Carmel-by-the-Sea
Storm Drain Master Plan

Final Report By

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CONSULTING CIVIL ENGINEERS

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Table of Contents

List of Figures

List of Tables

List of Appendices

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

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Executive Summary

This Storm Drain Master Plan (SDMP) establishes a prioritized capital improvement program to reduce the risk of flooding within the City of Carmel-by-the-Sea (City). The identified storm drain system improvement projects are intended to provide 10-year (10% annual exceedance) storm conveyance throughout the City.

Study Objectives

- The basic objective of this master plan 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 Capital Improvement Program (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.

Work Products

This master plan 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 Capital Improvement Program (CIP) implementation and/or modification. Improvement descriptions, maps, project costs, and other modeling data have been included in the appendices of this report.

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 10-year event; however, portions of the system lack the capacity necessary to meet the 10-year standard. Some known, recurring problem areas have been identified by City staff. Carmel-by-the-Sea generally drains in a westerly direction to the Carmel Bay. Tidal flooding is not a significant concern for oceanfront parcels.

System Evaluation

A MIKE URBAN 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 lead 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 and it is not uncommon to observe gutter flows up to the top of adjacent curbs during high intensity rainfall events. Flooding greater than a foot in depth, however, is regarded as problematic regardless of the property damage caused by it. There is special concern in the City of Carmel because 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 report.

Capital Improvement Program

A Capital Improvement Program has been developed based on model results and suggested improvements. The roughly $8.2 million in capacity and $1.7 million in condition improvements, broken down into three priority levels, recommended by this master plan 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.

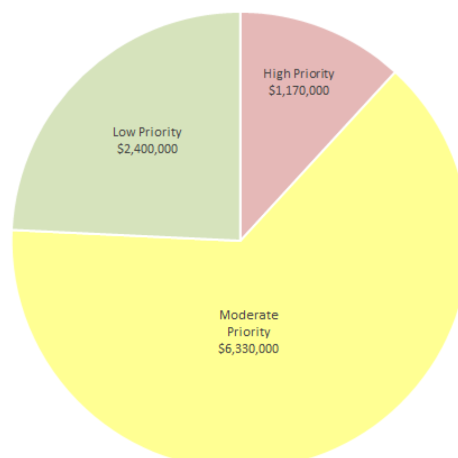

Figure ES-1: Capital Improvements Summary

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.

Conclusion

This Master Plan 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.

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Chapter 1: Master Plan Area Characteristics

1.1. Overview

This Storm Drain Master Plan (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 of Carmel-by-the-Sea. Its primary focus is on the City-owned drainage facilities. This Storm Drain Master Plan 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 Master Plan objectives, explains the criteria used to evaluate storm drain system performance, and presents a summary of the data collected as a part of this storm drain master planning process and from previous drainage studies. Existing hydrologic and environmental settings of the City are described along with flood protection and storm drain facilities.

1.2. 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 1-1 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.

1.3. Climate

Carmel-by-the-Sea 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).

1.4. 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 1-1.

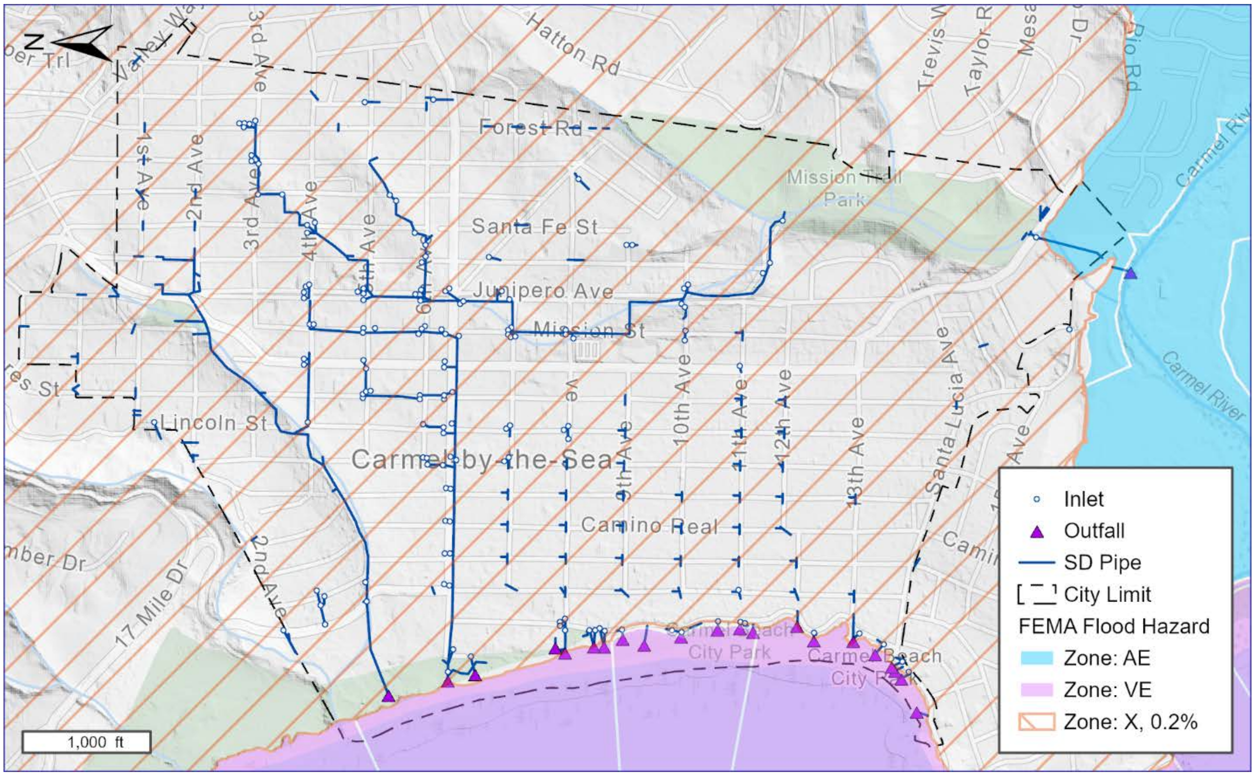

Figure 1-1: Existing Carmel-by-the-Sea Drainage System

1.5. 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 4.4.

1.6. 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 maintain 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.

1.7. Master Plan Process

Carmel-by-the-Sea'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,
   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 Carmel-by-the-Sea for the 10-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 Capital Improvement Program (CIP) for storm drainage infrastructure.
10) Project and summarize capital improvement costs for the CIP.

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Chapter 2: Data

2.1. 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 are used to complete remaining data gaps. This chapter summarizes the findings and data acquired as part of the Carmel-by-the-Sea Storm Drain Master Plan (SDMP). Data limitations, assumptions, and impacts are also summarized herein. Previous drainage studies and engineering designs provide useful data and analysis to support this master plan.

2.1.1. 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 2-1) 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.

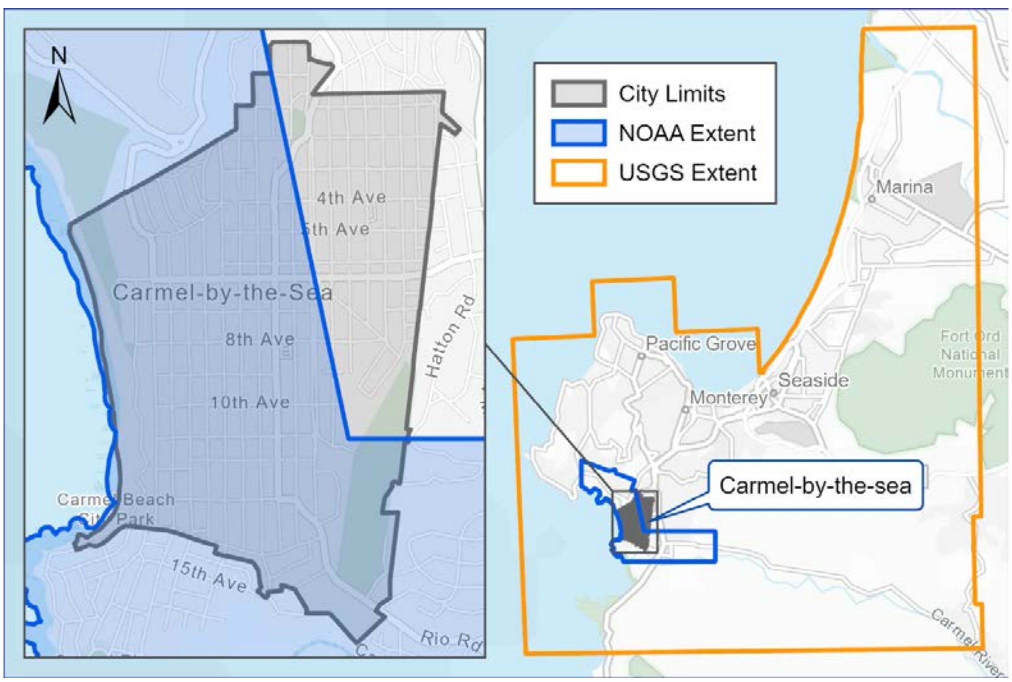

Figure 2-1: Study Topography

[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*

2.1.2. GIS Data

The most current storm drain network data (Figure 2-2) 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),
- 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
- Some outlet locations

The storm network elements were imported into GIS and filtered to use only main-line pipes 12-inches 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]. 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 on 2019.*

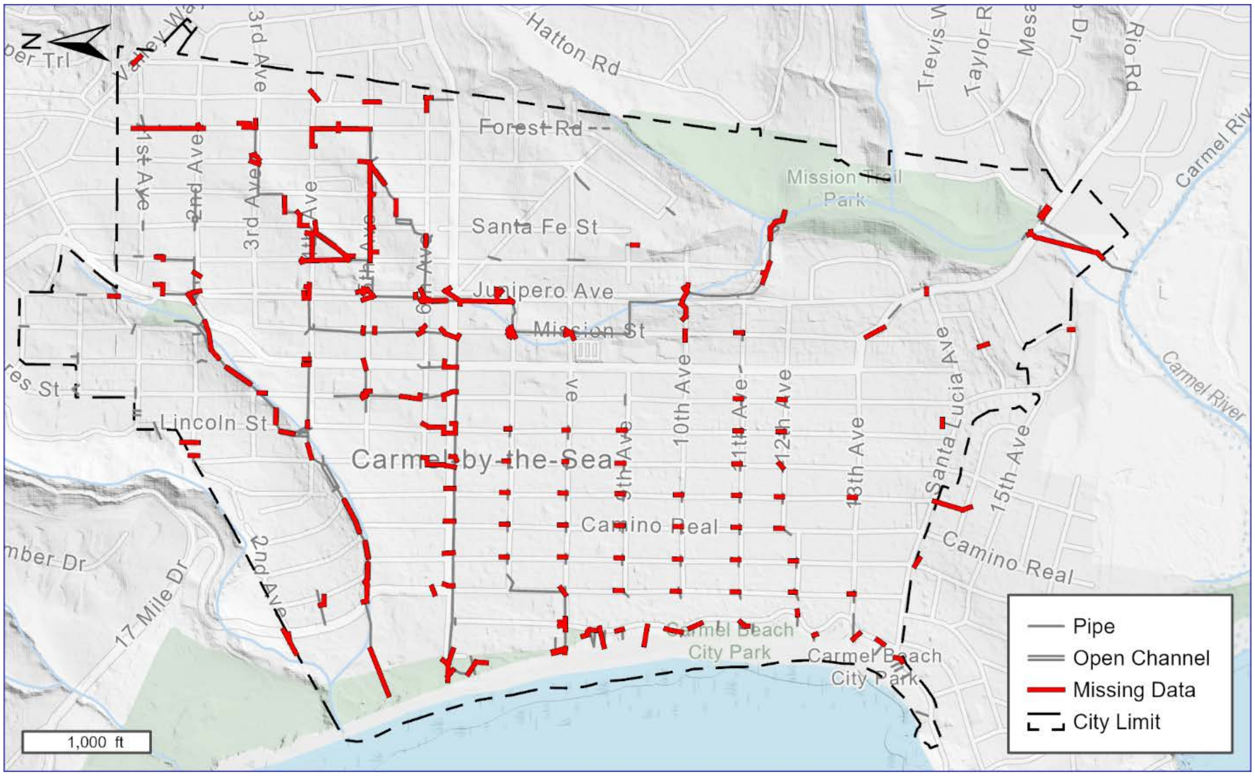

Figure 2-2: City Provided GIS

2.1.3. 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.
5. February 14, 2020: additional field measurements

Field information was collected by Schaaf & Wheeler staff. Because 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 2-3).

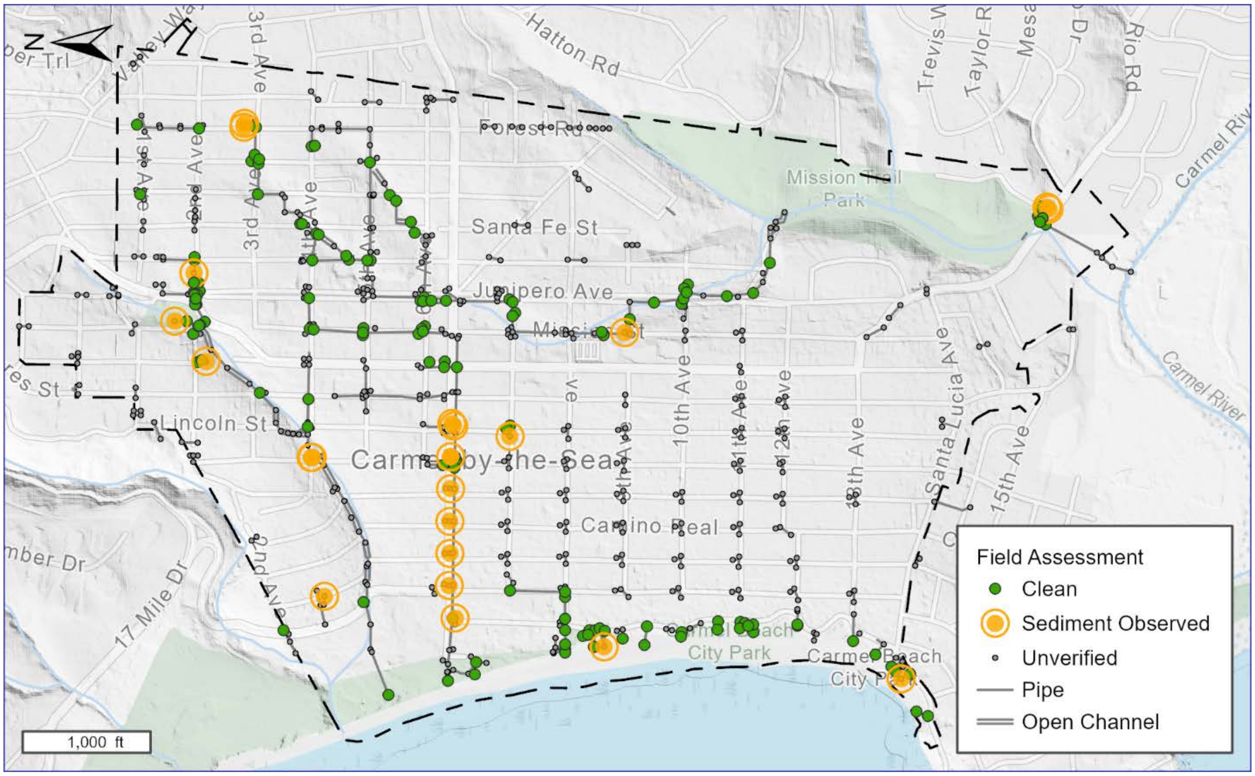

Figure 2-3: GoPro Observations

2.1.4. CCTV Inspections

Presidio Systems spent five days inspecting the drainage system using closed caption television (CCTV) technology. It is cost-prohibitive to inspect the entire system; therefore, Presidio focused on regions with known issues and segments that were noted during the Schaaf & Wheeler field work (Figure 2-3). The CCTV (Figure 2-4) data was reviewed by Schaaf & Wheeler and utilized for condition improvements. Appendix G contains the detailed CCTV reports.

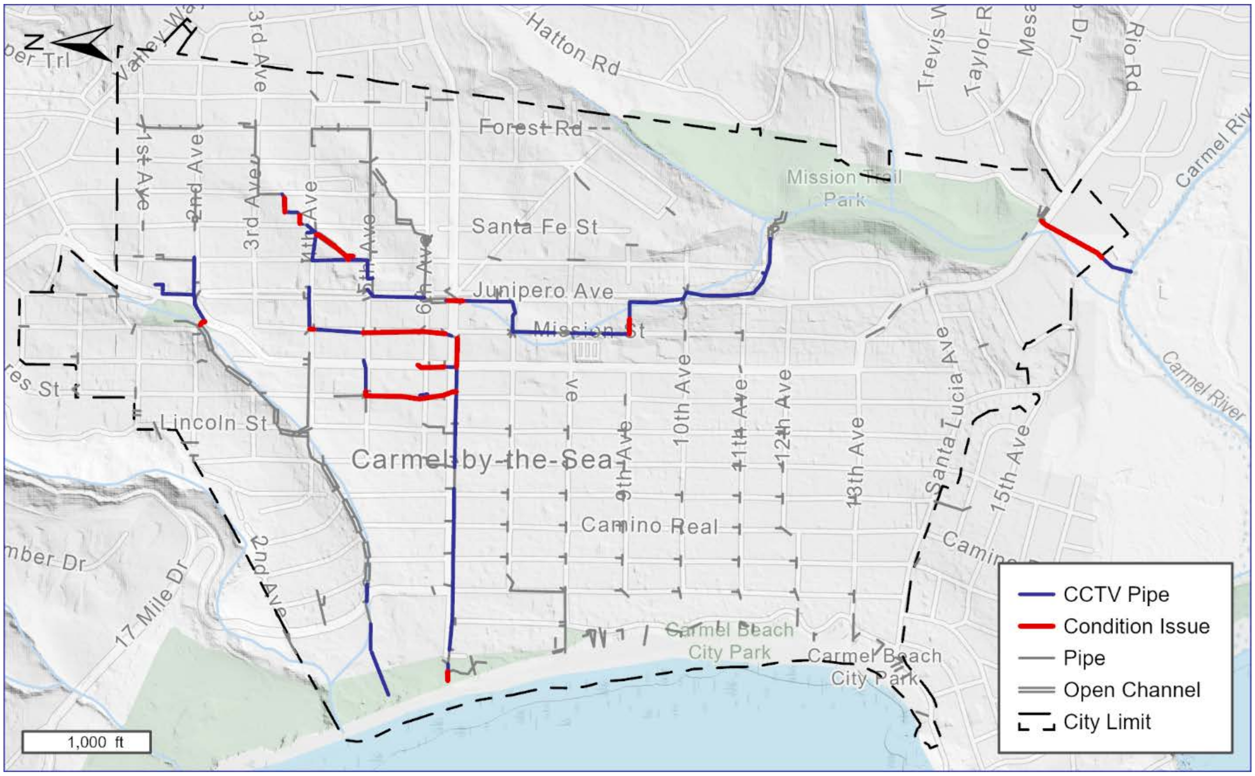

Figure 2-4: CCTV Observations

2.1.5. 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.

2.1.6. 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 3 details the catchment delineations along with a map of the catchments (Figure 3-1).

2.2. 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.

2.2.1. Land Use

Based on Zoning Designation of the City of Carmel-by-the-Sea, 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 2-5 (Appendix I).

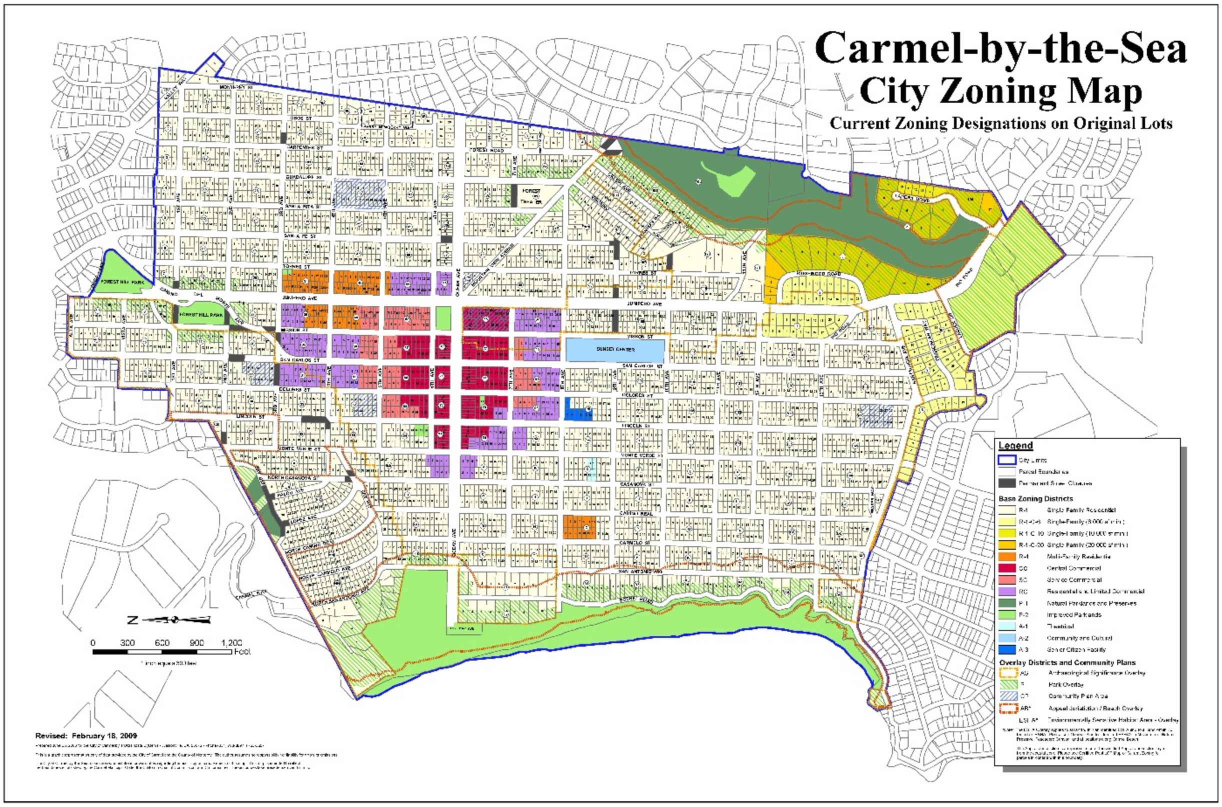

Figure 2-5: City Zoning/General Plan Map

2.2.2. 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 10-year peak discharge. However, redevelopment in Carmel-by-the-Sea, in general, is not expected to increase the 10-year flow. Based on zoning requirements, future land use condition is not estimated to be 'worse' than the existing condition and 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 Storm Drain Master Plan; however, these detailed studies are not part of this contract.

2.2.3. 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 2-1.

Table 2-1: 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%

2.2.4. 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 2-6 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’.

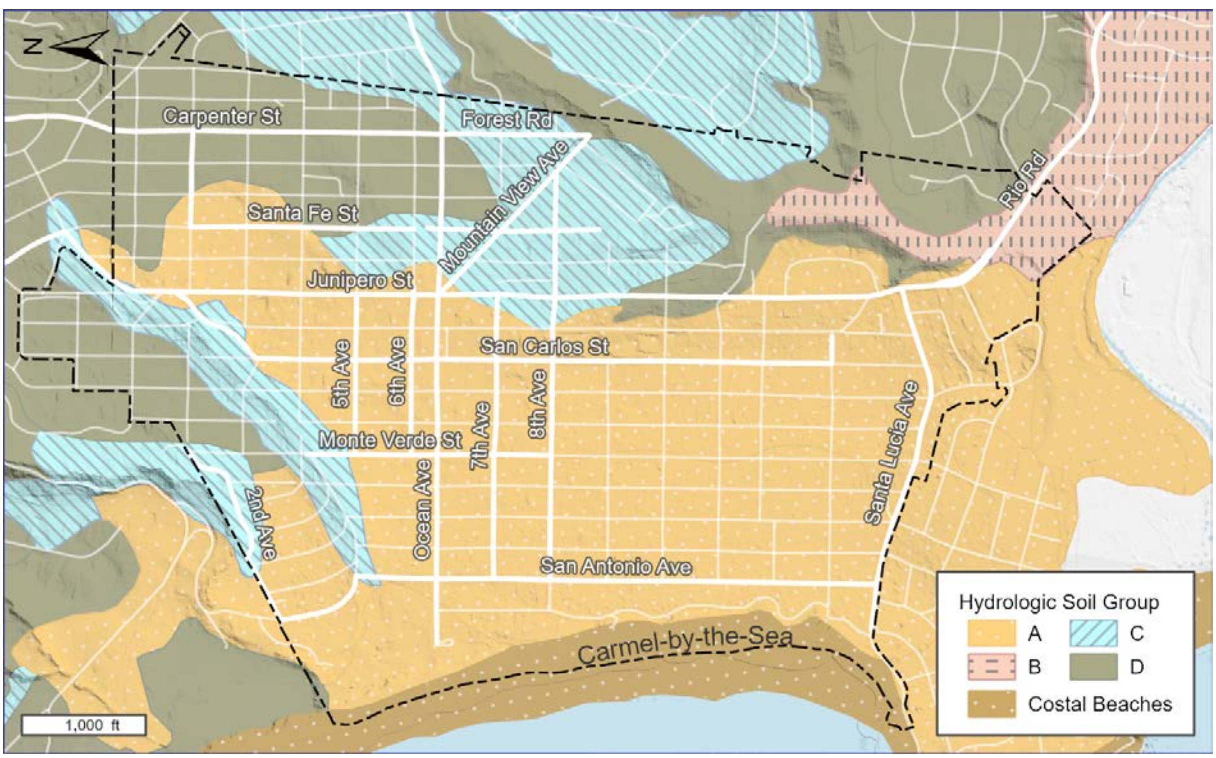

Figure 2-6: NRCS Soil Classification in Study Area and Immediate Vicinity

2.2.5. 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 2-2). Then, an area weighted average of the CN was calculated to obtain a representative CN of the pervious portion within each catchment.

Table 2-2: 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

2.3. Data Quality

There were 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 the help from the City.

2.3.1. 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 MIKE URBAN (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.

2.4 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.

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Chapter 3: Master Plan Methodology

3.1. 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 also continue to be used for future infrastructure design. Schaaf & Wheeler applied NRCS hydrology methods to estimate storm runoff from current land uses for the Carmel-by-the-Sea Storm Drain Master Plan. This method is being used along with MIKE URBAN storm drain modeling software by 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 2 - Data. Storm drain evaluation criteria described in the following section have been discussed with and agreed upon by the City.

3.2. Evaluation Criteria

Hydrologic analysis and one dimensional (1-D) hydraulic models have been created for the 10-year event. The 10-year storm event was used as the design event for the storm drain system evaluation since the 10-year level-of-service standard was agreed upon as the governing criteria for general storm drain system conveyance. Improvements are recommended to reduce the 10-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.

3.3. Modeling Software

The Danish Hydraulic Institute (DHI) MIKE-URBAN (MU) software with MOUSE solver is selected to model the City of Carmel-by-the-Sea 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 Carmel-by-the-Sea 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. MIKE-URBAN (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.

3.3.1. 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 Carmel-by-the-Sea storm drain models use the Dynamic Wave option which incorporates the effects of gravitational, friction, pressure gradient, and inertial forces. Because 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 1000 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 and network flow calculations were set between 10 and 60 seconds with the resulting hydrographs set to be saved at 1-minute intervals.

3.3.2. 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 3-1. 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).

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 and include water depth, flooding level, pressure in closed conduits, percentage pipe filling, and the flow calculated for each link.

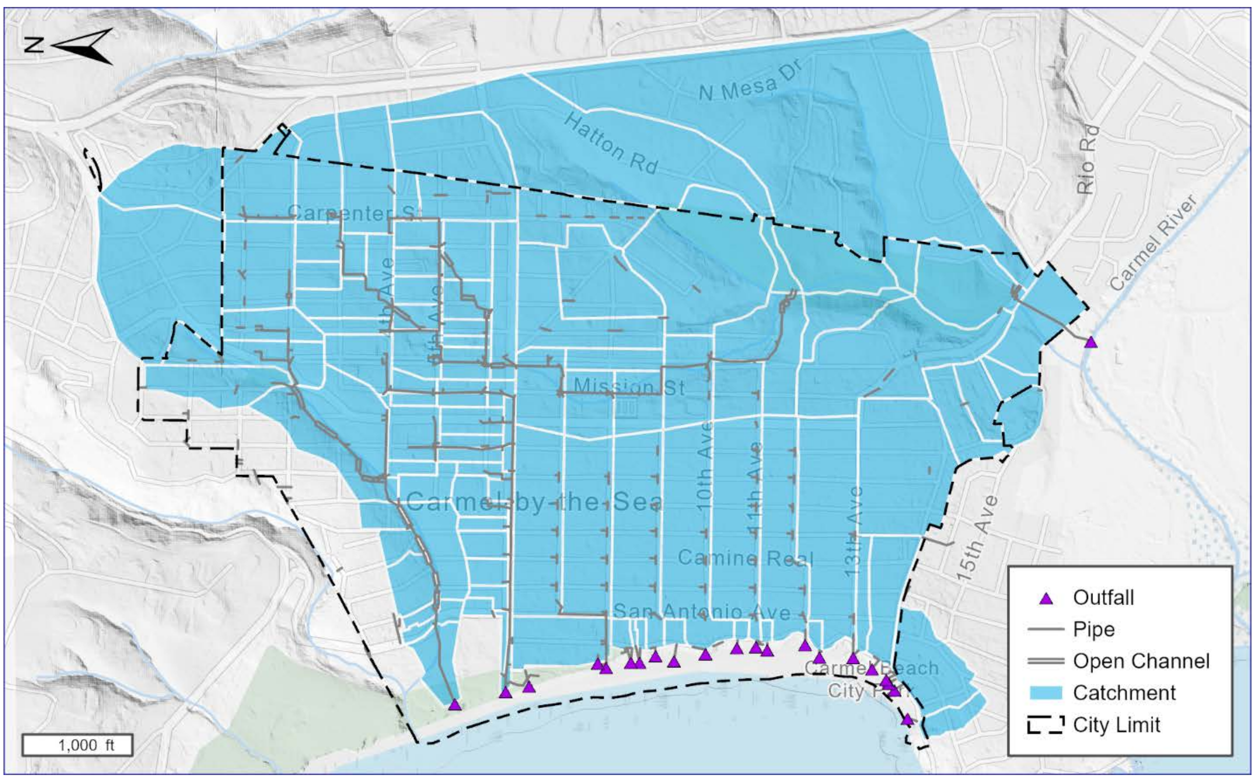

Figure 3-1: Carmel-by-the-Sea Storm Drain Catchments

A summary of inputs and outputs is listed in Table 3-1.

Table 3-1: 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

3.4. Hydrologic Calculations

Methods used in this master plan 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 10-year design storm pattern used for MU modeling creates results consistent with 10-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. Because 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 Carmel. This study identifies predicted changes based on available data and highlights potential impacts on the City drainage systems.

3.4.1. 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]. Point precipitation value of 10-year 24-hour storm in the study area is 3.0 inches.

3.4.2. 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 Storm Drain Master Plan[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 and the precipitation frequency estimates were applied to the design storm pattern to develop design storms for the 10-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 3-2.

3.5. Catchment Data

Carmel-by-the-Sea 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.

