Carmel-by-the-Sea
Storm Drain Master Plan
Updated Final Report 2023

Job # CBTS.02

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List of Abbreviations

AMC	Antecedent Moisture Condition
CCTV	Closed Caption Television
CDS	Contech Stormwater Separator
CIP	Capital Improvement Program
CFD	Community Facilities District
CFS	cubic feet per second
CMP	Corrugated Metal Pipe
CN	Curve Number
CPP	Corrugated Plastic Pipe
DHI	Danish Hydraulic Institute
FT	feet
GIS	Geographic Information System
HDPE	High-Density Polyethylene
IRWMG	Integrated Regional Water Management Group
LiDAR	Light Detection and Ranging
MAP	Mean Annual Precipitation
MU	MIKE URBAN (software)
NAVD	North American Vertical Datum of 1988
NOAA	National Oceanic and Atmospheric Administration
NRCS	National Resource Conservation Service
NSBB	Nutrient Separating Baffle Box
RCP	Reinforced Concrete Pipe
ROW	Right of Way
S&W	Schaaf & Wheeler
SDMP	Storm Drain Master Plan
SQ.MI	square mile
UHM	Unit Hydrograph Method
USGS	United States Geological Survey

1 Executive Summary

This Storm Drain Master Plan (SDMP) updates the prioritized Capital Improvement Program (CIP) established in 2020 to reduce the risk of flooding within the City of Carmel-by-the-Sea (City). The 2020 SDMP provided a path for the City to provide 10-year (10% annual exceedance) storm drain protection throughout the community. This update identifies storm drain system improvement projects that are intended to provide 20-year (5% annual exceedance) storm conveyance throughout the City. This change allows the system to adapt to possible climate changes.

1.1 Study Objective

The basic objective of this SDMP document is to provide an examination of the drainage risks within the City limits and recommend actions necessary to accomplish appropriate level-of-service and reliability for storm drain systems owned by the City. Several tasks have been undertaken and completed as part of this study:

- Collection of field data to supplement GIS data for building an existing conditions model of the storm drainage network
- Assessment of the performance of existing storm drainage systems
- Assessment of the condition of the existing system
- Identification of capital improvements to reduce flood risk
- Identification of capital improvements to reduce failure risk
- Prioritization of capital improvements for risk reduction and cost benefit
- Establishment of a prioritized CIP for storm drainage
- Estimation of project costs for the prioritized CIP

In accordance with California Environmental Quality Act (CEQA) Guidelines, Section 15262 (Statutory Exemptions), this SDMP is considered a planning document. The adoption of this document is exempt from the requirements to prepare Environmental Impact Reports (EIR) or Negative Declarations (ND). However, CEQA must be satisfied for any capital improvement project described in this report that may be implemented by the City in the future through the preparation of an appropriate EIR, ND, or determined to be categorically excluded.

1.2 Work Products

This SDMP is intended to function as a multipurpose storm drain system resource guide for the City's staff and residents. City engineers responsible for the storm drain capital improvements should find sufficient background information and data in this document to serve as the basis for storm drainage CIP implementation and/or modification. Improvement descriptions, maps, project costs, and other modeling data have been included in the appendices of this report.

1.3 Background

The City's storm drainage system consists of storm drain pipes with outlets to creek channels or Carmel Bay. Most of the City's system has capacity for the 20-year event. However, portions of the system lack the capacity necessary to meet the 20-year standard. Some known, recurring problem areas have been identified by City staff. Carmel-by-the-Sea generally drains in a westerly direction to Carmel Bay. Tidal flooding is not a significant concern for oceanfront parcels.

1.4 System Evaluation

A MIKE URBAN (MU) rainfall-runoff model has been developed for the City, which contains the portions of the overall storm drainage pipe and channel system that provide essential conveyance capacity for storm runoff.

Detailed review, field investigations, analysis, and modeling of the area's storm drainage system led to several conclusions. These conclusions have been utilized to recommend improvements to the system intended to reduce flood risk within the city. The recommended improvements are preliminary in nature and are based on currently available information. Detailed project designs will ultimately require more data, including utility locations, which remain to be obtained.

The drainage system surcharges in areas where the pipes do not provide the necessary capacity to convey runoff. Some flooding may occur in areas where the surcharge is higher than the ground surface. Generally, streets provide some capacity for conveying flow. It is not uncommon to observe gutter flows up to the top of adjacent curbs during high intensity rainfall events.

However, flooding greater than a foot in depth is regarded as problematic regardless of the property damage caused by it. There is special concern in the city since most residential areas lack curb-and-gutter, and the existing asphalt swales and berms vary block-to-block.

The current physical condition of the drainage system was evaluated using pole-mounted camera topside observations and CCTV. The CCTV work focused on the City identified critical segments along with reaches noted during the topside work. Most of the observed system is in good condition. However, there are reaches with debris and sediment, damaged pipes, and other concerns. Improvements for the condition-related projects are detailed in this SDMP.

1.5 Capital Improvement Program

A CIP has been developed based on model results and suggested improvements. The roughly $12.76 million in capacity and $1.94 million in condition improvements, broken down into three priority levels, recommended by this SDMP are based on the capacity and condition of the existing system and the need to correct identified deficiencies. Recommended improvements are intended for public rights-of-way and other City-owned property, not private facilities or private property.

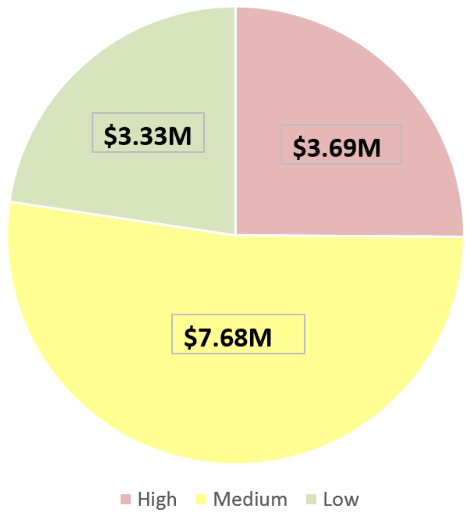

Figure 1-1: Capital Improvements Summary

1.6 Future Development

The CIP does not include the cost of new facilities related solely to new development (e.g., pipeline extensions to serve areas that are currently undeveloped). These new facilities would be constructed as part of the new developments and are not included in the CIP. Much of the future development within the City is anticipated to be in the form of infill projects. While this type of development may in fact reduce stormwater flows to the system, a detailed study should be conducted at the expense of the developer to analyze any impacts more accurately.

In addition, some developments may occur in areas where the existing or possibly improved downstream systems are currently undersized. The City may request assistance from developers to improve the system and in turn be reimbursed for improvements made to the existing system.

1.7 Conclusion

This SDMP provides a tool for citizens and City officials to use in their efforts to reduce both nuisance flooding and the likelihood of more serious storm water-related hazards to private and/or public property.

This study and proposed CIP are merely the conceptual starting point. It is anticipated that City staff and/or their consultants will perform more detailed studies and alternatives analyses to identify the most affordable and effective improvement projects with information gathered as part of the design process, including detailed topography, utility conflicts, available easements and rights-of-way, construction impacts, and long-term operation and maintenance.

2 Master Plan Area Characteristics

2.1 Overview

This SDMP provides a capacity analysis and condition assessment of existing storm drain collection systems, a discussion of drainage design standards, and recommended improvement projects to reduce the risk of flooding with estimated costs within the City. Its primary focus is on the City-owned drainage facilities.

This SDMP should be used to guide the City in planning, financing, engineering, and maintaining its own infrastructure. Each chapter of this report is intended to help the City identify problems, manage resources, and provide cost-effective and comprehensive solutions.

This chapter provides a general discussion of drainage and flood management systems and issues currently affecting the City, historic flooding, and a summary of FEMA floodplain mapping efforts within the City. It also describes the SDMP objectives, explains the criteria used to evaluate storm drain system performance, and presents a summary of the data collected as a part of this SDMP process and from previous drainage studies.

Existing hydrologic and environmental settings of the City are described along with flood protection and storm drain facilities.

2.2 Setting

The City of Carmel-by-the-Sea is in Monterey County, California located 4 miles south of Pacific Grove and 17 miles southwest of Salinas. The City is bound by Pebble Beach in the north, unincorporated areas to the east and south, and Carmel Bay to the west. The area is predominantly urban and ranges in elevation from sea level to approximately 400 feet on the 1988 North American Vertical Datum (NAVD88). The study area, defined primarily by the City limits, covers an area of approximately 1.2 square miles. Figure 2-1 shows the vicinity of the City limits and study area.

Carmel River and Mission Trails are the only streams located in the study area. The Carmel River only functions as a boundary condition for the drainage system. The Mission Trails channel conveys runoff from the easterly portion of the city to the Carmel River. Pescadero Canyon conveys runoff from portions of the northwest quadrant of the City.

2.3 Climate

The City has a climate consisting of warm to foggy summers and wet winters. The average annual high temperature is 65°F, and the average annual low temperature is 48°F. While mean annual precipitation varies throughout the City, the City-wide average is 20 inches per year. Most of the rainfall occurs during winter months (November – March).

2.4 Flood Protection Facilities

Runoff generated by precipitation within the city and surrounding area is conveyed through various flood protection systems. The majority of runoff captured by the storm drain networks is discharged through gravity outlets into Mission Trails and Carmel Bay as shown in Figure 2-1.

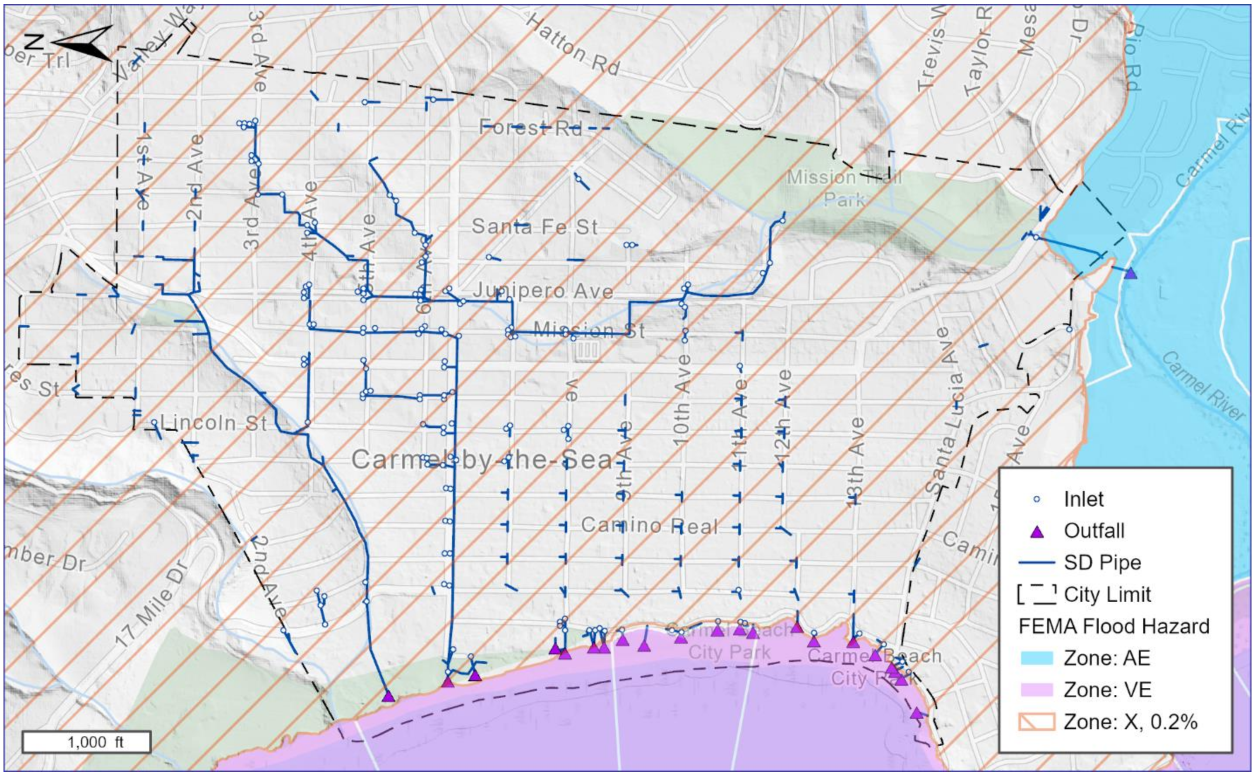

Figure 2-1: Existing Carmel-by-the-Sea Drainage System

2.5 History of Flooding within Carmel-by-the-Sea

Historical flooding information can be valuable in highlighting areas of recurring problems and prioritizing future improvements. Information about areas with known flooding problems was provided to Schaaf & Wheeler by the City employees. More discussion about the historical flooding problems in Carmel-by-the-Sea is presented in Section 5.4.

2.6 Regional Storm Water Coordination

A variety of agencies and municipalities maintain storm drainage systems within the study area. The most relevant of these is Monterey County, which maintains stormwater infrastructures outside the City of Carmel-by-the-Sea boundary. County runoff enters Carmel systems at 4th Avenue and Mission Trails Park. The City participates in the IRWMG and Regional Stormwater Resource Plan, which identify stormwater capture opportunities throughout the region.

2.7 Master Plan Process

The City's storm drain system performance has been analyzed using the level-of-service criteria established herein to identify deficiencies and recommend capital improvements. Several tasks have been completed to reach this goal:

1) Create a hydraulic model using the GIS data provided by the City. Network features include:
   a) Manhole invert and rim elevations;
   b) Pipe length, diameter, and material; and

    c) Watershed runoff characteristics.

2) Review existing data and field verify where necessary to complete representative models of the system.
3) Establish storm drainage analysis methodologies and performance criteria with the City staff.
4) Establish channel and ocean boundary conditions for storm drain system models.
5) Perform hydrologic and hydraulic analyses of the existing storm drain facilities throughout the city for the 20-year event based on methodology previously developed for use in Monterey County. System deficiencies on City-owned facilities are categorized in terms of the risk to public safety, property, and infrastructure.
6) Inspect the condition of the drainage network using a pole-mounted camera and CCTV.
7) Identify projects that will improve storm drain system performance and reliability.
8) Outline a prioritized operations and maintenance program.
9) Outline a prioritized CIP for storm drainage infrastructure.
10) Project and summarize capital improvement costs for the CIP.

3 Data

3.1 Data Sources

Schaaf & Wheeler reviewed and utilized readily available land use, topographic, geological, geographical, and storm drain system data within the Carmel-by-the-Sea Storm Drain Master Plan Area (study area). Available data, while mostly complete, had some missing or incorrect information. Efforts have been made to improve and add to the collective data. Where necessary, assumptions and engineering judgment have been used to complete remaining data gaps.

This chapter summarizes the findings and data acquired as part of the City's SDMP. Data limitations, assumptions, and impacts are also summarized herein. Previous drainage studies and engineering designs provide useful data and analysis to support this SDMP.

3.1.1 Topography and Aerial Imagery

All project data and results are in vertical datum NAVD88 (feet) and the State Plane (California Zone IV) coordinate system. An integrated citywide digital elevation model from USGS[1] and NOAA[2] (Figure 3-1) was created to develop the hydraulic model for the SDMP. The NOAA data has a higher level of accuracy. In addition, aerial imagery available in ArcGIS[3] was also used to obtain related data such as road networks, land use, and water bodies.

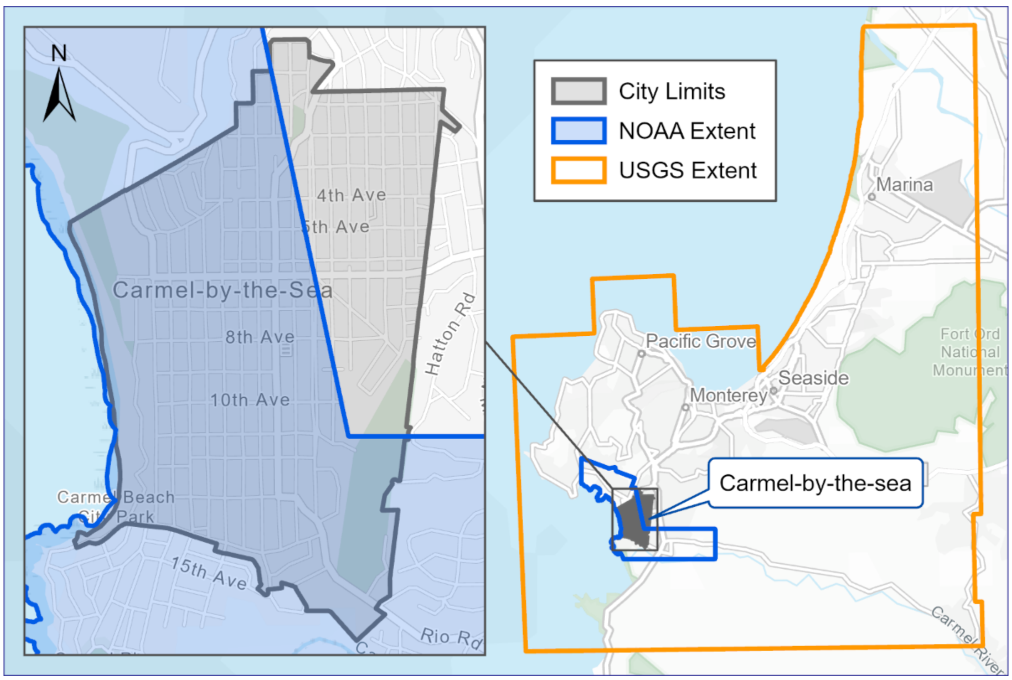

Figure 3-1: Study Topography

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[1] U.S. Geological Survey, USGS NED ned19_n36x75_w122x00_ca_centralcoast_2010 1/9 arc-second (https://www.sciencebase.gov/catalog/item/5d0ae96ae4b0e3d3116020bd)
[2] 2009 - 2011 CA Coastal Conservancy Lidar DEM: Coastal California, NOAA (https://coast.noaa.gov/htdata/raster2/elevation/California_Lidar_DEM_2009_1131/)
[3] ESRI

3.1.2 GIS Data

The most current storm drain network data (Figure 3-2) was provided to Schaaf & Wheeler in the format of geodatabase (.gdb). Initial data included:

- Dimensions for 42% of the pipes;
- Rim Elevations for 0% of the nodes (manholes and catch basins); and
- Depths for 0% of the nodes.

Schaaf & Wheeler identified missing data as well as items in need of verification. Information needed to create a hydraulic model of the system included:

- Missing pipe diameter;
- Missing node depth and rim elevation;
- Verification of some pipe diameters and node depths; and
- Some outlet locations.

The storm network elements were imported into GIS and filtered to use only main-line pipes 12-inches in diameter and larger for hydraulic modeling. Measures were taken to collect or approximate data necessary to compile a master plan-level analysis. No surveying was completed under this study.

Land use designations for the City were obtained from the data made available by the Carmel-by-the-Sea Planning Department. Hydrologic soil groups were obtained from the NRCS WSS website[4]. The percentage impervious area for each delineated basin was estimated using zoning data and aerial imagery in ArcGIS.

[4] Web Soil Survey. https://websoilsurvey.nrcs.usda.gov/app/WebSoilSurvey.aspx. Accessed in 2019.

