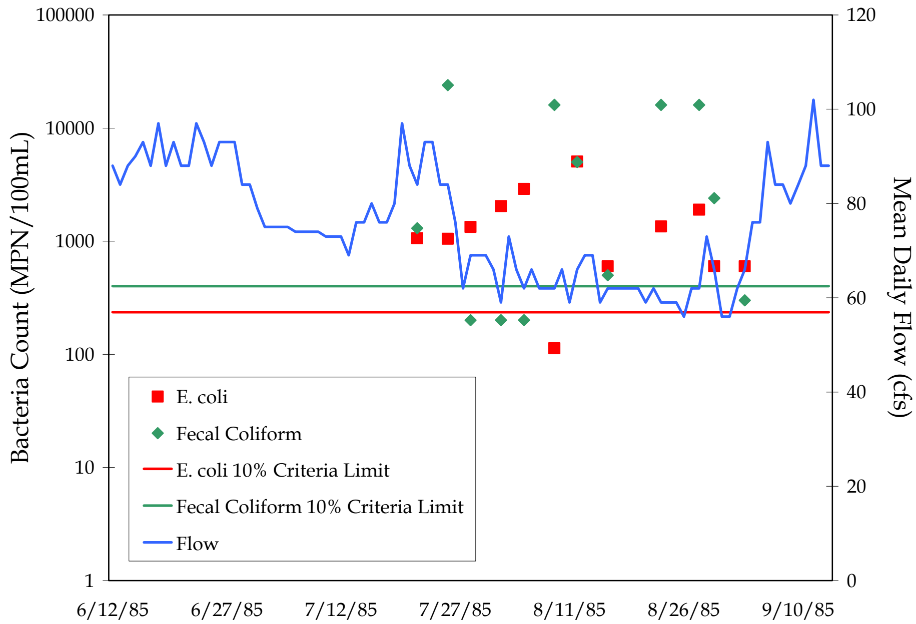


Figure 98
Time Series of Bacteria Concentrations and Flow in the Santa Ana River at the MWD Crossing Study Site

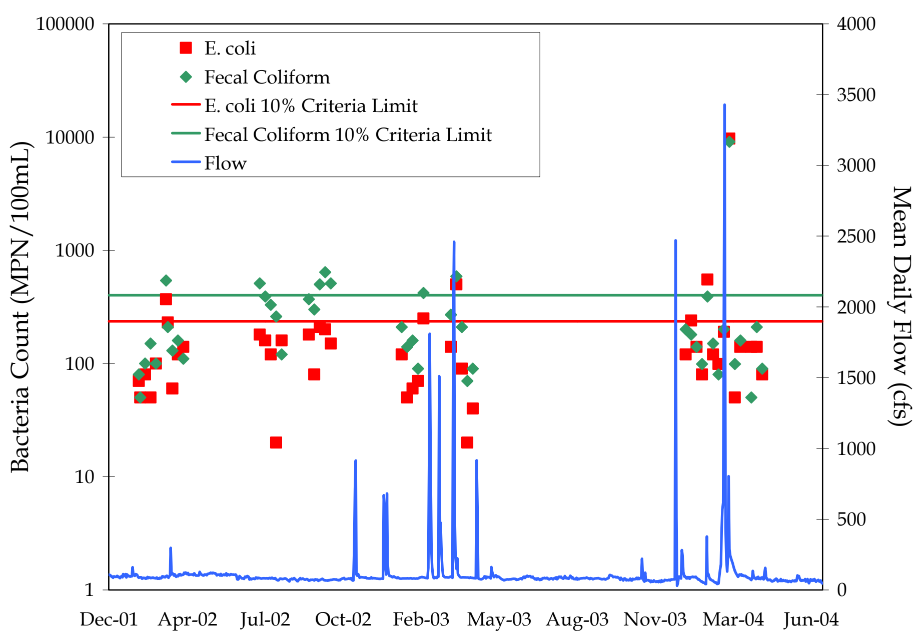


Figure 99
Time Series of Bacteria Concentrations and Flow in the Santa Ana River at the MWD Crossing Study Site

Single monthly results or monthly geometric means of bacteria data gathered during the last two years are summarized in Table 11 and plotted in Figure 100. Monthly geometric means for E. coli exceed proposed bacteria water quality objectives approximately two thirds of the time, while fecal coliform geometric means exceed existing water quality objectives approximately fifty percent of the time. There are no obvious trends in the data during this time period.

Table 11
Fecal Coliform and E. coli Concentrations in the Santa Ana River at MWD Crossing

Month	E. Coli Monthly Geometric Mean or Single Sample Results	Fecal coliform Monthly Geometric Mean or Single Sample Results	Sample Size
Jul-85	1141	1841	3
Aug-85	1152	2366	8
Sep-85	600	300	1
Feb-02	67	90	5
Mar-02	157	220	4
Apr-02	140	110	1
Jul-02	91	361	4
Aug-02	160	120	1
Sep-02	145	381	3
Oct-02	173	571	2
Jan-03	59	126	3
Feb-03	250	420	1
Mar-03	185	322	3
Apr-03	28	79	2
Jan-04	134	149	4
Feb-04	188	175	4
Mar-04	312	291	4
Apr-04	106	137	2

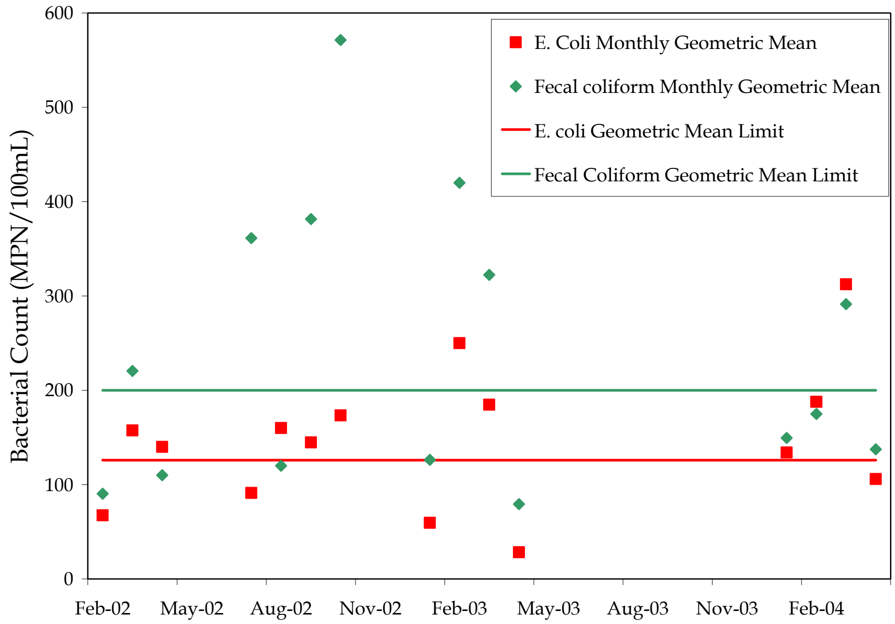


Figure 100
Monthly Single Sample Result or Geometric Mean of Sample Results for fecal coliform and E. coli in the Santa Ana River at the MWD crossing

The relatively strong correlation between fecal coliform and E. coli concentrations in the Santa Ana River at MWD Crossing indicates that regardless of the pathogen indicator used, exceedences of water quality objectives would have occurred (Figure 101).

Figure 102 shows the percentage of calendar months when existing fecal coliform and E. coli bacteria counts may have exceeded objectives. This figure shows the number of calendar months when sufficient water quality data was available to be compared to objectives (number at the end of each bar) and the percent of those calendar months that may have exceeded water quality objectives. Potential exceedences occurred during dry weather flows during both summer and winter months.

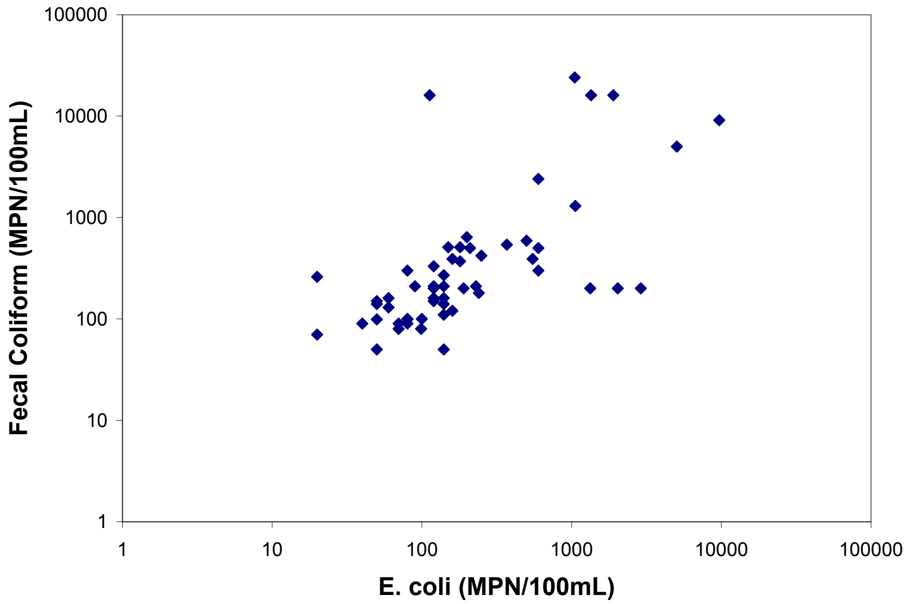


Figure 101
Relationship between E. coli and Fecal Coliform in the Santa Ana River at the MWD Crossing

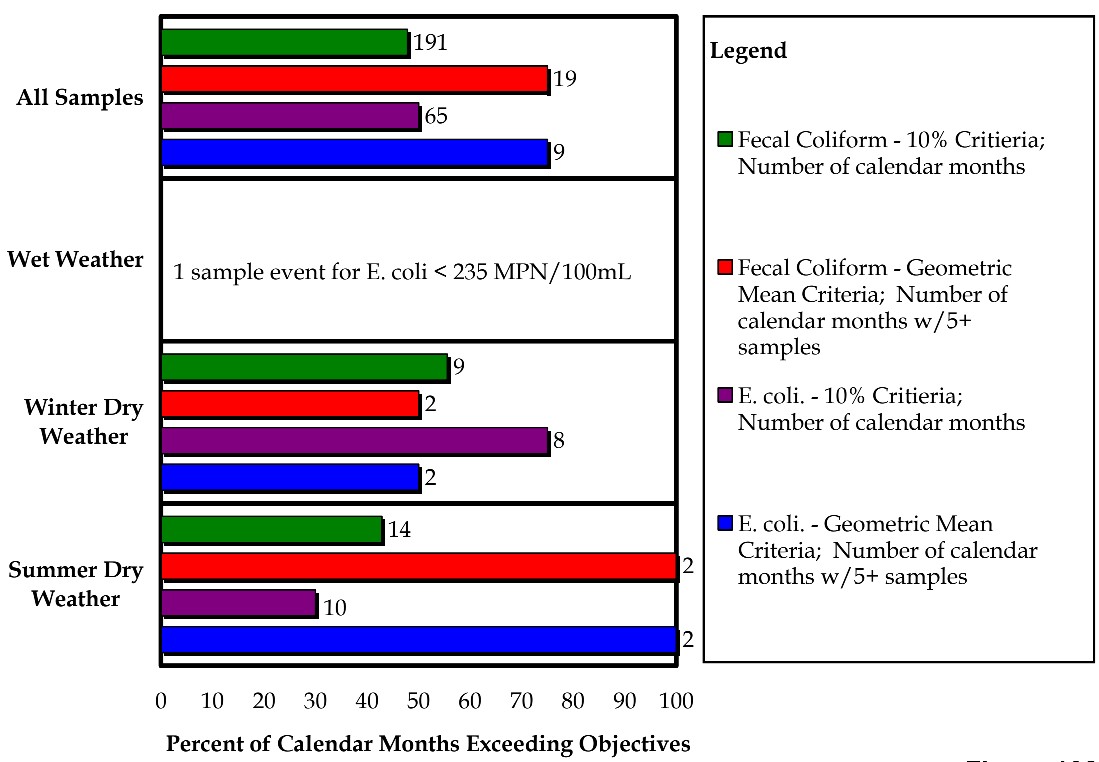


Figure 102
Comparison with Existing and Potential Bacteria Water Quality Objectives

Icehouse Canyon Creek

Channel Section

The Icehouse Canyon Creek study site is located in the Angeles National Forest at 5,100 feet above mean sea level at the Icehouse Canyon trailhead (Figure 103). The channel is a natural mountain stream about 10 feet wide with a bed slope that is significantly steeper than the other study site channels (Figure 104). This predominantly gravel bottom stream also includes large boulders and waterfalls in sections. Ambient water temperature is significantly lower than water temperatures in surface waters at lower elevations (Figure 105). These water temperatures were recorded at the time sample collection. The Icehouse Canyon Creek study site is included in the analysis to identify a background or naturally occurring bacteria condition.

