Final Draft Chollas Creek Watershed Master Plan

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Presented To

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Executive Summary

The *Chollas Creek Watershed Master Plan* (WMP) significantly advances the watershed management goals of the City of San Diego (City) Transportation and Storm Water Department as outlined in the water quality improvement plan (WQIP), watershed asset management plan (WAMP), and Master Storm Water System Maintenance Program. This document details the transition from the broad-scale objectives and overarching levels of service outlined in those plans to specific, prioritized activities that align with the City's capital improvement program (CIP) framework and asset management needs. Not only does this plan outline a project-by-project pathway to meeting the stated goals, but it will ensure that efficiencies are maximized by packaging together and integrating projects to achieve shared objectives. Ultimately, the WMP will replace or supplement the existing planning documents as part of the City's overall adaptive management and storm water program evolution processes.

The WMP was a collaborative effort by Tetra Tech, Inc.; Rick Engineering Company; HELIX Environmental Planning; and their respective sub-consultants (the Project Team) working on behalf of the City. The following paragraphs provide an overview of WMP components, overall processes, resulting recommendations, and recommended project implications.

While all master planning efforts strive to deliver a list of actions strategically designed to achieve an overarching goal, the veracity of such efforts depends heavily on (1) the quality of the data, (2) the robustness of the analysis, and (3) the usability of the results. This groundbreaking effort has achieved a unique outcome by leveraging the value of high-resolution data through the application of high-powered (yet efficient) analytical platforms and synthesizing the results into tangible and executable projects. The projects generated from this effort represent those with the highest overall value and contain sufficient detail to be executed in priority order with the assurance that each of the multiple objectives articulated in the respective planning documents will be achieved. This comprehensive approach was used to propose improvements to the storm drain system and surrounding infrastructure to mitigate flooding, restore the natural environment via stream restoration activities, and improve water quality using green infrastructure (GI) practices.

One of the principal objectives of the WMP is to identify and prioritize the ideal projects necessary to meet the watershed's water quality objectives. The inherent complexity of the requirements, watershed characteristics, and numerous WQIP strategies makes creating an accurate and implementable solution challenging. Due to a lack of data and/or insufficient analytical tools, no agency has yet successfully created a plan of this detail at such a scale. To meet this challenge, Tetra Tech developed a powerful system capable of analyzing the entire watershed simultaneously to capture the inherent complexity of this interconnected system. The WMP models build upon the existing and scientifically sound WQIP modeling, accommodate the use of high-resolution watershed data to characterize runoff and pollutant responses, acknowledge the on-the-ground engineering challenges of building and operating water quality solutions, and account for the highly variable (and sometimes hidden) costs of implementation. The computational platform simplifies this vast amount of data to the maximum extent possible to retain the precision necessary for informed decision-making and produces a solution that optimally meets the Chollas Creek water quality target. It is this balance of high-resolution data, analytical robustness, and simplification of results that yields the most value for the City as part of this WMP.

The water quality analyses resulted in the selection of 19 regional multiuse treatment areas (MUTAs) and 561 catch basins with distributed GI to reach the watershed-wide allowable load for total zinc (TZn). The recommended MUTAs (11 on public parcels and 8 on private parcels) are responsible for 58 percent of the required load reduction and the distributed GI projects are responsible for 42 percent of the required load reduction. Each of the individual projects were evaluated for both load removal efficiency (cost per pound of TZn removed) and total load reduction to provide a comprehensive water quality ranking that clearly identifies the high-efficiency, high-impact projects (Figure ES-1).

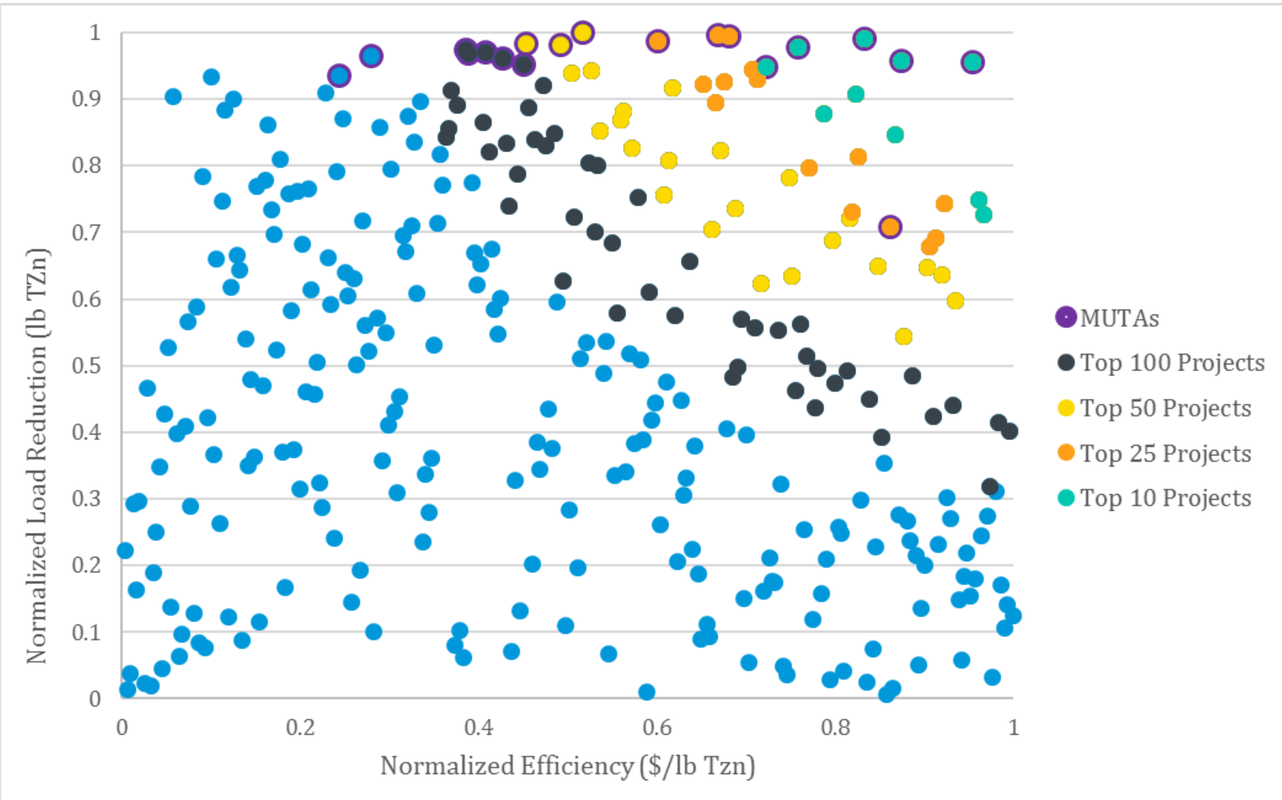

Figure ES-1. Summary of water quality projects selected to meet the TZn load reduction target.

Where applicable, the individual water quality opportunities selected were systematically bundled together into CIP-scale projects (resulting in a total of 311 water quality project bundles) that focused on proximity of the GI to streamline construction, and operations and maintenance (O&M) as well as to minimize community disturbance. The water quality recommendations and associated models will ultimately be able to replace the structural best management practice components of the Chollas Creek WQIP, which is reflective of the City's adaptive management program.

Rick Engineering assessed the flood control components for the WMP by using the same high-resolution spatial data sets to generate detailed hydrologic and hydraulic (H&H) models in PCSWMM for the 2-year, 10-year, 50-year, and 100-year (24-hour) storm events. In addition, Rick Engineering and Hoch Consulting developed **the most complete storm drain infrastructure dataset generated for the City to date,** which served as the basis for the most accurate representations of runoff potential and hydraulic characteristics of the watershed feasible. The newly compiled drainage infrastructure data coupled with high resolution one-/two-dimensional (1-D/2-D) modeling efforts highlighted a paradox for the City's flood management strategy: upsizing all infrastructure to meet level of service requirements would significantly exacerbate flooding conditions all the way down to San Diego Bay.

The high-definition modeling methodology developed by Rick Engineering allowed for more intelligent solutions to be considered (e.g., distributed detention storage and integrated project opportunities), resulting in larger cost savings for drainage infrastructure than traditional H&H approaches. The 2-D surface modeling allowed for the modeling of frequently occurring split flow conditions, generated a refined representation of surface storage and conveyance capacity in the streets, and characterized inundation limits along streets, streams, channels, and open space that will provide key data for future City decision-making. These **innovations in modeling and flood management approaches generated nearly 79 acre-feet of additional surface storage** that otherwise would have been required as retrofit detention or infrastructure improvements in a highly urbanized and constrained watershed, further exacerbating the deficiencies and cost of improvements. These results reflect the City goal of controlling peak flow rates through the strategic implementation of storage locations, which allows any increase in flow resulting from improvements to be attenuated and thus not further increase the deficiencies downstream.

HELIX Environmental performed a stream restoration assessment to identify and prioritize potential candidate sites through the watershed that provide: (1) viable opportunities for removing concrete, widening streams, and restoring native riparian and wetland habitat; (2) spatial and functional gains in City Wetlands and U.S. Army Corps of Engineers (USACE), Regional Water Quality Control Board (RWQCB), and California Department of Fish and Wildlife (CDFW) jurisdictional resources; (3) multi-benefits to the watershed and community; and (4) mitigation and partnership opportunities. Potential candidate sites were identified through a comprehensive review of existing data and literature for the watershed, analysis of the H&H modeling and flood control improvement data generated for the WMP, and collaboration with stakeholders and other entities involved in previous and ongoing restoration planning efforts in the watershed.

Twenty-four (26) potential stream restoration candidate sites were initially identified, encompassing 60,134 linear feet (11.4 miles) of streams; nine of these sites were removed from further analysis due to unsuitable conditions or significant constraints, primarily associated with the necessity to retain existing flood functions or existing land use constraints hindering the ability to widen a particular stream reach. The remaining 17 candidate sites encompassed 15,895 linear feet (3.0 miles) of viable stream restoration in the watershed and underwent further screening using a standardized tool developed for the WMP that included multiple criteria and prioritization ranking (e.g., jurisdictional gains, riparian and wetland habitat expansion, habitat connectivity and regional preserve design, land acquisition and long-term preservation, and other mitigation needs).

Restoration concepts were developed for each of the 17 priority stream restoration candidate sites, including dimensions based on the H&H modeling and preliminary engineering analyses that were generally focused on the feasibility of concrete removal and widening of stream reaches. The restoration concepts were tailored for each site by assigning one of two restoration plant palettes depending on the general site conditions: (1) an open cobble concept, which is characteristic of the majority of the watershed; and (2) a riparian/wetland concept, which is appropriate at select sites where hydrology conditions are expected to be suitable. Once dimensions and restoration palettes were applied, spatial gains in jurisdictional area were calculated for each site, preliminary costs were determined, and restoration sites were ultimately prioritized and integrated with symbiotic flood control improvement, where applicable.

The ultimate benefit of developing a WMP that assesses the potential for attaining multiple functional improvements is the inherent emergence of integrated projects that meet multiple City objectives simultaneously, while providing opportunities for cost sharing and design efficiencies, and minimizing community disturbance. **A total of 125 integrated projects were identified as part of the WMP, with an estimated 20 percent ($72.1 million) cost savings when compared to traditional, isolated planning efforts.** The emphasis on holistic watershed management and integration generated new, innovative project concepts (e.g., the stream restoration, flood detention, and water quality facility at Auburn Creek) that will expand the opportunities available to meet City objectives.

The WMP along with the associated GIS data set, web tool, and spreadsheets will provide a highly detailed drainage improvement plan that will allow the City to easily assess and implement improvements for the area's current flooding issues. This WMP summarizes the recommendations and presents them within the Chollas Creek Watershed Master Plan Web Mapping Application https://gis.tetratech.com/Chollas_WMP/).

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B. FLOOD CONTROL MODELING

C. BIOLOGICAL RESOURCE

D. WATER QUALITY AND FLOOD CONTROL INTEGRATION MODEL

Acronyms/Abbreviations

Acronym/Abbreviation	Definition
BMP	best management practice
CCBI	cost/capacity benefit index
CDFW	California Department of Fish and Wildlife
CDP	Coastal Development Permit
CFG	California Fish and Game
CIP	capital improvement program
CLRP	comprehensive load reduction plan
CNDDB	California Natural Diversity Database
CR	cost ratio
cfs	cubic feet per second
CWA	Clean Water Act
DEM	digital elevation model
EMC	event mean concentration
EPA	U.S. Environmental Protection Agency
ESA	environmentally sensitive area
ESL	environmentally sensitive lands
ft	foot, feet
FY	fiscal year
GI	green infrastructure
GIS	geographic information system
H&H	hydrology and hydraulics
HRU	hydrologic response unit
HSPF	Hydrologic Simulation Program-FORTRAN
IHHA	individual hydrologic and hydraulic assessment
IP	integrated project
IPaC	Information for Planning and Consultation
lbs/yr	pounds per year
LCP	Local Coastal Program
LECC	Law Enforcement Coordinating Council
LF	linear foot, linear feet
LiDAR	Light Detection and Ranging
LOS	level of service
LSPC	Load Simulation Program in C++

Acronym/Abbreviation	Definition
MHPA	multi-habitat planning area
MS4	municipal separate storm sewer system
MSCP	Multiple Species Conservation Program
MSWSMP	Master Storm Water System Maintenance Program
MUTA	multiuse treatment area
NEPA	National Environmental Policy Act
NGA	National Geospatial-Intelligence Agency
NOAA	National Oceanic and Atmospheric Administration
NWP	nationwide permits
O&M	operations and maintenance
QA/QC	quality assurance/quality control
PFDS	Precipitation Frequency Data Server
RCB	reinforced concrete box
RCP	reinforced concrete pipe
ROW	right-of-way
RTC	real-time control
RWQCB	Regional Water Quality Control Board
SANDAG	San Diego Association of Governments
SanGIS	San Diego Geographic Information Source
sq. mi.	square miles
SSURGO	Soil Survey Geographic Database
SUSTAIN	System for Urban Stormwater Treatment and Analysis Integration
SWMM	Storm Water Management Model
TMDL	total maximum daily load
TZn	total zinc
USACE	U.S. Army Corps of Engineers
USDA	U.S. Department of Agriculture
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
WAMP	watershed asset management plan
WMA	watershed management area
WMP	watershed master plan
WQIP	water quality improvement plan

1.0 Introduction

The City of San Diego (City) Storm Water Division (Division) has the challenging task of managing multiple storm water objectives in the Chollas Creek watershed, including flood risk management, protection and enhancement of environmental resources, improvement of water quality in receiving waterbodies, and operations and maintenance (O&M) of existing projects and initiatives. Each of these overarching goals is subject to its own complex regulatory drivers, differing compliance timelines, and varying extent of applicability (e.g., watershed scale versus jurisdictional scale). Traditionally, these differences have led to separate analyses, competing objectives, and parallel planning efforts related to meeting requirements for water quality improvement, flood control, and environmental resource protection. Specifically, the City has completed three comprehensive planning documents for Chollas Creek that outline high-level strategies for achieving the Division's overarching objectives: (1) the water quality improvement plan (WQIP), (2) the watershed asset management plan (WAMP), and (3) the Master Storm Water System Maintenance Program (MSWSMP), which is applicable to the entire City jurisdictional area.

Integrated watershed planning provides a holistic storm water strategy and identifies new, innovative solutions by addressing flood risk reduction, water quality, habitat, and community simultaneously

The WQIP presents a planning-level, comprehensive framework for the strategies and schedules necessary to comply with water quality improvement requirements, including both structural and nonstructural approaches. The WAMP summarizes all drainage infrastructure improvements necessary to meet the required level of service (LOS) using traditional LOS assessment criteria. The MSWSMP provides maintenance methods and regulatory procedures required to maintain open flood control facilities. However, these plans do not currently contain sufficient detail to identify project-by-project priorities using site-specific information, nor do they identify potential execution synergies between the three plans. The purpose of the current effort has been to integrate the water quality requirements presented in the WQIP, drainage system improvement needs summarized in the WAMP, and environmental restoration and rehabilitation credits identified in the MSWSMP into a comprehensive watershed master plan (WMP) for the Chollas Creek watershed (see Figure 1-1). In addition, the WMP contains the requisite information and level of detail to identify prioritized and integrated projects (IPs) that can be easily transitioned into the capital planning and asset management processes. The WMP can be systematically implemented to demonstrate progress towards satisfying the requirements of the municipal separate storm sewer system (MS4) permit, total maximum daily loads (TMDLs), and additional flood control and water quality issues the Division has, including the upcoming state trash policy and potential off-site storm water alternative compliance applications. The WMP also could be used to identify and leverage program synergies to streamline the City's efforts related to storm water management, water quality, environmental restoration, capital improvement projects (CIPs), asset management, and grant funding.

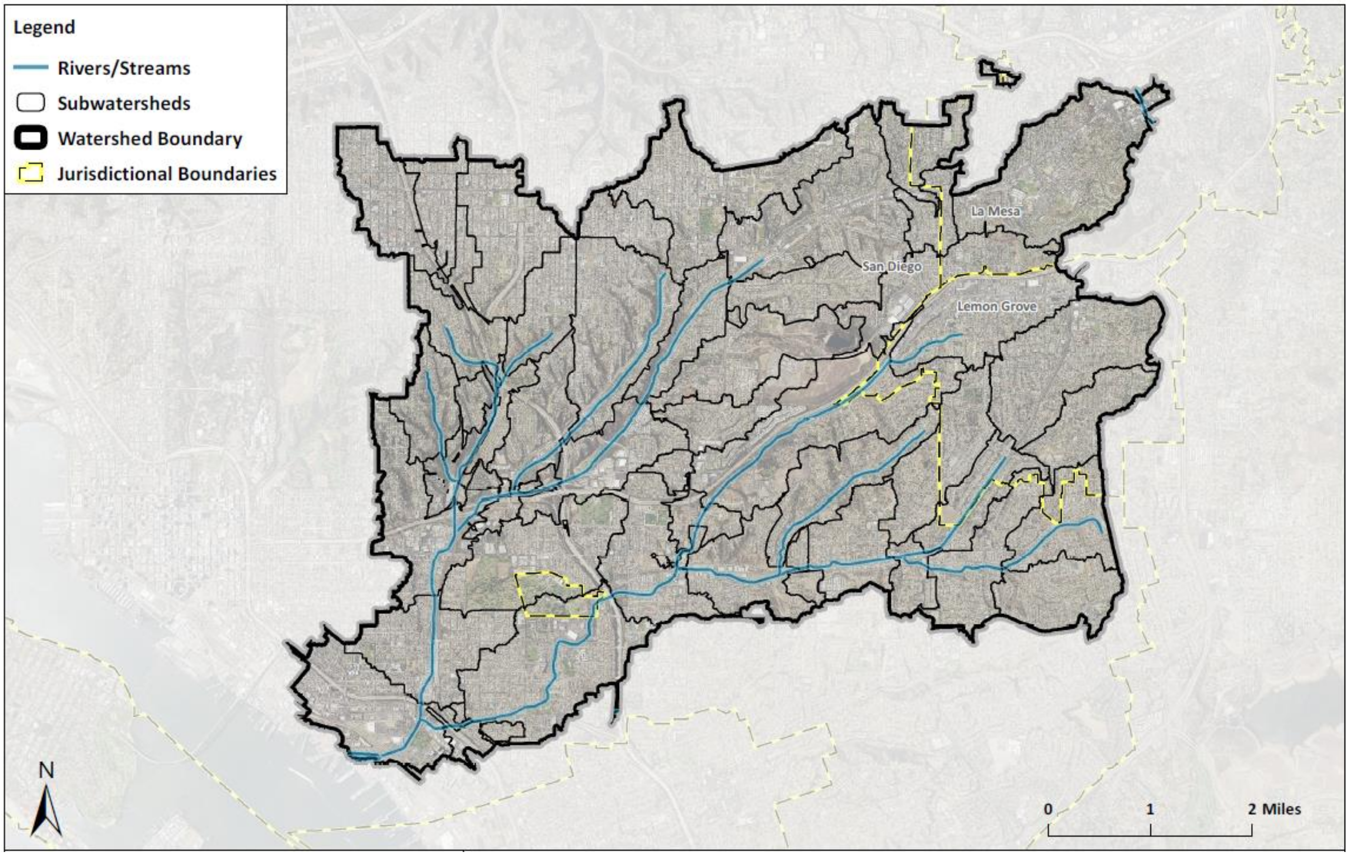

Figure 1-1. Watershed master plan study area.

The major components involved in developing the WMP are shown in Figure 1-2. The essential foundation for the entire WMP process was the creation of new high-resolution data sets (e.g., storm drain system, surface cover, and topography) to provide the most accurate characterization of existing conditions within the watershed to date. These new data sets allowed for unprecedented representations of the watershed to be developed and inform the hydrologic, hydraulic, and water quality models that are critical for the City to make smart, data-driven decisions. The second component of the WMP involved two parallel modeling efforts: (1) H&H models developed to assess flooding conditions and identify infrastructure improvements, and (2) water quality models developed to identify and optimize green infrastructure (GI) and multiuse treatment area (MUTA) opportunities to meet relevant permit requirements and interim compliance milestones. Both of these modeling efforts identified thousands of potential projects and infrastructure improvements, necessitating the strategic grouping of individual projects into larger water quality and flood control bundled projects. These groups of projects provide the City with tangible CIP-scale projects that can be used for further planning and design. The baseline data used by the two models are consistent to ensure a uniform representation of the watershed. In conjunction, qualitative and field-based assessments were also completed to identify potential stream restoration opportunities within the watershed. Ultimately, the groups of projects from the two modeling efforts and the stream restoration assessments were strategically evaluated and integrated to provide a comprehensive relative ranking of all potential improvements within the Chollas Creek watershed. The coordinated assessment of multiple Division objectives for the WMP allowed for the identification of innovative, IP opportunities, which are often overlooked when conducting traditional watershed-scale planning assessments. The resulting recommendations for the WMP are presented in this report and the associated web application.

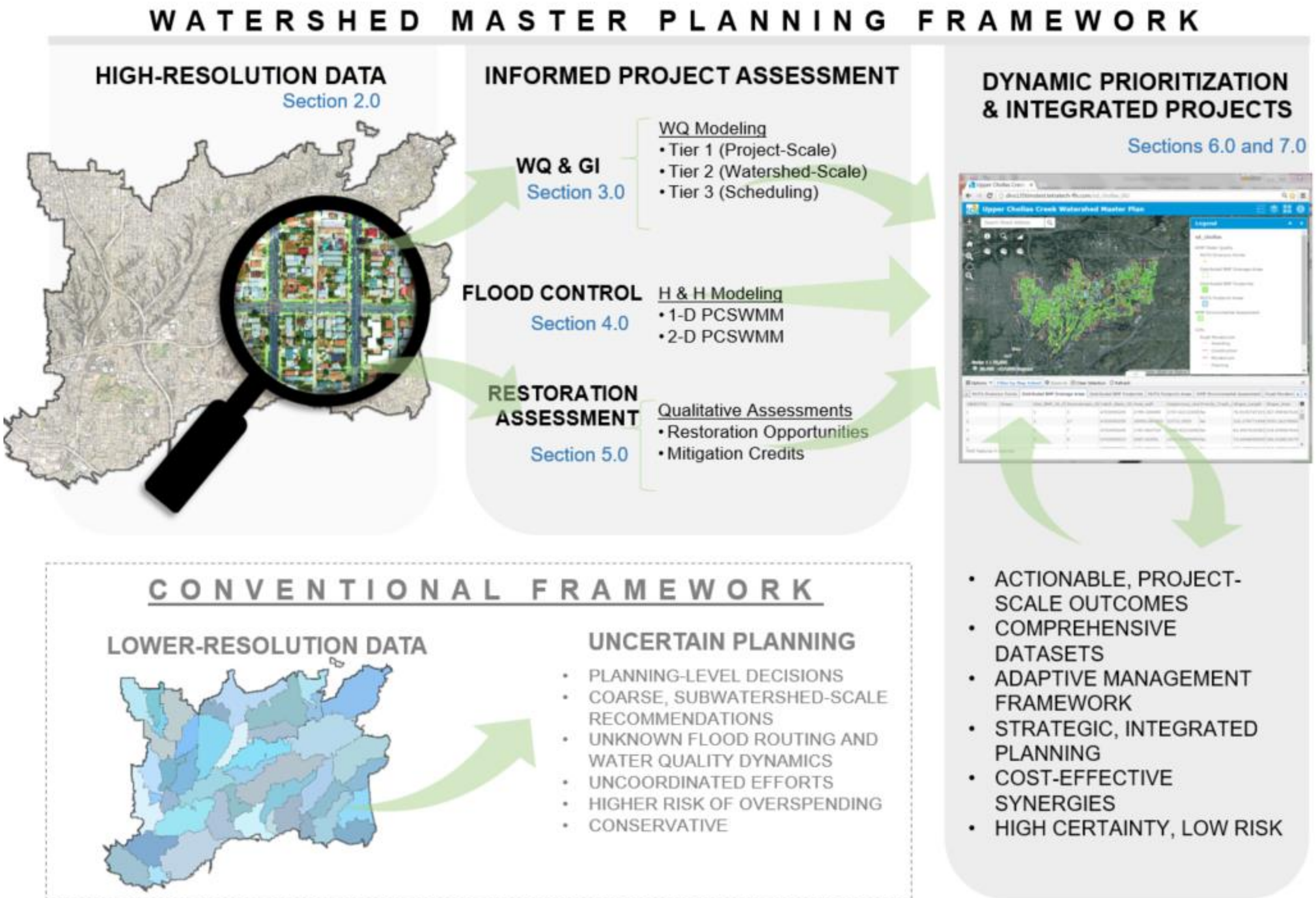

Figure 1-2. WMP framework.

1.1 Regulatory Framework

The City's Storm Water Division must be responsive to a number of regulatory drivers that apply to flood control, storm water infrastructure management, water quality, and environmental mitigation in the Chollas Creek watershed, including local TMDLs, the MS4 permit, and numerous wetland permit requirements. These regulatory drivers are typically focused on addressing one particular storm water-related component, each with different compliance metrics, timelines, and monitoring requirements. Understanding the nuances inherent in meeting the overall regulatory framework in the watershed was a critical component in developing the WMP and is summarized in the sections below.

1.1.1 TMDL and MS4 Permit Requirements

The Chollas Creek watershed is located within the San Diego Bay Watershed Management Area (WMA) and currently has two applicable TMDLs: (1) the TMDL for Dissolved Copper, Lead and Zinc in Chollas Creek (No. R9-2007-0043) and (2) the revised TMDL for Indicator Bacteria Project I-Twenty Beaches and Creeks in the San Diego Region (including Tecolote Creek) (No. R9-2010-0001). Attachment E of the MS4 permit specifies that demonstration of the compliance pathways for both the dissolved metals TMDL and the bacteria TMDL shall include one of the following methods:

- Demonstrate that there are no direct or indirect discharges from the Copermittee's MS4s to the receiving water;
- Demonstrate that there are no exceedances of the final receiving water limitations in the receiving water at, or downstream of, the Copermittee's MS4 outfalls;
- Demonstrate that there are no exceedances of the final effluent limitations at the Copermittee's MS4 outfalls; OR
- Develop and implement a WQIP.

The MS4 permit specifies that a WQIP is required to guide the Copermittees' interim progress towards the final water quality-based effluent limitations in the TMDLs; however, it is not the sole pathway for demonstrating final compliance as indicated above. The San Diego Bay WMA Copermittees developed a WQIP that included watershed-wide water quality models that evaluated the limiting pollutants of concern for both wet and dry weather conditions. Zinc was identified as the limiting pollutant for wet weather conditions, and bacteria was identified as the limiting pollutant for dry weather conditions. As part of the compliance evaluation, the WQIP identified potential pollutant sources, assessed fate and transport of pollutants, and established required pollutant load reductions to meet water quality objectives based on the best data available during the development process. The WQIP provides one potential combination of strategies (e.g., distributed GI, MUTAs, street sweeping, catch basin cleaning, and source control) as a compliance pathway for the City to meet the applicable MS4 permit requirements. As part of the permit-required adaptive management process, the pollutant loading and strategies identified in the WQIP may be revised as new data become available and implementation of storm water strategies progress. This WMP is inherently part of the adaptive management process by providing linkage between the overarching load reduction targets and strategies proposed in the WQIPs, the preponderance of newly available data, and identification of specific project-by-project priorities within the Chollas Creek watershed based on this refined data-driven decision-making.