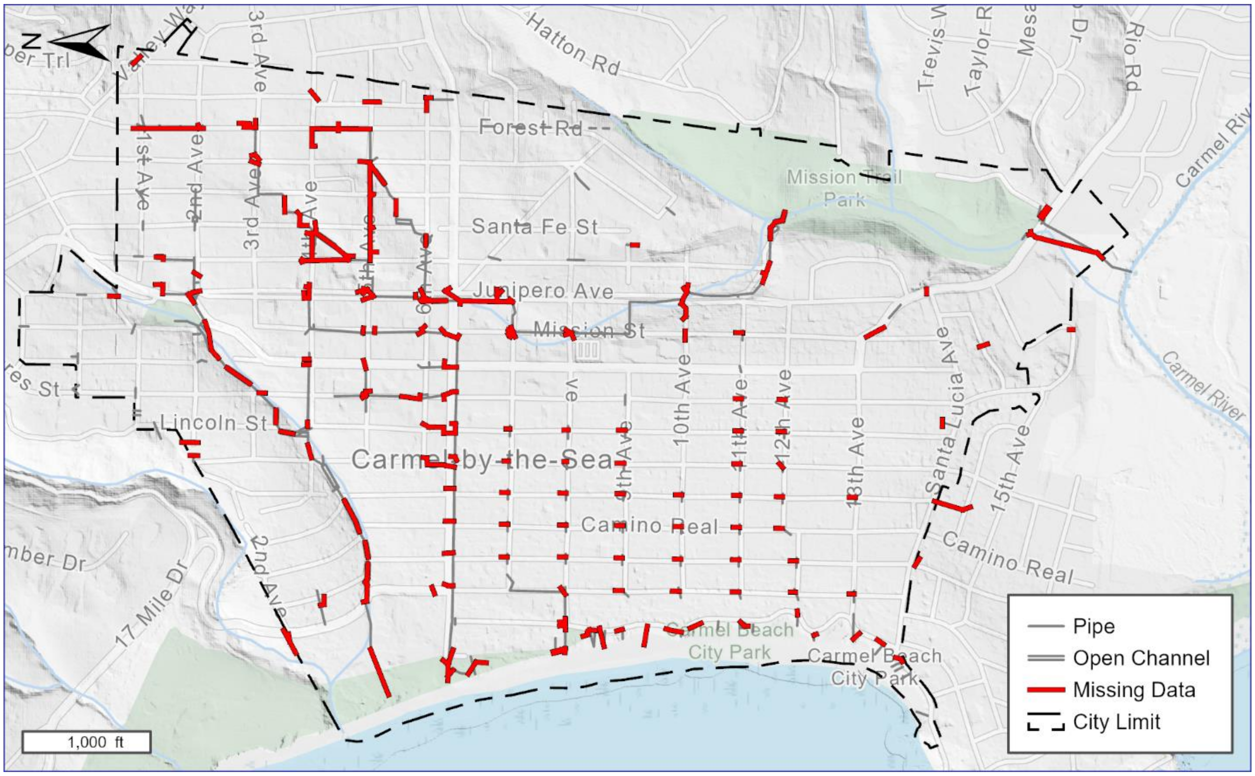


Figure 3-2: City Provided GIS

3.1.3 Field Measurements

Field visits carried out to collect or verify data included:

1. October 10, 2019: To visit the network and collect system data including pole-mounted condition photos;
2. October 15-17, 2019: To visit the network and collect system data including pole-mounted condition photos. Outfalls documented;
3. November 11-15, 2019: CCTV by Presidio Systems Inc.;
4. January 21, 2020: Ditch and channel measurements and additional network measurements; and
5. February 14, 2020: Additional field measurements.

Field information was collected by Schaaf & Wheeler staff. Since storm drain systems are designed for pressure flow and surcharge, the system's hydraulic grade lines (HGLs) are typically not governed by open channel flow dynamics. For this reason, pipe diameters are a more critical component of the model than the invert elevations. A pole-mounted GoPro camera was used to observe the existing condition at several manholes and inlets (Figure 3-3).

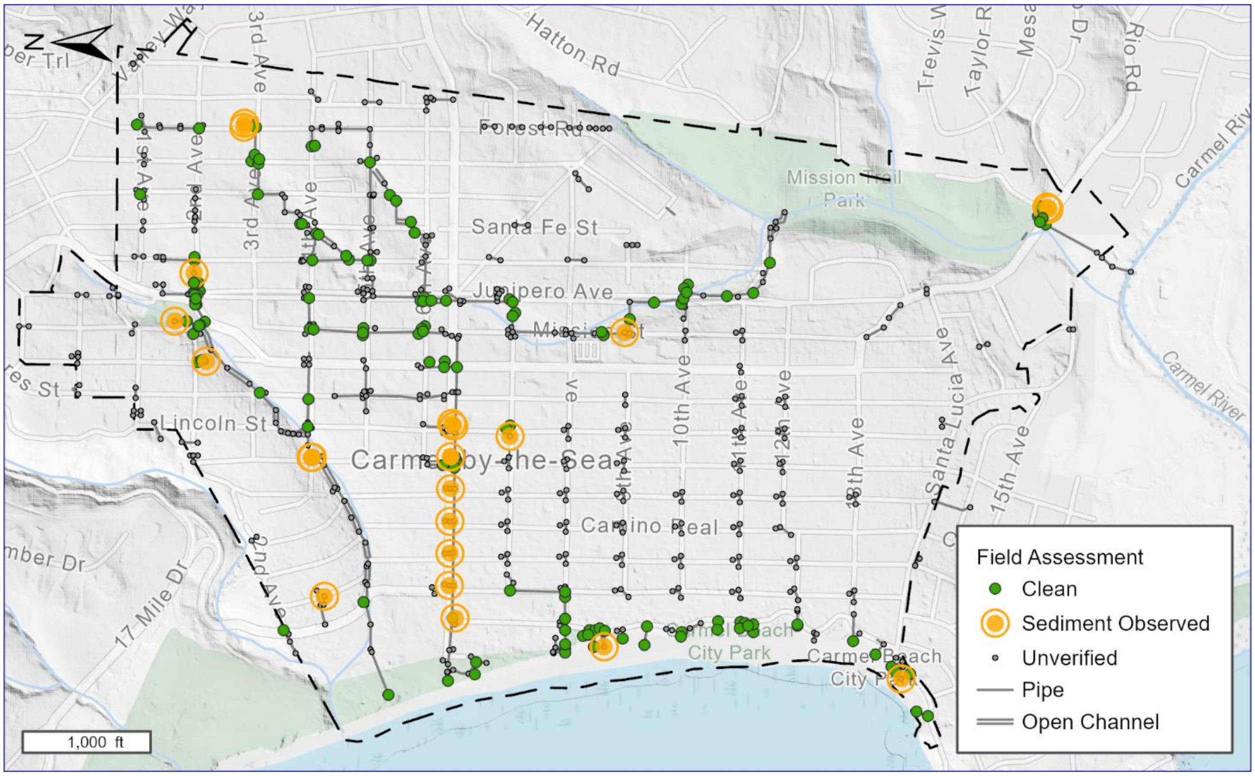


Figure 3-3: GoPro Observations

3.1.4 CCTV Inspections

Presidio Systems spent five days inspecting the drainage system using closed caption television (CCTV) technology. Since it is cost-prohibitive to inspect the entire system, Presidio Systems focused on regions with known issues and segments that were noted during the Schaaf & Wheeler field work (Figure 3-3). The CCTV data (Figure 3-4) was reviewed by Schaaf & Wheeler and utilized for condition improvements. Appendix G contains the detailed CCTV reports.

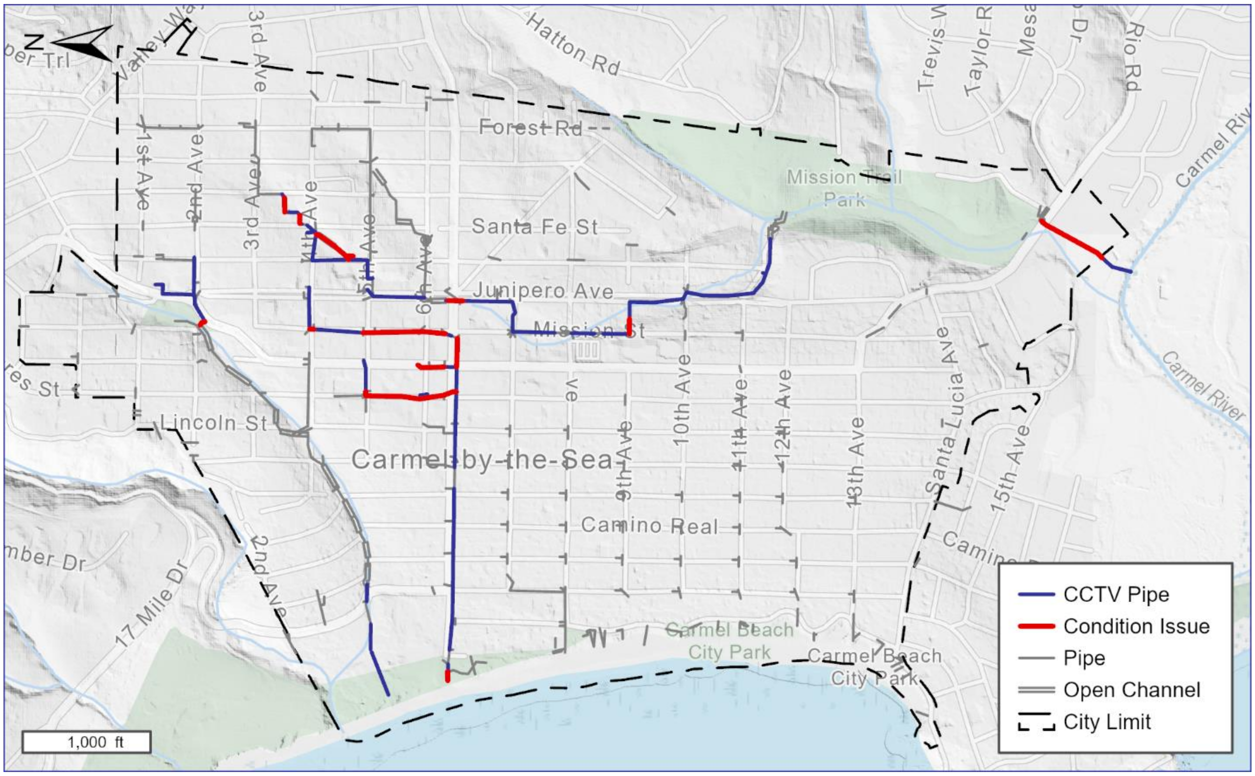


Figure 3-4: CCTV Observations

3.1.5 Record Drawings

Few record drawings of the storm drain infrastructures were available to Schaaf & Wheeler. The improvement plans for the system between Guadalupe and 3rd to Santa Fe and Fourth were helpful in updating the GIS.

3.1.6 Catchments

Catchments were delineated based on surface data using topography and GIS and then refined based on the City's stormwater drainage network data and engineering judgement. Chapter 4 details the catchment delineations along with a map of the catchments (Figure 4-1).

3.2 Land Use Data and Runoff Characteristics

National Resource Conservation Service (NRCS) Curve Numbers (CN) were assigned to the delineated catchments in accordance with the hydrology methodology in Monterey County. Curve Numbers are empirical parameters used to predict runoff or infiltration from runoff excess. These rainfall runoff characteristics are estimated based on land use, soil classification, and percent impervious surface.

3.2.1 Land Use

Based on the City's Zoning Designation, land use in the study area was separated into five types. Land use in the study area is predominantly Residential (59% by area including all densities) followed by Streets and Public Right-of-Way (25%). Undeveloped parcels in the study area were assumed to be built out based on their current zoning. A map showing selected land use types, which make up most of the study area, are shown in Figure 3-5 (Appendix I).

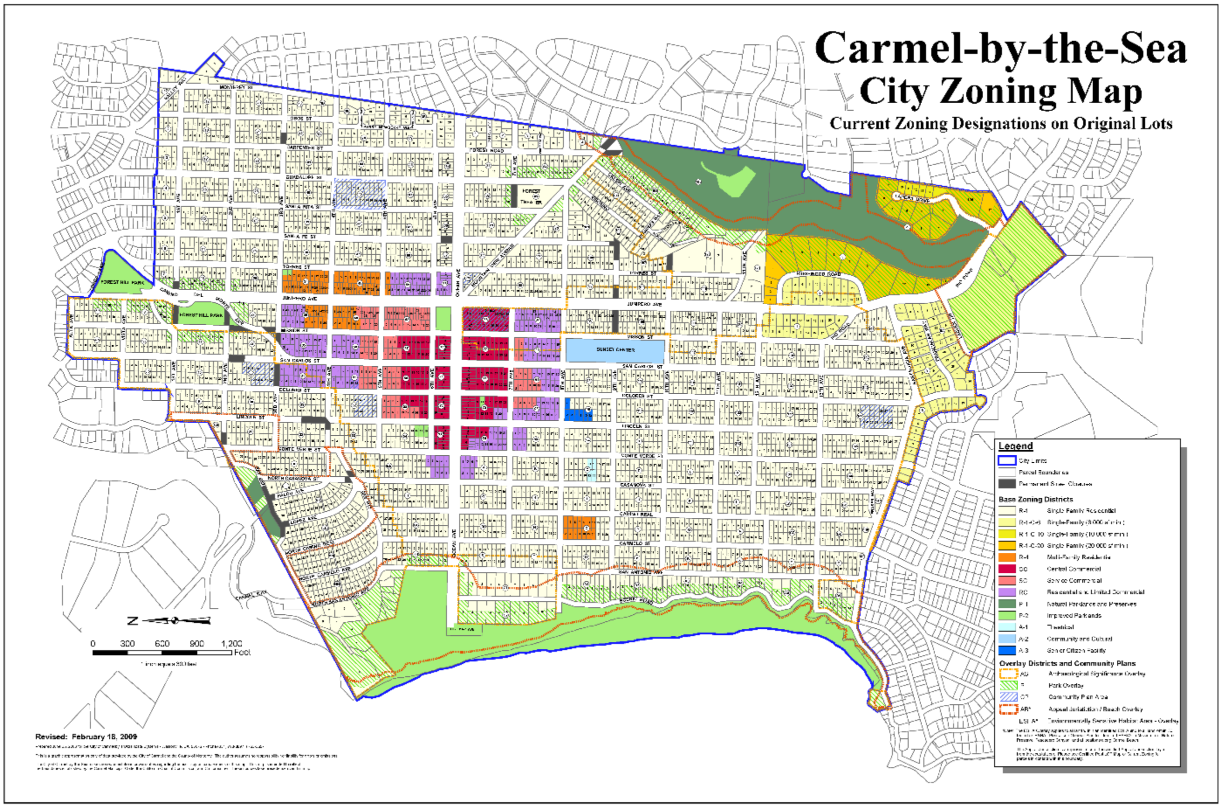


Figure 3-5: City Zoning/General Plan Map

3.2.2 Future Land Use

The City is currently close to build-out with very few empty lots. Most future development will involve the redevelopment of sites, such as infill projects. Future development will need to comply with the State Water Resources Control Board (State Water Board) under the Phase II National Pollutant Discharge Elimination System (NPDES) Municipal Stormwater Permit. The requirements to treat storm water runoff may result in a reduction of impervious surface.

The measures related to Provision E.12 are typically only designed to target smaller storms and are not anticipated to significantly reduce the 20-year peak discharge. However, redevelopment in the City, in general, is not expected to increase the 20-year flow.

Based on zoning requirements, future land use condition is not estimated to be worse than the existing condition. The CIPs developed for the existing condition are expected to meet or exceed future conditions. Impacts of planned development can be analyzed in detail by the storm drain model created for the SDMP. However, these detailed studies are not part of this contract.

3.2.3 Percent Impervious Surface

By sampling representative sub-areas in GIS for each land use type, percentage pervious and impervious cover was estimated based on aerial images. Percent impervious values for each land use type are summarized in Table 3-1.

Table 3-1: Percent Impervious Surface Comparison and Assumed Model Values

Land Use Type	Percent Impervious Surface
Residential	31%
Commercial	63%
Open Area	3%
Impervious (Roadways)	100%
Public Right-of-Way (Outside Roadway)	32%

3.2.4 Soil Classification

The soils within the study watershed vary with deposits comprised primarily of Oceano Loamy Sand (43%), Baywood Sand (16%), and Chamise Channery Loam (16%). Figure 3-6 presents a map showing the hydrologic group of the soils found in the study area. The Natural Resources Conservation Services (NRCS) has classified soils into four hydrologic soil groups ("A", "B", "C", and "D") according to their infiltration rates. Group "A" soils have low runoff potential when thoroughly wet and typically consist of sand or gravel type soils.

Group "B" soils are moderately well draining when thoroughly wet and consist of loamy sand or sandy loam textures. Group "C" soils have moderately high runoff potential when thoroughly wet and consist of loam, silt loam, sandy clay loam, clay loam, and silty clay loam textures. Group "D" soils have high runoff potential when thoroughly wet and consist of clayey textures. All soils with a water table within 24-inches of the surface are in Group "D."

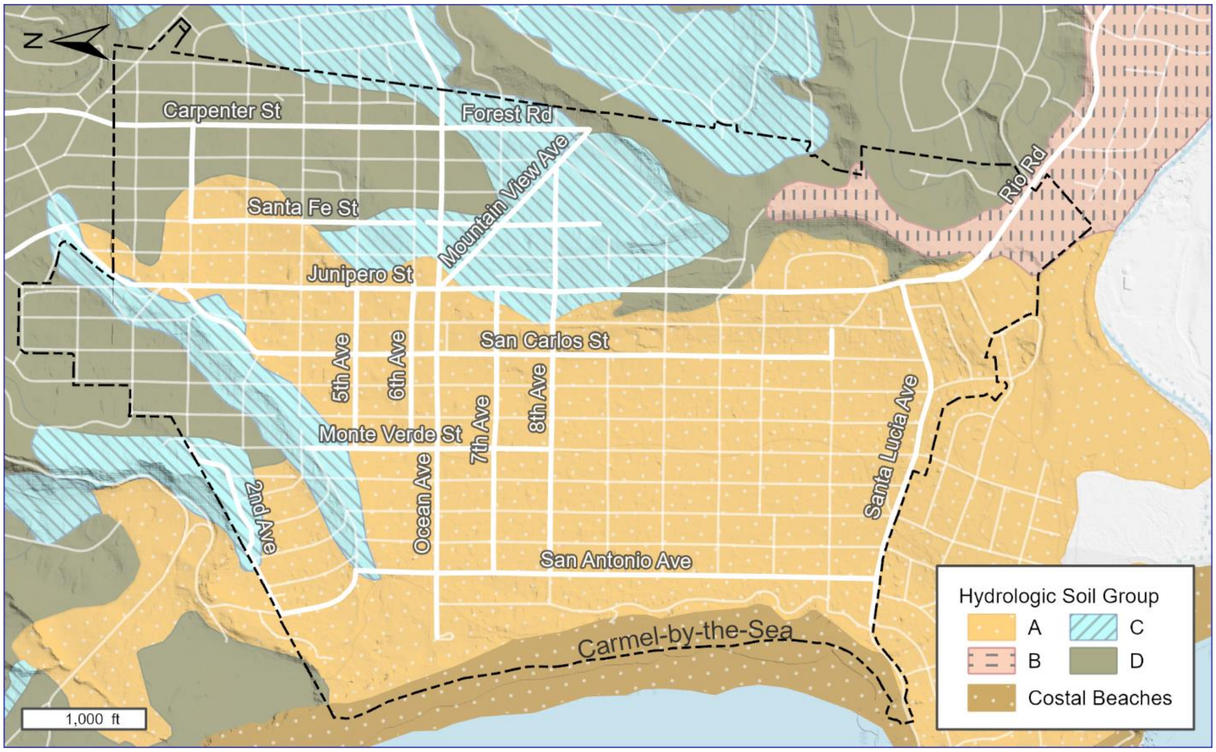


Figure 3-6: NRCS Soil Classification in Study Area and Immediate Vicinity

3.2.5 Runoff Curve Numbers

The runoff Curve Numbers (CN) of the impervious portion of the catchments was assumed to be 98. To determine the CN for the pervious portion in each catchment, the CN of the sub-areas with different hydrologic soil groups was first determined (Table 3-2). Then, an area weighted average of the CN was calculated to obtain a representative CN of the pervious portion within each catchment.