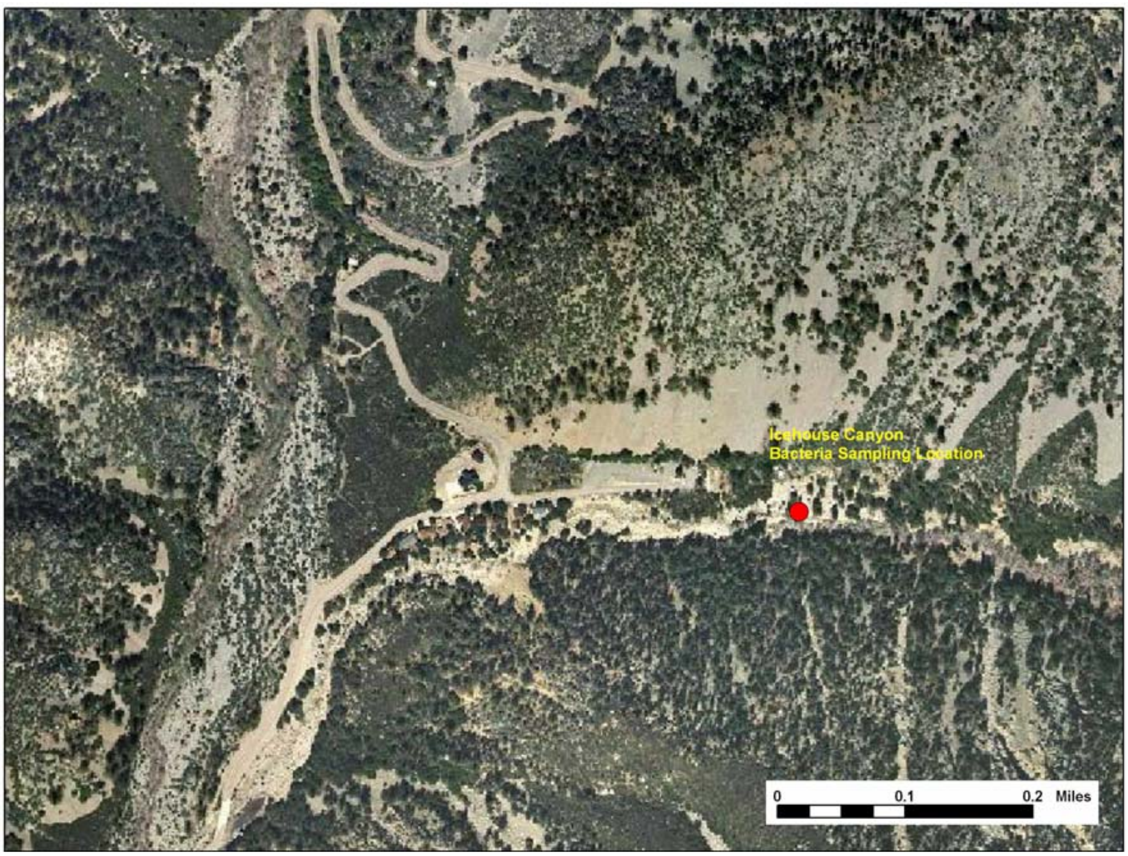


Figure 103
Aerial Photograph of the Icehouse Canyon Creek Study Site

Figure 104
Icehouse Canyon Creek Study Site

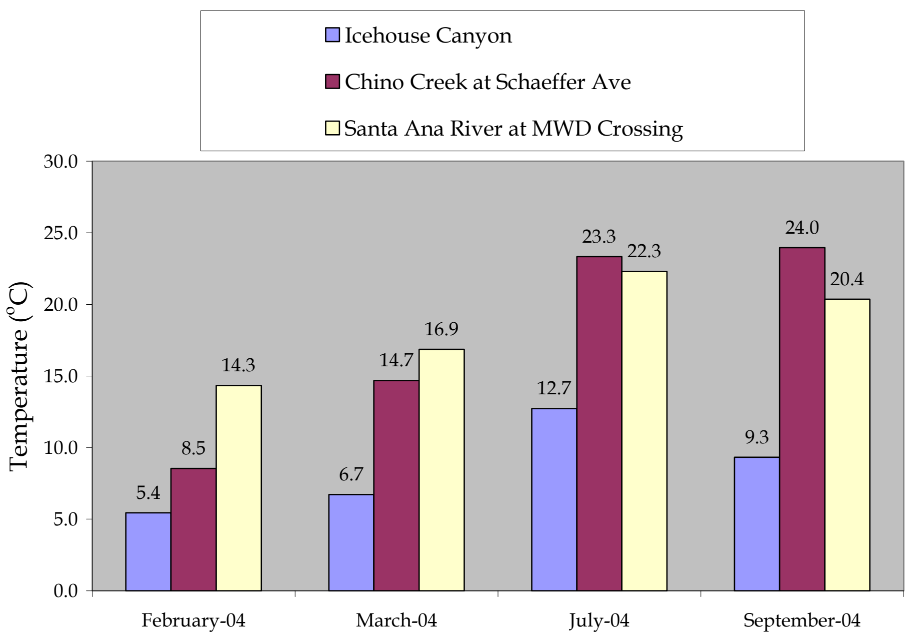


Figure 105
Water Temperature in Icehouse Canyon, Chino Creek at Schaeffer Ave, and Santa Ana River at MWD Crossing Study Sites

Drainage Area Characteristics

Icehouse Canyon Creek is a small headwater stream. The Icehouse Canyon Creek watershed is comprised of undeveloped land in the San Gabriel Mountains. The drainage area is very steep with intermittently dispersed trees and shrubs.

Evidence of Recreational Activity

Icehouse Canyon Creek is located alongside a regularly utilized hiking trail in the Angeles National Forest. The creek includes several pools and other areas where visitors can recreate. Although no one was observed recreating in the water, the results of the field observation checklist illustrate the recreational appeal of this site (Figure 106).

Evaluation Criteria (Scale = Low - 0 to High - 3)	Santa Ana River at Van Buren Blvd.
Direct Evidence of Water Contact Recreation	0
Indirect Evidence of Recreational Activity	3
Ease of Access	2
Channel Slope	3
Concrete to Natural	3
Flow Depth and Volume	3
Flow Velocity	3
Water Quality Aesthetics	2
Vegetation Quality	2
Adjacent Land Use	1

Figure 106
Field Observation Checklist for the Icehouse Canyon Study Site

Flow

This site does not have a flow gage; therefore, no data was available to characterize flow. Based on observations, spring flow provides a year-round water source during most years. Rocky ground cover coupled with steep watershed slopes will facilitate a quick increase in streamflow during wet weather events.

Analysis of Bacteria Data

Fecal coliform and E. coli bacteria samples were taken in Icehouse Canyon Creek as part of the Chino Basin TMDL monitoring program. Weekly bacteria samples were collected during wet weather months from February 2002 to present and during summer 2002.

Bacteria Trends

Figure 107 provides a time series plot of fecal coliform and E. coli bacteria concentrations recorded in Icehouse Canyon Creek. With one exception all sample results complied with existing or anticipated bacteria water quality objectives.

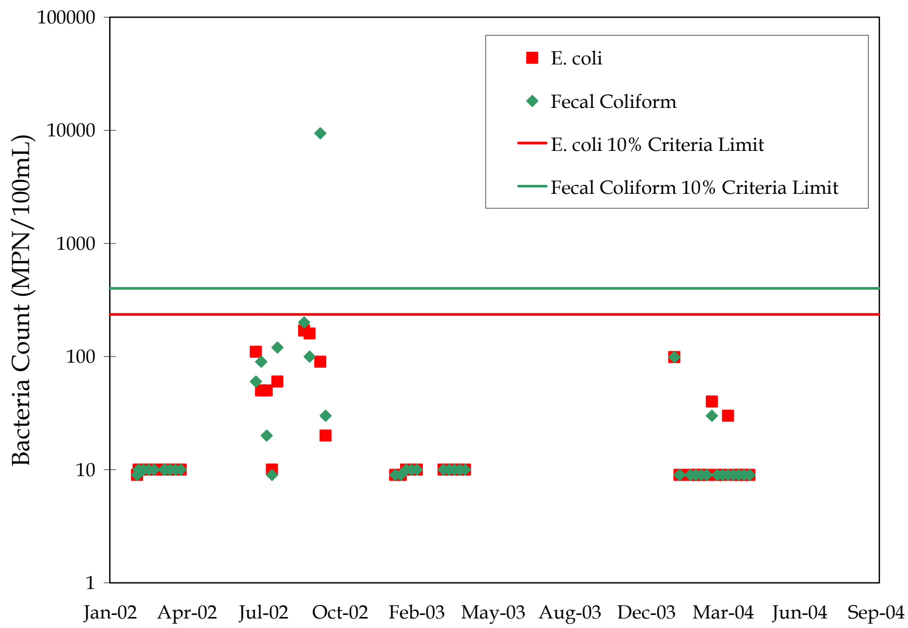


Figure 107
Time Series of Bacteria Counts and Flow in Icehouse Canyon Creek Study Site

Monthly single sample results or monthly geometric means of bacteria data for Icehouse Canyon Creek are summarized in Table 12 and plotted in Figure 108**.** With the exception of the summer of 2002, E. coli and fecal coliform monthly geometric means are relatively low.

The relatively strong correlation between fecal coliform and E. coli concentrations in Icehouse Canyon Creek indicates that regardless of the pathogen indicator used, exceedences of water quality objectives would have occurred (Figure 109).

Existing data shows that fecal coliform water quality objectives may have been exceeded on one occasion, with a bacteria count of 9,400 MPN/100mL on October 2, 2002. Excluding the sample size limitation, the proposed E. coli geometric mean standard of 126 MPN/100mL may have been exceeded in September and October of 2002 (Figure 110). This figure shows the number of calendar months when sufficient water quality data was available to be compared to objectives (number at the end of each bar) and the percent of those calendar months that may have exceeded water quality objectives.

Table 12
Fecal Coliform and E. coli Concentrations in Icehouse Canyon Creek

Month	E. coli Monthly Geometric Mean or Single Sample Results	Fecal coliform Monthly Geometric Mean or Single Sample Results	Sample Size
Feb-02	10	10	5
Mar-02	10	10	4
Apr-02	10	10	1
Jul-02	41	31	4
Aug-02	60	120	1
Sep-02	165	141	2
Oct-02	165	141	2
Jan-03	9	9	4
Feb-03	10	10	1
Mar-03	10	10	2
Apr-03	10	10	1
Jan-04	20	20	3
Feb-04	13	12	4
Mar-04	11	9	5
Apr-04	9	9	2

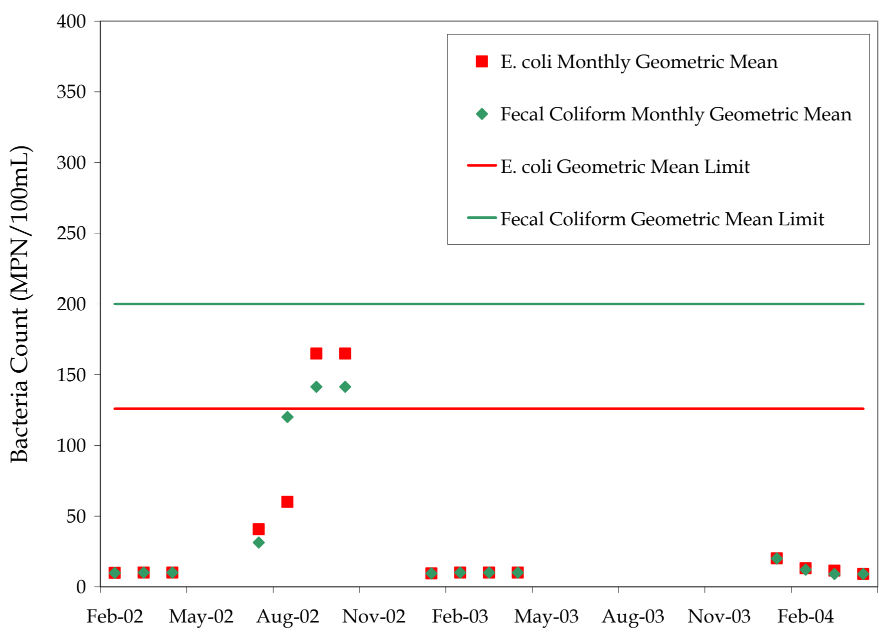


Figure 108
Monthly Single Sample Result or Geometric Mean of Fecal Coliform and E. coli in Icehouse Canyon Creek Study Site