1.1.2 Trash Amendments Requirements

On April 7, 2015, the California State Water Resources Control Board (State Water Board) adopted amendments to the *Water Quality Control Plan for Ocean Waters of California* (Ocean Plan) and the *Water Quality Control Plan for Inland Surface Waters, Enclosed Bays, and Estuaries of California* (ISWEBE Plan) that are referred to as the "Trash Amendments." These amendments prescribe a land-use-based compliance approach that focuses on trash controls in areas with the highest trash generation rates (priority land uses).

The Trash Amendments allow for a dual alternative compliance method (i.e., Track 1 and Track 2). Track 1 involves the installation, operation, and maintenance of full capture systems in storm drains that capture runoff from priority land-use areas. Track 2 requires an implementation plan combining full capture systems, multi-benefit projects, institutional controls, or other treatment controls to reach full capture system equivalency. Pending the outcome of a lawsuit challenging the Trash Amendments, the City of San Diego will develop an implementation plan describing its trash control approach. The Trash Amendments require that the implementation plan be submitted within 18 months of receipt of a Water Code 13267 letter from the State Water Quality Control Board.

1.1.3 Drainage Infrastructure Requirements

The City of San Diego maintains certain regulatory standards for storm water improvements as stipulated in the *City of San Diego Drainage Design Manual*. The governing design storm used as the basis for all flood control recommendations for this study area was the 100-year storm event, which is consistent with the requirements per the *City of San Diego Drainage Design Manual*. One of this study's objectives was to assess the existing drainage infrastructure to determine the current LOS. Any facilities determined to be deficient in capacity to convey the 100-year storm event were addressed in the "proposed improvement" phase of the flood control study.

To maintain a balanced approach to the flood control portion of the infrastructure improvements, a combination of upsizing storm drains while allowing flows in excess of the storm drain conveyance capacity to flow on the surface within the City right-of-way (ROW) would be recommended for severely deficient systems. This approach also entails the identification of strategic detention locations, emphasizing preference for combined water quality and flood control benefits throughout the watershed. Flows could be mitigated to acceptable levels, reducing the impact to downstream drainage facilities.

1.1.4 Wetland Permit Requirements

Water quality, flood control, and stream restoration activities within jurisdictional waters and wetlands are subject to existing federal, state, and local regulations. In the context of this assessment, jurisdictional waters and wetlands include waters of the U.S. subject to the regulatory jurisdiction of the U.S. Army Corps of Engineers (USACE) pursuant to Section 404 of the federal Clean Water Act (CWA); waters of the State subject to the regulatory jurisdiction of the Regional Water Quality Control Board (RWQCB) pursuant to Section 401 of the federal CWA and State Porter-Cologne Water Quality Control Act (Porter-Cologne); streambed and riparian habitat subject to the regulatory jurisdiction of the California Department of Fish and Wildlife (CDFW) pursuant to Sections 1600 et seq. of the California Fish and Game Code (CFG Code); City wetlands pursuant to the City's Environmentally Sensitive Lands (ESL) regulations; and coastal wetlands within the Coastal Overlay Zone pursuant to the City's ESL regulations, certified Local Coastal Program (LCP), and California Coastal Act.

Waters of the U.S.–USACE Jurisdiction

Activities resulting in permanent or temporary fill, discharge, or dredge impacts within non-tidal wetland or non-wetland waters of the U.S. are regulated by the USACE pursuant to CWA Section 404. The type of Section 404 permit is dependent upon the type and extent of the impacts on waters of the U.S. In general, impacts that do not exceed certain impact thresholds determined by the USACE (e.g., 0.5 acre of permanent impact, 300 linear feet of permanent impact, 500 feet of bank stabilization impact, etc.) can be permitted under one or more Nationwide Permits (NWPs). Activities permitted under the NWP program do not require additional National Environmental Policy Act (NEPA) review or analysis of project alternatives by the USACE. A Standard Individual Permit (IP) is generally required when the activities would exceed the NWP impact threshold. Activities permitted under an IP require additional NEPA review and alternatives analysis pursuant to CWA Section 404(b)(1).

Waters of the State–RWQCB Jurisdiction

Activities requiring a CWA Section 404 permit for impacts to waters of the U.S. also require a CWA Section 401 Water Quality Certification from the RWQCB. Activities resulting in permanent or temporary fill, discharge, or dredge impacts, including discharge of waste, to waters of the State that are exclusive of waters of the U.S. require a Report of Waste Discharge and Waste Discharge Permit issued by the RWQCB pursuant to Porter-Cologne.

Streambed and Riparian Habitat–CDFW Jurisdiction

Activities resulting in permanent or temporary modification of streambed or destruction of riparian habitat that provides benefit to plant or wildlife resources are regulated by the CDFW pursuant to CFG Code Sections 1600 *et seq*. A Notification of Lake or Streambed Alteration is required prior to initiation of activities. Upon review of the Notification, a Streambed Alteration Agreement may be issued by CDFW.

City Wetlands–City Jurisdiction

Activities resulting in permanent or temporary impacts to wetland habitat types are included in Tables 2A and 2B of the City's Land Development Code Biology Guidelines are regulated in accordance with the City's ESL regulations. Where unavoidable impacts must occur to City wetlands, the activities require a Site Development Permit (SDP) issued by the City.

City Wetlands are defined as areas persistently or periodically containing wetland habitat types, areas containing hydric soils or wetland hydrology, previously existing wetlands, and/or areas mapped as wetlands on Map No. C-713 as shown in Chapter 13, Article 2, Division 6 (Sensitive Coastal Overlay Zone). Artificially created wetlands in historically non-wetland areas, with the exception of wetlands created for the purpose of providing wetland habitat, are not considered wetlands by this definition. Although not a City Wetland habitat type included in Tables 2A and 2B of the City's Land Development Code Guidelines, concrete-lined drainages constructed over the general flow path of historical drainage features and wetlands are also typically considered City Wetlands.

Coastal Wetlands–City and California Coastal Commission Jurisdiction

Activities resulting in permanent or temporary impacts to wetlands located in the Coastal Overlay Zone are regulated in accordance with the City's ESL regulations, LCP, and California Coastal Act. This includes those wetland types from Tables 2A and 2B of the City's Land Development Code Biology Guidelines, as well as concrete-lined drainages constructed over the general flow path of historical drainage features and wetlands. Where unavoidable impacts must occur to City wetlands, the activities require a Coastal Development Permit (CDP) issued by the City, unless located within a deferred certification or coastal permit area, whereby the CDP is issued by the California Coastal Commission.

2.0 High Resolution Data

The linkage between watershed-scale planning and the prioritization of site-scale individual projects is made possible through the availability and analysis of high-resolution data to allow for accurate geospatial representations of the study area. In previous studies of this scale (e.g., WQIP), a coarser characterization of the physical and pollutant generating surfaces has been used to allow for a timely and cost-effective analysis. With the recent collection of highly detailed aerial imagery and Light Detection and Ranging (LiDAR) data, rapid and accurate assessment of the critical inputs to hydrologic and water quality models is possible. The success of this WMP is entirely dependent on the synthesis of the new data sets, with strategic field assessments to validate the data and fill in unknowns, where necessary. Later sections of this report demonstrate how the data help to create finely tuned and less-expensive compliance solutions.

This section presents:

- Geospatial data used for study area surface cover and drainage characteristics (section 2.1)
- Monitoring data used to calibrate and validate the watershed models (section 2.2)
- Field assessments needed to supplement and ground truth the geospatial and monitoring data (section 2.3)

2.1 Geospatial Data

The geospatial data incorporated as part of this WMP represent the most current and detailed characterization of the Chollas Creek watershed, improving significantly on the data available for the WQIP and WAMP. The improved data have facilitated rapid assessment of water quality GI opportunities, surface features, and drainage characteristics within the Chollas Creek watershed.

2.1.1 Raw Geospatial Data

In 2014, the San Diego Geographic Information Source (SanGIS), San Diego Association of Governments (SANDAG), National Geospatial-Intelligence Agency (NGA), San Diego Law Enforcement Coordinating Council (LECC), Regional Public Safety GIS, and all 18 incorporated cities in San Diego County collected LiDAR data for the urbanized area of San Diego County, including the Chollas Creek watershed. The data were collected at a resolution of 2 points per square meter (Level 2) and were used to generate 2-foot (-ft) contours and a digital elevation model (DEM) over the coverage area. The LiDAR collection effort also generated ortho-rectified aerial imagery at 0.1-meter (approximately 4-inch) resolution. The vertical datum for the data was North American Vertical Datum of 1988 and was projected to the National Geodetic Vertical Datum of 1929 to align with all other City data sets.

The Project Team used several additional data sets for this WMP that are summarized in Table 2-1 with their associated version dates and available metadata.

Table 2-1. Geospatial data inventory

Data Layer	Version Date	Source (Agency)
LiDAR	June 15, 2015	SanGIS, SANDAG, NGA, LECC, Regional Public Safety GIS, 18 Incorporated Cities
Aerial Imagery	June 19, 2015	SanGIS, SANDAG, NGA, LECC, Regional Public Safety GIS, 18 Incorporated Cities
Storm Drain Network Files (Drain Conveyance, Drain Structures)	April 23, 2015	City of San Diego, SanGIS, SANDAG
Land Use	May 10, 2016	SanGIS, SANDAG
Hydrologic Soil Groups (SSURGO)	November 11, 2013	National Resources Conservation Service
Priority Trash-Generating Areas	February 15, 2016	City of San Diego
CIPs	March 11, 2016	City of San Diego
Parcel Layer	October 2, 2016	SanGIS, SANDAG, Assessor/Recorder/County Clerk
Environmentally Sensitive Areas	February 11, 2015	City of San Diego, D-Max Engineering, Inc.
Floodplain Layers	May 16, 2012	Federal Emergency Management Agency
Utility Layers (Sewer Main, Water Main)	September 28, 2016	SanGIS, SANDAG
Road Moratorium	October 25, 2017	City of San Diego
Census Block District Groups	April 25, 2016	City of San Diego
Soil Contamination Sites	July 29, 2014	State Water Board
Municipal Boundaries	July 25, 2011	SanGIS, SANDAG
National Hydrography Dataset Flowline	April 12, 2016	U.S. Geological Survey
Flooding Complaints	April 5, 2016	City of San Diego (Excel, compiled into geodatabase by Hoch Consulting)
Outfall Surveys	March 11, 2016	City of San Diego
Access Staging Areas	October 2011	City of San Diego
Channel Survey Areas	February 9, 2011	City of San Diego
MMP Channel Units	May 10, 2011	HELIX Environmental
MMP Field Map Extents	May 26, 2017	HELIX Environmental
Multi-Habitat Planning Areas (MHPA)	April 20, 2015	SanGIS
Existing Vegetation	May 26, 2017	HELIX Environmental

2.1.2 Geospatial Processing

Using the raw data sets listed in Table 2-1, the Project Team produced several new data sets as part of the WMP to facilitate the rapid identification of surface features and develop detailed surface drainage information. The general procedure for processing those data sets to identify various GI opportunities and their associated drainage boundaries is presented in the following sections.

Surface Feature Extraction

The aerial imagery and LiDAR data were processed to develop land cover data sets pertaining to the classification of storm water runoff and pollutant-generating surfaces. The aerial imagery was used primarily to separate remotely sensed data into vegetated (pervious) and non-vegetated (impervious) surfaces based upon spectral response properties. The LiDAR data were then used to further refine the surface coverage into various height classes (e.g., vegetation into low, medium, and high; non-vegetated surfaces into roofs and ground-level imperviousness).

A manual approach was taken to identify and digitize curbed roads since the resolution of the LiDAR data was too coarse to ensure appropriate collection. The accurate representation of curbed roads is critical for both the identification of GI opportunities within the ROW and the routing of flows along the outer edges of the roads for flood control modeling. Table 2-2 summarizes the extracted surface features, and Figure 2-1 demonstrates the processed results for a subsection in the study area.

Table 2-2. Extracted surface features and collection methods

Land Cover	Height Classification	Collection Method
Low Vegetation	0–6 feet above ground elevation	Algorithms; manual QA/QC
Medium Vegetation	6–10 feet above ground elevation	Algorithms; manual QA/QC
High Vegetation	> 10 feet above ground elevation	Algorithms; manual QA/QC
Surface Level Imperviousness	At ground elevation	Algorithms; manual QA/QC
Roofs	> 8 feet above ground elevation	Algorithms; manual QA/QC
Curbed Roads	At ground elevation	Manual Delineation

Note: QA/QC = quality assurance/quality control.

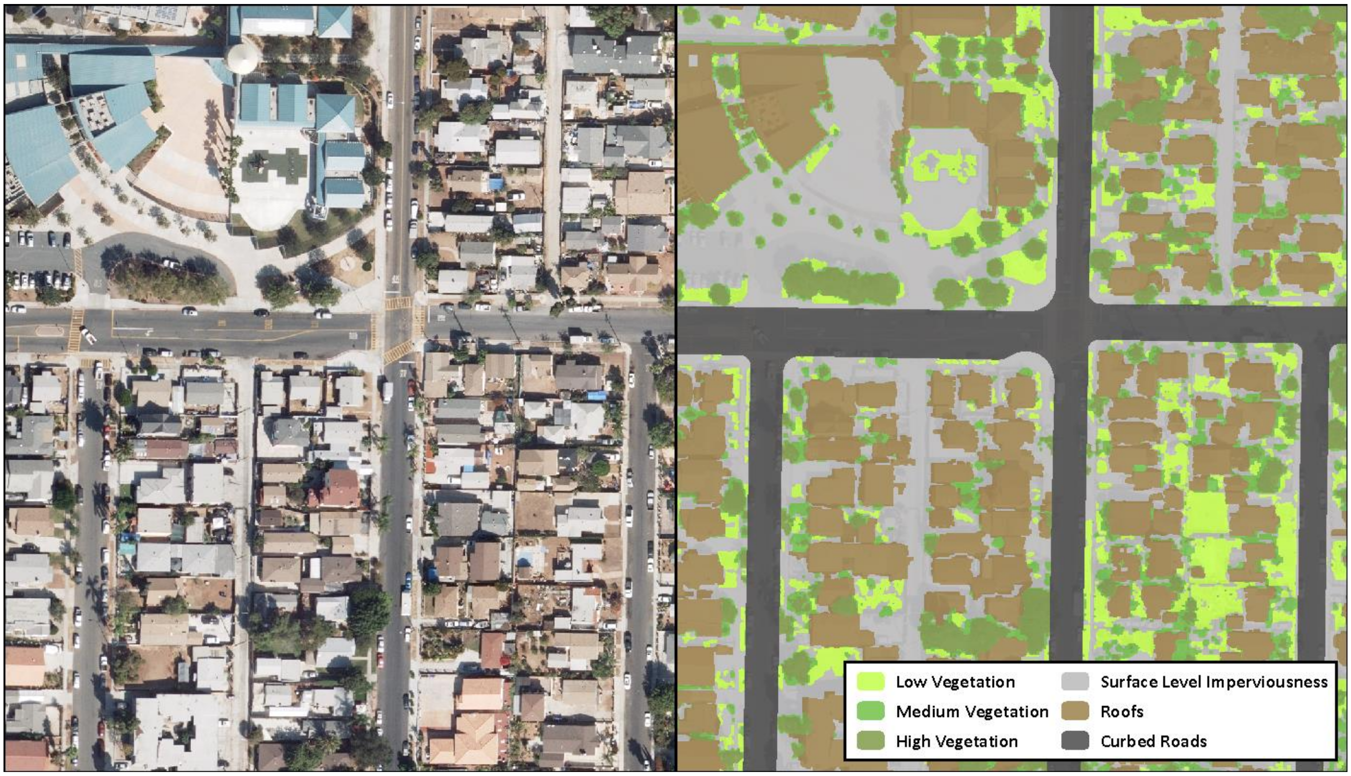

Figure 2-1. Example of surface feature extraction.

Hydrologic Response Unit Development

Hydrologic response units (HRUs) are used to characterize the hydrologic and water quality conditions in the Load Simulation Program in C++ (LSPC) model (see section 3.1). The surface features summarized in Table 2-2 were overlain with the SANDAG 2009 land cover data, Soil Survey Geographic Database (SSURGO) soils data, and 2015 LiDAR data to create a composite index of land cover that was further simplified into the modeled HRU categories (Table 2-3). The high-resolution spatial data obtained as part of this task order allowed for refinement of the HRUs beyond what had been previously assessed in the comprehensive load reduction plan (CLRP) watershed models. Identification of rooftop areas within each developed land use and disconnected impervious areas was extracted to more accurately assign pollutant-generating capacity to different land use categories.

Table 2-3. Modeled HRUs

Model HRU ID	Land Cover	Impervious/Pervious	Slope[a]	Irrigated	Area (acres)
46	Grassland	Pervious	N/A	No	1,220
53	Low-Density Developed Pervious	Pervious	Low	No	2,726
56	High-Density Developed Pervious	Pervious	High	No	2,342
63	Low-Density Developed Pervious	Pervious	Low	Yes	898
66	High-Density Developed Pervious	Pervious	High	Yes	547
83	Disconnected Impervious	Pervious	Low	No	179
86	Disconnected Impervious	Pervious	High	No	67
91	Low-Density Residential	Impervious	Low	No	1,275
92	High-Density Residential	Impervious	High	No	287
93	Institutional/Offices	Impervious	N/A	No	509
94	Commercial	Impervious	n/a	No	360
95	Industrial	Impervious	n/a	No	126
96	Road	Impervious	n/a	No	2,912
97	Freeway	Impervious	n/a	No	482
98	Residential	Impervious	n/a	Yes	41
99	Other Impervious	Impervious	n/a	Yes	103
100	Roof	Impervious	n/a	No	3,311
Chollas Creek Watershed Total					17,385

Note:
[a] High slopes were assigned to land segments with ≥ 10% slopes, while low-slope areas were defined as < 10%.

Catch Basin Drainage Areas

The resolution of the 2014 LiDAR data provided detailed enough elevation information to accurately simulate the flow of water across the landscape at the individual parcel scale. The LiDAR-derived DEM used to delineate the catch basin drainage areas was produced at a resolution of 2 feet per pixel, which provides sufficient information to simulate routing through backyards, across driveways, and along curbed streets.

ArcMap contains a suite of hydrology tools that process the DEM into various layers, including a flow direction raster. The raster can then be combined with the locations of the catch basin inlets—which function as pour points—to calculate all surface drainage upstream of a particular point, resulting in a contiguous, non-overlapping catchment data layer with 3,037 catchments identified. The overall boundary of the Chollas Creek watershed changed from previous modeling efforts (e.g., WQIP and CLRP) to reflect the refined understanding of drainage in the study area as well as the inclusion of areas within the Caltrans ROW that were previously omitted. Staff from both Tetra Tech and Rick Engineering reviewed the catchment areas to ensure accuracy (see Figure 2-2).

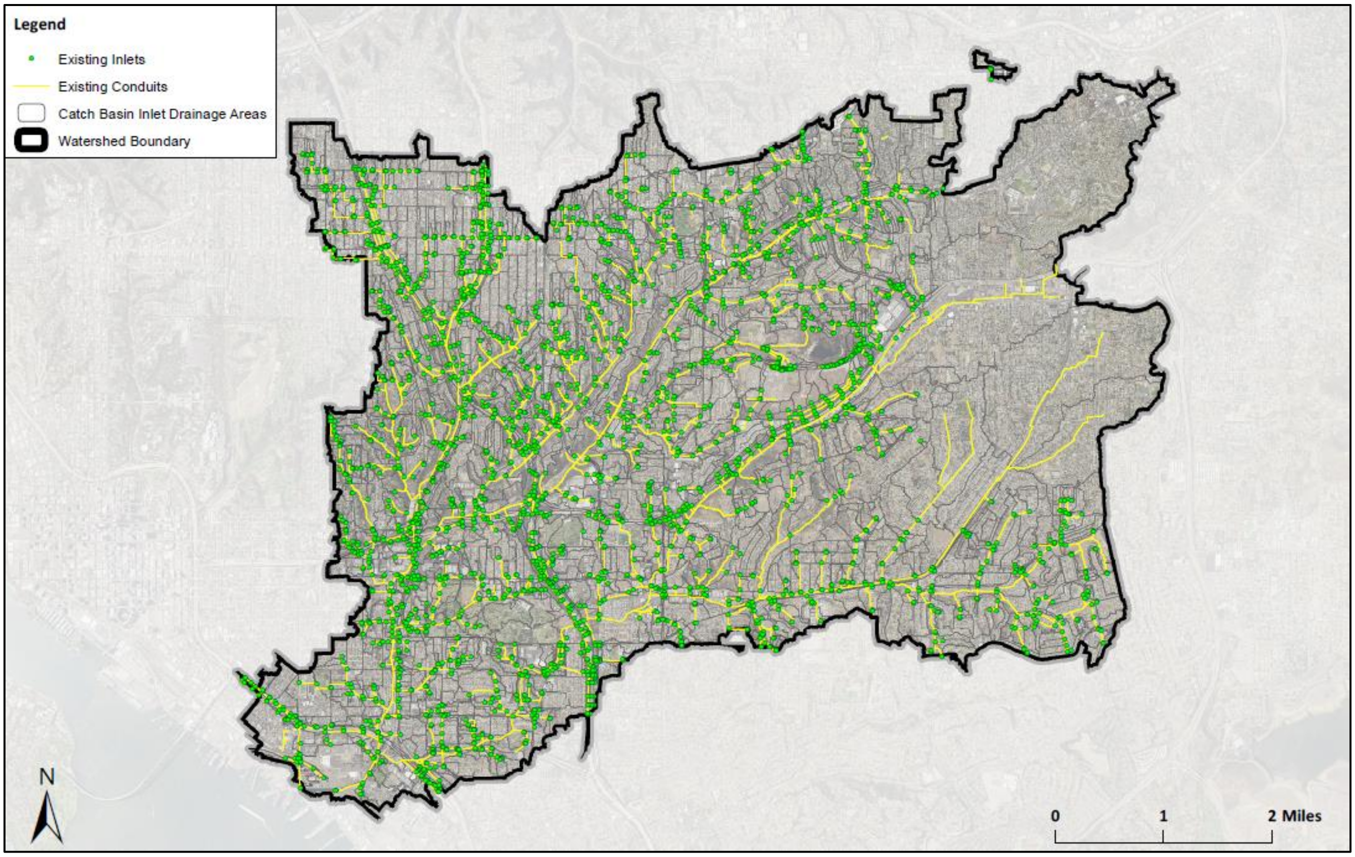

Figure 2-2. Catch basin inlet drainage areas.

GI opportunities

Three different types of GI opportunities were identified as part of the water quality and GI analysis: distributed biofiltration areas, suspended pavement opportunities within the ROW,[1] and regional MUTA opportunities (subsurface and in-canyon).

Using automated algorithms, biofiltration opportunities were identified as "low vegetation" within a 10-ft buffer (estimated ROW) of a curbed road. Those opportunities were further refined by analyzing sidewalk configurations in residential areas: (1) streets with no open space between the sidewalk and road were eliminated; (2) streets with open space between a sidewalk and road had only the open space selected for consideration; and (3) streets with no sidewalks had the entire 10-ft buffer selected for biofiltration. Any identified areas smaller than 50 square feet (sq. ft.) were eliminated. Opportunities located on the same side of the street as a water main or sanitary sewer were also excluded from consideration. The resulting bioretention layer was manually inspected to ensure that only open space was selected.

[1] Suspended pavement uses structural frames to support the weight generated by sidewalks and roadways while providing open void space for runoff storage and treatment underneath. The runoff is treated as it passes beneath the pavement and through an engineered soil media before exiting through infiltration or an underdrain.

Suspended pavement opportunities were automatically identified as roadway segments within a 6-ft internal buffer of curbed roads. The area was further refined to eliminate areas within intersections (60-ft buffer of intersection point), high-sloped street segments (any 50-ft street segment averaging greater than a 5-percent slope), and any segments on the same side of the street as water or sewer mains. Additionally, suspended pavement opportunities located in drainage areas tributary to a downstream MUTA were not explicitly modeled, as sensitivity analyses indicated that the additional water quality benefit of nesting suspended pavement with a MUTA was insignificant when compared to the added costs (see section A.2 in appendix A). Figure 2-3 presents all of the biofiltration and suspended pavement GI opportunities considered as part of the WMP models.

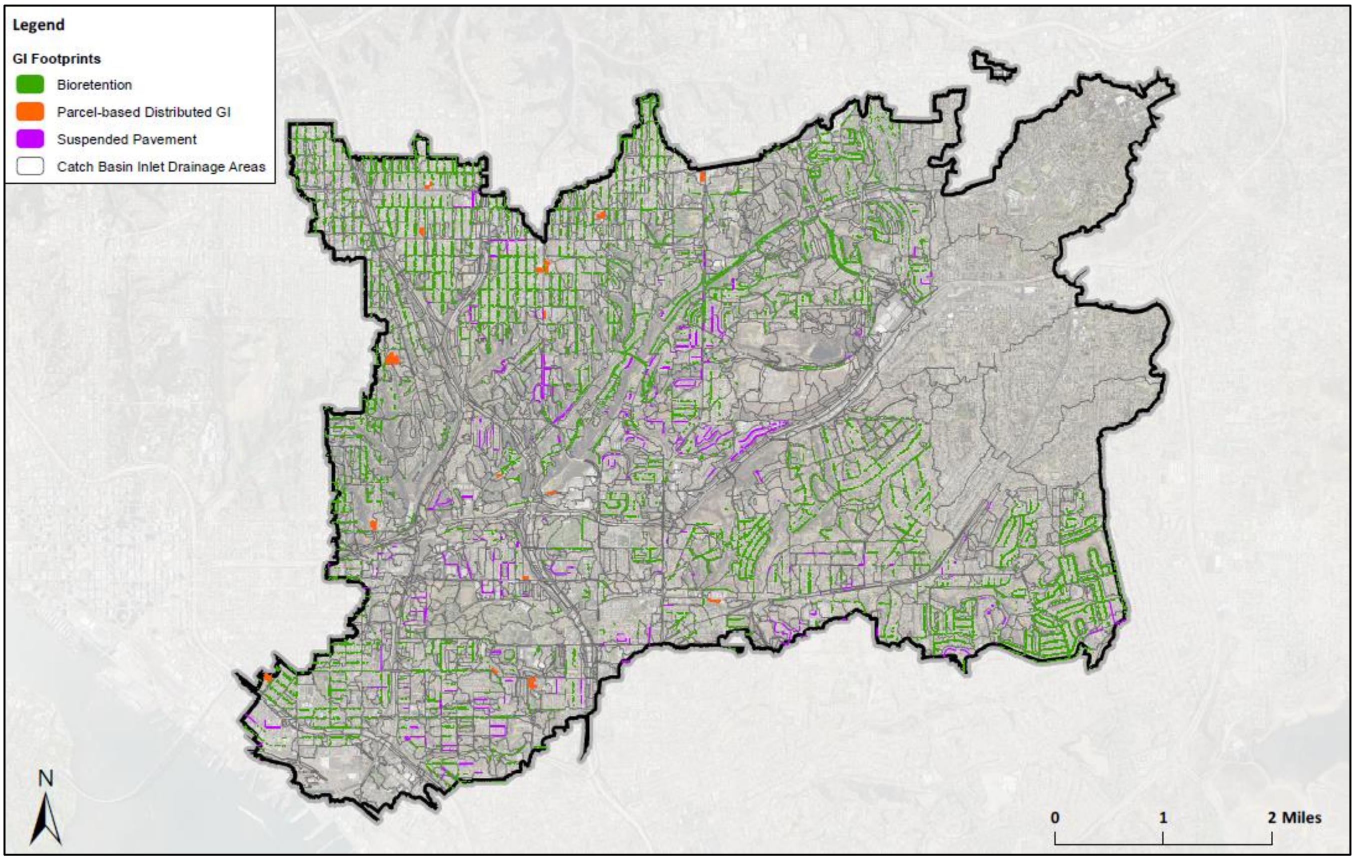

Figure 2-3. Distributed GI opportunities identified.