Table 3-2: Curve Numbers for Pervious Surfaces

Hydrologic Soil Group (HSG)	Curve Number (AMC II)
A	44
B	58
C	71
D*	75

* Areas with C/D and unavailable HSG were assumed to be D

3.3 Data Quality

There was some variation and inconsistency in the quality and accuracy of available data. While a small amount of information was present in City GIS files at the start of the study, the invert of many nodes (manholes, inlets, and outlets) was not included. In the absence of record drawings to fill in these data gaps, missing inverts were estimated based on the data already available in GIS, depth data collected during field visits, and terrain data. New data was added to the City GIS.

The City has an estimated 8.6 linear miles of pipe (503 links), 1.2 miles of open channel, and 593 nodes (including manholes, catch basins, detention basins, inlets, and outlets). Not all of these components are analyzed in detail. The hydraulic model contains all known pipes 12-inches in diameter or larger, primarily belonging to the City of Carmel-by-the-Sea, with some pipes belonging to Monterey County.

After an initial model was built and missing data was estimated or interpolated, results revealed some locations where further verification was necessary. These areas were investigated with help from the City.

3.3.1 Modeled Data Assumptions

To create a uniform ground surface for hydraulic modeling, rim elevations at all system nodes have been extracted to the system node shapefile from the DEM terrain model. Invert elevations were assigned to each node based on depths from City-provided GIS data or field measurements where available. Where node depths were unknown or missing, invert elevations were assumed or interpolated for modeling purposes. These inverts were estimated based on the nearby nodes with known depth data.

Pipe profiles were investigated thoroughly to identify areas where assumed inverts resulted in negative slopes or other unrealistic conditions. For these cases, invert elevations were interpolated between nodes with known depth data using the interpolation tool in the MU. Once surcharged, storm drain pipe slopes (and therefore inverts) do not affect hydraulic analyses.

Inverts and ground elevations in the model have been checked manually for irregularity (e.g., ground elevations below the top of pipes, negative pipe slopes, and incorrect pipe diameters) and corrected as necessary. Pipe diameters missing from City GIS have been assumed based on the connecting pipes or the pipe location.

3.4 Future Use of Models

The models developed for this SDMP can be used to analyze future development impacts to the existing system or alternative improvements that are not part of this SDMP. It is recommended that the models are continually updated when new information is received or when improvement projects are completed. The models should serve as a tool that the City can use to further analyze the storm drain system.

4 Master Plan Methodology

4.1 Overview

The criteria used to evaluate storm drain system performance must be technically sound yet simple to understand and apply. Ideally, the same methodology used to analyze system performance for this report will continue to be used for future infrastructure design.

Schaaf & Wheeler applied NRCS hydrology methods to estimate storm runoff from current land uses for the City's SDMP. This method is being used along with MU storm drain modeling software by Danish Hydraulic Institute (DHI) to evaluate system performance, identify deficiencies, and recommend necessary improvements.

Physical parameters used in the model are based on the City's GIS data and other information detailed in "Chapter 3: Data." Storm drain evaluation criteria described in the following section have been discussed with and agreed upon by the City.

4.2 Evaluation Criteria

Hydrologic analysis and one dimensional (1-D) hydraulic models have been created for the 20-year event. The 20-year storm event was used as the design event for the storm drain system evaluation since the 20-year level-of-service standard was agreed upon as the governing criteria for general storm drain system conveyance.

Improvements are recommended to reduce the 20-year hydraulic grade to no higher than 0.5 foot above the rim elevation at any location. These criteria minimize the risk to private property and public safety and are common standards used throughout California by other jurisdictions.

4.3 Modeling Software

The DHI MU software with MOUSE solver was selected to model the City's storm drain system. MU is a package of software programs designed by DHI for the analysis, design, and management of urban drainage systems, including storm water sewers and sanitary sewers.

The MU model works within the ArcMap GIS interface and can simulate runoff, open channel flow, pipe flow, water quality, sediment transport, and two-dimensional surface flow. The City's modeling package consists of two interrelated products:

1. MIKE-1D is a group of hydrologic, hydraulic, water quality and sediment transport modeling modules which can be used together or used independently. The modules used in the City's storm drain model include the Surface Runoff Module, which computes surface runoff using one of five computational methods, and the Hydrodynamic Pipe Flow Module, which calculates an implicit finite-difference numerical solution of the St. Venant flow equations for the modeled pipe network.
2. MU is an ArcMap-based program which includes tools specifically designed to develop urban drainage models. MU provides a graphical user interface for data input and editing and serves as a bridge between ArcMap GIS and the MOUSE modeling program. Capabilities of MU include import and export of model data, network editing and gap-filling, catchment delineation, and network simplification. MU can also be used to present results including plan, longitudinal, and cross-section views; animation of results;

presentation of flooding including water depth and pressure; and overlay of results on background graphics, such as maps or aerial photos.

The entire City's "main" conveyance pipes are included in a single model. Small lateral pipes are not included.

4.3.1 Operation

Two separate calculations are performed by MU for the City models. First, a runoff calculation (hydrologic analysis) estimates the amount of water entering the storm drain system during a design rainfall event. Second, a network flow calculation (hydraulic modeling) replicates how the storm drain system will convey flows to outlet locations. Flows resulting from the runoff calculation are used as inflows for the subsequent network flow calculation.

The MU runoff model offers a choice of infiltration methods. The City storm drain models use the NRCS dimensionless unit hydrograph method (UHM) to calculate surface runoff. A simulation can be started at any point during the chosen design storm to assess surface runoff for any period of the design storm, with computations made based on a user-specified time step.

The MU network flow model also offers a choice of three flow description approximations distinguished by the set of forces each considers: Diffusive Wave, Dynamic Wave, and Kinematic Wave. The City's storm drain models use the Dynamic Wave option, which incorporates the effects of gravitational, friction, pressure gradient, and inertial forces. Since the Dynamic Wave option accounts for all major forces affecting flow conditions, it allows the model to accurately simulate fast transients and backwater profiles.

For a one-dimensional pipe flow simulation, flooding at a node is accommodated by the insertion of an artificial "basin" above the node, which will store water when the water level rises above the ground level. The surface area of the "basin" gradually increases (up to a maximum of 1,000 times the node surface area) with rising water levels at the node, replicating the effects of flooding.

Water stored in the "basin" begins to reenter the system when the outflow from the node becomes greater than the inflow. The pipe flow simulation can be executed using either a constant or variable time step and can be run for any portion of the time interval specified by the input rainfall time series and corresponding calculated runoff hydrograph.

The simulation time step for runoff calculation was set at 1-minute. Network flow calculations were set between 10 and 60 seconds with the resulting hydrographs set to be saved at 1-minute intervals.

4.3.2 Input and Output

MU surface runoff calculations require two types of input data: boundary data and urban catchment data. Boundary data for the run-off computation consists of an input rainfall time series representing the design storm event for the model. Urban catchment data includes the pipe network and boundaries of each drainage catchment, along with relevant physical and hydrologic parameters including surface area and parameters used to calculate basin lag time. Drainage catchments for the study area are shown in Figure 4-1.

While most of the city drains directly into the pipe system, a few drainage areas consist of open space or parks that drain directly into the adjacent stream.

MU network flow calculations require two types of inputs: network element data (links and nodes) and boundary data (rainfall and creek/river water surface elevations). Network elements consist of nodes (which can include manholes, catch basins, retention/detention basins, and outlets) and links (which can include pipes, culverts, and open channel cross sections).

Parameters required to describe links include the name of upstream and downstream nodes ("to node" and "from node"), shape (circular, egg shaped, defined cross section, etc.) and dimensions, material or roughness, and upstream and downstream node invert elevation. Geometry and data corresponding to network elements are imported from GIS shapefiles.

Connections to urban catchments are defined within the MU interface as node elements where catchment runoff enters the network. Boundary data can include direct results of runoff calculations based on rainfall input, external loadings, inflow discharges, or external water levels at interaction points with receiving waters (outlets). Outlets include the Carmel River, Mission Trails Park, Monterey Bay, and Pescadero Canyon.

Output from the pipe flow computation includes the calculated water level at each node, discharges, water level in network branches, discharge in network branches, velocity in network branches, water volume in the system, and time step data. Output is viewed using GIS, MU, or the MIKE-VIEW program. Results may be displayed in plan-view or as a profile for a selected network section and may be viewed as a temporal animation or at maximum or minimum values.

Additional outputs, which can be derived from MU pipe flow results using GIS, include water depth, flooding level, pressure in closed conduits, percentage pipe filling, and the flow calculated for each link.

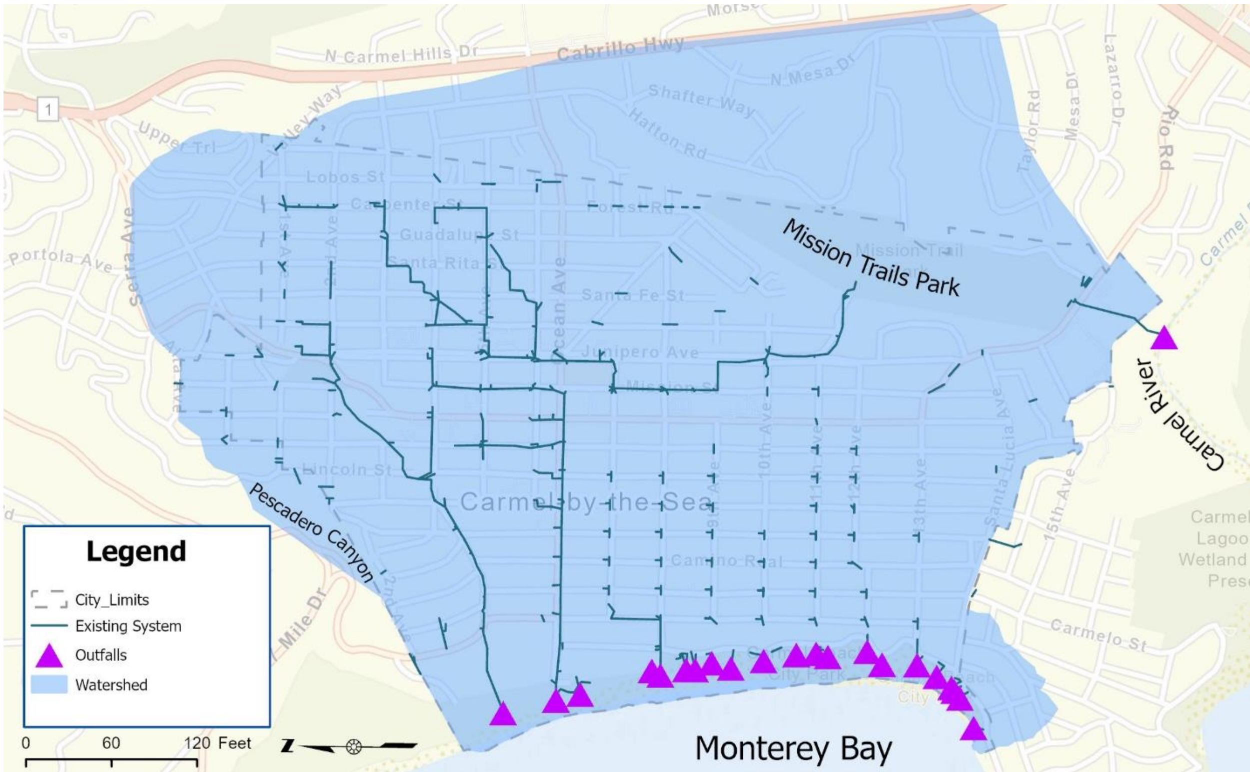


Figure 4-1: Carmel-by-the-Sea Storm Drain Catchments

A summary of inputs and outputs is listed in Table 4-1.

Table 4-1: Summary of Inputs and Outputs for Each Model Element

Model	Inputs	Outputs
Runoff	Boundary Data ▪ Rainfall time series Urban Catchment Data ▪ Drainage catchments ▪ Lag time ▪ Curve number	Runoff hydrographs for each individual catchment
Pipe Flow	Storm Drain Network ▪ Nodes (catch basins, manholes, outlets, etc.) ▪ Links (pipes, culverts, open channels) ▪ Operational Data ▪ Catchment connections ▪ Junction Losses ▪ Boundary Data ▪ Catchment runoff hydrographs ▪ Water surface elevation time series	Water level at each node Water level in network links Velocity in network links Water volume in the system Discharges

4.4 Hydrologic Calculations

Methods used in this SDMP to estimate peak storm water flow rates and volumes require the input of precipitation data. Since it is impossible to anticipate the impact of every conceivable storm, precipitation frequency analyses are often used to design facilities that control storm runoff. A common practice is to construct a design storm, which is a rainfall pattern used in hydrologic models, to estimate surface runoff.

A design storm is used in lieu of a single historic storm event to ensure that local rainfall statistics (i.e., depth, duration, and frequency) are preserved. When combined with regional specific data for land use and loss rates, the model should produce runoff estimates that are consistent with frequency analyses of gauged stream flow around Monterey County. In other words, the 20-year design storm pattern used for MU modeling creates results consistent with 20-year storm runoff events.

Precipitation frequency analyses are based on concepts of probability and statistics. Engineers generally assume that frequency (probability) of a rainfall event is coincident with frequency of direct storm water runoff, although runoff is determined by several factors (particularly land use conditions in the basin) in addition to the precipitation event. Since the County's 24-hour pattern has been adjusted to preserve local statistics, there is increased confidence in the runoff predictions created by the City models.

Climate change may impact storm frequencies and intensities in the City. This study identifies predicted changes based on available data and highlights potential impacts on the city drainage systems. The 2020 SDMP was based on a 10-year event. This update provides 20-year level improvements, which will adapt to precipitation increase from climate change.

4.4.1 Point Precipitation Values

Point precipitation value estimates for several randomly generated locations in the study area were obtained from the NOAA Atlas 14 website[5]. The point precipitation value of a 20-year 24-hour storm in the study area is 3.66 inches.

4.4.2 Rainfall Depth and Pattern

The NRCS Unit Hydrograph Method was used to estimate storm water runoff in Carmel-by-the-Sea and was developed by Schaaf & Wheeler for City of Soledad's SDMP[6]. Monterey County does not have a hydrology manual. Therefore, this approach is valid for Carmel. The Unit Hydrograph method allows for the development of a flood hydrograph using a design storm, an appropriate infiltration technique, varying antecedent moisture condition, storage within the watershed, and a synthetic unit hydrograph.

The rainfall distribution pattern for this study is based on the December 1955 storm, which was shortened to a 24-hour design storm and balanced with NOAA Atlas 14 statistics. The design storm is balanced to the following durations: 15-minute, 30-minute, 1-hour, 2-hour, 3-hour, 6-hour, 12-hour, and 24-hour.

The final 24-hour design storm pattern was developed using a 5-minute time-step. The precipitation frequency estimates were applied to the design storm pattern to develop design

[5] PF Map: Contiguous US. https://hdsc.nws.noaa.gov/hdsc/pfds/pfds_map_cont.html?bkmrk=pa. Accessed in 2019.
[6] Schaaf & Wheeler. July 2016. "City of Soledad Storm Drain Master Plan".

storms for the 20-year storm events and prorated based on statistical data provided by NOAA Atlas 14 for those storm events. The pattern intensity values are presented in Figure 4-2.

4.5 Catchment Data

The City is divided into 105 drainage areas, called catchments. The catchment delineations completed by Schaaf & Wheeler rely on engineering judgment and experience using contours, lot lines, storm drainage system, and aerial imagery. Urban catchment data includes the boundaries of each drainage catchment, along with relevant physical and hydrologic parameters including surface area, land use characteristics, and parameters used to calculate basin lag times.

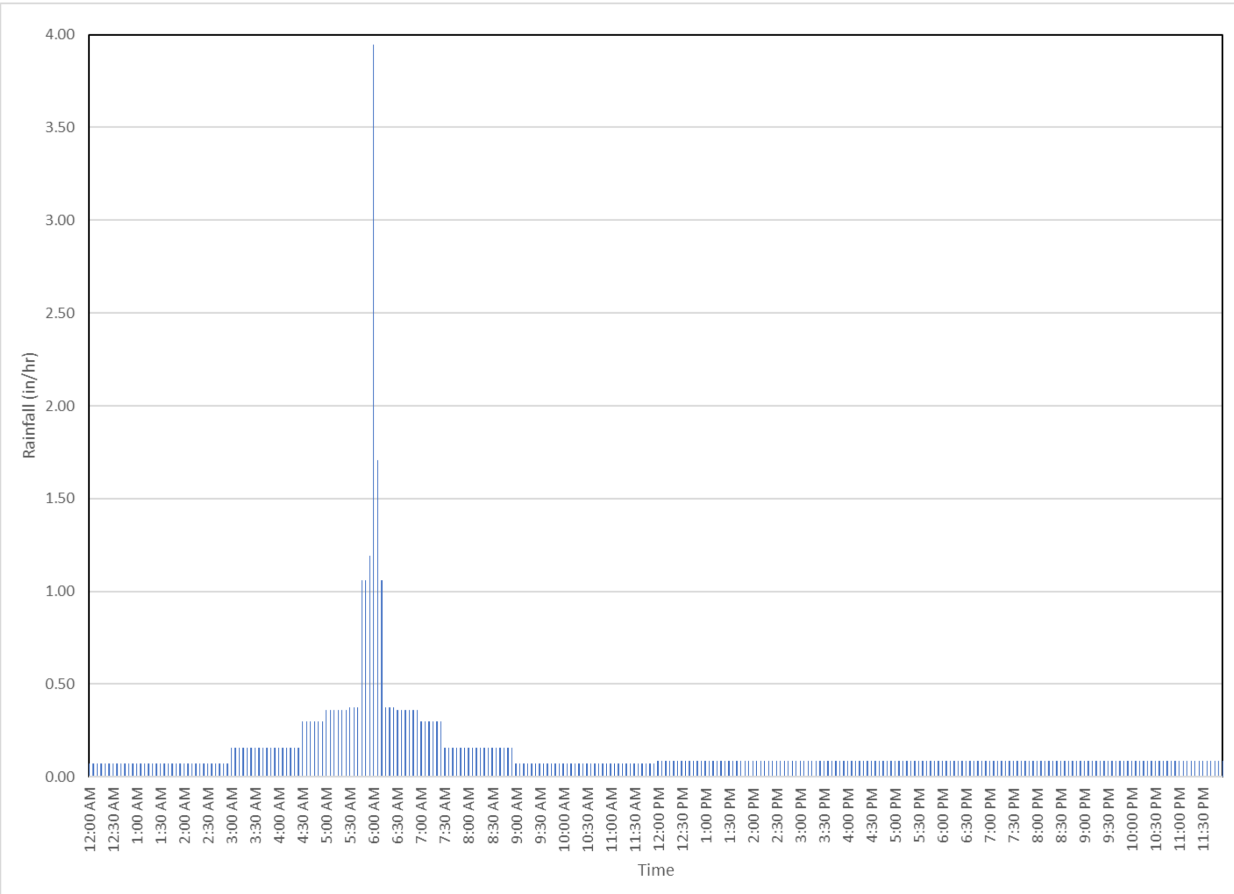


Figure 4-2: 20-year 24-Hour Design Storm Used for the Carmel-by-the-Sea SDMP

4.5.1 NRCS Curve Number

The NRCS CN methodology was used to determine storm water runoff from each catchment with design precipitation. CNs are used to characterize basin infiltration and runoff potential based on a combination of land use and soil characteristics discussed in Section 3.2 and a parameter known as antecedent moisture condition (AMC). AMC is defined as the moisture content of a soil prior to any precipitation event. AMC is characterized by the NRCS as:

AMC I Soils are dry

AMC II Average conditions

AMC III Heavy rainfall, saturated soil

A calibrated AMC value is used to properly convert the rainfall event's frequency of occurrence into the equivalent frequency of runoff event. The standard AMC assumption for a 20-year model is II, lying between heavily saturated and average conditions. AMC calibration for the design storm used in this study yields an AMC of I ½.