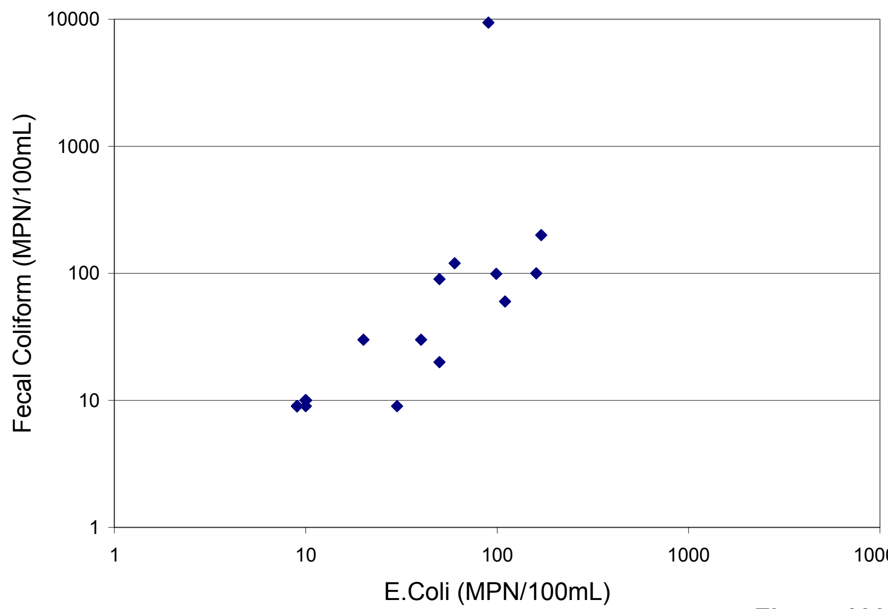


Figure 109
Relationship between E. coli and Fecal Coliform Concentrations in Icehouse Canyon Creek Study Site

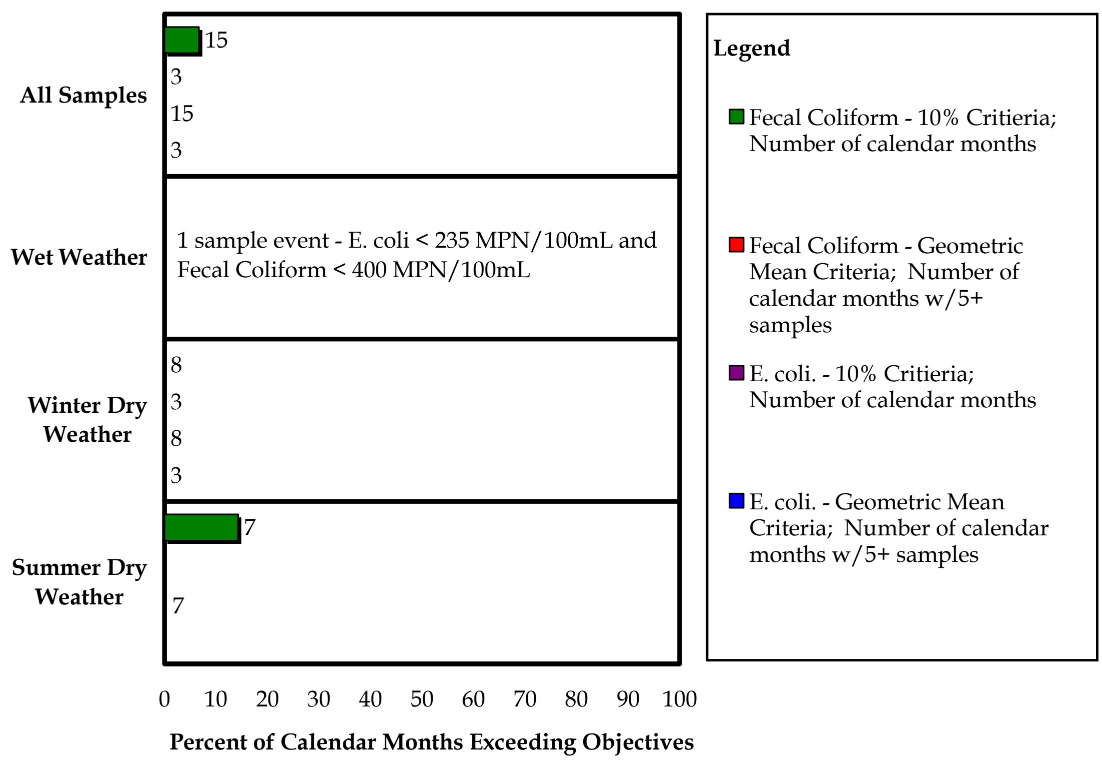


Figure 110
Comparison with Existing and Potential Bacteria Water Quality Objectives

Technical Memorandum 4
Inventory and Analysis of Existing Major Control Programs and Structural Measures

Throughout the Santa Ana River watershed, cities, counties, and other agencies manage programs and implement control measures that directly or indirectly address waterborne bacteria and pathogens. This memorandum provides a summary and description of the programs and control measures researched as part of Phase I of the Stormwater Quality Standards Study Task Force's efforts to support the Regional Board's triennial review of Basin Plan water quality standards. The summary includes information collected publicly owned treatment works (POTW) discharges, and municipal separate storm sewer system (MS4) source control and treatment control programs.

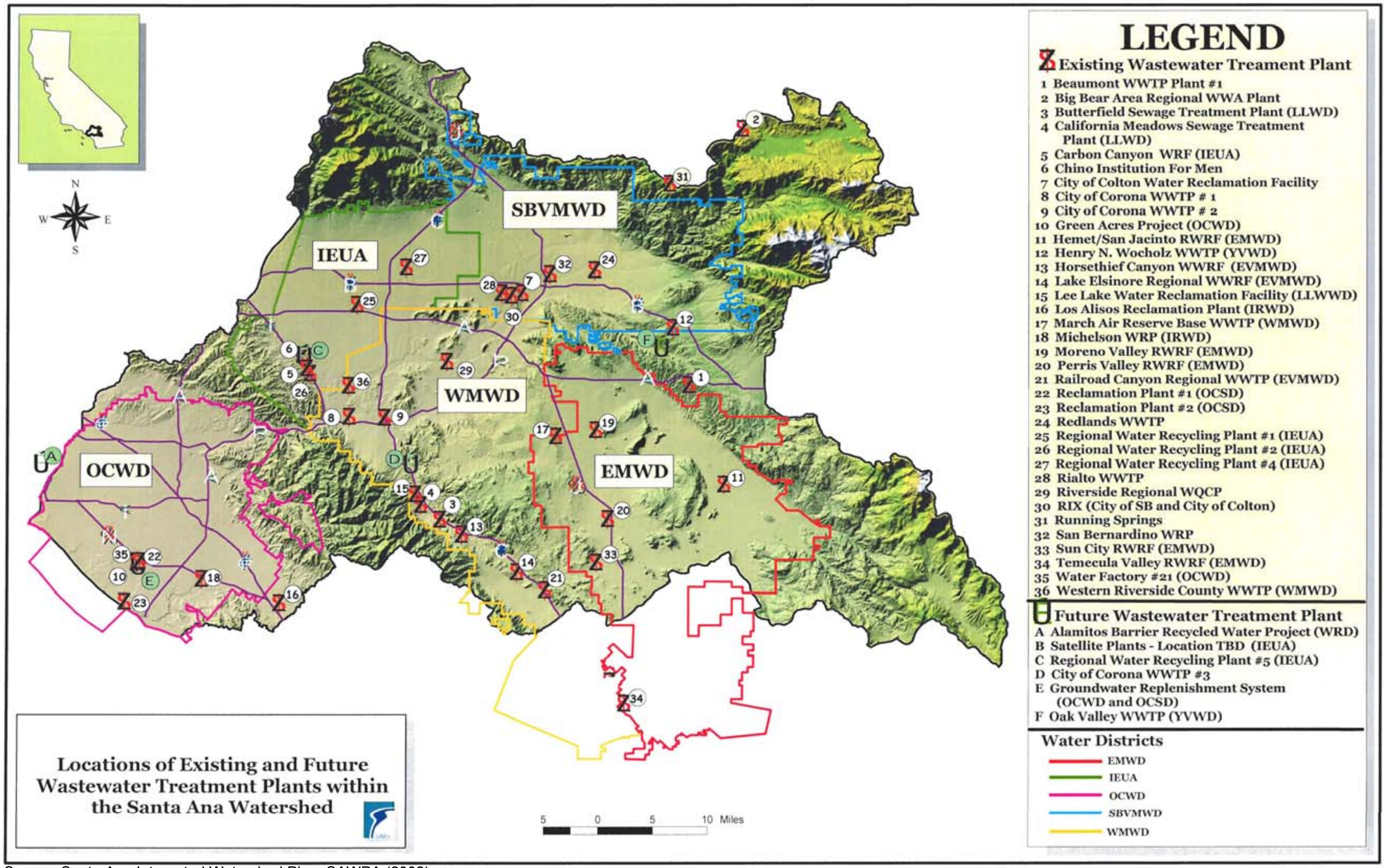
Publicly Owned Treatment Works Discharge Characteristics and Reclamation Requirements

According to the Santa Ana Integrated Watershed Plan (SAWPA, June 2002), there are 37 operational publicly owned treatment works (POTW) in the Santa Ana Watershed and 5 plants currently planned for construction. Figure 1 shows the POTWs within the Santa Ana basin.

There are 42 operational and planned plants that range in design discharge capacity from 0.08 million gallons per day (MGD) to 151 MGD:

- 24 plants produce advanced or tertiary treated effluent (Title 22 level of treatment as discussed in Section 4.1.1)
- 7 produce discharge at a level receiving only secondary treatment (without tertiary)
- 11 produce a combination of primary, secondary, and tertiary treated effluent, depending on effluent receiving water

In order to describe potential bacteria contributions from POTWs within the watershed, an effort was made to characterize the level of treatment provided for facilities discharging to inland receiving waters. Of the 42 facilities mentioned previously, 6 discharge directly to a receiving water, and 15 discharge to a receiving water in combination with some effluent recycling. Effluent from the remaining plants is either discharged to the Pacific Ocean, into aquifers for groundwater recharge, or fully recycled.



Source: Santa Ana Integrated Watershed Plan, SAWPA (2002)

Figure 1
POTWs Within the Santa Ana Basin

All 6 plants discharging to inland receiving waters provide either tertiary treatment (5) or a combination of secondary and tertiary treated effluent (1, Western Riverside County Regional WWTP).

Of the 15 facilities that discharge to receiving waters in combination with effluent recycling, 11 provide tertiary treatment, 1 provides secondary treatment (Hemet/San Jacinto RWRF), and 3 provide a combination of secondary and tertiary treated effluent.

There are 7 facilities in the watershed that provide only secondary treated effluent, of which only 1 discharges to an inland receiving water (Hemet/San Jacinto). The remaining facilities provide water for recycling or groundwater recharge.

In summary, of the 21 facilities that discharge to inland receiving waters, or discharge in combination with recycling, all except one provide tertiary treated effluent consistent with Title 22 effluent requirements. This level of treatment minimizes or eliminates the bacteria and pathogen load of these point sources to the Santa Ana Watershed. Many of these facilities produce all or a substantial portion of the downstream receiving water's dry weather flow regime.

Recycled Water Regulation (Title 22 Requirements)

The State Water Resources Control Board (SWRCB), through the Porter-Cologne Water Quality Control Act, is responsible for formulating and adopting state policy for water reclamation, policy that does affect inland water body water quality criteria. The California Department of Health Services (DHS) is responsible for establishing uniform statewide reclamation criteria to ensure that the use of recycled water is not detrimental to public health, criteria that protect beneficial uses.