Regional MUTA (subsurface) opportunities were first identified by using automated detection tools and then manually refining the new features to align exactly over the aerial imagery, focusing on large parking lots/paved surfaces and open green space. Several layers were overlain to assist in collection, including the parcel data (e.g., preference for commercial, industrial, and multifamily residential), elimination of high-slope areas (greater than 10 percent), and exclusion of areas overlaying water mains and sanitary sewers with a 20-ft buffer. Features were drawn to ensure proper boundary spacing and to avoid areas within 10 ft of land cover change such as parking lot edges, building footprints, parcel boundaries, and stands of mature trees.

Regional MUTA (canyon-based) opportunities were identified by manually identifying the outfalls of the MS4 system and evaluating the area immediately downstream. If the MS4 system ended in a tributary canyon offset from the main channel, it was identified as a possible in-canyon opportunity and later evaluated with in-field visits (see section 2.3). If the outfall occurred within close proximity to the primary channels and creeks, the area near the outfalls was not considered for potential in-canyon MUTAs. Figure 2-4 presents all subsurface and canyon-based MUTAs identified and modeled as part of the WMP. Table 2-4 presents a summary of all GI identified, inclusive of both distributed GI and MUTAs.

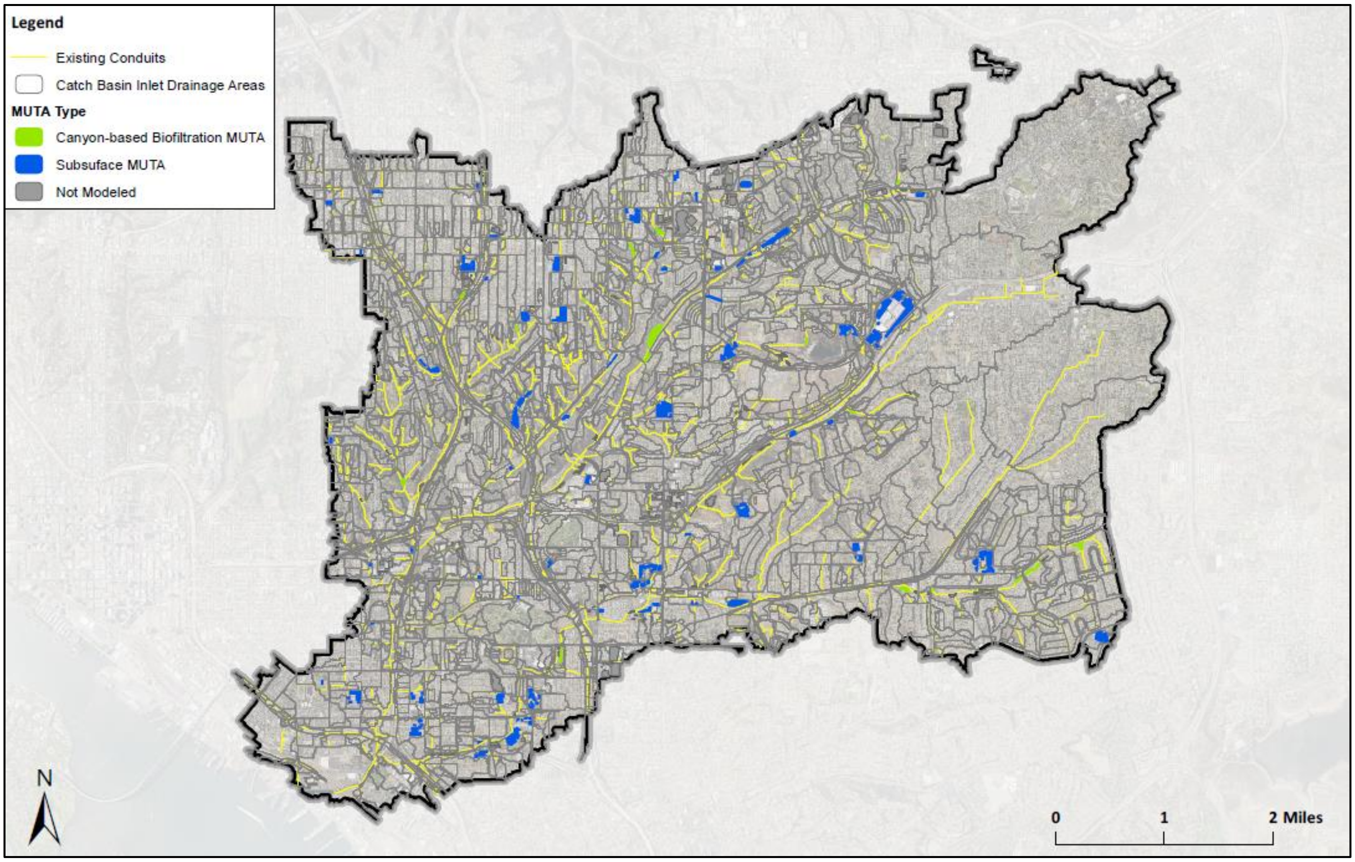

Figure 2-4. MUTA types and opportunities modeled.

Table 2-4. Inventory of structural GI identified

GI Type	Number of GI Opportunities in Study Area
Distributed Biofiltration	13,229
Suspended Pavement	2,484 (368 modeled)[a]
Subsurface Infiltration MUTAs	135 (63 modeled)[b]
Surface Canyon MUTAs	52 (19 modeled)[c]

Notes:
[a] Total number of suspended pavement GI opportunities modeled was reduced to 368 features based on the assumption that suspended pavement would not be implemented where a catch basin was nested with a MUTA.
[b] Total number of MUTAs modeled was reduced to 63 following diversion and feasibility analyses (see section 3.2.2.2).
[c] Total number of canyon-based MUTAs was reduced to 19 following site assessments (section 2.3.2).

GI Drainage Areas

The final step in processing geospatial data for GI characterization was to develop surface drainage areas to each of the individual opportunities. For biofiltration and suspended pavement, the process was the same as for the catch basin delineations: substituting the GI footprints for the catch basin inlets as pour points. Downstream flow routing between GI projects also was developed programmatically using flow accumulation relationships at routing nodes to ensure that, if a particular GI opportunity is not selected, the flow will be routed to the next downgradient opportunity. This approach ensures that no flows are lost in the optimization process and that each GI opportunity is effectively modeled independently at the distributed scale. An example of the delineated drainage areas to distributed GI is presented in Figure 2-5.

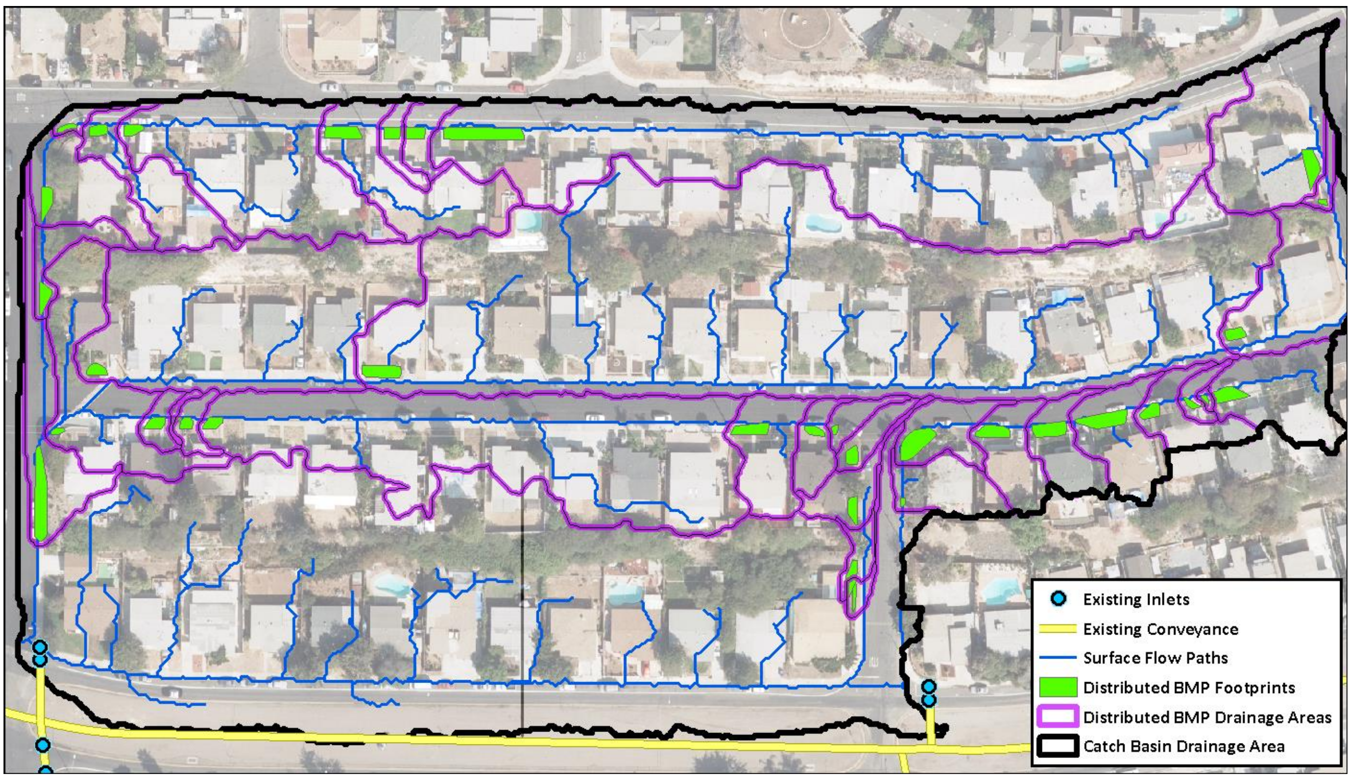

Figure 2-5. Example of distributed GI drainage area delineations.

Compiling the total drainage areas to MUTA opportunities required an additional geoprocessing step that identified the upgradient storm drain network that would drain to the selected MUTA diversion point. All catch basins tributary to the diversion point were identified. Section 3.2 discusses additional assumptions made regarding the effective drainage area to a MUTA diversion point.

2.2 Monitoring Data

This section presents the monitoring data used to calibrate the water quality models (section 2.2.1) and the flood conditions monitoring data used to inform areas of concern based on observations (section 2.2.2).

2.2.1 Water Quality Monitoring Data

The characterization of the existing conditions in the study area was completed by leveraging the hydrology and water quality monitoring data used to calibrate the LSPC models compiled for the Chollas CLRP, San Diego WQIP, and pending bacteria TMDL reopener. This consistency ensures that the same baseline condition is used to assess progress towards water quality-based compliance.

Development of the CLRP watershed models used a regional calibration approach where the primary model hydrology calibration and validation were done for the Los Peñasquitos watershed, which had the only available recent continuous flow monitoring downstream of an urbanized area. As part of the CLRP effort, the calibrated hydrology parameters were then applied to the Chollas Creek watershed, using additional validation data from two Chollas Creek monitoring stations (MAC 11 / SD8(1) and MAC 17 / DPR2 / DPR3), which represent the outlets of the North and South forks of Chollas Creek. These two locations represent the stations furthest downstream for which there are flow data as well as the locations with the most available data. The WMP effort refined the existing CLRP models using newly available Chollas Creek watershed flow monitoring data at MAC 13, MAC 14, and MAC 16 to tailor the hydrology calibration to local conditions, with an emphasis on capturing a good model fit for the watershed outlets for which the majority of monitoring data are available. A summary of the instream flow monitoring data used for the WMP model updates is given in Table 2-5. Additional detail is provided in section A.1 in appendix A.

Table 2-5. Chollas Creek flow monitoring data

Monitoring Station ID	Location	Period of Record
MAC 11 / SD8(1)	North Chollas Creek	02/17/06–04/17/06 10/26/09–01/31/10 09/30/11–01/23/11 10/10/13–02/15/14
MAC 13	North Chollas Creek—North Fork	10/01/09–02/01/10
MAC 14	North Chollas Creek—South Fork	10/26/09–01/31/10
MAC 16	South Chollas Creek—South Fork	10/02/09–01/31/10
MAC 17 / DPR2 / DPR3	South Chollas Creek	02/17/06–05/17/06 10/07/09–01/30/10 09/30/11–11/23/11 10/10/13–02/15/14

In addition to instream monitoring, parcel-level monitoring of storm events and event mean concentrations (EMCs) was conducted in the Chollas Creek watershed and surrounding areas that was intended to capture the water quality conditions resulting in runoff from specific land uses. The land use-based storm water monitoring data were used to verify the upland contributions of metals and sediments for the modeled land covers. A summary of the monitoring locations and the data counts for these sites is presented in Table 2-6. The flow and water quality monitoring stations with geospatial data available are presented in Figure 2-6. Flow calibration results are presented in the water quality and GI modeling appendix (appendix A).

Table 2-6. Parcel-level storm water monitoring (data count)

Station ID	Land Use	Watershed	Start Date	End Date	TSS	TCu	TPb	TZn
CHC07	Commercial	Switzer Creek	12/7/2009	1/18/2010	19	44	44	44
CHC12	Commercial	Chollas Creek	12/7/2009	1/18/2010	20	40	40	40
CHI08	Industrial	Switzer Creek	12/7/2009	1/18/2010	20	44	44	44
CHI09	Industrial	Chollas Creek	12/7/2009	1/18/2010	21	42	42	42
CHI11	Industrial	Chollas Creek	12/7/2009	1/18/2010	18	40	40	40
CHM05	Municipal	San Diego River	12/7/2009	1/18/2010	20	42	42	42
CHR03	Residential	Tecolote Creek	12/7/2009	1/18/2010	20	46	46	46
CHR04	Residential	Tecolote Creek	12/7/2009	1/18/2010	20	40	40	40
CHR06	Residential	San Diego River	12/7/2009	1/18/2010	19	42	42	42
CHR10	Residential	Chollas Creek	12/7/2009	1/18/2010	19	36	36	36

Note: TCu = total copper; TPb = total lead; TSS = total suspended solids; TZn = total zinc.

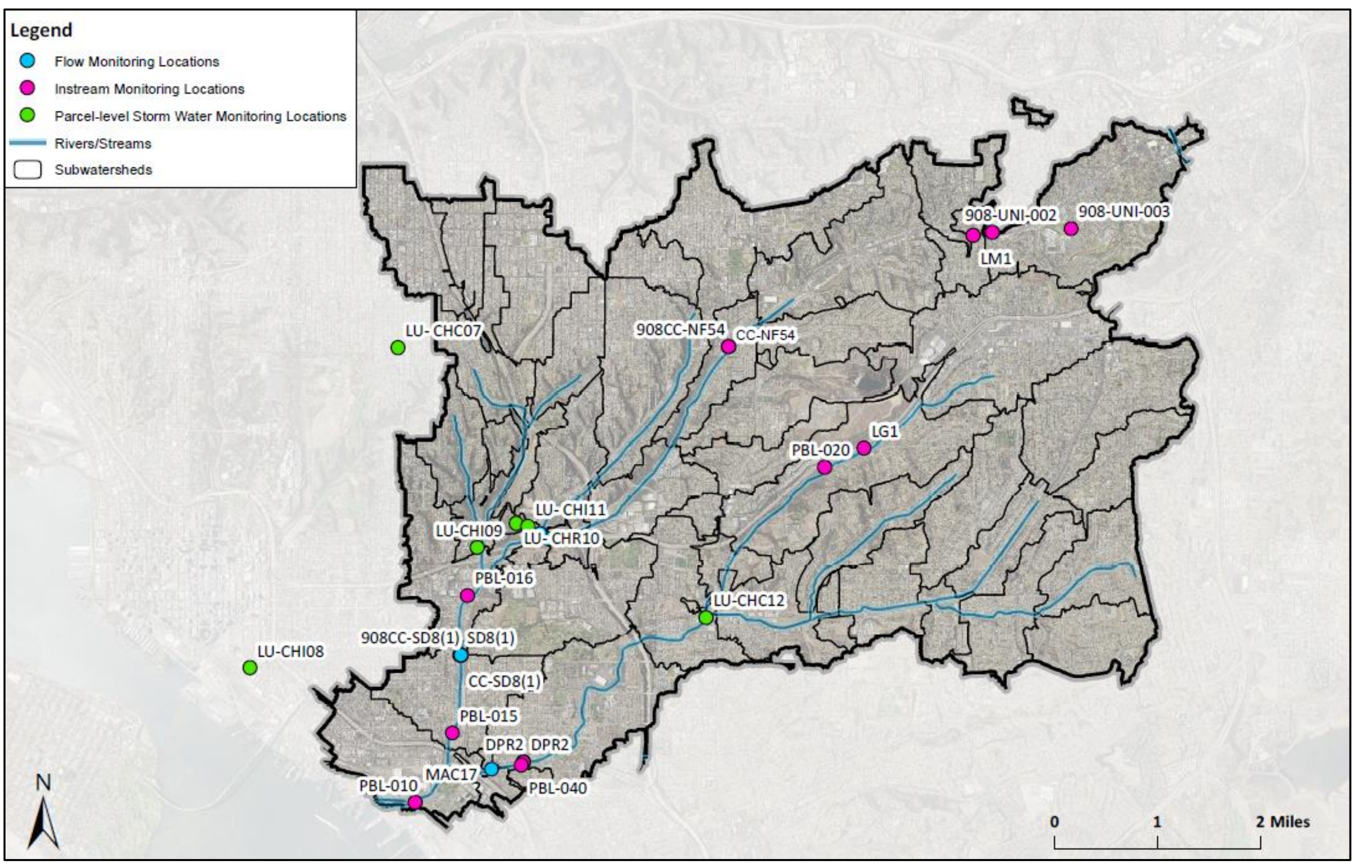

Figure 2-6. Water quality monitoring locations.

2.2.2 Flood Monitoring

A flood complaint record in spreadsheet form was converted into a GIS shapefile using the provided address fields. The reports of flooding were phone complaints from the general public, and it was acknowledged that the information they provided could not be guaranteed to be a completely accurate representation of actual flooding conditions. The GIS shapefile was used as a visual verification tool for the existing condition 2-D models as well as to ensure that any areas with reported flooding complaints were inspected in the existing condition and addressed in the proposed condition models, if needed. The GIS shapefile contained 104 flood complaints dating from 2006 to the present. The flood complaint reports seemed to align with varying consistency with the 2-D model results, which provided a tentative verification of some of the flood complaints mapped in the record.

Along with the flood complaints, it is recommended that stream gages and/or high water marks within the study area be implemented to both validate and calibrate the current as well as any future modeling efforts in the area.

2.2.3 Stream Restoration Existing Data

A thorough review of existing and readily available literature, data, maps, and other information was completed as part of establishing a baseline condition, and identifying potential restoration opportunity areas within the watershed. The literature review included regional planning efforts, such as the City's Multiple Species Conservation Plan (MSCP); existing watershed restoration planning documents, and individual restoration planning documents.

A comprehensive review of watershed data and maps was also completed, including but not limited to U.S. Department of Agriculture (USDA) soils mapping, U.S. Environmental Protection Agency (EPA) My Waters, U.S. Fish and Wildlife Service (USFWS) National Wetland Inventory (NWI), USFWS species records, USFWS Information for Planning and Consultation (IPaC), U.S. Geological Survey (USGS) topographic mapping, California Natural Diversity Database (CNDDB) species records, Calflora What Grows Here application, City Multi-Habitat Planning Area (MHPA), SANDAG vegetation community mapping, SanBIOS species records, San Diego Plant Atlas (SDNHM 2010), recent and historical imagery, and engineering data provided by the project team, among others.

ArcGIS and Google Earth applications were used extensively to evaluate, catalogue, and navigate regional data sets. The review also included data-sharing meetings and correspondence with watershed partners, including Groundwork San Diego, in addition to other consultant team members, including Dudek.

2.3 Field Investigations

The Project Team conducted several field investigations as part of the WMP effort to supplement the geospatial and monitoring data. These assessments included (1) storm drain system inventory verification to assess inlet sizes, inlet location, storm drain diameters, storm drain materials, and drainage patterns;

(2) MUTA opportunity assessment and feasibility analyses; and (3) stream restoration existing conditions and environmental assessments. This section summarizes the additional field assessments that were completed and demonstrates how the information was integrated into the planning process.

2.3.1 Storm Drain Inventory

The existing storm drain inventory was a critical component of the existing H&H model. Updates to the ArcGIS storm drain inventory feature class provided by the City were required to model the existing conditions of each individual subwatershed. Rick Engineering Company and Hoch Consulting performed the inventory updates for the Upper Chollas Creek study area as part of the Phase I WMP efforts. Michael Baker International and Evari GIS Consulting prepared the draft inventory for the Phase II areas of the Chollas Creek watershed. For the entire watershed extent, extensive quality assurance/quality control (QA/QC) was performed by each Project Team firm. Refer to Table 2-7 for a summary of the changes to the original storm drain inventory received from the City. The existing inventory was updated for storm drains that were larger than 18 inches in diameter (or deemed crucial). The inventory was updated to correct several properties such as pipe diameter, material, pipe location and alignment, and invert and rim elevations. The inventory was also updated to add missing drainage structures such as inlets, pipe segments, headwalls, cleanouts, and culverts. It can be observed that several structures and conveyance segments were added to the inventory. Also, it is important to note that an additional category was added to the inventory for "channel confluence" locations for modeling purposes.

Table 2-7. Summary of original and existing (revised) storm drain inventory

Asset Type	Original Data Set	Existing Condition Data Set	Additional Features	Percent Change
Structure				
Spillway	26	19	-7	-27%
Cap	14	5	-9	-64%
Drop Manhole	47	49	2	4%
Energy Dissipater	48	13	-33	-73%
Headwall	370	373	3	1%
Inlet	2219	2599	380	17%
Connector	415	717	302	73%
Cleanout	700	719	19	3%
Outlet	799	649	-150	-19%
Unknown	5	3	-2	-40%
Conveyance				
Ditch (Miles)	1.2	6.7	5.5	464%
Channel (Miles)	19.2	20.7	1.5	8%
Storm Drain Pipe (Miles)	83.9	107.3	36.6	28%
Encased Storm Drain Pipe (Miles)	1.0	0.1	-0.9	-91%
Culvert (Miles)	5.8	5.0	-0.8	-13%

2.3.2 MUTA Opportunity Assessment

Tetra Tech conducted site visits to 58 potential canyon MUTA sites (20 in Phase I and 38 in Phase II) to evaluate the feasibility of implementing GI within tributary canyons outside of the main receiving body of Chollas Creek. Many of the MUTA opportunities are strategically located for capturing large drainage areas and providing substantial water quality benefits; therefore, classifying the actual constructability constraints and maintenance requirements was critical for developing a realistic implementation plan. Specifically, the sites were evaluated for surrounding structural stability, distance from the main stem of the jurisdictional water, and potential utility conflicts.

The structural stability and site access for O&M activities are heavily impacted by the topography of the area surrounding each potential MUTA opportunity. In areas in which steep slopes are prevalent, excessive cuts and fills can decrease the stability of the soil and prevent access by equipment required to construct and maintain the MUTA; therefore, steeply sloped areas were eliminated from consideration.

Construction of water quality GI within the main stem jurisdictional water requires extensive permitting and might be prohibited altogether. The MUTA opportunity field assessments were completed before HELIX Environmental conducted the environmental assessments, so the estimation of the extent of the jurisdictional water boundary was an approximation based on best professional judgement. Therefore, potential MUTA sites were evaluated for their potential structural and water quality impacts to the surrounding area.

The tributary canyons that were assessed are often the lowest point within a specific watershed and naturally act as the ultimate conveyance from the surrounding neighborhoods to the receiving water. Similarly, sewer utilities are often placed within the canyons to capitalize on the natural tendency for water to gravity flow to these areas. Each potential MUTA site was inspected for utility conflicts and the feasibility of siting a MUTA that would not significantly impact or disrupt existing assets.

The MUTA opportunity assessment narrowed the list of potential canyon MUTA opportunities from 58 to 19. The information obtained as part of the site investigations also was incorporated into later refinements of the process for selecting specific canyon MUTA opportunities for modeling and prioritization.

2.3.3 Stream Restoration Existing Data

A thorough review of existing and readily available literature, data, maps, and other information was completed as part of establishing a baseline condition and identifying potential restoration opportunity areas within the watershed. The literature review included regional planning efforts, such as the City's MSCP plan; existing watershed restoration planning documents, and individual restoration planning documents.

A comprehensive review of watershed data and maps was also completed, including but not limited to USDA soils mapping, U.S. Environmental Protection Agency (EPA) My Waters, USFWS NWI, USFWS species records, USFWS IPaC, USGS topographic mapping, CNDDB species records, Calflora What Grows Here application, City MHPA, SANDAG vegetation community mapping, SanBIOS species records, San Diego Plant Atlas (SDNHM 2010), recent and historical imagery, and engineering data provided by the project team, among others.

ArcGIS and Google Earth applications were used extensively to evaluate, catalogue, and navigate regional data sets. The review also included data-sharing meetings and correspondence with watershed partners, including Groundwork San Diego, in addition to other consultant team members, including Dudek.

2.3.3.1 Stream Restoration Opportunity Inventory

Methodology

Methods used to accomplish the initial inventory of potential candidate stream restoration areas for the WMP included a combination of existing information review and field survey components. Section 5.0 discusses methods for stream restoration assessment, and section 6.0 discusses stream prioritization.

Preliminary Identification of Potential Candidate Restoration Sites

For the purposes of this plan, “candidate restoration site” or “site” refers to the study area for each stream restoration candidate, which generally includes the stream and surrounding areas in the immediate vicinity (i.e., generally within 100 feet). A total of 24 sites were preliminarily identified as potential candidate sites for stream restoration based on information gathered during the desktop GIS review. The locations of these sites are depicted on Figure 2-7, with key features described in Table 2-8. Field surveys were conducted subsequent to the desktop review, as described below.

Primary factors considered in the preliminary identification of potential candidate restoration sites included the following:

- Opportunity to provide flood control benefits and eliminate long-term maintenance needs
- Opportunity to convert channel composition from concrete to earthen material
- Presence of nonnative vegetation
- Presence of wetland and riparian vegetation
- Relationship to an MHPA
- Connectivity with any existing conserved lands[2]
- Connectivity with other restoration or mitigation sites
- Watershed size
- Flow volume entering the reach

[2] Conserved lands are defined as areas conserved for the purpose of protecting the open space and natural habitats including lands inside and outside of Natural Community Conservation Planning (NCCP) areas. Conserved lands are those lands that are legal to conserve to protect natural habitats, species, and open space (including agricultural lands that are important components of the regional habitat preserve design), contribute to the existing and planned regional habitat preserve system, and are managed to protect the open space or natural resources in the future (SanGIS 2016).

- Volumetric flow rate (Q) entering the reach
- Accessibility
- Ownership
- Presence of existing utilities or easements

Field Surveys of Potential Candidate Restoration Sites

HELIX Environmental conducted general biological surveys of the 24 potential candidate areas in 2016 and 2017. Surveys targeted areas on and generally within approximately 100 feet of each candidate site. Vegetation was classified in accordance with the City's *Land Development Code–Biology Guidelines* and mapped on a 1 inch = 100-ft-scale aerial image. A minimum mapping unit size of 0.10 acre was used when mapping upland habitat; and 0.01 acre was used when mapping wetland and riparian habitat types. Survey areas were inspected on foot with the aid of binoculars. Representative photographs of each site were taken. Plant and animal species observed or otherwise detected were recorded in field notebooks. Plant identifications were made in the field or in the laboratory through comparison with voucher specimens or photographs. Animal identifications were made in the field by direct visual observation or indirectly by detection of calls, burrows, tracks, or scat. The locations of special status plant and animal species incidentally observed or otherwise detected were mapped.

Preliminary jurisdictional delineations were also conducted for each restoration candidate site to determine baseline jurisdictional limits. The preliminary delineations included evaluation of topographic contour data provided by the Project Team and fieldwork. Areas generally characterized by depressions, drainage features, and riparian and wetland vegetation were evaluated. Although no formal sampling points were established and no soil pits were excavated, the fieldwork component included inspection of ordinary high water mark and bed and bank features. In addition, vegetation, soils, and hydrology were used to aid in determining potential limits of jurisdiction. The delineations were conducted to identify and map potential waters of the United States subject to the regulatory jurisdiction of the USACE pursuant to CWA section 404; waters of the state subject to the regulatory jurisdiction of the RWQCB pursuant to CWA section 401 and Porter-Cologne; streambed and riparian habitat subject to the regulatory jurisdiction of CDFW pursuant to CFG Code section 1600 *et seq*.; City wetlands pursuant to the City's ESL regulations; and coastal wetlands within the Coastal Overlay Zone pursuant to the City's ESL regulations, certified LCP, and California Coastal Act.