Curve numbers vary from 0 to 100, with a CN of 0 representing no runoff from a basin, and a CN of 100 meaning that all precipitation will run off. As shown in Section 3.2, pervious surface CNs were applied to the City's model based on land use and soil type. The area weighted CN for the pervious portion of each catchment is adjusted to AMC I 1/2 for use in the 20-year analysis. The impervious portion of the catchments were assigned a CN of 98.

4.5.2 Basin Lag

Lag times were initially calculated using the US Army Corps of Engineers lag equation. This equation uses basin length, shape, slope, and land use to estimate lag. Schaaf & Wheeler used the terrain model discussed in "Chapter 3: Data" to estimate basin flow paths and slopes.

GIS routines were used to determine basin centroids and centroid lengths. The resulting lag times were shorter than anticipated based on engineering judgment. The basin lag equation was adjusted by removing the D/2 term, where D equals the unit hydrograph duration, and adding 5 minutes (0.083 hour) to produce the following lag equation. Any lag times calculated below 10 minutes were raised to 10 minutes, which is a typical time used for roof to gutter flow time.

$$t_{lag} = (0.862) * 24 * N * \left(\frac{L * L_c}{\sqrt{S}} \right)^{0.38} + 0.083$$

where:

t_{lag} SCS basin lag (hours)

N watershed roughness (calculated per catchment)

L longest flow path from catchment divide to outlet (miles)

Lc length along flow path from a point perpendicular with the basin centroid to its outlet (miles)

S effective slope along main watercourse (feet/mile)

4.6 Model Calculations

MU pipe flow calculations require network data, operational data, and boundary data as input. Network data consists of the pipe network elements including nodes (manholes, outlets, and storage nodes) and links (pipes, culverts, and open channels).

Detailed analyses of peak storm water discharge are performed by the MU program, which also determines the flow condition in each drainage system element. The MU technical manuals may be referenced for a more detailed description.

4.6.1 Links

Parameters required to describe model links include the name of upstream and downstream nodes, pipe shape and dimensions, material or roughness, and upstream and downstream inverts.

Structural system elements are modeled as functional relationships connecting two nodes in the system or associated with one node in the case of free flow out of the system. Operational data consists of parameters that describe how these elements function in the network. Boundary data for the pipe flow computation can include any external loading, inflow discharges, water levels at interaction points with receiving waters, as well as the results of a run-off calculation.

Pipes are modeled as one-dimensional closed conduit links that connect two nodes in the models. The conduit link is described by a constant cross-section along its length, constant bottom slope, and straight alignment. Unsteady flow in closed conduits is calculated using conservation of continuity and momentum equations, distinguishing between pipes flowing partially full (free surface flow) and completely full (pressurized flow).

Most pipes within the City model are modeled as reinforced concrete pipe (RCP) with a Manning's 'n' of 0.015 or corrugated metal pipe (CMP) with an 'n' of 0.024.

4.6.2 Nodes

Parameters required to describe nodes include x and y coordinates of the node, a unique name, node type (junction, outlet, or basin), depth and invert levels, and water levels at outlets. Hydraulic losses at junctions (manholes, inlets, or intersections) can be significant in pressurized drainage systems. Losses can vary due to construction methods, condition, and shape. The MU Weighted Inlet Energy Method is used for this study.

4.6.3 Outlet Boundary Conditions

Pipe network outlets can be modeled with either a free outlet or a water surface elevation (fixed or variable with time) which captures backwater effects due to receiving water levels. The modeled system contains 22 nodes modeled as outlets. Mean higher-high tidal water surface elevation was used as the boundary condition.

4.6.4 Calibration and Validation

The hydrologic method used for this study is based on the study of Bryant Canyon for Monterey County where the AMC was calibrated to a value of I ½ for the 20-year storm event. Schaaf & Wheeler validated the method using the USGS stream gage on Big Sur River (11143000) and confirmed that this AMC value is appropriate for the City.

5 Evaluation of Storm Drain Systems

5.1 Overview

A performance and condition analysis of the City's storm drain system is the primary focus of the SDMP. This chapter:

- Describes the City's storm drainage facilities and known drainage system issues;
- Shows 20-year flooding depths predicted by the one-dimensional model;
- Details observed condition-related issues;
- Identifies and prioritizes improvement projects that alleviate or minimize flooding; and
- Identifies and prioritizes projects to fix condition-related issues and improve system reliability.

5.2 Prioritizing Deficiencies and Needed Capital Improvements

Storm drain systems in the City (both City-owned systems and those owned by others) convey the majority of storm water runoff toward the ocean through storm drain systems consisting of gutters, catch basins, pipes and channels.

Recommended improvements have been prioritized based on the results of the above process, combined with consideration of the anticipated severity of flooding at each location and the benefit/cost relationship of proposed improvements. The following color code is used to highlight project prioritization:

Priority	Description
High Priority	Projects under this category eliminate areas of 20-year flooding with significant depths, or address areas where City staff has indicated frequent and/or significant historical flooding issues. These projects improve conditions at locations with the deepest and longest-duration flooding situations.
Moderate Priority	These improvements are intended to contain most of the 20-year flooding within the street right-of-way. The duration and depth of flooding corrected by a moderate priority improvement is less than that of a high priority improvement.
Low Priority	Low priority improvements are aimed at containing the remaining 20-year flooding in the street right-of-way. The areas of flooding addressed by low priority projects are much smaller than those of moderate and high priority projects.

This chapter summarizes improvements to City-owned systems needed to achieve a level-of-service characterized by flooding no greater than street level for a 20-year event. Improvements have been grouped together to reflect projects that could feasibly be undertaken simultaneously. Project naming conventions use major street names where possible. Project names and unique numerical IDs assigned to each project identify improvements in maps and tables included in this SDMP.

5.3 Evaluation of Storm Drain Capacity

The conveyance capacity of Carmel's storm drain system was analyzed with current land use conditions during the 20-year design storm.

- Areas of notable flooding based on historic occurrences and results of the MU models are discussed.
- Improvement projects are recommended based on required additional flow capacity.
- Projects have been developed by upsizing existing pipes in the MU model until flooding is contained within the street right-of-way for the 20-year event.

It is impossible to entirely remedy every drainage issue throughout the City, due to local topography (for example, at minor "bathtub' areas that can occur in parking lots where private systems are not modeled). However, the majority of model-predicted flooding due to storm drain pipe system surcharge can be mitigated with the capital improvements proposed.

Figure 5-1 below shows the existing conditions for the City's storm drain pipes for the 20-year storm event as modeled in MU. Appendix A contains system profiles and more detailed model results.

5.3.1 Design Criteria

Based on initial discussion with the City, storm drain system improvements are designed in this SDMP such that the 20-year storm runoff would not be higher than the rim elevation at any location. Similar standards are common practice to prevent flooding during more frequent storm events and utilize street conveyance capacity and storage in large, less frequent events. This standard will form the basis of the SDMP effort and development of a CIP. It is important to note the lack of curb-and-gutter on many City streets reduces the system's ability to convey runoff.

While specifying a design standard such as conveyance of 20-year runoff is the most important element in governing the sizing of a system, a minimum pipe diameter and slope may also be established to reduce maintenance requirements through the life of the system. Where feasible, reinforced concrete pipe (RCP) with a minimum pipe size of 18 inches should be used. Setting such requirements helps to ensure that pipes remain clean and clear of blockage to the greatest extent possible.

A citywide model was developed to analyze the 20-year event for existing land use conditions and recorded soil conditions. The model revealed that a portion of the City's storm drain system does not meet the 20-year criteria while the 2020 SDMP showed the system did not have 10-year capacity throughout. While containing the 20-year below the street surface forms the foundation of this analysis in general, at certain project locations this standard is not necessarily economically feasible to achieve.

This does not necessarily mean that a standard should not be enforced on future construction. However, a CIP may deviate from the standard for several reasons (for example, utility conflicts that make meeting a standard prohibitively expensive).

5.3.2 System Evaluation

This SDMP focuses on the major conveyance components within the City. Therefore, not all of the City drainage infrastructure is in the models. The modeled drainage area is approximately

1.2 square miles. The modeled collection system within City limits consists of 271 pipe segments, 264 nodes, and 22 outlets. The project area has a total of 30,000 linear feet (5.7 miles) of modeled storm drain pipe. The CIPs identified from the system evaluation and summary of associated cost estimates are presented in Chapter 6.

5.3.3 Modeling Results

Based on modeling results (Figure 5-1), the following areas with potential inadequacies in the storm drain network were identified.

1. Area around Ocean Avenue and Junipero Avenue
2. Area near 5th Avenue and Torres Street
3. Area near 2nd Avenue and Torres Street
4. Rio Road and Mission Trails Park
5. Ocean Avenue and Mission Street
6. 2nd Avenue and Monte Verde

For each of the areas identified to have a potential deficiency in the storm drain network, a possible CIP was developed and verified using hydraulic modeling (Figure 5-2).

Figure 5-1: 20-year Existing Conditions Model Results

Figure 5-2: Capacity Projects

5.4 Known Nuisance Drainage Problem Areas

City staff and citizens have raised drainage concerns throughout the City (Figure 5-3). Appendix E contains detailed documentation. Locations of concern identified by City staff include:

1. Runoff overtops berm near 4th Avenue and Lincoln Street
2. Runoff overtops berm near 7th Avenue and Santa Rita Street
3. Runoff overtops berm and erodes beach in parking lot at the bottom of Ocean Avenue
4. Runoff bypasses inlets at 8th Avenue and Mission Street and ponds along Mission south of 8th Avenue
5. Runoff enters driveway on west side of Monte Verde Street near 3rd Avenue
6. Runoff bypasses inlets at 11th Avenue and San Antonio Avenue and overtops berm
7. Ponding and mud in driveway near 13th Avenue and Camino Real
8. Heavy street flow along Santa Fe Street south of Mountain View Avenue
9. Heavy street flow, ponding, and sediment along Lasuen Drive
10. Channel erosion in Forest Hill Park
11. Carpenter Street, 2nd to 3rd Avenues

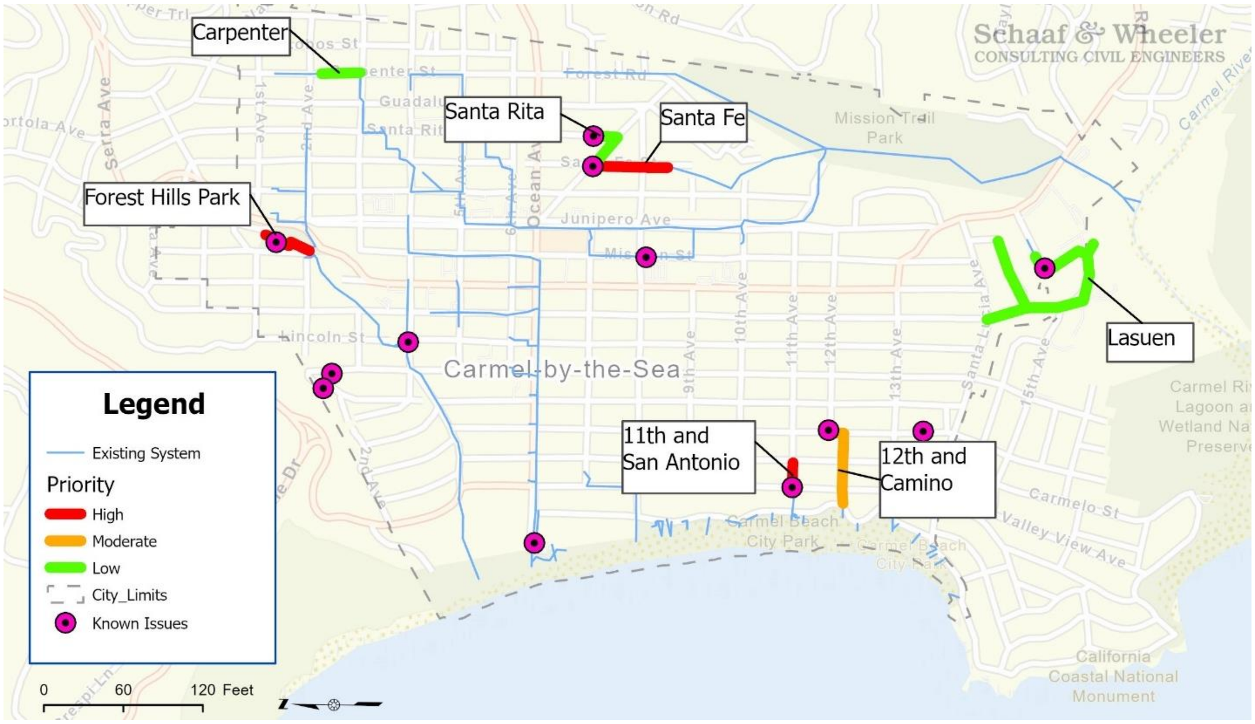


Figure 5-3: Known Nuisance Drainage Problem Areas and CIPs

5.5 Condition Assessment

5.5.1 Observations

Based on the field visits and CCTV most pipes were found to be in satisfactory condition except for a few lined pipes and some pipes with sedimentation detailed in Figure 5-4 and Table 5-1.

In the pipes and manholes that were not immediately upstream of an outlet, very little buildup of sediments or noticeable physical damage was observed. However, several inlets were blocked with sediment, particularly along Ocean Avenue. Some low-lying outlets were observed to contain a significant amount of sediment which reduces conveyance capacity.

Photographs of selected locations are presented in Appendix F. CCTV data shows several pipes with failing liners, standing water, debris, and sedimentation, and in a few locations damaged concrete.

5.5.2 Condition Improvements

Each pipe segment with noticeable condition related issues was assigned a repair priority. In most cases, cleaning and re-inspection is recommended. Select pipes will require more extensive improvements including spot repairs, lining, shoring and replacement. Capital projects related to condition are detailed in Chapter 6.

Figure 5-4: Observed Condition Issues

Table 5-1: Condition Issues

Location	Condition Problem	Priority
Santa Rita 1	Structural	High
Santa Rita 2	Damaged Liner	Moderate
Camino del Monte	Damaged Liner	Low
Ocean Avenue	Structural	Moderate
Dolores	Cracks	Low
Rio Rd	Sediment	Low

5.6 Prioritized Improvements

Six high priority projects (Figure 5-5) are aimed at reducing significant flooding in problematic areas and at carrying out short term condition improvements.

Eight moderate priority projects aim to reduce most flooding at the 20-year level of service and perform condition improvements at selected locations. Extending the City's system to alleviate drainage issues in certain neighborhoods is also included. The City may need to progressively re-prioritize moderate priority projects based on funding, other utility improvements, land use changes, and condition assessments.

Eight low priority projects are recommended to alleviate minor flooding and reliability issues. These projects are not likely to be constructed before the next SDMP update.

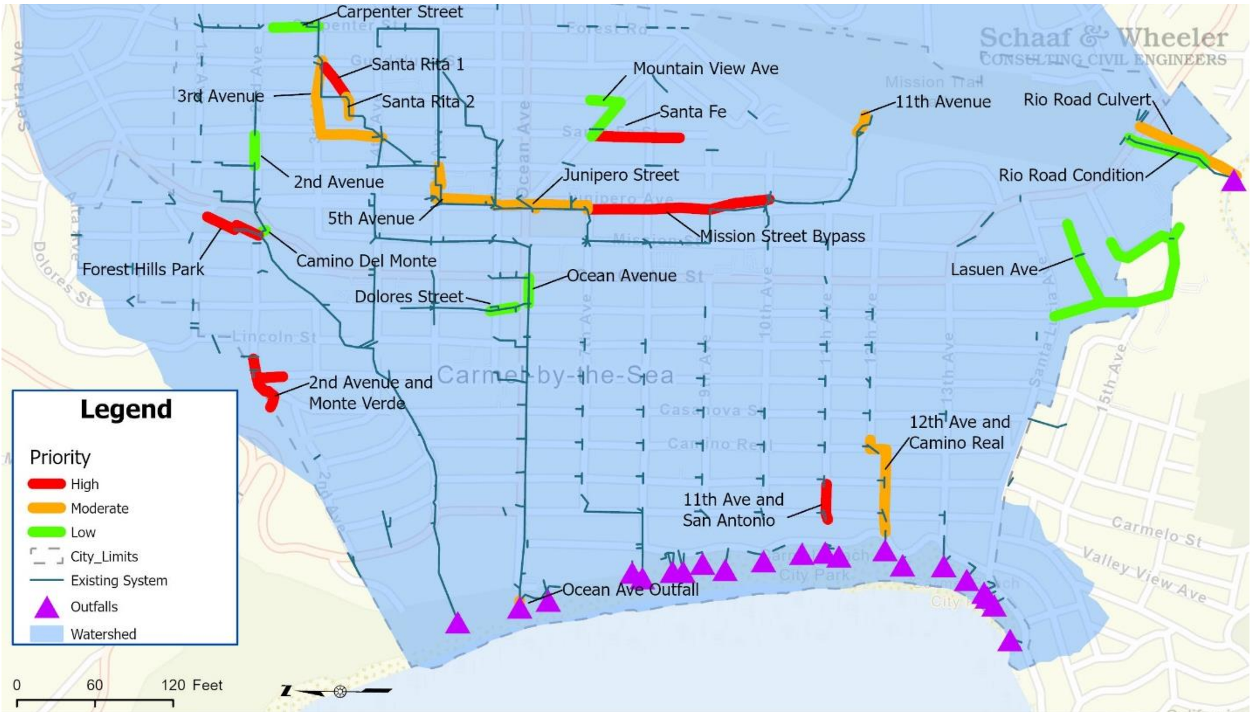


Figure 5-5: Prioritized CIP Projects

5.6.1 Annual Inspection of Pipes

CMPs typically are more susceptible to corrosion and damage compared to concrete pipes. Observations made during field inspections identified several CMPs in the City's storm drain system with visible damage and deformities. Several other pipes had varying levels of sedimentation. This project recommends performing continued CCTV video inspections. The CCTV inspections could potentially result in additional capital projects to repair the system.

5.6.2 Six High Priority Projects

The highest priority projects (Figure 5-5) are a combination of nuisance, condition, and capacity CIPs.

Mission Street Bypass – 7th to 10th Avenues
Modeling results indicate inadequacies along Junipero Avenue north of Ocean Avenue. There has also been observed flooding near 8th Avenue and Mission Street. This improvement adds a 36-inch RCHP bypass pipe and inlets along Junipero between 7th and 9th Avenues to provide more capacity and capture local runoff. Between 9th and 10th Avenue, the system will also need to be upsized with a parallel 24-inch pipe.

Santa Rita 1
The existing concrete box in an easement between Guadalupe Street and Santa Rita Street (between 3rd and 4th Avenue) has been bifurcated from the City system but may still convey local runoff. The CCTV inspection shows damage to the concrete in various locations, and there is concern the box could collapse. The alignment, based on GIS, indicates the box may be

under existing buildings and collapse could cause extensive damage. The proposed project will further identify the box alignment and reinforce the structure to minimize failure risks.