There are no federal standards governing wastewater reclamation and reuse in the United States, although the EPA has sponsored the preparation of Guidelines for Water Reuse. Many states, including California, have developed wastewater reclamation regulations. In all cases, the regulations have been established with the objective of protecting public health and allowing for the safe use of recycled wastewater. The DHS established water quality criteria, treatment process requirements, and treatment reliability criteria for reclamation operations, which are set forth in Title 22, Division 4, Chapter 3, of the California Code of Regulations (CCR) Water Recycling Criteria.

The existing criteria address treatment requirements for recreational impoundments. Many inland water bodies within the watershed that receive POTW discharges have been considered non-restricted recreational impoundments. Since POTW discharges make up all or the majority of dry-weather flows within these receiving streams, Title 22 disinfection requirements for recreational impoundments have been applied to NPDES Permits when the dilution is less than 20:1 (receiving water flow: wastewater flow). The dilution criterion serves to relax effluent standards during large storm events. The treatment requirements are based on the expected degree of human contact with wastewater. Treatment requirements are expressed as treatment process requirements (e.g., bio-oxidation, coagulation) as well as performance standards (e.g., disinfection standards and contaminant reduction). The existing Title 22 standards are among the most stringent standards for public health protection. To be considered adequately disinfected, the median number of coliform organisms in the wastewater may not exceed a most probable number (MPN) of 2.2 per 100 milliliters (mL) over a seven-day period. The waste discharge requirements for the Inland Empire Utilities Agency's Regional Pants 1 & 4 [Order No. 01-1, NPDES Number CA0105279] show how these standards are incorporated:

- The discharge shall at all times be an adequately filtered and disinfected wastewater (tertiary treated effluent) if the flow in the receiving water is less than that required for a dilution of 20:1 (receiving water flow: wastewater flow) at the point of discharge. Filtered wastewater means an oxidized, coagulated, and clarified wastewater which has been passed through natural undisturbed soils or filter media, such as sand or diatomaceous earth (or equivalent as determined by the State Department of Health Services). The discharge shall be considered adequately filtered if the turbidity does not exceed an average of 2.0 turbidity units nor exceeds 5.0 turbidity units more than 5 percent of the time during any 24-hour period. The discharge shall be considered adequately disinfected if the median number of coliform organisms does not exceed 2.2 per 100 milliliters and the number of coliform organisms does not exceed 23 per 100 milliliters in more than one sample within any 30-day period. The median value shall be determined from the bacteriological results of the last 7-days for which analyses have been completed.

- The discharge of secondary treated wastewater when the flow in the receiving water results in a dilution of 20:1 (receiving water flow: wastewater flow) or more at the point of discharge shall be an adequately disinfected and oxidized wastewater. The discharge shall be considered adequately disinfected if at some location in the treatment process, the median number of coliform organisms does not exceed 23 per 100 milliliters. The median value shall be determined from the bacteriological results of the last 7-days for which analyses have been completed. The discharge shall be considered adequately oxidized if it complies with the average weekly and average monthly effluent limitations for BOD and suspended solids as specified in Discharge Specification A.1.a. The discharger shall make provisions for the measurement of the receiving water flow at a suitable location upstream of the discharge point and determine whether a 20:1 dilution exists before discharging secondary treated effluent. A dilution of 20:1 or more is required at the point of discharge.

Title 22 requirements were adopted in 1978. POTWs operating prior to 1978 began constructing facilities to meet Title 22 requirements at that time. It is believed that all of the inland POTWs completed improvements to meet Title 22 requirements by the mid-1990s and all treatment plants constructed since then have been designed to meet these requirements.

Considering inland POTW discharges as discharging to recreational impoundments, Title 22 requirements provide for protecting human contact recreation with POTW discharge channels and receiving streams.

Not all POTWs in the Santa Ana Basin discharge to recreational impoundments. POTWs that discharge to groundwater recharge basins as opposed to surface waters are not required to meet Title 22 standards. These POTWs still provide treatment to secondary levels. In groundwater recharge basins, soils may provide additional treatment of effluent by natural bacteria reduction.

Urban Runoff Control Measures and BMPs

Source Control Measures

All cities and counties in the Santa Ana River Watershed implement municipal separate storm sewer system (MS4) water quality programs aimed at reducing the amount of pollutant discharges in stormwater runoff. The programs are required by MS4 discharge permits issued under the National Pollutant Discharge Elimination System (NPDES) by the Santa Ana Regional Water Quality Control Board. The counties implementing such programs include San Bernardino County, Riverside County, and Orange County. These counties serve a leadership role (principal permittee role) for large, area-wide groups of city MS4 permittees.

The MS4 programs currently implemented within the Santa Ana River Watershed have broad program elements in common that can directly or indirectly provide some reduction of bacteria and pathogens within urban (both dry and wet weather) runoff. Recent annual reports for the MS4 programs were reviewed to identify and summarize program elements and innovative measures aimed at controlling pollutants within stormwater discharges. The annual reports reviewed included:

- San Bernardino County Stormwater Program Annual Report FY2002-2003
- Riverside County Flood Control and Water Conservation District, County of Riverside and Cities of Riverside County 2003 Annual Progress Report
- Unified Annual Progress Report; Program Effectiveness Assessment 2002-2003 Reporting Period, published jointly by the County of Orange, the Cities of Orange County, and the Orange County Flood Control District

The three MS4 programs consist of common elements/programs aimed at reducing pollutant discharges. These program elements include the following:

- Illegal Discharge/Illicit connection control
- Industrial/Commercial Source Program
- New Development/Redevelopment (including construction)
- Public Agency (Municipal) Activities
- Public information/participation
- Water Quality Monitoring

The above listed programs function through the implementation of best management practices (BMPs) defined by each MS4 program. The BMP measures included in these programs are intended to reduce the loading of the following type of pollutants:

- Bacteria
- Sediments and total suspended solids
- Nutrients and fertilizers
- Pesticides and herbicides
- Other pollutants generated from municipal, industrial, commercial and household activities.

Of the listed MS4 program elements, the following BMPs directly address bacteria/pathogen control. These include:

- Public education regarding pet waste management

  Outreach efforts to educate pet owners of the impact of pet waste on water quality is a component of each County MS4 program. Pet waste management includes emphasizing the direct impact that unmanaged pet waste has in introducing bacteria to the storm drain. All pet wastes are required to be collected and properly disposed. Pet owners are encouraged to bring a plastic bag when walking pets at the park. Pet wastes are to be disposed in the trash or through the sanitary sewer system. Many parks trails also have containers to dispense pet waste collection bags.

- Practices to identify and rectify septic system problems

  Area MS4 permits require that the MS4 programs determine a mechanism to address septic failures. Plans and programs to locate and address failed septic systems have been developed. Homeowner education is conducted to emphasize the need for regular operation and maintenance of septic systems and notify system owners when sewer service is newly available in older residential areas.

  As part of Orange County's assessment of its stormwater program, an assessment was conducted on it septic systems. Septic systems are located throughout the County but are of greatest concentration in the Santa Ana River watershed. Based upon a survey of septic system owners, a failure rate of 1.25% was determined. This failure rate was similar to a finding in Oregon. Literature reviews indicate that the most prevalent reason for failure is due to poor operation and maintenance. Excessive water use or insufficient system capacity is also a reason for system failure.

  An analysis was also conducted to predict the mass loading resulting from failed septic system failures. Study results show that failed septic systems are a marginal contributor to pathogen indicators and do not represent a significant source of constituents of concern to Orange County receiving waters.

- Portable toilet pollution prevention program

  Portable toilets are used at parks, construction sites, parks and recreational areas, and temporary events. Improper operation and maintenance of these units can have direct impact on receiving waters. Area MS4 permits require that the MS4 programs develop BMPs to properly manage portable toilets, aimed at preventing accidental discharges and providing for proper handling of wastes, as well as proper cleaning procedures. BMPs for proper portable toilet management have been developed.

As part of Orange County's annual review of its stormwater program, an assessment was conducted on practices and impacts associated with the maintenance, use and oversight of portable toilets. The assessment identified a small number of formal incidents over several years involving observed or potential direct impact to drainage channel.

Current industry practices were found to be sufficient to prevent receiving water impacts from spills from portable toilets. The practices were recommended to be formalized to ensure consistent implementation by suppliers and users of the portables and disseminated through inspection, education and outreach efforts and through BMP fact sheets.

- Water Quality Management Plan (WQMP) requirements for new developments that have the potential to discharge bacteria/pathogens, or will discharge runoff into receiving waters 303(d) listed for bacteria/pathogens

  WQMP checklists for new projects/ developments require any downstream receiving waters be identified as well as any known water quality impairments. If the downstream receiving water is on the 303(d) list for bacteria, best management practices can be required as a prerequisite to project approval. These measures should be designed to help prevent bacteria loading to the downstream receiving water.

Of the MS4 elements, the following BMPs indirectly affect bacteria/ pathogens within stormwater runoff:

- Identification and elimination of illicit connections to the storm drain system

  Each MS4 program includes a program to detect, respond, and eliminate illegal discharges and illicit connections which are a significant source of pollutants to the storm drain system. Illegal discharge and illicit connection programs integrate municipal, industrial, commercial, residential, and construction inspection programs by training authorized inspectors to investigate, and detect incidences of violations. By identifying and eliminating illegal discharges and illicit connections, the potential for discharges which contain bacteria/ pathogens to enter the storm drain system is reduced.

- Spill response plans for certain types of spills and illegal discharges (sanitary sewer overflows)

  Each MS4 program has a program element to address spills and illegal discharges. These activities are related to the identification of illicit connections and illegal discharges as described above. Spill responders are designated by each County to coordinate with fire departments and other agencies in case of accidental spills, leaks, or prohibited discharges. Spill response procedures consist of record keeping, notifications of relevant authorities, on-scene assessments, containment, cleanup, investigations, reporting, and education and enforcement.

- Trash collection

  Each MS4 program contains trash collection BMPs as part of its municipal activities. Trash left uncollected or improperly contained can enter the storm drain systems. Trash is required to be collected on a regular basis and disposed of properly. Placement of trash receptacles, appropriate receptacle size, and frequency of trash collection is important so as to prevent unnecessary accumulation of the trash and discourage illegal dumping. These management practices prevent the decomposing trash that may be high in bacteria/ pathogen populations from entering the storm drain system.

- Street sweeping

  Each MS4 program contains municipal street sweeping as a program BMP. Sweeping activities occur throughout each city within the program, and target areas where historically elevated litter loads are observed. Regular sweeping not only prevents accumulation of trash, debris, and sediment but indirectly reduces the potential and medium for bacterial growth.

For the County of Orange, the "Unified Annual Progress Report; Program Effectiveness Assessment 2002-2003 Reporting Period" measured the effectiveness of BMP measures. The assessment measured effectiveness based on: (1) verification of program implementation, and (2) improved water quality or environmental conditions. However, the assessment "recognizes that scientifically robust evidence of improved water quality will follow confirmation on program implementation and should not be expected to be evident initially."

The assessment concluded that "while evidence of the connection between programmatic activities and changing environmental conditions remains elusive, the Permittees believe that there is strong evidence of increasing program effectiveness." Many specific achievements were identified in the assessment; however, bacteria-specific achievements were not mentioned.

In summary, information directly addressing reduction in bacteria/pathogen loading or concentration in receiving waters as a result of MS4 program implementation is not readily available.

Structural Treatment Controls

In addition to source control BMPs required by MS4 programs, structural treatment controls (treatment control BMPs) are now required for certain new development and significant redevelopment projects within the MS4's jurisdiction. Furthermore, there are a number of existing local or regional facilities such as detention or retention (recharge) basins, treatment wetlands, and diversions that have been constructed throughout the watershed that provide opportunities for reduction of pollutants in runoff including bacteria and pathogens.

Treatment control BMPs that are described within the WQMP requirements for the MS4 programs include:

- Biofilters, including:
    - Vegetated Buffer Strips
    - Vegetated Swales
    - Wetland Vegetated Swales
- Bioretention
- Detention Basins (extended dry basins, pervious and impervious lined)
- Infiltration Basins and Trenches
- Wet Ponds and Constructed Wetlands
- Filtration Systems, including
    - Media Filters / Sand Filtration

- Water Quality Inlets
  - Trapping Catch Basins
  - Oil Water Separators
- Hydrodynamic Separators
- Porous Pavement or Landscape Detention
- Manufactured Proprietary Control Measures

Development project proponents consider expected pollutants, receiving water pollutants of concern, site conditions, building restrictions, restriction on the use of infiltration, and economic feasibility when selecting treatment control BMPs. MS4 programs have researched treatment control BMP removal efficiencies and have provided some insight into selecting an appropriate BMP. Table 1 summarizes general removal effectiveness information provided in model WQMPs for MS4 programs.