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

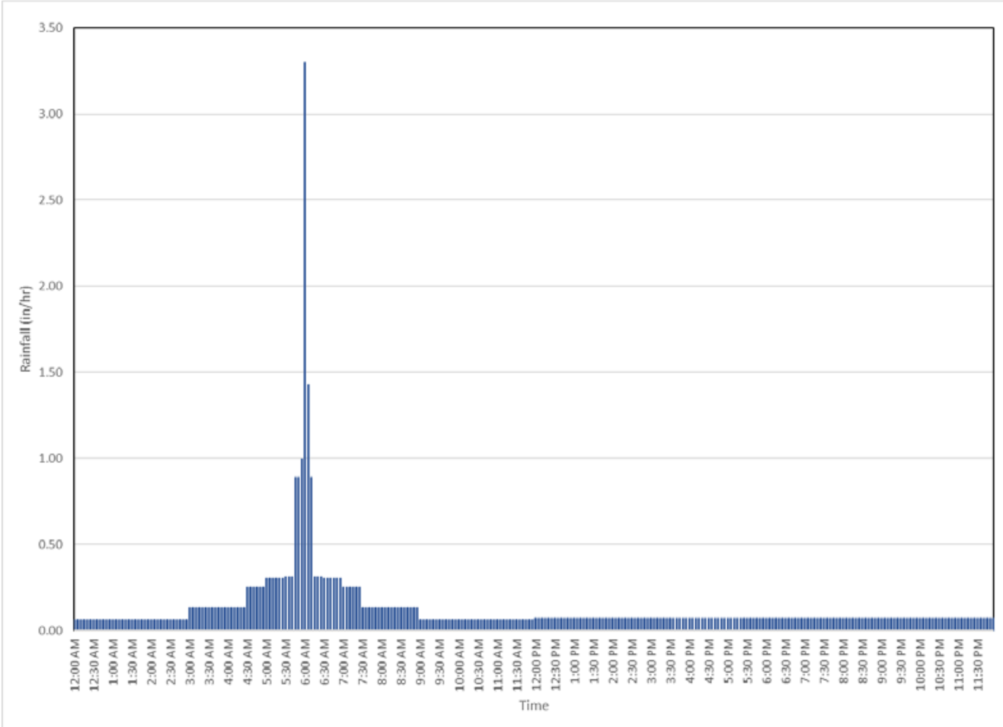

Figure 3-2: 24-Hour Design Storm Used For the Carmel-by-the-Sea SDMP

3.5.1. NRCS Curve Number

The NRCS Curve Number (CN) methodology was used to determine storm water runoff from each catchment with design precipitation. Curve numbers are used to characterize basin infiltration and runoff potential based on a combination of land use and soil characteristics discussed in Section 2.2.4 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 10-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 Table 2-2, pervious surface curve numbers were applied to the Carmel-by-the-Sea 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 10-year analysis. The impervious portion of the catchments were assigned a CN of 98.

3.5.2. 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 2, 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)

3.6. 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.

3.6.1. 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 which 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 which 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 Carmel-by-the-Sea 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.

3.6.2. 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.

3.6.3. 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.

3.6.4. 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 10-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 Carmel-by-the-Sea.

Chapter 4: Evaluation of Storm Drain Systems

4.1. Overview

A performance and condition analysis of Carmel-by-the-Sea's storm drain system is the primary focus of the storm drain master plan. This chapter:

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

4.2. Prioritizing Deficiencies and Needed Capital Improvements

Storm drain systems in Carmel-by-the-Sea (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 10-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 10-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 10-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 10-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.

4.3. Evaluation of Storm Drain Capacity

The conveyance capacity of Carmel's storm drain system was analyzed with current land use conditions during the 10-year design storm.

- Areas of notable flooding based on historic occurrences and results of the MIKE URBAN (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 10-year event

It is impossible to entirely remedy every drainage issues throughout the City, either 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 4-1 below shows the existing conditions for Carmel-by-the-Sea storm drain pipes for the 10-year storm event as modeled in MU. Appendix A contains system profiles and more detailed model results.

4.3.1. Design Criteria

Based on initial discussion with the City of Carmel-by-the-Sea, storm drain system improvements are designed in this SDMP such that the 10-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 storm drain master plan effort and development of a capital improvement plan. 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 10-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 10-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 10-year criteria. While containing the 10-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).

4.3.2. System Evaluation

This master plan focuses on the major conveyance components within the City; therefore, not all the City drainage infrastructure is in the models. The modeled drainage area is approximately 1.2 square miles. The modeled collection system within Carmel-by-the-Sea City limits consists of 271 pipe segments, 264 nodes, and 22 outlets. The project area has a total of 35,000 linear feet (6.5 miles) of modeled storm drain pipe. The Capital Improvement Projects (CIPs) identified from the system evaluation and summary of associated cost estimates are presented in Chapter 5.

4.3.3. Modeling Results

Based on modeling results (Figure 4-1), 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

For each of the areas identified to have a potential deficiency in the storm drain network, a possible capital improvement plan (CIP) was developed and verified using hydraulic modeling (Figure 4-2).

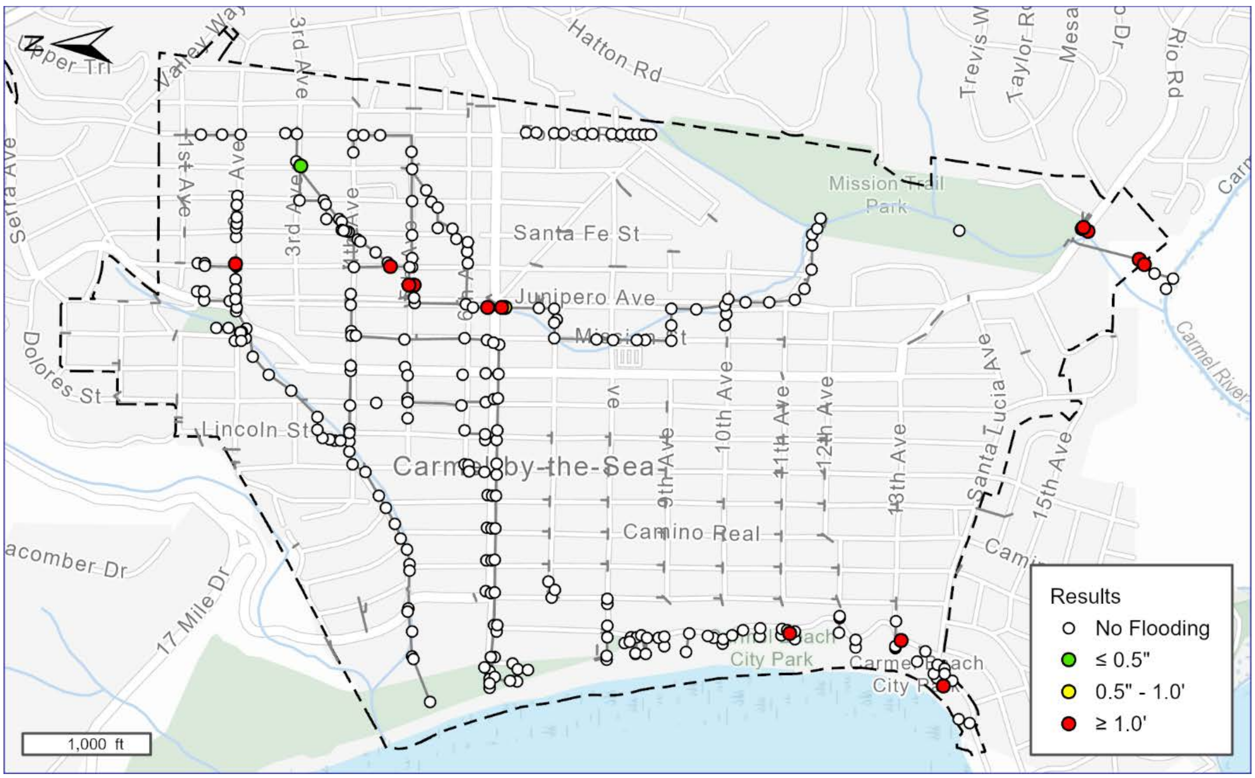

Figure 4-1: 10-year Model Results

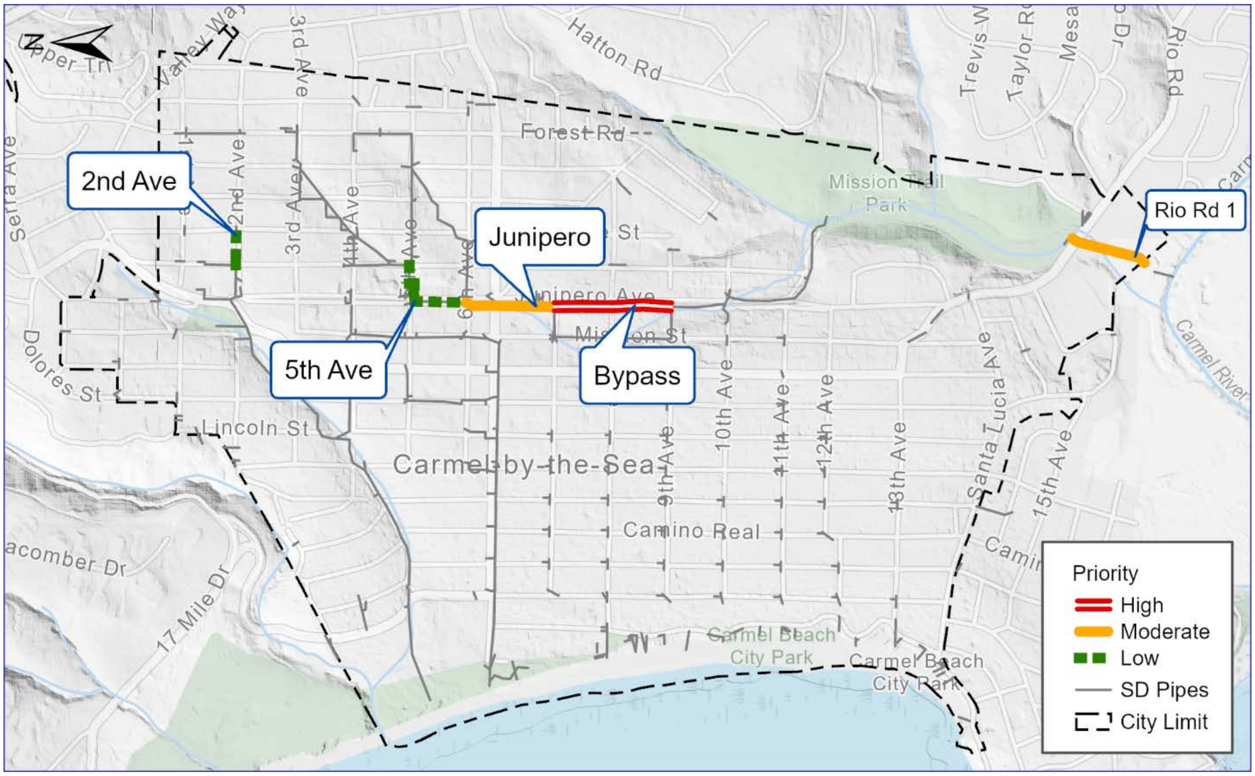

Figure 4-2: Capacity Projects

4.4. Known Nuisance Drainage Problem Areas

City staff and citizens have documented drainage and flooding issues throughout the City (Figure 4-3). Appendix E contains detailed documentation. Known problem areas 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

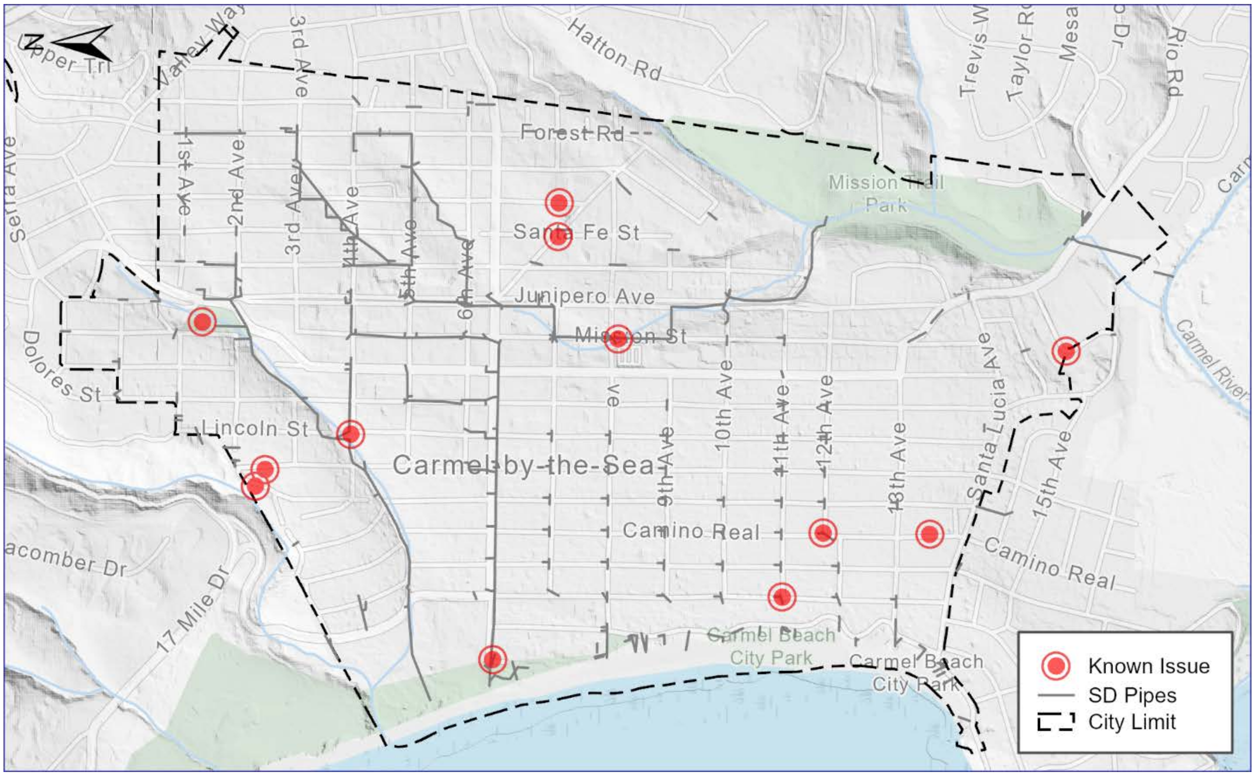

Figure 4-3: Know Nuisance Drainage Problem Areas

4.5. Condition Assessment

4.5.1. Observations

Based on the field visits and CCTV discussed in Sections 2.1.3 and 2.1.3, most pipes were found to be in satisfactory condition except for a few lined pipes and some pipes with sedimentation detailed in Figure 4-4 and Table 4-1. 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.

4.5.2. 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 5.

Figure 4-4: Observed Condition Issues

Table 4-1: 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	High

4.6. Prioritized Improvements

Three high priority projects (Figure 4-5) are aimed at reducing significant flooding in problematic areas and at carrying out short term condition improvements.

Nine moderate priority projects aim to reduce most flooding at the 10-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.

Five low priority projects are recommended to alleviate minor flooding and reliability issues. These projects are not likely to be constructed before the next storm drain master plan update.

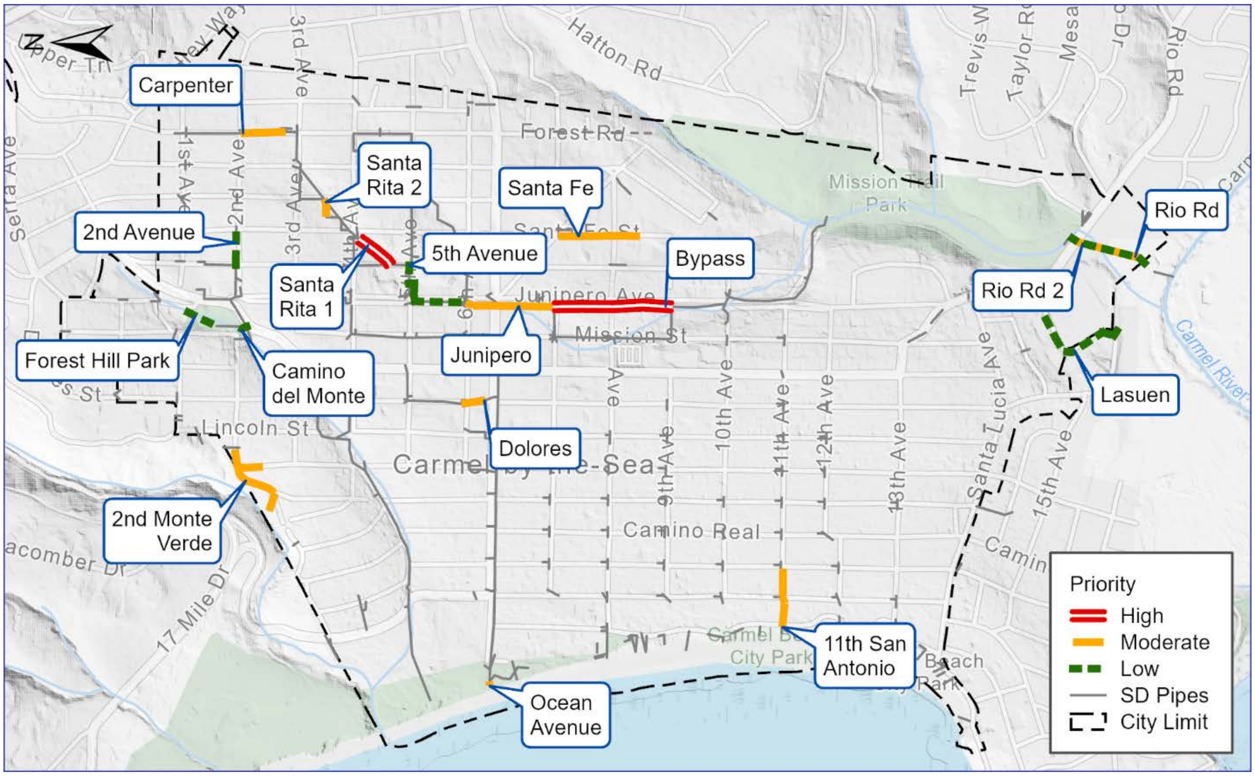

Figure 4-5: Prioritized CIP Projects

4.6.1. 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 City of Carmel-by-the-Sea'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.

4.6.2. High Priority Projects

The highest priority projects (Figure 4-5) are a combination of condition and capacity CIPs.

Mission Street Bypass

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 an additional pipe and inlets along Junipero between 7th and 9th Avenues to provide more capacity and capture local runoff.

Santa Rita 1

The existing concrete box in an easement between Torres Street and Santa Fe Street (between 4th and 5th Avenues) 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 damages. The proposed project will further identify the box alignment and reinforce the structure to minimize failure risks.

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 ten-year cycle.

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.

4.6.3. Moderate Priority Projects

The moderate priority projects (Figure 4-5) are a combination of nuisance, condition, and capacity CIPs.

Rio Road 1

The drainage system from Mission Trails Park out to the Carmel River is undersized for the 10-year event. Though this portion of the City is not densely urbanized, and risk of damages are low, Rio Road is a key thoroughfare for the south end of the City. The proposed project would upsize the existing dual 36-inch culverts with new box culverts. This project will likely require permitting for outfall changes.

Junipero

Modeling results indicate possible inadequacies around Junipero and Ocean. This improvement upsizes the pipes to provide more capacity for upstream flows and lowers the peak hydraulic grade line (HGL). This project could be completed in conjunction with the Mission Street Bypass and 5th Avenue projects.

Santa Fe Avenue

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.

Carpenter Avenue

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

11th and San Antonio

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.

2nd and Monte Verde

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 outfall to the existing open space at the City boundary. Coordination with Monterey County may be necessary.

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 replace the roughly 100-foot section with a new 24-inch line.

Ocean Avenue

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.

4.6.4. Low Priority Projects

The low priority projects (Figure 4-5) are a combination of condition and capacity CIPs that can be addressed as funding allows.

5th Avenue

Modeling results indicate possible inadequacies in the area near intersection of 5th Avenue and Torres Street. This improvement upsizes the pipes to provide more capacity.

Rio Road 2

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

Modeling results indicate possible inadequacies in the area near intersection of 2nd Avenue 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

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

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

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

4.7. Other System Components

4.7.1. 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 4-6 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 cyclist 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
- Develop and implement new cross-culvert systems

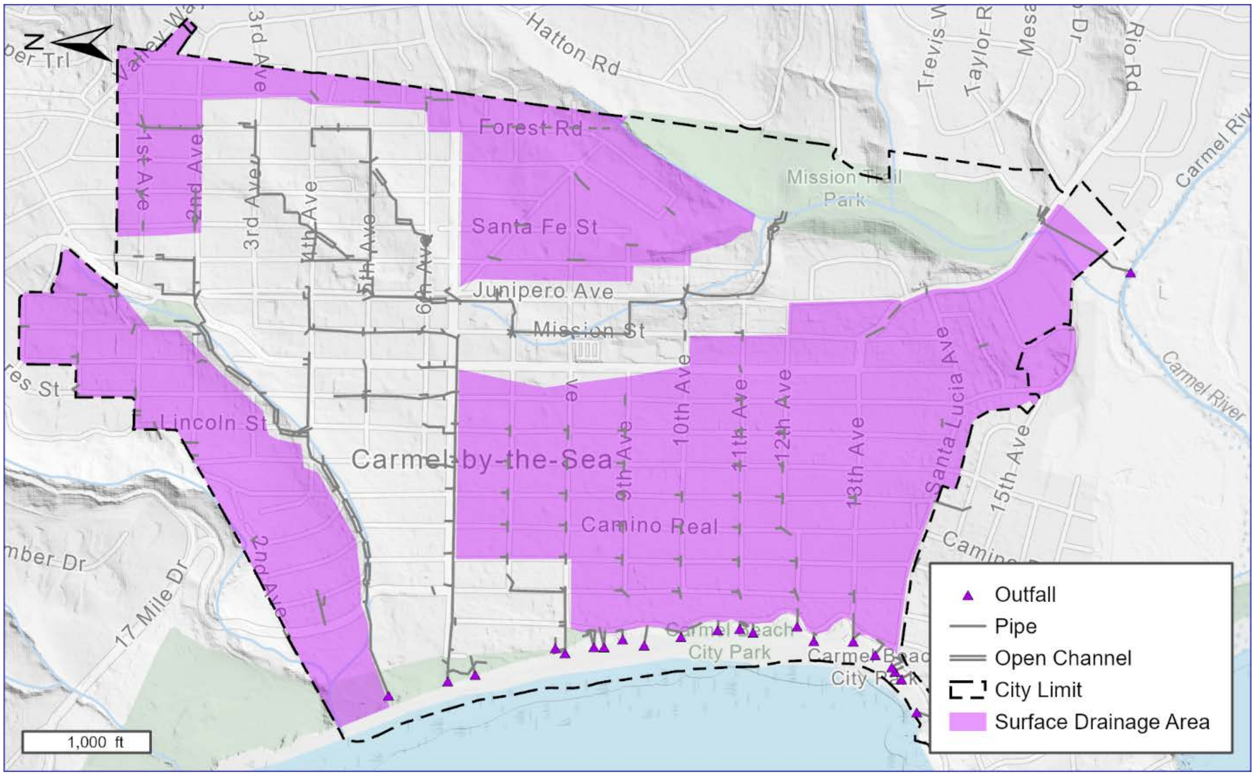

Figure 4-6: Surface Drainage Streets

4.7.2. 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 10-year flow rates from the Mission Trails study are close to the model results from this master plan. 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 as they pose little threat of property damage; however, these projects have strong potential for grant funding due to their ecological benefits.

4.7.3. Southern Annexation

There is potential for Carmel to annex portions of the County Unincorporated area directly south of the City limits (Figure 4-8). This area was not included in the field data collection, condition assessment nor hydraulic modeling for this master plan. 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. The proposed Ecosystem Protection Barrier (EPB), all floodwall 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 4-7: Conceptual Street Improvement

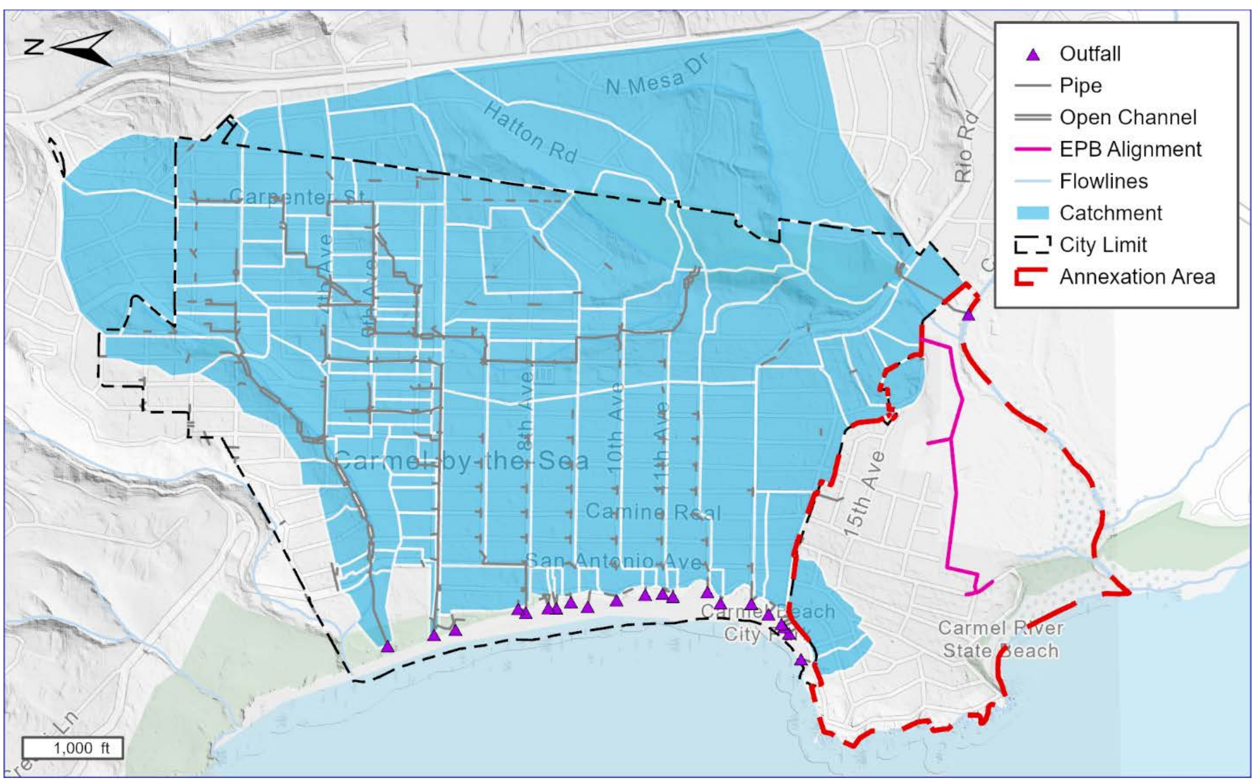

Figure 4-8: Southern Annex Area

4.7.4. Water Capture and Reuse

There may be potential projects in Carmel 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. One potential storage area is Devendorf Park; underground storage could be added to the park as part of a redesign.

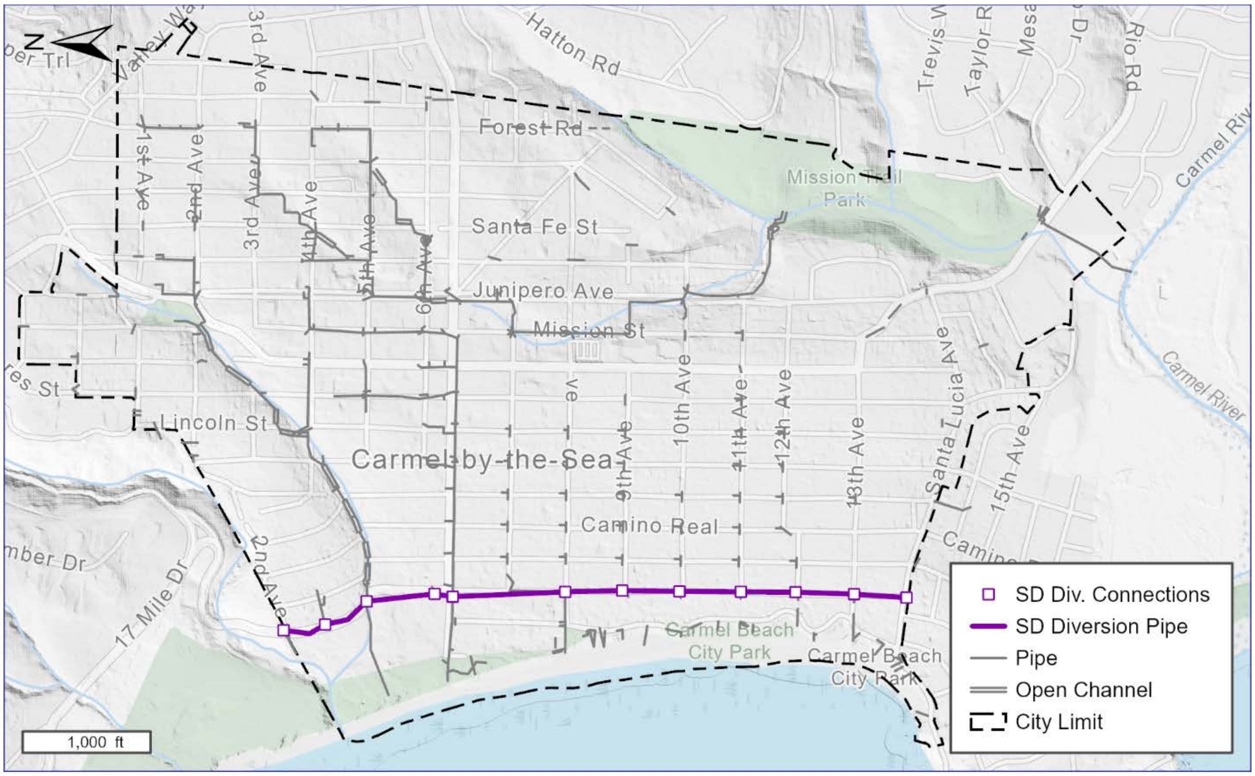

Figure 4-9: Water Capture System Layout

4.7.5. CDS Units

The City currently owns and operates four (4) CDS units (Figure 4-10). These hydrodynamic separators help remove pollutants from the drainage system prior to discharging into Carmel Bay. Each CDS unit requires annual maintenance to remove captured pollutants and assure proper operation. Currently this effort is contracted for a fee of approximately $25,000 per year. Over time the CDS units need replacement while 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.