Forest Hill Park – Emergency Repair
The existing drainage channel through Forest Hill Park is becoming eroded in sections due to runoff scouring, threatening adjacent trees, and exposing a utility line. The City will need to develop a project to armor the channel, particularly surrounding the exposed utility line. Due to the exposed utility line, undermined trees, and biological significance, this is a high priority project and should be designed, permitted, and constructed immediately.

A separate moderate priority project to realign the channel through the park and into a detention basin will reduce downstream peak flows and better stabilize the channel.

2nd Avenue and Monte Verde Street
There are several drainage issues at the western end of 2nd Avenue near Monte Verde Street. This project will add a new 18-inch drainage system along 2nd Avenue with inlets at key locations. The system will connect to an existing outfall adjacent to 2507 2nd Avenue. A survey and condition assessment of the exiting outfall may be necessary. This project works in conjunction with the already proposed 1st and Lincoln drainage project and should be constructed simultaneously if practicable.

Santa Fe Avenue – Mountain View to Mission Trails Park
This project will add a new system along Santa Fe Street from Mountain View to Mission Trails Park. The new 18-inch system and inlets will reduce drainage issues at several locations.

11th Avenue and San Antonio Street
The existing system at 11th Avenue and San Antonio Street has limited inlet capacity. This project will extend the existing system along 11th Avenue to Carmelo Street with additional inlets. The project will reduce the overland flow at San Antonio and reduce drainage issues.

5.6.3 Nine Moderate Priority Projects

The moderate priority projects (Figure 5-5) are a combination of nuisance, condition, and capacity CIPs.

Rio Road New Culvert
The drainage system from Mission Trails Park out to the Carmel River is undersized for the 20-year event. Though this portion of the City is not densely urbanized, and the risk of damage is low, Rio Road is a key thoroughfare for the south end of the City. The proposed project would create a new 6-foot by 4-foot box culvert out to the Carmel River, and the culvert under Rio Road would be upsized to a 10-foot by 4-foot culvert. This project will likely require permitting for outfall changes.

Junipero – 5th to 7th Avenues
Modeling results indicate possible inadequacies around Junipero and Ocean. This improvement adds a parallel 30-inch system on the east side of Junipero Street between 5th Avenue and 7th Avenue. The proposed pipes provide more capacity for upstream flows and lowers the peak hydraulic grade lines (HGL). This project could be completed in conjunction with the Mission Street Bypass and 5th Avenue projects.

5th Avenue – Torres to Junipero Streets
Modeling results indicate possible inadequacies in the area near the intersection of 5th Avenue and Torres Street. This improvement adds a parallel 24-inch pipe to provide more capacity.

12th Avenue and Camino Real
The existing system at 12th Avenue and Camino Real has limited inlet capacity. This project will extend the existing system along Camino Real and down 12th Avenue with additional inlets. The project will reduce the overland flows and drainage issues.

11th Avenue at Mission Trails Park
Modeling results indicate possible inadequacies near the system outfall on 11th Avenue. This CIP will replace the existing open channel with a new 4-foot by 4-foot box culvert. The existing CDS unit and diversion weir will also need replacing.

Santa Rita 2
This section of the drainage network is HDPE CPP pipe and has several significant joint offsets and tares in the liner. This project will line the roughly 100-foot section.

Ocean Avenue Outfall
The Ocean Avenue outfall pipe is severely deformed and should be replaced. This project will replace the roughly 100-foot section with a new 24-inch fused HDPE line and upgrade the existing outfall. The existing CDS unit should also be replaced with a larger device. Newer trash removal technologies, such as nutrient separating baffle boxes (NSBB), may be more cost effective and easier to maintain than CDS units and should be vetted during the selection process. This project could be constructed in concert with water quality projects proposed by the City and will likely require permitting for outfall changes.

Forest Hill Park – Channel Realignment
The drainage channel through Forest Hills Park is unstable and very erosive. This project would realign the channel through the park. The existing low-lying field at the southern end of the park that floods regularly would be graded to better detain flows, capture sediment, and improve water quality. The new channel should be an enhancement to the park and work with the overall park plan. Public education, habitat enhancement, and recreation activities can be incorporated into the project design. Multipurpose projects have higher potential for grant funding and public approval.

3rd Avenue – Guadalupe to Santa Fe
This project would add an 18-inch bypass system along 3rd Avenue and Santa Fe Street. This would allow the existing system through private parcels to be abandoned in place. Additional inlets should be added at roadway sags and intersections.

5.6.4 Eight Low Priority Projects

The low priority projects (Figure 5-5) are a combination of condition and capacity CIPs that can be addressed as funding allows.

Carpenter Avenue – 2nd to 3rd Avenues
This project will add a new pipe along Carpenter Avenue between 2nd and 3rd Avenues where flows are currently conveyed overland.

Rio Road Condition
Heavy sediment under Rio Road has reduced the conveyance capacity of the outfall from Mission Trails Park to the Carmel River. This project will remove the sediment from both culverts and repair the bottom of the box culvert under Rio Road.

2nd Avenue at Torres Street
Modeling results indicate possible inadequacies in the area near the intersection of 2nd Avenue and Torres Street. This improvement replaces the street (gutter) flow on 2nd Avenue, between Torres and Santa Fe, with a new pipe. Additional inlets would also be added.

Lasuen Avenue System
Drainage along Lasuen Avenue near the Carmel Mission often creates nuisance ponding. There is no formal underground drainage network in this neighborhood and runoff is routed via roadside swales to the Carmel River. This project would add an 18-inch RCP line and inlets along Lasuen Avenue. Coordination with Monterey County may be necessary.

Camino del Monte Repair
The liner in the existing 30-inch HDPE CPP pipe at 2nd and Camino del Monte is separating. There are joint offsets along the 21-foot reach that should be repaired. Relining the pipe is advised.

Dolores Street and 6th Avenue
The existing 24-inch RCP pipe at Dolores Street and 6th Avenue has several cracks that require spot repairs.

Mountain View Avenue – Santa Rita to Santa Fe Streets
This project would add a new 18-inch pipe along Mountain View Avenue from Santa Rita Street to Santa Fe Street. Inlets would be added at both intersections. This project would connect to the proposed Santa Fe Street project and should be constructed at the same time if funding allows.

Ocean Avenue – Dolores to San Carlos Streets
The existing 18-inch RCP pipe on Ocean Avenue between Dolores Street and San Carlos Street needs to be upsized to a 21-inch pipe.

5.6.5 Ongoing Activities

Continued CCTV, Inspections, and Cleaning
The City should continue inspecting and cleaning the drainage system on a periodic basis. The locations of sediment and debris should be noted and tracked using GIS to identify long term trends. CCTV of the system should continue a regular basis with the entire system being inspected on a 15-year cycle.

5.6.6 Devendorf Park Detention Alternative

Adding underground detention storage at Devendorf Park has the potential to reduce downstream flows and reduce CIP project sizing and costs. The park's existing lawn area is roughly 10,000 square-feet. Assuming this area is available for underground storage units, there is the potential to store roughly 1-acre-foot of water underground. High flows at the intersection of Junipero Street and 6th Avenue would divert to the storage cells and then metered back to the system at the intersection of Junipero Street and Ocean Ave. Modeling shows an 8 cfs reduction in the 20-year flows along Junipero Street. This could allow for the elimination of the proposed 24-inch pipes along Junipero Street between 9th and 10th Avenues. This would also allow for the reduction of proposed pipe size along Junipero Street between Ocean and 7th Avenues to 24-inch (from 30-inch).

We estimate CIP savings of roughly $450,000. Underground storage units range from $300,000 to $400,000 per acre-foot not including site work. The estimated cost of the park storage, without significant park enhancements, is roughly $600,000. The cost-to-benefit ratio for this alternative does not make it attractive. However, if there are any future pack projects, underground storage should be considered.

5.7 Other System Components

5.7.1 Surface Drainage Systems

A large portion of the south side of Carmel lacks underground drainage networks. Rainfall runoff is mostly conveyed by asphalt swales and berms. At intersections, the flows are captured in cross-culverts to reduce ponding in the roadway. This system configuration is common in communities with lower density development wanting to maintain a semi-rural aesthetic.

Figure 5-6 maps the streets served by surface systems. Over time, these systems can experience a reduction in capacity and steepening of the swale from roadway surface overlays. The cross-culverts can pose a safety hazard to cyclists and pedestrians, and the steep swales can cause damage to parked vehicles. The flows at the downstream end of these systems can be quite large and difficult to capture into a drainage network.

Possible solutions for these systems are:

- Develop underground drain networks
- Reconfigure swale and berm shapes
- Incorporate Green Infrastructure practices
- Place grates over steep swales (Figure 5-7)
- Develop and implement new cross-culvert systems

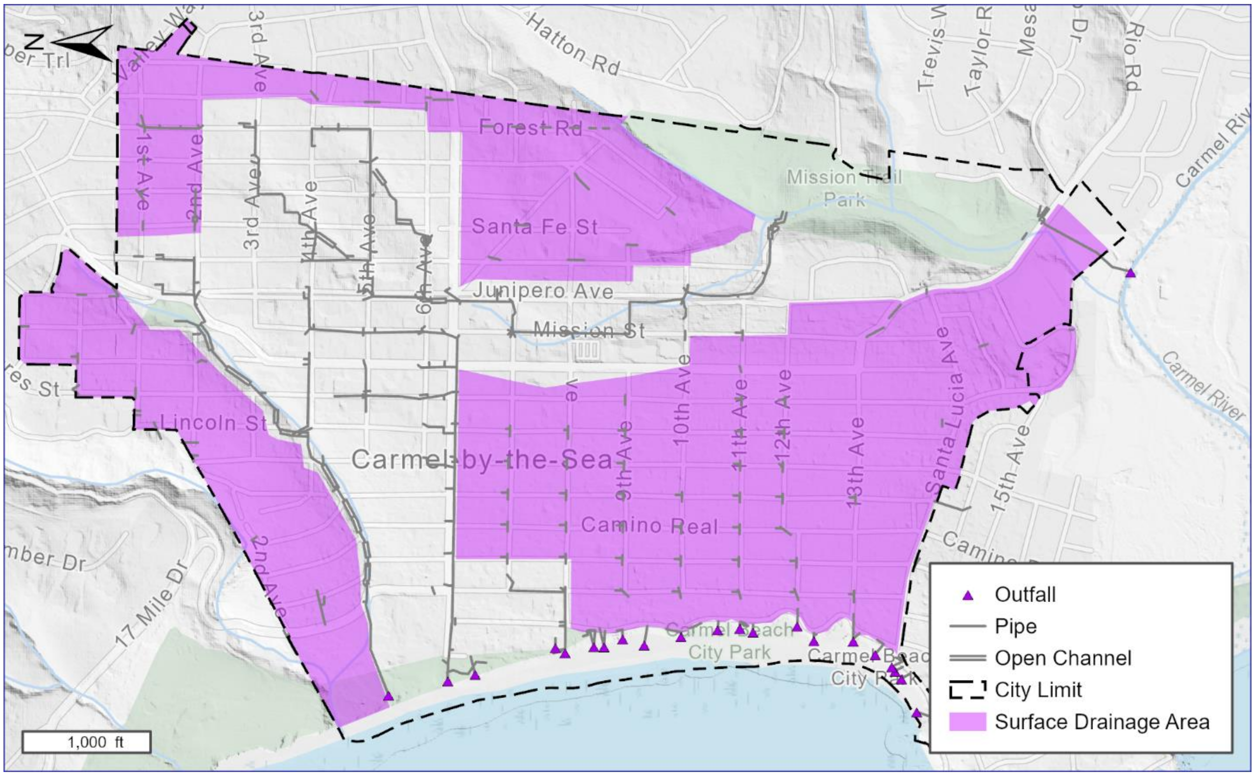


Figure 5-6: Surface Drainage Streets

5.7.2 Mission Trails Stream Stability

The channel that runs through Mission Trails Nature Preserve conveys a large portion of the City's runoff to the Carmel River. Portions of this channel are steep and erosive. A recent study (Appendix H) has identified several projects to stabilize the channel and enhance the riparian habitat. The 20-year flow rates from the Mission Trails study are close to the model results from this SDMP. The culvert under Rio Road is identified as a possible location to capture sediment. The projects identified in this study are included as low priority CIPs since they pose little threat of property damage. However, these projects have strong potential for grant funding due to their ecological benefits.

5.7.3 Southern Annexation

There is potential for the City to annex portions of the County Unincorporated area directly south of the city limits (Figure 5-8). This area was not included in the field data collection, condition assessment, or hydraulic modeling for this SDMP. Based on readily available data, most of this area lacks a formal drainage system and relies mostly on street conveyance. Portions of this area are subject to flooding from the Carmel River and may experience drainage issues related to backwater effects.

According to the proposed Ecosystem Protection Barrier (EPB), all floodwalls designed to protect low-lying properties could complicate drainage and require pumping to provide drainage protection. This area should be studied before annexation to determine potential drainage issues and possible capital projects.

Figure 5-7: Conceptual Street Improvement

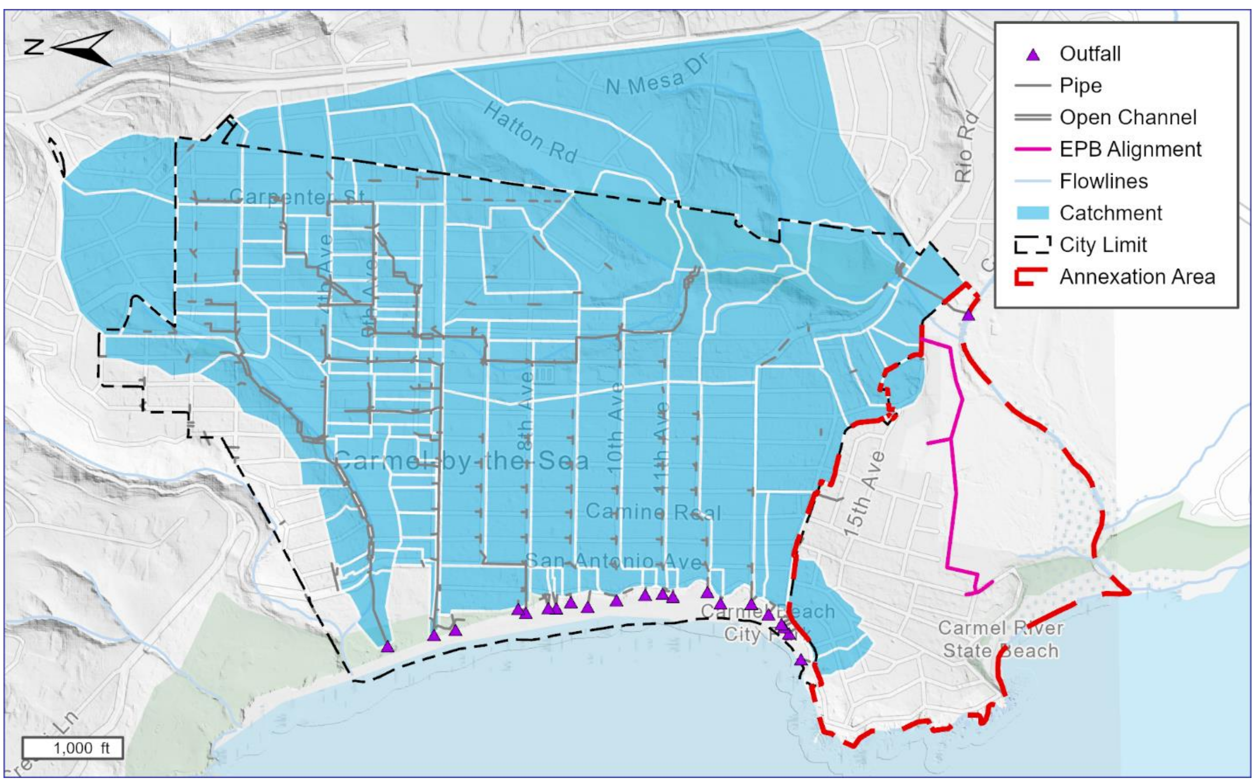


Figure 5-8: Southern Annex Area

5.7.4 Water Capture and Reuse

There may be potential projects in the city to capture stormwater runoff for reuse. There is an existing system along San Antonio Avenue that conveys wastewater from Pebble Beach to the Carmel Area Wastewater facility south of the city. Capturing stormwater runoff and conveying it through this system has the potential to reduce stormwater and pollutant discharges to Carmel Bay.

The systems that cross San Antonio Avenue could be connected to the return pipeline and discharge when the system has capacity. Adding storage elements to the City's drainage system could reduce peak runoff rates and allow for diversion to the treatment plant after the storm peak. See Figure 5-9.

One potential storage area is Devendorf Park. Underground storage could be added to the park as part of a redesign. See Section 5.6.5.

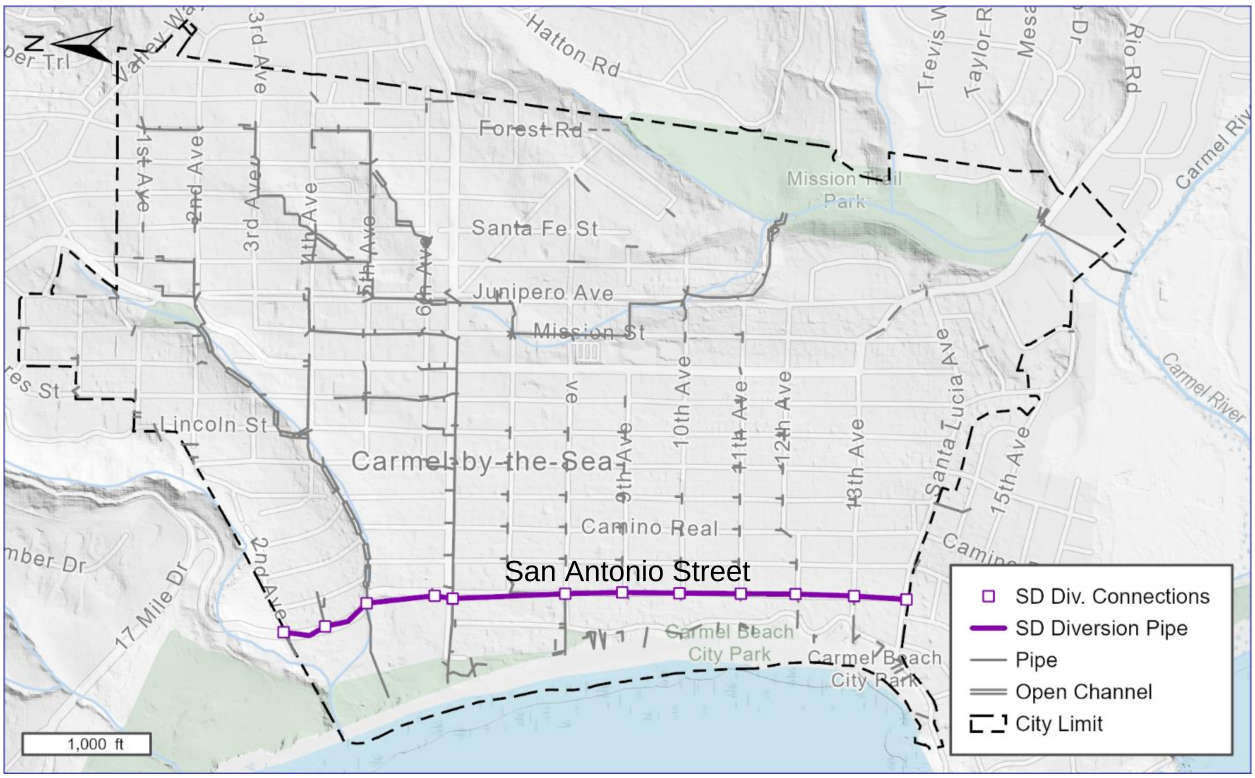


Figure 5-9: Water Capture System Layout

5.7.5 CDS Units

The City currently owns and operates four CDS units (Figure 5-10). These hydrodynamic separators help remove pollutants from the drainage system prior to discharging into Carmel Bay. Each CDS unit requires ongoing maintenance to remove captured pollutants and ensure proper operation. Currently, this effort is contracted for a fee of approximately $25,000 per year. Over time, the CDS units need replacement and NPDES permits could require additional units and/or newer technologies such as NSBBs.