Table 1
BMP Removal Effectiveness

Pollutant of Concern	Treatment Control BMP Categories					
	Biofilters	Detention Basins	Infiltration Basins	Wet Ponds or Wetlands	Filtration	Hydrodynamic Separator Systems
Sediment Turbidity	H/M	L/M	H/M	H/M	H/M	H/M (L for Turbidity)
Nutrients	L	L/M	H/M	H/M	L/M	L
Organic Compounds	U	U	U	U	H/M	L
Trash & Debris	L	H/M	U	U	H/M	H/M
Oxygen Demanding Substances	L	L/M	H/M	H/M	H/M	L
Bacteria & Viruses	U	U	H/M	U	H/M	L
Oil & Grease	H/M	L/M	U	U	H/M	L/M
Pesticides (non-soil bound)	U	U	U	U	U	L

L: Low removal efficiency
H/M: High or medium removal efficiency
U: Unknown removal efficiency

Sources: Guidance Specifying Management Measures for Sources of Nonpoint Pollution in Coastal Waters (1993), National Stormwater Best Management Practices Database (2001), and Guide for BMP Selection in Urban Developed Areas (2001).

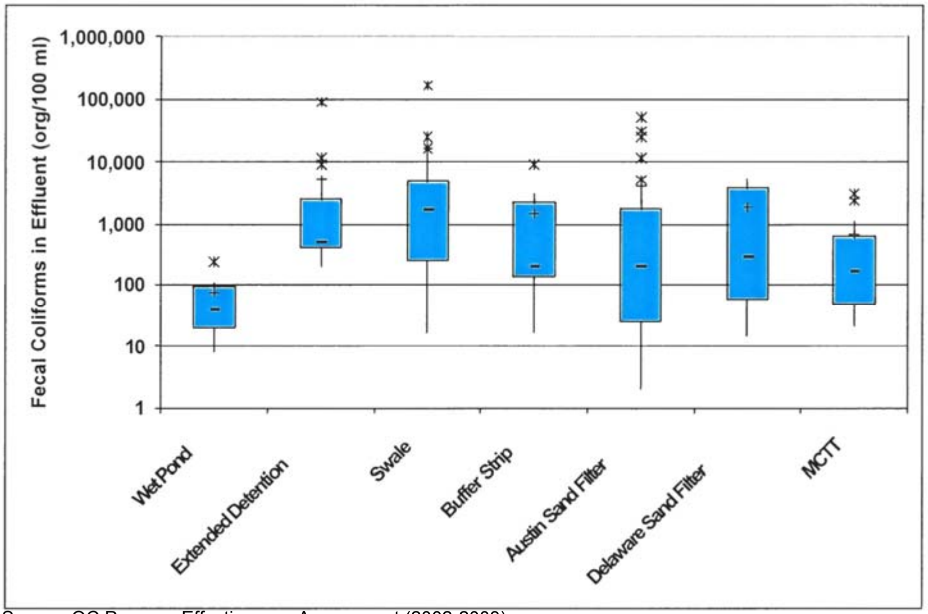
Specific to bacteria and pathogens, infiltration and filtration control BMPs are described as having a medium to high removal efficiency. Hydrodynamic separators are described as having low removal efficiency. Biofilters, detention basins, and wet ponds or wetlands are described as having unknown removal efficiency. Traditional design and operating practices for such systems have focused largely on trash and debris and suspended solids removal with some ability to reduce metals and nutrients. Only in the past several years has there been more emphasis on investigating methods to enhance bacteria removal from "typical" stormwater treatment methods. Examples include providing shallow zones to enhance natural UV penetration and looking at subsurface wetland systems.

Recent research indicates that wet ponds and constructed wetlands may have the potential for higher bacteria and pathogen removal efficiency; potentially the highest among treatment control BMPs currently described within MS4 programs. Larger wet pond and constructed wetland systems are typically integrated into regional treatment control programs to serve large drainage areas rather than from single project sites. Some larger, multi-acre projects could incorporate wet pond or wetland treatment.

Orange County's "Unified Annual Progress Report; Program Effectiveness Assessment 2002-2003 Reporting Period" contains performance reviews of structural BMPs. According to the Assessment, structural BMPs in Orange County have been constructed primarily to address nutrient loads and bacteria/pathogen concentrations. These structures have been designed to primarily treat dry-weather flows.

The Assessment describes wet ponds and constructed wetlands as suitable for treating dry-weather flows when sufficient flow is present to maintain a water pool and sustain necessary vegetation. The Assessment also describes wet ponds as capable of producing effluent that meets contact recreation standards for fecal coliform, although notes that reduction in bacteria concentrations can be achieved from other BMP measures.

The Assessment further compares the observed concentrations of fecal coliform in the effluent of the BMPs such as wet ponds, extended detention basins, swales, buffer strips, sand filters, and multi-chambered treatment trains as shown in Figure 2. Although substantial reduction is observed for many of the BMPs, contact recreation standards (REC1) are only observed to be met more consistently in the discharge from the wet pond.



Source: OC Program Effectiveness Assessment (2002-2003).

Figure 2
Comparison of Fecal Coliform Effluent Concentrations

Existing BMP Treatment Controls in Santa Ana Basin

Numerous structural BMPs exist within the watershed that were designed and installed for a variety of purposes but that have the potential to improve the quality of stormwater runoff on a regional (non-site specific) basis. Many of these directly or indirectly address bacteria/pathogens. These BMPs include:

- Low-flow diversion to sanitary sewer system
- Recharge (Infiltration) basins
- Detention basins, swales, and buffer strips
- Natural treatment wetlands/ wet ponds
- Ultraviolet disinfection
- Ozone

Low-Flow Diversion to Sanitary Sewer System

Dry-weather diversions consist of pumping or otherwise diverting low flows from storm drains to a sanitary sewer system for treatment at a waste water treatment plant, which would include disinfection as necessary to meet the discharge requirements for the plan. By eliminating dry weather flows from directly entering the receiving waters, the impact from bacteria levels in the dry weather runoff is eliminated.

In the County of Orange, the Dry Weather Diversion Plan, October 2003, evaluated the effectiveness of the dry weather diversions to the Orange County Sanitation District (OCSD). These diversions have been implemented in various coastal locations since 1997 (Table 2). The diversion program is not a requirement of the County's NPDES Permit but has been implemented as a result of continual closures and postings at coastal beaches due to unsafe bacteria levels. Existing diversion facilities are operating in 38 locations near the coastline or at a main drainage system facility of major watersheds. Figure 3 shows the locations of the existing diversion facilities in Orange County.

The report also describes an additional 38 proposed dry weather diversions. These diversions are proposed in the cities of Dana Point (5), Huntington Beach (13), Laguna Beach (11), San Juan Capistrano (6), Seal Beach (1), and San Clemente (2).

An example of one of the low flow diversions is the Greenville-Banning Channel diversion.

Greenville-Banning Channel

The Greenville-Banning Channel Urban Runoff Diversion (GBCURD) intercepts all dry weather urban runoff in the channel to prevent the runoff from reaching the Santa Ana River and then the ocean at Huntington State Beach. The physical diversion is an inflatable custom manufactured rubber dam (6.5 feet high by 60 feet long) placed in the Greenville Banning Channel upstream of the confluence with the Santa Ana River. Approximately 80 million gallons of urban runoff was diverted to OCSD for treatment during 2003 (Average flow 200,000 gpd). The County of Orange produced a report entitled, "Greenville Banning Channel Urban Runoff Diversion Project, Final Report" in April 2003, specifically to address findings from the Greenville Banning Channel Diversion

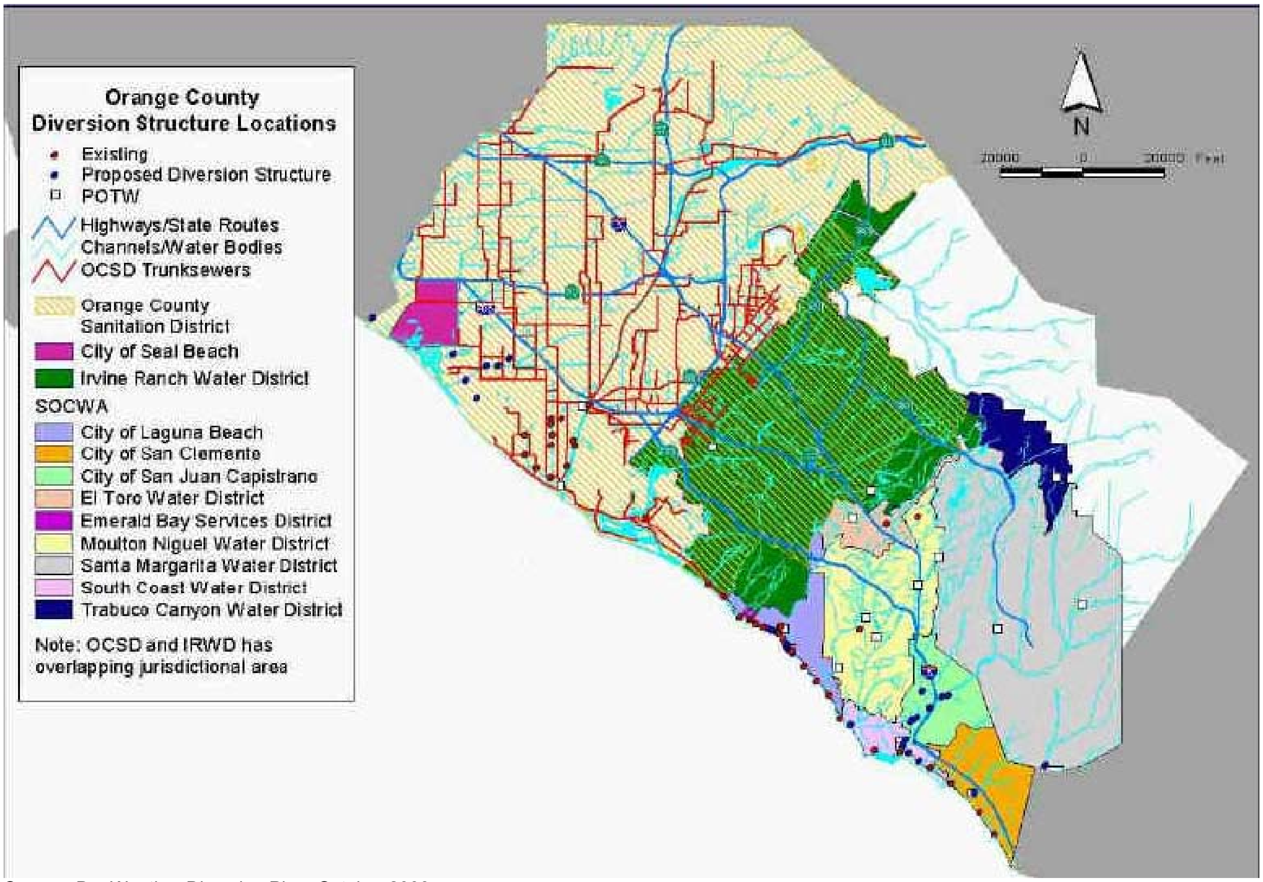
Table 2
List of Existing Low Flow Diversions