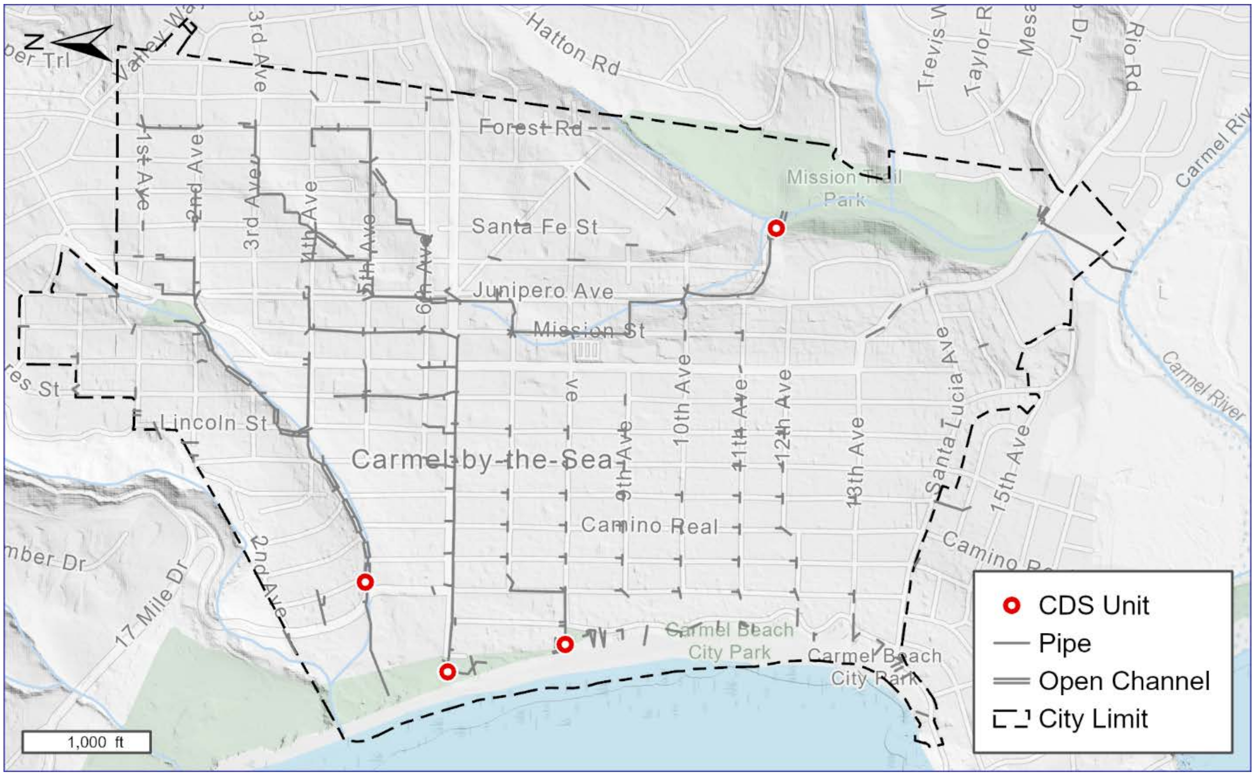

Figure 4-10: CDS Unit Locations

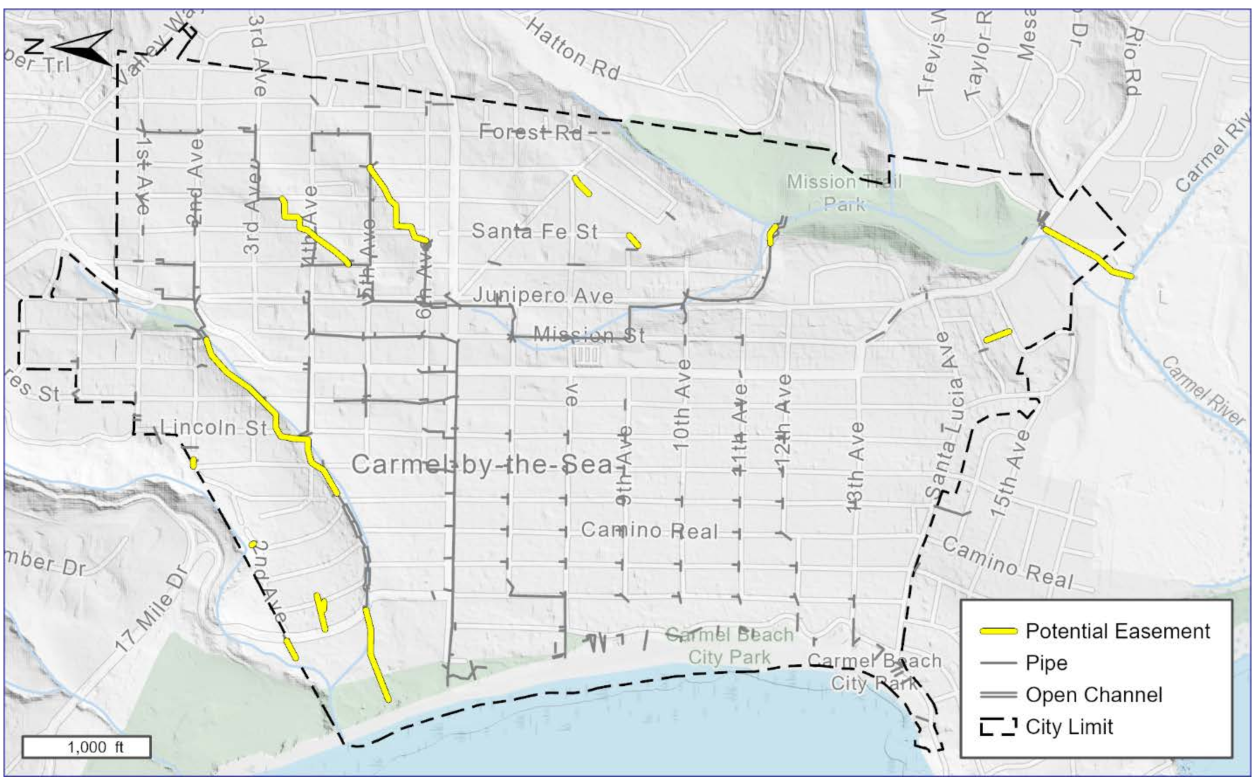

Figure 4-11: Potential Easement Location

4.7.6. Drainage Easements

Urban runoff is conveyed though private parcels throughout the City. Figure 4-11 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.

4.7.7. 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 4-12 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 impacts on buildings.

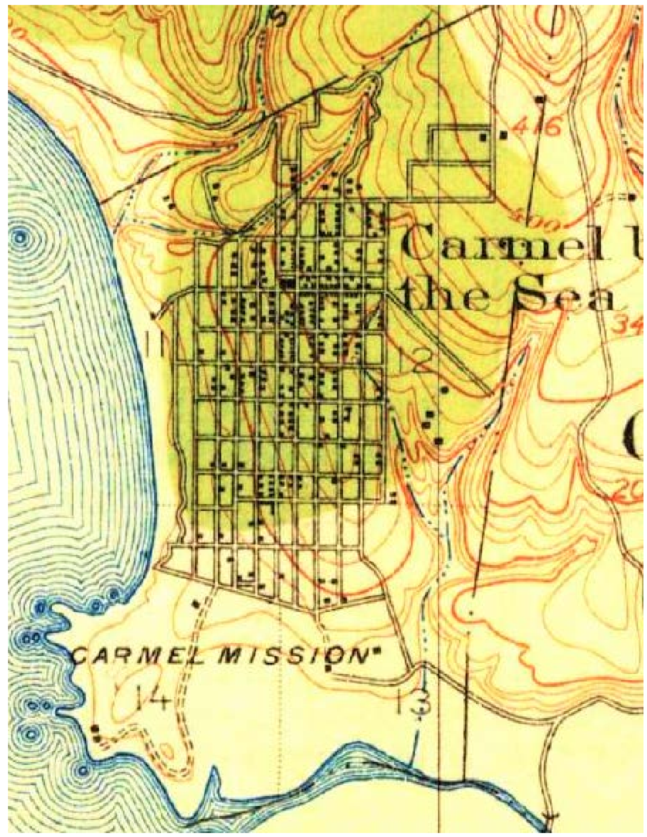

Figure 4-12: Historic Channels (1913)

4.7.8. Climate Change

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. The US EPA has developed SWMM-CAT 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.

SWMM-CAT estimates a 16-percent increase in the 24-hour 10-year storm event for the years 2045-2075 as shown in Figure 4-13. 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 16-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 model results show (Figure 4-14) that most of the City's system will be adequate for the increased storm intensity. The City should monitor climate change and consider precipitation changes when planning or designing long-term drainage projects.

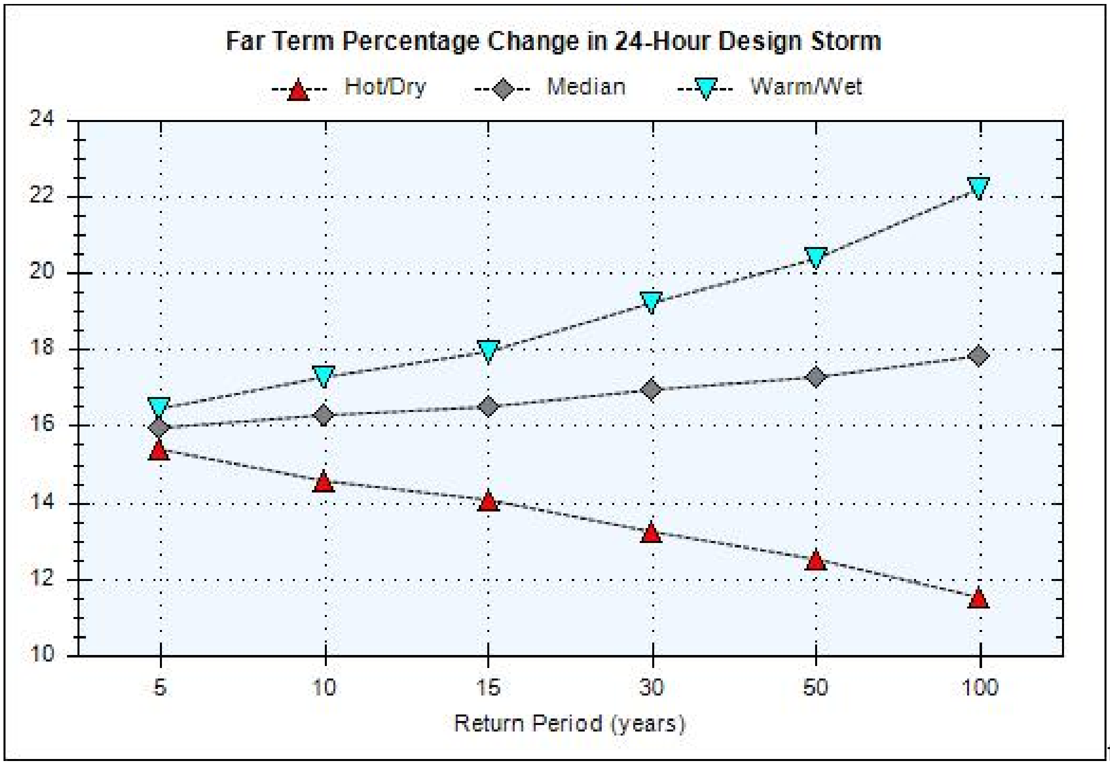

Figure 4-13: EPA SWMM-CAT 24-hour Precipitation Estimates

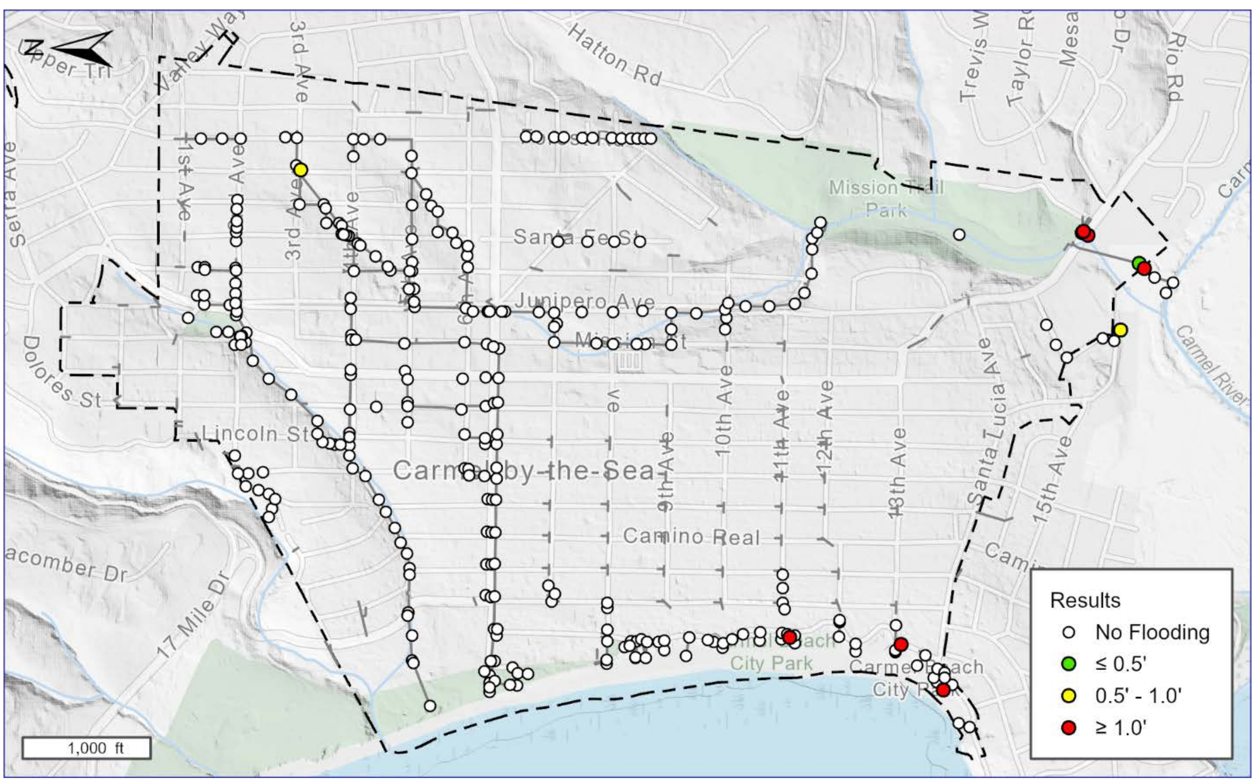

Figure 4-14: Climate Change Flooding

Chapter 5: Capital Improvement Plans

5.1. Summary of Findings

While there are many areas within the City of Carmel-by-the-Sea that provide adequate stormwater conveyance for a 10-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 45,000 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 Carmel-by-the-Sea's storm drain system's performance to ensure level-of-service during a 10-year storm. The improvements recommended in this Master Plan should be considered a comprehensive Capital Improvement Program within the study area.

5.2. Overview

Chapter 4 discusses Carmel-by-the-Sea's storm drain collection system and recommends prioritized capital improvements to address known and modeled deficiencies. This chapter provides a Capital Improvement Program (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. A master plan 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.

5.3. 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 5-1.

Table 5-1: Summary of CIP Costs Based on Priority Level (Total Project Cost)

Priority Level	Cost
High Priority Capital Improvements	$1,170,000
Moderate Priority Capital Improvements	$6,230,000
Low Priority Capital Improvements	$2,400,000
Total Capital Improvement Program	**$9,800,000**

The above costs include a 40% contingency for design, administration, and construction contingencies.

5.4. 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 5-2, 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 and thus, 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 $18,700 (18-inch pipe) to $19,900 (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 5-2.

Table 5-2: Storm Drain Replacement Unit Costs for Pipes and Connections

Diameter (inches)	2020 Rate	
	Per linear foot of Pipe[1]	Per Connection[1]
18	$400	$18,700
24	$490	$19,100
30	$630	$19,500
36	$730	$19,900
4' x 4' Box	$900	
10' x 5' Box	$2,500	

[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 4-feet of ground cover over the pipe. Greater cover will raise estimated costs.

5.5. Capital Improvement Program

5.5.1. Annual Inspection of Pipes

The total cost for CCTV video inspection of approximately 40,000 feet of pipe was estimated to be $75,000. Assuming that the video inspection will be carried out every three years over a fifteen-year term, the annualized cost for video inspection is estimated to be $5,000.

5.5.2. Annual System Maintenance

The City currently spends roughly $90,000 per year in consulted cleaning for the drainage system and permit compliance. This work includes removing debris from the 4 CDS units and numerous inlets. The City should continue these efforts along with the additional locations identified under this study. The estimated annual fee is $90,000 for consultants and $30,000 for City staff labor.

5.5.3. Storm Drain Improvement CIP

The CIP costs priority levels are summarized in Table 5-1. Detailed project sheets with required replacement pipe for high and moderate priority CIPs are included in Appendix D.

Table 5-3: CIP Projects for the City of Carmel-by-the-Sea

Priority	Asset Name	Estimated Cost[1]
High Priority	Mission Street Bypass	$820,000
	Forest Hill Park – Emergency Repair	$130,000
	Santa Rita 1	$220,000
	High Priority Total	**$1,170,000**
Medium Priority	Junipero	$800,000
	Rio Road 1	$2,420,000
	Santa Rita 2	$170,000
	Ocean Ave	$250,000
	Santa Fe	$490,000
	Carpenter	$270,000
	11th and San Antonio	$400,000
	2nd and Monte Verde	$830,000
	Forest Hills Park - Realignment	$700,000
	Medium Priority Total	**$6,330,000**
Low Priority	2nd Avenue	$150,000
	5th and Junipero	$660,000
	Mission Trail Preserve Projects	$940,000
	Camino del Monte	$30,000
	Dolores	$20,000
	Rio Road 2	$140,000
	Lasuen	$460,000
	Low Priority Total	**$2,400,000**
Grand Total		**$9,900,000**

[1]Includes Contingencies (40%). 2020 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.

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Chapter 6: 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.

6.1. 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.
- The City's system operation and maintenance and permit compliance costs are expected to be approximately $90,000 for consulted service and $30,000 for City staff on an annual basis (in 2020 values).
- 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

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

mitigation fees from new development or redevelopment that impact the Stormwater infrastructure.

6.2. 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 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.
- Determination of net annual revenue requirements for the program.

6.3. 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.

6.3.1. 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.

6.3.2. 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.

6.4. 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.

6.4.1. 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 Stormwater Master Plan 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.

6.4.2. 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 which 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.
- 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.

6.4.3. 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.

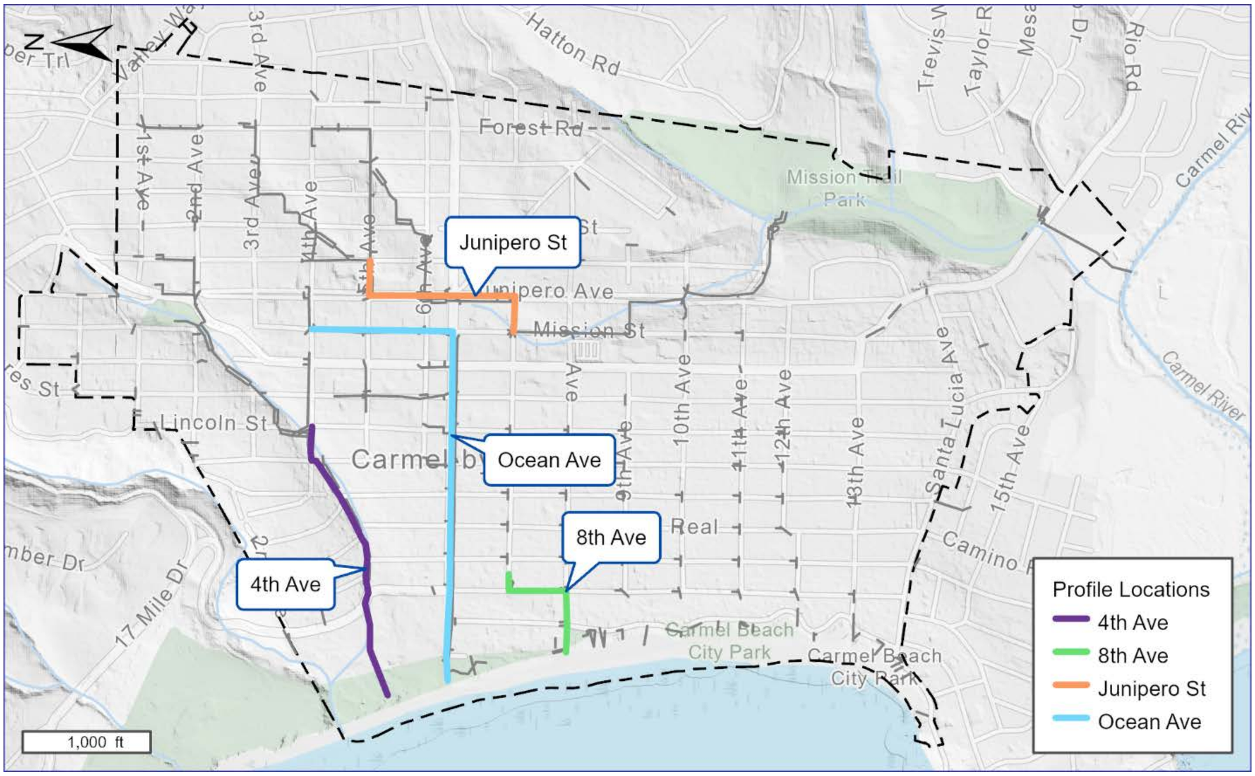
6.4.4. Grants

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.

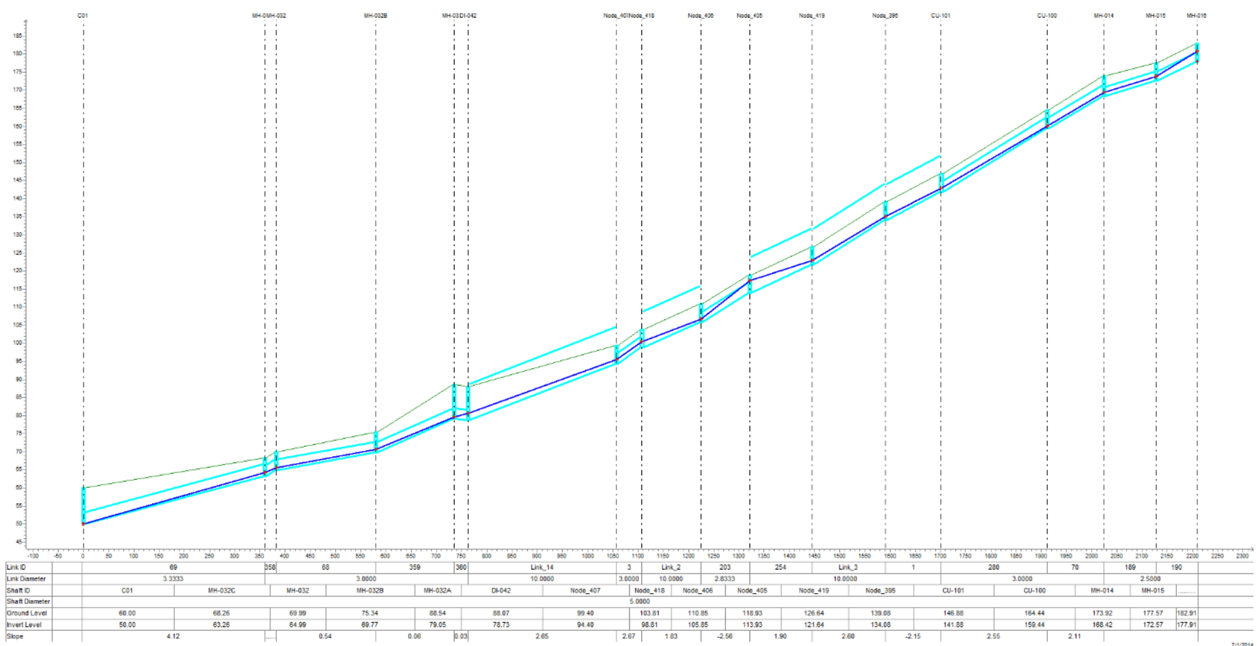
6.5. SB 231

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 are 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.

Appendix A. Existing Storm Drain System and Modeling Results for 10-year 24-hour storm

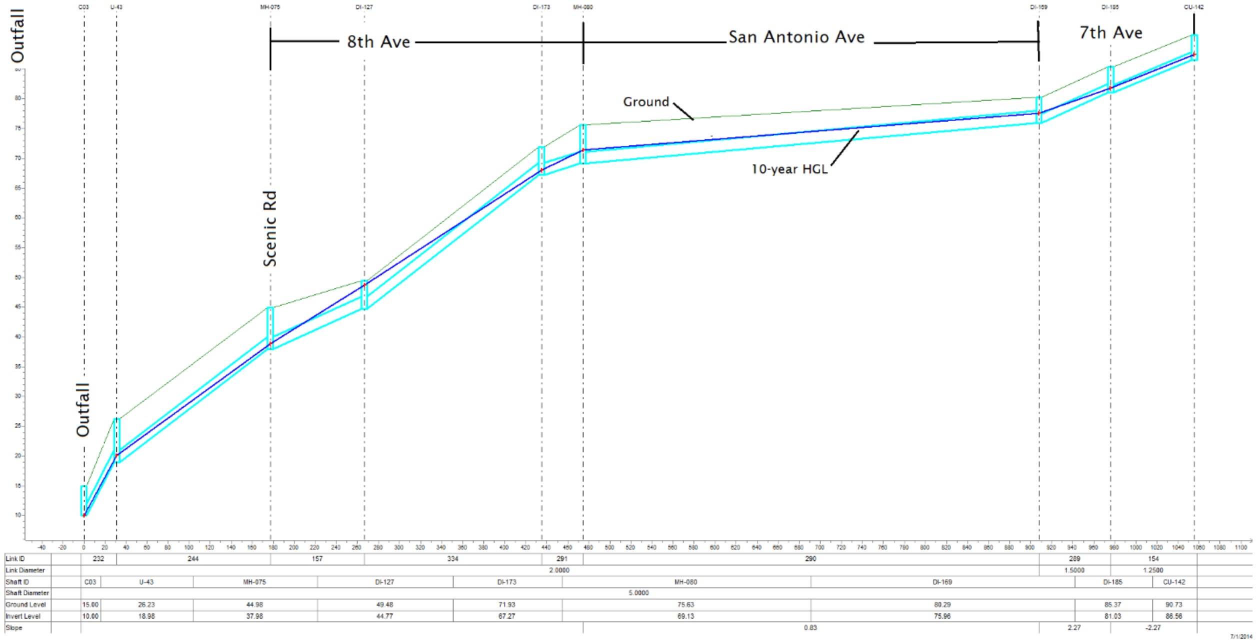


Profile Location Map

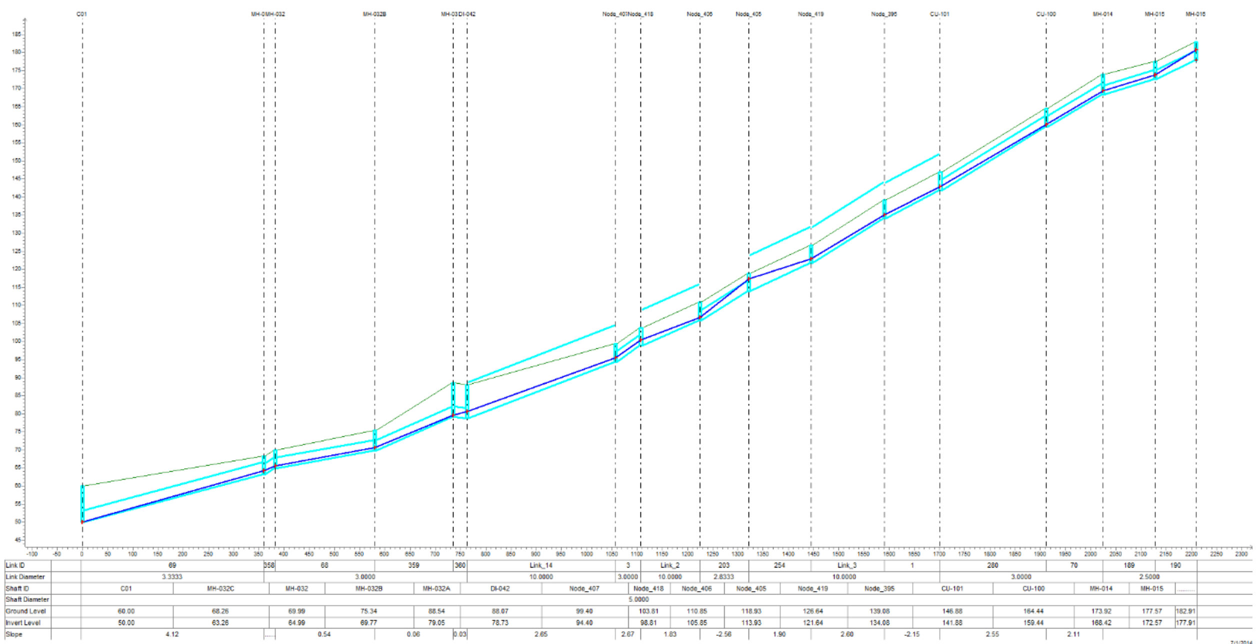


Ocean Avenue

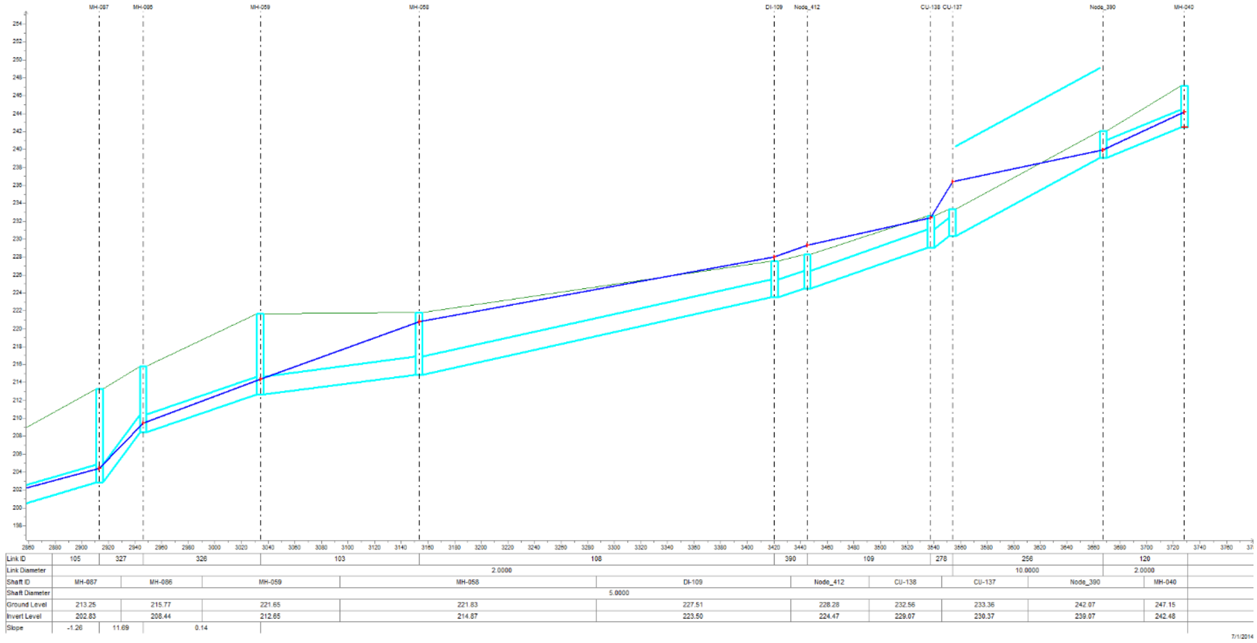
f



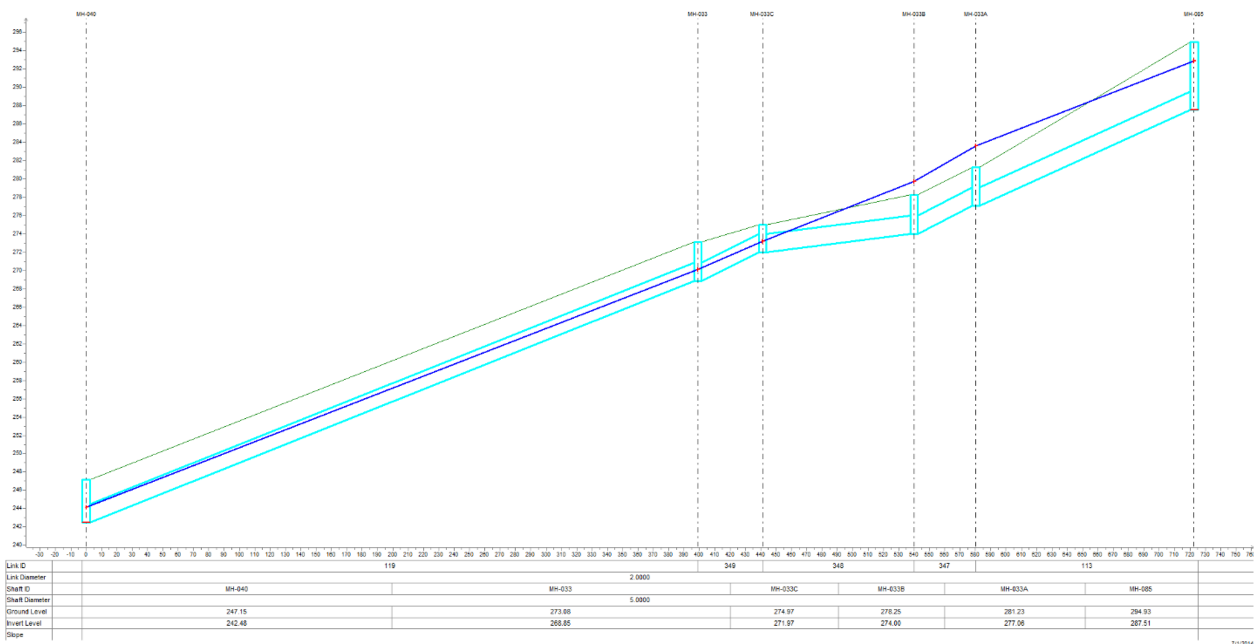
8th Avenue



4th Avenue



Junipero #1



Junipero #2

Appendix B. Meeting Minutes

Schaaf & Wheeler
CONSULTING CIVIL ENGINEERS

Meeting Minutes

Meeting Date	10/10/19	**Project No.**	CBTS.01.19
Time	8:30am	**Project Name**	Carmel SDMP
Meeting Location	Public Works Dept.	**Prepared By**	Dan Schaaf, PE
Attendees	Dan Schaaf, Emily Straley, Michelle Garza, Bob Harary, Agnes Martelet, Rob Culver		
Copies:	Attendees		