Replacement of one unit should be included in near-term funding; the Ocean Avenue outfall CDS unit is the most likely to be replaced and should be completed with the outfall repair project.

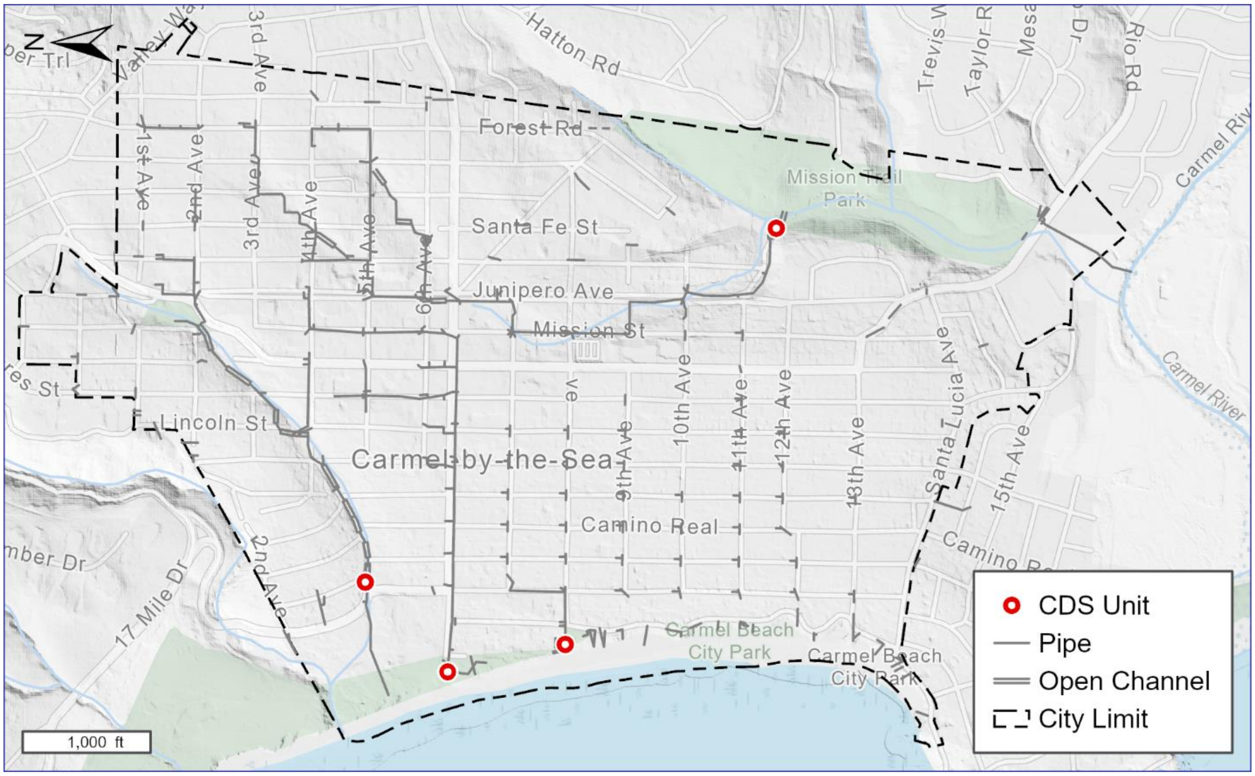


Figure 5-10: CDS Unit Locations

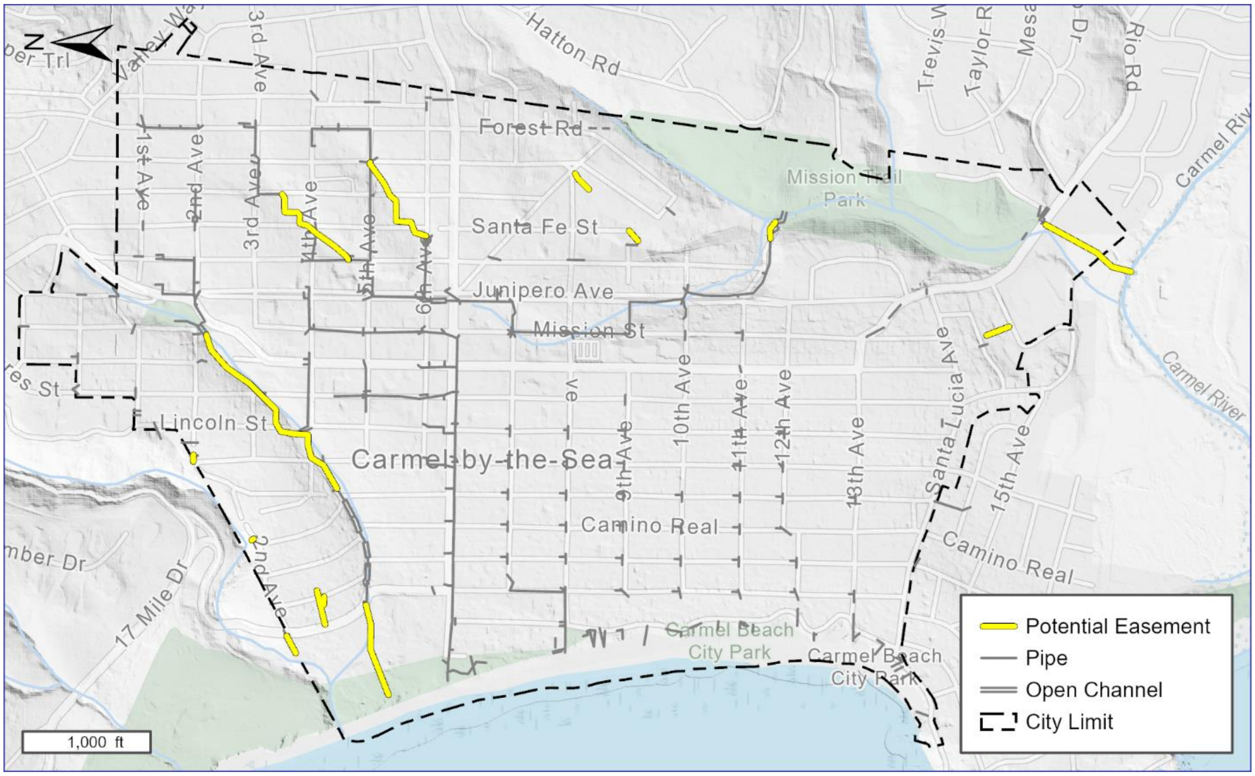


Figure 5-11: Potential Easement Location

5.7.6 Drainage Easements

Urban runoff is conveyed through private parcels throughout the city. Figure 5-11 maps known drainage systems on private parcels. The City should develop a program to acquire drainage easements for these systems as it is often assumed public stormwater conveyed through private lands is the responsibility of the local government to operate and maintain. Projects to redirect systems outside private parcels can also be developed.

5.7.7 Underground Rivers

Though most of the City's storm runoff is conveyed to formal drainage systems, there are naturally occurring underground rivers that convey water through the City's sandy soil. These rivers are typically non-ephemeral and convey runoff from large areas. Their path is typically directed by soil geology and can migrate over time.

Figure 5-12 maps the historic channels in the region and potentially the path of these underground streams. Underground flows can be a nuisance to buildings with basements and require sump-pumps to reduce flooding. Without an extensive hydrogeological study, it is difficult to know the exact path of these streams or to develop projects to reduce their impact on buildings.

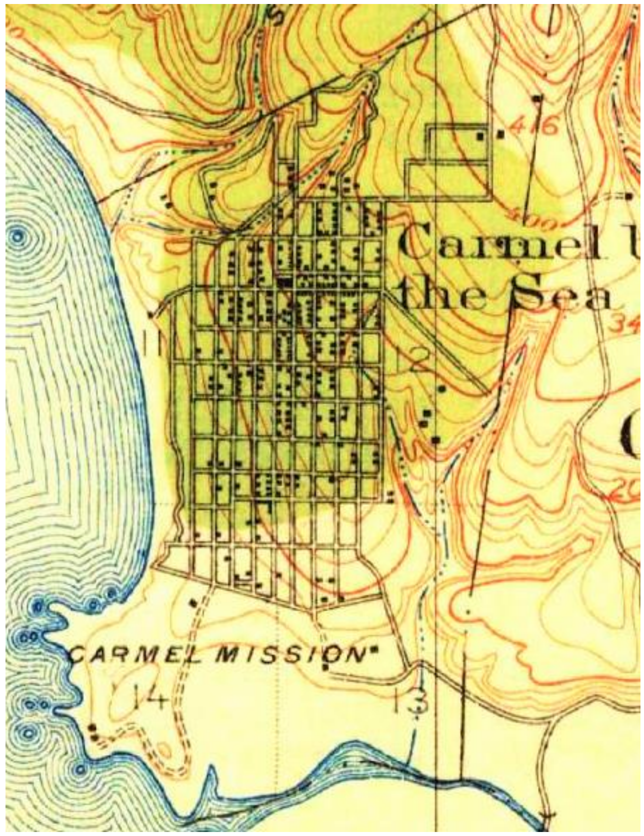


Figure 5-12: Historic Channels (1913)

5.7.8 Climate Change

The CIPs developed under this master plan are designed with climate change in mind. Climate change has the potential to modify rainfall patterns along the Pacific Coast. Though no one knows the exact impact of climate change on storm patterns, science has provided useful predictions. Cal-Adapt was developed to help engineers estimate the increase in precipitation in the future. These predictions have a high degree of uncertainty and should not be used to design current projects. However, they are helpful in long-term planning of drainage infrastructure.

Cal-Adapt estimates a 19-percent increase in the 24-hour 20-year storm event for the years 2034 – 2064 as shown in Figure 5-13. This program does not estimate the potential changes for shorter durations storms which are more impactful to Carmel, as the watersheds are small. We assumed the 19-percent increase is applied to all time steps in our design storm. That proposed storm was modeled with the City’s CIP (all proposed improvements) model to determine potential impacts.

The CIP projects developed under this scope of services would still provide a 10-year level-of-service to Carmel with the projected climate changes.

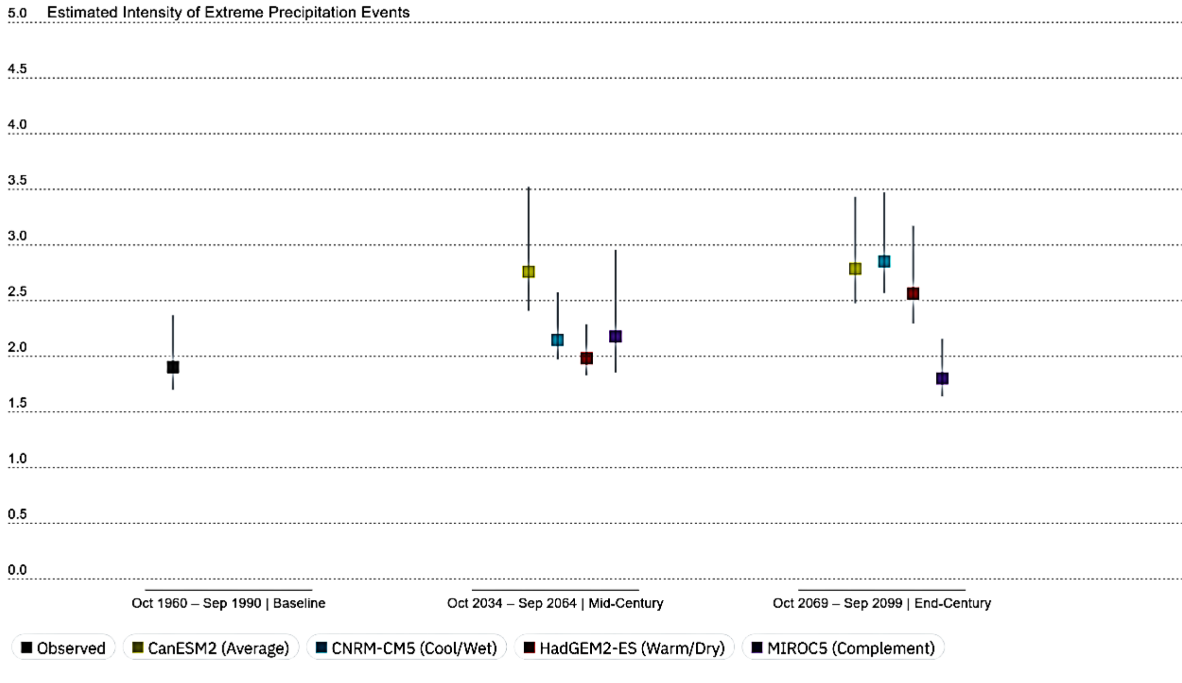


Figure 5-13: Cal-Adapt 1-Day Precipitation Estimates

6 Capital Improvement Plans

6.1 Summary of Findings

While there are many areas within the City that provide adequate stormwater conveyance for a 20-year event, there are also areas that would benefit from improvements to enhance stormwater conveyance capacity. There are also regions of the City that lack a formal drainage system and require improvements. There are approximately 30,000 feet of pipe in the City's storm drain system that should be periodically inspected via CCTV for condition assessment.

Improvements are recommended for the City's storm drain system's performance to ensure level-of-service during a 20-year storm. The improvements recommended in this SDMP should be considered a comprehensive CIP within the study area.

6.2 Overview

Chapter 5 discusses the City's storm drain collection system and recommends prioritized capital improvements to address known and modeled deficiencies. This chapter provides a CIP that recognizes these priorities. The CIP provides an overall guideline for the City to use as a tool in preparing annual budgets. Exigent circumstances and future in-field experiences may necessitate deviations from the Storm Drain CIP. An SDMP is intended to be a tool for planning. Capital improvement priorities are not intended to be hard and fast.

The CIP assumes that the discussed capital improvements are not partially funded or planned for implementation. The CIP also does not include the cost of new facilities related to new development (e.g., pipeline extensions to serve areas that are currently undeveloped). These new facilities may be constructed as part of the new developments and are not included in the CIP.

6.3 Capital Improvements Priorities

Assuming that the continued CCTV video inspection of the system will be carried out over five years, the annual cost for video inspection is estimated to be $16,000.

The remaining proposed CIP for storm drainage in Carmel-by-the-Sea is broken into three priority levels for the purpose of funding and implementation. The total cost summary for CIP projects is shown for each priority level in Table 6-1.

Table 6-1: Summary of CIP Costs Based on Priority Level (Total Project Cost)

Priority Level	Cost
High Priority Capital Improvements	$3,690,000
Moderate Priority Capital Improvements	$7,680,000
Low Priority Capital Improvements	$3,330,000
Total Capital Improvement Program	**$14,700,000**

The above costs include a 20% contingency for design, administration, and 20% for construction contingencies.

6.4 Cost Basis for Improvements

Costs have been estimated using information from other projects, other master plans, and engineering judgment. The cost per linear foot of improvement used for the pipe cost estimates are given in Table 6-2, and most projects assume replacement pipe is installed using the open trench method (note that these costs do not include the cost of design, administration, permitting, land acquisition, and other unforeseen special circumstances).

Costs are likely to vary greatly depending on site specific circumstances and the economic climate at the time of bidding; in some cases, it may be more practical to use trenchless methods or a parallel pipe for construction. These cost estimates are also based on larger scaled projects. Therefore, the replacement of shorter lengths of pipe as individual projects may incur significantly higher costs due to the nature of construction work.

Cost estimate of replacing connections (manhole or catch basin) depend on connecting pipe diameters and range from $22,100 (18-inch pipe) to $23,500 (36-inch pipe). CCTV video inspection costs were estimated to be $2500 per day. Since most of these improvement projects are expected to qualify for negative declarations from permitting agencies, these costs do not include permitting or any environmental documentation. Unit costs for pipes and connections assuming four feet of pipe cover are shown in Table 6-2.

Table 6-2: Storm Drain Replacement Unit Costs for Pipes and Connections

Diameter (inches)	2023 Rate	
	Per linear foot of Pipe[1]	Per Connection[1]
18	$490	$22,100
24	$610	$22,600
30	$770	$23,000
36	$910	$23,500
4’ x 4’ Concrete Box	$2,000	
10’ x 5’ Box Culvert	$10,000	

[1]Dollar amounts rounded to the nearest ten. Includes construction contingencies (40%).

Note: These costs do not include increases for design, administration, and unforeseen special circumstances. Unit costs are based on an average of 4-feet of ground cover over the pipe. Greater cover will raise estimated costs.

6.5 Capital Improvement Program

6.5.1 Annual Inspection of Pipes

The City should CCTV the nearly 30,000 feet of storm drain. Portions of the system could be inspected every few years with the entire system being inspected over a 20-year span.

6.5.2 Annual System Maintenance

The City currently consulted cleaning for the drainage system and permit compliance. This work includes removing debris from the four (4) CDS units and numerous inlets. The City should continue these efforts along with the additional locations identified under this study.

6.5.3 Storm Drain Improvement CIP

The CIP costs priority levels are summarized in Table 6-1. Detailed project sheets with required replacement pipe for high and moderate priority CIPs are included in Appendix D.

Table 6-3: CIP Projects for the City of Carmel-by-the-Sea

Priority	Asset Name	Estimated Cost[1]
High Priority	Mission Street Bypass – 7th to 10th Avenue	$1,630,000
	Santa Rita 1	$280,000
	Forest Hill Park – Emergency Repair	$130,000
	2nd and Monte Verde	$980,000
	Santa Fe Street – Mountain View to Mission Trails Park	$410,000
	11th and San Antonio	$260,000
	High Priority Total	**$3,690,000**
Medium Priority	Rio Road Culvert	$2,970,000
	Junipero Street – 5th to 7th Avenues	$910,000
	5th Avenue – Torres to Junipero Streets	$560,000
	12th Avenue and Camino Real	$480,000
	11th Avenue at Mission Trails Park	$630,000
	Santa Rita 2	$200,000
	Ocean Ave Outfall	$320,000
	Forest Hills Park - Realignment	$700,000
	3rd Avenue – Guadalupe to Santa Fe Streets	$910,000
	Medium Priority Total	**$7,680,000**
Low Priority	Carpenter Avenue – 2nd to 3rd Avenues	$260,000
	Rio Road Cleaning	$210,000
	2nd Avenue at Torres Street	$340,000
	Lasuen System	$1,730,000
	Camino del Monte Repair	$50,000
	Dolores and 6th Avenue	$50,000
	Ocean and Mission	$280,000
	Mountain View - Santa Fe to Santa Rita Streets	$410,000
	Low Priority Total	**$3,330,000**
Grand Total		**$14,700,000**

[1]Includes Contingencies (40%). 2023 Construction cost only. Construction cost includes mobilization, traffic control, trench, and surface restoration. Does not include costs associated with permitting, land acquisition, or other unforeseen special circumstances.

7 Financial Analysis and Funding Strategies

This chapter presents the funding strategies and their implications that are available to the City to fund capital projects for the stormwater system. The findings presented in this chapter represent a high-level overview of the financial condition of the City's Stormwater Program and potential impacts to the General Fund and/or property owners. Financial plans and levy/fee options should not be implemented without the specific analysis and justification required by statutory obligations for the revenue mechanism the City selects.

