

# **CITY OF PLACENTIA**

## **STORM DRAIN MASTER PLAN UPDATE**

**City of Placentia, Orange County, California**

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**November 2023**

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## List of Acronyms

<b>Acronym</b>	<b>Definition</b>
1D	One-Dimensional
2D	Two-Dimensional
as-builts	Construction plans/record drawings
BFE	Base Flood Elevation
CB	Catch Basin
Cfs	Cubic Feet per Second
CHI	Computational Hydraulics International
CIP	Capital Improvement Plan
DBL	Double
DEM	Digital Elevation Model
DTM	Digital Terrain Model
ENR	Engineering News Record
ESRI	Environmental Systems Research Institute
FEMA	Federal Emergency Management Agency
FIS	Flood Insurance Study
GIS	Geographic Information System
HGL	Hydraulic Grade Line
H&H	Hydrologic and Hydraulic
ID	Identification
LiDAR	Light Detection and Ranging
MPD	Master Plan of Drainage
N/A	Not Applicable
NAD	North American Datum
NAVD 88	North American Vertical Datum of 1988
NGVD 29	National Geodetic Vertical Datum of 1929
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
OCFCD	Orange County Flood Control District
OCHM	Orange County Hydrology Manual or Orange County Hydrology Method
PCSWMM	Personal Computer Storm Water Management Model
QA/QC	Quality Assurance/Quality Control
RCB	Reinforced Concrete Box
RCP	Reinforced Concrete Pipe
RHNA	Regional Housing Needs Assessment
ROW	Right-of-Way
SDMP	Storm Drain Master Plan
SWMM	Stormwater Management Model
SWPPP	Storm Water Pollution Prevent Plan
SR	State Route
Tc	Time of Concentration
USACE	United States Army Corps of Engineers
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey

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<b>Acronym</b>	<b>Definition</b>
WSPG	Water Surface Pressure Gradient for Windows software by CivilDesign Corporation

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## Executive Summary

The City of Placentia Storm Drain Master Plan (SDMP) is a long-term planning tool that evaluates the existing storm drain system based on hydraulic analyses. This document updates the 2001 Storm Drain Master Plan. The 2001 SDMP divided the city of Placentia (city) into six watersheds: A, B, C, F, G and H. Watershed C is located to the east of Watersheds A and B and west of Watersheds G and H, and it includes area tributary to the Carbon Canyon Channel (E03). Watersheds G and H are located in the southeast corner of the city and are tributary to the Richfield Channel. The watersheds are shown on Figure E-1.

The goals of the MPD are to update the previous MPD to account for new developments since 2001, and to prepare a long-term planning tool that expedites the process for identifying future drainage system maintenance and improvements. The master plan is considered a “living document,” intended to be updated over time, where current recommended system improvements can be modified to accommodate future development or redevelopment. To better allow for future updates, this report and its accompanying data document the assumptions used during the analysis.

Included as part of the SDMP was updating the city’s Geographic Information System (GIS) storm drain database for storm drain pipes 18 inches and larger. Information for storm drain structures and storm drains was populated with additional hydraulic data required for one-dimensional (1D)/two-dimensional (2D) modeling which included inverts, slope, grade changes, ground elevation, material, size, owner, and date, etc. Field work was completed to verify drainage patterns and missing information as necessary for the modeling process.

The results of the hydrologic and hydraulic (H&H) modeling were analyzed and deficiencies were determined based on the Orange County Local Drainage Manual. In addition, improvements were proposed and grouped together for cost estimating and prioritization. As a result, seven (7) projects totaling \$14.3 million are recommended for future improvements. The projects can be programmed based on funding availability or city priorities.

The 5 year capital improvement plan (CIP) was developed using the prioritization criteria listed below:

1. Street Improvement Program Schedule
2. Areas of Known Flooding
3. Project Cost
4. Proximity to Critical Infrastructure/Economic Zones

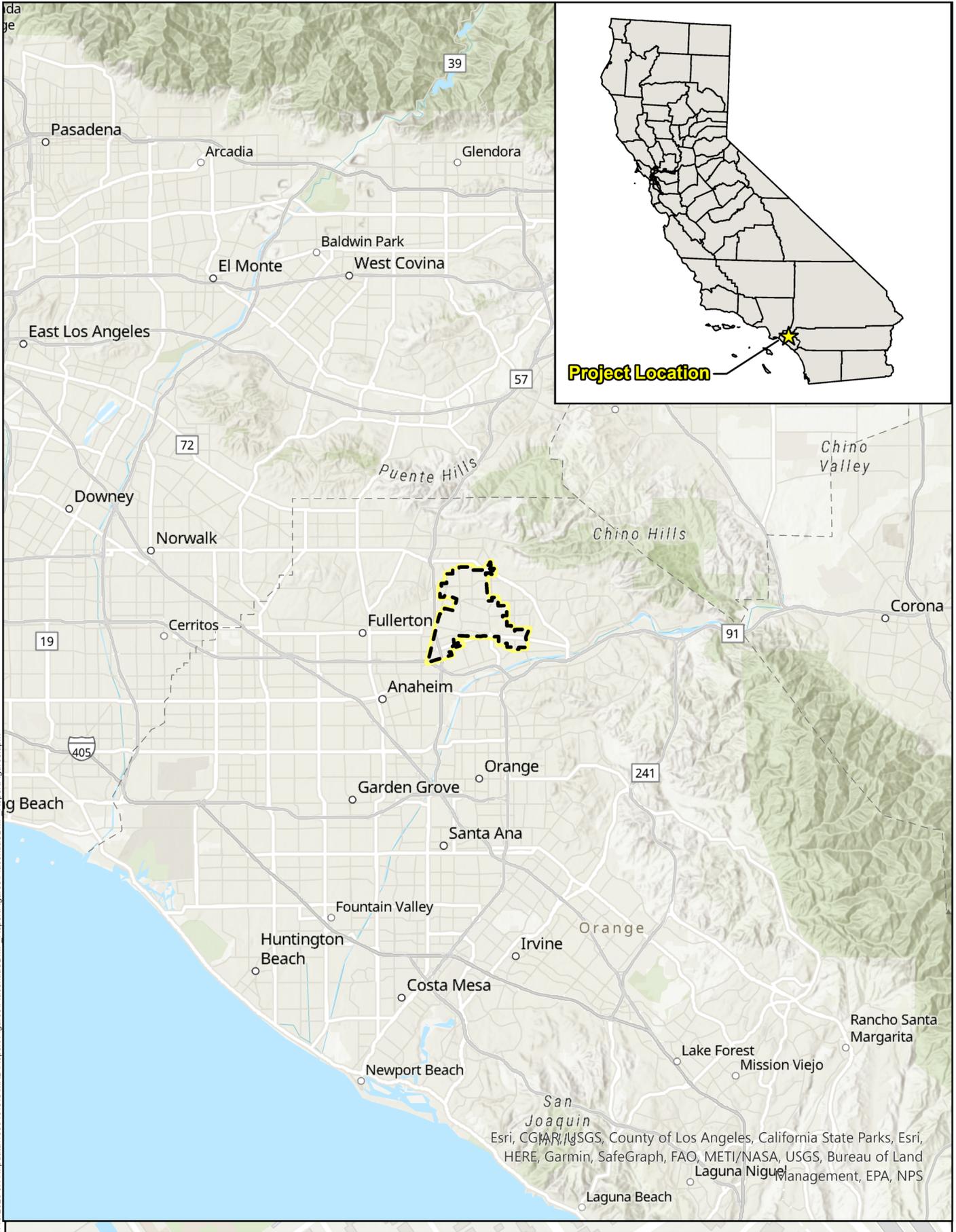
Based on the prioritization, the top recommended projects within the city are as follows:

1. Bradford Avenue
2. Walnut Avenue
3. Seaview Circle
4. Kevin Way
5. Primrose Avenue
6. Pinehurst Avenue
7. Delaware Way

Before proceeding with implementation/construction of a proposed improvement, it is recommended that hydraulic modeling be updated prior to final design to verify that current conditions still warrant

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completion of the project as proposed. The entire hydraulic model can be partially adjusted or the proposed segment can be extracted and evaluated on its own.



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Esri, CGRS, USGS, County of Los Angeles, California State Parks, Esri, HERE, Garmin, SafeGraph, FAO, METI/NASA, USGS, Bureau of Land Management, EPA, NPS



Source:

CITY OF PLACENTIA STORM DRAIN MASTER PLAN  
**Location Map**

Figure E-1

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## **1 Introduction**

### **1.1 Purpose**

The purpose of this study is to update the current city of Placentia’s (city) 2001 Storm Drain Master Plan (SDMP), and to comprehensively evaluate it to support short- and long-term planning for future development and implementation of storm drain facility improvements. This master plan study will analyze the existing infrastructure in the city, identify deficiencies, propose drainage improvements, determine mitigation drainage costs, discuss priorities of the drainage improvements implementation, and provide a capital improvement plan and a basis of nexus study with updated drainage impact fees. The study also includes an evaluation of the city trail system to locate potential sources of erosion and flooding.

### **1.2 Previous Studies**

The city has three master plan documents that were previously completed:

- City of Placentia Master Plan of Drainage (February 1971)
- Master Plan of Drainage for the City of Placentia (September 1976)
- City of Placentia Storm Drain Master Plan (January 2001)

Additional documents reviewed for this study include:

- General Plan (October 2019)
- City of Yorba Linda Master Plan of Drainage Update (March 2022)

### **1.3 Goals and Objectives**

The goal of this study is to evaluate the existing storm drain network, identify deficiencies, propose and prioritize improvements, determine cost estimates, and produce a capital improvement plan that can be used as a basis to update drainage impact fees.

The detailed objectives of this study include the following:

- Research and collect data for storm drain as-builts.
- Update the citywide drainage facility Geographic Information System (GIS) database for facilities 18 inches and larger.
- Create an integrated hydrologic and hydraulic (H&H) model and map.
- Complete H&H analysis assuming ultimate built-out condition.
- Complete an existing system capacity and deficiency analysis for all watersheds.
- Identify locations for storm drain improvements.
- Prepare a list of Priority Projects and a Capital Improvement Plan (CIP).
- Prepare an updated MDP.
- Use the MDP as the basis of the nexus study with updated drainage impact fees.

### **1.4 Existing Drainage Conditions**

The city was incorporated in 1926 and is located in the northeast portion of Orange County, California. It is approximately seven square miles and is bounded by the city of Fullerton to the west, the city of Brea to the north, the city of Anaheim to the South, and the city of Yorba Linda area to the east.