Meeting Purpose/Subject: Storm Drain Master Plan Kickoff Meeting

Items Discussed/Action Required	Notes/Action Items
1. Introduction	
1.1. Introduction of all parties 1.2. Prime points of contact 1.2.1. City: Bob Harary 1.2.2. Schaaf & Wheeler: Dan Schaaf	**Rob Culver for field support as needed. (831) 901-4888**
2. Project Scope Review	
2.1. Data Collection and Review 2.1.1. Field Protocols 2.1.2. Traffic Control 2.2. Infrastructure Inventory 2.2.1. GIS Format 2.2.2. Metadata 2.3. Outside Data 2.4. Condition Assessment 2.4.1. S&W Pole Camera 2.4.2. CCTV 2.5. Existing Condition Analysis 2.5.1. Model Selection 2.5.2. Coordination with other studies 2.6. Goals/Objectives	**48 hour notice for parking space blockage.** **CCTV likely in November.** **Areas of Pebble Beach to be studied as needed if they impact the City drainage network.** **S&W to give a general drainage review of Carmel Point neighborhood. This area could be anexed in the City.** **CIP will be designed for the 10-yr storm event and checked for the 100-yr and 85th% for BMPs.**

Items Discussed/Action Required	Notes/Action Items
2.7. Capital Improvements and Plan 2.8. Coordination 2.8.1. Monthly 2.8.2. Notes	
3. Schedule (see attached schedule)	
3.1. Review Schedule handout 3.2. Report Review 3.3. Final Report	
4. Data Gathering (see attached maps)	
4.1. City/County GIS Data 4.1.1. Pipes (diameter, material) 4.1.2. Catch Basins 4.1.3. Channels 4.1.4. Structures, Manholes, Outfalls 4.1.5. Topography 4.2. City Data 4.2.1. Land use mapping 4.2.1.1. Zoning 4.2.1.2. General Plan 4.2.2. Easements 4.2.3. Call logs/Reports 4.2.4. Maintenance reports 4.3. Models and data from Stetson	**Rob to provide 2018 field notes and cost estimates from recent SD project bids.** **Agnes to provide Mission Trails study data.** **Schaaf & Wheeler to debrief City after initial data collection and condition observations are complete. Recommended map of CCTV lines to be provided.** **The City is not aware of any currently accepted easements. Report will state something along the lines of 'to the best of our knowledge these are City pipes.'**
5. Questions and Next Meetings	
5.1. Questions 5.2. Next Meeting	

Schaaf & Wheeler
CONSULTING CIVIL ENGINEERS

Meeting Minutes

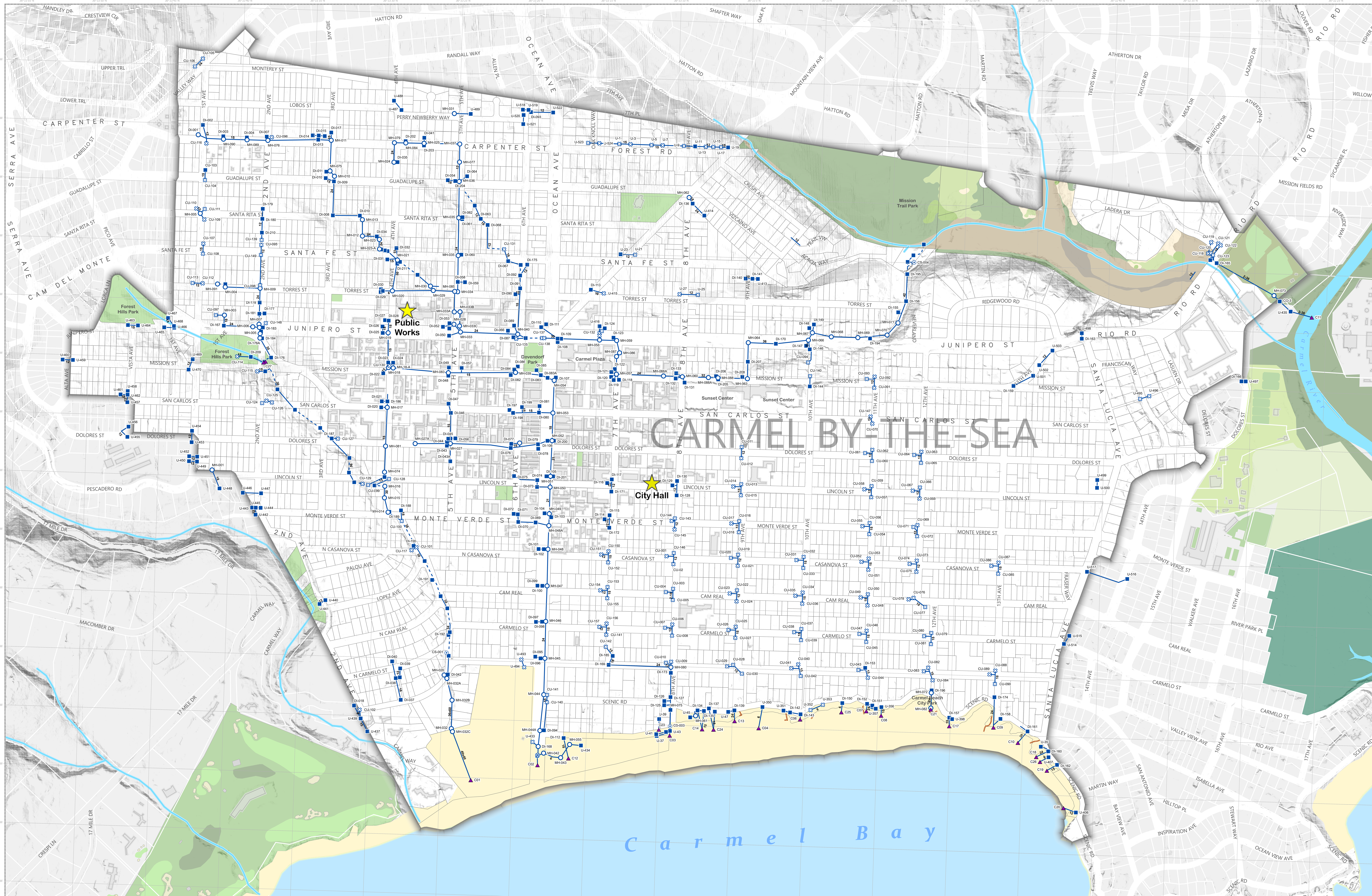
Meeting Date	5/19/20	**Project No.**	CBTS.01.19
Time	11:00am	**Project Name**	Carmel SDMP
Meeting Location	Google Meeting	**Prepared By**	Dan Schaaf, PE
Attendees	Dan Schaaf, Brandon Nyo, Bob Harary, Agnes Martelet, Rob Culver		
Copies:	Attendees		

Meeting Purpose/Subject: Storm Drain Master Plan Report Review Meeting

Items Discussed/Action Required	Notes/Action Items
1. Overall Report Structure	
1.1. Level of Content 1.2. Figures	**Overall format is OK with City. Several sections are missing.** **Figures need updated basemap and better explanation of channels.**
2. Sections to Add	
2.1. South portion of City without formal drainage system 2.1.1. Typical section showing issues 2.1.2. Example improvement 2.1.3. Cost estimate per block/intersection 2.2. South Annex Area Review 2.2.1. Map of area and SD system 2.2.2. CIP for new SD system 2.3. Diversion Project 2.4. Green Infrastructure 2.5. Climate Change 2.6. Underground "Rivers" 2.7. Drainage Easements 2.8. Mission Trails Restoration 2.9. County Stormwater Plan	**A figure showing how the continued paving of the streets is reducing conveyance capacity. A figure showing safety concerns for cross culverts along with possible solutions. Cost estimate to be added.** **A figure and rough cost estimate for an updated drainage system for the annex area will be added.** **The stormwater diversion plan will be added as a section along with a figure.** **A section of GI will be added. A table and figure of potential GI projects will be included. Devandorf Park, outfalls, diversions, green streets to be included.** **A section of SLR and precipitation will be added. The CIP model will be run with 2050 10-year storm.** **The underground rivers will be explained along with next steps.**

Items Discussed/Action Required	Notes/Action Items
2.10. Appendix is large scale map of all CIPs and known issues 2.10.1. Sediment 2.10.2. Capacity Sizes 2.10.3. Condition Issues 2.11. 2nd and Lincoln 2.11.1. Add to Monte Verde CIP	**A section on drainage easements will be added. A plan to acquire easements will be included. A figure showing area of potential easement locations will be included.** **The Mission Trails project will be added.** **A section on the County stormwater plan will be included. Projects within the City will be shown in a figure.** **The 30% plans for 2nd and Lincoln will be added to the 2nd and Monte Verde CIP.**
3. Schedule	
3.1. Final Draft 3-4 weeks 3.2. Sections to City as ready 3.2.1. CIP priorities	
4. Questions and Next Meetings	
4.1. Questions 4.2. Next Meeting	

Appendix C. System Map



CARMEL-BY-THE-SEA

Legend

SD Node Type		SD Pipe Type	
CDS Unit	Inlet	Pipe	Stream
Cross Culvert	Manhole	Open Channel	City Limit
	Outfall		Parcel

SOURCES: ELEVATION DATA COURTESY OF AMBAG AND USGS. STORM SYSTEM DATA ACQUIRED FROM CITY OF CARMEL AND UPDATED BY SCHAAF & WHEELER. CITY DATA COURTESY OF CITY OF CARMEL. ADDITIONAL DATA USED FROM OSM. PROJECTION: NAD 1983 2011 STATEPLANE CALIFORNIA IV FIPS 0404 FT US. ORIGINAL MAP SIZE: 48X36. BN

N E S W

0.05 0.03 0 0.05 0.1 0.15 0.2 0.25 Miles

375 187.5 0 375 750 1,125 1,500 Feet

Schaaf & Wheeler
CONSULTING CIVIL ENGINEERS

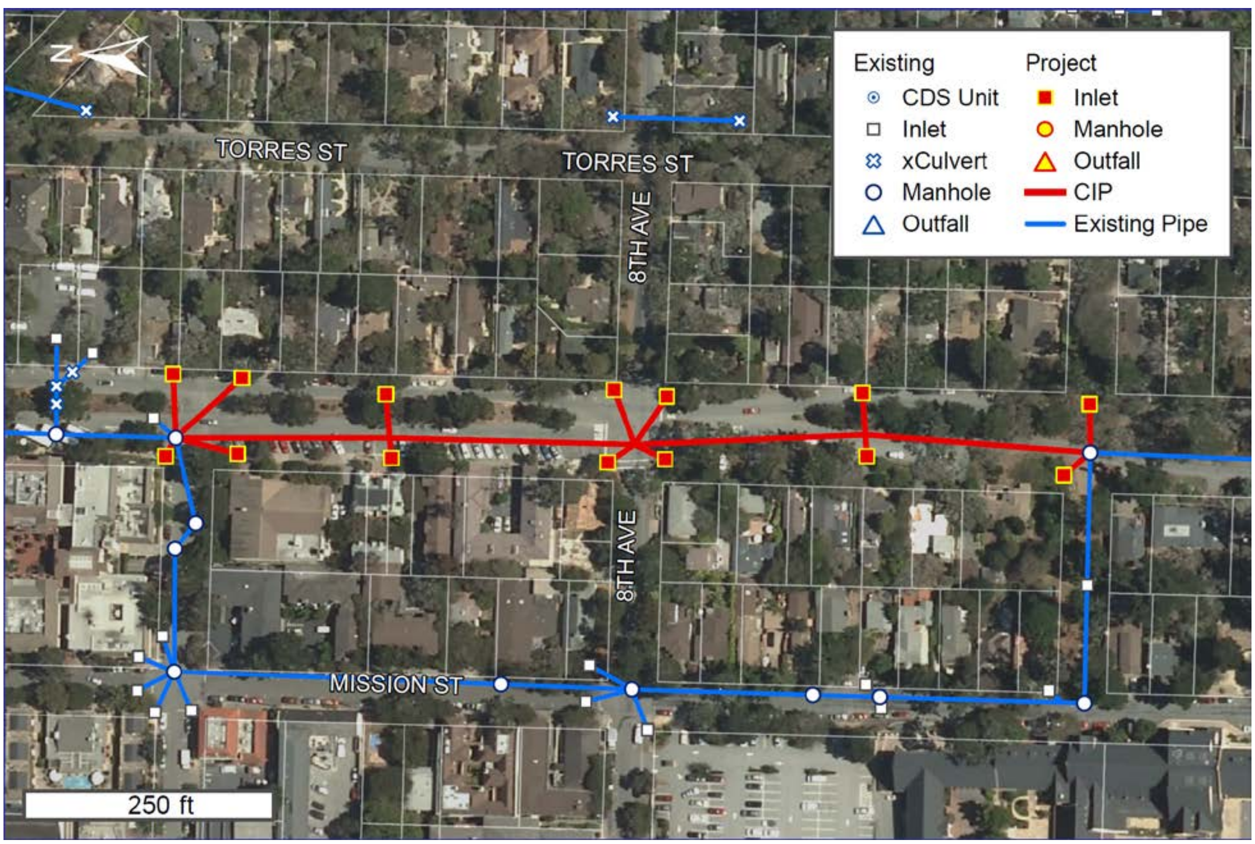
Appendix D. Capital Improvement Program Project Sheets

Project Name:	Mission Street Bypass
Project ID:	1
Priority:	High
Cost:	$ 820,000

Project Description: There is currently recurring drainage issues along Mission Street between 8th and 9th Avenues. There is also a capacity constraint in the existing storm drain that services the eastern portion of the City. This project would add a 24-inch bypass along Junipero Avenue between 7th and 9th Avenues to reduce the hydraulic gradeline in the system. 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 Cost	Total Cost[1]
Bypass Main	915	24	$ 490	$ 448,000	5	$ 19,100	$ 545,000
Inlets/Laterals	550	12	$ 300	$ 165,000	14	$ 8,000	$ 275,000
	1,465				**19**		**$ 820,000**

1. *2020 Construction cost with 40% contingency.*

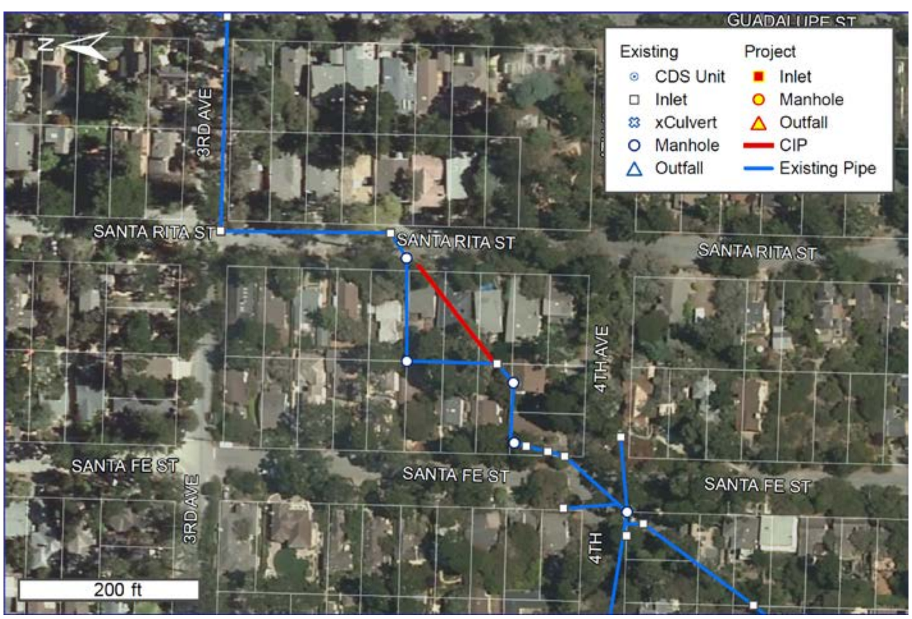


Project Name:	Santa Rita 1
Project ID:	2
Priority:	High
Cost:	$ 220,000

Project Description: The abandon box culvert between Santa Rita Street and Santa Fe 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. Because 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	$44,000
Pipe Repair	110	$1,600	$176,000
Total	**1501**		**$ 220,000**

1. *2020 Construction cost with 40% contingency.*

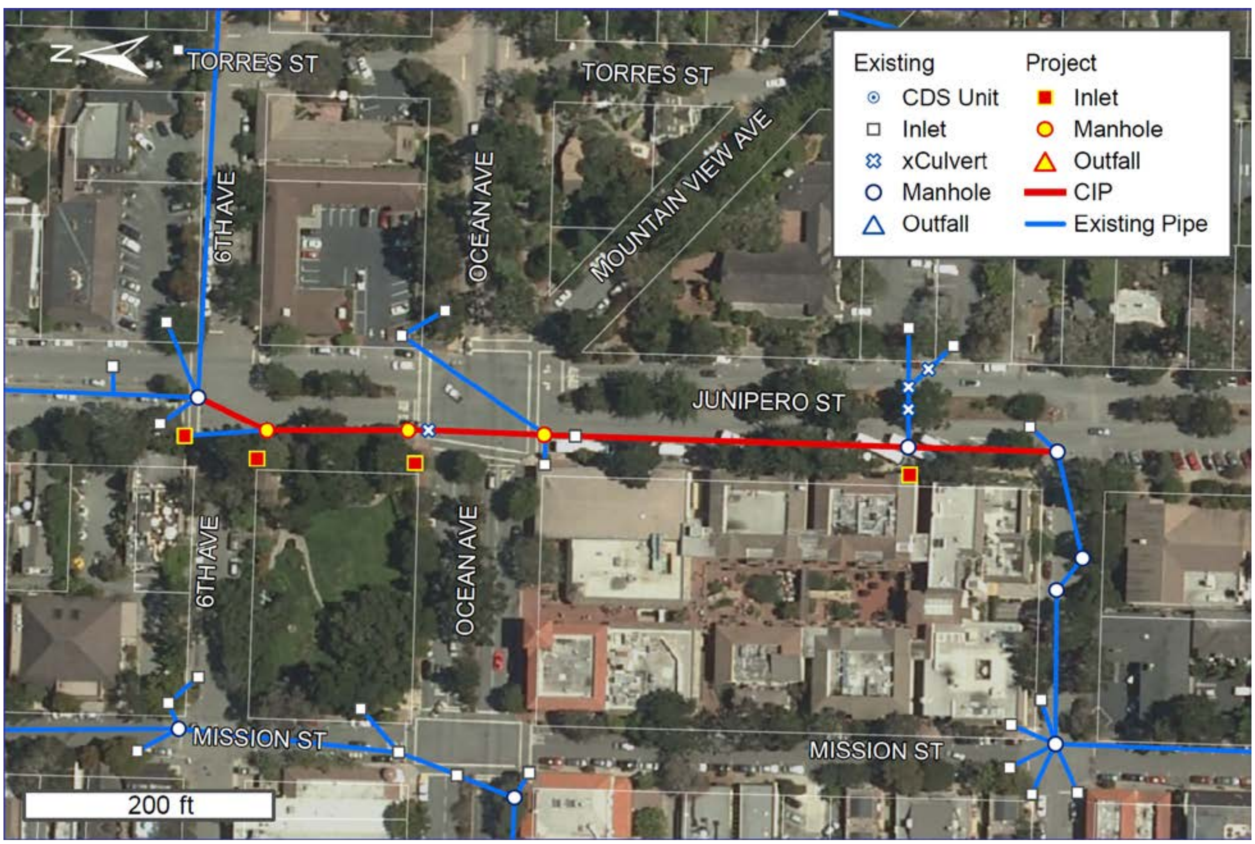


Project Name:	Junipero
Project ID:	3
Priority:	Moderate
Cost:	$ 803,000

Project Description: The existing drainage system along Junipero Street between 6th Avenue and 7th Avenue is undersized to convey the 10-year event. Upsizing this portion of the system to a 36-inch RCP system will lower peak stages during large storm event. The existing open channel section adjacent to Devendorf Park can be either left for aesthetics or removed. 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	725	36	$ 730	$ 529,000	6	$ 19,900	$ 649,000
Inlets/Laterals	300	12	$ 300	$ 90,000	8	$ 8,000	$ 154,000
	1,465				**14**		**$ 803,000**

1. *2020 Construction cost with 40% contingency.*

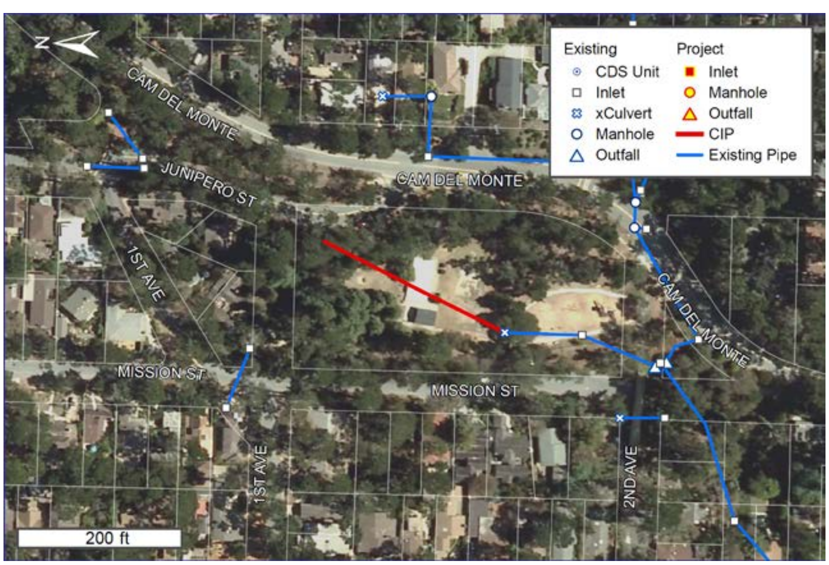


Project Name:	Forest Hill Park – Emergency Repair
Project ID:	4
Priority:	High
Cost:	$ 130,000

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. *2020 Construction cost with 40% contingency.*

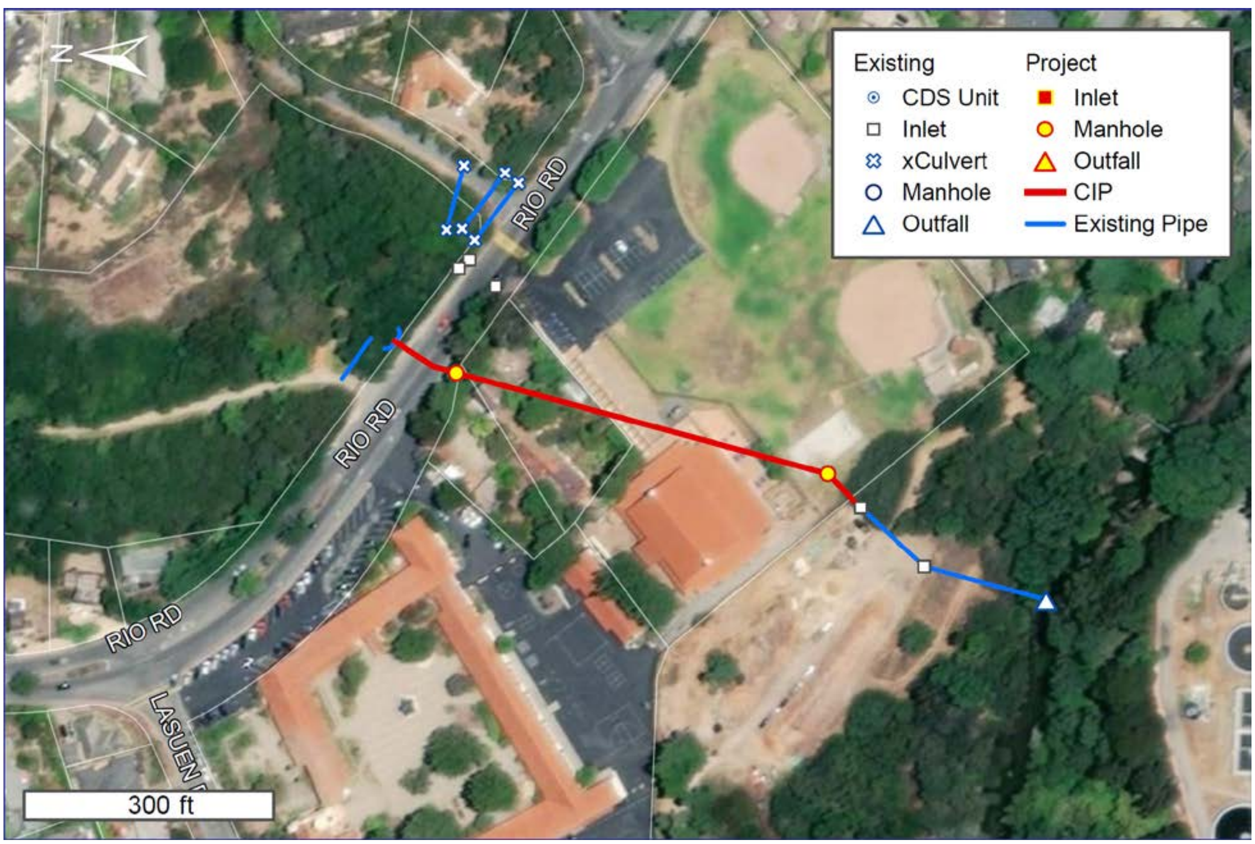


Project Name:	Rio Road 1
Project ID:	5
Priority:	Moderate
Cost:	$ 2,420,000

Project Description: The Mission Trails Channel outfall to the Carmel River is currently undersized to convey the 10-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 54-inch high box culvert. Downstream of the Rio Road the system would consist of twin 4-foot by 4-foot RCBs. 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’	$ 2,500	$ 138,000	0	$ 19,500	$ 574,000
RCB	1,600	5’x3’	$900	$ 1,440,000	10	$ 20,000	$ 1,640,000
Sediment Capture							$206,000
	1,655				**10**		**$ 2,420,000**

1. *2018 Construction cost only. Construction cost includes mobilization, traffic control, trench and surface restoration*

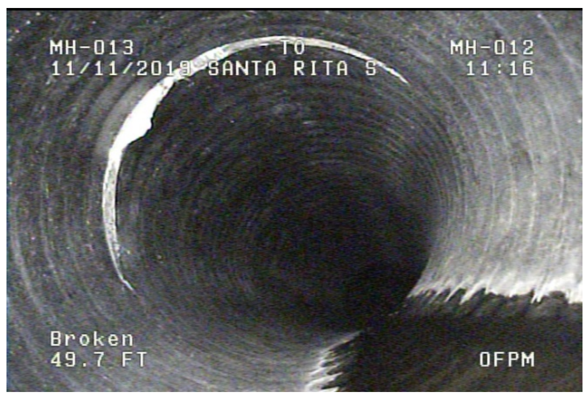


Project Name:	Santa Rita 2
Project ID:	6
Priority:	Moderate
Cost:	$ 167,000

Project Description: The existing corrugated lined pipe west of Santa Rita Street, between 4th and 3rd Avenues, is damaged. This segment should replace 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	$ 490	$ 71,000	3	$ 19,100	$ 128,000
Inlets/Laterals	50	12	$ 300	$ 15,000	3	$ 8,000	$ 39,000
	195				**6**		**$ 167,000**

1. *2020 Construction cost with 40% contingency.*

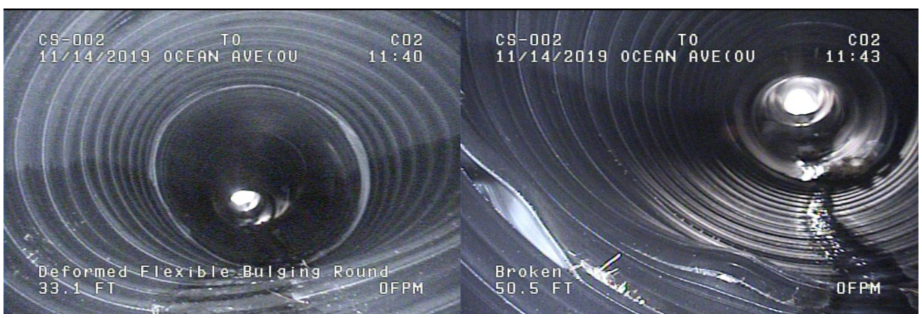


Project Name:	Ocean Avenue
Project ID:	7
Priority:	Moderate
Cost:	$ 250,000

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	$ 490	$54,000	0	$ 19,100	$ 54,000
CDS Unit Replacement				$150,000			$150,000
Outfall/Baffles					1	$ 20,000	$ 46,000
	195				**6**		**$ 250,000**

1. *2020 Construction cost with 40% contingency. Outfall permitting not included.*

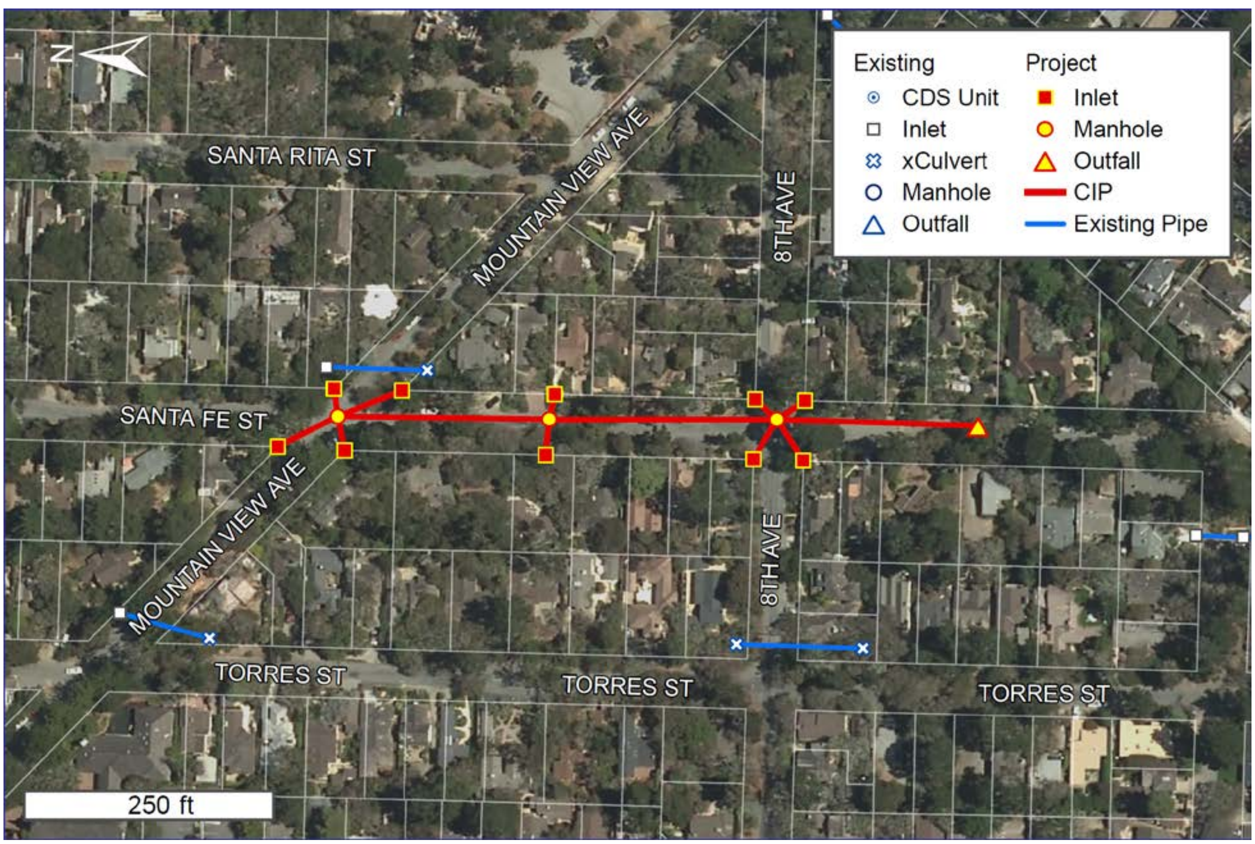


Project Name:	Santa Fe
Project ID:	8
Priority:	Moderate
Cost:	$ 487,000

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	$ 400	$256,000	3	$ 18,700	$ 312,000
Inlets/Laterals	250	12	$ 300	$ 75,000	10	$ 8,000	$ 155,000
Outfall					1	$20,000	$20,000
	890				**14**		**$ 487,000**

1. *2020 Construction cost with 40% contingency. Outfall permitting not included.*