7.1 Summary of Findings

This chapter finds:

- The City of Carmel-by-the-Sea, like many California cities, faces increasing expenditures to fulfill mandated obligations and community expectations associated with its Stormwater Program.
- The Stormwater Program has historically been supported by the General Fund. However, the projected cost of these expenditures in a time of increasing demands on the City's General Fund warrants the consideration of a dedicated revenue stream.
- Over the next 10 years, the Stormwater Program could invest approximately $2 million to improve or construct capital infrastructure. These investments, while ordered in a prioritized manner, could occur in an uneven pattern from year to year.
- Over this 10-year period, the Stormwater Program is also projected to spend approximately $30,000 annually (in 2020 values) on maintenance in problem spots in the system.
- CCTV inspection of the entire system should be completed over a 15-year cycle with inspections occurring every three years. The annual cost would be $5,000.
- This annual revenue stream can be generated through an annual levy on properties ranging from an estimated $25 to $100 per equivalent dwelling unit[7] per year. Further studies are recommended to refine these numbers and to establish Land Use based fees.
- While multiple levy/fee mechanisms are available to create a dedicated revenue stream from properties in the City, some form of direct property owner or voter approval of the fee will be required. The City will need to determine the political feasibility of this new funding source, in addition to preparing the formal justification and documentation of the selected levy/fee mechanism.

Other minor revenue streams may also be developed which would reduce the annual levy on property owners. These might include fees for specific operational or regulatory tasks and/or mitigation fees from new development or redevelopment that impact the stormwater infrastructure.

7.2 Introduction

This chapter has been prepared following a "revenue requirements" analytical methodology common to financial analyses underlying most utility rates and charges imposed by traditional utilities, similar to the sanitary sewer systems. While California law does not enable municipalities to impose "utility rates" for stormwater management services, the Stormwater

[7] An equivalent dwelling unit is equal to a typical single-family residential parcel.

Program shares similarities to traditional utilities and will likely require a primary, dedicated revenue source akin to rates.

The Stormwater Program includes long-term capital financing requirements to fund equipment, infrastructure, and problem-spot maintenance projects and will eventually have ongoing operations, maintenance, administration, and regulatory obligations to fund. Properly managing the Program may also require establishing reserves and using debt financing. Therefore, the following analyses have been prepared:

- Evaluation of financing strategies for the capital improvement program;
- Projected debt proceeds and debt service payments;
- Analysis of cash and reserve requirements; and
- Determination of net annual revenue requirements for the program.

7.3 Potential Revenue Sources

In establishing a dedicated revenue stream for the Stormwater Program, the City will likely want to pursue a property-related fee or a special tax. The political feasibility of these mechanisms will likely be critical factors in determining which one the City implements.

7.3.1 Property-Related Fee

A property-related fee is a fee for service attributable to the parcel being charged. A fee for stormwater services is levied upon the County tax roll and is imposed as an incident of property ownership. As such, it would be subject to the substantive and procedural requirements of California Constitution Article XIII D (known commonly by its enacting ballot measure: Proposition 218). The fee must be submitted and approved by a majority vote of the property owners or by a two-thirds vote of the electorate.

The amount charged to each parcel must be proportional to the cost of service attributable to that parcel. Due to this proportionality requirement, the costs attributable to public parcels should be paid by City revenues (e.g., General Fund appropriation) or by individual City departments.

For a property owner election, each parcel generally receives one ballot, and each ballot has one vote regardless of the potential levy amount, although the City may also have the power to provide for weighted voting. In one-parcel-per-vote elections, a large commercial parcel with a calculated levy that is an order of magnitude greater than that of a smaller parcel would have the same, single vote as the smaller parcel.

The revenue stream from a property-related fee may be used for capital, annual operating, and maintenance costs. This revenue stream could also be pledged as credit support for a revenue bond issued to fund major capital improvements.

7.3.2 Special Tax

A Community Facilities District (CFD) can be formed pursuant to the Mello-Roos Community Facilities Act of 1982. A CFD can fund capital projects as well as ongoing maintenance. Bonds would be issued to pay for capital costs secured by a special tax levy. The same CFD can also fund ongoing maintenance costs through a special tax levy.

There is great flexibility in both the geographic area to be levied and the formula by which to levy when using a CFD. A CFD may include non-contiguous geographic areas. There is no requirement that the special tax be apportioned based on benefit to any property. Property owned by a public entity is generally exempt from the CFD special tax, ensuring no lingering obligation of other City revenues.

Successful creation of a CFD requires approval of two-thirds of the registered voters voting in an election. With a voter election, each voter has one vote, regardless of their weighted share of the proposed special tax levy. In a landowner election, the vote is one vote per acre or portion thereof.

7.4 Other Sources of Revenue

Although the revenue strategy introduced in this chapter has estimated the full cost to property owners of funding the entire Stormwater Program, there are at least two other additional revenue sources that, if justifiable and collectible on a substantive scale, would reduce that final levy amount needed from the community, or in other words, the total revenue requirement. The chief benefit of examining the viability of these revenue sources is that both may be approved by consensus of the City Council alone after proper public noticing and public hearing processes.

7.4.1 Development Impact Fees

A development impact fee is a one-time fee imposed as a condition of approval on new development, infill, or redevelopment that creates new, unmitigated impermeable surface area. Development impact fees are authorized by Government Code 66000 et seq., created by the Mitigation Fee Act, and commonly referred to as “AB 1600” fees.

A development impact fee may be justifiable for the Stormwater Program under one of two conditions:

- The City has previously invested in Stormwater infrastructure which has remaining value and is available and/or sized to meet impacts caused by future development/ redevelopment.
- The capital projects documented in this SDMP are sized to meet stormwater related impacts caused by future development/redevelopment and not just the demands of existing development.

An impact fee may be based on (1) a “buy-in” to existing infrastructure, or (2) the “incremental” costs of new facilities necessary to serve new development that will create additional impermeable surface areas. A combination of these two impact fees may also be used to repay existing customers for historical capital investments. However, they cannot be used to fund operating or maintenance costs, which must be met through the Stormwater Program’s annual fees.

7.4.2 Regulatory Fees

Regulatory fees are imposed to recover costs associated with the City’s constitutional and statutory power to govern activities, such as development and construction. For example, within the Stormwater Program, the City provides services/activities that may be eligible for recovery in a regulatory fee. These services/activities may include:

- Plan review and site inspection of development/construction that must meet Stormwater Program regulations (a common area for stormwater program activity is grading and drainage permitting/oversight);
- Review of maintenance plans for, and periodic site inspection of onsite stormwater management/mitigation facilities; and
- Inspection of properties documented under the municipal permit as high-pollution risk operations requiring onsite management and/or facilities to mitigate risk to the environment and public rights-of-way.

The statutory limit in imposing these fees is that they may not exceed the estimated reasonable cost of service. Most regulatory fees like these have historically been implemented by consensus of the City Council alone. Data used to justify fee amounts must be prepared and made available to the public in advance of the public hearing.

7.4.3 Benefit Assessment District

A benefit-assessment district assigns project costs in direct proportion to the benefits received. Benefit assessment districts are often formed for specific projects within a specific watershed. The only properties assessed are those that directly benefit from the projects and in direct proportion to that benefit.

7.4.4 Grants

There are grant opportunities for stormwater, flood control and climate adaptation projects in California. These grants are competitive and require a good deal of effort to secure. If the City wishes to pursue grant opportunities, it is recommended they secure a grant writer or dedicate significant staff time to the application process.

7.5 SB 231

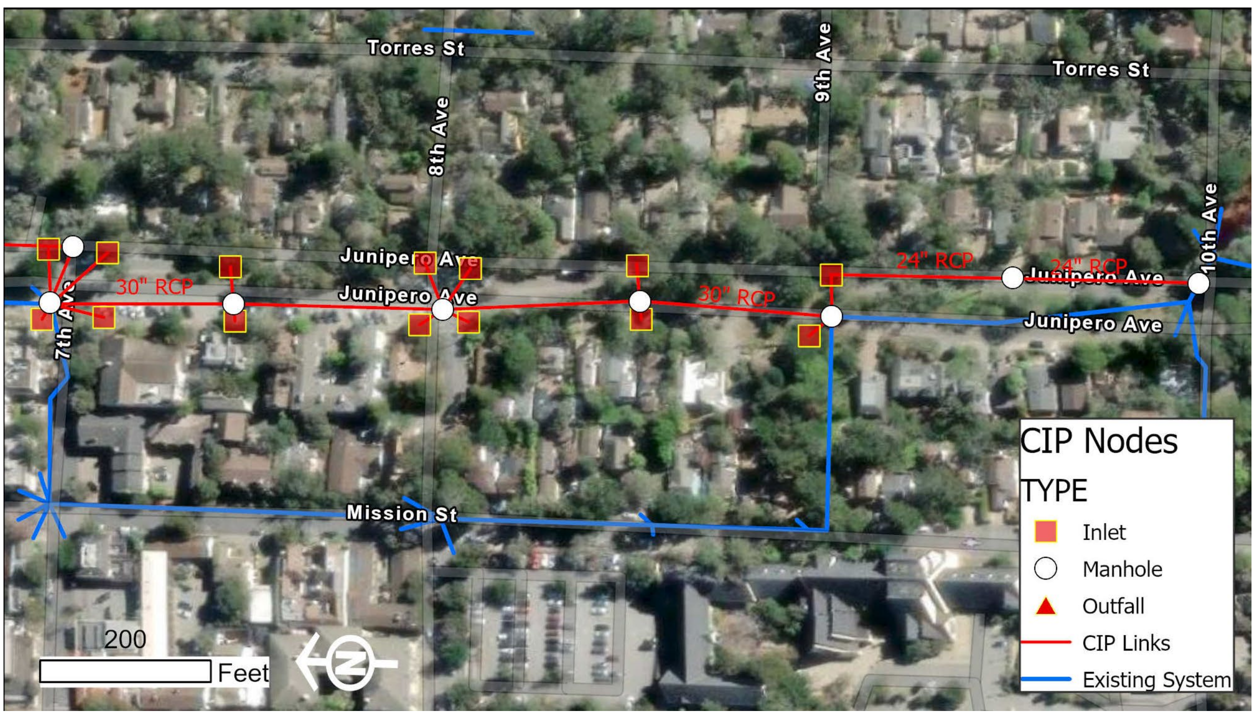
The 2017 passage of Senate Bill 231 by the California legislature has defined “sewer” to include “storm waters.” While this legislation appears promising for simplifying the storm drain fee process, it has yet to be successfully utilized by any municipality. The likelihood of this bill being challenged in court is very high and many cities and counties are awaiting a court decision before relying on SB 231 to form or modify a storm drain fee without voter approval.

Project Name:	Mission Street Bypass
Project ID:	1
Priority:	High
Cost:	$1,630,000

Project Description: There is currently recurring drainage issues along Mission Street between 8th and 9th Avenue. There is also a capacity constraint in the existing storm drain that services the eastern portion of the City. This project would add a 36-inch bypass along Junipero Avenue between 7th and 9th Avenue to reduce the hydraulic gradeline in the system. A new parallel 24-inch pipe would also be added between 9th and 10th Avenue. Several inlets will be added to the system to divert runoff from reaching Mission Street. Additional inlets and curb configurations along Mission Street may be necessary.

Item	Length (ft)	New Diameter (inches)	Pipe Unit Cost	Pipe Cost	Manholes/ Inlets	Manhole/Inlet Cost	Total Cost[1]
Bypass Main	915	36	$910	$833,000	5	$23,504	$950,000
9th to 10th Ave	420	24	$606	$255,000	3	$22,558	$322,000
Inlets/Laterals	550	12	$395	$217,000	14	$10,000	$357,000
	1,885				**22**		**$1,630,000**

1. 2023 Construction cost with 40% contingency.



Project Name:	Santa Rita 1
Project ID:	2
Priority:	High
Cost:	$280,000

Project Description: The abandon box culvert between Santa Rita Street and Guadalupe Street runs through an easement and likely under existing structures. Though this culvert no longer conveys upstream flows, it may capture local runoff. CCTV inspection shows significant deterioration, cracking, and upheaving of the concrete within the box that needs to be addressed. Since this culvert may be underneath existing structures, it should be considered a high priority improvement. Possible solutions include open trench replacement, sliplining, and cured-in-place treatments. Further investigation of the pipe alignment and easements will help determine the appropriate action.

Item	Length (ft)	Pipe Unit Cost	Total Cost[1]
Survey/Engineering	110	LS	$60,000
Pipe Repair	110	$2,000	$220,000
Total	**110**		**$280,000**

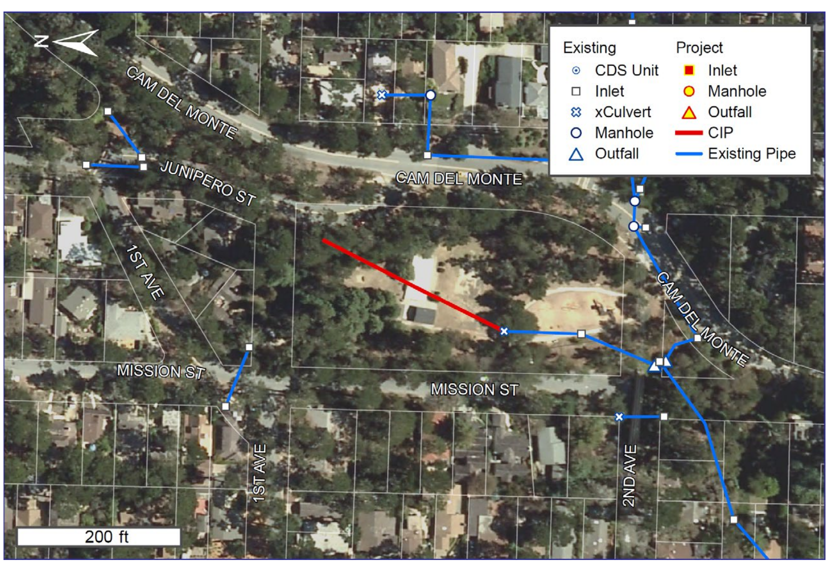
1. 2023 Construction cost with 40% contingency.

Project Name:	Forest Hill Park – Emergency Repair
Project ID:	3
Priority:	High
Cost:	$130,000

Project Description: The natural channel running through Forest Hill Park is severely eroded due to channel scour. An existing utility (sanitary sewer or water) line has been exposed and poses a threat to this area of biological significance. This project would repair the damaged channel sections and reduce the possibility of future damages. Adding rock protection between the concrete lined channel to a drop structure downstream of the utility line will provide temporary channel stability. A long-term channel stability and enhancement project should be developed to reroute the channel into a detention basin to reduce downstream flows and scour potential.

Item	Length (ft)	New Diameter (inches)	Pipe Unit Cost	Pipe Cost	Manholes/ Inlets	Manhole Unit Cost	Total Cost[1]
Rock Protection	100		$500	$50,000			$70,000
Engineering							$15,000
Permitting							$15,000
Mitigation							$30,000
	100						**$130,000**

1. *2023 Construction cost with 40% contingency.*

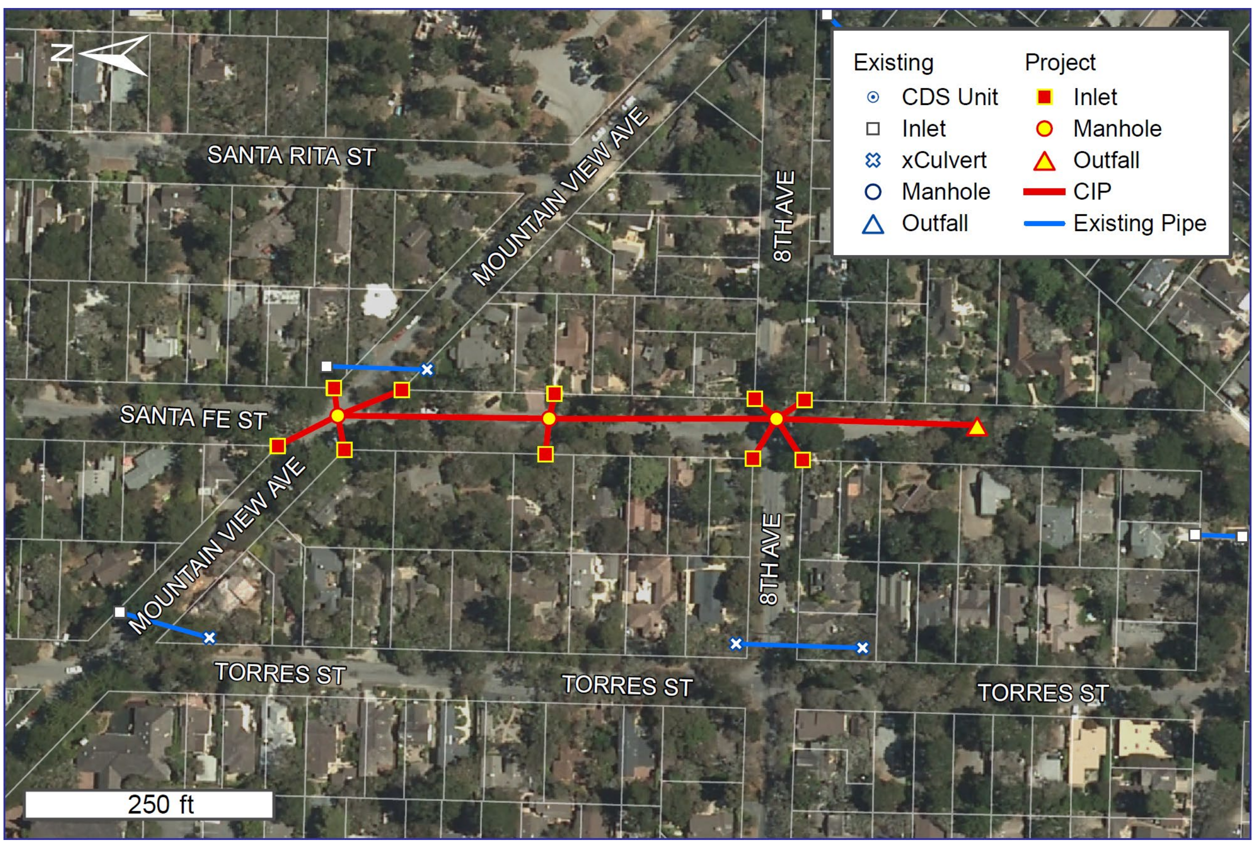



Project Name:	Santa Fe
Project ID:	4
Priority:	High
Cost:	$610,000

Project Description: The intersection of Mountain View Avenue and Santa Fe Street has experienced drainage issues. This region of the City lacks a formal underground drainage network. This project would create a new 18-inch system along Santa Fe Street from Mountain View Avenue to an outfall south of 8th Avenue. New inlets would be added at the intersections of 8th Avenue and Mountain View Avenue along with key locations along the alignment.

Item	Length (ft)	New Diameter (inches)	Pipe Unit Cost	Pipe Cost	Manholes/ Inlets	Manhole Unit Cost	Total Cost[1]
Replacement Pipe	640	18	$490	$314,000	3	$22,085	$380,000
Inlets/Laterals	250	12	$395	$99,000	10	$10,000	$199,000
Outfall					1	$30,000	$30,000
	890				**14**		**$610,000**

1. *2023 Construction cost with 40% contingency. Outfall permitting not included.*



Project Name:	11th and San Antonio
Project ID:	5
Priority:	High
Cost:	$500,000

Project Description: The existing inlets along 11th Avenue, east of San Antonio Avenue, do not capture the high velocity valley gutter flows effectively. This project would extend the drainage network east along 11th Avenue to capture runoff upstream. Inlets would be added at the intersection of 11th Avenue and Carmelo Street, 11th and San Antonio, and along 11th Avenue. The system currently utilizes a walkway easement west of San Antonio Avenue to convey flows to an inlet on Scenic Road. This overland flow would be replaced with a 24-inch pipe.