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The city drainage area was divided into six watersheds based on the city’s limits, topography, and tributary regional facility. More details on these watersheds are described in Section 3.1.3. Generally, the city drains toward the southwest, and it ranges from hilly topography in the north to relatively flat topography in the south. The city drainage system consists of local, city-owned storm drains which tie into regional facilities owned and maintained by the Orange County Flood Control District (OCFCD). A complete list of the regional facilities is discussed in Section 1.4.1 and shown on Figure E-1. The drainage watersheds and sub-watersheds are shown on the hydrology maps which are included in Exhibit A.

The city has noted several areas within the city that flood regularly during storm events. These locations were highlighted on a map by a member of city staff, included as Figure 1-3.

## 1.4.1 Regional Facilities

The drainage system within the city consists of both city and county-owned facilities. The OCFCD-owned facilities are listed below and shown in Exhibit B. The regional facilities are shown on Figure 1-1.

**Table 1-1: Regional Facilities**

Facility	Watershed	Confluence Location	Notes
Santa Ana River (E01)	All	Pacific Ocean	
Carbon Canyon Channel (E03)	Watersheds A, B, C and F	Atwood Channel (E04)	
Richfield Channel (E05)	Watershed G	Atwood Channel (E04)	Known to be deficient per 2017 OC Regional Deficiency Study
Atwood Channel (E04)	Watersheds A, B and F	Carbon Creek Channel (E02)	Known to be deficient per 2017 OC Regional Deficiency Study
East Richfield Channel (BO1S03)	Watersheds F, G and H	Richfield Channel (E05)	

## 1.5 Federal Emergency Management Agency Floodplain Mapping

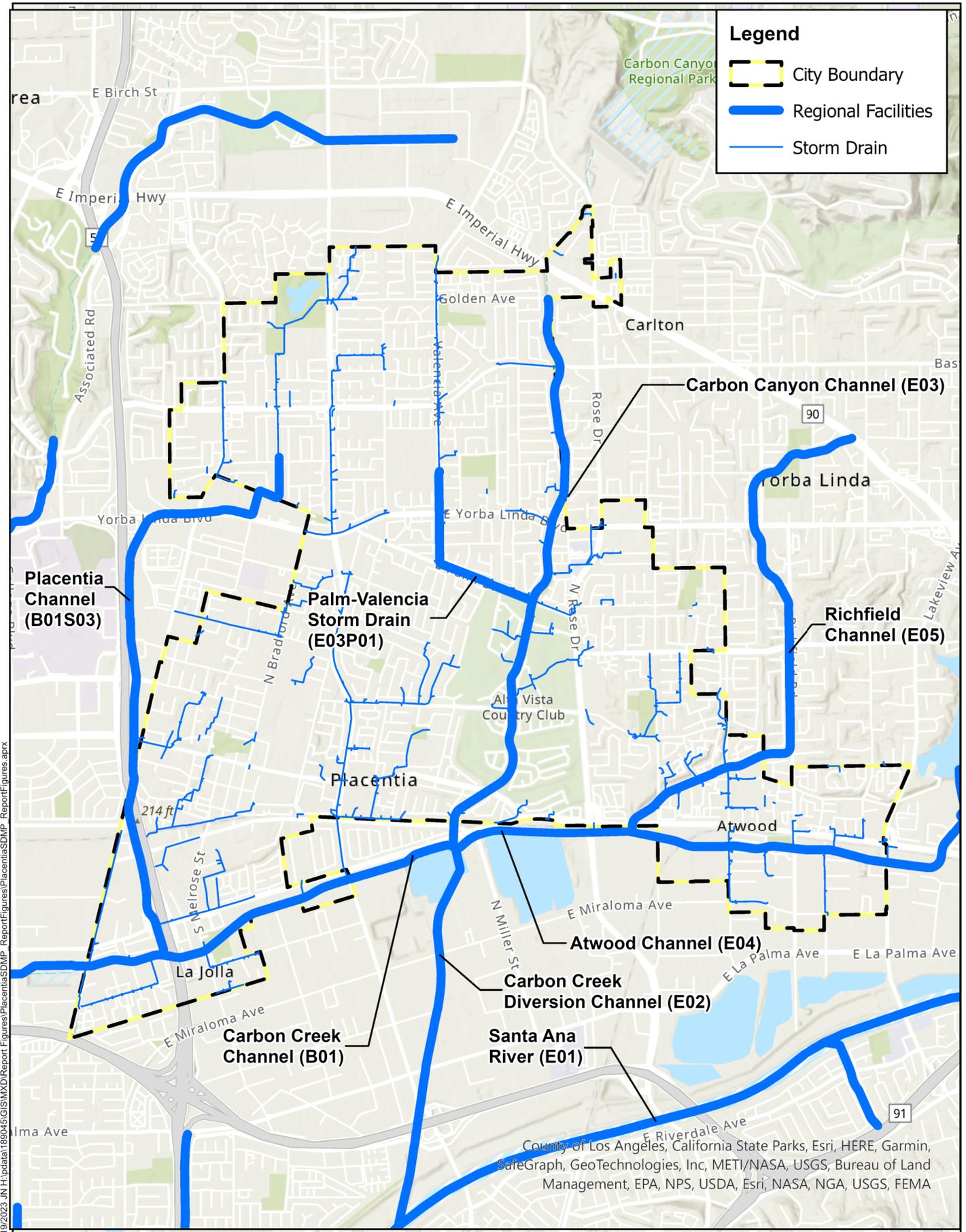
The city is a participant in the U.S. Department of Homeland Security Federal Emergency Management Agency’s (FEMA) National Flood Insurance Program (NFIP). Communities participating in the NFIP must adopt and enforce minimum floodplain management standards, including identification of flood hazards and flooding risks. Participating in the NFIP allows communities to purchase low-cost insurance protection against losses from flooding. The city contains multiple locations of Zone A and Zone AE flood zones. Figure 1-2 shows the floodplains for the city and surrounding areas. Descriptions of each flood zone include:

- Zone A areas are locations with a 1% annual chance of flooding.
- Zone AE areas also have a 1% annual chance with base flood elevations (BFE).

The city is within the effective Flood Insurance Rate Map panels 06059C0044, 06059C0061, 06059C0063, 06059C0064, 06059C0132, 06059C0151, and 06059C0152. The FEMA flood zones are shown on Figure 1-2.

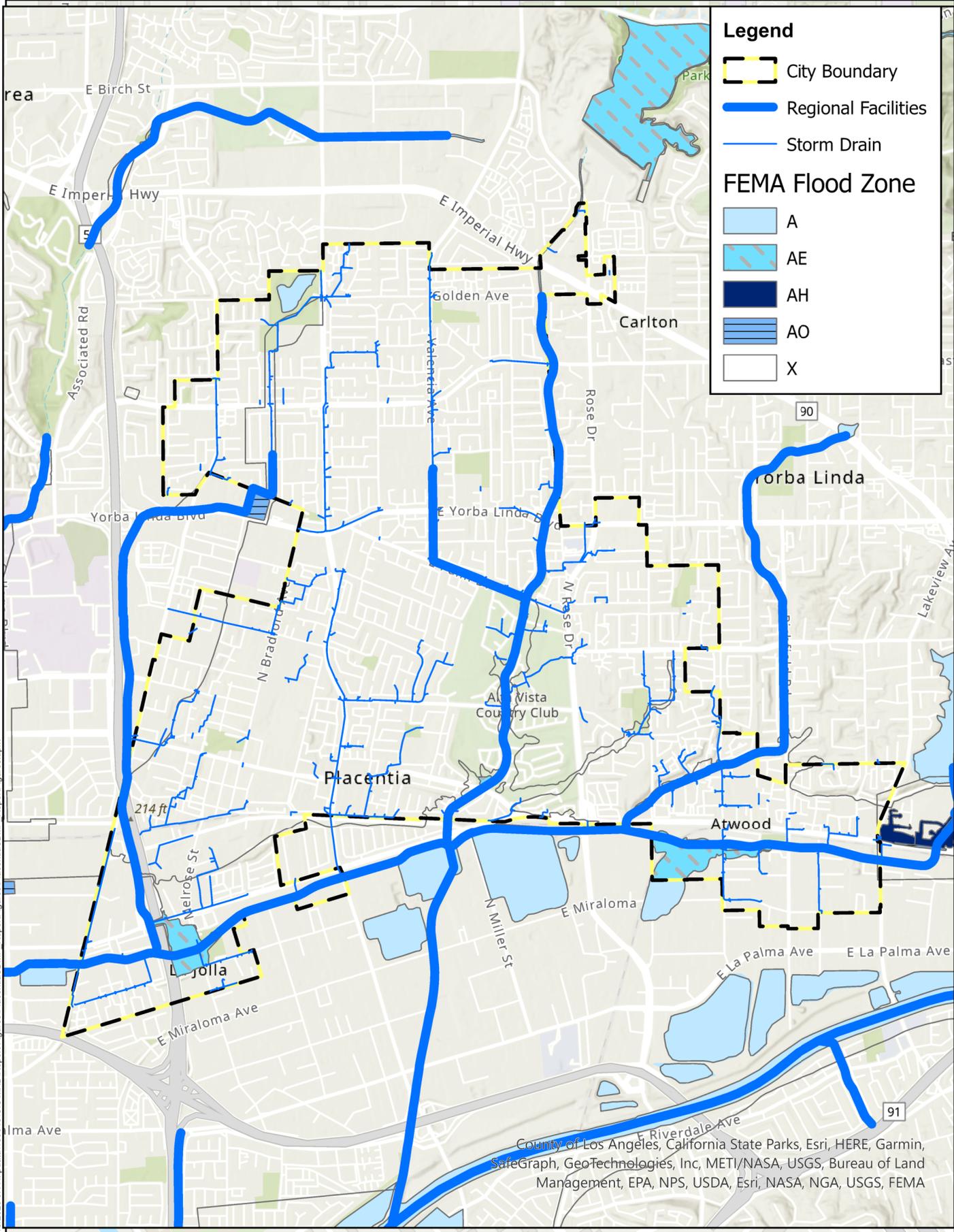
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## 2 Storm Drain GIS Database

This section describes the general methodology used to gather, organize and prepare the storm drain system GIS data, which was used as the basis for the city MPD update.

### 2.1 Coordinate System and Datum

The project used the following coordinate system and datum:

1. Horizontal data: North American Datum (NAD)\_1983\_StatePlane\_California\_VI\_FIPS\_0406\_Feet
2. Vertical data: North American Vertical Datum 1988 (NAVD 88)
  - a. Note: Older as-built drawings that were designed using the National Geodetic Vertical Datum of 1929 (NGVD 29) were converted to NAVD 88 using the Orange County Benchmark system recommendations for the project areas within the county jurisdiction. The adjustment factor is +2.41 feet (NAVD 88 higher than NGVD 29).