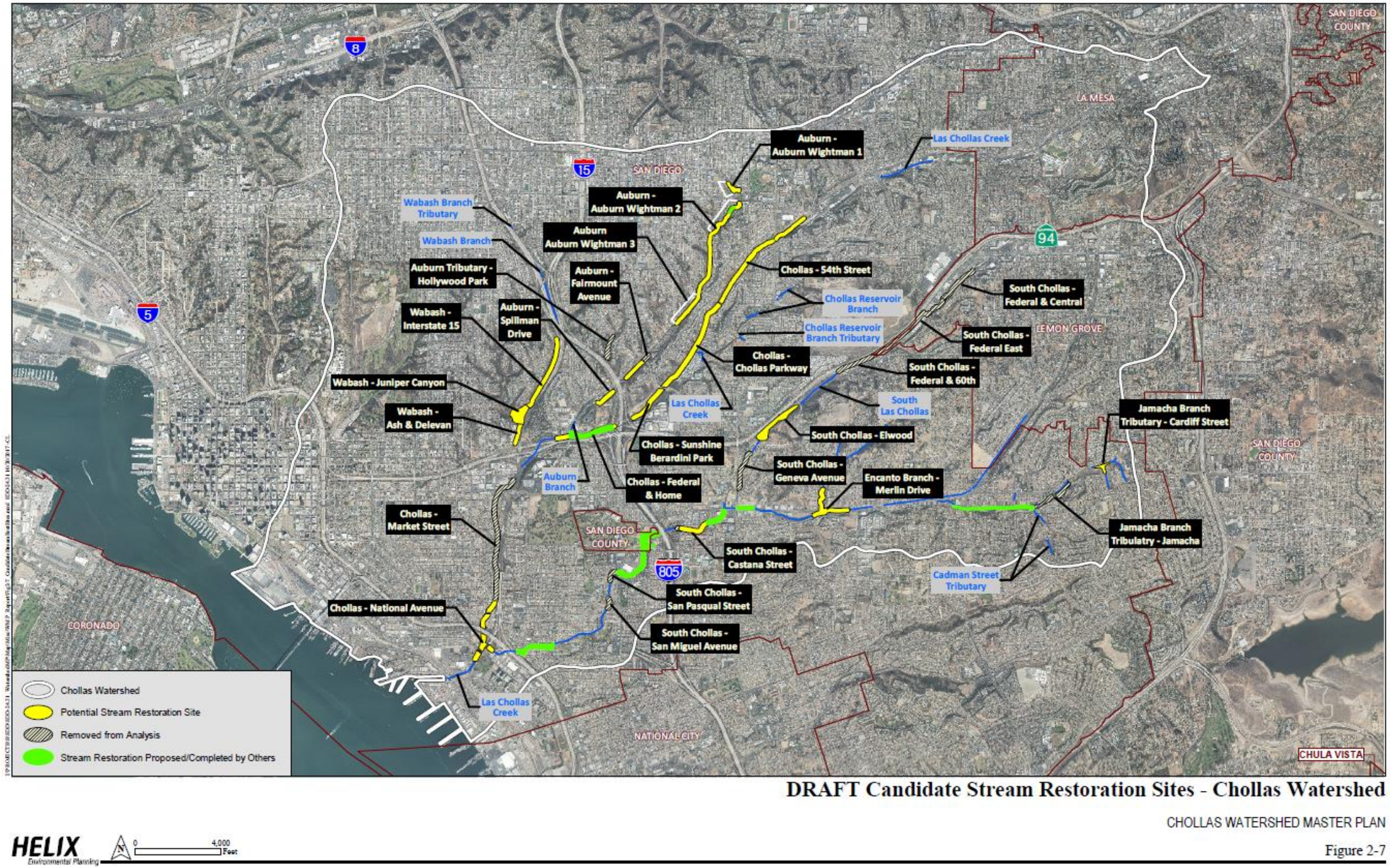

Figure 2-7. Potential candidate restoration sites.

Table 2-8. Existing conditions in potential restoration areas

Site Name	Total Length (LF)	Concrete Bottom (LF)	Earthen Bottom (LF)	Nonnative Vegetation Percentage	Vegetation Communities [1]	Regulatory Agencies	MHPA?	Adjacency with Conserved Land?	Upstream Watershed Area (ac)	Incoming Flow Rate (cfs)	City, Other Public Agency, or Private Ownership?[2]	Utility Conflict?[3]	Available Construction and Maintenance
Auburn - Auburn Wightman 1	505	0	505	100%	AR, DEV, DL, DW, EW, ORN	USACE, RWQCB, CDFW, City	Out	Out	Over 1.0 sq. mi.	0-2,954	Private	Major	Good
Auburn - Auburn Wightman 2	1,733	0	1,733	85%	DCSS, DEV, DL, DW, EW, MFS, NFC, NNG, ORN, SRF, SWS	USACE, RWQCB, CDFW, City	Out	Out	Over 1.0 sq. mi.	0-2,954	Private/City	Major	Good
Auburn - Auburn Wightman 3	1,670	829	841	55%	DCSS, DEV, DL, NFC, ORN, SWS	USACE, RWQCB, CDFW, City	Adj	Out	Over 1.0 sq. mi.	0-2,954	City/ Private	Minor	Good
Auburn - Fairmont Avenue	1,127	692	435	85%	DCSS, DEV, DL, DW, MFS, NFC, NNG, ORN,	USACE, RWQCB, CDFW, City	In	In	Over 1.0 sq. mi.	1,507-1,532	Private	Minor	Poor
Auburn - Spillman Drive	953	0	953	90%	AR, DCSS, DEV, DL, NFC, ORN, SRF	USACE, RWQCB, CDFW, City	Out	Out	Over 1.0 sq. mi.	1,456-1,532	Private	Minor	Moderate
Auburn Tributary - Hollywood Park	1,600	1,600	0	100%	DEV, DL, EW, ORN	N/A	Out	In	0.5 – 1.0 sq. mi.	83-156	City	Major	Good
Chollas - 54th Street	5,485	0	5,485	60%	DCSS, DEV, DL, DW, EW, MFS, NFC, NNG, ORN, SMC, SWS, ORN	USACE, RWQCB, CDFW, City	In	In	Over 1.0 sq. mi.	508–1,532	City	Minor	Good
Chollas - Chollas Parkway	4,747	0	4,747	10%	DCSS, DEV, DL, NFC	USACE, RWQCB, CDFW, City	In	In	Over 1.0 sq. mi.	2,000-2,137	Private/City	Minor	Good
Chollas - Federal & Home	2,759	2,759	0	70%	DCSS, DEV, DL, DW, FWM, NNG, ORN, SRF, SWS	USACE, RWQCB, CDFW, City	Out	Out	Over 1.0 sq. mi.	4,321-4,325	Public	Minor	Good
Chollas - Market Street	5,991	5,177	814	95%	AR, DCSS, DEV, DL, EW, NFC, NNG, ORN, SMC, SRW	USACE, RWQCB, CDFW, City	Out	Out	Over 1.0 sq. mi.	2,335-4,436	Private	Major	Good
Chollas - National Avenue	3,149	1,211	1,938	95%	AR, CMS, DEV, DL, FWM, NFC, NNG	USACE, RWQCB, CDFW, City	Out	Out	Over 1.0 sq. mi.	1,950-4,929	City/Public	Major	Good
Chollas - Sunshine Berardini Park	1,959	230	1,729	45%	DCSS, DEV, DL, EW, MFS, NFC, NNG, ORN, SRF, SWS	USACE, RWQCB, CDFW, City	In	In	Over 1.0 sq. mi.	2,857-2,987	City	Moderate	Good
Encanto Branch - Merlin Drive	2,758	803	1,954	85%	AR, DCSS, DEV, DL, FWM, MFS, NFC, NNG, ORN, SWS	USACE, RWQCB, CDFW, City	In	In	Over 1.0 sq. mi.	490-2,597	Private/City	Major	Good
Jamacha Branch Tributary - Cardiff Street	1,177	0	1,177	100%	DEV, DL, NNG, ORN	USACE, RWQCB, CDFW, City	Out	In	0.5 – 1.0 sq. mi.	150	City	Major	Good
Jamacha Branch Tributary - Jamacha	2,350	0	2,350	85%	AR, DEV, DL, FWM, NNG, ORN, SMC	USACE, RWQCB, CDFW, City	Out	Out	Over 1.0 sq. mi.	270-347	City/ Private	Major	Good
South Chollas - Castana Street	1,595	0	1,595	90%	AR, DCSS, DEV, FWM, MFS, NFC, ORN, SWS	USACE, RWQCB, CDFW, City	Out	Out	Over 1.0 sq. mi.	3742-3870	City	Minor	Good
South Chollas - Elwood Avenue	2,451	0	2,451	30%	DW, DCSS, FWM, NFC, ORN, SWS	USACE, RWQCB, CDFW, City	In	In	Over 1.0 sq. mi.	993	City	Moderate	Moderate

Site Name	Total Length (LF)	Concrete Bottom (LF)	Earthen Bottom (LF)	Nonnative Vegetation Percentage	Vegetation Communities [1]	Regulatory Agencies	MHPA?	Adjacency with Conserved Land?	Upstream Watershed Area (ac)	Incoming Flow Rate (cfs)	City, Other Public Agency, or Private Ownership? [2]	Utility Conflict? [3]	Available Construction and Maintenance [4]
South Chollas - Federal & 60th	1,913	1,283	630	100%	AR, DCSS, DEV, DL, DW, FWM, NNG, ORN	USACE, RWQCB, CDFW	Adj	Adj	Over 1.0 sq. mi.	480-1,220	Private	Minor	Poor
South Chollas - Federal & Central	1,937	37	1,900	100%	AR, DEV, DL, DW, EW, NFC, ORN	USACE, RWQCB, CDFW, City	Out	Out	Over 1.0 sq. mi.	480-1,220	Private	Minor	Good
South Chollas - Federal East	2,975	0	2,975	100%	DCSS, DEV, DL, FWM, NNG, ORN	USACE, RWQCB, CDFW	Adj	Adj	Over 1.0 sq. mi.	480-1,220	Private	Moderate	Poor
South Chollas - Geneva Avenue	1,786	1,786	0	95%	DCSS, DEV, DL, ORN, NNG	USACE, RWQCB, CDFW	Out	Out	Over 1.0 sq. mi.	834-1,026	Private	Major	Moderate
South Chollas - San Miguel Avenue	696	188	509	100%	DEV, DL, DW, ORN	USACE, RWQCB, CDFW	Out	Out	Over 1.0 sq. mi.	3,725-3,831	Private/City	Minor	Good
South Chollas - San Pasqual Street	853	614	2390	95%	DCSS, DEV, DL, DW, NFC, NNG	USACE, RWQCB, CDFW, City	Out	Out	Over 1.0 sq. mi.	3,488-3,846	Private/City	Minor	Good
Wabash - Ash & Delevan	952	0	952	75%	DCSS, DEV, DL, NFC, NNG, ORN	USACE, RWQCB, CDFW	Adj	Adj	Over 1.0 sq. mi.	2,147-2,312	Private	Moderate	Good
Wabash - Interstate 15	3,553	0	3,553	80%	DCSS, DEV, DL, EW, NNG, ORN, MFS, NFC, NNG, SMC, SWS	USACE, RWQCB, CDFW, City	In	In	Over 1.0 sq. mi.	2,171-2,506	Private/City	Major	Moderate
Wabash - Juniper Canyon	982	0	982	5%	DCSS, DEV, DL, MFS, NFC, ORN	USACE, RWQCB, CDFW, City	In	In	Over 1.0 sq. mi.	2,171-2,506	City	Moderate	Moderate

Notes:
[1] AR=Disturbed Wetland–Arundo Dominated, CSM=Coastal Salt Marsh, DCSS=Diegan Coastal Sage Scrub, DEV=Developed, DL=Disturbed Land, DW=Disturbed Wetland, EW=Eucalyptus Woodland, FWM=Freshwater Marsh, MFS=Mulefat Scrub, NFC=Natural Flood Channel NNG=Nonnative Grass, ORN=Ornamental Vegetation, SMC=Southern Mixed Chaparral, SRF=Southern Riparian Forest, SRW=Southern Riparian Woodland, SWS=Southern Willow Scrub.
[2] City = lands owned by the City of San Diego, Private = lands owned by private entities, Public = lands owned by other federal, state, or local agency or government other than the City of San Diego
[3] Major = Easements cross more than 5 times or reduce restoration acreage by more than 20%; Minor = Easements cross 0-2 times or reduce restoration acreage by less than 10%; Moderate = Easements cross 3-5 times or reduce restoration acreage by 10-20%.
[4] Good = 75% of adjacent upland directly accessible; Moderate = 25% of adjacent upland directly accessible; Poor = 25% or less of adjacent upland directly accessible.

Screening of Potential Candidate Restoration Sites for Prioritization

Once surveys were completed, the team evaluated the field data along with the information gathered during the desktop review to complete a rough screening of the candidate sites. Each site was screened based on the best available desktop and field data given the scope of the effort. In most cases, the field survey data revealed additional opportunities and constraints associated with the candidate site such as the presence of nonnative vegetation, riparian, or wetland habitat where it was not readily apparent based on review of aerial imagery alone; the presence of unsuitable soil and substrate conditions; or an additional utility easement that was not known before. In some cases, it was determined during the initial screening process that all or portions of a candidate site were already subject to restoration efforts, whether as a previously completed restoration site, a project currently undergoing entitlement and permitting, or an already planned project. In other cases, it was determined that stream restoration was infeasible because of the necessity to retain existing flood functions or existing land-use constraints hindering the ability to widen a stream reach. These sites were eliminated from further analysis.

Overview of Baseline Conditions at Candidate Restoration Sites

An inventory of baseline conditions was gathered for each potential candidate restoration site based on the desktop review and field surveys (see Table 2-8). This discussion provides a general overview of the existing conditions for each of the 24 candidate sites initially screened for restoration potential. In general, sites were named according to their affiliated named stream and nearest cross street. The sites are discussed and presented in Table 2-8 in alphabetical order by affiliated stream.

Auburn-Auburn Wightman 1

The Auburn–Auburn Wightman 1 site is an approximately 505-LF site composed of one reach of Auburn Creek, also referred to as the "Home Avenue Branch," which is a tributary of Chollas Creek within watersheds with ID 4703. The existing channel is composed of entirely earthen segments that run parallel with Oakcrest Drive. Steep slopes occur to the west. The channel is generally surrounded by residential development.

The site is located within City-owned and private parcels and no portion of the site is within or adjacent to MHPA or existing conserved lands. The site is supported by a watershed area over 1 square mile (sq. mi.) in size, and the existing flow rates are estimated at 0 to 2,954 cubic feet per second (cfs). Existing vegetation communities include disturbed wetland - arundo-dominated (AR), developed (DEV), disturbed land (DL), disturbed wetland (DW), eucalyptus woodland (EW), and ornamental (ORN). All of the vegetation (100 percent) is nonnative. DW, including AR, is a City wetland ESL habitat type. Pure stands of arundo are present in portions of the reach. Existing jurisdictional waters and wetlands include 0.10 acre of USACE/RWQCB-jurisdictional waters of the United States/state, 0.39 acre of CDFW-jurisdictional riparian and/or streambed, and 0.39 acre of City wetlands.

Auburn-Auburn Wightman 2

The Auburn–Auburn Wightman 2 site is an approximately 1,733-LF site composed of seven separate reaches of Auburn Creek, also referred to as the "Home Avenue Branch," which is a tributary of Chollas Creek within watersheds with IDs 4703 and 4705. The existing channel is composed of entirely earthen segments with portions that run underground and between University Avenue and Auburn Drive. Steep slopes occur to the west. The channel is generally surrounded by residential development.

The site is primarily located within private parcels and no portion of the site is within or adjacent to MHPA or existing conserved lands. The site is supported by a watershed area over 1 square mile (sq. mi.) in size, and the existing flow rates are estimated at 0 to 2,954 cubic feet per second (cfs). Existing vegetation communities include Diegan coastal sage scrub (DCSS), DEV, DL, DW, EW, mulefat scrub (MFS), natural flood channel (NFC), nonnative grassland (NNG), ORN, southern riparian forest (SRF), and southern willow scrub (SWS). The majority of the vegetation (85 percent) is nonnative. DCSS is a Tier II upland ESL habitat type, and NNG is a Tier IIIB upland ESL habitat type. DW, MFS, NFC, SRF, and SWS are City wetland ESL habitat types. Existing jurisdictional waters and wetlands include 0.52 acre of USACE/RWQCB-jurisdictional waters of the United States/state, 1.68 acres of CDFW-jurisdictional riparian and/or streambed, and 1.16 acres of City wetlands.

Auburn-Auburn Wightman 3

The Auburn–Auburn Wightman 3 site is an approximately 1,670-LF site composed of three separate reaches of Auburn Creek, also referred to as the "Home Avenue Branch," which is a tributary of Chollas Creek within watersheds with ID 4705. The existing channel is composed of entirely concrete-lined segments that run parallel with Home Avenue. Steep slopes occur to the east. The channel is generally surrounded by residential development, with non-contiguous remnants of native habitat on canyon slopes.

The site is primarily located within private parcels and adjacent to MHPAs. The site is supported by a watershed area over 1 square mile (sq. mi.) in size, and the existing flow rates are estimated at 0 to 2,954 cubic feet per second (cfs). Existing vegetation communities include DCSS, DEV, DL, NFC, ORN, and SWS. The majority of the vegetation (55 percent) is nonnative. DCSS is a Tier II upland ESL habitat type. NFC and SWS are City wetland ESL habitat types. Existing jurisdictional waters and wetlands include 0.60 acre of USACE/RWQCB-jurisdictional waters of the United States/state, 1.66 acres of CDFW-jurisdictional riparian and/or streambed, and 1.56 acres of City wetlands.

Auburn-Fairmont Avenue

The Auburn-Fairmont Avenue site is an approximately 1,364-LF site composed of two separate reaches of Auburn Creek within watershed ID 4703. The existing channel is a combination of earthen and concrete-lined segments that run parallel to Home Avenue. A steep slope is located southeast of the channel with residential development at the top of the slope. Commercial development is adjacent to the channel in the northwest.

The site is located within private parcels. Portions of the site are within MHPAs and adjacent to existing conserved lands, specifically, portions of the slope on the south side of the channel. The site is supported by a watershed area over 1 sq. mi. in size and the existing flow rates are estimated at 1,507 to 1,532 cfs. Existing vegetation communities include DCSS, DEV, DL, DW, MFS, NFC, NNG, and ORN. The majority of the vegetation (85 percent) is nonnative. DCSS is a Tier II upland ESL habitat type, and NNG is a sensitive Tier IIIB upland ESL habitat type. DW, MFS, and NFC are City wetland ESL habitat types. Existing jurisdictional waters and wetlands include 0.37 acre of USACE/RWQCB-jurisdictional waters of the United States /state, 0.91 acres of CDFW-jurisdictional riparian and/or streambed, and 0.69 acre of City wetlands.

Auburn-Spillman Drive

The Auburn-Spillman Drive site is an approximately 953-LF site composed of two separate reaches of Auburn Creek within watershed ID 4702. The existing channel is an entirely earthen segment that runs parallel to Home Avenue between Spillman Drive and Interstate 805. The channel is surrounded by residential and commercial development. There is a steep slope, consisting of primarily nonnative vegetation and coastal sage scrub to the south.

The site is located within private parcels and no portion of the site is within or adjacent to MHPA or existing conserved lands. The site is supported by a watershed area over 1 sq. mi. in size, and the existing flow rates are estimated at 1,456 to 1,532 cfs. Existing vegetation communities include AR, DCSS, DEV, DL, NFC, ORN, and SRF. The majority of the vegetation (90 percent) is nonnative. DCSS is a Tier II upland ESL habitat type. NFC and SRF are City wetland ESL habitat type. Existing jurisdictional waters and wetlands include 0.83 acre of USACE/RWQCB-jurisdictional waters of the United States /state, 1.76 acres of CDFW-jurisdictional riparian and/or streambed, and 0.83 acre of City wetlands.

Auburn Tributary–Hollywood Park

The Auburn Tributary–Hollywood Park site is an approximately 1,600-LF site composed of a single reach of Auburn Creek within watershed ID 4702. The existing channel is composed entirely of a concrete underground pipe that runs under Hollywood Park off Juniper Street. The site consists of a small developed park completely surrounded by residential development.

The site is primarily located within City-owned parcels and no portion of the site is within or adjacent to MHPA or existing conserved lands. The site is supported by a watershed area between 0.5 and 1.0 sq. mi. in size, and the existing flow rates are estimated at 83 to 156 cfs. Existing vegetation communities include DEV, DL, EW, and ORN. All of the vegetation (100 percent) is nonnative. There are no Tier I-IIIB upland or City wetland ESL habitat types or existing jurisdictional waters or wetlands. This site was eliminated from further consideration as detailed below.

Chollas-54th Street

The Chollas-54th Street site is an approximately 5,485-LF site composed of 10 separate reaches of Chollas Creek within watershed IDs 4802 and 4803. The existing channel is composed entirely of earthen segments that run parallel to Chollas Parkway and is transected by 54th Street. The channel is surrounded by residential development, but portions abut upland open space areas.

The site is located within primarily City owned parcels within MHPA and existing conserved lands. The site is supported by a watershed area over one square mile in size and the existing flow rates are estimated at 508 to 1,532 cfs. Existing vegetation communities include DCSS, DEV, DL, DW, EW, MFS, NFC, NNG, ORN, southern mixed chaparral (SMC), and SWS. The majority (85 percent) of vegetation is composed of non-native vegetation. DCSS is a Tier II upland, SMC is a Tier IIIA upland, and NNG is a Tier IIIB upland ESL habitat type. DW, MFS, NFC, and SWS are City Wetland ESL habitat types. Existing jurisdictional waters and wetlands include 3.12 acres of USACE/RWQCB-jurisdictional waters of the U.S./State, 7.32 acres of CDFW-jurisdictional riparian and/or streambed, and 5.08 acres of City Wetlands.

Chollas-Chollas Parkway

The Chollas-Chollas Parkway site is an approximately 4,747-LF site composed of four separate reaches of Chollas Creek within watersheds with IDs 4801 and 4802. The existing channel is composed entirely of earthen segments that run parallel to Chollas Parkway between Euclid Avenue and Fairmont Avenue. The channel is bordered by a narrow strip of coastal sage scrub on both sides with a large open space at the southern end.

The site is located within private and City-owned parcels within MHPA and existing conserved lands. The site is supported by a watershed area over one square mile in size and the existing flow rates are estimated at 2,000 to 2,137 cfs. Existing vegetation communities include DCSS, DEV, DL, and NFC. The majority (90 percent) of vegetation is composed of native vegetation, only 10 percent is non-native. DCSS is a Tier II upland ESL habitat type. NFC is a City Wetland ESL habitat types. Existing jurisdictional waters and wetlands include 2.14 acres of USACE/RWQCB-jurisdictional waters of the U.S./State, 6.30 acres of CDFW-jurisdictional riparian and/or streambed, and 1.84 acres of City Wetlands.

Chollas-Federal & Home

The Chollas - Federal & Home site is an approximately 2,759-linear-foot site composed of six separate reaches of Chollas Creek within watershed IDs 4701 and 4801. The existing channel is composed entirely of concrete-lined segments that run parallel to Federal Boulevard to the north and State Route (SR) 94 to the south from Home Avenue to Interstate 805. The southern end of the channel is located at the base of a steep slope. The channel is surrounded by a road and commercial development to the north, and SR 94 and a strip of non-native vegetation to the south.

The site is located within public parcels (City and Caltrans) ROW and no portion of the site is within or adjacent to MHPA or existing conserved lands. The site is supported by a watershed area over one square mile in size and the existing flow rates are estimated at 4,321 to 4,325 cfs. Existing vegetation communities include DEV, DL, NNG, and ORN. Areas mapped as DEV include the existing concrete-lined channel. The majority (70 percent) of vegetation, where present, is composed of non-native vegetation. NNG is a Tier IIIB upland ESL habitat type. Although concrete-lined channel is present, there are no City Wetland ESL habitat types, as defined in Tables 2A and 2B of the City's Biology Guidelines. Existing jurisdictional waters and wetlands include 2.18 acres of USACE/RWQCB-jurisdictional waters of the U.S./State, 3.54 acres of CDFW-jurisdictional riparian and/or streambed, and 3.08 acres of concrete-lined channel.

Chollas-Market Street

The Chollas-Market Street site is an approximately 5,991-LF site composed of seven separate reaches of Chollas Creek within watersheds with IDs 4501 and 4502. The existing channel is primarily concrete-lined segments; however, the northern and southern ends are earthen. The channel runs parallel to Interstate 15 from Market Street to Logan Avenue. Residential development is located to the west, while Interstate 15 is located to the east, with commercial/industrial at the north end of the channel segment.

The site is located within private parcels and no portion of the site is within or adjacent to MHPA or existing conserved lands. The site is supported by a watershed area over one square mile in size and the existing flow rates are estimated at 2,335 to 4,436 cfs. Existing vegetation communities include AR, DCSS, DEV, DL, EW, NFC, NNG, ORN, SMC, and southern riparian woodland (SRW). The majority (95 percent) of vegetation is composed of non-native vegetation. DCSS is a Tier II upland, SMC is a Tier IIIA upland, and NNG is a Tier IIIB upland ESL habitat type. NFC and SRW are City Wetland ESL habitat types. Existing jurisdictional waters and wetlands include 3.52 acres of USACE/RWQCB-jurisdictional waters of the U.S./State, 8.26 acres of CDFW-jurisdictional riparian and/or streambed, and 0.40 acre of City Wetland habitat type. This site was eliminated from further consideration as detailed below.

Chollas-National Avenue

The Chollas-National Avenue site is an approximately 3,149-LF site composed of seven separate reaches of an unnamed tributary to Chollas Creek within watersheds with IDs 4401, 4501, and 4901. The existing channel is a combination of earthen and concrete-lined segments that run parallel to Interstate 15 and Wabash Boulevard from Logan Avenue to Main Street. The channel is surrounded by commercial and industrial development.

The site is located within private and City-owned parcels and no portion of the site is within or adjacent to MHPA or existing conserved lands. The site is supported by a watershed area over one square mile in size and the existing flow rates are estimated at 1,950 to 4,929 cfs. Existing vegetation communities include AR, Coastal Salt Marsh (CMS), DEV, DL, FWM, NFC, and NNG. The majority (95 percent) of vegetation is composed of non-native vegetation. NNG is a Tier IIIB upland ESL habitat type. CMS, FWM, and NFC are City Wetland ESL habitat types. Existing jurisdictional waters and wetlands include 3.02 acres of USACE/RWQCB-jurisdictional waters of the U.S./State, 5.63 acres of CDFW-jurisdictional riparian and/or streambed, and 4.39 acres of City Wetlands.

Chollas-Sunshine Berardini Park

The Sunshine Berardini Park site is an approximately 1,128-linear-foot site composed of three reaches of Chollas Creek within watershed ID 4801. The existing channel is primarily earthen with a small section of concrete-lined channel at the downstream end between Fairmont Avenue and Federal Boulevard east of Interstate 805. Baseball fields and park uses are located immediately adjacent to the northwest of the downstream reaches. Open space, consisting primarily of Tier II DCSS, is located south of the channel through its entirety and on either side of the channel in the upstream reaches.

The site is primarily City owned and the majority is located within MHPA and existing conserved lands. The site is supported by a watershed area over one square mile in size and the existing flow rates are estimated at 2,857 to 2,987 cfs. Existing vegetation communities include DCSS, DEV, DL, EW, MFS, NFC, NNG, ORN, SRF, and SWS. The majority (95 percent) of the vegetation is composed of native vegetation; only approximately 10 percent is non-native. DCSS is a Tier II upland and NNG is a Tier IIIB upland ESL habitat type. MFS, NFC SRF, and SWS are City Wetland ESL habitat types. Existing jurisdictional waters and wetlands include 1.16 acre of USACE/RWQCB-jurisdictional waters of the U.S./State, 2.64 acres of CDFW-jurisdictional riparian and/or streambed, and 1.37 acres of City Wetlands.