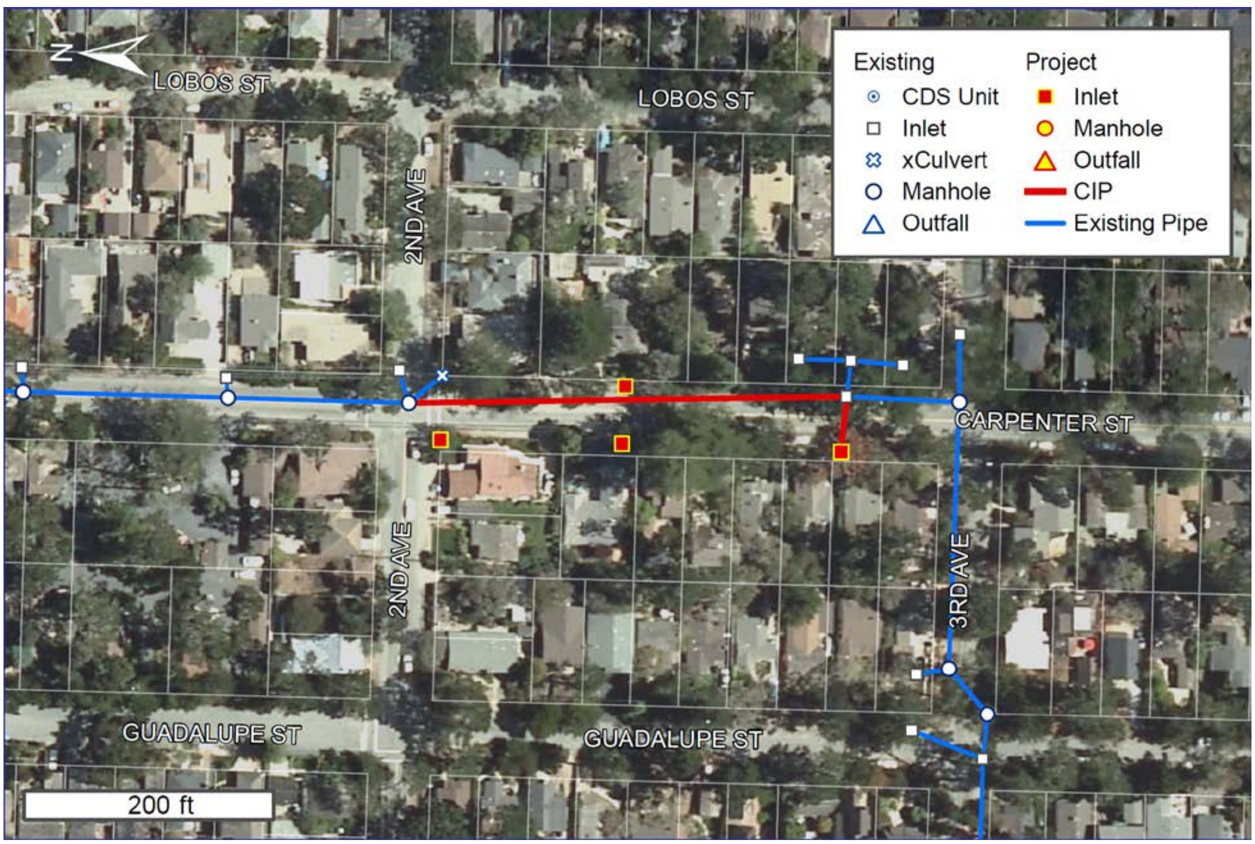


Project Name:	Carpenter
Project ID:	9
Priority:	Moderate
Cost:	$ 272,000

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	$ 490	$172,000	2	$ 19,100	$210,000
Inlets/Laterals	100	12	$ 300	$ 30,000	4	$ 8,000	$ 62,000
	450				**6**		**$ 272,000**

1. *2020 Construction cost with 40% contingency.*



Project Name:	11th and San Antonio
Project ID:	10
Priority:	Moderate
Cost:	$ 402,000

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	$ 490	$221,000	3	$ 19,100	$278,000
Inlets/Laterals	200	12	$ 300	$ 60,000	8	$ 8,000	$ 124,000
	650				**11**		**$ 402,000**

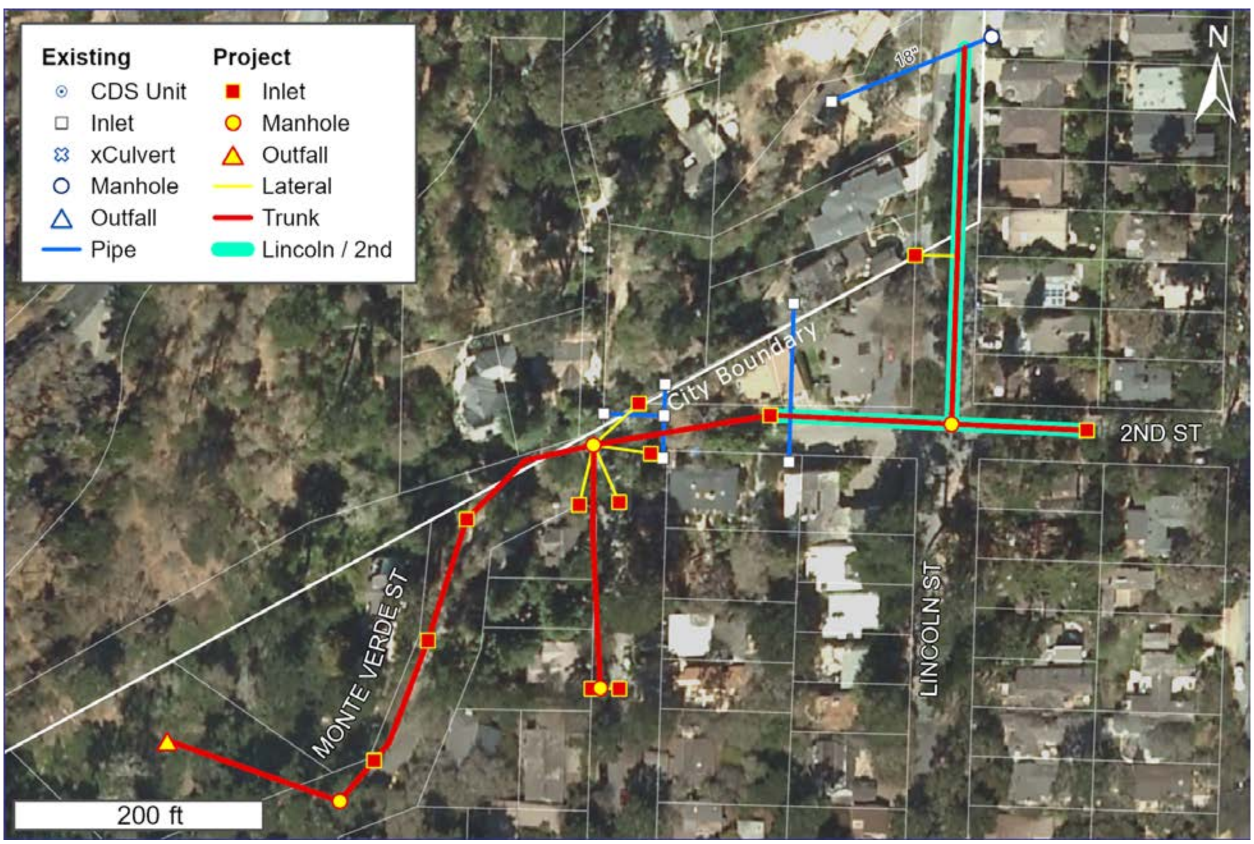
1. *2020 Construction cost with 40% contingency.*

Project Name:	2nd and Monte Verde
Project ID:	11
Priority:	Moderate
Cost:	$ 602,000 ($828,000 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 the trail just west of Casanova Street. A pipe along Monte Verde would also be included. Inlets at intersection and key locations along the alignment will be included to capture runoff. The outfall will need to be in a location where scour potential is minimized. If funding allows, 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	860	18	$ 400	$344,000	4	$ 18,700	$419,000
Inlets/Laterals	250	12	$ 300	$ 75,000	11	$ 8,000	$ 163,000
Outfall					1	$20,000	$20,000
	1,110				**15**		**$ 602,000**
Lincoln/2nd	425	18	$400	$170,000	7	$8,000	$226,000

1. *2020 Construction cost with 40% contingency. Outfall permitting not included.*

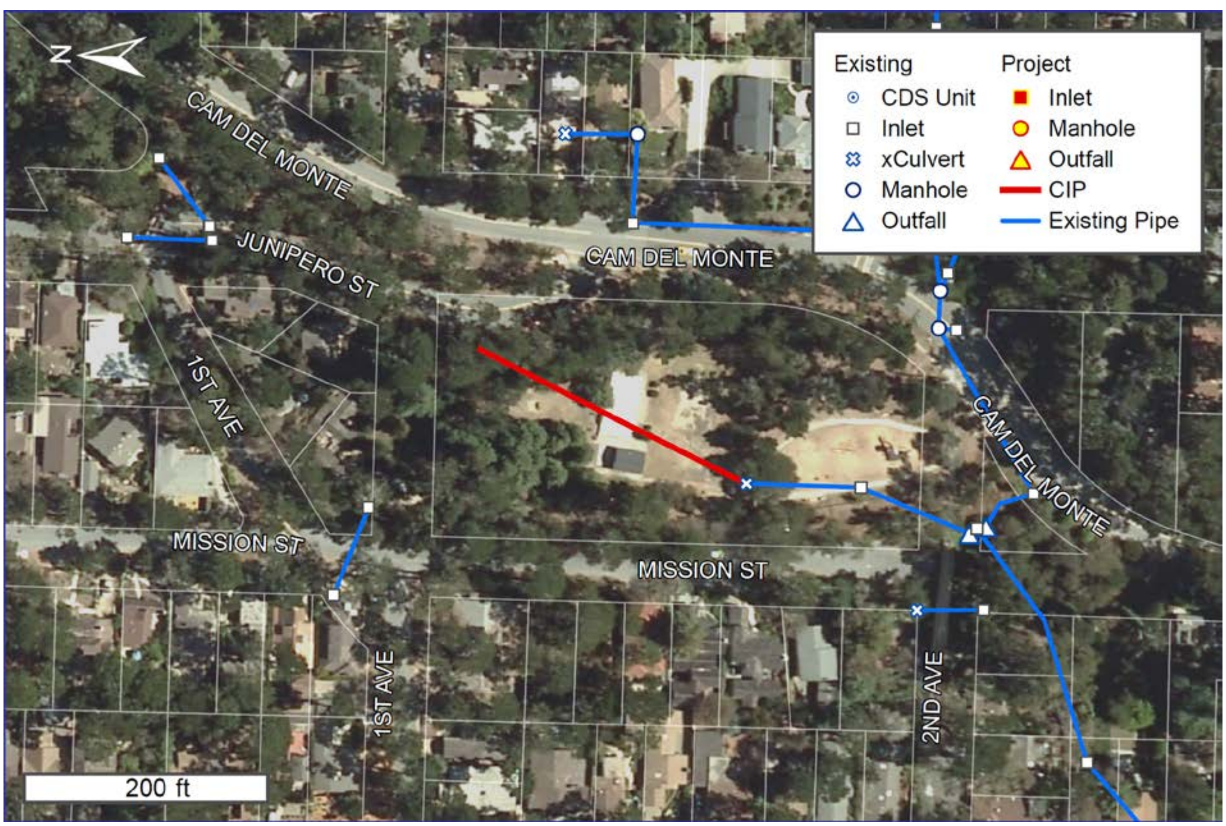


Project Name:	Forest Hill Park – Channel Realignment
Project ID:	12
Priority:	Moderate
Cost:	$ 700,000

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. *2020 Construction cost with 40% contingency.*

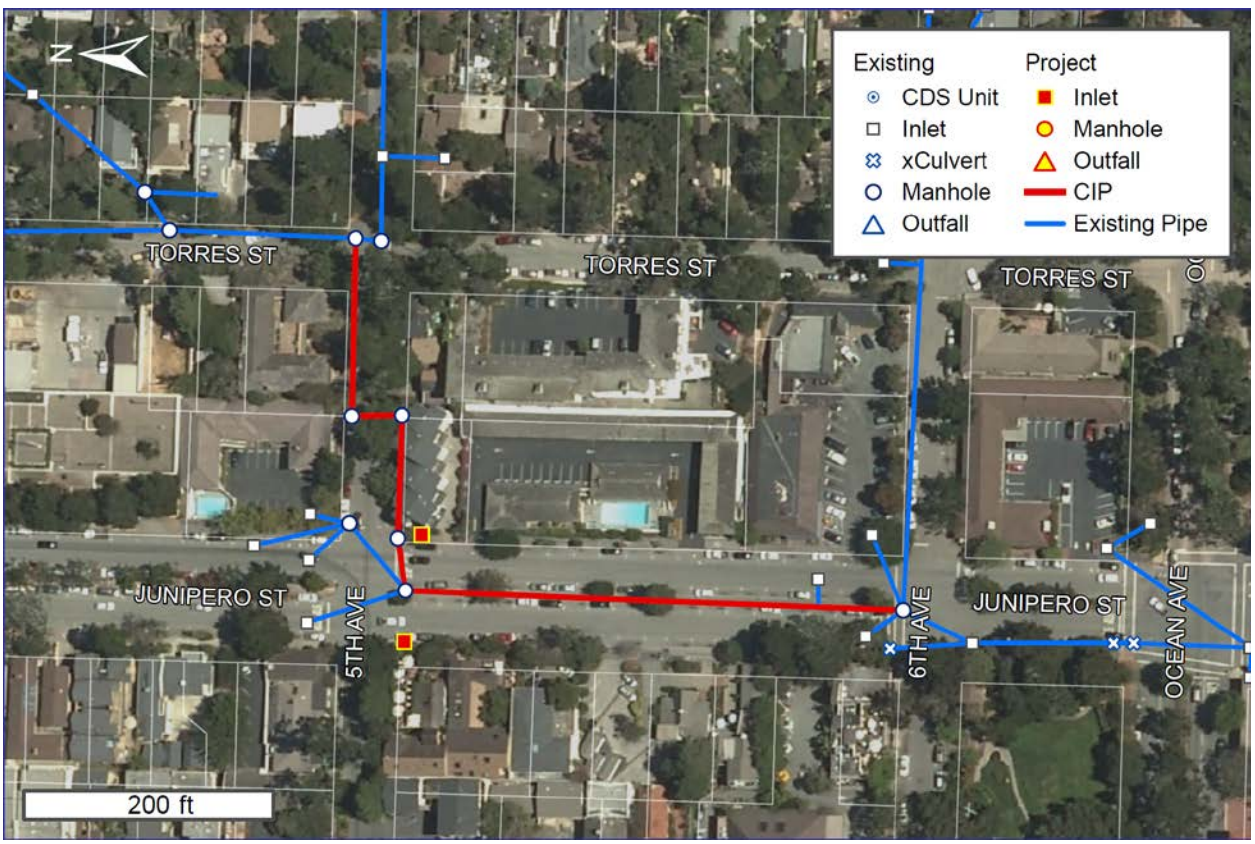


Project Name:	5th Avenue
Project ID:	13
Priority:	Low
Cost:	$662,000

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 10-year event. Upsizing this portion of the system to a 30-inch RCP 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 Avenues 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	620	30	$ 630	$ 390,000	6	$ 19,500	$ 508,000
Inlets/Laterals	300	12	$ 300	$ 90,000	8	$ 8,000	$ 154,000
	920				**14**		**$ 662,000**

1. *2020 Construction cost with 40% contingency.*



Appendix E. Nuisance Problem Documentation

2nd and Monte Verde

On Wed, Dec 4, 2019 at 5:18 PM Chris Hardy wrote:

Hi Bob,

Hope you are surviving our wet weather!!

I spoke to one of your work crews today and they suggested I reach out to you.

I live at Monte Verde 3 SW of 2ND Ave.

There is a storm drain across the street from my home that is poorly designed in that when it rains heavily the drain quickly closes due to a combination of silt and pine needles that are flowing on the east side of Monte Verde from the corner at 3RD Ave

The rain water then surges in a westerly direction across Monte Verde, jumps an asphalt berm and then proceeds down my driveway.

It then either fills the drain in front of my garage door and then water comes into the garage, or it flows down the pathway to the south side of my home and deposits the silt and pine needles behind my house.

Since the rains started last week I have personally cleared the drain top 4 times and I understand from the crew that they have cleared it at least 3 times just in the last two days.

I am sure that you are dealing with bigger problems and I am not sure that there is a better solution (in this case bigger may be better!!) but I would ask that you consider placing this drain opening on a review schedule to look to see if it can be re-engineered to drain more efficiently.

I would be happy to meet you if you stop by to look at this

Thanks for your time

Regards,

Chris Hardy

San Antonio and 11th

*From: **Mike McCarver***
Date: Sun, Dec 8, 2019 at 1:17 PM
Subject: Re: Storm drain at San Antonio and 11th
To: Rob Culver <rculver@ci.carmel.ca.us>

Flooded again!! Rob. the rain Sunday morning flooded my property again. The drain on San Antonio seemed to work ok, but the 11th Ave drains clogged and water skipped right over them. I think the water is traveling at such velocity that even with little debri blockage water would fly right over both drains.

This really has to get fixed! I'm getting too old to go out there in the rain and tend to the problem!

I've attached a video. I'll send it both as an attachment and I'll send separately via dropbox.

Mike McCarver

On Mon, Dec 2, 2019 at 10:13 AM Mike McCarver wrote:

Hi Rob,

Remember the problems we had with this drain a couple years ago? You had an additional drain installed in 11th, and another one on San Antonio, West side near my house which is in the NW corner of San Antonio & 11th. Back them, the storm drain in 11th would get clogged, and water would skip over it to San Antonio, jump the West side curb and flooded my property.

*I thought those modifications along with the higher street curbs had fixed the problem. Then the storm Tue last week proved me wrong. Storm drain was clogged, water came across San Antonio and f**looded my property!** I cleared the drain Wed am, thinking it was the first storm, lots of pine straw and debri. Then it happened again Sunday morning. I cleaned it again. Now it happened again just this am. Both 11th ave drains were clogged, and water was flowing right over them. I partially unblocked them. I'm getting too old to do that often!*

Last time we talked about this, you mentioned that there was a plan to install a storm drain at 11th and Carmello to run under the street down to the existing drains. Is this still a plan?

I request 2 things: 1. Please have your maintenance folks keep and eye on that drain and keep it clear. 2. Please advise the status of a more permanent fix.

Thanks Mike McCarver

13^{th} and Camino Real

Mr. Harary -
I just left a voice mail for you regarding our new construction property at 3NE of 13th on Camino Real. We have a water/drainage (and now mud) issue in front which is very concerning, especially because the house is on the market.
Is it possible to meet with you or one of your staff to talk about possible resolutions? I will be in Carmel until this Thursday.
Thank you -
Shari Lasher

Lasuen Drive

Proposal for Rainwater Management Project – Lasuen Drive

Stefan and Tatiana Karapetkov
3009 Lasuen Drive, Carmel, CA

March 1, 2020

Problem description

1. *Rainwater from Santa Lucia Ave, Franciscan Way, and Lasuen Drive converge and build a "creek" that covers one lane on Lasuen Drive, opposite to the Carmel Mission. The water follows the road around the Mission and towards the tennis courts (Mission Ranch Tennis Club), where it goes into a street gutter.*
   - *The creek is wide and cannot be safely passed on foot (see photo below). The only way out of the house is by car.*
   - *The "creek" erodes the road*
   - *Drivers on Lasuen Drive (homeowners, visitors to the Carmel Mission and Mission Ranch, parents bringing their children to Carmel River Elementary School and Junipero Serra School…) try to avoid the water and drive in the opposite lane which is dangerous because the road curves around the Mission and cars in the opposite direction cannot be seen*
2. *The "creek" leaves mud, sand, and other debris along its path; they remain for weeks after the rain.*
   - *Cars continue driving through the mud and sand for weeks after the rain*
   - *Tourists / visitors of the Carmel Mission frequently make comments about the dirt on the street, try to take photos without capturing it*
   - *Bicycles riders and joggers try to avoid the dirt creating dangerous conditions on the road*
   - *Even if homeowners clean the dirt on the road, the next rain brings it back, so the road is dirty for the majority of the rainy season*

Proposal

- *Bury a drainage pipe along Lasuen Drive that captures the rainwater coming from Franciscan and Santa Lucia at the bottom of the alley and leads it to the existing street gutter opposite to the tennis courts.*
- *To avoid sand and dirt coming down from Franciscan Way, install a drainage pipe or improve the alley connecting Franciscan Way and Lasuen Drive.*

This proposal is supported by the homeowners on Lasuen Drive, for example:

- *Gene and Diane Roller, 3001 Lasuen Drive*
- *Joe and Shannon Haar, 3073 Lasuen Drive*
- *Anne Kelly, 2985 Lasuen Drive*

Santa Fe and Mountain View

*From: **Tony Seton***
Date: Mon, Jan 20, 2020 at 11:19 AM
Subject: water drain problem at Mountain View and Santa Fe
To: Dave Potter , Jeff Baron , Bobby Richards , crerig@ci.carmel.ca.us>, rculver@ci.carmel.ca.us <rculver@ci.carmel.ca.us>

Gentlemen,

Some of you are already aware of the problem of water pouring from Ocean down Santa Fe to Mountain View (and beyond) but the matter deserves the attention of all of you. The water comes down the west side and middle of Santa Fe, missing the drain on the southeast corner of the intersection.

You can see it somewhat more clearly in this next photograph where the rain has stopped and the run-off is coming down Santa Fe and crossing Mountain View, missing the drain (in the upper right hand corner of the pic).

We have had major problems with the water flowing through our yard, washing away several cubic yards of top soil, overwhelming the French drain at the bottom of the driveway, and flooding the garage. I have been out in the middle of the night a number of times bailing out a pool in front of the garage door a foot deep. The French drain has recently been cleared out, which should help, and I have a double layer of sandbags in front of the garage door and towels on the inside.

I also am grateful that the city raised the berm in front of the property, to which I've added a layer of sandbags and stretched a wattle down Santa Fe where the water was coming over the berm and down the driveway.

But the sandbags and wattle at the roadsides should be temporary measures. What's needed, as Rob and some of his staff have already recognized, is <u>at least</u> a drain on the southwest corner of Mountain View and Santa Fe. I'm guessing the section of Santa Fe north of Mountain View probably needs some different leveling or sculping or more drains to catch the flow from Ocean.

I trust that we will get through the current rainy season (and unseasonal May deluges) with the measures already taken, but I'm writing to you about this matter to assure that permanent remedial action be taken by next fall. I believe that means special budgeting and scheduling.

Let me add that the problem is not just at our house, but further down Santa Fe between Mountain View and Eighth Avenue, where the fast and heavy flow of water has dug trenches in front of several houses, pouring rock and sand over several roadways.

If I can be of any further assistance in making sure that this matter is resolved, I have more photographs and I am willing to point out the details at the site and to testify if appropriate.

Thank you for your attention.

Respectfully,

Tony Seton

2nd Avenue

*From: **Sam Fonte***
Date: Wed, Apr 1, 2020 at 11:42 PM
Subject: Another tree falling on my property
To: Chip Rerig <crerig@ci.carmel.ca.us>
Cc: Sara Davis <sdavis@ci.carmel.ca.us>, <rharary@ci.carmel.ca.us>

Hello Chip!

Sorry to bother you at this difficult time in our city and country. But I am writing to you again because a 2nd big oak tree had fallen last week on my property causing considerable physical and electrical damage to my house and property (see attached email thread below).

The first tree that fell in February which I wrote to you about on Feb 13, 2020 had been removed by California American Water (CalAm) after they took responsibility for the tree. However, on this 2nd oak tree (located about 15 feet east of the first), they are hesitating and I sense, diverting full responsibility because, they say, there is an underlying problem inherent in the area that was created by the City. They claim the tree(s) were along the path of a water channel that the City of Carmel built on 2nd avenue just north of my property. The channel as you may or may not know directs storm runoff originating from Monte Verde and 2nd Avenues to drain at Pescadero Creek.

The water channel, it is worth noting, was built to drain storm runoff from the elevated section of 2nd Ave but mostly for the high volume of runoff coming downhill from Monte Verde. Water runoff from Monte Verde which was enormous last November has to turn sharply right (about 270 degrees) northward on the channel, such that during the last big rain in November, the rushing water spilled over the shallow asphalt berm and created a new water path along the way to the creek. Also, during that big November rain, there was flooding that occurred in my backyard, prompting me to put sandbags at the edge of the asphalt curb on 2nd Ave later. The enormous amount of water that overflowed on the channel may very well have caused the erosion of the soil, undermining the roots, that ultimately caused the trees to topple down one after the other. When I look over the creek on the deck of my house now, there are a lot of fresh soil and mud sludge at the edge of the creek. This is evidence of erosion and can definitely cause more trees to fall if no mitigation measures are done.

A 3-day rain is forecasted these coming weekend and <u>I have concerns now that another Pine tree maybe at risk of falling</u> and sever once again my newly restored service power line. I am really worried about this especially if this weekend storm is accompanied by strong winds and heavy rains. <u>I am also concerned on how this big oak tree gets removed now from my backyard if CalAm is not going to take responsibility</u>.

I already left a message to the public works department on Monday, and Yvette told me she will pass this on to either Sara or Bob to call me. Sara is aware of this 2nd fallen tree as I copied her *on my email to CalAm when it fell on the early hours of March 23. I have followed this up with voice messages since but nobody has called me about it until now.*

Hope you can help us fix this problem as soon as possible.

Thank you!

Sam Fonte

Appendix F. Photographs

(provided on flash drive)

Appendix G. CCTV Report

Appendix H. Mission Trail Preserve Study

REGISTERED PROFESSIONAL ENGINEER
MATT W. WELD
No. 62235
Exp. 9-30-19
CIVIL
STATE OF CALIFORNIA

Digitally signed by Matt Weld
DN: cn=Matt Weld, o=Waterways, ou, email=mattw@watways.com, c=US
Date: 2019.02.14 10:56:11 -08'00'

TECHNICAL MEMORANDUM

To:	Agnes Martelet, Environmental Compliance Manager, City of Carmel
From:	Dudek and Waterways Consulting, Inc.
Prepared by:	Matt Weld, PE and Dudek (Permit Requirements)
Date:	February 14, 2019
Re:	Mission Trail Stream Stability Assessment

INTRODUCTION

The goal of this memorandum is to summarize methodology, results, and recommendations of our work performed in response to the City of Carmel's request for a stream stability survey within the Mission Trail Nature Preserve (Preserve). Specifically, the City requested the completion of the following tasks:

- Determine factors contributing to instability, as evidenced where steep channel banks are failing, the channel bed is incising, and high flows are utilizing downstream roads and trails instead of the stream course.
- Evaluate the stability of access and drainage improvements (e.g., gabion baskets, bridge crossings, wet ford crossing, culverts, and trails within the riparian corridor) to determine which are stable and which may need some sort of adjustment to address drainage-related concerns.
- Recommend actions to stabilize the stream and enhance overall habitat conditions in the riparian corridor.
- Identify anticipated permitting requirement associated with proposed maintenance, repairs or enhancements.

Work was performed by Waterways Consulting, Inc. (Waterways) and Dudek during the months of July through November of 2018.

The Preserve is located near the southeastern edge of the city of Carmel-by-the Sea. The 34-acre property was acquired by the City in the 1970s and was designated a nature park in 1979 by the Carmel City Council. A Master Plan for the Preserve was adopted by the City in the mid-1990s that sets forth goals and policies for long-term preservation and use of the Preserve. The southern edge of the Preserve fronts Rio Road and extends north into the wooded neighborhoods of Carmel near the Highway 1 corridor. The narrow, linear property is surrounded by improved residential properties within the City and unincorporated County areas. The Preserve is accessed from four signed trailheads and has a number of trails through the property.

Two main perennial drainages and several smaller drainages transect the Preserve. The main perennial drainage enters the Preserve at its northern end, runs along its western boundary and forks near the center of the Preserve. Another perennial drainage feeds into the Preserve from the east. The Preserve supports a mix of vegetation types.

METHODOLOGY

Background Data Review

Past Studies reviewed to inform our assessment included:

- Mission Trail Nature Preserve Master Plan
- Drainage Investigation for the Mission Fields Area of Carmel Valley – Summary Report (Nolte & Associates, 1986)
- Baseline Biological Assessment , Mission Trail Nature Preserve (Nedeff, 2016)
- Preliminary Soil Investigation for Storm Water Detention Pond (Neill Engineers, Inc., 1984)
- Carmel General Plan/Local Coastal Program (2004)

Topographic mapping and utility layers were also provided by the City in GIS format for review and incorporation into our study.

Visual Site Assessment and Meetings with Project Advisory Committee

The project was initiated with a kickoff meeting on July 9th, 2018, attended by Waterways, Dudek, Nicole Nedeff, and City Staff. The meeting focused on discussion of project goals and objectives, available resources, and scheduling.

An introductory site walk was attended on July 27th to review existing conditions. This walk was again attended by Dudek, Waterways, Nicole Nedeff, a representative of Friends of the Mission Trail Nature Preserve, and City staff. During this walk, the group walked the length of the Preserve and discussed known points of concern.

Waterways returned to visit the site on numerous occasions during and after mapping to hike the park perimeter and adjacent streets as design and analysis progressed.

A final site visit to the lower end of the Preserve was performed on October 25th and was attended by Waterways, Dudek, Nicole Nedeff, and City Environmental Compliance Manager Agnes Martelet. The purpose of this meeting was to review preliminary design drawings in the vicinity of the Preserve entrance at Rio Road.

Topographic Mapping

Topographic mapping was performed by Waterways staff on five separate dates in July and August 2018, using a combination of RTK GPS and total station equipment. Elevation Datum is NAVD 88. The horizontal datum is NAD83 California State Plane, Zone 3. Control was established using the Leica Geosystems Smartnet Global Navigation Satellite System (GNSS) Network. Our survey included a long profile of the primary channel, periodic cross sections, and topographic mapping at select areas where drainage concerns were most apparent. Our work was overlain onto watershed scale topography 2010 LiDAR survey provided by the City (AMBAG, 2010).

Long Profile Survey

The long profile survey extended from Rio Road to the upstream limit of the Preserve. Points were surveyed at cross sections, at significant grade breaks, and on prominent features such as grade controls, weirs, or culverts. The profile is presented on Sheet C2 of the Attachment A, with stationing that corresponds to the site overview on Sheet C1.

Notable features on the profile include the following:

- Shallow channel in vicinity of stations 6+00 to 8+00, where flooding has been observed.
- Channel incision below the confluence at approximately Station 22+25
- Distinct break in channel profile at the station 22+25, where average channel gradient changes from approximately 1.4% to 7%.
- High number of constructed grade control elements (over 20) between Station 22+50 and upstream limit of Preserve, ad distance of approximately 1600 feet.

Cross Section Survey

Cross sections were surveyed periodically through the Preserve at representative locations or where features relevant to the study were observed. Twenty cross sections are presented on Sheets C9 through C11. Sheet C8 shows the cross section locations overlain onto the Preserve overview map.

Beginning at cross section A and extending through cross section I, there is clearly a broad flat floodplain available to the channel. However, it appears as if the channel has been relocated to the east side of the floodplain, hugging the toe of the slope. Cross sections C through F demonstrate that the channel is no longer occupying the lowest point in the floodplain, which appears to be well to the west of the current alignment. Channel realignment to the valley margins was a common management technique in the past, often used to optimize floodplains for ranching or farming, allowing uninterrupted access and improved opportunities to dry floodplains in early spring. The result appears to be a channel with an unnaturally straight planform and entrenched condition, offering reduced floodplain function.

Detailed Site Survey Maps

Detailed topographic maps were prepared to allow for development of higher resolution site plans at areas where erosion, sedimentation, or flooding problems were evident, or where potential projects were discussed during our site meetings. The following areas were mapped in greater detail, and area shown on Sheets C3 through C6 of Attachment A.

1. Tributary Crossing and Trail Junction
2. Concrete Ford and Trail Re-route Site
3. Bridges at Confluence

These sheets also provide preliminary repair recommendations, as described further below.

Hydrologic Assessment

A rainfall-runoff simulation model was prepared to allow us to analyze the project site hydrology during design storm events. The purpose of this modeling was to determine approximate runoff rates that would support hydraulic analysis of erosive forces, floodplain interaction, and hydraulic capacity at individual locations. The model was developed in sufficient detail for the purposes of this study, but should still be considered approximate since it did not include a calibration effort or a comprehensive mapping of the watershed outside the park boundaries, especially where located on private property.

These efforts would be considered outside the scope of the current study, but may be warranted in support of the final design of certain scenarios.

Mapping Sources

Our analysis was based on several different mapping resources. General watershed topography was provided by the City of Carmel in the form of a digital terrain model resulting from a LiDAR survey (AMBAG, 2010). Within the park boundaries, dense vegetation rendered the LiDAR mapping unreliable, so we used our own field observations and topographic data collection. Outside the park, drainage paths were determined by walking and/or driving the city and county streets and Caltrans right of way to visually inspect surface flow splits and pipe alignments where topography alone was not sufficiently detailed to accurately determine watershed or subwatershed boundaries. Outfall locations and approximate subwatershed boundaries were also provided by the City of Carmel and Monterey Resources Agency on large format maps included within Appendix 3. Figure 1A within Appendix 1 shows the resulting stormwater basin map with subwatersheds and junctions labeled.