### 2.2 Software

The primary software used for data collection and compilation was Environmental Systems Research Institute's (ESRI) ArcGIS Pro. The GIS data were supplemented using Google Street View to perform a desktop review of features such as inlets. In addition, Google Earth Pro was used to view drainage features from different perspectives.

### 2.3 Data Inventory

The city provided a storm drain dataset to serve as the baseline for the data collection effort. The storm drain datasets provided by the city were divided into two main categories: storm drain lines and storm drain structures. The city provided additional datasets that included City Boundary and Zoning Parcels from the General Plan. The data in the inventory were reviewed and overlaid with aerial imagery (from NearMap) and contours derived from the United States Geological Survey (USGS) data. The team reviewed each storm drain segment and populated the required attributes from the as-built drawings provided by the city.

In addition to the as-builts, the 2001 MPD hydrology map was georeferenced and overlaid as a reference. Data limitations and assumptions are discussed further in Section 2.5 and Section 3.3, respectively. Appendix D contains the GIS data collection workflow and the procedures to organize the project GIS database.

Terrain data were obtained from the USGS's 3D Elevation Program. The downloaded terrain provides basic elevation information for mapping applications in the United States. This dataset, used as the primary source of ground elevation data, was obtained as a 1x1-degree Digital Elevation Model (DEM) product with a 1/3-arc-second resolution with a horizontal projection of NAD83 (2011) Albers Equal Area, meters, and a vertical datum of NAVD88 (GEOID12B) meters. The downloaded terrain recorded an NAVD 88 elevation of approximately 329.344 feet at the same location of the city's benchmark 2H-9-76 and the intersection of Kraemer Boulevard and Bastanchury Road, which has a recorded NAVD 88 elevation of 327.992 feet. The vertical accuracy of the downloaded terrain is approximately within 1.4 feet (0.43 meters) for the city of Placentia.

## 2.4 GIS Database Update

The update began with assessing the city’s existing storm drain GIS inventory. From this baseline GIS inventory, several methods were implemented to fill gaps in either storm drain and structure data, or in the attributes available for storm drain and structure data.

Storm drains 18 inches or larger were updated in the GIS database. If a pipe smaller than 18 inches was required for connectivity, it was also updated and included in the model. Table 2-1 shows the hydraulic data populated for the storm drain lines and structures. Appendix D contains a detailed data dictionary that discusses all populated fields and workflow.

**Table 2-1: GIS Database Attribute Data Populated for the Storm Drain Lines and Structures**

Storm Drain Line Data	Storm Drain Structure Data
<ul style="list-style-type: none"> <li>• Unique ID</li> <li>• Invert elevations (upstream and downstream)</li> <li>• Length (based on GIS)</li> <li>• Slope</li> <li>• Material type</li> <li>• Conduit size</li> </ul>	<ul style="list-style-type: none"> <li>• Unique ID</li> <li>• Invert elevations</li> <li>• Rim elevation (per NOAA data discussed in Section 2.3 )</li> <li>• Material</li> <li>• Owner</li> <li>• Date</li> </ul>

- The database was updated based on assumptions summarized in Section 3.3; any inconsistencies in pipe sizes between those in the existing GIS database and the as-built plans were corrected in the appropriate Michael Baker field per the sizes on the as-built plans. In instances where as-built information was not available, Michael Baker made engineering assumptions and listed all assumptions in a comments field in the GIS data. In cases where the city did not have an as-built, the source field of the layer was marked with an explanation of how the GIS data were populated (GIS, field verification, assumption, Google Street View or calculated) to signify that the as-built was not available, and assumptions were made.
- Where structure or pipe data were not available, the areas were tagged, and a desktop review was conducted. Assumptions in pipe sizes and structure locations were made using the best available data. For assumptions in pipe sizing, similar pipe networks in the area were referenced, and the source field of the structure was stated as an assumption. The locations of data with unavailable as-builts were determined by aerial imagery when possible.
- The identification of missing attribute data, as well as features that were not represented in the source GIS files, was a crucial step in the data collection effort. Segments and areas of the storm drain system that were omitted from the existing county-provided GIS files (e.g., those with missing links and large developed areas with little or no data) were assessed using as-built, aerial imagery, topographic information, and Google Street View. If attributes could not be determined from existing GIS data or as-builts, engineering-based planning-level assumptions were made to fill in the gaps. Missing invert elevations were generally populated using a calculation with the assumption that the pipe slope matched that of the ground slope.
- A thorough quality assurance/quality control (QA/QC) check of the final GIS dataset was performed to ensure data accuracy. All features were checked to ensure the required attributes were populated, line segments were checked for correct direction, connections and junctions were reviewed, and the conveyance elevations were checked for positive drainage throughout the system. Topology checks were then run on the data to ensure sound data integrity. The QA/QC checklist is included in Appendix D.

## **2.5 Data Limitations**

As-built drawings and GIS data were obtained for a significant portion of the city. However, some areas lacked data. These areas were completed to the extent possible where partial data were obtained, and assumptions were made elsewhere. Figure 2-1 shows the data gaps due to missing as-built information.



## 3 Technical Approach

This chapter describes the methodology and analysis that was performed to evaluate the existing and proposed condition drainage within the city. The assumptions and criteria that were used in this analysis were consistent with the Orange County Hydrology Manual (OCHM), and any deviations were discussed with the city based on engineering industry acceptance.

### 3.1 Hydrologic Analysis

#### 3.1.1 Methodology

Ultimately, the hydrologic analysis was performed using the Personal Computer Storm Water Management Model (PCSWMM) program by Computational Hydraulics International (CHI). PCSWMM was used to run the USEPA SWMM 5.0 engine (SWMM). PCSWMM integrates both hydrology and hydraulic analyses into one software module. Hydrology can be modeled using any one of several methods, including both the SCS unit Hydrograph and Rational Method. The advantages of PCSWMM include the ability to model a wide array of components, such as H&H, proposed improvements, and Low Impact Developments, into one single module.

A comparison between hydrology methodologies (Orange County Hydrology Method [OCHM] and the EPA SWMM Runoff Method [using PCSWMM]) was performed for a study area within the city of Placentia prior to selecting PCSWMM. The study area, also known as Watershed F (approximately 230 acres) is located in the southernmost portion of the city along E. Orangethorpe Avenue. It contains eight (8) relatively small (diameters ranging from 18-inch to 60-inch) storm drain systems. Watershed F consists of subareas with varying sizes (ranging from 0.2 acres to 7 acres) to assist in comparing the methodologies on various sizes of subareas. A technical memorandum was prepared to summarize the findings from the comparison of the two methodologies. The results of the analysis determined that PCSWMM could be used for the hydrologic analysis with some calibration defined in the technical memorandum. The Hydrology Method Comparison Technical Memorandum is included in Appendix A.

#### 3.1.2 PCSWMM Hydrologic Model

PCSWMM uses EPA's SWMM Version 5 (SWMM5) engine, which uses the nonlinear reservoir modeling methodology to estimate the rainfall-runoff relationship for a subarea. Nonlinear reservoir modeling uses a combination of mass conservation and the Manning equation to determine the volumetric flow rate from a subcatchment. SWMM5 requires several parameters to calibrate each subcatchment. The parameters include area (in acres); characteristic width of the subcatchment; slope; percent impervious; Manning's "n" values for pervious and impervious overland surfaces; depression storage for pervious and impervious surfaces; percent of impervious area with no depression storage; and infiltration parameters. The Green-Ampt Method was used to estimate infiltration potential, which requires the following parameters: soil capillary suction head, soil saturated hydraulic conductivity, and initial moisture deficit (i.e., the difference between soil porosity and initial moisture content).

Each subcatchment is connected via a conveyance node and link network (e.g., inlets and pipes), which routes runoff generated towards the outlet of a sub-watershed. See Section 3.2 for more information regarding the hydraulic analysis methodology and modeling procedures.

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The developed hyetographs were imported into PCSWMM as a DAT file with five-minute time steps. Both the existing and proposed condition hydraulic models used the hyetographs to generate the runoff hydrographs for each sub-watershed. See Section 3.1.2.2 for more detailed discussion on how the hyetographs were developed and Section 3.2 for more information regarding the hydraulic analysis methodology and modeling approach.

To determine the overland Manning's "n" values and percent impervious parameters, an area-weighting analysis was performed. An ArcGIS feature class synthesized from the high-resolution LiDAR data, with seven land cover categories: impervious, roofs, curbed roads, unknown, high vegetation, medium vegetation, and low vegetation. The land cover feature class was used to determine the percent impervious for each subcatchment based on assumed impervious percentages. Manning's "n" values also were determined using the land cover feature class based on assumed values, see Table 3-3 below.

New hydrology models were completed for all watersheds, since the 2001 study did not include models in its partially reconstructed report. The hydrology inputs required for the PCSWMM program are topography, storm drain data, hydrologic soil types, and land use. The results of the hydrology calculations for all watersheds are included in Appendix A. The hydrology maps for each watershed are included in Exhibit A.

### 3.1.2.1 Topography

The terrain data used in this analysis are 2019 USGS LiDAR downloaded from the National Map Viewer. The data are in the NAVD 88 datum. The dataset accuracy is shown in Table 3-1.