Encanto Branch-Merlin Drive

The Encanto Branch-Merlin Drive site is an approximately 2,758-LF site composed of seven separate reaches of an unnamed tributary to South Chollas Creek within watersheds with IDs 4907, 4908, and 4909. The existing channel is a combination of earthen and concrete-lined segments that run parallel to Imperial Avenue and Radio Drive. The channel is surrounded by residential development, but the north end is adjacent to native habitat.

The site is located within private and City-owned parcels. Portions of the site are within MHPA and adjacent to existing conserved lands. The site is supported by a watershed area over one square mile in size and the existing flow rates are estimated at 490 to 2,597 cfs. Existing vegetation communities include AR, DCSS, DEV, DL, FWM, MFS, NFC, NNG, ORN, and SWS. The majority (85 percent) of vegetation is composed of non-native vegetation. DCSS is a Tier II upland and NNG is a Tier IIIB upland ESL habitat type. FWM, MFS, NFC, and SWS are City Wetland ESL habitat types. Existing jurisdictional waters and wetlands include 1.48 acres of USACE/RWQCB-jurisdictional waters of the U.S./State, 4.01 acres of CDFW-jurisdictional riparian and/or streambed, and 1.99 acres of City Wetlands.

Jamacha Branch Tributary-Cardiff Street

The Jamacha Branch Tributary-Cardiff Street site is an approximately 1,177-LF site composed of one reach of an unnamed tributary to South Chollas Creek within watershed ID 4917. The existing channel is an entirely earthen segment that runs parallel to Jamacha Road. The channel is surrounded by residential development to the north, but the southern half is open to nonnative vegetation.

The site is located within City-owned parcels and adjacent to MHPA. The site is supported by a watershed area of 0.5 to 1.0 square mile in size and the existing flow rates are estimated at 150 cfs. Existing vegetation communities include DEV, DL, NNG, and ORN. All (100 percent) of vegetation is composed of non-native vegetation. NNG is a Tier IIIB upland ESL habitat type. Existing jurisdictional waters and wetlands include 0.26 acre of USACE/RWQCB-jurisdictional waters of the U.S./State and 0.56 acres of CDFW-jurisdictional riparian and/or streambed. No City wetland habitat types occur within the site study area.

Jamacha Branch Tributary-Jamacha

The Jamacha Branch Tributary-Jamacha and Meadowbrook site is an approximately 2,350-LF site composed of one reach of an unnamed tributary to South Chollas Creek within watershed ID 4917. The existing channel is entirely composed of an earthen segment that runs parallel to Jamacha Road and is bisected by Meadowbrook Drive. The channel abuts residential development to the north with open, nonnative habitat to the south.

The site is located within private and public parcels and no portion of the site is within or adjacent to MHPA or existing conserved lands. The site is supported by a watershed area over one square mile in size and the existing flow rates are estimated at 270 to 347 cfs. Existing vegetation communities include AR, DEV, DL, FWM, NNG, ORN, and SMC. The majority (85 percent) of vegetation is composed of non-native vegetation. NNG is a Tier IIIB upland and SMC is a Tier IIIA upland ESL habitat type. FWM is a City Wetland ESL habitat types. Existing jurisdictional waters and wetlands include 0.37 acre of USACE/RWQCB-jurisdictional waters of the U.S./State, 0.97 acre of CDFW-jurisdictional riparian and/or streambed, and 0.20 acre of City Wetlands. This site was eliminated from further consideration as detailed below.

South Chollas-Castana Street

The South Chollas-Castana Street site is an approximately 1,595-LF site composed of two separate reaches of South Chollas Creek within watershed ID 4903. The existing channel is composed entirely of earthen segments that run parallel to Castana Street. The channel is surrounded by residential development and a small park.

The site is located within private and City-owned parcels and no portion of the site is within or adjacent to MHPA or existing conserved lands. The site is supported by a watershed area over one square mile in size and the existing flow rates are estimated at 3742 to 3870 cfs. Existing vegetation communities include AR, DCSS, DEV, FWM, MFS, NFC, ORN, and SWS. The majority (90 percent) of vegetation is composed of non-native vegetation. DCSS is a Tier II upland ESL habitat type. FWM, MFS, NFC, and SWS are City Wetland ESL habitat types. Existing jurisdictional waters and wetlands include 0.81 acre of USACE/RWQCB-jurisdictional waters of the U.S./State, 2.59 acres of CDFW-jurisdictional riparian and/or streambed, and 1.99 acres of City Wetlands.

South Chollas-Elwood Avenue

The South Chollas-Elwood Avenue site is an approximately 2,451-LF site composed of one reach of South Chollas Creek within watershed ID 4905. The existing channel is composed entirely of earthen segments that run parallel to Highway 94. The channel is bordered by DCSS on both sides with a large open space to the east.

The site is located within City-owned parcels within MHPA and existing conserved lands. The site is supported by a watershed area over one square mile in size and the existing flow rates are estimated at 993 cfs. Existing vegetation communities include DW, DCSS, FWM, NFC, ORN, and SWS. The majority (70 percent) of vegetation is composed of native vegetation, only 30 percent is non-native. DCSS is a Tier II upland ESL habitat type. DW, FWM, NFC, and SWS are City Wetland ESL habitat types. Existing jurisdictional waters and wetlands include 0.83 acre of USACE/RWQCB-jurisdictional waters of the U.S./State, 2.94 acres of CDFW-jurisdictional riparian and/or streambed, and 1.11 acres of City Wetlands.

South Chollas-Federal & 60th

The South Chollas-Federal & 60th site is an approximately 1,913-LF site composed of three separate reaches to South Chollas Creek within watershed ID 4905. The existing channel is a combination of earthen and concrete-lined segments that run parallel to Federal Boulevard and Highway 94 from Oriole Avenue to Highway 94. The channel is narrow and abuts commercial development.

The site is located within private parcels and portions abut MHPA and existing conserved lands. The site is supported by a watershed area over one square mile in size and the existing flow rates are estimated at 480 to 1,220 cfs. Existing vegetation communities include DCSS, DEV, DL, DW, FWM, and NNG. All (100 percent) of vegetation is composed of non-native vegetation. DCSS is a Tier II upland and NNG is a Tier IIIB upland ESL habitat type. DW and FWM are City Wetland ESL habitat types. Existing jurisdictional waters and wetlands include 0.62 acre of USACE/RWQCB-jurisdictional waters of the U.S./State, 1.62 acres of CDFW-jurisdictional riparian and/or streambed, and 0.06 acre of City Wetland habitat types. This site was eliminated from further consideration as detailed below.

South Chollas-Federal & Central

The South Chollas-Federal & Central site is an approximately 1,937-LF site composed of one reach of South Chollas Creek within watershed ID 4906. The existing channel is composed entirely of earthen segments that run parallel to Federal Boulevard from Central Avenue to College Place. The channel is surrounded by commercial and residential development with small pockets of native habitat along the channel. The site is entirely located within the City of Lemon Grove.

The site is located within private parcels and no portion of the site is within or adjacent to MHPA and existing conserved lands. The site is supported by a watershed area over one square mile in size and the existing flow rates are estimated at 480 to 1,220 cfs. Existing vegetation communities include AR, DEV, DL, DW, EW, NFC, and ORN. All (100 percent) of vegetation is composed of non-native vegetation. DW and ST are

City Wetland ESL habitat types. Existing jurisdictional waters and wetlands include 0.87 acre of USACE/RWQCB-jurisdictional waters of the U.S./State and 1.72 acres of CDFW-jurisdictional riparian and/or streambed. The site is located within the City of Lemon Grove; therefore, there are no City Wetland habitat types present and the site was eliminated from further consideration, as detailed below.

South Chollas-Federal East

The South Chollas-Federal East site is an approximately 2,975-LF site composed of three separate reaches of South Chollas Creek within watersheds with IDs 4905 and 4906. The existing channel is composed entirely of earthen segments that run parallel to Federal Boulevard and Highway 94 from Central Avenue to Oriole Avenue. The channel is narrow and abuts commercial development to the southeast and is adjacent to Highway 94 to the northwest. The entire site is located within the City of Lemon Grove.

The site is located within private and City of Lemon Grove-owned parcels and portions abut MHPA and existing conserved lands. The site is supported by a watershed area over one square mile in size and the existing flow rates are estimated at 480 to 1,220 cfs. Existing vegetation communities include DCSS, DEV, DL, FWM, NNG, and ORN. All (100 percent) of vegetation is composed of non-native vegetation. DCSS is a Tier II upland and NNG is a Tier IIIB upland ESL habitat type. FWM is a City Wetland ESL habitat type. Existing jurisdictional waters and wetlands include 1.06 acres of USACE/RWQCB-jurisdictional waters of the U.S./State and 2.41 acres of CDFW-jurisdictional riparian and/or streambed. The site is located within the City of Lemon Grove; therefore, there are no City Wetland habitat types within the site and the site was eliminated from further consideration, as detailed below.

South Chollas-Geneva Avenue

The South Chollas-Geneva Avenue site is an approximately 1,786-LF site composed of six separate reaches of South Chollas Creek within watershed ID 4904. The existing channel is composed entirely of concrete-lined segments that run parallel to Geneva Avenue. The channel is surrounded by residential development with little vegetation within it.

The site is located within private parcels and no portion of the site is within or adjacent to MHPA or existing conserved lands. The site is supported by a watershed area over one square mile in size and the existing flow rates are estimated at 834 to 1,026 cfs. Existing vegetation communities include DCSS, DEV, DL, ORN, and NNG. The majority (95 percent) of vegetation is composed of non-native vegetation. DCSS is a Tier II upland and NNG is a Tier IIIB upland ESL habitat type. There are no City Wetland ESL habitat types. Existing jurisdictional waters and wetlands include 0.75 acre of USACE/RWQCB-jurisdictional waters of the U.S./State and 1.28 acres of CDFW-jurisdictional riparian and/or streambed. No City Wetland habitat types occur within the site. This site was eliminated from further consideration as detailed below.

South Chollas-San Miguel Avenue

The South Chollas-San Miguel Avenue site is an approximately 696-LF site composed of two separate reaches of South Chollas Creek within watershed ID 4902. The existing channel is a combination of earthen-bottom with concrete banks and concrete-lined segments that run parallel to San Miguel Avenue. The channel is surrounded by residential development with open, disturbed lots located to the west.

The site is located within private and City-owned parcels and no portion of the site is within or adjacent to MHPA or existing conserved lands. The site is supported by a watershed area over one square mile in size and the existing flow rates are estimated at 3,725 to 3,831 cfs. Existing vegetation communities include DEV, DL, DW, and ORN. All (100 percent) of vegetation is composed of non-native vegetation. There are no Tier I-IIIB habitats types. DW is a City Wetland ESL habitat type. Existing jurisdictional waters and wetlands include 0.52 acre of USACE/RWQCB-jurisdictional waters of the U.S./State, 0.71 acre of CDFW-jurisdictional riparian and/or streambed, and 0.54 acre of City Wetland habitat type. This site was eliminated from further consideration as detailed below.

South Chollas-San Pasqual Street

The South Chollas-San Pasqual Street site is an approximately 853-LF site composed of one reach of South Chollas Creek within watershed ID 4902. The existing channel is a combination of earthen and concrete-lined segments that run along San Pasqual Street. The channel is surrounded by residential development, but abuts native habitat and conservation lands upstream.

The site is located within private and City-owned parcels and portions abut MHPA and existing conserved lands. The site is supported by a watershed area over one square mile in size and the existing flow rates are estimated at 3,488 to 3,846 cfs. Existing vegetation communities include DCSS, DEV, DL, DW, NFC, and NNG. The majority (95 percent) of vegetation is composed of non-native vegetation. DCSS is a Tier II upland and NNG is a Tier IIIB upland ESL habitat type. DW and NFC are City Wetland ESL habitat types. Existing jurisdictional waters and wetlands include 0.58 acre of USACE/RWQCB-jurisdictional waters of the U.S./State, 1.19 acres of CDFW-jurisdictional riparian and/or streambed, and 0.21 acre of City Wetland habitat type. This site was eliminated from further consideration as detailed below.

Wabash-Ash & Delevan

The Wabash-Ash & Delevan site is an approximately 952-LF site composed of five separate reaches of the Wabash Branch within watershed ID 4601. The existing channel is entirely composed of earthen segments that run parallel and to the east of Interstate 15. The channel is surrounded by industrial development and Interstate 15.

The site is located within private parcels and portions are adjacent to MHPA and existing conserved lands. The site is supported by a watershed area over one square mile in size and the existing flow rates are estimated at 2,147 to 2,312 cfs. Existing vegetation communities include DCSS, DEV, DL, NFC, NNG, and ORN. The majority (75 percent) of vegetation is composed of non-native vegetation. DCSS is a Tier II upland and NNG is a Tier IIIB upland ESL habitat type. ST is a City Wetland ESL habitat type. Existing jurisdictional waters and wetlands include 0.37 acre of USACE/RWQCB-jurisdictional waters of the U.S./State, 1.04 acres of CDFW-jurisdictional riparian and/or streambed, and 0.42 acre of City Wetlands.

Wabash-Interstate 15

The Wabash-Interstate 15 site is an approximately 3,553-LF site composed of 11 separate reaches of the Wabash Branch within watershed ID 4603. The existing channel is entirely composed of earthen segments that run parallel to Interstate 15. The channel is surrounded by residential development, but the southern end is adjacent to native habitat.

The site is located within City-owned parcels and portions abut MHPA and existing conserved lands. The site is supported by a watershed area over one square mile in size and the existing flow rates are estimated at 2,171 to 2,506 cfs. Existing vegetation communities include DCSS, DEV, DL, EW, MFS, NFC, NNG, ORN, SMC, and SWS. The majority (80 percent) of vegetation is composed of non-native vegetation. DCSS is a Tier II upland, SMC is a Tier IIIA upland, and NNG is a Tier IIIB upland ESL habitat type. MFS, NFC, and SWS are City Wetland ESL habitat types. Existing jurisdictional waters and wetlands include 1.56 acres of USACE/RWQCB-jurisdictional waters of the U.S./State, 3.90 acres of CDFW-jurisdictional riparian and/or streambed, and 1.51 acres of City Wetlands.

Wabash-Juniper Canyon

The Wabash - Juniper Canyon site is an approximately 982-linear-foot site composed of three separate reaches of the Wabash Branch within watershed IDs 4602 and 4603. The existing channel is entirely composed of earthen segments that run parallel to Interstate 15. The channel is comprised primarily of and surrounded by DCSS.

The site is located within City-owned parcels and is located within MHPA and existing conserved lands. The site is supported by a watershed area over one square mile in size and the existing flow rates are estimated at 2,171 to 2,506 cfs. Existing vegetation communities include DCSS, DEV, DL, MFS, NFC, and ORN. The majority (95 percent) of vegetation is composed of native vegetation, only 5 percent is non-native. DCSS is a Tier II upland ESL habitat type. MFS and NFC are City Wetland ESL habitat types. Existing jurisdictional waters and wetlands include 0.47 acre of USACE/RWQCB-jurisdictional waters of the U.S./State, 1.04 acres of CDFW-jurisdictional riparian and/or streambed, and 0.42 acre of City Wetlands.

Sites Eliminated from Further Consideration

The following sites were eliminated from further consideration due to existing mitigation allocations, inability to remove concrete from primarily concrete-lined channels, highly constricted segments with existing development immediately adjacent to the channel, or a combination of various factors. This discussion provides the major factor for disqualifying each site.

Auburn Tributary-Hollywood Park

Daylighting the underground pipe was preliminarily determined infeasible because it would require removal of most, if not all, of the existing Hollywood Park. In addition, the upstream watershed area is relatively small; therefore, the potential to implement a viable and cost-effective stream restoration project is low.

Chollas-Market Street

The majority of the site consists of an entirely concrete-lined channel segment. The site is highly constricted by development and the existing hydrology regime needs to be retained (i.e., no flood control improvements are recommended), which precludes the removal of concrete and widening the existing channel. This site was determined to be infeasible to support a viable stream restoration project.

Jamacha Branch Tributary-Jamacha

This site is already in the planning and entitlement phases for stream restoration.

South Chollas-Federal & 60th

The majority of the site consists of an entirely concrete-lined channel segment. The site is highly constricted by development, which precludes the removal of the concrete.

South Chollas-Federal & Central

The site is located entirely within the City of Lemon Grove.

South Chollas-Federal East

The site is located entirely within the City of Lemon Grove.

South Chollas-Geneva Avenue

The entire site consists of a concrete-lined channel segment. The site is highly constricted by development, and the existing hydrology regime needs to be retained (i.e., no flood control improvements are recommended), which precludes the removal of concrete and widening the existing channel. This site was determined to be infeasible to support a viable stream restoration project.

South Chollas-San Miguel Avenue

The entire site consists of a concrete-lined channel segment. The site is highly constricted by development, and the existing hydrology regime needs to be retained (i.e., no flood control improvements are recommended), which precludes the removal of concrete and widening the existing channel. This site was determined to be infeasible to support a viable stream restoration project.

South Chollas-San Pasqual Street

This site consists of an entirely concrete-lined, right-turn channel segment. The site is completely surrounded by residential development and experiences high flow rates and volumes, which precludes the removal of concrete. This site was determined to be infeasible to support a viable stream restoration project.

3.0 Water Quality and Green Infrastructure Assessment

The Chollas Creek watershed is subject to multiple water quality-based regulatory drivers, including the MS4 permit and applicable TMDLs as well as significant siting constraints for water quality solutions (e.g., a highly urbanized setting, and private ownership and jurisdictional water restrictions). Distributed and regional-scale GI opportunities have been identified in previous compliance plans such as the WQIP and the CLRP as critical strategies for achieving compliance with those regulations through mitigation of water quality contaminants. Previous efforts to identify and quantify the benefits of structural GI have been at a coarse scale because of (1) the lack of high-resolution data for the watershed and (2) the limitations of standard model platforms to evaluate the complex and interdependent nature of thousands of GI projects at the watershed scale. Tetra Tech leveraged the preponderance of high-resolution spatial data (section 2.1) and enhanced monitoring and calibration data (section 2.2) to execute innovative modeling techniques that optimize structural GI implementation at the watershed scale, while simultaneously including extremely high levels of detail. Those innovations include a highly refined representation of (1) the pollutant-generating land uses and drainage areas within the study area, (2) conceptual design-level detail for GI representations and routing at the project scale, (3) identifying and quantifying additional GI components not considered in previous studies (e.g., diversion structures for MUTAs and storm drain infrastructure extensions for underdrain connection), and (4) the capability to optimize GI placement and sizing for a study area of this scale.

The inherent complexity associated with the detailed drainage area, routing, and GI representations incorporated within the models coupled with the sheer number of GI opportunities and models necessitated strategically segmenting the analyses into five main components:

1. Watershed model (LSPC) to characterize the existing water quality conditions (Section 3.1)
2. Tier 1 project-scale GI optimization models (System for Urban Stormwater Treatment and Analysis Integration [SUSTAIN]) (Section 3.2)
3. Tier 2 watershed-scale comprehensive optimization to identify all GI required to reach the final water quality target (Section 3.2.1)
4. Strategic grouping of individual GI (catch basin scale and MUTA scale) into water quality projects that can be easily integrated into the CIP process (Section 6.1)
5. Prioritization of these water quality projects to identify the highest-yield, early action opportunities for implementation (Section 6.2)

The following sections present a summary of each of the model formulations and significant assumptions used by Tetra Tech to provide an effective strategic GI implementation plan for the City to meet the required water quality targets.

3.1 Watershed Model (LSPC)

Tetra Tech used the LSPC model to simulate hydrology, water quality, and stream transport at the watershed scale to represent the existing water quality conditions in the watershed. This model was selected for its (1) strong spatial and temporal scale capabilities, (2) capacity to represent diverse and urban land uses, (3) flexibility to represent multiple pollutant source and loading mechanisms, and (4) strong history of application in the Chollas Creek watershed for active TMDLs and regulatory support studies, including the WQIP and the bacteria TMDL reopener. Developing a robust and representative watershed model is essential as it provides the foundation for characterizing hydrology and pollutant fate and transport, as well as determining appropriate regulatory metrics. The LSPC models developed for the WMP leveraged the original models developed as part of the CLRP/WQIP process, which were subsequently updated as part of the bacteria TMDL reopener. The TMDL reopener is still in progress; however, the updates and recalibration of the watershed model for hydrology resulted in a *significantly more accurate representation of storm water flows within Chollas Creek*. The LSPC model updates that are part of the WMP incorporated the recalibrated hydrology from the TMDL reopener and focused on updating the water quality calibration for TZn based on the new monitoring data.

The LSPC model uses HRUs to represent a composite characterization of upland areas that captures the hydrologic and pollutant loading differences across the watershed (see section 2.1.2). Each modeled HRU has a sediment-bound TZn pollutant contribution during wet weather conditions, which accounts for the variable generation of the Chollas Creek pollutant of concern by different land cover characteristics. The initial model sediment load results were subsequently calibrated to achieve two goals: (1) to capture an appropriate unit-area load by each HRU and (2) to obtain a good fit of modeled results with observed data at instream monitoring locations. Model calibration parameters also were adjusted to be consistent with available literature values and the available parcel-level storm water monitoring data (see section 2.2.1). Appropriate unit-area loads, coupled with a good fit between modeled and observed instream water quality, ensured that the processes that link upland loading and instream pollutant concentrations were well represented in the model.

3.1.1 Watershed Model Results

The LSPC model was set up to simulate the detachment and transport of sediment from land surfaces as the primary pathway for metals loading to surface waters, where total metals loads, including zinc, are simulated as sediment associated. Sediment-associated pollutants are parameterized using a “potency factor”, which is defined as the mass of pollutant per mass of sediment generated from the land. Potency factors are specified independently for sediment generated through detachment and wash-off and/or through scour. The LSPC model simulates sediment using algorithms identical to those in the Hydrologic Simulation Program-FORTRAN (HSPF). The LSPC/HSPF modules used to represent sediment include SEDMNT (pervious production and removal of sediment), SOLIDS (accumulation and removal of solids on impervious land), and SEDTRN (transport and behavior of inorganic sediment in streams). A detailed description of relevant sediment algorithms is presented in the *HSPF Version 12 User’s Manual* (Bicknell et al. 2005). In brief, SEDMNT simulates detachment of sediment from the soil matrix by raindrop impact, reattachment into the matrix, and transport of detached sediment by overland flow energy. Overland flow can also cause gully scouring in which the material available for transport is not limited by raindrop detachment. SOLIDS simulates sediment availability and wash-off from impervious surfaces using a buildup/wash-off formulation.

The calibration efforts completed for the LSPC model confirm that the relative contributions of sediment and total zinc (TZn) by the modeled HRUs are within acceptable bounds (see appendix A.1 for detailed calibration). Figure 3-1 presents the unit sediment loads for each modeled HRU, demonstrating that pervious areas with exposed surfaces and roadways generate the largest loads per acre. Figure 3-2 presents unit zinc loading by HRU, which indicates that freeways and roads are the largest contributors per acre, followed by industrial and commercial land uses. Figure 3-3 and Figure 3-4 account for the actual distribution of each HRU within the watershed and present the total average annual sediment and zinc loading, respectively. The calibrated models demonstrate that the overall largest sediment loads within the study area are generated by roadways and pervious developed areas (Figure 3-5). TZn contributions, however, are further attributed to roadways and other impervious areas (Figure 3-6), which reflects the highly urbanized conditions present and source characterization of TZn assessed as part of the Chollas Creek dissolved metals TMDL. Figure 3-7 displays the spatial distribution of the zinc loading within the watershed at the catch basin scale to indicate the specific areas with the greatest contributions. The refinement of HRUs beyond previous efforts allowed for an enhanced representation of pollutant loading for the Chollas Creek watershed and informs strategic placement of structural GI to address the most significant areas of concern.

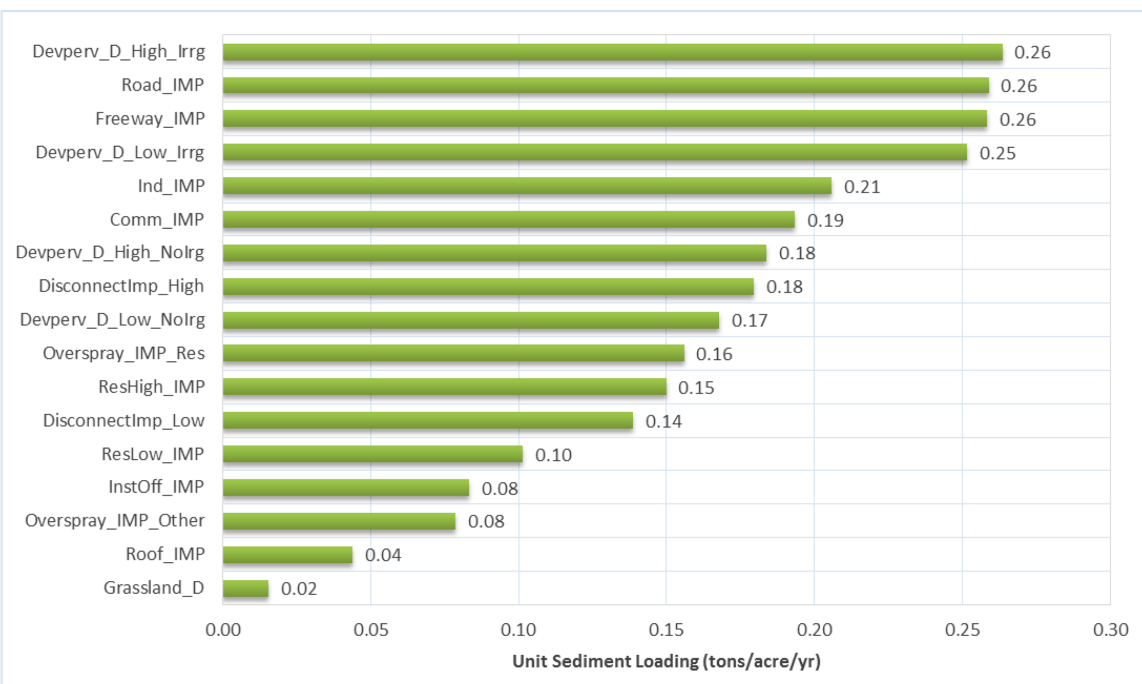

Figure 3-1. Average annual unit sediment load allocations (tons/acre/yr).

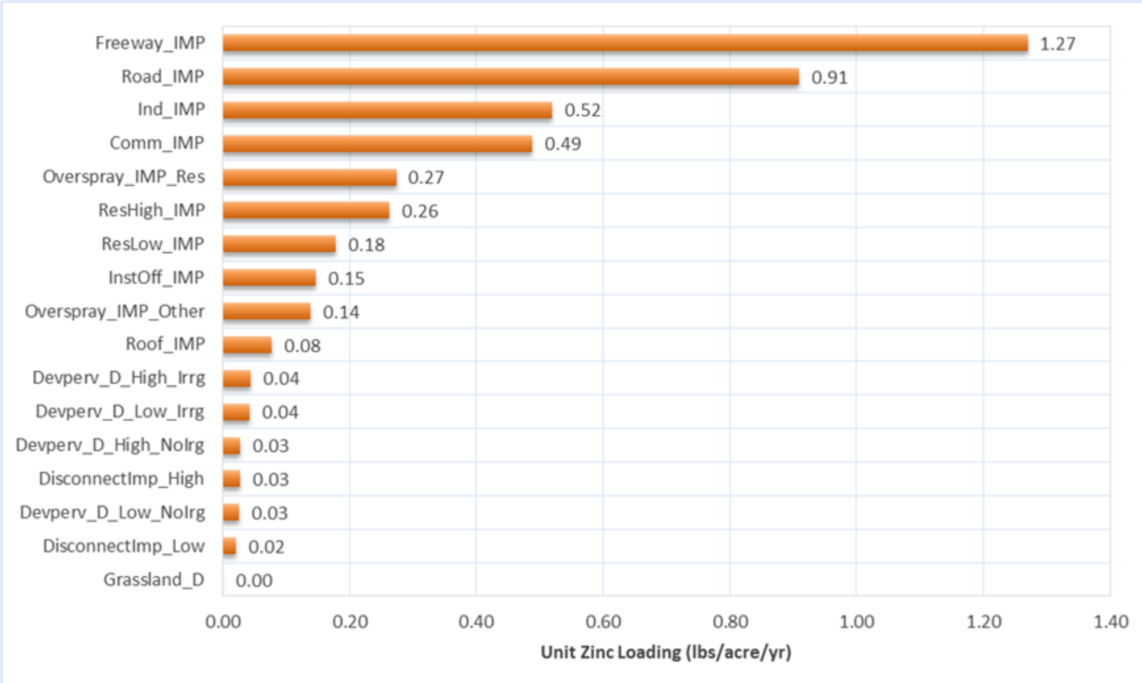

Figure 3-2. Average annual unit zinc load allocations (lbs/acre/yr).