Location	Sanitary Sewer Treatment Agency	Permittee	Month/Year Built	Flow Diverted GPD
9731 Flounder Dr @ D02 (Flounder PS)	OCSD	Huntington Beach	Feb. 2000	72,000
9211 Yorktown Ave @ D02 (Yorktown PS)	OCSD	Huntington Beach	Feb. 2000	72,000
19661 Chesapeake Ln @ D02 (Adams PS)	OCSD	Huntington Beach	Feb. 2000	72,000
20192 Midland Ln @ E01 (Meredith PS)	OCSD	Huntington Beach	Feb. 2000	288,000
9221 Indianapolis Ave @ D02 (Indianapolis PS)	OCSD	Huntington Beach	Feb. 2000	144,000
8151 Atlanta Ave @ D01(Atlanta PS)	OCSD	Huntington Beach	July 1999	504,000
10101 Hamilton Ave @ E01 (Hamilton PS)	OCSD	Huntington Beach	Feb. 2000	144,000
2201 Malibu Ln @ D02 (Banning PS)	OCSD	Huntington Beach	July 1999	288,000
8612 Hamilton St @ D01(Newland PS)	OCSD	Huntington Beach	July 1999	288,000
1131 Back Bay Dr (Newport Dunes)	OCSD	Newport Beach	March 2001	8,640
Santa Ana Channel (E01)	OCSD	County of Orange	May 2001	295,000
Greenville-Banning Channel	OCSD	County of Orange	May 2001	215,000
Talbert Channel (D02)	OCSD	County of Orange	May 2001	120,000
Downstream of Adams Ave @ D01 (Huntington Beach)	OCSD	County of Orange	May 2001	-
Linda Ln @ Via Mecha	City of San Clemente	San Clemente	Aug. 2001	14,000
Camino del Estrella (est. location)	South Coast Water District (SCWD)	Dana Point	NA	1,000
Laguna Cyn @ Forest Ave	City of Laguna Beach	Laguna Beach	1987	140,000

Table 2 (continued)
List of Existing Low Flow Diversions

Location	Sanitary Sewer Treatment Agency	Permittee	Month/Year Built	Flow Diverted GPD
Bluebird Canyon	City of Laguna Beach	Laguna Beach	1997	30,000
Dumond Dr./Victoria Beach	City of Laguna Beach	Laguna Beach	1997	5,000
Fisherman's Cove	City of Laguna Beach	Laguna Beach	1998	2,000
El Paseo@Laguna Ave (Main Beach)	City of Laguna Beach	Laguna Beach	1998	10,000
5th Ave @ Coast Hwy	City of Laguna Beach	Laguna Beach	1999	2,000
Barranca St. @ Cliff Dr	City of Laguna Beach	Laguna Beach	2001	1,400
Cleo St. @ Gaviota	City of Laguna Beach	Laguna Beach	2001	35,000
Aliso Creek/ Sulphur Creek Confluence	Moulton Niguel Water District (MNWD)	Laguna Nigel	May 2000	175,000
Muddy Canyon	OCSD	Newport Beach/IRWD	April 2002	288,000
Los Trancos	OCSD	Newport Beach/IRWD	April 2002	288,000
Los Lobos (est. loc)	City of San Clement	San Clemente	Aug. 2001	29,000
Aliso Creek (J01) at mouth*	OCSD	County of Orange	May 2001	234,000
Riviera Beach (150 yards upstream of MO	City of San Clemente	San Clemente	-	29,000
Pump Station #1 (Emerald Point)	Emerald Bay Serice District (EBSD)	Laguna Beach	-	1,000
Three Arches Bay	SCWD	Laguna Beach	-	-
Dana Point Harbor-Baby Beach	SCWD	Dana Point	NA	1,300
Doheny State Beach	SCWD	Dana Point	NA	10,000
#118 Emerald Bay	EBSD	Laguna Beach	-	1,000
#206 Emerald Bay	EBSD	Laguna Beach	-	1,000
#101 Emerald Bay	EBSD	Laguna Beach	-	1,000
Crescent Bay Dr and Circle Way	City of Laguna Beach	Laguna Beach	2001	7,500

- Data not available
* Presently decommissioned



Source: Dry Weather Diversion Plan, October 2003
Orange County

Figure 3
Existing Low Flow Diversions Facilities in Orange County

Recharge (Infiltration) Basins

A number of basins that were designed for a variety of purposes exist throughout the Santa Ana Basin (Table 3). The design and intent of the some of these basins was not for bacteria removal, but rather to either recharge groundwater aquifers or reduce flood hazard potential downstream. Some basins were designed for both recharge of groundwater and for flood control purposes. SAWPA provided a GIS layer of basins throughout the Santa Ana Basin that includes recharge, flood control, and multifunction basins (Figure 4).

Table 3
Recharge Basins in Santa Ana River Watershed

Number	Agency	Name	Basin	County
1		Miller Basins	Santa Ana Forebay	Orange
2	Orange County Water District	Santa Ana River Forebay Rech.	Santa Ana Forebay	Orange County
3	Orange County Water District	Santiago Basin Rech. Ops.	Santa Ana Forebay	Orange County
4		Santiago Creek Basins	Santa Ana Forebay	Orange
5	San Bernardino Co. Flood Control	Montclair Basins	Chino I	San Bernardino
6		Cucamonga Basins North & South	Cucamonga	San Bernardino
7		Eighth Street Basins	Chino I	San Bernardino
8		Fifteenth Street Basin	Chino I	San Bernardino
9	Chino Basin Water Conservation District	Ely Basins	Chino II	San Bernardino
10		Red Hill Basin	Cucamonga	San Bernardino
11	Chino Basin Water Conservation District	Chris Basin	Chino II	San Bernardino
12	Chino Basin Water Conservation District	Lower Cucamonga Spr. Grounds	Chino II	San Bernardino
13		Turner Basins	Chino II	San Bernardino
14		Church Street Basin	Chino I	San Bernardino
15	Chino Basin Water Conservation District	Riverside Basins	Chino II	San Bernardino
16	Chino Basin Water Conservation District	Wineville Basin	Chino II	San Bernardino
17		Lower Day Creek Basin	Chino I	San Bernardino
18		Upper Day Creek Basins	Cucamonga	San Bernardino
19		Etiwanda Basin	Chino I	San Bernardino
20	San Bernardino Co. Flood Control District	Etiwanda Conservation Basins	Chino I	San Bernardino
21		East Ave. Spreading Grounds	Chino I	San Bernardino
22	San Bernardino Co. Flood Control District	Hickory Basin	Chino I	San Bernardino
23	San Bernardino Co. Flood Control District	Victoria Basin	Chino I	San Bernardino
24		East Etiwanda Creek Channel	Chino I	San Bernardino
25	San Bernardino Co. Flood Control District	Banana Basins	Chino I	San Bernardino
26	San Bernardino Co. Flood Control District	San Sevaine Spreading Area	Chino I	San Bernardino

Table 3 (continued)
Recharge Basins in Santa Ana River Watershed

Number	Agency	Name	Basin	County
27	Lytle Creek Water Conservation Assoc.	Lytle Creek Spreading Grounds	San Bern./Lytle Creek	San Bernardino
28		Merrill Basin	Chino I	San Bernardino
29		Linden	San Bernardino GW Basin	San Bernardino
30		Linden Basin	Chino I	San Bernardino
31		Mill Basin	Colton-Rialto	San Bernardino
32		Pepper Basin	Colton-Rialto	San Bernardino
33		Randall Basin	Colton-Rialto	San Bernardino
34	San Bernardino Co. Flood Control District	Devil Cyn/Swt. Spill. Spr. Gr.	San Bern./Bunker Hill	San Bernardino
35		Muscoy (North)	San Bernardino GW Basin	San Bernardino
36		Muscoy (South)	San Bernardino GW Basin	San Bernardino
37	Chino Basin Water Conservation District	Jurupa Basins	Chino II	San Bernardino
38		Mayfield	San Bernardino GW Basin	San Bernardino
39	San Bernardino Co. Flood Control District	Waterman Cyn. Spr. Grounds	San Bern./Bunker Hill	San Bernardino
40		Waterman (North)	San Bernardino GW Basin	San Bernardino
41		Waterman (South)	San Bernardino GW Basin	San Bernardino
42		Twin	San Bernardino GW Basin	San Bernardino
43		Marshall	San Bernardino GW Basin	San Bernardino
44		Patton	San Bernardino GW Basin	San Bernardino
45	San Bernardino Co. Flood Control District	City Creek Spreading Grounds	San Bern./Bunker Hill	San Bernardino
46	Eastern MWD	Skiland Ponds	Perris South II	Riverside
47	Eastern MWD	Winchester Ponds	Winchester	Riverside
48	San Bernardino Valley Water Conservation District	Santa Ana River Spr. Grounds	San Bern./Bunker Hill	San Bernardino
49	Eastern MWD	Salt Creek Water Harvesting	Winchester	Riverside
50	San Bernardino Valley Water Conservation District	Mill Creek Spreading Grounds	San Bern./Bunker Hill	San Bernardino
51	Eastern MWD	Fish & Game Wetlands	San Jacinto - Lower Pres.	Riverside

Table 3 (continued)
Recharge Basins in Santa Ana River Watershed

Number	Agency	Name	Basin	County
52	Eastern MWD	EMWD Trumble Ponds - Romoland	Perris South II	Riverside
53	San Bernardino Co. Flood Control District	Wilson Creek Spr. Grounds	San Bern./Bunker Hill	San Bernardino
54	Eastern MWD	San Jacinto Reservoir	San Jacinto - Upper Pres.	Riverside
55	Eastern MWD	Alessandro Ponds	San Jacinto - Upper Pres.	Riverside
56	Eastern MWD	SPW Recharge Ponds	San Jacinto Intake	Riverside
57	Eastern MWD	Fruitvale 20 Ac. Basins - (L)	San Jacinto Canyon	Riverside
58	Eastern MWD	Fruitvale 40 Ac. Basins - (U)	San Jacinto Canyon	Riverside
59	Chino Basin Water Conservation District	Brooks		
60	Chino Basin Water Conservation District	College Heights		
61	City of Upland	Upland		
62	San Bernardino County Flood Control District	Declez		
63	IEUA	RP3		
64		Thomson Creek SG		
65		San Antonio Dam		
66		Pomona SG		
67		Live Oak SG		
68	IEUA	Cucamonga SG1-2-3		
69	IEUA	Cucamonga 1		
70	IEUA	Cucamonga 2		
71	IEUA	Alta Loma 1-2		
72	IEUA	Turner 1		
73	IEUA	Turner 2-3-4		
74	IEUA	Turner 5-8-9		
75	IEUA	Grove Ave. Basin		
76	IEUA	Jurupa		
77	IEUA	San Sevaine 2		
78	IEUA	San Sevaine 1		
79	IEUA	Rich		

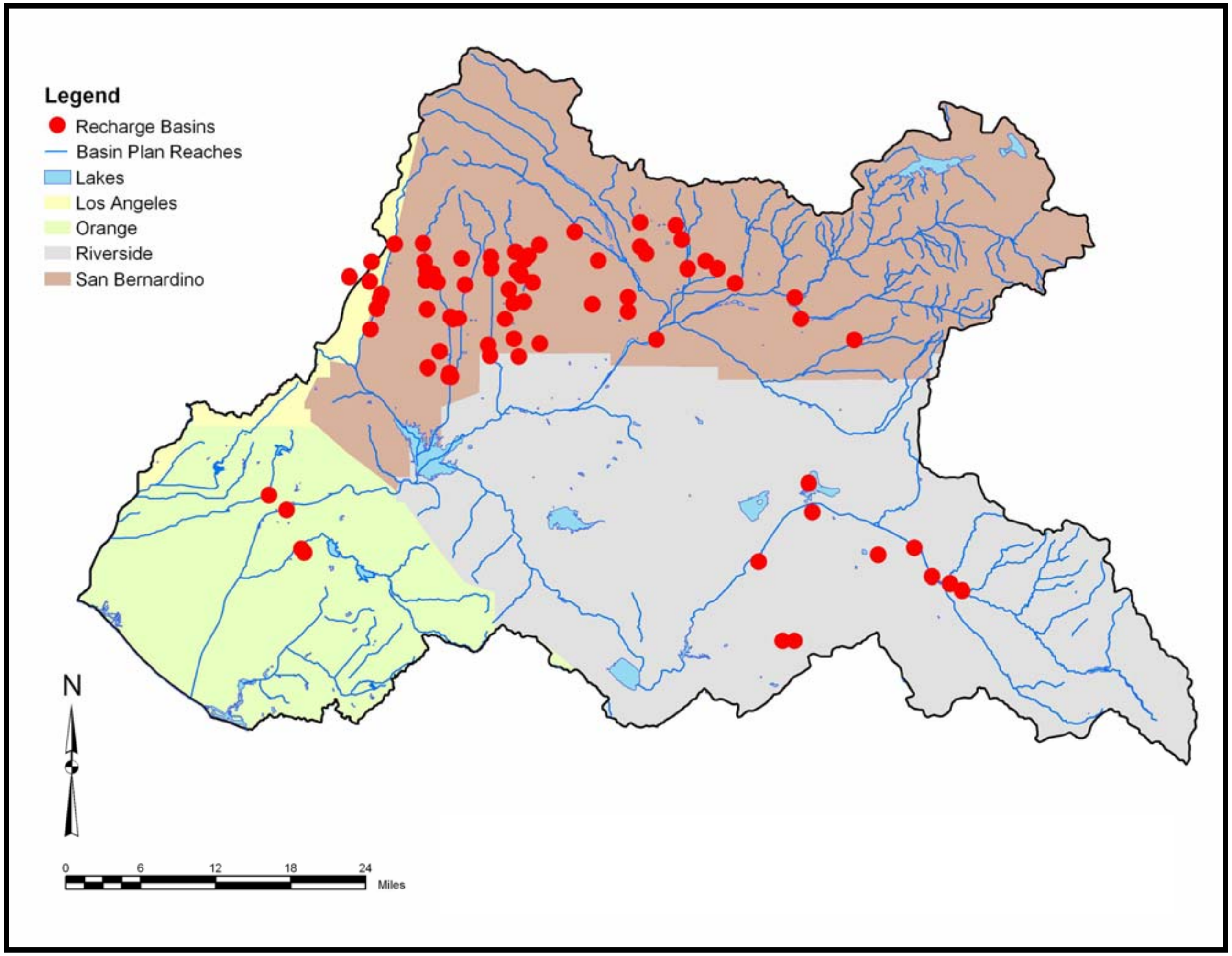


Figure 4
Surface Water Basins with Potential for Bacteria Reduction

Recharge, flood control, or multi-function surface water basins may also be reducing bacteria in downstream receiving waters. This water quality functionality is achieved by filtration and removal through adsorption and decay within the soil matrix and underlying formation. The Santa Ana Regional Water Quality Control Board encourages basin owners to look for opportunities to retrofit surface water basins for water quality improvement. This can be accomplished by facilitating infiltration or through construction of multi-stage outlets.