**Table 3-1: Topography Accuracy**

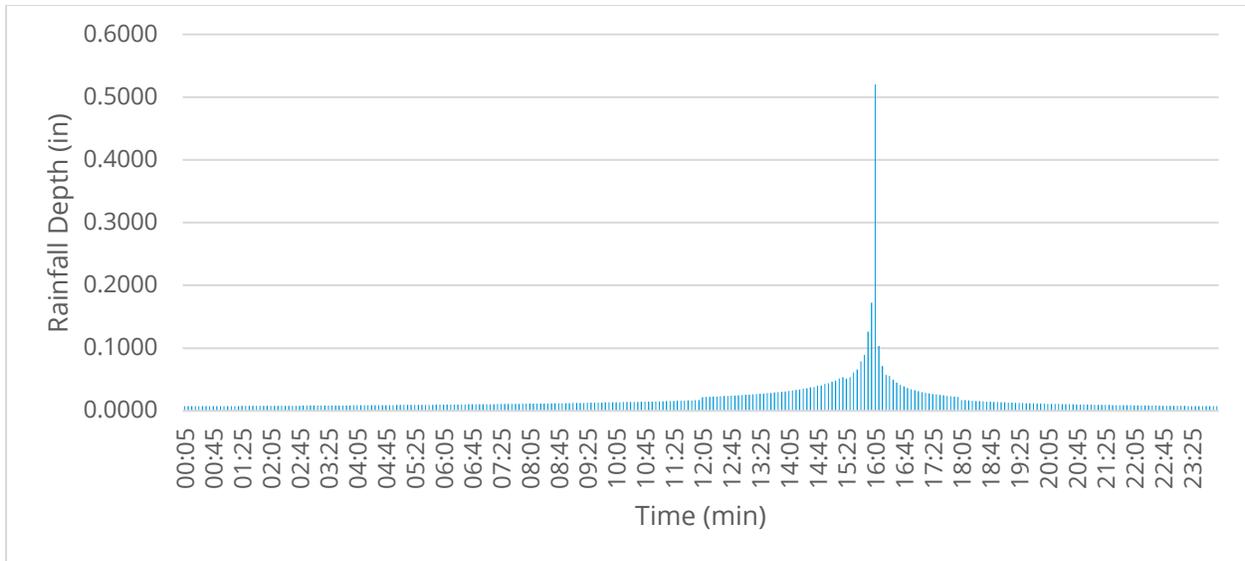
Accuracy	
Range Resolution	1/3 arc-second
Elevation Accuracy	~2.69 feet (1.4 feet for the city of Placentia)
Horizontal Accuracy	1/5,500 x altitude (meters above ground level)

### 3.1.2.2 Rainfall

Orange County Hydrology Point precipitation data (per Table B.2, OCHM) were applied and interpolated to create the 100-year, 25-year, and 10-year five-minute hyetographs used in the models.

Setting up a storm simulation in PCSWMM requires a hyetograph to distribute rainfall across the subcatchments over the storm duration. A 24-hour storm duration was selected for the study. The nested storm distribution based on USACE's guidance, Hydrologic Analysis of Ungaged Watersheds Using HEC-1 (USACE 1982), was selected because it meets this study's goals. The nested storm provides the peak intensities necessary to assess drainage infrastructure at the inlet scale (up to five-minute rainfall intensities).

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**Figure 3-1: PCSWMM Time Series Hyetograph**

### 3.1.2.3 Soils

Soil data for the hydrology analysis are based on the OCHM, which shows a majority of soil types B and C, although the city contains all four soil types.

### 3.1.2.4 Land Use

The hydrology analysis incorporated land use data from the City of Placentia General Plan (2019), which shows a mix of land uses such as high-, medium- and low-density residential, commercial, parks, and industrial. Land use from the city’s General Plan was associated with land use equivalents from the OCHM to determine imperviousness percentages. Land use associations are listed in Table 3-2.

**Table 3-2: Land Use Designations**

General Plan Land Use	Orange County Land Use Equivalent	Impervious %
HIGH-DENSITY RESIDENTIAL	MORE THAN 10 Dwelling Unit (DU)/ACRE	50
LOW-DENSITY RESIDENTIAL	3-4 DU/ACRE	20
MEDIUM-DENSITY RESIDENTIAL	5-7 DU/ACRE	30
PARK	PUBLIC PARK	10
TRANSIT-ORIENTED DEVELOPMENT (TOD)	CONDOMINIUMS	45
SPECIFIC PLAN	VARIES	50
PLANNED COMMUNITY	3-4 DU/ACRE	60
SCHOOL	SCHOOL	30
RAILROAD	COMMERCIAL	80
PARKWAY VISTA	COMMERCIAL	80
OLD TOWN	DOWNTOWN BUSINESS	80
OFFICE	COMMERCIAL	80
INDUSTRIAL	INDUSTRIAL	80
COMMERCIAL MANUFACTURING	COMMERCIAL/INDUSTRIAL	80
COMMERCIAL	COMMERCIAL	80

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### **3.1.3 Watershed Delineation**

The city was divided into six watersheds, each of which is listed and described in the following sections and shown on the hydrology map (Exhibit 1). The major watersheds were delineated using one-foot contours which were extracted from the USGS LiDAR surface described in Section 3.1.2.1.

#### **3.1.3.1 Watershed A**

Watershed A is the largest of the six major watersheds in the city at approximately 1,680 acres (2.6 square miles). Storm drain systems within this watershed have an outlet in either the Santa Ana River or an Orange County Flood Control channel system. Watershed A is located in the western portion of the city. It is bounded by the city of Fullerton to the north and west, Angelina Drive and Valencia Drive to the east, and Orangethorpe Avenue to the south. The watershed is predominantly comprised of single and multifamily housing. Additionally, there are commercial developments in the southern portion north of Orangethorpe Ave and south of the AT&SF railroad.

#### **3.1.3.2 Watershed B**

Watershed B is approximately 566 acres (0.89 square miles). Storm drain systems within this watershed have an outlet in Carbon Creek. Watershed B is located in the central and southern portions of the city. The area is bounded by Palm Drive to the north, Alta Vista Country Club to the east, Crowther Drive to the south, and Angelina Drive to the west. The flows in this watershed tend to flow in a southwesterly direction.

#### **3.1.3.3 Watershed C**

Watershed C is approximately 1,075 acres (1.7 square miles). Storm drain systems within this watershed have an outlet in Carbon Canyon Creek. This area is centrally located in the city. The watershed is bounded by the city of Brea to the north, the city of Yorba Linda to the east, Crowther Avenue to the south, and Valencia Avenue to the west. Carbon Canyon Channel runs along the northeastern portion of the area before continuing centrally through the remainder of the watershed area.

#### **3.1.3.4 Watershed F**

Watershed F is the smallest of the six major watersheds in the city at approximately 230 acres (0.4 square miles). Storm drain systems within this watershed have an outlet in Carbon Creek. Watershed F is located in the southwestern most portion of the city and is bounded by Orangethorpe Avenue to the north, the city of Anaheim to the south and east, and the city of Fullerton to the west. Flows in this watershed tend to flow in a southwesterly direction.

#### **3.1.3.5 Watershed G**

Watershed G is approximately 481 acres (0.8 square miles). Storm drain systems within this watershed have outlets in Atwood Channel and Richfield Channel. Watershed G is located in the southeasternmost portion of the city. It is bounded by and includes Richfield Channel to the northwest, the city of Yorba Linda to the north and east, and the city of Anaheim to the south. The watershed is comprised predominantly of single and multifamily development with industrial zones located centrally along East Orangethorpe Avenue. Flows in this watershed flow in a westerly direction.

### 3.1.3.6 Watershed H

Watershed H is approximately 445 acres (0.7 square miles). Storm drain systems in this watershed have an outlet in Richfield Channel. Watershed H is located in the central and eastern portions of the city and is bounded by the city of Yorba Linda to the north and east. The southern boundary follows Richfield Channel but does not include the channel, and the western boundary approximately follows Rose Drive. The watershed is comprised predominantly of single and multifamily homes. Flows in this watershed flow in a southwesterly direction.

### 3.1.3.7 Sub-Watershed Delineation

The sub-watershed delineation for the six major watersheds was completed by georeferencing the 2001 MPD hydrology map's portable document format (PDF) into GIS using the aerial imagery as reference. The areas were then delineated following the PDF linework. The linework was reviewed and updated to follow the latest contours and land use definitions from the 2019 General Plan.

A review of the contours along the city boundary was reviewed to verify offsite drainage patterns. Sub-watersheds were added outside of the city boundary if the offsite flows were tributary to the city of Placentia.

## 3.2 Hydraulic Analysis

The hydraulics analysis was completed for existing conditions and proposed conditions using the proprietary stormwater management model software PCSWMM by CHI.

### 3.2.1.1 Modeling Scenarios

Two scenarios were modeled: existing condition and proposed condition. The first scenario modeled the existing drainage system, which was used as a baseline to determine any potential deficiency locations. The second scenario modeled proposed city improvements to the drainage system and was created through an iterative process.

The existing condition was performed with a one-dimensional (1D)-only PCSWMM model for the whole city. Deficiencies were determined within the 1D existing condition model based on the criteria described in Section 4. Two-dimensional (2D) models were conducted for areas of known flooding to capture the extent of the flooding. Proposed improvements were added to reduce the water surface elevation (WSE) in the 2D models below the curb height (6 inches) and right-of-way (ROW) (8 inches) for the 10-year and 100-year storm events, respectively. Proposed storm drains are shown in the Storm Drain Facility Index Map in Exhibit C.

#### 3.2.1.1.1 Flow Modeling

The PCSWMM platform uses SWMM5 to perform hydraulic calculations and presents the same flow routing options. Flow routing is governed by the equations of continuity, mass, and momentum—also known as the St. Venant Flow equations—with flexibility offered to the modeler regarding the complexity of the terms considered in the equations. The program allows the modeler to select from the Steady Flow, Kinematic Wave, and Dynamic Wave routing options. The Manning normal depth equation is used in all routing options to relate flow depth, flow rate, and surface friction.

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Steady Flow routing was judged to be inappropriate for modeling this study area as it does not actually represent flow routing per a defined time step during the simulation. This method does not represent any backwater effects or pressurized flow, and it does not take into account the user-defined computational time steps during the storm simulation.

Kinematic Wave routing was not selected for this study as it was incompatible with the 2D analysis. It employs a simplified form of the momentum equation but does not take into account all of the equation's terms. This routing method does not account for any backwater effects or pressurized flow.

Dynamic Wave routing was the option selected for all analyses performed in this study. The purpose of this study was to produce a model that would most closely relate the actual conditions of the dynamic relationship between surface and subsurface conveyance, and potential flooding concerns. This routing option considers all terms of the St. Venant Flow equations and presents the most theoretically correct results accounting for backwater effects, pressurized flow, flow attenuation, and reversal of flow. The caveat in selecting this routing option, however, was maintaining numerical stability in the model by using extremely small computational time steps that resulted in significant simulation times for 2D analyses.

### 3.2.1.2 1D Modeling

The 1D analysis includes multilink modeling (overland and subsurface). Sections were prepared for various street width and lane configurations and assigned to PCSWMM 1D links based on aerial data. PCSWMM street sections were evaluated according to the city's standard street sections. Figure 3-2 shows an example schematic of the 1D drainage network layout.