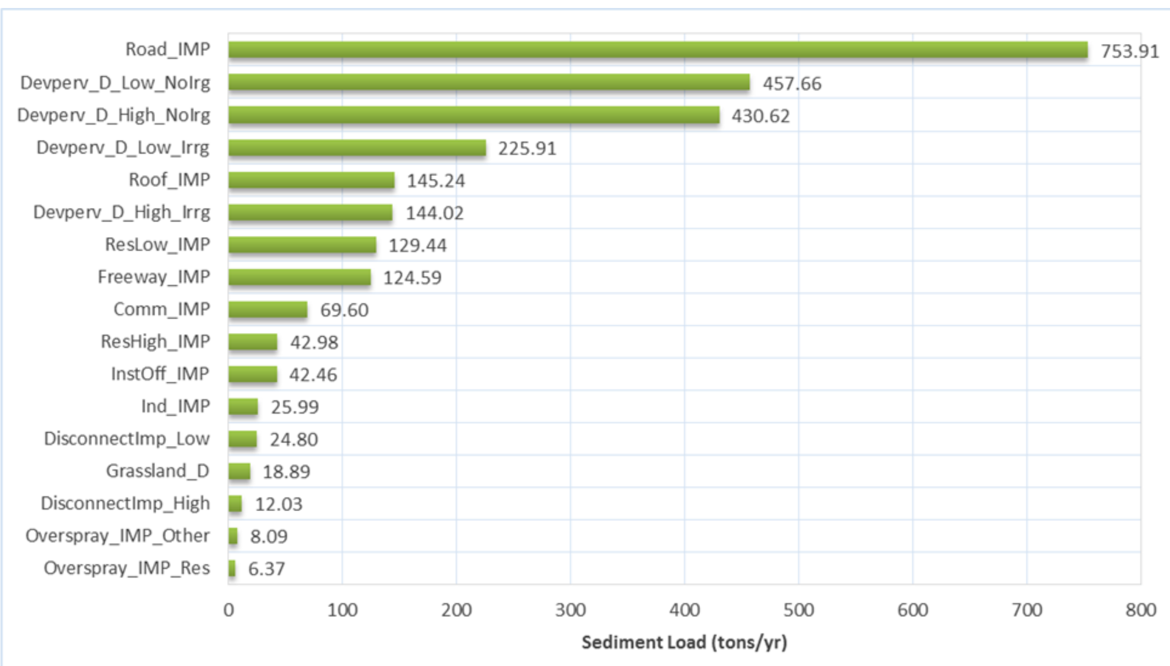

Figure 3-3. Total average annual sediment loads for Chollas Creek (tons/yr).

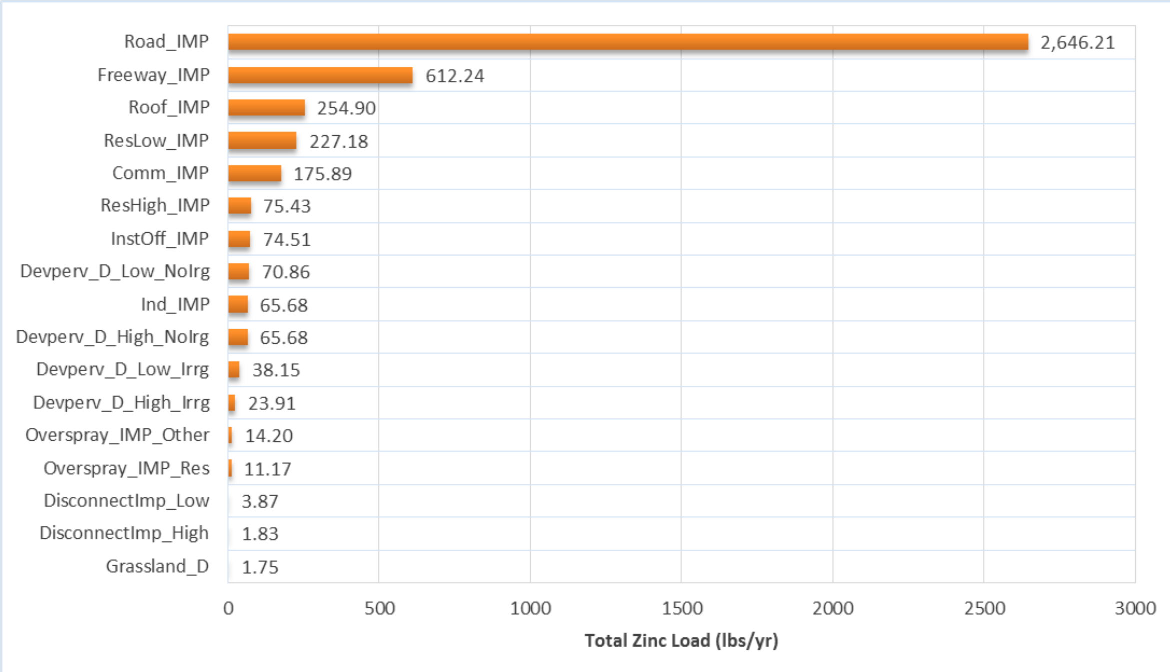

Figure 3-4. Total average annual TZn loads for Chollas Creek (lbs/yr).

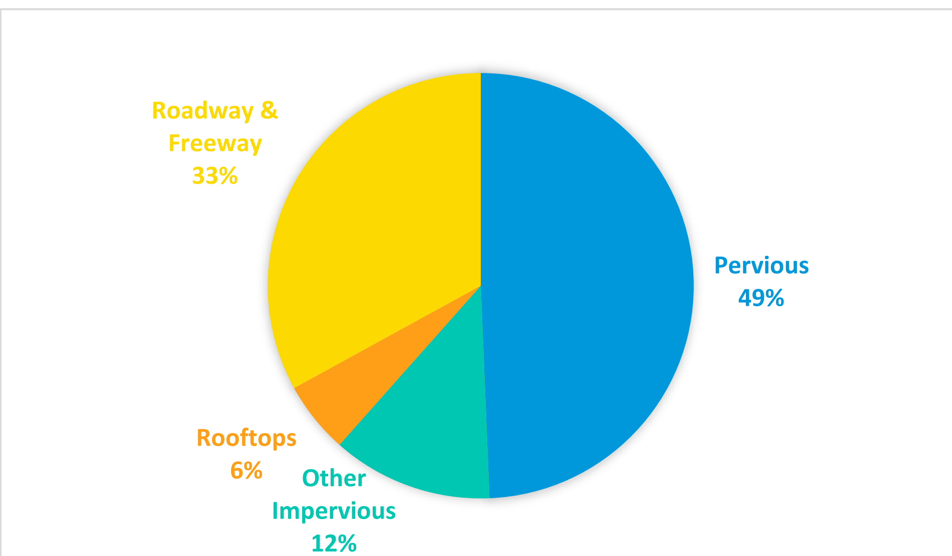

Figure 3-5. Distribution of sediment allocations in Chollas Creek.

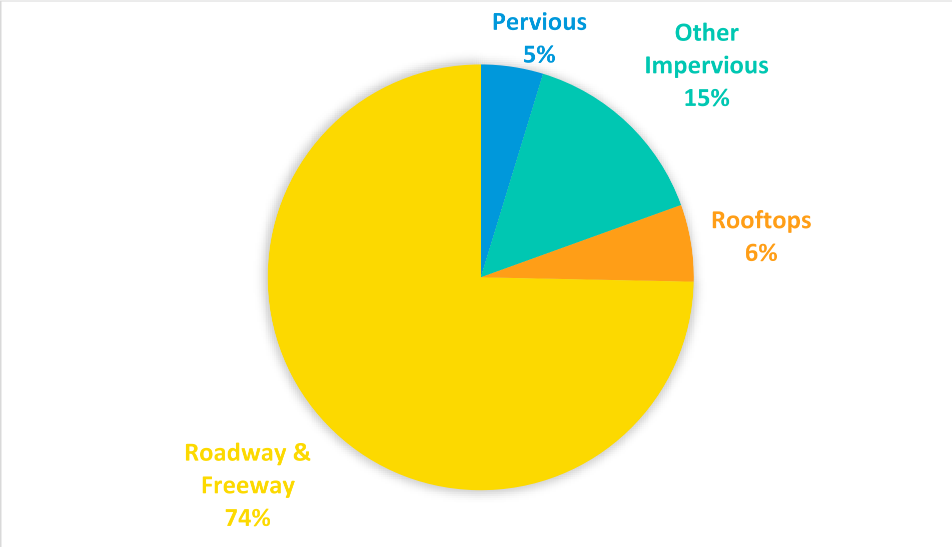

Figure 3-6. Distribution of TZn allocations in Chollas Creek.

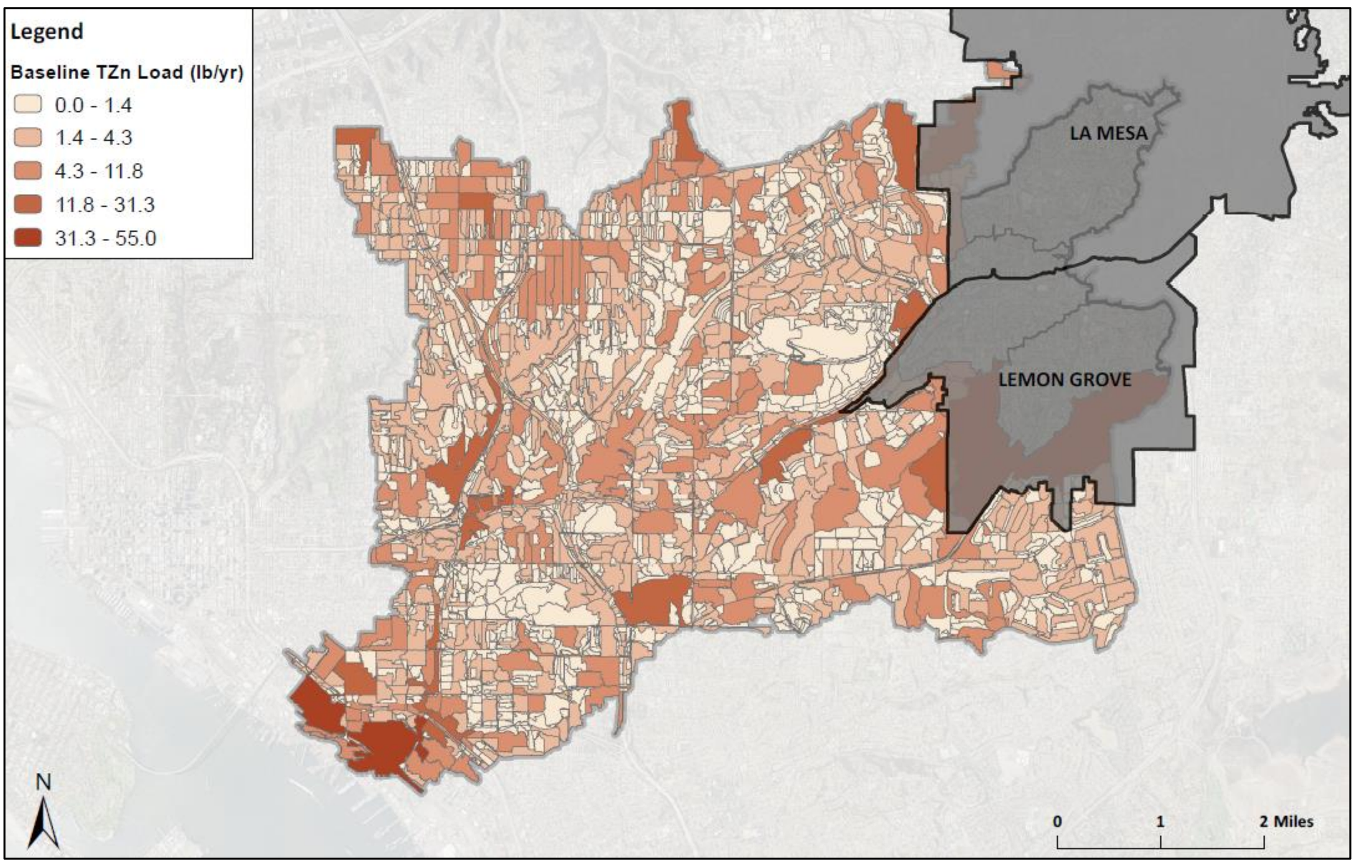

Figure 3-7. Pollutant loading heat map (TZn).

The output of the calibrated LSPC models was 25 HRU-specific time series used as inputs into the GI optimization models (SUSTAIN) to represent the storm water runoff and TZn contributions. This allows for the generation of unique cumulative pollutant loadings to each GI opportunity based on the HRU distribution tributary to that opportunity. Time series files were generated by subwatershed (originally delineated as part of the WQIP and updated as part of the WMP based on drainage updates) for each of the simulated HRUs to provide the most refined characterization of the watershed possible.

3.1.2 Watershed Model Update Implications (versus WQIP)

The WMP watershed model includes improvements to both the hydrology and water quality simulation when compared to the WQIP watershed model for Chollas Creek (City of San Diego 2015). These improvements to the model better capture actual flow and monitoring within the watershed and result in changes in the simulated baseline loading and the associated zinc load reduction targets.

Improvements in hydrology were initiated as part of the bacteria TMDL reopener process and focused on better matching the low-flow conditions observed in the Chollas Creek watershed. Nearly 60 percent of the watershed is made up of impervious surfaces, with a significant portion of the stream network modified to be concrete lined. As a result, little or no baseflow occurs in the receiving waters during either dry- or wet-weather conditions. The model was updated to reflect these observed low-flow conditions, which resulted in a more representative hydrologic calibration.

The watershed model improvements for water quality focused on better matching modeled land-based EMCs with monitoring data. The WQIP model did not include explicit calibration to land use-based TZn source data due to limited data availability at the time of model development. In lieu of this data, the Project Team developed the WQIP model to capture overall water quality trends; however, this resulted in a tendency to over-predict nonpeak concentrations and under-predict concentration peaks. These trends are evident in the reduction in number of exceedance days in the WMP model (8 days for WMP versus 16 days in WQIP), but a higher level of exceedance during the peaks in the WMP models versus the WQIP models. A comparison of the WMP and WQIP watershed models is further discussed in appendix A.

Ultimately, the process of updating the watershed models to better represent monitoring and observation data resulted in a decrease in both the existing load (5,165 pounds per year [lbs/yr]) and allowable load (3,214 lbs/yr) for TZn. The resulting required load reduction is similar between the WQIP (2,102 lbs/yr) and the WMP (1,951 lbs/yr); however, the reduction in allowable load capacity results in a higher relative percent load reduction required. A summary of significant hydrologic and water quality model results are presented in Table 3-1.

Table 3-1. Watershed model results comparison (WQIP versus WMP)

Watershed Model Results	WMP	WQIP
Wet Days Summary	**Days**	
Total Wet Days (10/1/2002 - 9/30/2003)	42	42
Total Wet Exceedance Days	8	16
Days Requiring Load Reduction	8	16
Metals Load Summary (TZn)	**Lbs/yr**	
Total Existing Load (Wet Days)	5,165	7,247
Total Allowable Load Capacity (Watershed-wide)	3,214	5,146
Total Required Load Reduction (Watershed-wide)	1,951	2,102
Total Percent Load Reduction (Watershed-wide)	37.8%	29.0%
Total GI Required Load Reduction (City Allocation)[a]	875	912
Total GI Percent Load Reduction (City Allocation)[a]	19.4%	16.2%

Note:
[a] The total GI percent load reduction is only for the contributing area from the City of San Diego MS4 and removes the load reduction allocated to nonstructural best management practices.

3.2 GI Optimization Models

The GI optimization models for the WMP were developed using a tiered approach to capture the complexity and interdependency of storm water GI within a developed, urbanized area. The models leverage the EPA SUSTAIN platform, which is a decision support system with the capacity to spatially optimize GI opportunities for both cost and water quality benefits at various scales. In previous regulatory support efforts at the watershed scale, such as the WQIPs and TMDL implementation plans, the water quality benefits attributed to structural GI were assessed at the overall watershed and/or strategy-wide level. These high-level representations could not account for the specific siting of opportunities, localized constraints, design requirements, or the inherent interconnectedness of GI implementation. The WMP GI model builds upon previous efforts and incorporates an unprecedented level of detail consistent with a conceptual design, providing the information needed to make informed, data-driven implementation decisions at the project level. Some of the additional complexities introduced into the GI model include (1) detailed drainage area routing and nesting of GI projects within the study area, (2) refinement of GI type opportunities, (3) inclusion of effluent GI EMCs, (4) improvement of GI cost functions, and (5) MUTA-specific characterization (e.g., diversion rate analysis, pumping evaluation, private property acquisition, and O&M considerations).

Optimization based on high-resolution data and detailed GI representations at the watershed scale is critical for determination of the most cost-effective solution

3.2.1 Tiered Water Quality Model Approach

The geospatial analyses described in section 2.1.2 identified 13,597 distributed GI opportunities and 82 MUTAs, which would result in countless ($2^{13,679}$) permutations of GI implementation scenarios within the SUSTAIN modeling platform. To identify the most cost-effective combination of GI (i.e., GI type and design capacity) across the entire watershed, the model formulation considered all distributed GI opportunities and all MUTA locations, and represented the complex downstream flow routing and variable diversion rates for each MUTA using robust algorithms. A tiered modeling approach was formulated to create manageable model scales from both model development and result synthesis perspectives. This approach was strategically developed to provide a high level of detail where needed (e.g., for GI components that significantly impact water quality and performance), while streamlining the modeling complexity for other less critical components, as determined by the Project Team.

A summary of the tiered modeling approach is presented in Table 3-2 and Figure 3-8. The spatial distribution of GI drainage areas that are tributary to each combination of potential GI opportunities is shown in Figure 3-9.

Table 3-2. Water quality model tiers

Model Tier	Description	Model Platform	Inputs	Outputs
Tier 1a	1,186 distributed GI models[a]	SUSTAIN	LSPC HRU unit-area time series GI footprint areas GI drainage areas GI routing information GI parameters Cost functions	Inlet cost-effectiveness curve with specified bounds (best solution) Inlet baseline TZn load Inlet optimized GI design capacities for a range of TZn load reduction scenarios
Tier 1b	82 MUTA models[b]	SUSTAIN	LSPC HRU unit-area time series Tier 1a curves MUTA footprint areas MUTA drainage areas MUTA parameters Maximum diversion rate Cost functions	MUTA cost-effectiveness curve with specified bounds (best solution) MUTA baseline TZn load MUTA optimized design capacity for a range of TZn load reduction scenarios
Tier 2	Total study area final TMDL target optimization[c]	Optimization Algorithms	Tier 1a curves Tier 1b curves Final TMDL TZn load target	Watershed cost-effective combination of optimized GI (distributed and MUTA) from Tier 1a and Tier 1b models needed to reach final TMDL target

Notes:
[a] See section 3.2.2.1 for GI types.
[b] See sections 3.2.2.2 and 3.2.2.3 for GI types.
[c] An optimization logic was developed to formulate the study watershed-specific objective function (depending on the number of inlets, distributed GI, and MUTA locations) using nonlinear optimization algorithms.

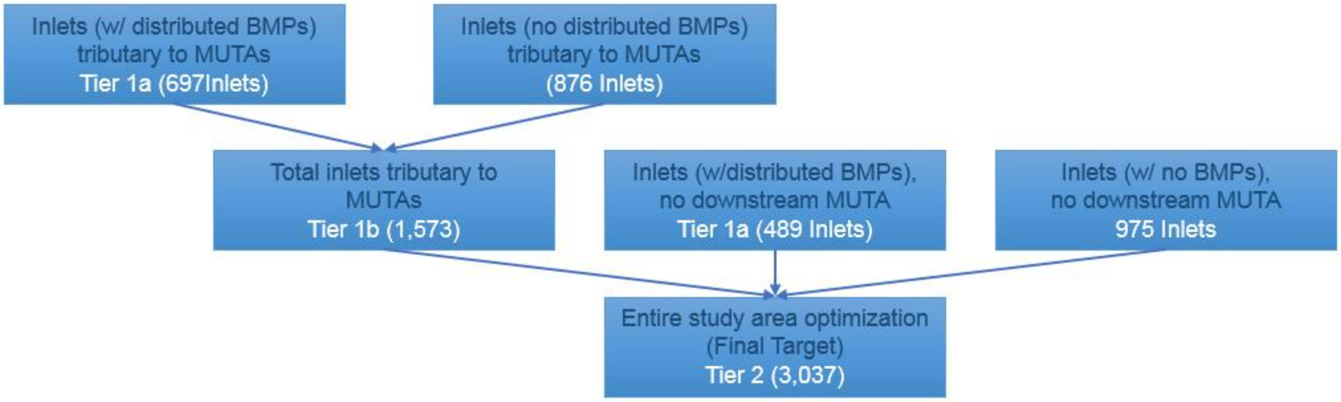

Figure 3-8. Tiered modeling approach (water quality and GI).

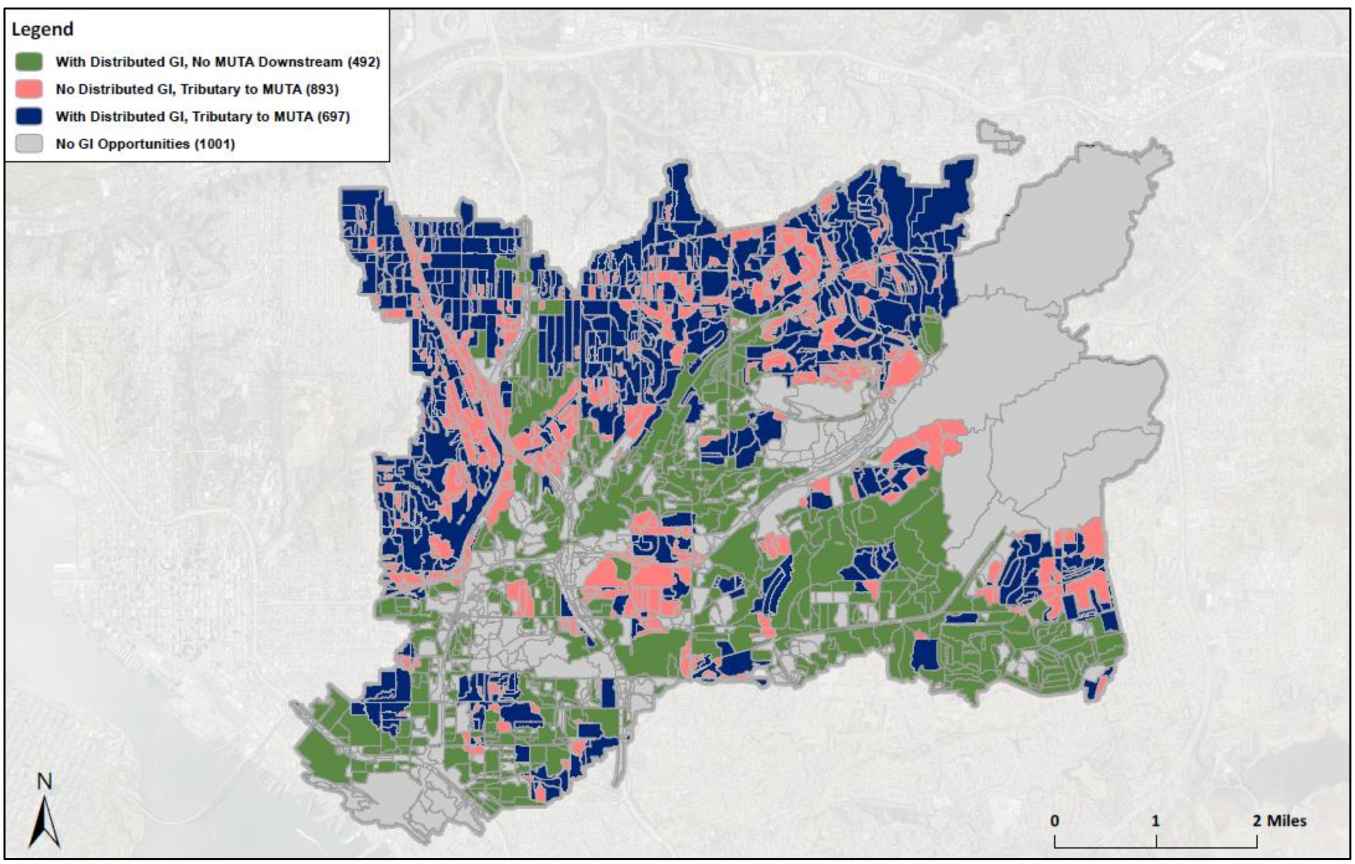

Figure 3-9. GI applicability and routing at the catch basin scale.

Tier 1a Model (Distributed GI)

The Tier 1a models were performed within the SUSTAIN modeling platform with the goals of establishing the baseline loading and optimizing all of the distributed GI opportunities identified within each catch basin inlet drainage area (e.g., biofiltration and suspended pavement). The Tier 1a models consist of two SUSTAIN model runs for each inlet: (1) an upper bound model that incorporates the maximum possible GI opportunity implementation using explicit drainage areas, footprints, and routing; and (2) an aggregated optimization model to generate the cost-effectiveness curves for all possible solutions below the maximum implementation level. The aggregated optimization models significantly reduce the number of permutations needed in the optimization by summing the explicit GI opportunity footprints and their delineated drainage areas within each catch basin into a single footprint with a single drainage area. The cost-effectiveness curves generated by the aggregated models closely match the curves generated by the explicit models (e.g., modeling each individual footprint) and significantly streamline the Tier 1a optimization models (e.g., run times take only a few minutes versus hours). A full discussion of the aggregation analysis can be found in section A.2 in appendix A.

The SUSTAIN model uses the unit-area HRU time series created by the LSPC model to estimate the flow and pollutant load contribution from the delineated drainage areas to each distributed GI opportunity identified in section 0 (see section 3.1 for information about the LSPC model). The SUSTAIN model routes the simulated runoff through variable levels of GI implementation within each catch basin drainage area to assess all potential water quality benefits and the associated costs with the inlet as the assessment point. Table 3-3 summarizes the assumptions and sensitivity analyses conducted to establish robust input parameters to the SUSTAIN models. See section A.2 in appendix A for additional detail.

Table 3-3. Significant Tier 1a (distributed GI) model assumptions

Parameter	Assumption	Source/Rationale
Distributed GI Assumptions		
Biofiltration	See section 3.2.2.1.	See section 3.2.2.1.
Suspended Pavement	See section 3.2.2.1.	See section 3.2.2.1.
GI Selection and Routing		
GI Footprint	Variable based on optimization.	Footprints will vary based on performance needed at the catch basin inlet scale.
Routing	Overflow/bypass travel to next downstream GI opportunity. Underdrain outflows travel to the inlet.	GI projects are modeled offline and, once full, will overflow/bypass the curbline to the next GI opportunity.
Storm Drain Improvements		
Length of Underdrain Pipe to Existing Infrastructure	Variable based on GIS.	Cost will vary; impacts selection during optimization.

The GI sizing and optimization algorithms produced thousands of potential GI combinations for the inlet drainage area for each catch basin, from which one "best solutions" curve was extracted that characterizes the optimal relationship between total GI cost and TZn load reduction (see Figure 3-10). The best solutions curve is shown with blue dots and represents the rising limb of the aggregated cost-effectiveness curve. The curves were translated to third-degree polynomial regression equations (or lower degree equations, as appropriate) to be used as inputs to the subsequent modeling steps. As shown in Figure 3-10, upper and lower bounds also were established to limit computational inefficiencies and to ensure strategic implementation of GI.