Item	Length (ft)	New Diameter (inches)	Pipe Unit Cost	Pipe Cost	Manholes/ Inlets	Manhole Unit Cost	Total Cost[1]
Replacement Pipe	450	24	$606	$273,000	3	$ 22,558	$341,000
Inlets/Laterals	200	12	$395	$79,000	8	$10,000	$159,000
	650				**11**		**$500,000**

1. *2023 Construction cost with 40% contingency.*

Project Name:	2nd and Monte Verde
Project ID:	6
Priority:	High
Cost:	$520,000 ($800,000 with Lincoln/2nd)

Project Description: The area of 2nd Avenue and Monte Verde Street has experienced various drainage issues. There is no formal underground drainage system in this area and relies on streets to convey runoff to Pescadero Canyon. This project would add an 18-inch RCP system along 2nd Avenue from Monte Verde Street to an existing outfall west of Monte Verde Street. A new pipe along Monte Verde would also be included. Inlets at intersections and key locations along the alignment will be included to capture runoff. The outfall may need rehabilitation or modifications. If funding is available, this project should incorporate the improvements proposed along 2nd Avenue and Lincoln Street.

Item	Length (ft)	New Diameter (inches)	Pipe Unit Cost	Pipe Cost	Manholes/ Inlets	Manhole Unit Cost	Total Cost[1]
Replacement Pipe	450	18	$490	$221,000	4	$ 22,085	$309,000
Inlets/Laterals	150	12	$395	$59,000	7	$10,000	$163,000
Outfall					1	$50,000	$50,000
	600				**12**		**$520,000**
Lincoln/2nd	425	18	$490	$208,000	7	$10,000	$280,000

1. *2023 Construction cost with 40% contingency. Outfall permitting not included.*

Project Name:	Junipero
Project ID:	7
Priority:	Moderate
Cost:	$850,000

Project Description: The existing drainage system along Junipero Street between 6th Avenue and 7th Avenue is undersized to convey the 20-year event. Adding a parallel 30-inch system will lower peak stages during large storm events. Diversions to future underground storage at Devendorf Park could be built into the design of this project. If funding allows, this project could be built in concert with the downstream Mission Street Bypass project or the upstream 5th Avenue project. If necessary, adding additional inlets along Junipero Avenue could improve local drainage.

Item	Length (ft)	New Diameter (inches)	Pipe Unit Cost	Pipe Cost	Manholes/ Inlets	Manhole Unit Cost	Total Cost[1]
Replacement Pipe	755	30	$773	$584,000	4	$23,031	$676,000
Inlets/Laterals	300	12	$395	$119,000	5	$10,000	$169,000
	1,055				**14**		**$850,000**

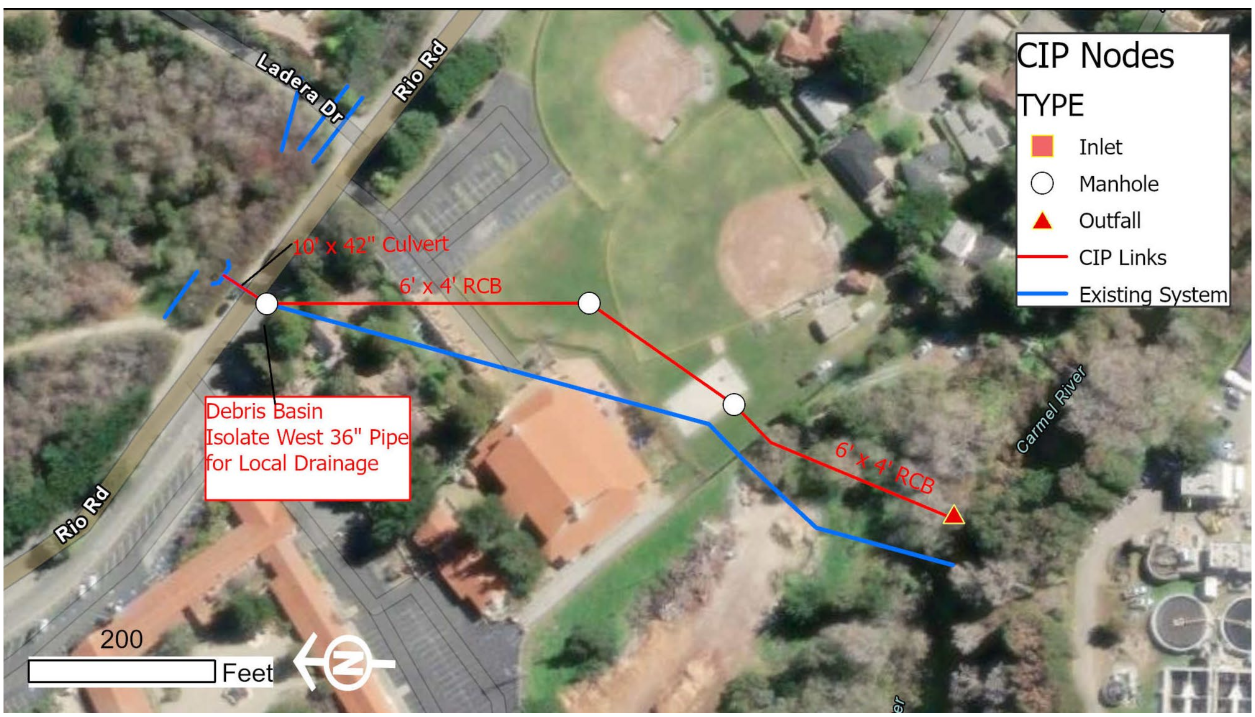
1. 2023 Construction cost with 40% contingency.

Project Name:	Rio Road 1
Project ID:	8
Priority:	Moderate
Cost:	$3,240,000

Project Description: The Mission Trails Channel outfall to the Carmel River is currently undersized to convey the 20-year event. The combination of undersized pipe culverts and the low-lying crossing at Rio Road make this area at risk of flooding. The proposed project would replace the Rio Road culvert (currently a 48-inch by 42-inch box) with a 10-foot wide by 42-inch high box culvert. Downstream of the Rio Road the system would consist of new parallel 6-foot by 4-foot RCB. Due to the heavy siltation at the downstream end of this watershed, the project should incorporate sediment management mechanisms to reduce future sediment buildup.

Item	Length (ft)	New Diameter (inches)	Pipe Unit Cost	Pipe Cost	Manholes/ Inlets	Manhole Unit Cost	Total Cost[1]
Rio Road Culvert	55	10’x3.5’	$14,000	$770,000	0	$19,500	$574,000
RCB	800	6’x4’	$2,800	$2,240,000	5	$25,000	$2,365,000
Sediment Vault							$300,000
	855				**5**		**$3,240,000**

1. *2023 Construction cost with 40% contingency.*

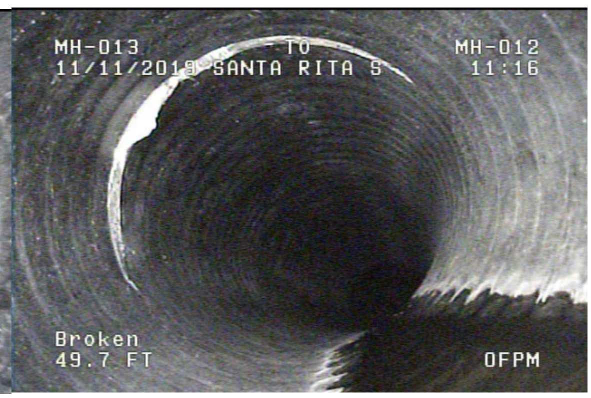


Project Name:	Santa Rita 2
Project ID:	9
Priority:	Moderate
Cost:	$200,000

Project Description: The existing corrugated lined pipe west of Santa Rita Street, between 4th and 3rd Avenue, is damaged. This segment should be replaced with a 24-inch RCP line. Alternatively, the pipe may be repaired with a new CIPP liner. This project should be completed with Santa Rita 1 if funding allows.

Item	Length (ft)	New Diameter (inches)	Pipe Unit Cost	Pipe Cost	Manholes/ Inlets	Manhole Unit Cost	Total Cost[1]
Replacement Pipe	145	24	$606	$88,000	3	$21,612	$153,000
Inlets/Laterals	50	12	$ 395	$20,000	3	$10,000	$50,000
	195				**6**		**$200,000**

1. 2023 Construction cost with 40% contingency.

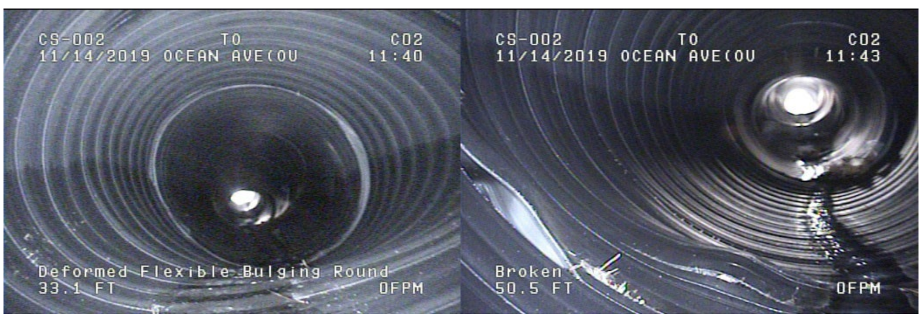


Project Name:	Ocean Avenue
Project ID:	10
Priority:	Moderate
Cost:	$320,000

Project Description: The existing corrugated pipe outfall at the west end of Ocean Avenue is damaged. This segment should be replaced with a 24-inch thick walled fused HDPE pipe with energy dissipation at the outfall or with baffles within the pipe. This project could include CDS unit upgrades along with possible stormwater diversions or green infrastructure projects. Newer trash removal technologies, such as nutrient separating baffle boxes (NSBBs), should be vetted during the design process.

Item	Length (ft)	New Diameter (inches)	Pipe Unit Cost	Pipe Cost	Manholes/ Inlets	Manhole Unit Cost	Total Cost[1]
Replacement Pipe	110	24	$606	$67,000	0	$19,100	$67,000
CDS Unit Replacement				$200,000			$200,000
Outfall/Baffles					1	$50,000	$ 50,000
	110				**1**		**$320,000**

1. *2023 Construction cost with 40% contingency. Outfall permitting not included.*

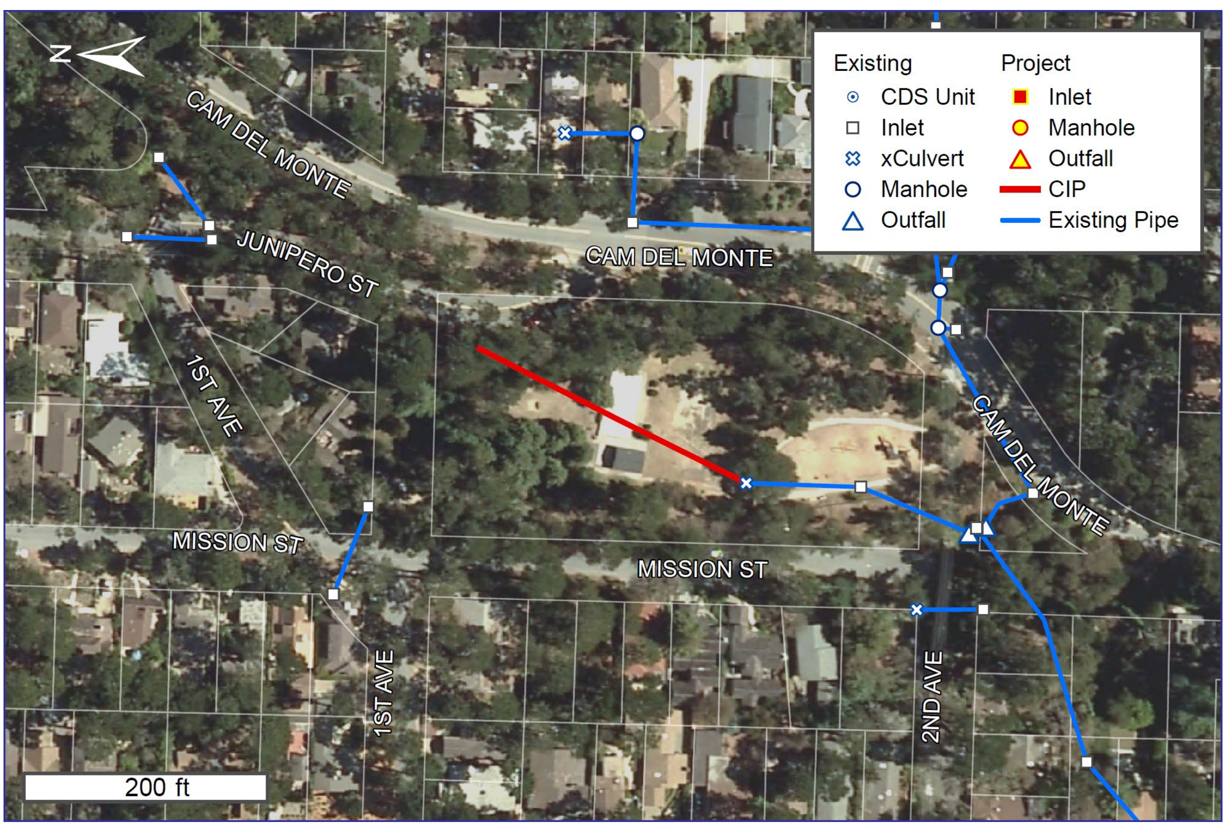


Project Name:	Forest Hill Park – Channel Realignment
Project ID:	11
Priority:	Moderate
Cost:	$700,000

Project Description: The natural channel running through Forest Hill Park is severely eroded due to channel scour. An existing utility (sanitary sewer or water) line has been exposed and poses a threat to this area of biological significance. This project would realign the existing channel through the park and into a detention area at the southern end of the park. This project could be incorporated into a park redesign to enhance the overall functionality of the entire area. The detention area has the potential to be a multiuse facility graded to optimize storage for reduction in downstream peak flows.

Item	Length (ft)	New Diameter (inches)	Pipe Unit Cost	Pipe Cost	Manholes/ Inlets	Manhole Unit Cost	Total Cost[1]
Diversion Pipe	100			$800			$80,000
Channel Realignment	300			$1,000			$300,000
Detention Basin							$120,000
Planting							$100,000
Engineering							$80,000
Permitting							$20,000
	300						**$700,000**

1. *2023 Construction cost with 40% contingency.*



Project Name:	5th Avenue
Project ID:	12
Priority:	Moderate
Cost:	$760,000

Project Description: The existing drainage system along Junipero Street, between 5th Avenue and 6th Avenue and along 5th Avenue between Junipero Avenue and Torres Street, is undersized to convey the 20-year event. Adding a parallel 24-inch system will lower peak stages during large storm event. If funding allows, this project could be built in concert with the downstream Mission Street Bypass and Junipero projects. If necessary, adding additional inlets along Junipero and 5th Avenue to this project to improve local drainage.

Item	Length (ft)	New Diameter (inches)	Pipe Unit Cost	Pipe Cost	Manholes/ Inlets	Manhole Unit Cost	Total Cost[1]
Replacement Pipe	710	24	$606	$430,000	6	$22,558	$565,000
Inlets/Laterals	300	12	$395	$119,000	8	$10,000	$199,000
	1,010				**14**		**$760,000**

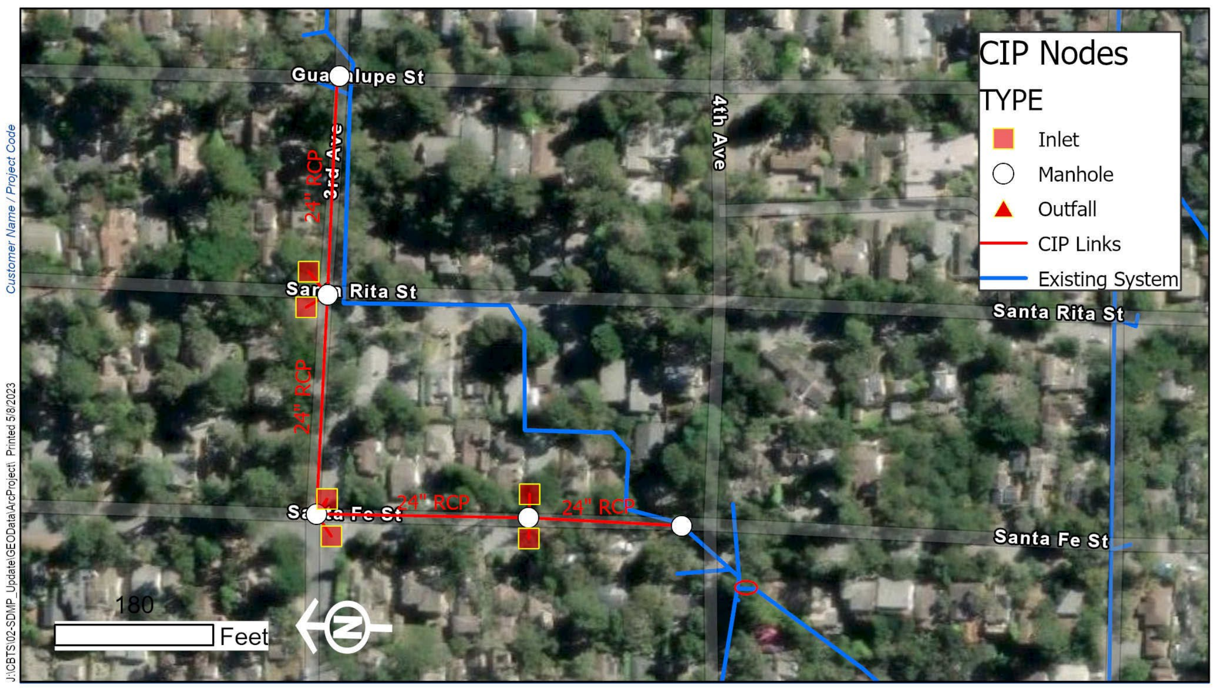
1. *2023 Construction cost with 40% contingency.*

Project Name:	3rd Avenue
Project ID:	13
Priority:	Moderate
Cost:	$910,000

Project Description: The existing drainage system between Guadalupe Street and 3rd Avenue and 4th Street and Santa Fe Avenue is mainly through easements between homes. This project would reroute the network to the public right-of-way along 3rd Street and Santa Fe Avenue.

Item	Length (ft)	New Diameter (inches)	Pipe Unit Cost	Pipe Cost	Manholes/ Inlets	Manhole Unit Cost	Total Cost[1]
Replacement Pipe	1,015	24	$606	$615,000	5	$22,558	$728,000
Inlets/Laterals	300	12	$395	$119,000	6	$10,000	$179,000
	1,315				**11**		**$910,000**

1. *2023 Construction cost with 40% contingency.*



Project Name:	Carpenter
Project ID:	14
Priority:	Low
Cost:	$340,000

Project Description: The existing drainage system along Carpenter Street between 2nd Avenue and 3rd Avenue utilizes the roadway right-of-way to convey runoff causing deterioration of the pavement and parking areas. This project would link the outfall south of 2nd Avenue with the existing system north or 3rd Avenue with a 24-inch pipe. Additional inlets along Carpenter Street would be included in this project.

Item	Length (ft)	New Diameter (inches)	Pipe Unit Cost	Pipe Cost	Manholes/ Inlets	Manhole Unit Cost	Total Cost[1]
Replacement Pipe	350	24	$606	$212,000	2	$22,558	$257,000
Inlets/Laterals	100	12	$395	$39,000	4	$10,000	$79,000
	450				**6**		**$340,000**

1. *2023 Construction cost with 40% contingency.*