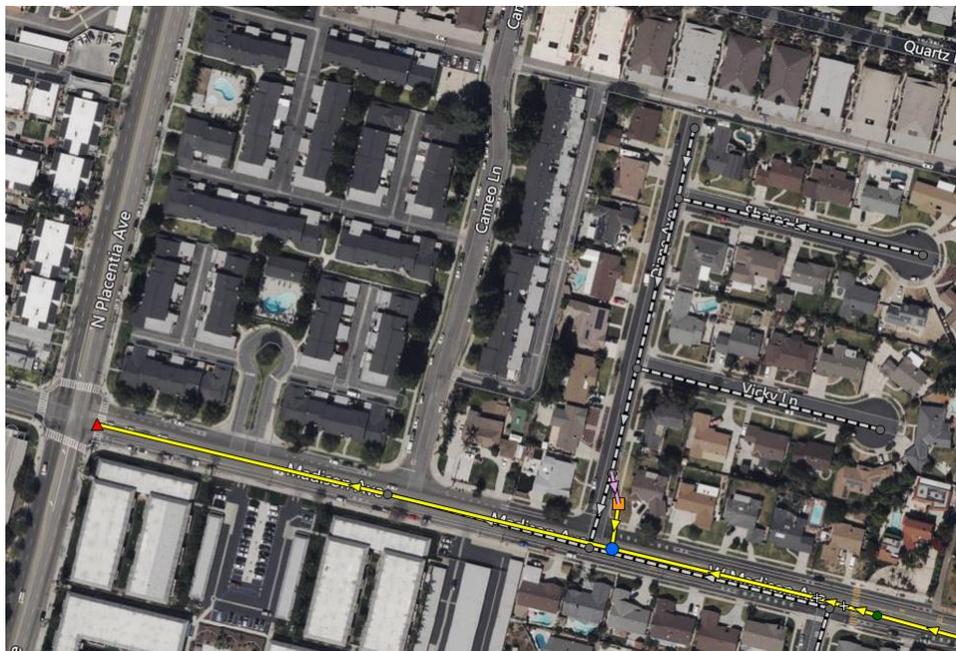


Figure 3-2: Schematic of the 1D Drainage Network Layout

### 3.2.1.2.1 Storm Drain Modeling

Storm drains were imported in PCSWMM from the GIS database update shapefiles. The GIS shapefile linework created the conduits in PCSWMM, and the information updated with the as-built information in the attribute table was imported into the conduit properties.

### 3.2.1.2.2 Inlet Modeling

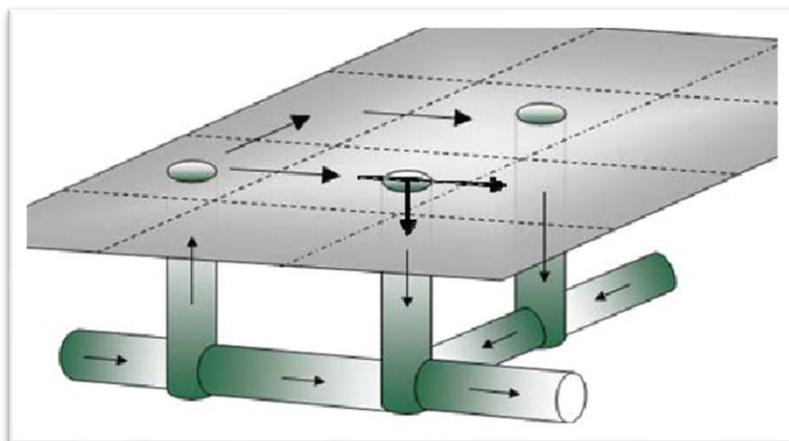
The existing stormwater conveyance system includes 560 inlet or catch basin structures for the collection of surface runoff from streets, ditches, swales, and overland flow. Undersized stormwater inlets can limit the efficiency of the existing conveyance infrastructure to collect and convey runoff during storm events. The flow interception capacity of each inlet type was estimated based on the inlet structure type, location, street slope, and structure dimensions. Inlets were assumed to be full capture. This assumption means that the storm drain system can convey the entire runoff, and it provides a conservative approach in evaluating system deficiency. Flow interception at each inlet was included in the PCSWMM model with inflow rating curves as a function of street flow depth, inlet type, inlet dimensions, and upstream street slope. The portion of stormwater flows exceeding the capacity of the inlet was bypassed to the street conveyance in the 1D models.

### 3.2.1.3 2D Modeling

PCSWMM is an H&H modeling tool used to develop comprehensive storm drainage and sanitary sewer scenarios. 2D PCSWMM models were developed for areas of known flooding indicated by the city and verified by the 1D model results.

#### 3.2.1.3.1 Grid Mesh

A grid mesh was created for the defined 2D areas for each flooding location. Streets use directional mesh (rectangular), and non-streets (residential, commercial and industrial zones) use hexagonal mesh. Grids ranging between five and 10 feet were used for directional mesh, and grids ranging between 20 and 30 feet were used for hexagonal mesh. The outlets used in the 1D existing models were kept the same for the 2D modeling. Additional 2D outlets were defined where addition of a downstream boundary condition seemed necessary. 1D nodes such as catch basins or inlet structures were connected to the 2D grid mesh by tagging the upstream nodes of outlets with "Connect2D." This communicated to the model that flows can transfer between 1D and 2D elements at the tagged nodes. Figure 3-3 shows a graphical representation of this connection.



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**Figure 3-3: Graphic Representation of 1D/2D Surface/Subsurface Model**

The grid mesh was further defined with breaklines, centerlines, and building outlines. A breakline shapefile was created to “burn” certain features into the grid mesh (for example, street curbs or fences). A centerline shapefile was created to note the roadway centerlines and force the grid mesh to render with more definition within the road. Lastly, a building outline shapefile was created so that the grid mesh would exclude buildings from the analysis, therefore forcing flows to be diverted around or indicate flooding against a building.

### 3.2.1.3.2 Manning’s Roughness Coefficient

The Manning’s value is a surface roughness coefficient that is used in hydraulic calculations. This value represents the amount of resistance runoff as it flows through varying overland terrain. The smaller the value, the smoother the surface. A varying Manning’s value was used to represent different land uses within the model. Manning’s “n” values were based on Chapter 3 of the manual for the computer modeling program HEC-RAS. Table 3-3 shows the “n” values used by land use type for this analysis.

**Table 3-3: Manning’s “n” Summary**

Land Use	Manning’s “n”
Open Space	0.030
Residential Areas	0.150
Streets	0.015

### 3.2.1.4 Tailwater

The PCSWMM models assumed no tailwater, since the city’s systems are not near the ocean or any major water body.

## 3.3 General Assumptions

Due to the complexity of this master plan, all assumptions are clearly stated in this document and the accompanying data. In general, if verification was impossible due to missing data or inaccessible locations in the field, an assumption was made using engineering judgment based on surrounding known information. **Error! Reference source not found.**

There is one general assumption regarding the database:

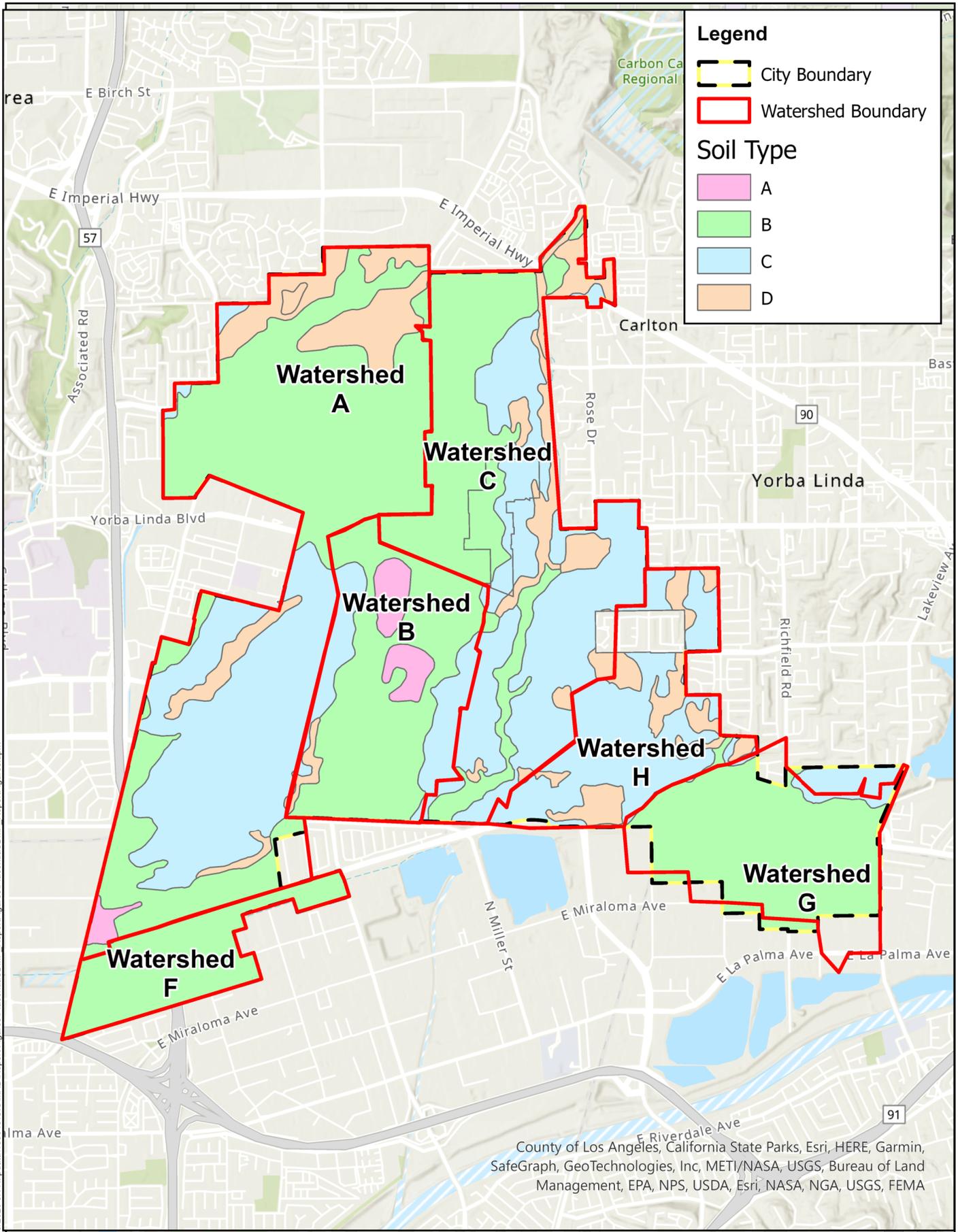
- Storm drain locations that were not in the city storm drain network dataset, nor provided in the as-builts, were digitized based on the Orange County Public Works Storm Drain Index Maps.

The following assumptions/guidelines were applied regarding the hydrology of the area and for use of the Unit Hydrograph Method for this study:

- For locations missing a soil type designation in the County GIS dataset, soil type D was assumed.
- Base flow was assumed to be zero.