Analysis

The contributing sub-basin drainage areas were evaluated using the Santa Barbara Urban Hydrology (SBUH) method in Autodesk® Storm and Sanitary Analysis 2016 (SSA) as follows:

- U.S. Department of Agriculture (USDA) Soil Conservation Service (SCS) Type 1A 24-hour storm events for Pebble Beach were used.
- Hydrologic soil types were determined from the USDA Natural Resources Conservation Service (NRCS) Web Soil Survey (see Appendix 1-B for NRCS Hydrologic Soil Report).
- Weighted average runoff curve number (CN) values were determined using the hydrologic soil type and percent type of cover as shown in Table 1, Appendix 1-C.
- Time of concentration was calculated in SSA using the SCS TR-55 method, see SSA reports in Appendix 1-D. Minimum time of concentration was set at 5 minutes.
- Area 1 (Basin CAR-10b) and Area 2 (Basin CAR-10a) were evaluated separately from each other to facilitate pipe sizing for future routing for each basin. Their combined flow was also evaluated for analysis of improvement downstream of these basins.

The pipes and channels were modeled as follows:

- Kinematic Wave link routing.
- Hazen-Williams force main equation.
- Pipes were modeled as concrete with a Manning's n value of 0.015.
- The open channel was modeled with a Manning's roughness of 0.04 for boulder steps in the upstream section and 0.025 for straight gravel beds in the downstream sections.
- The existing pipe system in Basin CAR-8 starts with a 24" pipe at the intersection of Ocean Avenue, Junipero Avenue, and Mountain View Avenue. After two blocks the pipe upsizes to a 36" pipe for another two blocks before upsizing to a 42" pipe prior to reaching the outfall. Initial modeling revealed that the existing 24" portion of the pipe system is undersized. This is resulted in a surcharge of the catch basin at the intersection and a net loss from the initial model due to overland flow. This reduced downstream flows in the primary channel located within the Preserve. According to the City, this pipe will eventually be upsized to prevent

overland flow. As a result, the existing 24” portion of the pipe was modeled as a future 36” pipe. The existing 36” and 42” portions of the system were below capacity during the 100-year storm so they were modeled as they exist today.

- Existing pipe inverts and slopes were assumed based on LIDAR surface topography to facilitate analysis of the stormwater flows in the creek. Any future upgrades to the existing pipe system in Basin CAR-8 should evaluate the system with measured inverts and slopes to ensure an accurate analysis of energy and hydraulic grade lines within the pipe system.

Results

Peak flows for the 2, 10, 50, and 100-year recurrence interval storms were calculated at points of interest or subwatershed boundaries and are provided within Table 1.

TABLE 1: Hydrology Study Results

	Storm Event Peak flow (cfs)			
Point of Interest	**2-year**	**10-year**	**50-year**	**100-year**
A (Upstream End of Project)	6.09	27.71	42.09	46.36
B (Station 22+00)	8.04	35.8	54.39	59.91
C (Tributary @Confluence, Sta 22+25)	27.02	97.31	142.13	155.30
D (Proposed Bridge, Sta 12+00)	30.65	117.23	174.08	190.87
E (culvert at Rio Rd)	31.28	124.10	186.31	204.81
Area 1 (Tributary from West, Sta 8+00)	0.22	2.05	4.24	4.95
Area 2 (existing culvert under Serra Trail, Sta 2+00)	0.18	1.22	1.95	2.16

Hydraulic Assessment

The results of the hydrologic assessment were used to provide preliminary design geometry for proposed pipes and channels, as well as to evaluate the approximate capacity of the existing channel at representative locations. Calculations are provided in Appendix 3 that show the approximate capacity of the existing channel, just before flows overtop channel banks and access floodplains. Analysis was performed using Manning’s equation applied at individual cross sections of interest that were surveyed by Waterways. Hydraulic roughness (Manning’s “n”) values were assigned at each location based on observations, photographs, and engineering judgement. Channel slope was estimated from the long profile survey. Results of the analysis are provided in Table 2.

Most locations appear to have less than 10-year capacity. Most notably, cross section M (where sandbags are being used to contain floodwaters) can only pass 55% of the 10-year event before overtopping its banks. Cross section K shows the capacity of a typical gabion weir, roughly four feet wide by 1 foot deep at the crest. Again, the capacity is only 64% of a 10-year storm peak. Many of these weirs are failing due to flanking, largely the result of this undersized geometry.

Cross Section A shows that the channel near the downstream end of the park has a capacity in excess of the 10-year event. Localized flooding that has been observed in this area is likely due to tributary drainages coming from Area 1 and Area 2.

Our analysis did not extend outside the park to include downstream storm drains. Backwater effects of undersized downstream conveyance structures, if present, may influence this result.

TABLE 2: Hydraulic Modeling Results

Cross Section ID/ Station	Description	Channel Capacity at Top of Bank (cfs)	Calculated Peak Flow (cfs) for Varying Return Periods		
			Q_{10}	Q_{50}	Q_{100}
A (3+21)	VEGETATED EARTH SWALE TYPICAL OF CONDITIONS WITHIN DOWNSTREAM REACH OF PARK	122	117.2	174.1	190.9
D (10+73)	VEGETATED EARTH SWALE LOCATED DOWNSTREAM OF CONCRETE FORD. CHANNEL ALIGNEMENT AT TOE OF HILLSLOPE	82	117.2	174.1	190.9
G (16+82)	VEGETATED CHANNEL INCISED ALONG ROAD WHERE TREES ARE THREATENED BY BANK EROSION	112	97.3	142.1	155.3
K (23+19)	CREST OF GABION WEIR	23	35.8	54.4	59.9
M (25+54)	CONSTRICTED CROSS SECTION NEAR RESIDENCE WITH SANDBAGS ON RIGHT BANK (SANDBAGS NOT MODELED)	20	35.8	54.4	59.9

CONCEPT LEVEL TREATMENT RECOMENDATIONS

Preliminary treatment recommendations are presented at a concept level for project sites selected based on observed conditions, modeling results, or input received during meetings with the project advisory committee. These concept level designs have been overlain on the topographic basemaps or cross section surveys for review. The designs have been developed sufficiently to review existing conditions and evaluate opportunities and constraints to repair alternatives. Additional mapping, analysis, and design effort would be required to provide plans at a detail suitable for permit applications or implementation. The project schedule did not allow the site to be reviewed during winter conditions. As a result, we may have missed some areas of concern, especially where the channel gradient is low and the floodplain is relatively flat within the downstream reaches of the project.

Potential projects are presented below, from downstream to upstream.

<u>Site #1 - Park Entrance at Rio (Sheets C3and C3A)</u>

The park entrance is reported to experience local flooding during winter months. At present, runoff enters this area from four sources, including two roadside ditches that run along the service road (Serra Trail), an asphalt swale discharging from Rio Way, and as ponded or sheet runoff from the depressed area to the north of the Serra Trail. The area is drained by an 18 inch culvert that starts on the north side of the road and discharges to a shallow and discontinuous grass lined swale that eventually meets with Mission Creek. The inlet elevation of the culvert and the shallow grade of the swale are very near the grade of the road, and do not take advantage of the available fall to the creek bed. As a result, the area is poorly drained.

Proposed repairs should seek to alleviate ponding on the road surface with a minimal amount of disturbance to the adjacent wetland or riparian areas. Further, the preferred option should not significantly lower local groundwater elevations.

We have presented two alternative solutions. Each alternative includes raising the access road by approximately 6 inches, over a distance of roughly 650 feet. This may not seem like a significant change, but it would greatly reduce ponding and saturation of the roads surface without damaging adjacent sensitive areas, and would minimize ongoing maintenance requirements at ditches.

The additional actions recommended under each of the two alternatives are influenced by a proposed drainage realignment further upstream within the Preserve, as shown in Sheet C4. As a result of actions shown on C4, additional drainage will be entering the area to the west of the Serra Trail near the Preserve entrance, where flooding is already a concern.

Alternative 1 (Sheet C3) would install a new drop inlet and 24 inch diameter culvert to convey these flows under the Serra Trail. Beginning at the culvert outlet, a newly excavated wetland swale would convey runoff to the creek. The swale would be excavated deeper than the current ditch line to take better advantage of the available fall to the creek. Although the initial construction of the swale would require removal of several small oak trees, the final project would result in a net increase in wet meadow. The swale construction would also necessitate relocation of a concrete slab and bench and two signs. The raised road surface would continue through the park entrance gate to allow for improved conveyance of street drainage to minimize ponding on the path.

Alternative 2 (Sheet C3A) varies in that it would use a subsurface pipe to convey flows from the new drop inlet at the west side of the Serra Trail. A second inlet would capture ditch flow from the north as it flows along the east side of the Serra Trail. The pipe alignment would be constructed below the existing path that heads east toward the creek, avoiding impacts to adjacent natural areas. Local grades would necessitate slightly raising the path to provide adequate cover for the pipe. A more detailed study would be required to guarantee the feasibility of this alternative as there is limited fall available from the west side of the Serra Trail to the creek invert. The pipe's outlet would need to be placed very near to the channel bed, introducing the risk of backwater effects or plugging with sediment.

A third alternative (not drawn) would raise the trail surface and asphalt approach, and would replace the culvert beneath the trail, but would not address drainage to the east. This alternative would address nuisance flooding associated with street runoff by replacing the existing asphalt water bar with a more functional drain directing flows off of the trail. The alternative would improve capacity for high flows to cross under the trail within the new culvert, allowing for Project #3 to proceed as described below. The drawback to this approach is that the trail section from the entrance to the creek (near the bridge) may still experience flooding during larger storms. There may be an opportunity to also raise this section of trail slightly, but additional survey would be required to ensure that doing so would not block drainage from the north.

Site #2 - Pedestrian Boardwalk (Sheets C1 & C7)

Near station 6+50, an existing unimproved trail crosses the low point of the valley in an area that is reported to experience occasional flooding under existing conditions. This flooding would be exacerbated by the actions shown on sheet C4. We recommend installation of a raised boardwalk here to provide improved year round access and minimize the environmental footprint of the Preserve's access paths. A profile of the proposed boardwalk is shown on Sheet C7. The required length would be approximately 120 lf. Installation of a boardwalk would benefit year-round pedestrian access, but would limit vehicular access and require modification of existing maintenance techniques. If vehicular access is required at this location, an alternative means of access improvement can be explored.

Site #3 - Tributary Crossing and Trail Junction (Sheet C4)

Sheet C4 shows a confluence of trails along the western side of the valley bottom, where a tributary drainage from the west is causing erosion and sedimentation of various trail segments. High sediment loads from outside the Preserve are currently routed down a ditch in an easterly direction and then settling out along the west side of the Serra Trail, where the profile flattens. The result has been flooding of the Serra Trail due to ditch blockages, as well as erosion of the ditch leading to the Serra Trail.

The proposed repair would consist of rerouting the drainage to the South, where it can dissipate and deposit sediment within the valley low to the west of the Serra Trail, ultimately crossing the Serra Trail near the Preserve entrance. The feasibility of this approach would need to be confirmed by additional topographic mapping within the densely vegetated area west of the Serra Trail. However, several cross sections already surveyed here show this as a promising alternative that could provide flow attenuation and sediment storage opportunities with low maintenance requirements.

Where the drainage crosses the path at the west edge of the valley, either a culvert or a concrete ford would be recommended. Either approach would need to extend somewhat up the slope to capture runoff before it hits the road shoulder. This area is at the head of an alluvial fan and may otherwise avulse and miss the pipe or ford inlet.

Photo 1: Sedimentation of ditch near station 8+00

<u>Site #4 - Concrete Ford and Trail Re-route Site (Sheet C5)</u>

Sheet C5 shows an area where several trails meet. Two separate concerns are addressed with the proposed repairs. The first concern is that an existing concrete ford was constructed over a larger than necessary footprint within the channel and the downstream end has become exposed by incision processes. The downstream half of the structure no longer appears necessary and can be removed to allow the natural stream channel to be restored. Demolition of the portion of the ford would require installation of a concrete cutoff wall at the point of demolition and construction of a "roughened channel" composed of boulders, cobble, gravel and fines) to transition to the downstream channel profile.

Removal of the concrete ford would discourage foot travel along the left bank of the channel just downstream of the ford, where the creek bank is denuded and eroding due to foot traffic along a narrow and unsafe section of trail. At present, the trail traverses along the top of bank immediately adjacent to the channel for approximately 75 feet before climbing up the eastern slope of the valley. The result has been degradation of the stream bank and local vegetation.

The second component of the work would be to decommission and restore this section of trail and reroute the alignment across a pedestrian bridge and through a redwood grove where benches have been placed. This trail realignment presents an opportunity to route pedestrians through a unique portion of the Preserve that is less sensitive to disturbance than the current path along the streambanks.

Photo #2: Looking upstream at Site #4, Concrete Ford.

<u>Site #5 - Bank Erosion along Serra Trail (Sheets C1 and C7)</u>

Bank erosion and channel incision were observed along a straight reach of channel between station 14+00 and station 21+00. AS can be seen from the profile on Sheet C2, the channel has started to climb somewhat at this location and has become slightly entrenched relative to the floodplain. The channel has begun to undermine trees along the road shoulder, as shown in photo #3 below.

The channel will continue to incise and further erode the banks if left untreated in this location, ultimately undermining the Serra Trail. Meanwhile, sediment storage and floodplain functions are diminished by the entrenched condition that prevents floods from accessing the floodplain. Erosive forces are magnified by the straightened planform and deepened cross section, which increases shear and velocity over natural conditions.

Sheet C1 shows the potential to realign the channel here to provide a little more breathing room and establish a profile and cross section that better connects floodwaters to the floodplain. Sheet C7 shows a typical cross section within this reach. Note that the valley low point is well to the west of the current channel alignment, as a sign that the channel alignment is likely artificially straightened here.

Photo 3: Looking in southerly direction along Serra Trail. Note creek immediately adjacent to the road and trees beginning to fail into creek as a result of channel incision and bank erosion.

A realigned channel could be constructed with a much smaller cross section, allowing more regular inundation of the floodplain, improved groundwater recharge, sediment storage, and flood attenuation. Trees along the current channel alignment would be protected, and future channel bank maintenance requirements would be greatly minimized. Additional mapping would be required to ensure there would be no unanticipated consequences from reintroducing flows to the floodplain, such as unwanted flooding downstream or risk to infrastructure or mature native riparian trees within the proposed alignment. The alignment shown is schematic and subject to revision pending further analysis.

If further analysis and design prove this option to be infeasible, another variant would be to raise the existing channel in place to achieve similar effects. Raising the channel could be accomplished by constructing intermittent raised riffle sections and by breaching the right bank to allow better access to the floodplain. Existing trees along the banks could be buttressed and protected in place with fill.

Site #6 - Bridge Replacement and Headcut Mitigation at Confluence (Sheet C6)

Sheet C6 depicts the confluence of the main channel with a primary tributary from the west, near the end of 11th Avenue. As seen best on the long profile (Sheet C2), this is the location with the valley profile transitions from relatively flat slope averaging 1.4% to a steeper slope averaging 7%. A large headcut (knick-point) of six to eight feet in height is migrating upstream and currently arrested at station 22+40, just below the bridge on the main channel. The headcut has already progressed up the western tributary to the location of a bridge crossing that currently acts as grade control. The bridge is undersized for the design flow of 97.6 cfs, and causes a constriction that currently exacerbates erosion and channel instability in this area. The narrow opening is further at risk of plugging and causing more damage. Channel banks downstream of the two bridges and beyond the confluence are overly steepened from recent incision, despite past efforts to stabilize the channel with rock.

Photo 4: Example of boulder weirs used to raise a channel profile to support an existing bridge (Murtaugh Creek, OR)

Stabilization of this area may need to extend one hundred feet or more downstream of the confluence in order to create a stable channel profile that prevents the headcut from migrating further upstream and destabilize the bridge, channel banks, or upstream improvements. Stabilization could be accomplished by replacing the bridge over the western tributary, laying back steep channel banks that are currently eroding, revegetating the area, and establishing grade control for the channel profile through weirs or a fully reconstructed channel, as shown.

The Preserve boundary limits are unclear within this area. A boundary survey is recommended here to better define opportunities and constraints.

<u>Site #7 - Flooding at Station 25+50</u>

One location within the upstream reaches of the Preserve (approx. station 25+50) shows evidence of recent flooding, based on the presence of sandbags along the right bank of the channel opposite a residence (Photo 5). At cross section M, shown on Sheet C10, one can clearly see the undersized channel cross section area available for flood conveyance. As noted above, the channel capacity here is only approximately 55% of the 10-year flood peak. The profile (Sheet C2) shows that the area of concern is immediately upstream of a gabion weir with a height of nearly 4 ft. The likely solution here would require locally lowering and/or widening the channel to accommodate high flows, possibly modifying or removing the existing gabion grade control. This action may require installation of a structural wall or rock slope protection to preserve the yard and/or path. The location of the Preserve boundary is uncertain in this vicinity. The entire channel may be located on private property.

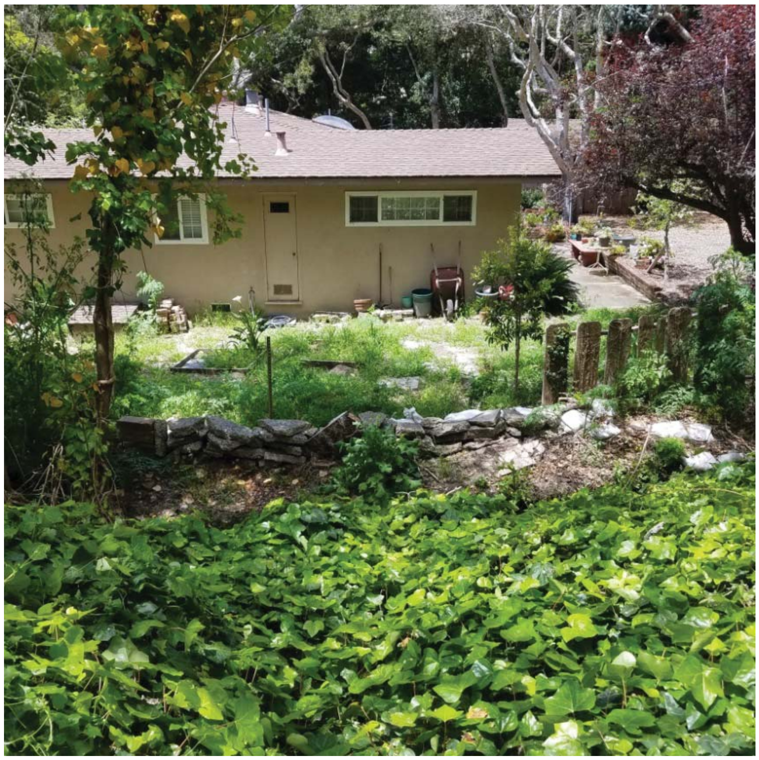


Photo 5: Looking west across channel at flood-prone area (station 25+50)

Site #8 - Headcuts in upper reaches (Existing conditions shown on Sheet C2)

The reach upstream of the confluence with the western tributary is characterized by steep valley walls and a highly confined channel at a very uniform average slope of 7%, with dozens of constructed grade control structures and debris jams forming drops of varying heights. Bank failures were apparent in many areas due to channel incision and subsequent widening, though the channel appears to have been temporarily arrested at the current profile. Though many of the existing drop structures are undersized, poorly constructed, or in disrepair, they are working together to provide hydraulic roughness and energy dissipation, as well as a physical structure to maintain the current profile grade.

The existing weirs are primarily composed of stone, timber, or gabion baskets, of varying geometry. Only the gabion weirs – of which there were over ten located- appear to have been installed under a coordinated effort, with a relatively uniform design approach. However, these weirs are nearly all undersized and showing signs of failure. The typical failure mode is by flanking, due to their undersized geometry (Photo 6, below). For instance, the ten year flow at this location, a flow commonly used to size such features, is approximately 40 cfs. A weir crest opening would need to be 3 feet wide at the base, with a depth of 2 feet to contain this flow, assuming 1h:1v side slopes. Many of the weirs were less than half this size.

Photo 6: Looking Upstream at a failing gabion weir with a spillway that is undersized for even moderate storm events.

Though we mapped a profile through each structure, the analysis of each weir was beyond the resources of this study. Further, it is uncertain where the Preserve boundary crosses the channel at many locations along this upper reach. We recommend that the City perform a boundary survey and determine land ownership within this reach before making further plans to stabilize the channel. Eventually, the existing weirs will fail and landowners will individually begin to experience related bank erosion, sometimes threatening structures. A comprehensive approach to monitoring and, if necessary, stabilizing the reach would benefit all.

Options for stabilization could include reconstructing weirs as they fail or proactively installing additional grade control structures between existing weirs. Natural approaches such as log weirs have been used with some success, but generally don't provide the same level of protection as stone, masonry, concrete, or similar hard structures. Gabions are a very desirable short term solution, if properly designed and installed. Benefits include their ease of installation at sites with access constraints and the ability for hand labor crews to construct them. The primary drawback to gabions is the fact that they typically do not last more than 40 years in a stream environment.

REGULATORY – PERMITTING REQUIREMENTS

Permit Requirements and Environmental Issues

The goal of the project recommendations is to implement measures to stabilize the existing perennial stream, reduce erosion and sedimentation and to enhance overall habitat conditions in the riparian corridor along the stream, consistent with goals and policies in the Preserve Master Plan and recommendations in the Baseline Biological Assessment (Nedeff, 2016). The conceptual recommendations include eight repair measures that could be implemented at separate times and/or in combination, two of which would require additional survey and study for feasibility. Federal, state and local permits and approvals are anticipated to be required for most of the recommended activities. An overview of required permits is provided in the following section. Anticipated required permits and key issues for each recommended repair are summarized on Table 3.

U.S. Army Corps of Engineers

The U.S. Army Corps of Engineers (Corps) exercises regulatory jurisdiction over certain activities within waters of the United States. The Corps receives its statutory authority from Section 404 of the Clean Water Act, which regulates placement of dredged or fill material in jurisdictional waters of the United States, and Section 10 of the Rivers and Harbors Act of 1899, which regulates the construction of any structure in or over any navigable water of the United States or any work affecting the course, location, condition, or capacity of such waters. Some of the recommended repairs involve the placement of fill material within non-navigable waters[1] of the United States associated with work in stream channels.

General permits are authorizations that are issued for a category or categories of activities that are similar in nature and do not cause more than minimal individual and cumulative adverse environmental effects. Nationwide Permits (NWPs) are a type of general permit issued by the Corps. Multiple NWPs could potentially be used to authorize the work needed to implement the recommendations in this report, including NWP 13, Bank Stabilization; NWP 27, Aquatic Habitat Restoration, Enhancement, and Establishment Activities; NWP 31, Maintenance of Existing Flood Control Facilities; NWP 42, Recreational Facilities; and NWP 46, Discharges in Ditches. The various work components could potentially be viewed as separate single and complete projects, each qualifying for a separate NWP authorization. If the work is considered one single and complete project, and multiple NWPs are used, the acreage loss of waters of the United States must not exceed the acreage limit of the NWP with the highest specified acreage limit, which is 1 acre for a NWP 46; NWP 42 has a limit of 0.5 acre. NWP 13 and 27 do not have a specified acreage limit.

[1] According to federal regulations, “navigable” waters of the United States are those waters that are subject to the ebb and flow of the tide and/or are presently used, or have been used in the past, or may be susceptible for use to transport interstate or foreign commerce.

TABLE 3. Summary of Recommendations and Potential Permit Requirements

Recommended Repair	Anticipated Permit				Issues
	ACOE	CDFW	RWQCB	CDP	
1. Park Entrance – Raise Road				X	• Avoid / minimize construction impacts to adjacent wetland and riparian habitat and creek water quality
Alt 1 – Swale and new drop inlet	X	X	X	X	• Avoid / minimize construction impacts to adjacent wetland and riparian habitat and creek water quality • Minor tree removal • Wetland enhancement
Alt 2- Subsurface drain and new inlets	X	X	X	X	• Avoid / minimize construction impacts to adjacent wetland and riparian habitat and creek water quality
2. Pedestrian Boardwalk					• Avoid / minimize construction impacts to adjacent wetland and riparian habitat and creek water quality
3. Reroute existing drainage with new culvert	X	X	X	X	• Avoid / minimize construction impacts to adjacent wetland and riparian habitat and creek water quality
4. Removal of concrete ford and decommission and restore existing trail segment and reroute trail with new pedestrian bridge	X	X	X	X	• Avoid / minimize construction impacts to adjacent wetland and riparian habitat and creek water quality
5. Channel Realignment	X	X	X	X	• Additional mapping required • Avoid/minimize riparian habitat impacts
6. Bridge Replacement over tributary, channel bank bio-remediation	X	X	X	X	• Avoid / minimize construction impacts to adjacent wetland and riparian habitat and creek water quality • Cultural resources review may be necessary
7. Channel modification	X	X	X	X	• Not known if in Preserve boundaries • NWP 31 potentially applicable if channel flood control activities have been previously authorized by the Corps.
8. Upstream bank failures and existing weir failures – further study recommended					• Bio-engineered approaches are preferred by regulatory agencies • No specific recommendations at this time except for further survey work to determine potential options

DATA REQUIRED: For all activities requiring permits and associated notification to the Corps, an application must be submitted, using standard ENG Form 4345. The application must include a complete description of the proposed activity including necessary drawings or plans; the location, purpose and need for the proposed activity; scheduling; the names and addresses of adjoining property owners; the location and dimensions of adjacent structures; and a list of authorizations required by other federal, state, or local agencies.

RELATED LAWS

- Endangered Species Act: If a project may affect federally listed species or their critical habitat, consultation with U.S. Fish and Wildlife Service (USFWS) and/or the National Oceanic and Atmospheric Administration's (NOAA's) National Marine Fisheries Service (NMFS) will be required. One federally-listed plant species has been identified at the Preserve: Yadon's rein orchid (*Piperia yadonii*). The City as the applicant would need to provide the Corps with a Biological Assessment (BA) or biological technical report identifying and analyzing the potential impacts to listed species. The Corps will initiate and conduct the Section 7 consultation.
- Section 401 Water Quality Certification: Water quality certifications are required for projects that require federal permits. The proposed Project will need to obtain the required certification from the California Central Coast Regional Water Quality Control Board (RWQCB) before the Corps can issue the 404 permit.
- Historic Properties: If the proposed activity would involve any property listed or eligible for listing in the National Register of Historic Places, consultation with the State Historic Preservation Officer will be required. The applicant would need to provide the Corps with a cultural resources report identifying and analyzing the potential effects to potential historic resources, e.g., structures that are over 45 years old. The Corps will initiate and conduct the consultation.

FEES: Local government agencies are not required to pay any fee in connection with permits.

Regional Water Quality Control Board

The California State Water Resources Control Board (SWRCB) oversees the policy objectives of the nine Regional Water Quality Control Boards (RWQCBs). The RWQCBs exercise jurisdiction over water quality in waters of the United States within their respective regions and administer Section 401 Water Quality Certification and Section 402 National Pollutant Discharge Elimination System (NPDES) permits pursuant to the Clean Water Act to ensure projects meet state water quality standards to regulate point source discharges of pollutants to waters of the United States. The RWQCBs also regulate impacts to waters of the state, including point-source and diffused-source discharges to land and groundwater, under California's Porter-Cologne Water Quality Control Act.

A Section 401 Water Quality Certification from the Central Coast RWQCB, Region 3 is anticipated to be necessary for the proposed improvements. Section 401 of the Clean Water Act requires any applicant for a federal license or permit to conduct any activity that may result in a discharge of a pollutant into waters of the United States to obtain a certification from the State in which the discharge originates or would originate, that the discharge will comply with the applicable effluent limitations and water quality standards. The RWQCB protects all waters in its regulatory scope, but has special responsibility for wetlands, riparian areas, and headwaters because these water bodies have high resource value, are vulnerable to filling, and are not systematically protected by other programs. Basin-level analysis focuses on pollutant removal, floodwater retention, and habitat connectivity.

DATA REQUIRED: Issuance of a Section 401 Certification requires information demonstrating the project will comply with state water quality standards and aquatic resources protection requirements. A Section 401 permit application should include information including a detailed project description, discussion of avoidance and minimization of impacts to waters of the state, impacts analysis, discussion of beneficial uses, identification of pollutants of concern and short- and long-term best management practices (BMPs) to minimize discharge of pollutants, and all associated figures (vicinity maps, project site maps, construction cross-sections, and others).

ANALYSIS REQUIRED: Analysis by the RWQCB is intended to authorize and regulate discharges into waters of the United States and waters of the State. The RWQCB will evaluate the Project's potential impacts on aquatic resources and ensure the applicant has demonstrated that: 1) a sequence of actions has been taken to first avoid, then to minimize, and lastly compensate (if required) for adverse impacts to waters of the state; 2) the potential impacts will not contribute to a net loss of the overall abundance, diversity, and condition of aquatic resources in a watershed; 3) the discharge of dredged or fill material will not violate water quality standards and will be consistent with all applicable water quality control plans and policies for water quality control; and 4) the discharge of dredged or fill material will not cause or contribute to significant degradation of waters of the State.

FEES: RWQCB fees are determined based on acreage of fill and excavation impacts within waters of the United States and waters of the State.

California Department of Fish and Wildlife

The California Department of Fish and Wildlife (CDFW) regulates impacts to rivers, streams, and lakes in California. Fish and Game Code Section 1602 requires notification to CDFW prior to commencing any activity that may: substantially divert or obstruct the natural flow of any river, stream or lake; substantially change or use any material from the bed, channel or bank of any river, stream, or lake; or deposit debris, waste or other materials that could pass into any river, stream, or lake. The waters included in the definition of a river, stream or lake include those that are episodic as well as those that are perennial. This includes ephemeral streams, desert washes, and watercourses with a subsurface flow.

A Section 1602 Lake or Streambed Alteration Agreement (LSA Agreement) is anticipated to be required for the project due to work within CDFW's jurisdiction which could substantially adversely affect an existing fish or wildlife resource. CDFW will include measures in the LSA Agreement to protect fish and wildlife resources including administrative measures, avoidance and minimization measures, and reporting measures.

DATA REQUIRED: The LSA Agreement application should include a project description, discussion of avoidance and minimization of impacts, a wetland delineation, impacts to sensitive plants and wildlife, a copy of the CEQA document, the application filing/processing fee, all associated figures (vicinity maps, project site map, construction/grading cross sections, mitigation area, etc.), and copies of the wetlands permit application submitted to the Corps and RWQCB.

ANALYSIS REQUIRED: Analysis by CDFW is required when it determines the activity may substantially adversely affect existing fish or wildlife resources. The LSA Agreement includes measures necessary to protect existing fish and wildlife resources. Negotiation with CDFW may include CDFW staff suggesting project modifications that would eliminate or reduce harmful impacts to fish and wildlife resources. Documentation of compliance with CEQA is required before CDFW can issue a LSA Agreement.

FEES: CDFW fees are determined based on the cost of Project work within CDFW jurisdiction.

RELATED LAWS

- California Endangered Species Act:Take of species listed as endangered, threatened, candidate, threatened, endangered (or state rare in the case of plants), may be authorized by CDFW under Section 2081(b) of the California Fish and Game Code if that take is incidental to otherwise lawful activities and if certain conditions are met. No state-listed species have been identified at the Preserve; two California species of special concern have been identified: Monterey dusky-footed woodrat and past observations of Monarch butterfly winter roosts.

Coastal Development Permit

A 5-year permit for park maintenance and management activities was approved by the California Coastal Commission (CCC) in 1997 to implement recommendations of the Master Plan. The primary maintenance activities included removal of invasive vegetation; trail consolidation or extension; and stream channel maintenance involving removal of obstructions to natural stream flow and placement of very limited rock slope protection (rip-rap) to reduce erosion.

The City's Local Coastal Program (LCP) was certified in 2004, which gave the City has authority to issue a Coastal Development Permit (CDP) for private or public projects within the City's coastal zone. The Mission Trail Nature Preserve Master Plan was incorporated into the City's General Plan/LCP. In 2016, the City approved a CDP for a five-year, renewable CDP for maintenance work in the Preserve in accordance with the Mission Trail Nature Preserve Master Plan. The CDP provides authorization for regular maintenance activities such as road clearance, hazardous tree removal, mowing and trail maintenance, as well as invasive species removal. The scope of the CDP also includes stream bank repair and removal of debris or fallen trees in stream channels as needed.