Orange County Water District (OCWD) operates and maintains a man-made series of T-levees within the Santa Ana River near Imperial Highway to increase groundwater recharge capacity. The levees are constructed along side the River and receive low flows from a diversion structure. The levees provide for spreading, slowing, and retention of River flows primarily to increase groundwater infiltration rates. During low flow periods, increased spreading decreases the amount of water flowing through the River, and provides for increased settling, both conditions that can decrease the amount of bacteria and pathogens within the River, potentially improving water quality.

Natural Treatment Wetlands / Wet Ponds

In its June 2003 study, Appendix E1 – BMP Effectiveness and Applicability for Orange County, wet ponds and wetlands are described as being particularly effective in reducing bacteria levels from dry weather flows diverted to the wet ponds. Examples of wet ponds/ wetlands in the Santa Ana basin are described below. Attachment A to this technical memorandum is an inventory of existing or planned wetland BMPs within the Santa Ana Basin.

Natural Treatment System (NTS) - Irvine Ranch Water District

The proposed Irvine Ranch Water District Natural Treatment System (NTS) is a network of 31 water quality wetlands designed to remove sediment, nutrients, pathogens, and other pollutants from urban runoff within the San Diego Creek Watershed to improve water quality in Upper Newport Bay. The 31 sites are located throughout the cities of Irvine, Tustin, Lake Forest, Newport Beach, Orange, and in unincorporated areas of Orange County.

The primary drainage channel in the treatment area is San Diego Creek and its main tributary, Peters Canyon Wash. San Diego Creek flows into Upper Newport Bay, which contains the 752 acre Upper Newport Bay Ecological Reserve. This coastal estuary is one of the largest remaining estuaries in Southern California.

Three basic facility types are proposed in the NTS. These include off-line, in-line, and combination treatment facilities. The off-line treatment type treats dry weather and wet weather low flows. Flows would divert to open water ponds. The ponds reduce flow velocities and trap sediment and aid in ultraviolet (UV) degradation of pathogens.

The in-line treatment facilities consist of a water quality treatment wetland located within existing stream channels. Wetland vegetation would be located in shallow ponds behind a series of constructed weirs within the channels.

The combination facilities would be built in existing flood control basins. While maintaining the flood control storage volume, the basin would be altered to accommodate constructed wetland areas. A separate outlet from the basin is required to remove flows from treatment wetland. Besides dry weather low flows and wet weather low flows, first flush from storms are designed to be removed from the combination type facility.

The NTS program is anticipated to result in reduced fecal coliform concentrations. The fecal coliform TMDL for Upper Newport Bay is expected to be met during the dry season. During wet weather, the fecal coliform TMDL may be met for low flow conditions but is not expected to be met during storm conditions.

San Joaquin Marsh

The San Joaquin Marsh is the largest coastal freshwater wetlands in Southern California. This 500 acre marsh is adjacent to the University of California, Irvine, and bounded by the San Diego Creek, Michelson Drive, and Carlson Drives. IRWD owns approximately 300 acres of the marsh, of which 150 acres were restored and enhanced in 1997. The University of California Natural Reserve System owns the remaining 200 acres. The restoration project re-established a water supply by diverting dry weather flows from San Diego Creek into a series of ponds for several days before most of the flow is returned to San Diego Creek, about a mile upstream of Newport Bay. The water released back to the creek has about a 50% reduction of nitrates prior to treatment. The primary goal of the marsh is to reduce nutrient concentrations in the San Diego Creek discharge to Newport Bay. Nutrient reduction of nitrogen and phosphorus reduces algae bloom and its effect of oxygen depletion. Approximately, 50,000 tons of sediment and 10,000 pounds of phosphorus are removed each year in desilting basins.

No specific studies were identified which have evaluated the specific effects on bacteria reduction by the San Joaquin Marsh.

Hidden Valley Wetlands Enhancement Project

The Hidden Valley Wetlands Enhancement Project (WEP) was developed in the Hidden Valley Wildlife Area (HVWA) in order to restore and improve existing wetlands within the HVWA by supplying tertiary treated effluent from the City of Riverside Regional Water Quality Control Plant (RWQCP). Within the WEP boundary, there is approximately 37 acres of constructed wetlands. HVWA is operated by the County of Riverside Parks and Open Space Department under a cooperative agreement with the California Department of Fish and Game.

WEP is a multi-purpose project aiming to provide the following:

- De-nitrification
- Enhancement of environment for riparian habitat for native and migratory wildlife species
- Groundwater recharge
- Basis of research for natural treatment processes design criteria

While reducing the nitrogen in the effluent, no specific studies have been conducted to determine the impact, if any, on reducing pathogens.

Prado Wetlands, Orange County Water District
Orange County Water District (OCWD) owns approximately 2,150 acres behind Prado Dam. Of this land, 465 acres are constructed wetlands. The wetland system consists of 50 shallow ponds used for reduction of nitrogen levels in the Santa Ana River since 1992. The Santa Ana River consists mainly of tertiary treated wastewater from upstream discharges. Since the Santa Ana River is the main source of water for groundwater recharge in Orange County, nitrogen levels in the water have been reduced prior to its use as recharge for the groundwater basins. This wetland system removes approximately 20 tons of nitrates per month.

Currently, the base flow of the river is approximately 120 cubic feet per second (cfs), with 60 cfs traveling through the wetland. The base flow of the river potentially may increase beyond 200 cfs due to population increases (and subsequent increases of recycled water discharge) in Riverside and San Bernardino Counties. In order to handle this potential increase in base flows, modifications have been made to increase the hydraulic capacity of the Prado Wetlands pond system.

Since 1999, OCWD has also conducted water quality monitoring of influent and effluent from the Prado Wetlands and analyzed for coliform, E.coli, and enterococci.

Optimal Basin Management Plan – Chino Basin
Chino Basin Watermaster is developing the Optimum Basin Management Program (OBMP). The Chino Basin consists of approximately 235 square miles of the upper Santa Ana River watershed. The Chino Basin is one of the largest groundwater basins in southern California.

The OBMP consists of nine key elements covering a wide range of water activity in the Basin. The OBMP elements as a whole are aimed to develop a groundwater management program that enhances the yield and quality of the Chino Basin. One of the missions of the plan is to increase the Basin water supplies by utilizing stormwater and reclaimed water recharge. The plan is composed of nine program elements which include:

- Comprehensive Monitoring
- Comprehensive Recharge
- Water Supply Plan for Impaired Areas
- Management Zone Strategies
- Regional Supplemental Water Program
- Cooperative Program
- Salt Management Program
- Groundwater Storage Management
- Storage and Recovery Program

The second element, Comprehensive Recharge, has a component that aims to capture wet weather storm flows for recharge to infiltration basins. The resulting reduction in urban runoff downstream could reduce bacteria levels. The Chino Basin Watermaster is looking at obtaining increased recharge capacity by expanding recharge capacity at Montclair Basins, Upland Basins, and Brooks Basins.

Other Emerging Technologies

There are several other emerging technologies that can be utilized to retrofit existing structural BMPS or for implementing in targeting reaches of impacted receiving waters. These alternative technologies include:

- Filtration

Several filtration technologies have been developed for treatment of urban runoff, some of which are specifically designed or indirectly effective at removing bacteria. Treatment devices range from highly specialized proprietary technologies to more conventional media filtration, such sand filters.

Sand filters function by filtering stormwater through sand media, and may be installed underground in trenches or pre-cast concrete boxes, or above ground. Large, above ground sand filters have been used with success for larger drainage areas. Pretreatment to remove large debris and other materials that can hinder sand filter performance is typically necessary. Sand filters have proven moderately effective at removing bacteria. Results have varied based upon site and climatic differences.

Sand filter designs include the surface sand filter basin (Austin sand filter), the underground vault sand filter (Washington, DC sand filter), the double trench sand filter (Delaware sand filter), the stone reservoir trench sand filter, and the peat sand filter system. Modifications are often made to these designs based on site-specific conditions.

A large amount of testing data is available for conventional media filtration for bacteria removal, with some studies showing high removal effectiveness. The ability of media filtration to meet bacterial water quality objectives would depend on source runoff conditions.

Media filtration is also the functional component of several proprietary devices advertised to remove bacteria. Several different configurations of proprietary devices are available through various vendors, though limited application and effectiveness data is available.

- Ozone

Ozone has been used in the water treatment industry since the late 1800s for disinfection, odor control, and other applications. Ozone is generated by an electrical discharge through either dry air or pure oxygen. As an oxidant, ozone is preferred to chlorine due to its extremely efficient disinfection properties and ability to dissipate very rapidly in water, leaving no residuals. Ozone is also considerably less hazardous to handle than chlorine. These properties have made ozone an effective chemical for water treatment for nearly a century. It is, however, a very expensive chemical to use for disinfection.

Ozone, like chlorine, is a strong oxidizing agent and is used in much the same manner. It is an excellent virucide, is effective against most amoebic cysts, and destroys bacteria and phenols. Ozone may not kill large cysts and some other large organisms, so these should be eliminated by filtration or other procedures prior to treatment.

- Ultraviolet Disinfection

Ultraviolet (UV) treatment is an emerging treatment technology for controlling bacteria and pathogens within urban runoff. The technology has been generally accepted in conventional water and wastewater treatment, but also has potential for treatment of urban runoff.

Conventional ultra-violet (UV) treatment technology involves passing water by a special UV light source. The light source is immersed in the water in a protective transparent sleeve, and emits UV waves that can inactivate microorganisms. The ultra-violet rays, similar to the sun's UV rays only stronger, alter the nucleic makeup of viruses, bacteria, molds, and parasites so that they cannot reproduce, and are thus inactivated. UV treatment does not alter the water chemically as nothing is added except light energy. UV treatment does not permanently divert stream flows, does not require chemical storage, and does not produce a chemical residual. Pretreatment of flows is necessary to remove sediments and other constituents prior to UV light exposure, to improve the clarity of water for increased UV light penetration.

Two Southern California examples of UV application for treating urban runoff include systems installed and operated at Moonlight Beach within Cottonwood Creek in Encinitas, and within a storm drain that discharges into Aliso Creek in Laguna Niguel, neither of which are in the Santa Ana Basin.

The Cottonwood Creek UV system installation became operational in December 2002. Cottonwood Creek flows year-round from Encinitas Ranch golf course to Moonlight Beach, draining a watershed of approximately three square miles. Most of the Creek is buried under strip malls, residential communities, and streets. The system has capacity to treat a rate of 200,000 gallons per day. The system is operated only during the dry season, and deactivated during the winter. The City is treating 85 percent of the Creek's flow, bypassing 15 percent of the flow to allow some nutrient contribution to the Creek and the beach. Water is collected directly from the Creek. The UV system was installed for $470,000, and monthly O&M costs are expected to be under $1,000.