There is one note regarding the hydraulic analysis and WSPG calculations:

- The Manning’s “n” values used in this analysis were assumed to be 0.013 for reinforced concrete pipes (RCP) and 0.015 for reinforced concrete boxes (RCB).



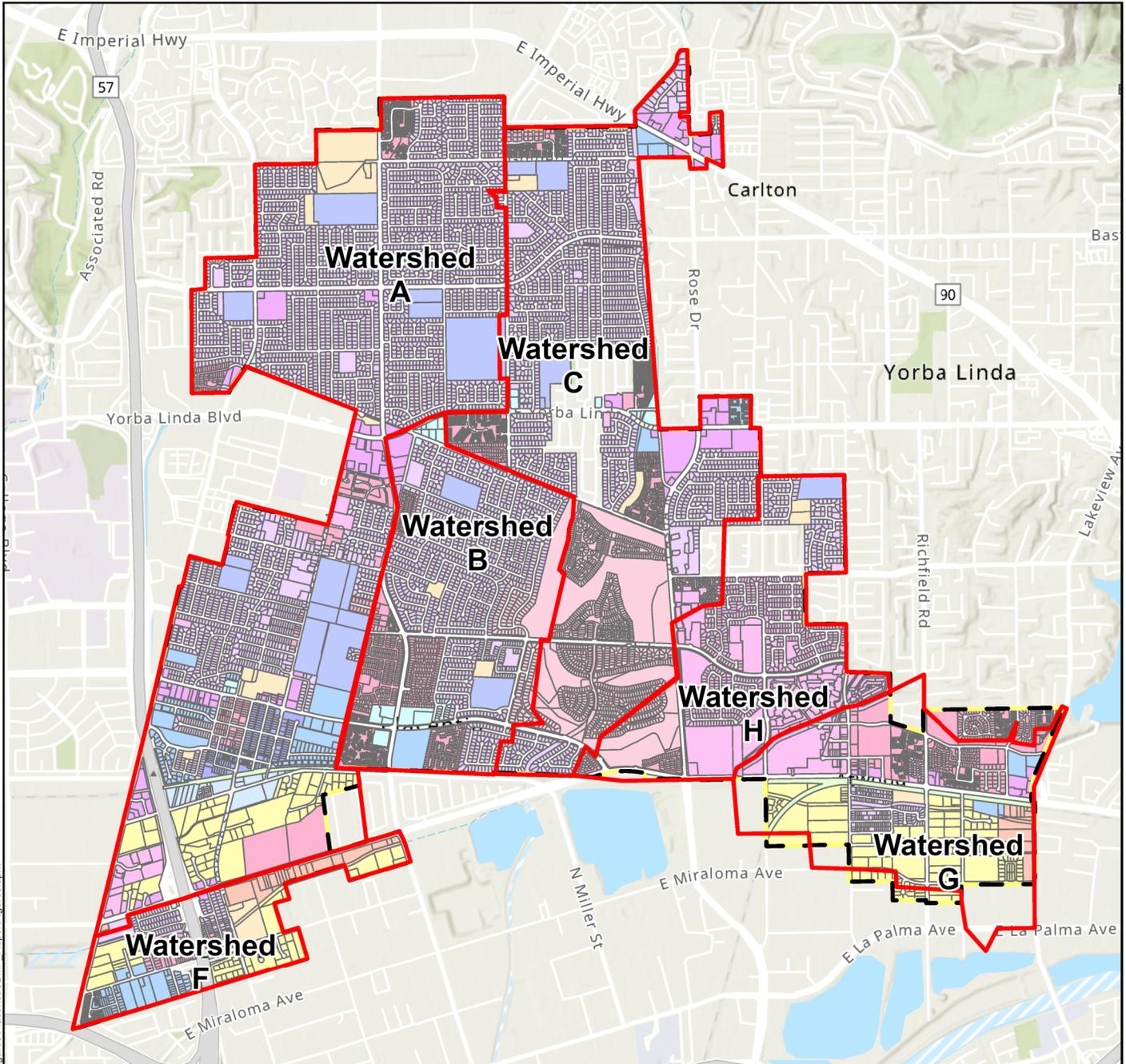
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County of Los Angeles, California State Parks, Esri, HERE, Garmin, SafeGraph, GeoTechnologies, Inc, METI/NASA, USGS, Bureau of Land Management, EPA, NPS, USDA, Esri, NASA, NGA, USGS, FEMA



CITY OF PLACENTIA STORM DRAIN MASTER PLAN  
Soils Map

Figure 3-4



**Legend**

City Boundary	Low Density Residential	Railroad
Watershed Boundary	Medium Density Residential	Schools

**Land Use**

Commercial	Office	Specific Plan
Commercial Manufacturing	Old Town	TOD
High Density Residential	Parks	Parkway Vista
Industrial	Planned Community	

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## 4 Capacity Analysis

This chapter discusses the methodology and results of the PCSWMM models for all watersheds.

### 4.1.1 Capacity Analysis Drainage Criteria

For the existing conditions street capacity hydraulics analysis, the Orange County Local Drainage Manual dated May 2021 was used to evaluate deficiencies. Here are the criteria used in this analysis:

- Storm drains were deemed deficient if:
  - The 100-year storm event HGL was greater than the roadway right-of-way (ROW), which is typically eight inches; or
  - The 10-year storm event HGL was greater than six inches (exceeding the top of the curb); or
  - The 25-year storm event HGL was greater than six inches (exceeding the top of the curb) for sump conditions only.
- National highway systems:
  - National highway systems within the city are required to be designed for Caltrans standards. The Caltrans standards require there to be a dry lane in the 10-year storm event. If this criterion was not met, storm drain improvements were recommended.
    - Using the Orange County typical street sections, the maximum depth of flow allowed in each street was determined and is shown in Table 4-1.

**Table 4-1: National Highway System Street Allowable Depth**

Street	Typical Street Section	Allowable Depth (feet [ft])
Rose Drive	Secondary four-lane	0.44
Yorba Linda Boulevard	Secondary four-lane	0.44
Kraemer Boulevard	Secondary four-lane	0.44
State Highway System 57	Major highway	0.44
Orangethorpe Avenue	Secondary four-lane	0.44
Chapman Avenue	Secondary four-lane	0.44
Tustin Avenue	Secondary four-lane	0.44
Placentia Boulevard	Secondary four-lane	0.44

### 4.1.2 Deficiency Analysis

A description of the flooding areas and deficiencies within all watersheds is discussed in this section, along with the proposed improvements to resolve the deficiencies. Locations with known flooding were analyzed through an iterative process to reduce the flooding to the maximum extent possible. The remaining deficiencies were based on the water surface in the storm drains. These locations were analyzed by reviewing the maximum water surface elevation in the nodes. If the maximum water surface elevation was higher than six inches above the ground elevation for the 100-year storm event, it was determined to be deficient, and the system was upsized. Flooded depth maps are included in Exhibit D.

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### 4.1.2.1 Bradford Avenue – Santa Fe Avenue

The Bradford Avenue – Santa Fe Avenue flooding location is known as a major flooding issue for the city located within what is considered “Old Town.” Major flooding (more than 0.5 feet in the 25-year storm event) occurs at the intersection of Bradford Avenue and Santa Fe Avenue. There is currently a 30-inch storm drain that runs along Santa Fe Avenue at the intersection of Bradford Avenue, before turning to run parallel to AT&SF railroad tracks, before terminating in the Placentia storm channel. Flooding originates along Bradford Avenue as inlets on the northeast and northwest corners are insufficient to accept the flows. In order to relieve the flooding, it is recommended that an additional 97 linear feet of 24-inch RCP be installed along Bradford Avenue, as well as an additional six catch basins.



Figure 4-1: Bradford Avenue – Santa Fe Avenue Model Results

### 4.1.2.2 Walnut Avenue – Center Street

The intersection of Walnut Avenue and Center Street currently experiences flooding as a result of insufficient inlets and storm drain capacity. Currently, a 42-inch RCP runs south from Chapman Avenue before tying into a seven-foot-by-two-foot RCB that runs under the intersection at Center Street before tying back into a 42-inch RCP for the remainder of Walnut Avenue. Additionally, there are two inlets, one of which is on the northwest corner of Walnut Avenue and the other being on the northeast corner of Center Street.

The 25-year storm event model shows the system is deficient where the 42-inch RCP joins the seven-foot-by-two-foot system at Center Street. Flooding was observed in the 25-year storm event at this location for multiple reasons.

To relieve the flooding, it is proposed to install an additional 111 lineal feet of 24-inch RCP along Walnut Avenue. It is also recommended that four additional catch basins be installed to alleviate the flows into the existing catch basins.

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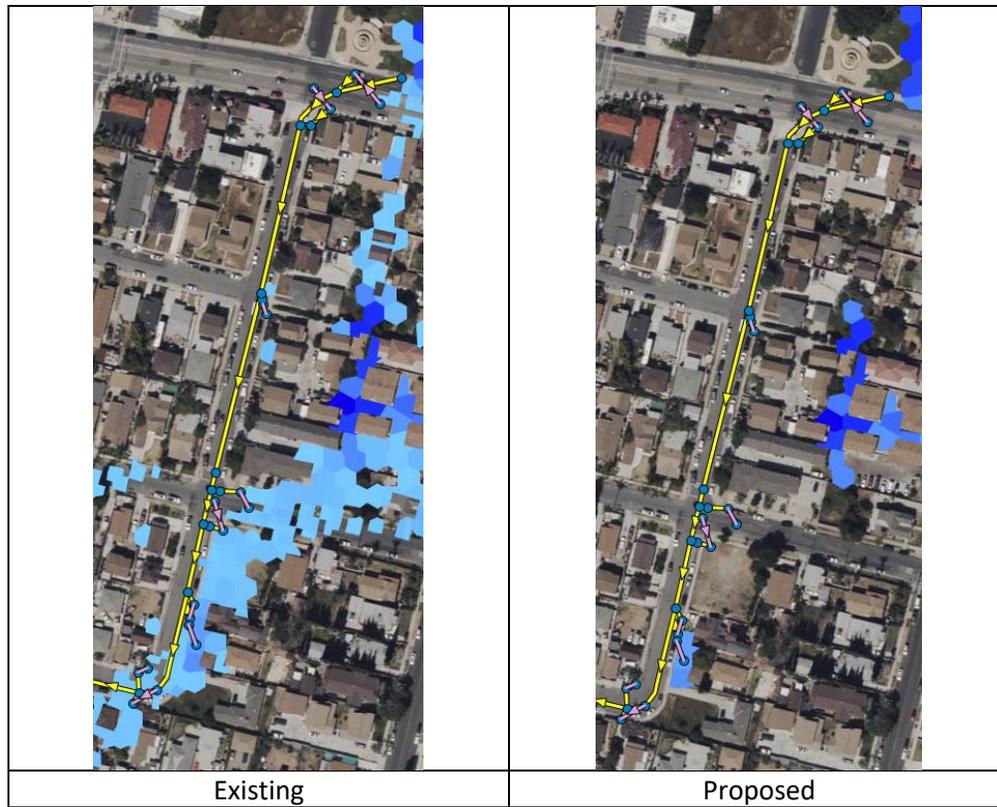


Figure 4-2: Walnut Avenue - Center Street Model Results

## 4.1.2.3 Kevin Way

Shallow flooding (0.5 feet) occurs in the cul-de-sac of Kevin Way near Ruby Drive Elementary School. Upon discussions with the city, the flooding is due to an old CMP pipe that has been damaged over time and no longer functions efficiently. Proposed improvements are to remove the existing CMP and replace it with a 24-inch RCP. The existing drainage ditch has capacity for the flows being held in the cul-de-sac.