Most of the Preserve is identified as an "environmentally sensitive habitat area" (ESHA), including the following: Monterey pine forest; central coast arroyo willow riparian forest; coastal terrace prairie; wet meadow; and known occurrences of special-status plant and wildlife species, including Monterey dusky footed woodrat, which is a state and/or federal species of special concern (Carmel-by-the-Sea, June 2003).

Preliminary discussions with City Community Planning and Building Department staff indicate that the City would be responsible for issuing a CDP for recommended projects. Once the recommendations are finalized, they can be reviewed with the City's Community Planning and Building Department to determine if any actions would fall under the existing 5-year CDP that authorizes specified maintenance activities, although it appears that most recommendations would not fall under the scope of regular maintenance activities.

Permitting Strategy

The permitting process can be streamlined if projects can be grouped together in one application. Design plans will be needed for all of the required permit applications. The first step would be to coordinate and facilitate agency pre-application consultation. The ACOE holds monthly inter-agency pre-application meetings and invites federal and state agencies, including CDFW and RWQCB. This meeting provides an initial opportunity to review the project with the agencies and understand agency concerns and/or permit requirements, so they are addressed in the permit application package. It also allows ACOE staff and other relevant agencies to provide direction on important project elements, such as methods and timing of work, avoidance and minimization measures, and other construction and post-construction Best Management Practices. The City would then be in the position to develop Project materials that address these concerns in advance to aid in streamlining agency review and processing of the applications.

IMPLEMENTATION AND PRELIMINARY CONSIDERATIONS FOR PRIORITIZATION

Project implementation order may be influenced by numerous factors, including but not limited to project benefits, implementation and maintenance budgets, permit considerations, land ownership, or risk. The following observations are provided for consideration and discussion.

- Projects #1 and #3 are low risk, and are straightforward in terms of design, permitting, and implementation. However, Project #3 should not proceed without Project #1. The flows routed from the realigned tributary drainage at Project #3 would otherwise exacerbate flooding in the area of Project #1.
- Project #2 provides seasonal access improvements, but is not “necessary” given that there are alternate access routes and this project could be considered lower priority. However, implementation of Project #3 would worsen existing conditions at Site #2 if project #2 was not implemented. In the absence of this improvement, seasonal closures of this informal trail could be implemented.
- Project #4 can be considered a stand-alone project. Design and implementation should be straightforward. This project is not dependent on any other projects. Delaying this project would not introduce significant additional risk. Removal of a portion of the concrete ford and restoration of the creek would be a positive habitat/resource enhancement. Project #4 includes cast in place concrete and structural work, and it may be advantageous to combine with Site #6.
- Project #5 is a stand-alone project. Delayed implementation of #5 may lead to loss of a few existing mature trees and/or additional maintenance or repairs to the adjacent road. The feasibility of this project should be verified with additional topographic and tree location surveys to evaluate re-alignment options to minimize/avoid riparian habitat and construction-related impacts. Given the scale, permitting and mitigation requirements could be more complex for this project than the other recommendations. If a preferable alignment is not identified near the

proposed location shown, in-place enhancements such as riffle-augmentation (i.e., raise channel in place) may be preferable.

- Project #6 is expensive and relatively complex, but is important to prevent ongoing channel incision, bank erosion, and potential failure of the existing bridge. Thus, this one of the most critical projects.
- The relative priority of Project #7 is difficult to determine without an accurate boundary survey. This project appears relatively simple to design and implement, but may be entirely outside the City's ownership and would primarily benefit the adjacent private property.
- The grade control features located within the upstream reach identified as Site #8 are in varying levels of disrepair. The long profile survey identified over fifteen individual constructed grade control structures. As these structures degrade, the channel will continue to erode. Ideally, this reach should be treated as a whole, based on the outcome of a detailed study that evaluates risk to adjacent homes. This is a complex project that may require a longer planning schedule. Aside from the discontinuity at site #6, the profile within this reach is a relatively straight grade. We did not observe one site that presented itself as a higher priority in need of immediate attention.

Preliminary Recommendations for Project Implementation Sequencing

Based on our understanding of opportunities and constraints and the City's expressed goals, we have provided the following preliminary recommendations for implementation order. We have divided the projects into two general categories based on whether they primarily provide maintenance or risk reduction versus ecological restoration or park enhancement. Several of the projects (e.g., project 3) address both risk reduction and restoration or enhancement goals.

Table 4: Risk Reduction and Repair Projects

PRIORITY	PROJECT SITE	FACTORS INFLUENCING RANKING
1	1	SIGNIFICANT FUNCTIONAL IMPROVEMENT TO HIGH USE AREA. PROJECT IS REQUIRED IN ORDER TO IMPLEMENT #3. RELATIVELY LOW COST AND EASE OF PERMITTING.
2	3	REDUCES MAINTENANCE REQUIREMENTS AND IMPROVES FUNCTIONALITY OF TRAIL/ROAD. PROVIDES ECOLOGICAL ENHANCEMENTS IN ADDITION TO REDUCED MAINTENANCE. LOW COST AND EASE OF PERMITTING.
3	6	PROJECT PROVIDES SIGNIFICANT RISK REDUCTION AGAINST FUTURE EROSION, BUT COMES AT HIGH COST. THERE REMAINS UNCERTAINTY REGARDING LAND OWNERSHIP.
4	8	PROJECT PROVIDES GREAT BENEFITS AND RISK REDUCTION, BUT THERE IS A SIGNIFICANT AMOUNT OF PLANNING AND COORDINATION REQUIRED GIVEN THE MULTIPLE LAND OWNERS INVOLVED.

Table 5: Restoration and Enhancement Projects

RECOMMENDED IMPLEMENTATION ORDER	PROJECT SITE	FACTORS INFLUENCING RANKING
1	5	Appears to provide greatest ecological benefit and is time-dependent due to threat to existing trees.
2	4	Provides significant ecological benefits as well as functional, safety, and aesthetic improvements. Project is not time-dependent since the damage here has already been done.
3	2	Provides recreational enhancement and possibly some ecological improvements, but not to the extent of other projects.

PROJECT COSTS

Preliminary Engineer's Construction Cost Estimates are provided below in Table 6. Since project designs have only been developed to a concept level of detail, these estimates should be considered to represent "order of magnitude" values. Estimates are based on the scope and details reflected in the concept designs, and reflect our experience on recently completed projects of similar scale and complexity. The prices do not reflect cost savings that might be realized if individual projects were grouped to reduce mobilization, administrative, and related costs. The prices assume prevailing wage. Actual costs may vary considerably, given the significant number of unknowns at the concept level.

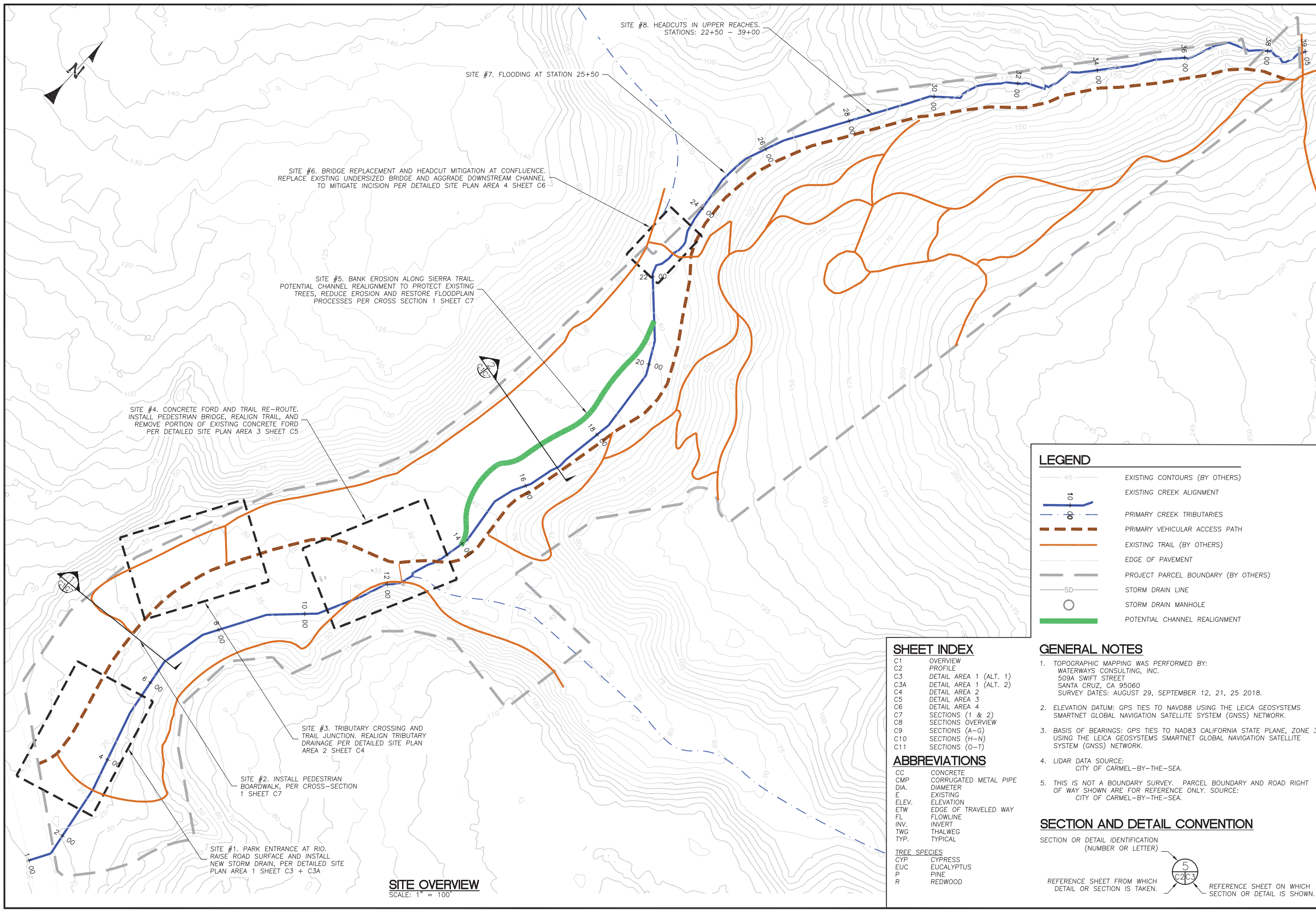
The cost of Project #8 cannot be estimated until further analysis is completed to determine the appropriate scale of the repair work required, which will vary based on geologic/geotechnical considerations, land ownership, and risk. Costs have been estimated for that analysis.

The cost of environmental review (CEQA) and regulatory permitting would be an additional cost if the City elects to hire a consultant for these tasks rather than complete with City staff. It is likely that categorical exemptions could be used for most recommendations. Permitting includes preparation of application and application materials, and likely will require technical reports including biological resources and cultural resources evaluations, and a formal jurisdictional delineation. Costs for permitting can typically range from $20,000 to $35,000 or more depending on the extent of needed biological reviews. Costs could be higher for Project #5, which would likely require a mitigation and restoration plan with multi-year monitoring for revegetation along a realigned channel.

Table 6: Project Design and Implementation Costs

PROJECT AREA	PROJECT COMPONENTS	APPROXIMATE COSTS	
		DESIGN	IMPLEMENTATION & ESTABLISHMENT
1 (Alt 1)	RAISE ENTRANCE ROAD, INSTALL NEW CULVERT BELOW ENTRANCE ROAD, CONSTRUCT OPEN SWALE TO CREEK	$17,000	$90,000
1 (Alt 2)	RAISE ENTRANCE ROAD, INSTALL NEW CULVERT BELOW ENTRANCE ROAD, CONSTRUCT PIPE TO CREEK	$17,000	$95,000
1 (Alt 3)	RAISE ENTRANCE ROAD, INSTALL NEW CULVERT BELOW ENTRANCE ROAD	$15,000	$75,000
2	CONSTRUCT APPROX. 100 LF PEDESTRIAN BOARDWALK	$8,000	$40,000
3	INSTALL CULVERT OR ROCKED FORD AND REALIGN TRIBUTARY DRAINAGE, INSTALL SMALL DITCH CULVERT AND PERFORM DITCH MAINTENANCE	$7,500	$22,500
4	DEMOLISH PORTION OF EXISTING FORD, RESTORE DOWNSTREAM REACH OF CHANNEL, REALIGN TRAIL, CONSTRUCT PEDESTRIAN BRIDGE, RESTORE OLD TRAIL ALIGNMENT	$17,500	$100,000
5	REALIGN APPROX. 700 LF OF CHANNEL. RESTORE OLD CHANNEL BED, REVEGETATE DISTURBED AREAS	$27,500	$300,000
6	REPLACE EXISTING UNDERSIZED BRIDGE, RESTORE DOWNSTREAM CHANNEL AND ARMOR REACH TO PREVENT FURTHER INCISION UPSTREAM	$25,000	$230,000
7	REMOVE EXISITING WEIR, LOWER CHANNEL, STABILIZE NEW CHANNEL BED AND BANKS	$9,500	$30,000
8	PERFORM BOUNDARY SURVEY, DETAILED TOPOGRAPHY, GEOLOGIC & GEOTECHNICAL INVESTIGATION. PRIORITIZE A PHASED REPAIR PLAN, AND PREPARE PRELIMINARY AND FINAL DESIGNS FOR GRADE CONTROL.	$50,000	N/A

Attachment A: Site Plans and Details



SITE OVERVIEW

SCALE: 1" = 100'

LEGEND

EXISTING CONTOURS (BY OTHERS)
EXISTING CREEK ALIGNMENT
PRIMARY CREEK TRIBUTARIES
PRIMARY VEHICULAR ACCESS PATH
EXISTING TRAIL (BY OTHERS)
EDGE OF PAVEMENT
PROJECT PARCEL BOUNDARY (BY OTHERS)
STORM DRAIN LINE
STORM DRAIN MANHOLE
POTENTIAL CHANNEL REALIGNMENT

SHEET INDEX

C1	OVERVIEW
C2	PROFILE
C3	DETAIL AREA 1 (ALT. 1)
C3A	DETAIL AREA 1 (ALT. 2)
C4	DETAIL AREA 2
C5	DETAIL AREA 3
C6	DETAIL AREA 4
C7	SECTIONS (1 & 2)
C8	SECTIONS OVERVIEW
C9	SECTIONS (A–G)
C10	SECTIONS (H–N)
C11	SECTIONS (O–T)

ABBREVIATIONS

CC	CONCRETE
CMP	CORRUGATED METAL PIPE
DIA.	DIAMETER
E	EXISTING
ELEV.	ELEVATION
ETW	EDGE OF TRAVELED WAY
FL	FLOWLINE
INV.	INVERT
TWG	THALWEG
TYP.	TYPICAL

TREE SPECIES

CYP	CYPRESS
EUC	EUCALYPTUS
P	PINE
R	REDWOOD

GENERAL NOTES

1. TOPOGRAPHIC MAPPING WAS PERFORMED BY:
   WATERWAYS CONSULTING, INC.
   509A SWIFT STREET
   SANTA CRUZ, CA 95060
   SURVEY DATES: AUGUST 29, SEPTEMBER 12, 21, 25 2018.
2. ELEVATION DATUM: GPS TIES TO NAVD88 USING THE LEICA GEOSYSTEMS SMARTNET GLOBAL NAVIGATION SATELLITE SYSTEM (GNSS) NETWORK.
3. BASIS OF BEARINGS: GPS TIES TO NAD83 CALIFORNIA STATE PLANE, ZONE 3 USING THE LEICA GEOSYSTEMS SMARTNET GLOBAL NAVIGATION SATELLITE SYSTEM (GNSS) NETWORK.
4. LIDAR DATA SOURCE:
   CITY OF CARMEL–BY–THE–SEA.
5. THIS IS NOT A BOUNDARY SURVEY. PARCEL BOUNDARY AND ROAD RIGHT OF WAY SHOWN ARE FOR REFERENCE ONLY. SOURCE:
   CITY OF CARMEL–BY–THE–SEA.

SECTION AND DETAIL CONVENTION

SECTION OR DETAIL IDENTIFICATION (NUMBER OR LETTER)

5
C2 | C3

REFERENCE SHEET FROM WHICH DETAIL OR SECTION IS TAKEN.

REFERENCE SHEET ON WHICH SECTION OR DETAIL IS SHOWN.

WATERWAYS CONSULTING INC.
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PH:(831)421-9291 // FAX:(888)819-6847
WWW.WATWAYS.COM

PRELIMINARY
NOT FOR CONSTRUCTION

PREPARED AT THE REQUEST OF:
CITY OF
CARFMEL-BY-THE-SEA

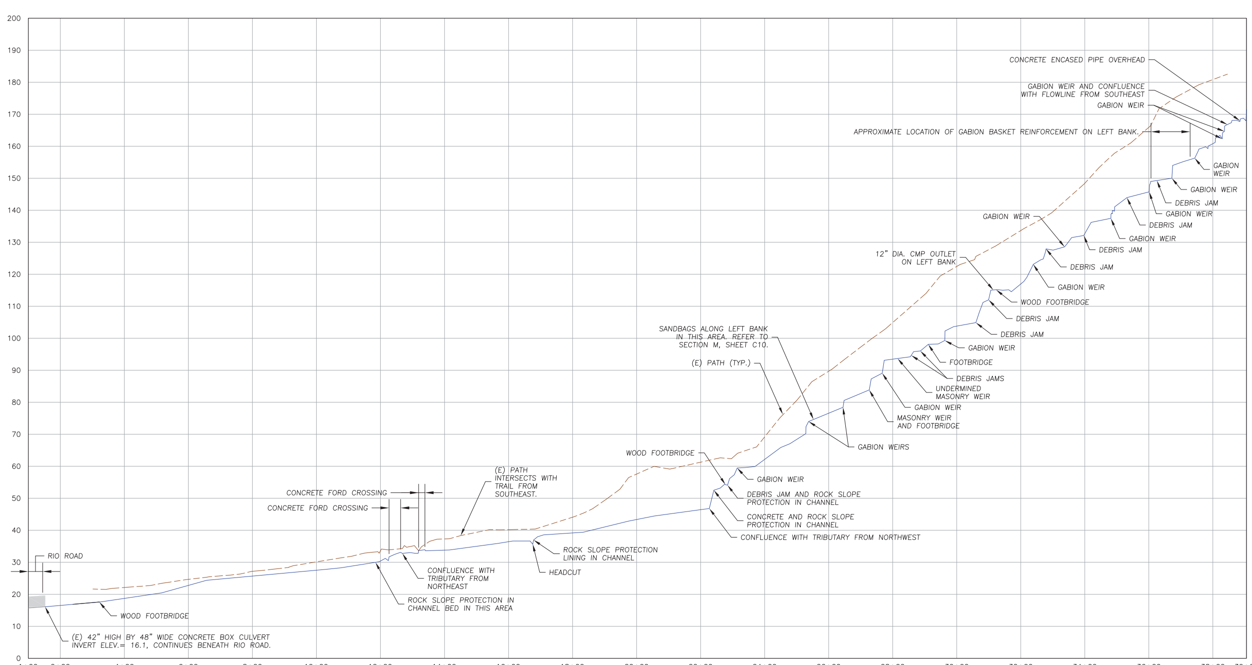
OVERVIEW

MISSION NATURE TRAIL
STREAM CHANNEL
STABILITY STUDY

DESIGNED BY:	–
DRAWN BY:	S.R.
CHECKED BY:	M.W.W.
DATE:	10/10/18
JOB NO.:	18–028

BAR IS ONE INCH ON ORIGINAL DRAWING, ADJUST SCALES FOR REDUCED PLOTS
0 1"

C1



PROFILE
SCALE: 1" = 150'H ; 1" = 15'V

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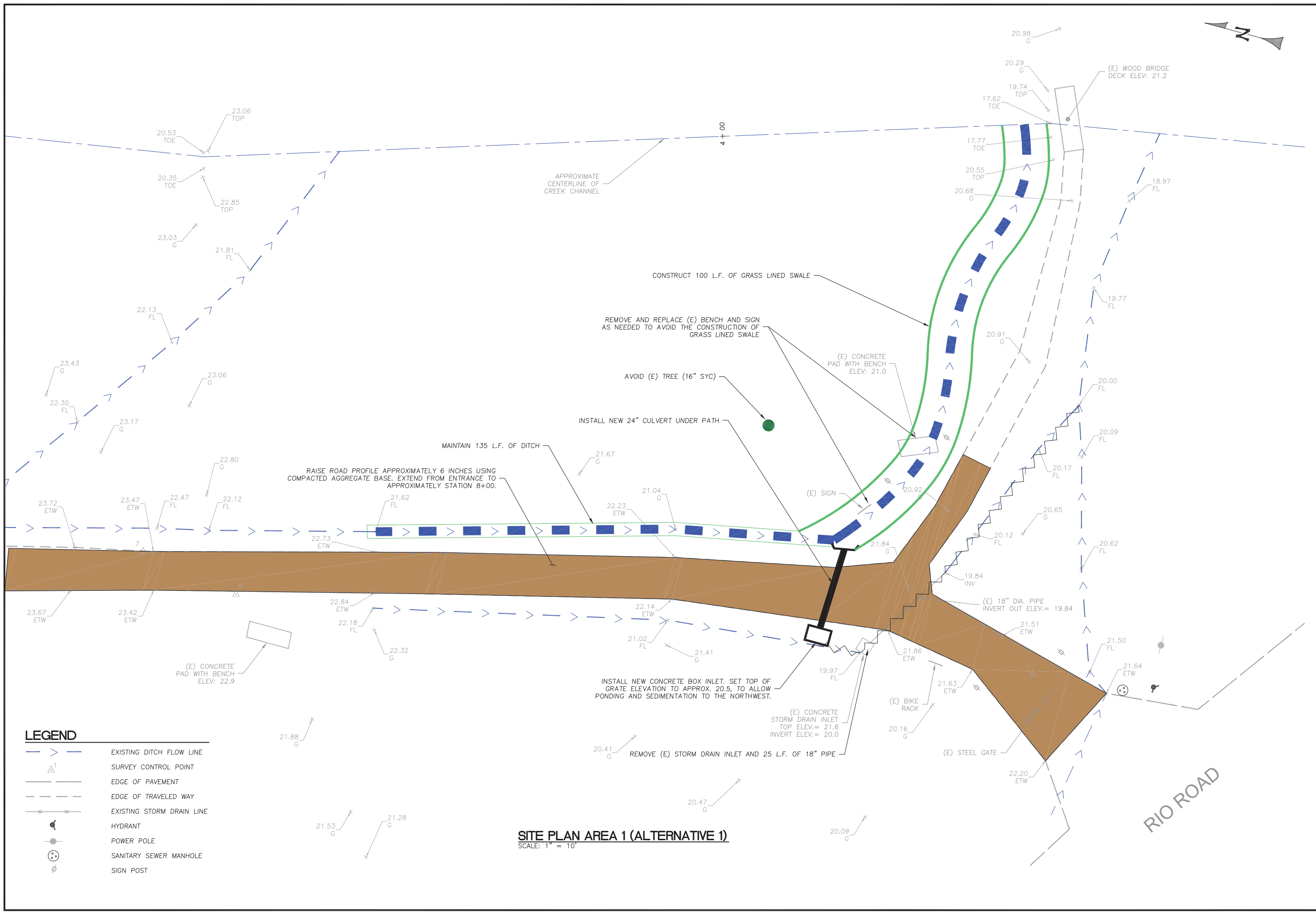
PROFILE

MISSION NATURE TRAIL
STREAM CHANNEL
STABILITY STUDY

DESIGNED BY:	–
DRAWN BY:	S.R.
CHECKED BY:	M.W.W.
DATE:	10/10/18
JOB NO.:	18–028

BAR IS ONE INCH ON ORIGINAL DRAWING, ADJUST SCALES FOR REDUCED PLOTS
0 1"

C2 2 OF 12



LEGEND

— > —	EXISTING DITCH FLOW LINE
△	SURVEY CONTROL POINT
———	EDGE OF PAVEMENT
— — —	EDGE OF TRAVELED WAY
—o—o—	EXISTING STORM DRAIN LINE
	HYDRANT
	POWER POLE
	SANITARY SEWER MANHOLE
	SIGN POST

SITE PLAN AREA 1 (ALTERNATIVE 1)

SCALE: 1" = 10'

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PREPARED AT THE REQUEST OF:
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SITE PLAN
AREA 1
ALTERNATIVE 1

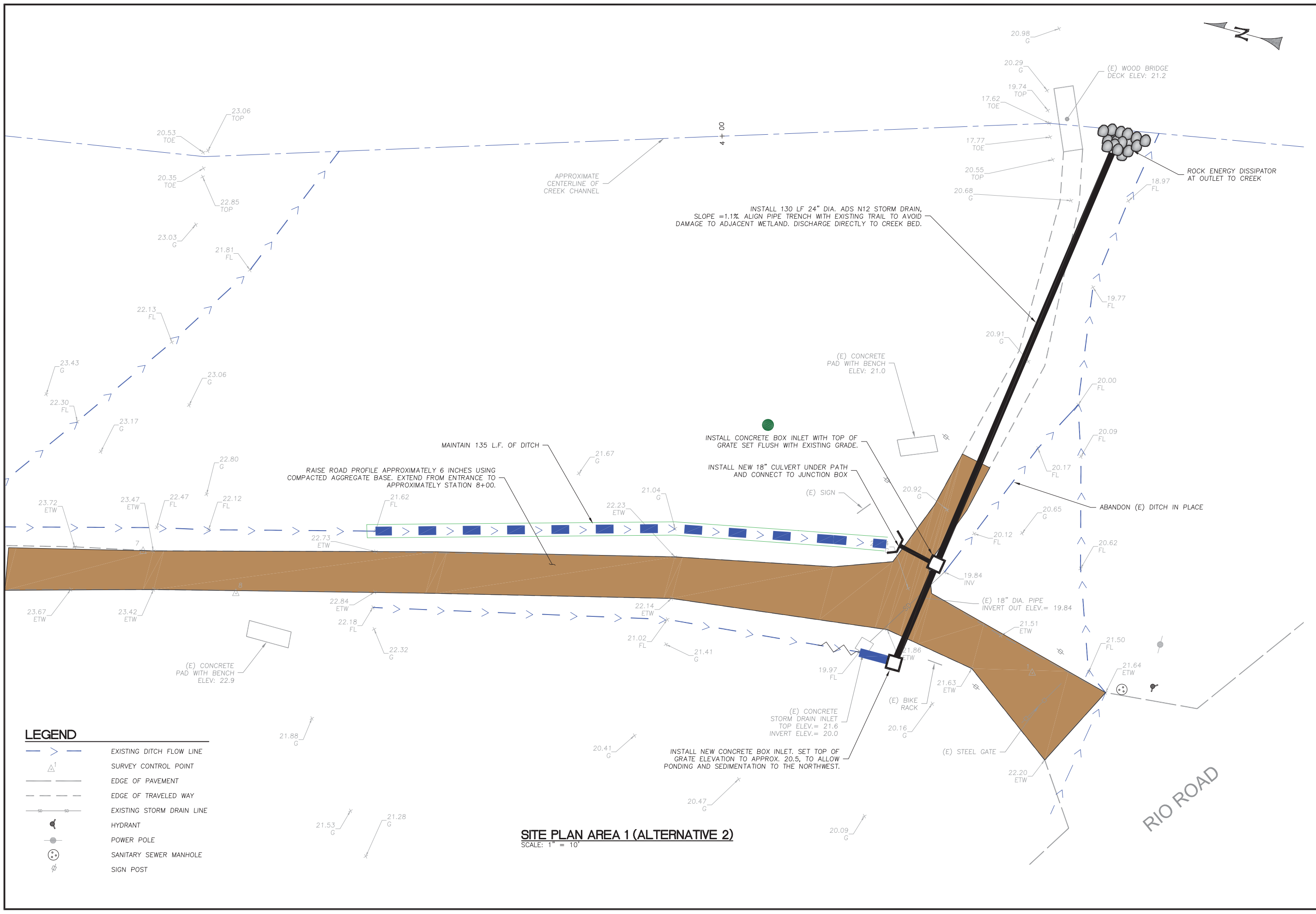
MISSION NATURE TRAIL
STREAM CHANNEL
STABILITY STUDY

DESIGNED BY: –
DRAWN BY: S.R.
CHECKED BY: M.W.W.
DATE: 10/10/18
JOB NO.: 18–028

BAR IS ONE INCH ON ORIGINAL DRAWING, ADJUST SCALES FOR REDUCED PLOTS
0 1"

C3

3 OF 12



SITE PLAN AREA 1 (ALTERNATIVE 2)

SCALE: 1" = 10'

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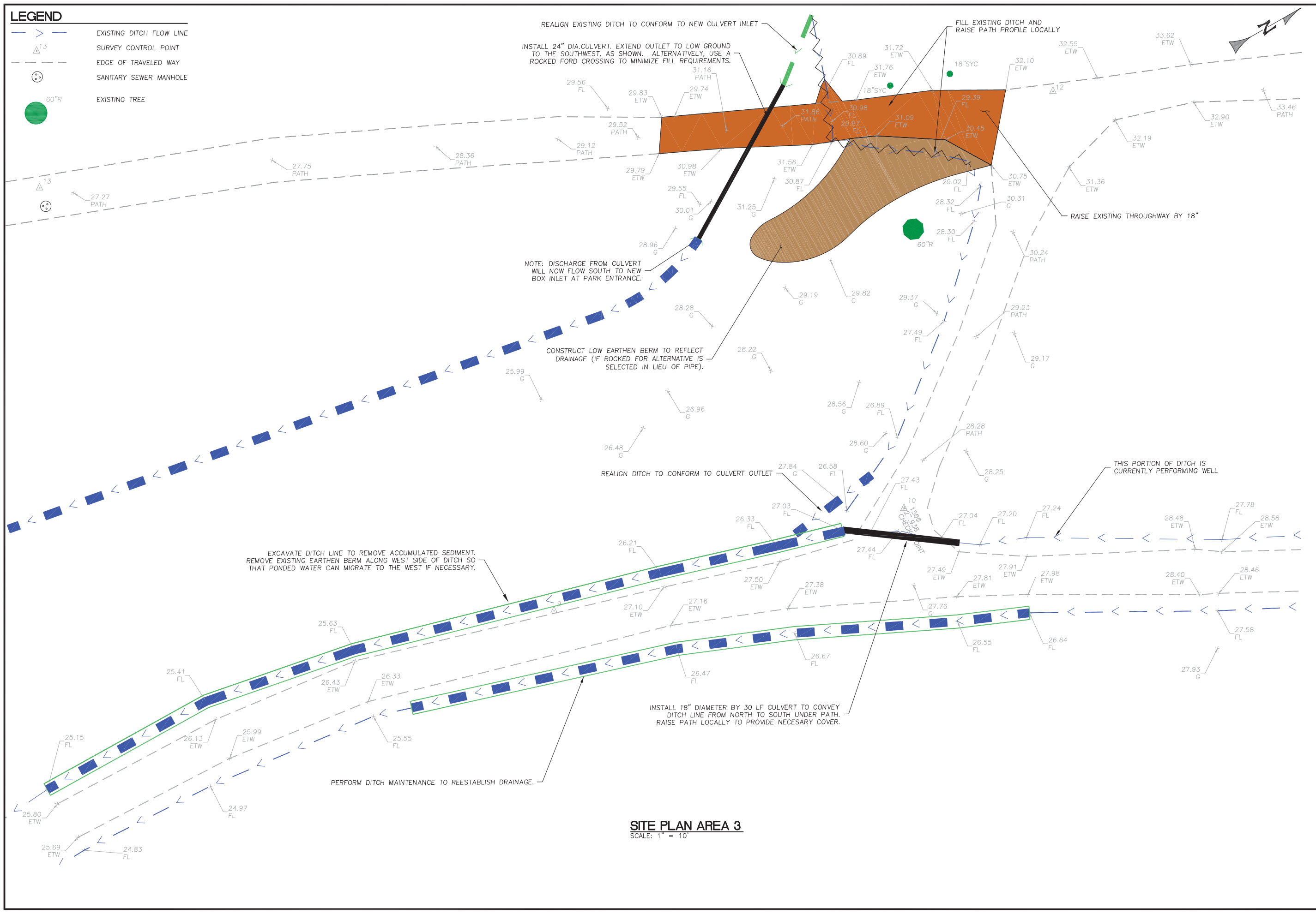
SITE PLAN
AREA 1
ALTERNATIVE 2