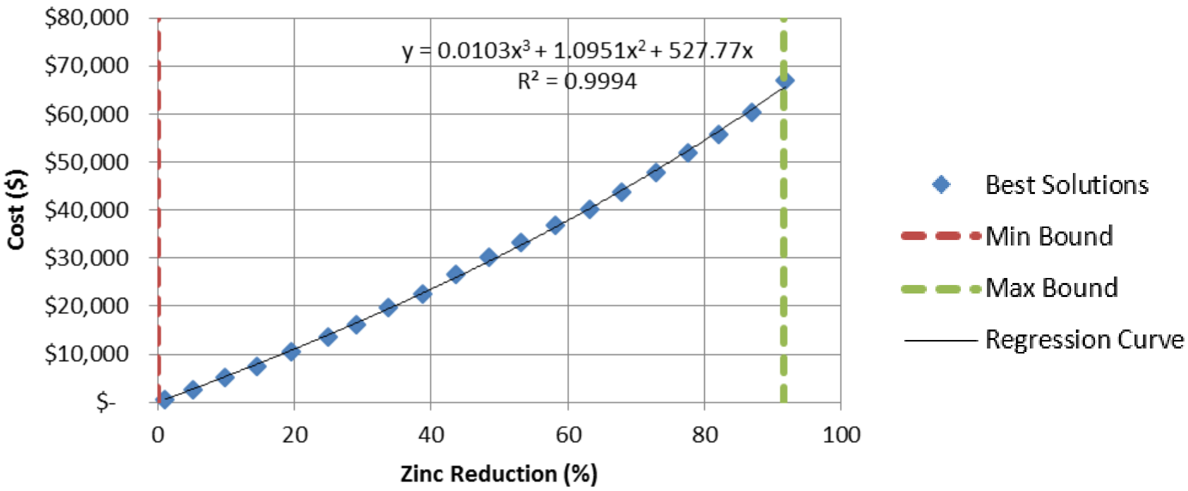

Figure 3-10. Example of Tier 1a polynomial curve (cost versus percent zinc reduction).

Tier 1b Model (MUTAs)

The Tier 1b models were developed within the SUSTAIN modeling platform with the goal of optimizing the inflow diversion and size of each MUTA opportunity, while also accounting for the impact of potential upstream distributed GI (Tier 1a) within the larger MUTA drainage area. Inlet drainage areas with upstream distributed GI (Tier 1a) and inlet drainage areas without distributed GI that are tributary to MUTAs are both incorporated into the Tier 1b models through best solutions curves and explicit routing, respectively. The downstream MUTA footprint and diverted inflow rate are varied to account for all possible permutations with different combinations of upstream Tier 1a GI and routing. The Tier 1b models do not explicitly simulate all distributed GI within upstream inlet drainage areas; instead, they pick a "best solution" from the cost-effectiveness curve developed under the Tier 1a modeling at each inlet. The best solution output at the inlet (hourly time series of flow and pollutant load) is directly linked to the Tier 1b model as inputs to each MUTA. Depending upon the number of upstream inlets with distributed GI, the number of permutations for optimizing the best solutions also could become very large and potentially cause extremely long model run times and memory issues. The magnitude of the permutations in a highly nested storm drain system again emphasizes the need to implement a tiered modeling approach in order to capture the complexities where necessary (GI/MUTA characterization) and streamline where possible.

The SUSTAIN model simulates the variable diverted runoff to each MUTA by incorporating all combinations of the best solutions from the inlet drainage area for each catch basin to enable assessment of all potential water quality benefits and the associated costs at the MUTA as an assessment point. Table 3-4 summarizes the assumptions and sensitivity analyses conducted to establish robust input parameters. Additional detail is presented in section A.2 in appendix A.

Table 3-4. Significant Tier 1b (MUTA) model assumptions

Parameter	Assumption	Source/Rationale
MUTA Assumptions		
Canyon-based MUTA	See section 3.2.2.2.	See section 3.2.2.2.
Subsurface MUTA	See section 3.2.2.3.	See section 3.2.2.3.
MUTA Selection and Routing		
GI Footprint	Maximum set to available footprint identified in GIS[1]	Optimize footprints in SUSTAIN; sized in Tier 2.
Routing	Distributed GI can be nested with MUTAs; MUTAs are not nested.	See section 3.2.2.2 and section 3.2.2.3.
Storm Drain Improvements		
Length of Underdrain Pipe to Existing Infrastructure	Variable based on GIS. Measured to centroid of each MUTA opportunity.	Cost will vary; impacts selection during optimization.

Note:
[1]MUTA adjacent the Auburn - Auburn-Wightman 1 Project (MUTA 4705_IS_2) footprint revised to reflect the Preliminary Engineering Design Report for Auburn Creek Channel Restoration (San Diego 2017).

The Tier 1b models simultaneously assess water quality and cost implications for three modeled variables: (1) upstream GI implementation at the inlet scale, (2) inflow diversion rate at the MUTA scale, and (3) size-based MUTA treatment capacity. There were 20 combinations for upstream GI implementation selected for each MUTA according to the best-fit equations and analysis bounds developed for the Tier 1a performance curves. Similarly, there were 20 diversion rates selected at equal intervals for each MUTA, considering the maximum potential diversion rate based on engineering feasibility at other regional storm water capture facilities in Southern California (0 to 100 cfs). Lastly, there were 20 equally incremental MUTA sizes modeled based on the maximum MUTA footprint available. In order to represent the interdependency of the three variables, model runs were developed to capture each permutation of the variables at each designated increment (8,000 scenarios for each MUTA were developed for the Tier 1b models). For each MUTA, the model outputs from these scenarios were compared to identify the maximum bounds for the diversion rate and MUTA load reduction ratio beyond which the MUTA would no longer be cost-effective. A second-degree surface relationship was developed for use in the Tier 2 watershed-wide optimization that captures each of these three critical implementation considerations for each MUTA (Figure 3-11). The "best solutions" surface characterizes the total GI cost versus the TZn percent load reduction with upper and lower bounds designated to constrain the models to optimize to realistic solutions.

The mathematical representation of the surface is given as follows:

$$Z = c_1 + c_2X + c_3Y + c_4XY + c_5X^2 + c_6Y^2$$

where Z = MUTA cost ($), X = flow diversion ratio (%), Y = MUTA load reduction ratio (%), and c_1, c_2, c_3, c_4, c_5, c_6 = surface coefficients.

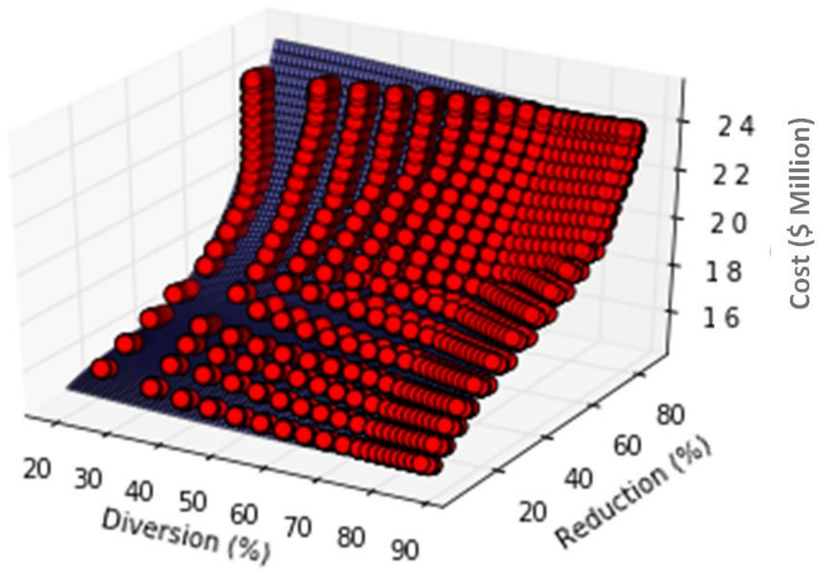

Figure 3-11. Example of Tier 1b surface used in Tier 2 models.

Tier 2 Model (Watershed-wide Optimization)

The Tier 2 model leverages the smaller scale regression equations generated as part of the Tier 1a and Tier 1b optimization analyses (best solutions curve and surface, respectively) and performs a watershed-scale spatial optimization for all of Chollas Creek to achieve the final water quality objective for TZn. The best solutions representations developed at the catch basin level or MUTA level already represent the most cost-effective solutions at that particular scale; however, an additional and compounded level of spatial optimization is required to identify the most cost-effective solution at the watershed scale using those intermediate optimization results. Randomly picking an optimal solution from Tier 1a and Tier 1b might eventually achieve water quality compliance, but efficiencies that result from understanding the interactions of different opportunities and the identification of the highest priority, early-action projects would not be reflected.

Completing the Tier 2 optimization explicitly using the SUSTAIN model platform would require linking an hourly time series output file for each best solution from the Tier 1a and Tier 1b models. The computational complexity would overwhelm the model due to the extensive amounts of data and innumerable permutations, which would ultimately necessitate a runtime on the order of months to complete the watershed-wide optimization. To overcome this problem, the Project Team used an external numerical model (LINGO) to spatially optimize with a nonlinear solver that allowed for the identification of the best combination of cost-effective projects based on the following inputs:

- Tier 1a regression equations and bounds for each catch basin inlet drainage area
- Tier 1b regression surfaces and bounds for each MUTA opportunity and inflow diversion rate

The Tier 2 optimization modeling was performed in two steps: (1) identify the combination of optimized GI to reach the required TZn load at the watershed scale using mathematical inputs alone (e.g., regression curve and surface representations of the optimized GI cost versus performance), and (2) verify that the selected GI within each inlet and/or MUTA size are reflective of reality. Through several iterations of the Tier 2 optimization, the specific combination of optimized GI within each catch basin drainage area and optimized MUTAs and diversion rates were identified and checked through a robust QA/QC process. The final refined optimization pass resulted in the comprehensive combination of GI required to achieve the water quality targets at the optimal cost.

3.2.2 GI Types Modeled

The GI types considered for this project fall into two main categories based on their relative size and placement: distributed GI and MUTAs. The distributed GI can be configured in several ways: (1) green streets with surface biofiltration in the parkway, (2) underground biofiltration within the ROW in a suspended paving unit, or (3) a parcel that can treat flows from the curbline before entry into the MS4 system. MUTAs also are subdivided into two categories: subsurface MUTAs—which pull flow from the MS4 system through a diversion structure—and canyon-based MUTAs—which are located at the current MS4 outfall and are diverted from the drainage system.

Water quality projects that have already been constructed were also modeled with actual construction data. Projects that are in the design phase were identified and included in the project opportunity inventory, but not explicitly selected in the optimization to provide water quality benefits. This was to allow for the watershed-wide assessment to evaluate the benefits of these locations relative to all other opportunities and determine whether those currently selected are in the optimal locations. Additional information on the characterization of constructed and planned GI projects is included in appendix A.

3.2.2.1 Distributed GI

Distributed GI modeled as part of this WMP consists of biofiltration within the parkway, suspended pavement along streets where parkway space was unavailable, and parcel-based GI practices. Parcel-based GI treats surface flow from larger areas and can be placed on the surface or as a subsurface system. The identified parcels are not considered MUTAs because they are located upgradient of entry into the MS4 system and do not have a feasible diversion point located nearby. Table 3-5 summarizes the assumptions and sensitivity analyses conducted to establish robust input parameters, and additional detail is presented in section A.2 in appendix A. Representative cross sections of each of the modeled distributed GI opportunities are provided in Figure 3-12 through Figure 3-15.

Table 3-5. Significant distributed green street GI model assumptions

Parameter	Assumption	Source/Rationale
Biofiltration GI Assumptions		
Ponding Depth	0.75 ft.	San Diego BMP Design Manual (San Diego 2016a).
GI Footprint	4.0 ft wide; variable length.	Average parkway width as measured in GIS.
ET Multiplier	1.0.	Surface; ET modeled.
Lining & Media Depth below Underdrain	Unlined; 50% efficiency of volume reduction applied. 2.5 ft actual media; 1.0 ft modeled.	City directive—unlined GI in the entire region not likely. 50% volume efficiency performance reduction for conservatism (see appendix A for further explanation).
Suspended Pavement GI Assumptions		
Ponding Depth	1.0 ft.	San Diego BMP Design Manual (San Diego 2016a); ensures drawdown of 36 hours.
GI Footprint	4.0 ft wide; variable length.	Average parkway width as measured in GIS.
ET Multiplier	0.0.	Subsurface; no ET modeled.
Lining & Media Depth below Underdrain	Unlined; 50% efficiency of volume reduction applied. 2.5 ft actual media; 1.0 ft modeled.	City directive—unlined GI in the entire region not likely. 50% volume efficiency performance reduction for conservatism (see appendix A for further explanation).
Surface Parcel-Based GI Assumptions		
Ponding Depth	1.0 ft.	San Diego BMP Design Manual (San Diego 2016a).
GI Footprint	Variable based on available footprint.	Geospatial analysis (section 2.1).
ET Multiplier	1.0.	Surface; ET modeled.
Lining & Media Depth below Underdrain	Unlined; 3.0 ft (no efficiency reduction).	Parcel-based are not in ROW; no reduction assumed.
Subsurface Parcel-Based GI Assumptions		
Ponding Depth	1.75 ft.	San Diego BMP Design Manual (San Diego 2016a); ensures drawdown of 36 hours.
GI Footprint	Variable based on available footprint.	Geospatial analysis (section 2.1).
ET Multiplier	0.0.	Subsurface; no ET modeled.
Lining & Media Depth below Underdrain	All units are assumed unlined in the model; 1.0 ft (no efficiency reduction).	Parcel-based are not in ROW; no reduction assumed.
Common GI Assumptions		
Media Depth (above Underdrain)	2.0 ft.	San Diego BMP Design Manual (San Diego 2016a).
Media Filtration Rate	5 inches per hour.	San Diego BMP Design Manual (San Diego 2016a).

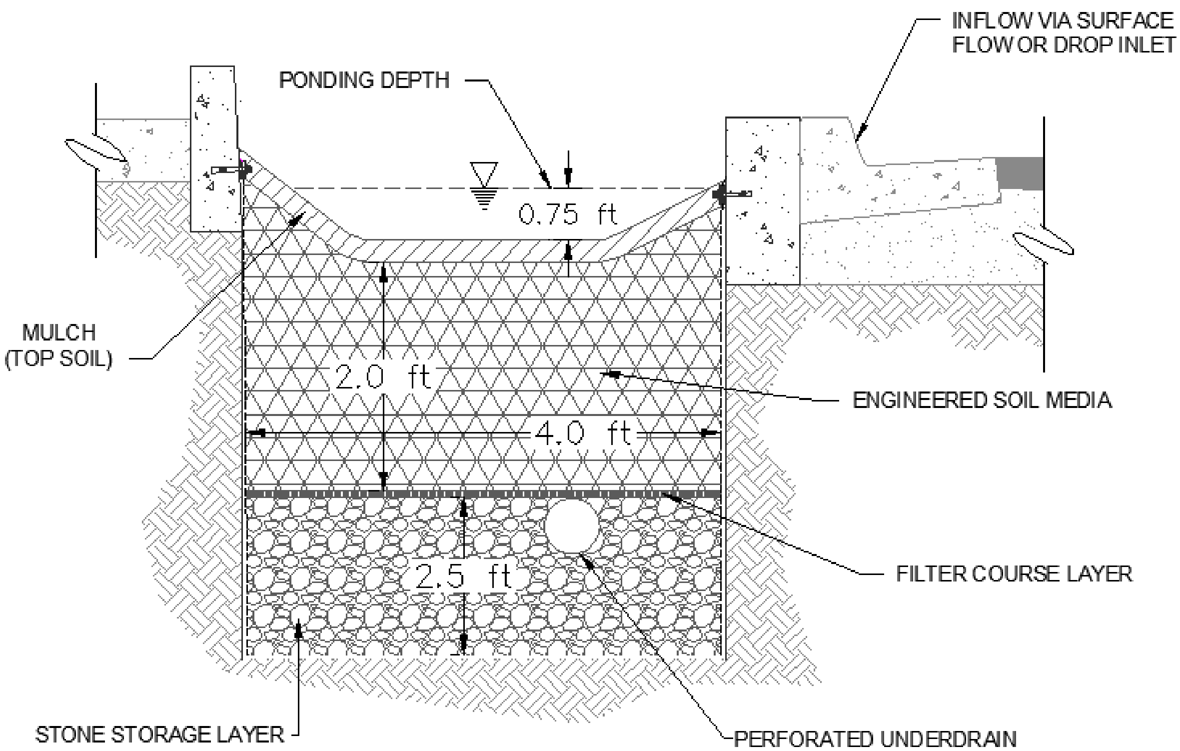

Figure 3-12. Green street biofiltration section with partial retention.

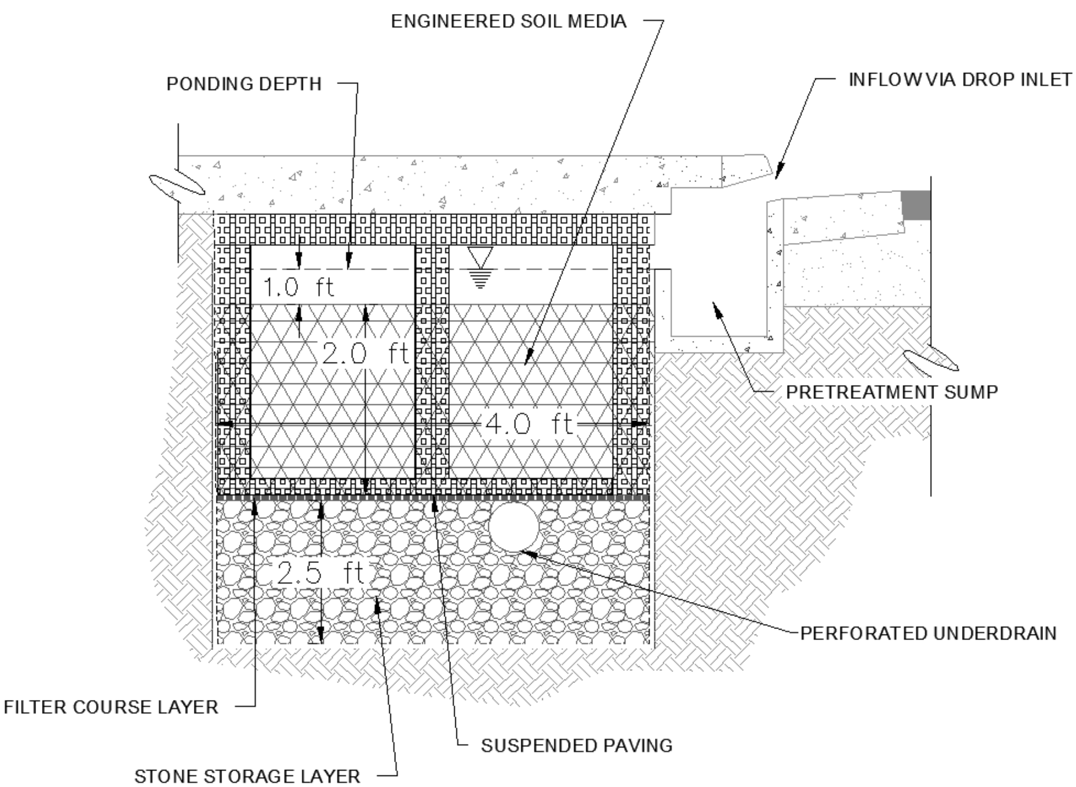

Figure 3-13. Green street suspended pavement biofiltration section with partial retention.

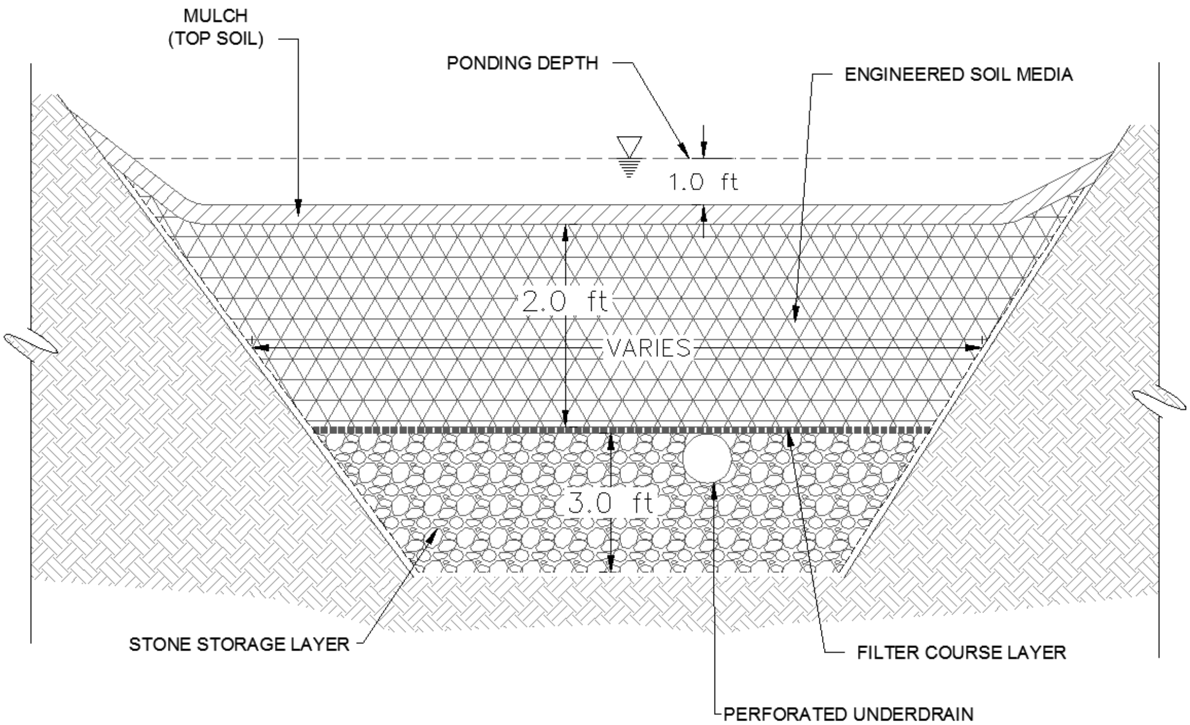

Figure 3-14. Parcel-based surface biofiltration section with partial retention.

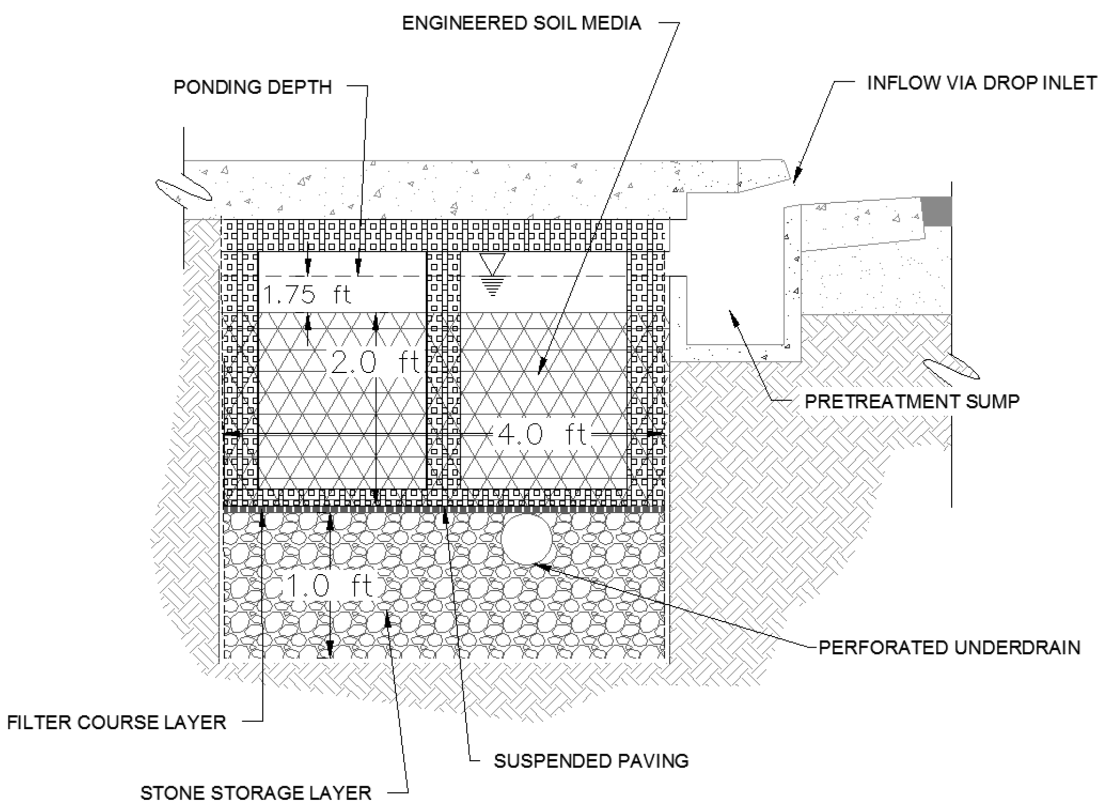

Figure 3-15. Parcel-based subsurface biofiltration section with partial retention.

3.2.2.2 Subsurface MUTAs (off-line)

MUTAs that are proposed underneath existing parcels that contain large open areas such as parking lots and sports fields are referred to as "subsurface MUTAs." These GI opportunities are assumed to be off-line from the MS4 system and will involve the design and construction of a diversion structure within an existing underground conduit to route storm water to the treatment area. All subsurface MUTAs are assumed to be below ground biofiltration units to ensure functionality of the existing parcels where opportunities were identified. Table 3-6 summarizes the assumptions and sensitivity analyses conducted to establish robust input parameters. Additional detail is provided in section A.2 in appendix A. A representative cross section of the modeled subsurface MUTAs can be found in Figure 3-16.

Table 3-6. Significant subsurface MUTA model assumptions

Parameter	Assumption	Source/Rationale
Drainage Area Assumptions		
Maximum Diverted Drainage Area	0.7% MUTA footprint-to-drainage area ratio.	Large drainage areas could overwhelm GI; no increase in pollutant reduction is observed beyond selection ratio. See section A.2 in appendix A for analyses.
MUTA Routing	No nested routing between MUTAs.	MUTAs designed to fill to capacity from the drainage area assigned; overflow/outflow from upstream MUTAs arrives after the MUTA is full and is not diverted.
Inflow Assumptions		
Diversion Rate	MUTA-specific rate.	See section A.2 in appendix A.
Pumping Requirements	MUTA-specific.	Inflow pumps recommended where excavation depths for gravity flow increase costs beyond threshold. Sump pumps recommended for gravity flow. See section A.2 in appendix A.
MUTA Properties Assumptions		
Ponding Depth	9.5 ft.	San Diego BMP Design Manual (San Diego 2016a); ensures drawdown of 96 hours. See section A.2 in appendix A for profile analysis.
MUTA Footprint	Variable based on available footprint.	Geospatial analysis (section 2.1).
ET Multiplier	0.0.	Subsurface; no ET modeled.
Media Depth (above Underdrain)	2.0 ft.	San Diego BMP Design Manual (San Diego 2016a).
Media Coverage	25% of total footprint.	Reflected through hybrid infiltration rate that represents the partial media coverage configuration selected. See section A.2 in appendix A for profile analysis.
Media Filtration Rate	5 inches per hour.	San Diego BMP Design Manual (San Diego 2016a).
Lining & Media Depth below Underdrain	Unlined; 0.5 ft.	ASTM #57 Stone (Obla 2007).

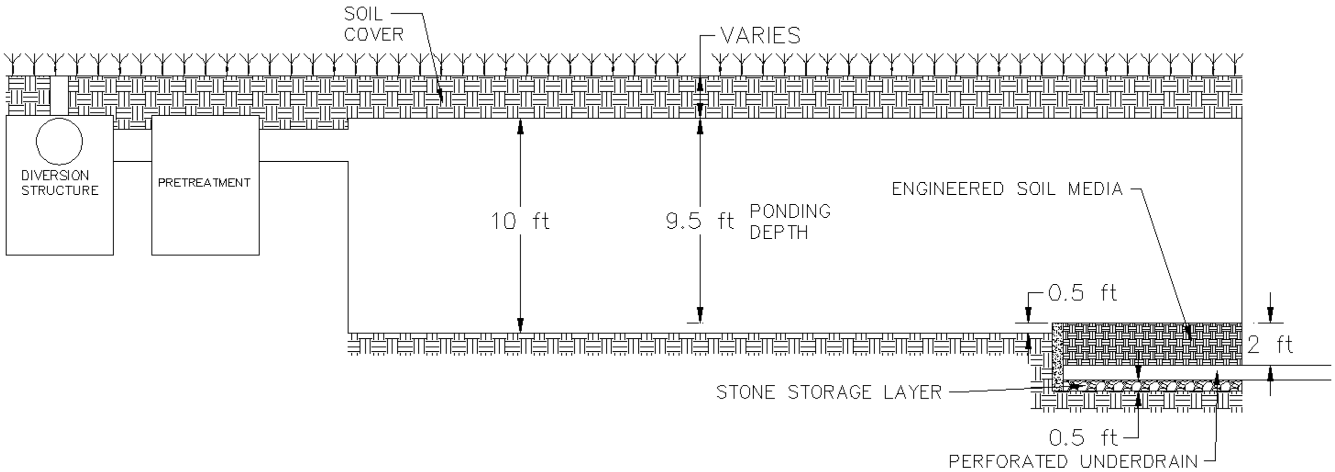

Figure 3-16. Subsurface MUTA (subsurface, biofiltration) cross section.