Figure 4-3: Kevin Way Model Results

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## 4.1.2.4 Sunset Drive – Placentia Avenue

Shallow flooding occurs at the intersection of Sunset Drive and Placentia Avenue. During rain events, flooding occurs as flows travel south down Placentia Avenue and accumulate as they reach Sunset Drive. In order to alleviate the flooding in this area, it is recommended to install 113 lineal feet of 30-inch RCP, as well as three new catch basins.



Figure 4-4: Sunset Drive - Placentia Avenue Model Results

## 4.1.2.5 Kraemer Park

Moderate flooding occurs in Kraemer Park during storm events as flows from Bradford Avenue travel south and flow into the park, ponding throughout central and southwest portions. After discussion with the city, it was determined that the park was designed to flood during storm events. No proposed improvement project is recommended at this time.

## 4.1.2.6 Primrose Avenue

Moderate street flooding occurs on the neighborhood streets along Primrose Avenue. The PCSWMM model indicates that a portion of the storm drain line that is tributary to these neighborhoods is undersized. Therefore, flooding occurs throughout the neighborhood during storm events. The proposed improvements consist of removing and replacing the undersized portions of storm drain system line and upsizing the pipes to accommodate more flow and reduce the flooding on the streets.

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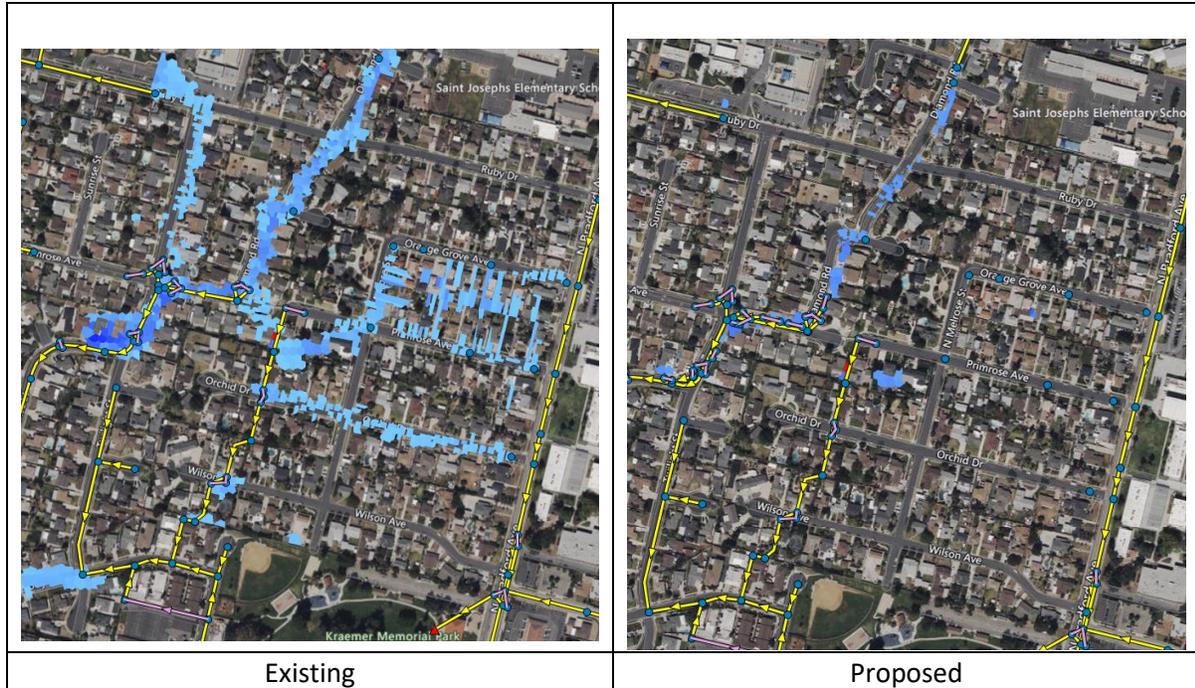


Figure 4-5: Primrose Avenue Model Results

### 4.1.2.7 Naples Avenue – Pinehurst Avenue

Major street flooding takes place throughout the residential neighborhoods along Pinehurst Avenue and Naples Avenue. The PCSWMM model indicates that the storm drain line that is tributary to these neighborhoods is at capacity. Therefore, flooding occurs throughout the neighborhoods during storm events. The proposed improvements consist of removing and replacing the entire storm drain system line and upsizing all the pipes to accommodate more flow and reduce the flooding on the streets.

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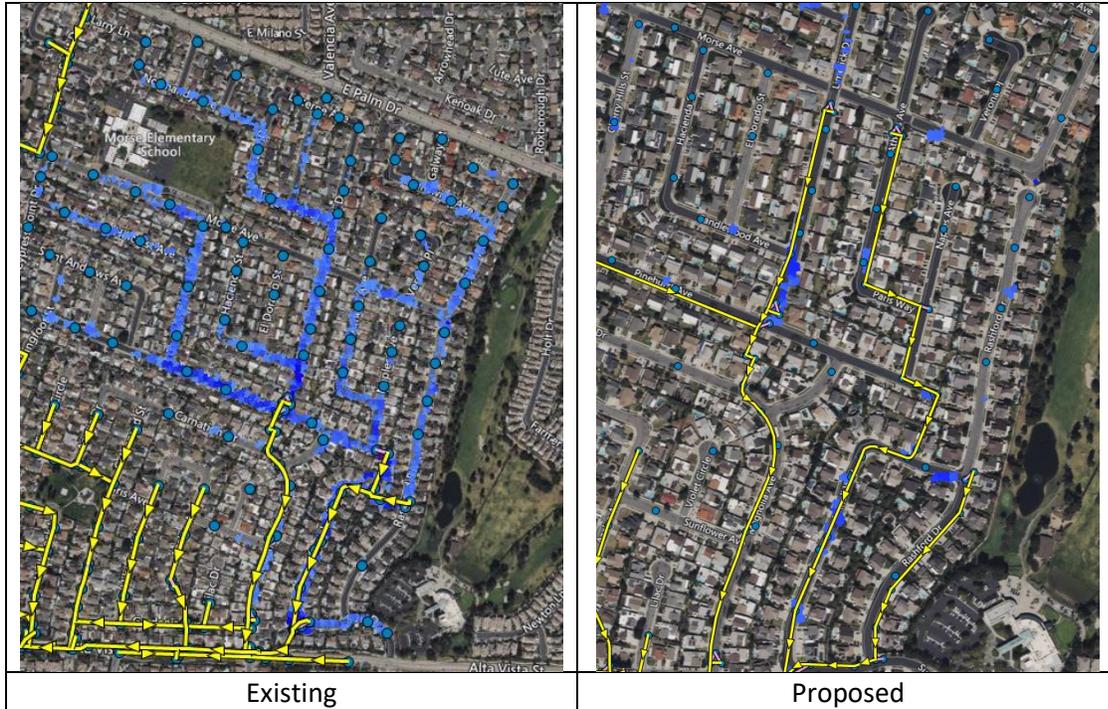


Figure 4-6: Naples Avenue – Pinehurst Avenue Model Results

### 4.1.2.8 Seaview Circle

Major flooding occurs at the end of Seaview Circle and along Moisl Lane connecting into W La Jolla Street. There is an existing parkway culvert into a small open channel at the end of Seaview Circle that outlets into a Caltrans system. To relieve the flooding, it is proposed to change the existing small open channel to a 24-inch RCP and install an additional 179 lineal feet of 18-inch RCP along Seaview Circle with two additional catch basins to capture more flows. It is also recommended that 458 lineal feet of 24-inch RCP and three additional catch basins be installed along Moisl Lane to alleviate the flooding on the street.

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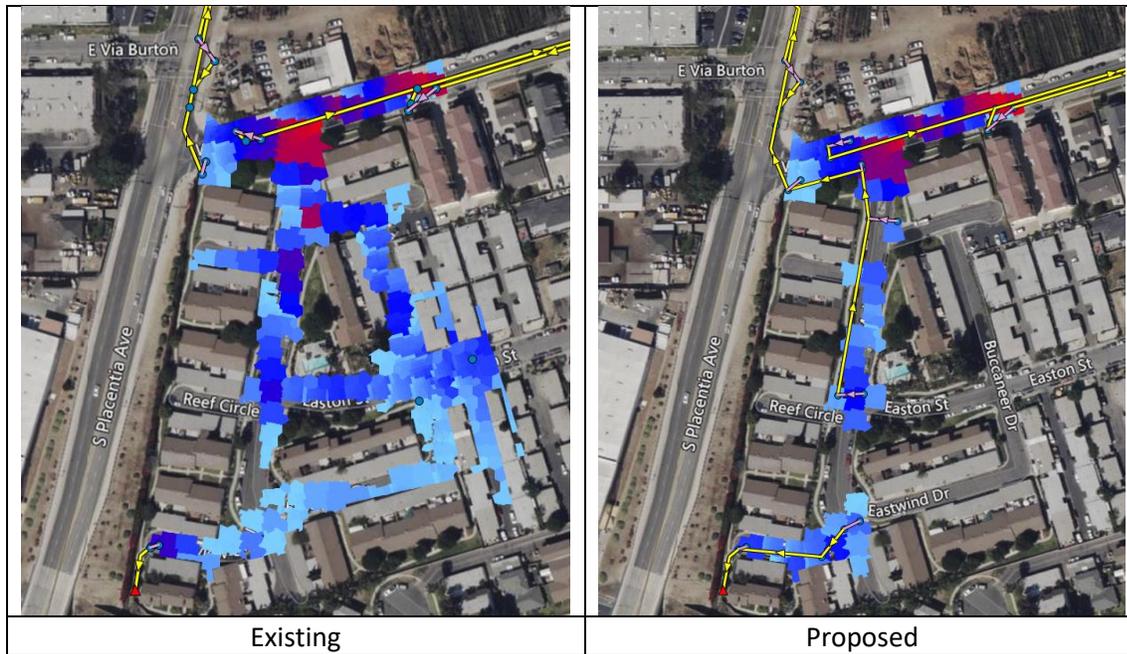


Figure 4-7: Naples Avenue - Pinehurst Avenue Model Results

### 4.1.2.9 Delaware Way

Minor flooding occurs in the cul-de-sac of Delaware Way. In the existing condition, there are three catch basins that connect to the main storm drain line on Kraemer Boulevard via a 24-inch RCP. The 1D existing model shows that the flooding overtops the curb height. The proposed improvement is to remove and replace the existing 24-inch RCP with a 36-inch RCP to remove the flooding.