MISSION NATURE TRAIL
STREAM CHANNEL
STABILITY STUDY

DESIGNED BY: M.W.W.
DRAWN BY: S.R.
CHECKED BY: M.W.W.
DATE: 10/10/18
JOB NO.: 18–028

BAR IS ONE INCH ON ORIGINAL DRAWING, ADJUST SCALES FOR REDUCED PLOTS
0 1"

C3A



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PRELIMINARY
NOT FOR CONSTRUCTION

PREPARED AT THE REQUEST OF:
CITY OF
CARFMEL-BY-THE-SEA

SITE PLAN
AREA 3

MISSION NATURE TRAIL
STREAM CHANNEL
STABILITY STUDY

DESIGNED BY: –
DRAWN BY: S.R.
CHECKED BY: M.W.W.
DATE: 10/10/18
JOB NO.: 18–028

BAR IS ONE INCH ON ORIGINAL DRAWING, ADJUST SCALES FOR REDUCED PLOTS
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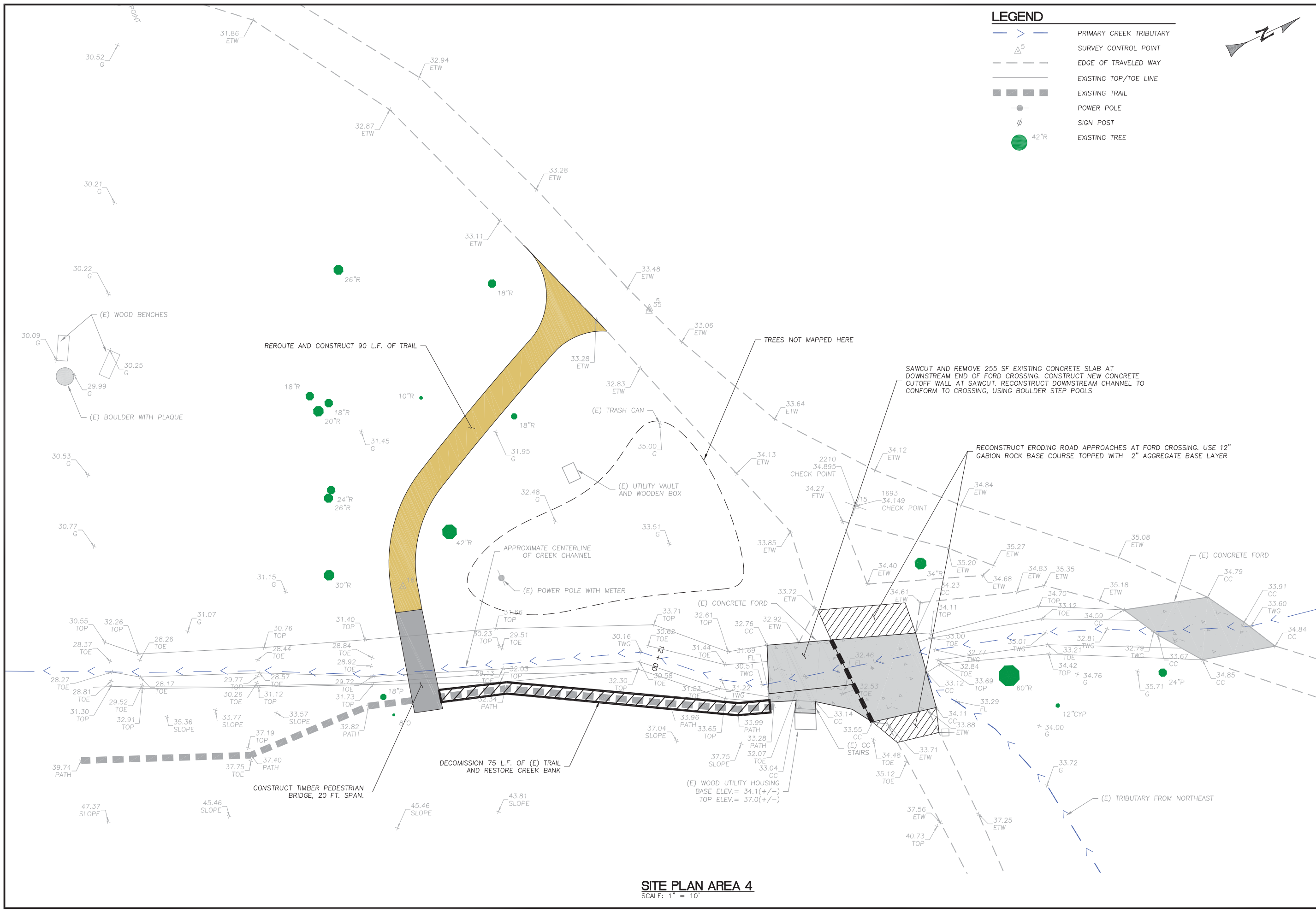
C4

5 OF 12



SITE PLAN AREA 4

SCALE: 1" = 10'

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NOT FOR CONSTRUCTION

PREPARED AT THE REQUEST OF:
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CARFMEL-BY-THE-SEA

SITE PLAN
AREA 4

MISSION NATURE TRAIL
STREAM CHANNEL
STABILITY STUDY

DESIGNED BY: –
DRAWN BY: S.R.
CHECKED BY: M.W.W.
DATE: 10/10/18
JOB NO.: 18–028

BAR IS ONE INCH ON ORIGINAL DRAWING, ADJUST SCALES FOR REDUCED PLOTS
0 1"

C5

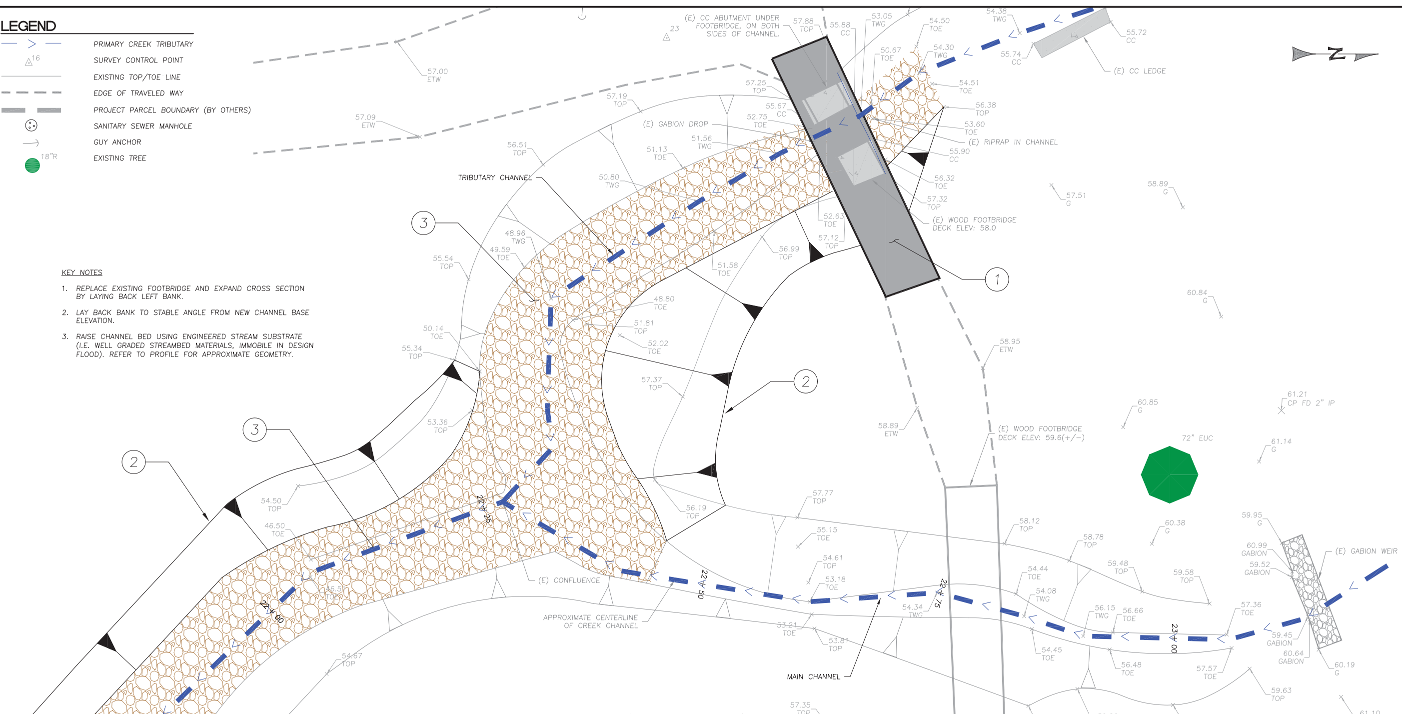
6 OF 12

LEGEND

- PRIMARY CREEK TRIBUTARY
- SURVEY CONTROL POINT
- EXISTING TOP/TOE LINE
- EDGE OF TRAVELED WAY
- PROJECT PARCEL BOUNDARY (BY OTHERS)
- SANITARY SEWER MANHOLE
- GUY ANCHOR
- EXISTING TREE

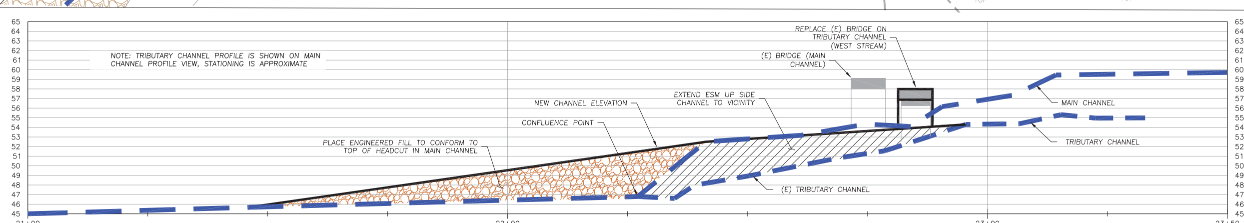
KEY NOTES

1. REPLACE EXISTING FOOTBRIDGE AND EXPAND CROSS SECTION BY LAYING BACK LEFT BANK.
2. LAY BACK BANK TO STABLE ANGLE FROM NEW CHANNEL BASE ELEVATION.
3. RAISE CHANNEL BED USING ENGINEERED STREAM SUBSTRATE (I.E. WELL GRADED STREAMBED MATERIALS, IMMOBILE IN DESIGN FLOOD). REFER TO PROFILE FOR APPROXIMATE GEOMETRY.



SITE PLAN AREA 6

SCALE: 1" = 5'



PROFILE

SCALE: 1" = 10' : 1" = 5'V

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PRELIMINARY
NOT FOR CONSTRUCTION

PREPARED AT THE REQUEST OF:
CITY OF
CARFMEL-BY-THE-SEA

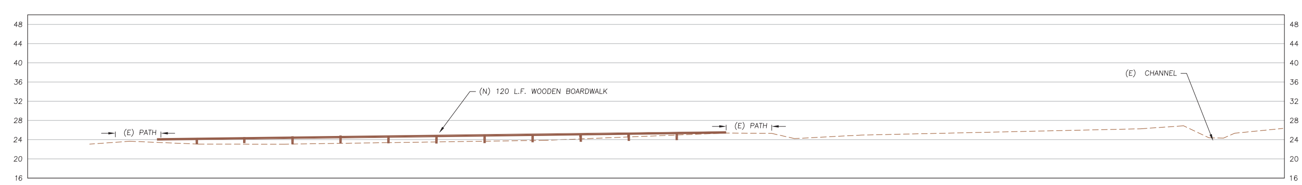
SITE PLAN AREA 6

MISSION NATURE TRAIL STREAM CHANNEL STABILITY STUDY

DESIGNED BY: –
DRAWN BY: S.R.
CHECKED BY: M.W.W.
DATE: 10/10/18
JOB NO.: 18–028

BAR IS ONE INCH ON ORIGINAL DRAWING, ADJUST SCALES FOR REDUCED PLOTS
0 1"

C6



SECTION
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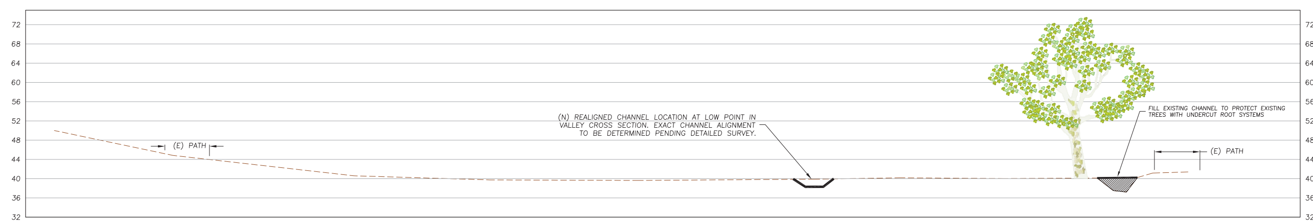

SECTION
SCALE: 1" = 10'
2
C7

WATERWAYS CONSULTING INC.
509A SWIFT ST.
SANTA CRUZ, CA 95060
PH:(831)421-9291 // FAX:(888)819-6847
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PREPARED AT THE REQUEST OF:
CITY OF
CARFMEL-BY-THE-SEA

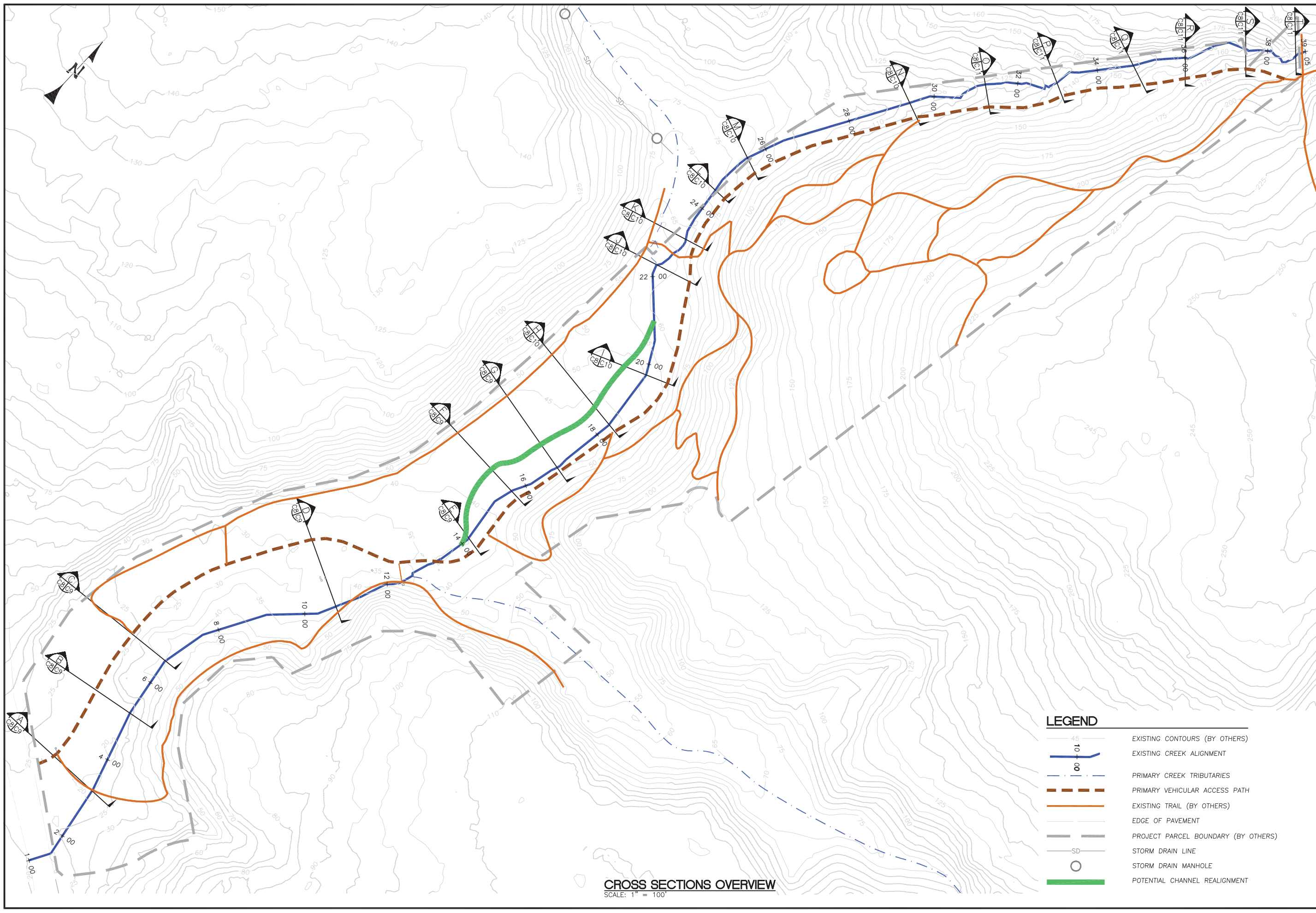
SECTIONS
(1 + 2)

MISSION NATURE TRAIL
STREAM CHANNEL
STABILITY STUDY

DESIGNED BY:	–
DRAWN BY:	S.R.
CHECKED BY:	M.W.W.
DATE:	10/10/18
JOB NO.:	18–028

BAR IS ONE INCH ON ORIGINAL DRAWING, ADJUST SCALES FOR REDUCED PLOTS
0 1"

C7



CROSS SECTIONS OVERVIEW

SCALE: 1" = 100'

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CROSS SECTIONS OVERVIEW

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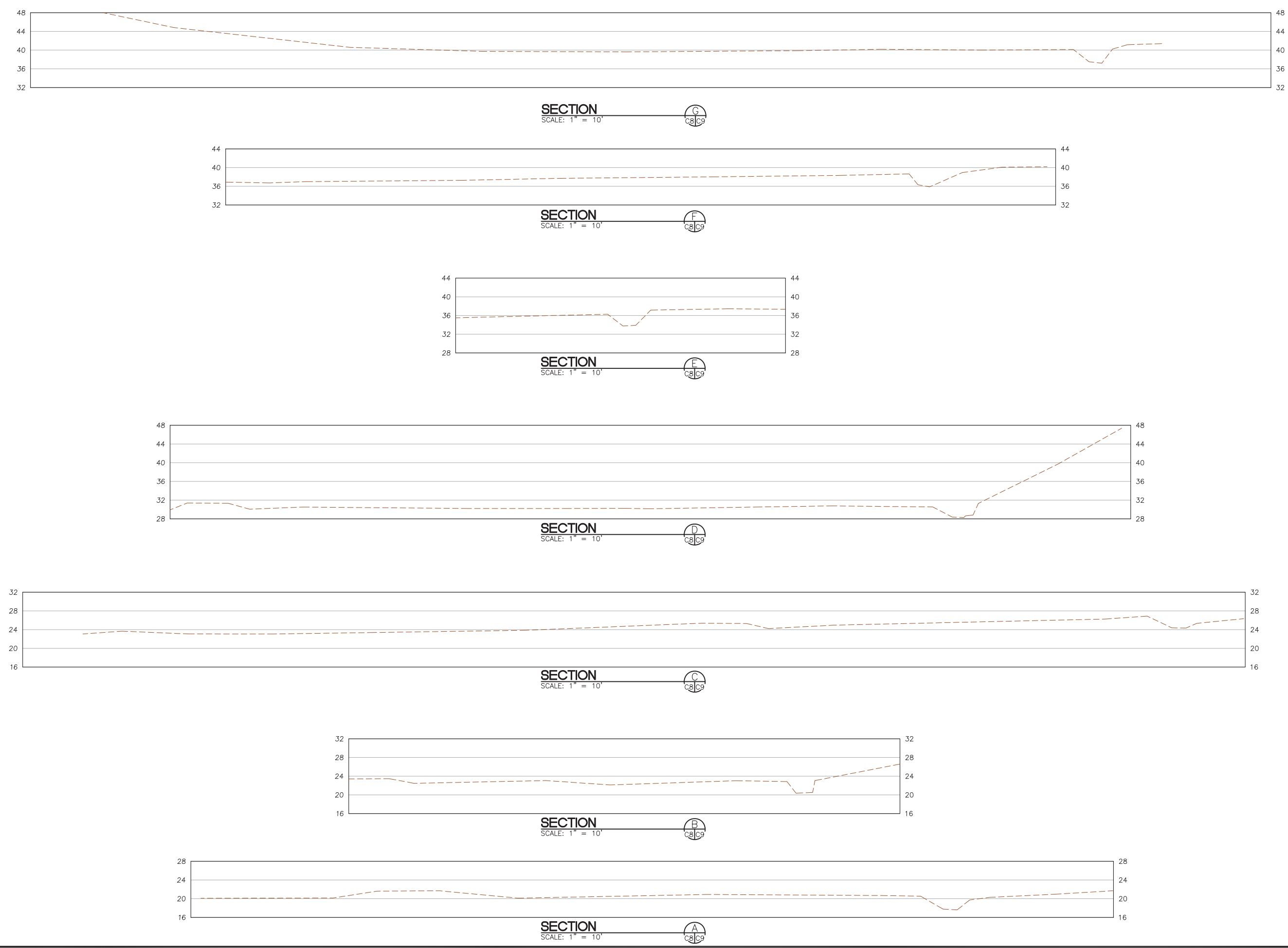
BAR IS ONE INCH ON ORIGINAL DRAWING, ADJUST SCALES FOR REDUCED PLOTS
0 1"

C8



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CROSS SECTIONS (A - G)

MISSION NATURE TRAIL STREAM CHANNEL STABILITY STUDY

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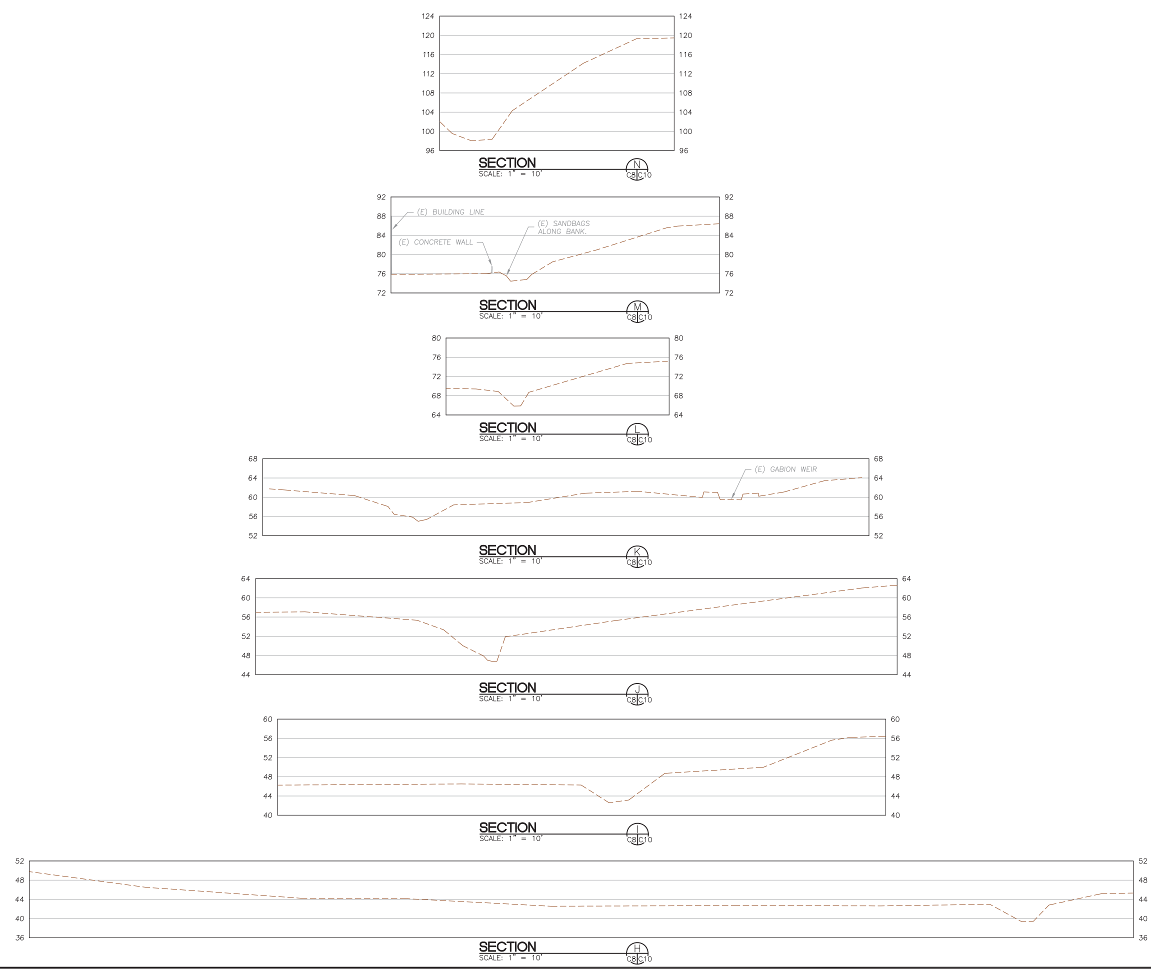
CHECKED BY:	M.W.W.
DATE:	10/10/18
JOB NO.:	18–028

BAR IS ONE INCH ON ORIGINAL DRAWING, ADJUST SCALES FOR REDUCED PLOTS
0 1"

C9



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CROSS SECTIONS (H - N)

MISSION NATURE TRAIL STREAM CHANNEL STABILITY STUDY

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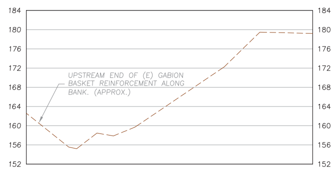
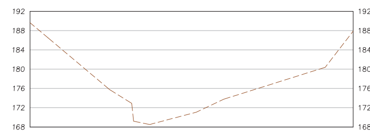
DRAWN BY:	S.R.
CHECKED BY:	M.W.W.
DATE:	10/10/18
JOB NO.:	18–028

BAR IS ONE INCH ON ORIGINAL DRAWING, ADJUST SCALES FOR REDUCED PLOTS
0 1"

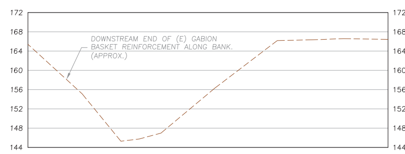
C10
11 OF 12



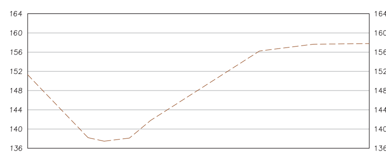
SECTION S
SCALE: 1" = 10'
C8 C11



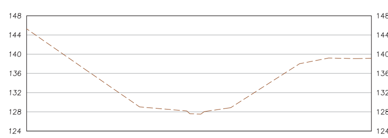
SECTION T
SCALE: 1" = 10'
C8 C11



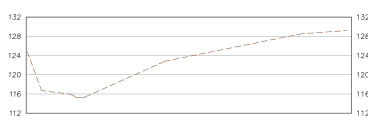
SECTION R
SCALE: 1" = 10'
C8 C11



SECTION Q
SCALE: 1" = 10'
C8 C11



SECTION P
SCALE: 1" = 10'
C7 C11



SECTION O
SCALE: 1" = 10'
C8 C11

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CROSS SECTIONS (O - T)

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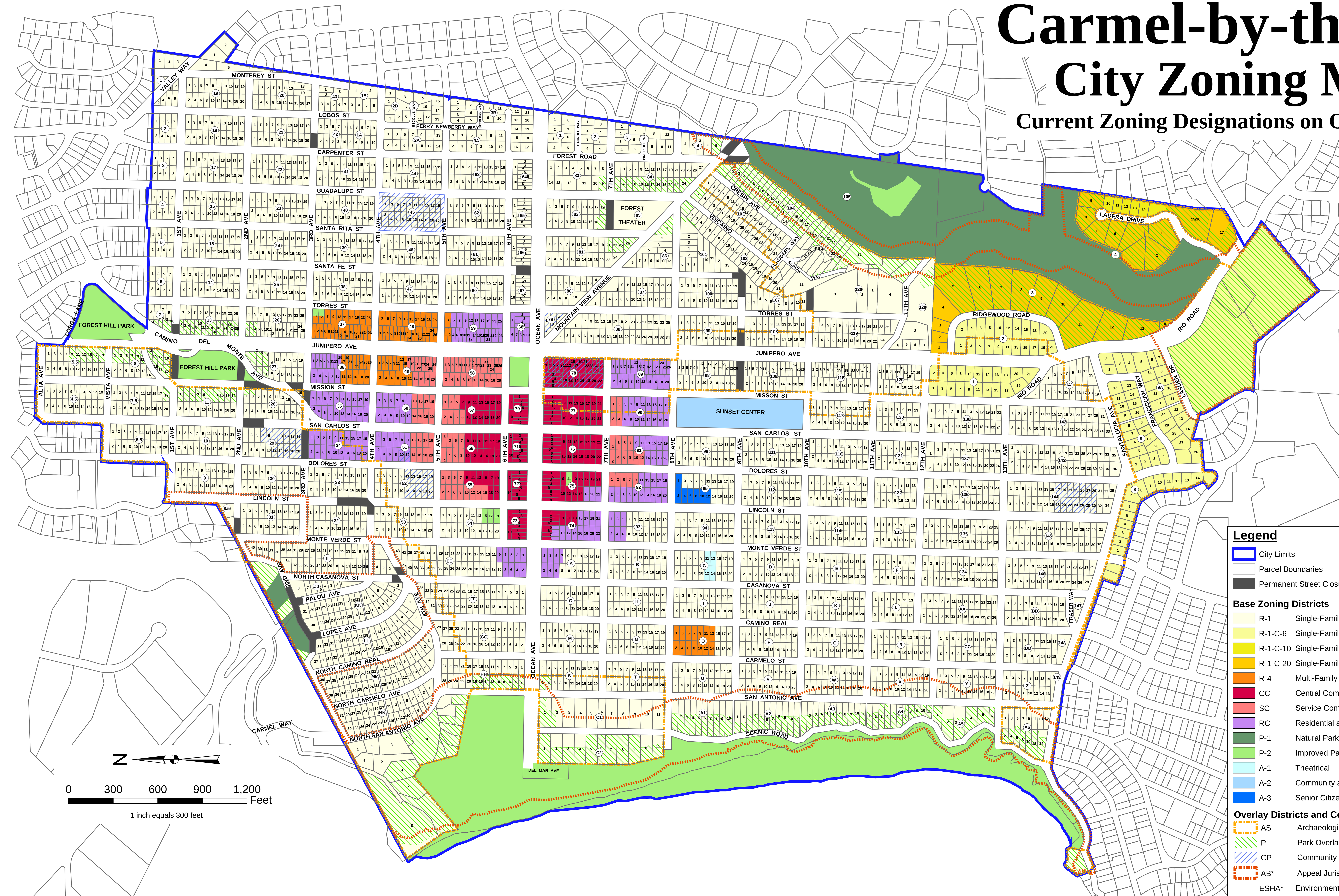
0 1"

C11
12 OF 12

Appendix 1: Hydrologic Modeling

Appendix I. Zoning Map

Carmel-by-the-Sea
City Zoning Map
Current Zoning Designations on Original Lots



Legend

- City Limits
- Parcel Boundaries
- Permanent Street Closures

Base Zoning Districts

R-1	Single-Family Residential
R-1-C-6	Single-Family (6,000 sf min.)
R-1-C-10	Single-Family (10,000 sf min.)
R-1-C-20	Single-Family (20,000 sf min.)
R-4	Multi-Family Residential
CC	Central Commercial
SC	Service Commercial
RC	Residential and Limited Commercial
P-1	Natural Parklands and Preserves
P-2	Improved Parklands
A-1	Theatrical
A-2	Community and Cultural
A-3	Senior Citizen Facility

Overlay Districts and Community Plans

AS	Archaeological Significance Overlay
P	Park Overlay
CP	Community Plan Area
AB*	Appeal Juristiction / Beach Overlay
ESHA*	Environmentally Sensitive Habitat Area - Overlay

*Note: The ESHA Overlay applies to all land within an identified ESHA and to all land within 30 feet of an ESHA. Please see General Plan for identified ESHA's in Mission Trail Nature Preserve, Pescadero Canyon, and at locations along Carmel Beach.

The Appeal Jurisdiction is a representation of the certified Appeal Jurisdiction layer from the coastal zone. Please see Certified Post LCP Map or Current Zoning for parcels in contact with this boundary.

Revised: February 18, 2009

Prepared June 25, 2008 for the City of Carmel by TriAxial Data Systems • Watsonville, CA 95076 • Phone (831) 763-3697) 763-3697