The UV system installed within the storm drain tributary to Aliso Creek in Laguna Nigel can also process 200,000 gallons per day. Flow is collected at the storm drain, treated, and discharged to nearby pond. The system is contractually operated at $664 per million gallons treated—averaging $3,000 a month. The system is considered temporary. Plans are to replace it with a system that will carry dry season flow into a series of constructed wetlands for treatment.

To adapt to variable flow rates or organic loading, flow equalization or recirculation is often used. Had ozonation been selected for the Moonlight Beach project, a monitored side stream of minimal flow would have been continuously re-circulated and injected with ozone. In the event of high ozone levels, an automated ozone system would have shut down the re-circulating stream.

In addition to pretreatment filtration, ozone generators, and ozone destruct units, a complete disinfection system requires ozone injectors and injector pumps, a closed-loop chiller, an ozone concentrator, oil-free compressors, an air receiver, an ozone contactor, and an ozone separator. Most of the equipment would have had to fit in the required footprint inside an enclosure, with ozone contact and destruct basins located above or below ground. The investigated system could have met the city's acoustical requirements with some attenuation.

The major benefit of ozone treatment is that ozone is extremely active as a disinfectant. In contrast to chlorine, ozone is active over a wide pH and temperature range. The required contact time is so short that it is not a consideration in system design.

Attachment A

Attachment A
Planned or Operating Wetlands in the Santa Ana Basin

Project	Owner	Location	Status	BMP Type	Objectives	Description
Hidden Valley Wetlands Enhancement Project	City of Riverside	Hidden Valley Wildlife Area	Operational	Natural treatment wetlands Wastewater treatment	Total organic nitrogen TMDL (1991) 10 mg/l; protection of groundwater basins Purposes: de-nitrification of tertiary effluent; environmental enhancements for riparian habitat; groundwater recharge; improvements to public use; research and development	Influent structure, conveyance channel, wetlands ponds; Average TIN removal in 2003 – 43% in surface flow; 38% in sub-surface flow; No specific studies conducted on potential pathogen reduction.
San Joaquin Marsh	Irvine Ranch Water District	San Diego Creek, Orange County	Five wetlands are operational	Natural treatment wetlands Runoff treatment	Nitrate and sediment removal	Currently IRWD is operating water quality treatment wetlands with 45 acres of open water and 11 acres of marshland vegetation. Water is diverted from San Diego Creek to marsh and circulated through ponds. Nitrogen loads to Newport Bay are reduced by 50%; No specific studies conducted on potential pathogen reduction.
San Diego Creek Watershed Natural Treatment System	Irvine Ranch Water District	San Diego Creek, Orange County	31 new wetlands are being planned	Natural treatment Wetlands Runoff treatment	Achieving TMDL targets for total nitrogen for dry season low flow conditions of 2007 and wet season low flow conditions by 2012. Achieve total phosphorous TMDL targets for 2002 and 2012 during stormwater runoff. Reduction in fecal coliform concentrations; fecal coliform TMDL will be met during the dry season only. Some facilities will be designed to remove selenium to meet TMDLs.	Proposed off-stream, in-stream and combined wetlands will treat low and runoff from small events, and first-flush from large storm events. Some of the proposed facilities will treat only dry weather flows. Aims to reduce fecal coliform loads.

Attachment A (continued)
Planned or Operating Wetlands in the Santa Ana Basin

Project	Owner	Location	Status	BMP Type	Objectives	Description
Prado Wetland	Orange County Water District	At Prado Dam in Riverside County	Operational	Wetlands for treatment of Santa Ana River flows	Nitrogen removal	465 acres of constructed wetlands consisting of 50 shallow ponds that remove approximately 20 tons of nitrate per month; OCWD has tested for coliform, E.coli, and enterococci pathogens since 1999.
Crystal Cove	The Irvine Company	Crystal Cove, Orange County	Operational	Detention and filtration; low-flow diversion to sewer system; storm-drain filters; wetlands	Eliminate low-flow during dry weather; remove sediments, bacteria and trash from runoff	Runoff control for residential development. Detention and filtration; low-flow diversion to sewer system; storm-drain filters; wetlands
Urban Runoff Diversion Projects – Greenville Banning Channel, Talbert Channel, Lower Santa Ana River, and Huntington Beach Channel	County of Orange	Santa Ana River Watershed, Orange County	Operational	Inflatable dams to divert urban runoff low flow to the sewer system	To reduce the number of beach-mile-days postings at Huntington State Beach by diverting urban runoff water to OCSD for treatment. The projects reduce the loading of fecal and total coliform bacteria reaching the ocean during dry-weather that contribute to beach closures	The four inflatable dams divert low flow urban runoff during dry weather to the sewer system for treatment at OCSD facilities.
Lytle Creek North	???	???	Proposed???	Infiltration basins and vegetated wet basins	TSS, Total N, Total P, Lead, Zinc, total hydrocarbons, fecal coliform, BOD removal	Four infiltration basins; two of them with vegetated wet basins to treat nuisance flows, and two with dry forebays
Orange Coast River Park	Friends of Harbors, Beaches and Parks	Lower end of Santa Ana River	Concept	Recreational park and programs	Enhance/restore ecological functions, improve habitat, recreation	1000-1400 acre park by Santa Ana River – trails, shared support facilities, and wildlife habitat and park management program; Continue wetland restoration at Huntington-Talbert Marsh area.

Attachment A (continued)
Planned or Operating Structural BMPs in the Santa Ana Basin

Project	Owner	Location	Status	BMP Type	Objectives	Description
Constructed Wetlands – Bolsa Chica Channel	County of Orange Public Facilities and Resources Dept.	Bolsa Chica Channel	Feasibility Study	Wetland system for urban runoff	Enhance/restore ecological functions, improve habitat, improve water quality	Route urban runoff from the Bolsa Chica Channel through wetlands constructed on property by the Seal Beach Naval Weapons Station. Detention system, vegetation system, and upstream debris removal included.
Chino Creek Wetlands	Orange County Water District	Chino Creek just above Prado Dam	CEQA Complete	Constructed wetlands	Restore/improve ecological habitat	100 acres of constructed wetlands to reduce nitrates/TIN in drinking water
Natural Treatment System – East Garden Grove Channel	City of Huntington Beach	East Garden Grove	In process	Wetland system and groundwater/surface water improvements	Divert urban runoff, rehabilitate surface water, recharge aquifer	Divert up to 4 mgd urban runoff into 2-acre wetland; treated water would rehabilitate Talbert Lake and recharge Huntington Beach Central Park aquifer; public education/outreach
Prado River Road Wetlands Expansion	Orange County Water District	Orange County, River Road	CEQA Complete	Constructed wetlands	Restore/improve ecological habitat, water quality	200 acres of constructed wetlands above River Road bridge to treat Santa Ana River flows; reduce nitrates/TIN in drinking water
Regional Plant Coordinated Habitat and Stormwater Management Plan	Inland Empire Utilities Agency	Inland Empire, Prado Basin	N/A	BMPs	Improve water/habitat/ ecosystem quality	IEUA properties site -plan to use BMPs for stormwater management, organics processing, habitat/water conservation

Attachment A (continued)
Planned or Operating Structural BMPs in the Santa Ana Basin

Project	Owner	Location	Status	BMP Type	Objectives	Description
Temescal Creek Riparian Enhancement	Riverside/ Corona	Temescal Creek	Ongoing planning	Habitat restoration	Improve ecosystem/water quality	50 acres of riparian habitat restoration, small ponds for fresh water marsh/water use; reintroduce native vegetation
Lake Elsinore Nutrient Removal (Wetlands)	Lake Elsinore/ San Jacinto Watersheds Authority	Lake Elsinore	Planning	Constructed wetlands	Improve habitat/ water quality	Construct wetlands and implementing other nutrient control measures for Lake Elsinore
Nutrient Removal Eastern Municipal Water District Water Reclamation Plants	Lake Elsinore/ San Jacinto Watersheds Authority	Eastern Municipal Water District Reclamation Plants	Planning	Improvements to Water Reclamation Plants	Improve habitat/ water quality	Increase nitrogen/phosphorus removal capacities at EMWD Water Reclamation Plants, which discharge into Lake Elsinore
Installation of Aeration Systems and Oxygenation System	City of Canyon Lake, County of Riverside	Canyon Lake, Riverside County	Planning	Structural water quality improvements	Improve water quality/ recreational	Install oxygenation systems to improve drinking water of Canyon Lake and water quality for recreational users
San Timoteo Canyon State Park	Riverside Land Conservancy	San Timoteo Canyon State Park	Planning	Creation of new state park	Enhance ecology, improve habitat/ water quality	Create new state park centered around San Timoteo Creek Watershed; create, restore, and protect wetlands
San Timoteo Habitat Enhancement Project	East Valley Resource Conservation District	San Timoteo Creek	Ongoing	Restore tributary to natural state	Restore ecology, improve habitat/water quality	Restore tributary by removing trash/debris in creek bed
San Jacinto Wildlife Area Environmental Enhancement and Recycled Water Storage Initiative	Eastern Municipal Water District	San Jacinto Wildlife Area	Ongoing	Wetlands restoration, water conservation	Restore ecology, improve habitat/water quality	Use recycled water for restoring historic wetlands; recycled water conservation; groundwater management

Attachment A (continued)
Planned or Operating Structural BMPs in the Santa Ana Basin

Project	Owner	Location	Status	BMP Type	Objectives	Description
San Jacinto Flow through Wetlands	Lake Elsinore San Jacinto Watershed Authority	San Jacinto River area	Planning	Constructed wetlands	Improve habitat/ water quality	Create flow-through wetland to enhance habitat and remove nutrients from San Jacinto River from Canyon Lake to Lakeshore Drive
San Jacinto River Project	Riverside County Flood Control and Water Conservation District	San Jacinto River area	Planning	Increase river width	Enhance ecology; improve habitat; flood control	Increase San Jacinto River width from 500-1200 feet to help with flood control and habitat improvement
Wetlands and Habitat Conservation Area	City of Ontario	City of Ontario	CEQA Complete	Constructed wetlands	Enhance/improve ecology/water quality/ habitat; education; recreation	Conjunctive uses with wetlands construction; 85 acres of restoration and 145 acres of land acquisition
Cucamonga Creek Wetlands	Inland Empire Utilities Agency	Cucamonga Creek, Inland Empire Utilities Agency	Planning	Constructed wetlands	Enhance ecology; improve habitat	Construct wetlands for natural treatment of Cucamonga Creek
Santa Ana River Wetlands (Mission Zanja Creek Channel)	San Bernardino County Dept. of Public Works, Regional Trails Division	Mission Zanja Creek Channel	Planning	Constructed wetlands	Enhance ecology; improve habitat/water quality	Create wetlands via removal of nonnative vegetation, planting of native species; put in place signage, boardwalk, bike path for access and educational opportunities
San Timoteo Wetlands	NA	San Timoteo Canyon	NA	Create, restore, protect wetlands	Enhance and restore habitat; improve water quality	Increase water quantity and quality by protecting/enhancing floodplains in San Timoteo Canyon and major tributaries beginning at Loma Linda
Yucaipa Valley Water District Wetlands Enhancement	Yucaipa Valley Water District	Yucaipa Valley, San Timoteo Creek	Planning	Constructed wetlands	Recreation; education; improve water quality	Constructed 30-acre wetlands in YVWD region prior to discharge to San Timoteo Creek; includes pipelines, hydraulic control structures

Attachment A (continued)
Planned or Operating Structural BMPs in the Santa Ana Basin

Project	Owner	Location	Status	BMP Type	Objectives	Description
Wilson and Polato Creek Watershed Plan	City of Yucaipa	Wilson and Polato Creeks	Planning	Constructed spillover detention basins	Improve habitat/ water quality; water conservation	Basins for flood control, groundwater recharge, habitat preservation in Wilson/Polato Creeks
Noble Creek/ Marshall Creek Wetland Project	Beaumont-Cherry Valley Water District	City of Beaumont	Planning	Utilize recycled water for wetlands construction	Improve water quality	Based on Recycled Water Master Plan; use recycled water for constructing wetlands and recharging groundwater to Beaumont Storage Unit
Native and Treatment Wetlands	NA	Orange, Riverside, San Bernardino Counties	Program Adoption	Restore wetlands; create treatment wetlands	Improve habitat/ ecosystem/ water quality; flood control	5-year program to identify projects where water quality improvements are most critical, promote wetlands restoration/construction