## 5 Proposed Improvement Projects

This section describes the process for evaluating the storm drain system to determine where drainage improvements are recommended to alleviate flooding and deficiencies in the city.

### 5.1 Methodology

The hydraulic modeling was completed with the following steps.

1. Proposed improvements for all watersheds were determined using an iterative process in PCSWMM. Once a location was determined to be deficient based on the existing system, a proposed model was evaluated and that system was upsized incrementally until the proposed water surface was below the existing ground elevation.
2. In addition to proposing improvements to alleviating hydraulic deficiencies in the existing condition, storm drain systems were proposed to alleviate known flooding and meet the National Highway System dry lane requirement.

#### 5.1.1 County Improvements

Proposed improvements for the Richfield and Atwood channels are based on the OC Deficiency Study. Since the city is not responsible for the proposed county improvements, they are not listed in the proposed improvements, nor are they included in the cost estimates or CIP program. A column on the priority list has been added to indicate city systems connecting to deficient regional drainage systems.

### 5.2 Improvement Summary

The hydraulic modeling resulted in seven (7) storm drain projects identified for future improvements. These projects represent approximately 10% of the entire storm drain system. The stormwater system analysis did not identify any storm drain segments that required immediate attention, and the general condition of the storm drain system is considered to work as intended. Recommended system improvements were generally needed due to stormwater from large tributary areas entering into smaller storm drain laterals or headworks of a system, as well as undersized storm drain mains and laterals. Table 5-1 below summarizes each improvement project identified in this MPD, and Figure 7-1 shows the locations of each improvement project. Detailed results of the analysis can be found in Appendices B and C.

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**Table 5-1: Improvement Summary**

Name	Index Map Page No.	Existing Size (in.)	Proposed Size (in.)	Project Length (ft.)	Notes
<b>Watershed A</b>					
Bradford Avenue	20, 25	24	24	97	
Walnut Avenue	19, 20	24	24	111	
Kevin Way	16	21	24	69	Remove and replace existing 21" CMP with 24" RCP
Primrose Avenue	15, 16, 19	30, 36, 42, 48	24, 30, 48, 54	1770	
<b>Watershed B</b>					
Pinehurst Avenue	16, 17, 20, 21	30, 42, 45, 48, 66	24, 30, 36, 48, 54, 60, 66, 72	6357	
Delaware Way	20	18, 24	24, 36	390	
<b>Watershed F</b>					
Seaview Circle	29	18, 24	18, 24	708	

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## 6 Cost Estimates

Cost estimates were developed for each proposed project that was developed during the deficiency analysis. Cost estimates were generated during the deficiency analysis for each proposed project.

Water Quality Management Plan costs were accounted for within the engineering costs. Pipe removal and construction costs are calculated per linear foot and include costs for excavation, shoring, removal, installation, bedding, backfill, compaction, removal of excess material, and trench resurfacing. A 20 percent contingency is applied to all cost estimates.

A review of the cost estimates was performed by Michael Baker’s cost estimating team and a detailed breakdown for unit cost of a catch basin and manhole was prepared. The Orange County Standard Plan Inlet Type IV (Std Plan 1304) was assumed for the catch basin cost and the 48” Reinforced Concrete Manhole (Std Plan 1504) was used to estimate the manhole cost. A copy of the cost breakdown analysis is included in Appendix C.

A review of the Los Angeles County Bid Price History website was conducted to derive the current prices for reinforced concrete pipes (RCP). For an 18” RCP with a D-Load of 2000, the unit prices range from \$150/LF to \$450/LF. Statistical analysis was used to determine the lineal cost of RCP which assumed a normal distribution. A copy of the cost breakdown for RCP is included in Appendix C.

The estimate of engineer’s opinion of probable construction cost (EOPCC) derived for each alternative is based on engineering judgment, RSmeans, and the Los Angeles County Department of Public Works bid history. The EOPCC is defined as the cost of material and labor to construct the Project; therefore, it does not include engineering design, supervision, management, construction management, construction engineering, bonds, markups, or contingency. Material and labor costs are identified in the estimate without markups.

Detailed cost estimates are included in Appendix C.

The table below summarizes the cost estimates for each project within each Watershed. The total cost to complete the proposed projects is approximately \$14.7 million.

**Table 6-1: Cost Estimate Summary**

Watershed	Location	Total Project Cost
A	Bradford Ave	\$323,000
A	Walnut Ave	\$266,000
A	Kevin Way	\$129,000
A	Primrose Ave/Sunset Ave	\$2,946,000
<b>Watershed A Total</b>	-	<b>\$3,664,000</b>
B	Naples Ave/Pinehurst Ave	\$9,733,000
B	Delaware Way	\$465,000
<b>Watershed B Total</b>	-	<b>\$10,198,000</b>
<b>Watershed C Total</b>	-	<b>\$0</b>
F	Seaview Circle	\$856,000
<b>Watershed F Total</b>	-	<b>\$856,000</b>
<b>Watershed G Total</b>	-	<b>\$0</b>
<b>Watershed H Total</b>	-	<b>\$0</b>
<b>Total Master Plan Cost</b>	-	<b>\$14,718,000</b>

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## 7 Capital Improvement Plan

A priority ranking system has been developed for all proposed drainage improvements within the city. The goal of the priority ranking system is to determine the projects of greatest importance that could be part of the city’s CIP. Factors that influenced the prioritization assignments to each proposed improvement include:

- Magnitude of deficiency in the existing condition.
- Potential to combine the project with other sewer/water projects in the same location.
- Proximity of the system to critical locations or known flooding locations.
- Overall storm drain configuration of interconnecting city systems.

By establishing a ranking for the proposed improvements, the city can then use the assigned priorities in judging which improvement should take precedence when funds become available.

### 7.1 Prioritization

A set of evaluation criteria was developed to assist in selecting the most viable options as the preferred projects for the city MPD update. The suitability of each option was considered using four evaluation criteria:

1. Areas of known flooding
2. Street improvement program schedule
3. Proximity to critical infrastructure/ economic zones
4. Project cost

A criterion scoring matrix helps to make informed decisions. In some instances, the most deficient system may not be the highest priority based on the scoring factors. The projects will need to be evaluated as funding becomes available.

#### 7.1.1 Areas of Known Flooding

The areas of known flooding criterion accounts for the project's potential to improve flooding in areas that have known flooding issues or have been documented as locations of concern by the city. Projects located in an area of concern or known flooding were ranked “5,” and projects in areas with no known concern were ranked “1.” Table 7-1 shows the criterion scoring for areas of known flooding.

**Table 7-1: Areas of Known Flooding Prioritization Scoring**

Description	Assigned Score
Project does not contain areas of known flooding	1
Project contains areas of known flooding	5

#### 7.1.2 Street Improvement Program Schedule

The street improvement program schedule criterion accounts for the potential to combine the project with other improvement projects taking place in the same location, such as sewer or water. Projects located in an area where street improvements were being conducted soon, or were already underway, were ranked “5,” and projects in areas that have recently had street improvements completed were ranked “1.” Table 7-2 shows the criterion scoring for the street improvement schedule.

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**Table 7-2: Street Improvement Program Schedule Prioritization Scoring**

Street Improvement Schedule	
Schedule	Assigned Score
Completed	1
2021-2022	1
2022-2023	5
2023-2024	5
2024-2025	4
2025-2026	3

## 7.1.3 Proximity to Critical Infrastructure/ Economic Zones

Projects that improve drainage facilities in close proximity to critical infrastructure (schools, hospitals, etc.) and high economic value (e.g., business districts) are preferred, because they promote public safety and revenue generation within the city. Table 7-3 below shows the criterion scoring.

**Table 7-3: Proximity to Critical Infrastructure Prioritization Scoring**

Description	Assigned Score
Greater than 1 mile	1
Between 1/2 mile and 1 mile	3
Within 1/2 mile	5

## 7.1.4 Project Cost

The project cost criterion accounts for the estimated proposed drainage improvements cost of each project. Projects with the lowest improvement costs were ranked “5,” and projects with the highest improvement costs were ranked “1.” Table 7-4 shows the criterion scoring for project costs.

**Table 7-4: Project Cost Prioritization Scoring**

Cost of Operations and Maintenance	Assigned Score
\$4 million and above	1
\$3 million to \$4 million	2
\$2 million to \$3 million	3
\$1 million to \$2 million	4
\$0 to \$999,000	5

## 7.1.5 Criteria Weighting Summaries

The four screening criteria were given the weights corresponding to the relative importance of each criterion as judged by the project team. The weights for the criteria, which add up to 100, are summarized in Table 7-5.

Once each project was scored on all criteria, the final project ranking would be determined by a weighting system that gives priority to some criteria over others. The weighting system, shown below, was developed to further prioritize the criteria and allow for specific criteria to hold more significance in the final rank. The assigned weight is multiplied by the assigned score, and each criterion is added to achieve the final rank.

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**Table 7-5: Evaluation Criteria Weighting**

Criteria	Weight
Areas of known flooding	50
Street improvement program schedule	35
Critical infrastructure/ economic zone	10
Project cost	5

## 7.2 Prioritized Projects

Based on the prioritization, the projects are listed below from highest priority to lowest priority. The proposed projects are shown in Table 7-6, project locations are shown on Figure 7-1, and the analysis is included in Appendix C.

**Table 7-6: CIP Summary**

Priority	Project	Project Score
1	Bradford Avenue – Santa Fe Avenue	100.00
2	Walnut Avenue – Center Street	96.00
3	Seaview Circle	92.00
4	Kevin Way	64.00
5	Naples Avenue – Pinehurst Avenue	64.00
6	Primrose Avenue	61.00
7	Delaware Way – Near Kraemer Middle School	60.00



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## **8 References**

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