3.2.2.3 Canyon-based MUTAs (off-line)

The canyon-based MUTAs modeled as part of this WMP are off-line GI that receives diverted runoff into the treatment area located at or adjacent to an existing outfall, frequently within disturbed or developed canyon areas. Site visits of potential canyon-based MUTA locations were conducted to assess the feasibility of implementing the projects (see section 2.3). Due to siting constraints, two placement scenarios were considered feasible: (1) the MS4 permitted outfall is assumed to be capable of relocation to the location of the MUTA outfall, and (2) the treated outflow from the MUTA will reenter a hardened channel immediately downstream from the existing outfall. All canyon-based MUTAs were assumed to be located at the surface, with properties and performance most similar to biofiltration GI. Table 3-7 summarizes the assumptions and sensitivity analyses conducted to establish robust input parameters for canyon-based MUTAs, with the exception of the MUTA located adjacent to Auburn – Auburn Wightman 1 (MUTA 4705_IS_2) that was parametrized according to the Preliminary Design Report for Auburn Creek Channel Restoration (San Diego 2017). Additional detail is presented in section A.2 in appendix A. A representative cross section of the modeled canyon-based MUTAs is presented in Figure 3-17.

Table 3-7. Significant canyon-based MUTA model assumptions

Parameter	Assumption	Source/Rationale
Drainage Area Assumptions		
Maximum Modeled Drainage Area	4.0% MUTA-to-drainage area ratio.	Large drainage areas could overwhelm GI; no increase in pollutant reduction is observed beyond selection ratio. See section A.2 in appendix A for analyses.
MUTA Routing	No nested routing between MUTAs.	MUTAs designed to fill to capacity from the drainage area assigned; overflow/outflow from upstream MUTAs arrives after the MUTA is full and is not assumed to be treated.
Inflow Assumptions		
Diversion Rate	MUTA-specific rate.	See section A.2 in appendix A.
MUTA Properties Assumptions		
Ponding Depth	0.75 ft.	San Diego BMP Design Manual (San Diego 2016a).
MUTA Footprint	Variable based on available footprint.	Geospatial analysis (section 2.1).
ET Multiplier	1.0.	Surface, ET modeled.
Infiltration Method	Green-Ampt.	SUSTAIN Manual (Shoemaker et al. 2009).
Media Depth (above Underdrain)	4.0 ft.	San Diego BMP Design Manual (San Diego 2016a)
Media Filtration Rate	2.0 inches per hour.	Based on 5 inches per hour as specified in the San Diego BMP Design Manual (San Diego 2016a) with a factor of safety of 2.5 applied to account for accumulation of fines and sediment from canyon walls.
Lining & Media Depth below Underdrain	Unlined; 0.5 ft.	City directive—no reduction in performance for MUTAs; San Diego BMP Design Manual (San Diego 2016a).

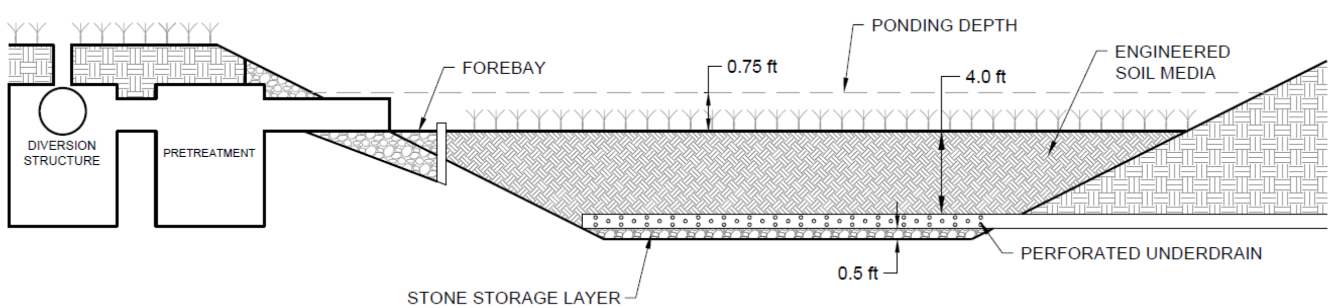

Figure 3-17. Canyon-based MUTA surface biofiltration section.

3.2.2.4 GI Effluent Data

EPA SUSTAIN was initially configured to use a percent reduction to represent the pollutant attenuation that occurs within a GI opportunity. The state of the practice indicates that this representation of GI performance does not account for the significant variability in percent reduction due to dynamics between inflow concentrations, media properties, and GI configuration. Therefore, as part of this study, modifications were made to the SUSTAIN algorithms to allow for the simulation of effluent EMCs as outflow from a particular GI type using the inclusion of a limiting EMC (effluent will never exceed the specified value).

The International Stormwater Best Management Practices (BMP) Database contains GI-specific EMCs that were filtered for studies both located in California and that contain an acceptable number of TZn observations (WERF 2016). Table 3-8 shows the different types of GI modeled with the associated limiting EMC representations. As a comparison, the average concentration of TZn generated by the highest pollutant-contributing HRU (impervious roadways) was extracted from the LSPC model results (1.05 milligrams per liter). This is the greatest potential pollutant contribution since the pollutant transport process within the SUSTAIN model is dynamic and there is typically a combination of tributary land uses; however, this comparison indicates that the selected GI will remove approximately 98 percent of the influent TZn loads.

Table 3-8. GI EMCs used in SUSTAIN models

Modeled GI Type	EMC Category	EMC Count	Limiting TZn EMC (mg/L)
Distributed Green Street Biofiltration	Bioretention	143	0.020
Distributed Green Street Suspended Pavement	Media filter	144	0.0179
Distributed Parcel-Based Surface Biofiltration	Bioretention	143	0.020
Distributed Parcel-Based Subsurface Biofiltration	Media filter	144	0.0179
Subsurface MUTA	Media filter	144	0.0179
Canyon-Based MUTA	Bioretention	143	0.020

Note: mg/L = milligram per liter.

As GI monitoring data for the City of San Diego becomes more readily available, the limiting effluent EMCs used for specific GI configurations and performance can be updated to represent a feedback loop and provide a refined quantification of progress towards compliance.

3.2.3 Cost Functions

The SUSTAIN model optimizes GI selection and sizing based on the two fundamental components inherent in all water quality compliance strategies: performance and cost. As part of this modeling effort, the cost functions previously developed for the WQIP were refined to reflect the enhanced understanding and accuracy for the suite of GI projects proposed. A review of current and local project cost estimates for similar GI types was conducted in the San Diego region, including contacting vendors and reviewing pertinent literature. Where local and applicable data were not available, best professional judgement was applied. All costs are reflective of the most up-to-date information available and are either consistent or more conservative than the City WQIP BMP cost database (San Diego 2016b).

The SUSTAIN cost function considers the total cost of planning, design, and construction of a particular GI opportunity, plus an estimated 20 years of O&M:

Total Cost = Planning + Design + Construction + O&M 20-years

The planning and design components are based upon the total construction cost, as those components are expected to scale up or down accordingly. The construction costs and O&M costs are highly dependent on the specific sizing and design of a particular GI opportunity and are described briefly in section 3.2.3.1 and section 3.2.3.2, respectively, with a more detailed breakdown presented in section A.2 in appendix A. Table 3-9 presents the major cost function components and related assumptions.

Table 3-9. Cost function components and assumptions

Cost Function Component	Assumption
Planning	10% of construction costs.
Design	20% of construction costs.
Construction	See section 3.2.3.1. 12% mobilization added onto total construction cost. 28% contingency added onto total construction cost.
O&M (20 years)	See section 3.2.3.2.

3.2.3.1 Construction Costs

The construction costs are highly variable based on the type of GI being considered. For this analysis, two different approaches were taken for each of the two major groups of GI that were modeled: distributed GI and MUTAs (subsurface and canyon-based).

Distributed GI Construction Costs

The distributed GI construction costs were primarily computed using the unit-area costs developed for the WQIP cost database (San Diego 2016b). The costs were assessed to contain an appropriate level of detail and accuracy with regard to this WMP, with one additional factor added to account for the cost associated with extending or adding storm drain infrastructure to tie biofiltration/suspended pavement underdrains to the existing system. The underlying soils in the study area have low infiltration rates and require that underdrains be implemented to ensure appropriate drawdown time and proper function. The farther a proposed GI opportunity is located from the existing infrastructure, the longer the required pipe length is and the larger the associated costs will be. The distance from the proposed GI centroid to the nearest existing storm drain asset varies with the number and extent of distributed GI projects selected in a particular catch basin; therefore, a unit cost or pipe length per square foot of GI was developed. For the selected GI, the average cost of construction, including mobilization and contingency, is $78 per square foot. A full description of the development of the distributed GI cost function is provided in section A.2 in appendix A.

MUTA Construction Costs

The cost functions for MUTAs developed for the WQIP cost database were generic in nature and did not characterize the types of MUTAs proposed for this WMP, nor did they contain an appropriate level of detail for specific cost components (e.g., diversion structure, acquisition costs, or permitting). Due to the wide variance in potential costs associated with regional-scale projects, cost estimates for MUTAs require site-by-site customization to accurately represent each site's configuration and operational needs. A total of 82 individual cost functions were developed to reflect the nuances for each of the 82 MUTA opportunities modeled in the watershed. The major additions and modifications to the WQIP construction costs for the WMP reflect the enhanced understanding of actual costs associated with MUTA implementation, including the following components:

1. MUTA configuration-based costs (e.g., surface or subsurface unit, landscaped or paved surface).
2. Diversion structures—A diversion cost function was developed to estimate the capital and O&M costs associated with various diversion structure sizes, with appropriate unit costs for the major components (e.g., diversion structure, pump station, pretreatment, and O&M) incorporated.
3. Pretreatment structures—Pretreatment for gross solids and trash is required for the successful operation and maintenance of MUTAs; costs associated with pretreatment were added.
4. Pump requirements—Pump costs were assigned to each MUTA based on the identified pump type (see section A.2 in appendix A). The cost varies with the specified flow rate.
5. Excavation over subsurface MUTA—WQIP cost functions accounted only for the volume of the MUTA itself and not for any additional excavation needed to place the MUTA in a functional location. Many MUTA opportunities are proposed to be subsurface GI with the top elevation located several feet below ground to allow for gravity flow from the storm drain system, which will require additional excavation and backfill volumes.
6. Acquisition costs—MUTAs located on private parcels were assumed to require additional acquisition costs. It was assumed that the City would purchase an easement on private property rather than acquire the entire parcel (e.g., parking lot or field areas). A cost of $32 per square foot was applied to MUTA footprints with a 10-percent buffer applied.
7. Environmental permitting requirements (e.g., major or minor permitting costs associated with canyon-based MUTAs).

MUTA costs are highly variable due to the site-specific components needed; however, the average cost of MUTA construction, including contingency and mobilization, is $169 per square foot. A full description of the development of MUTA cost functions is provided in section A.2 in appendix A.

3.2.3.2 Operations and Maintenance Costs

The representation of O&M costs was updated for the WMP to reflect the updates made to the City of San Diego WQIP cost database following the completion of the WQIP models (San Diego 2016b). The costs incorporated were for 20 years of O&M efforts and include the personnel, materials, and equipment needed for one entity to properly maintain distributed GI and MUTAs over that time period. Table 3-10 summarizes the O&M costs for each specific GI type.

Table 3-10. O&M cost assumptions

GI Type	Cost Unit	Assumption
Distributed Biofiltration	$42.00 per sq. ft.	WQIP Cost Database
Distributed Suspended Pavement	$35.80 per sq. ft.	WQIP Cost Database
Subsurface MUTA	$45.67 per sq. ft.	Average O&M cost for the City of Lakewood Bolivar and Mayfair GI
Canyon-based MUTA	$35.41 per sq. ft.	WQIP Cost Database

Sources: Tetra Tech 2016a, 2016b.

3.2.4 GI Model Update Implications (versus WQIP)

The representations for GI in the WMP far surpass those modeled as part of the WQIPs in terms of both resolution and scale. The identification and explicit representation of each distributed GI and MUTA opportunity allow for site-specific characteristics to be incorporated into the optimization modes, driving both pollutant removal and cost. The following important updates were included as part of the WMP:

- Explicit representation of each distributed GI and MUTA opportunity, including delineated drainage areas to each opportunity
- Modeling and optimization at the catch basin inlet scale
- Distributed GI shifting away from permeable pavement to bioretention
- Distributed GI accounting for the cost needed to tie the underdrain into existing infrastructure
- Inclusion of private MUTAs and canyon-based MUTAs
- Highly detailed MUTA characteristics, including diversion rates, pumping needs, top excavation, acquisition of private easements, and the cost needed to tie the underdrain into existing infrastructure
- Watershed-wide optimization for all solutions simultaneously

Additional detail on each of the updates to the GI models is presented in appendix A. The water quality optimization model results are included in section 3.3, with a discussion of model updates in the context of the recommended solution.

3.3 Water Quality Model Results

The solution generated by the water quality and GI optimization models identified a total of 18 subsurface MUTAs (10 public MUTAs and eight private MUTAs), one public canyon-based MUTA, and 561 catch basin inlet drainage areas with selected distributed GI to reach the final TMDL compliance target for TZn. The projects selected to meet the water quality target account for the water quality benefits provided by existing GI (e.g., 43rd and Logan, Beta Street, and Memorial Park) with no additional costs (because of the assumption that the construction and O&M costs are already reflected in City planning). Overall, the GI projects selected as part of the watershed-wide optimization demonstrate the benefit of strategic placement to provide coverage for a significant portion of the watershed (Figure 3-18). A summary of the watershed-wide water quality benefits attributed to each GI type is provided in Table 3-11. These results indicate that the optimization model is successful at eliminating unnecessary treatment redundancy when downstream, more cost-effective opportunities are available.

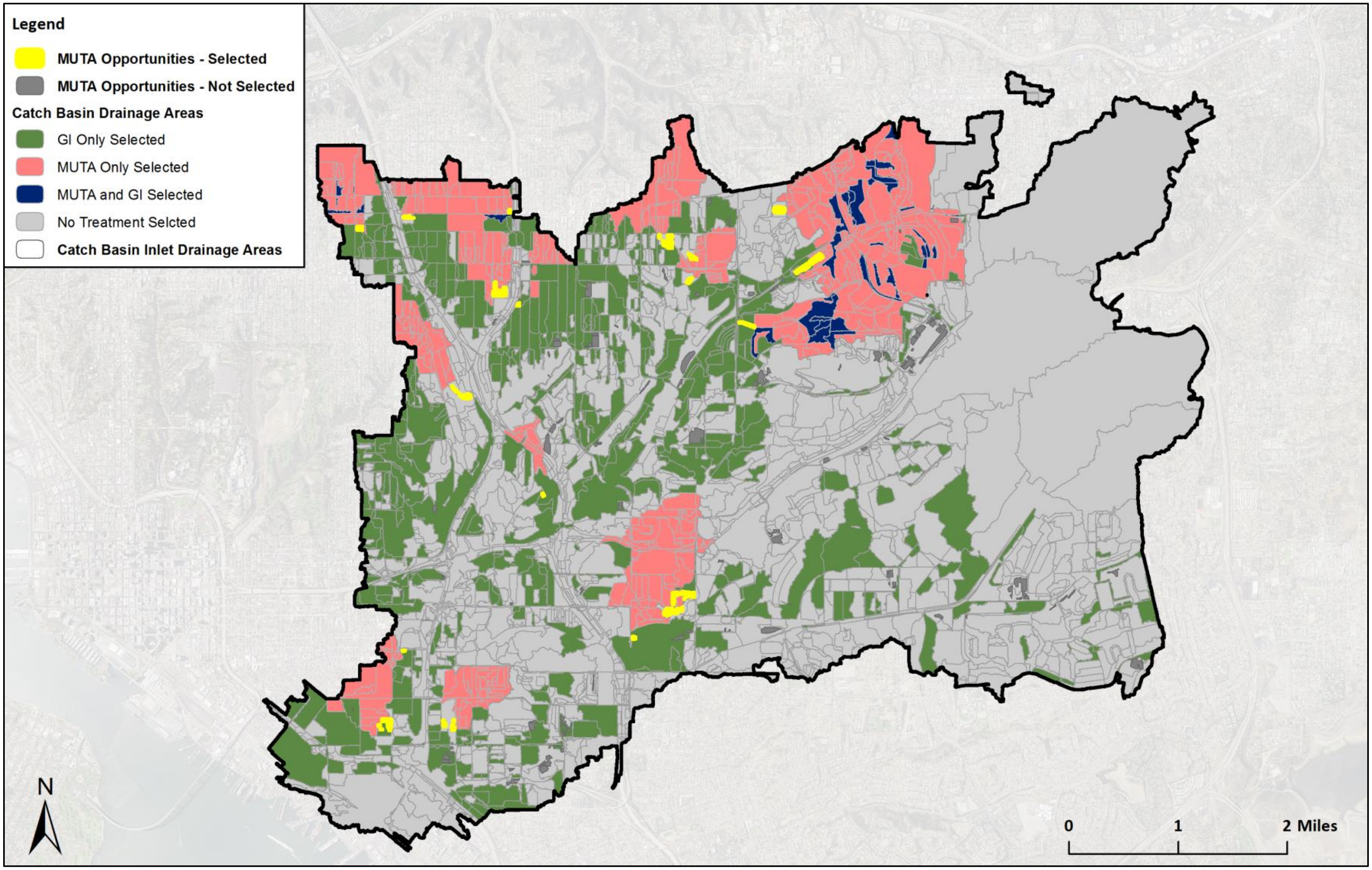

Figure 3-18. Selected GI and tributary catch basins.

Table 3-11. Summary of GI opportunities selected to achieve the TZn load reduction target

GI Type	Number of Opportunities	Opportunities Selected	Percent Projects Selected	Total TZn Load Reduction (lbs/yr)	Percent of Total Load Reduction
Total Distributed GI	**1,186**	**561**	**47%**	**369.6**	**42%**
No Downstream MUTA	489	266	55%	202.0	23%
Tributary to MUTA	697	295	42%	167.6	19%
Tributary to Selected MUTA	517	41	7%	10.0	1%
MUTAs	**82**	**19**	**23%**	**503.6**	**58%**
Public	50	11	22%	277.1	32%
Private	32	8	25%	226.5	26%
Existing Projects[a]	3	3	100%	1.6	0.1%
Total	**1,271**	**582**	**46%**	**874.8**	**100%**

Note:
[a] Memorial Park MUTA ID = 4501_2; 43rd & Logan Inlet IDs = 4902090586, 4902090585, 4902090583; Beta Street Inlet ID = 4901090531.

Figure 3-19 shows the cumulative load reduction and total cost (including O&M and acquisition costs, which is consistent with the project selection and optimization algorithms) for each of the individual selected projects ranked by efficiency. Locations where there are larger increases in load reduced and cost correspond with a MUTA. The distribution of GI and MUTAs throughout the entire efficiency range ($170,000 to $592,000 per pound of TZn removed) emphasizes that the results are not skewed towards one project type over the other. This confirms that the optimization is driven by specific project opportunities, design specifications, pollutant loading, and availability of nested treatment.

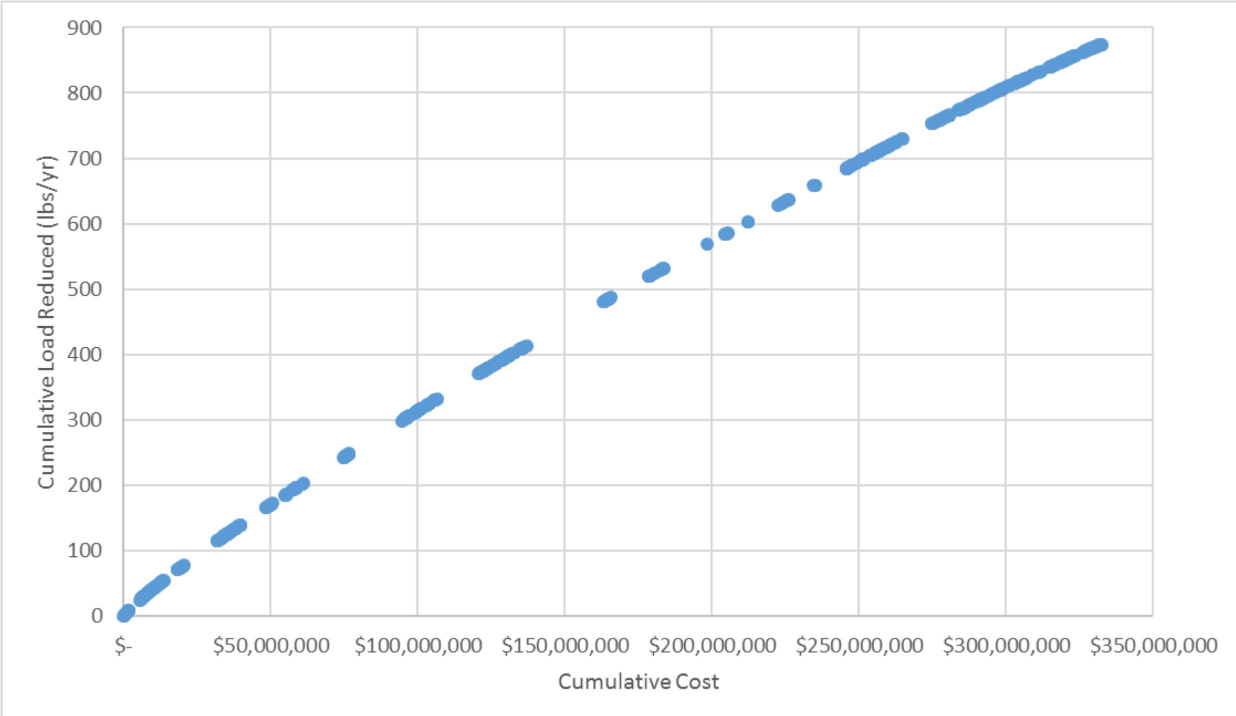

Figure 3-19. Load reduction and total cost ranked by efficiency.

Selected MUTAs

The water quality analyses resulted in the selection of 19 MUTAS, 11 of which are owned by the City and eight of which are privately owned. Eighteen (18) of the MUTAs that were selected were subsurface biofiltration projects, which is reflective of the additional storage depth provided in subsurface units (9.5 ft of ponding depth) when compared to the surface, canyon-based biofiltration MUTAs (0.75 ft of ponding depth). The single canyon biofiltration MUTA selected is located adjacent to the Auburn – Auburn Wightman 1 stream restoration project and was represented per the Preliminary Design Report for Auburn Creek Channel Restoration developed in parallel to the WMP (San Diego 2017). Figure 3-20 shows the drainage areas to each of the selected MUTAs as well as the location of the MUTA within the watershed. A summary of the MUTAs selected, along with the modeled water quality benefits and significant project characteristics, are presented in Table 3-12. Several of the MUTAs are constrained by either feasible diversion rate (10 MUTAs), available footprint area (two MUTAs), or both the diversion rate and footprint area (four MUTAs). These results indicate that the selected MUTAs are placed in strategic locations that provide maximum inflow and pollutant loading that can feasibly be managed given the site-specific conditions (e.g., diversion rate and footprint area).

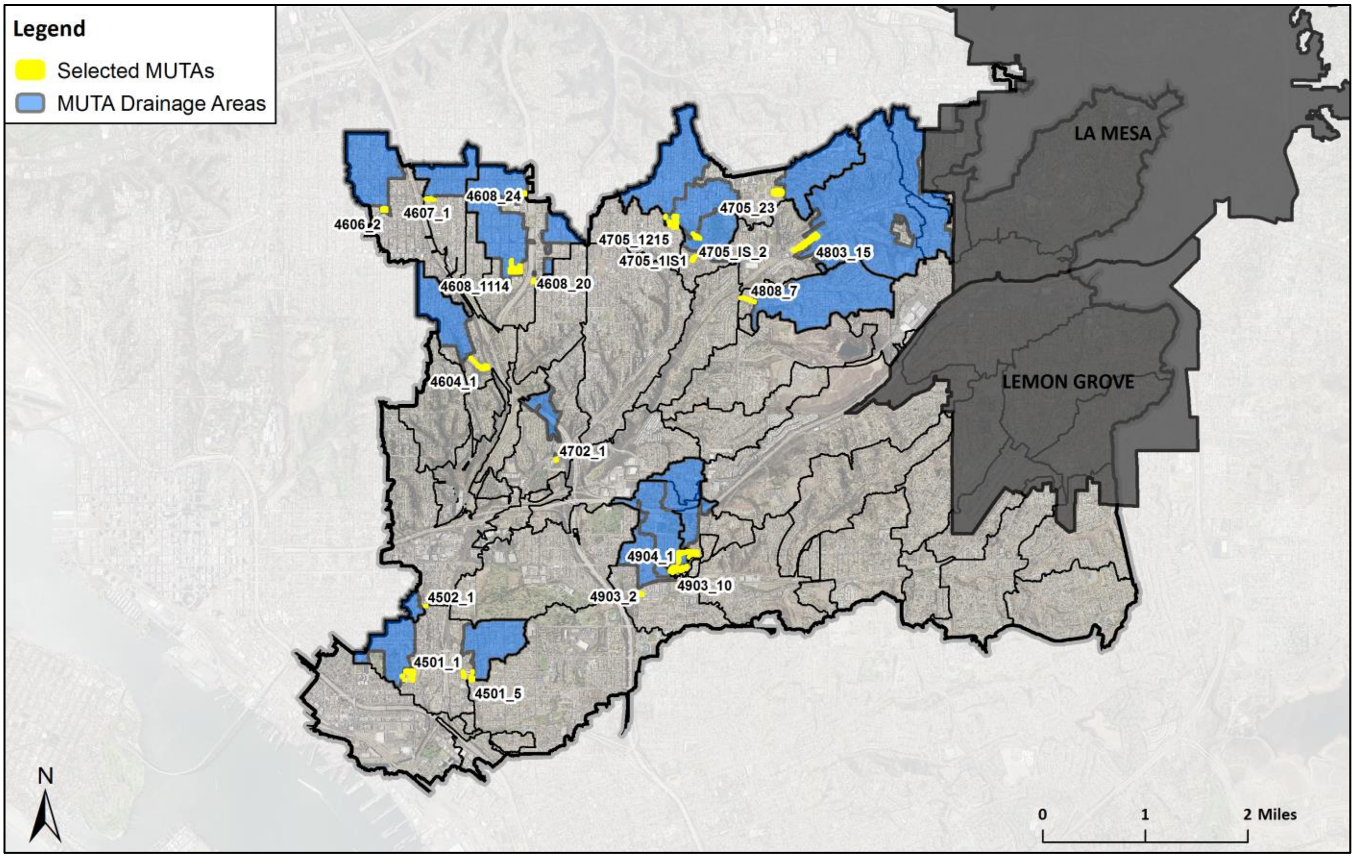

Figure 3-20. Selected MUTAs and tributary drainage areas.

Table 3-12. Selected MUTA characteristics

MUTA ID	Ownership	TZn Load Reduction (lbs/yr)	MUTA Footprint (ac)	MUTA Volume (ac-ft)	CIP Cost ($ million)	Acquisition Cost ($ million)	Total 20-Year Cost ($ million)[a]
4501_1	Public	22.6	0.42	4.49	$5.96	N/A	$9.72
4501_5	Private	25.2	0.45	4.74	$6.31	$1.06	$10.28
4502_1	Private	6.7	0.11	1.15	$1.37	$0.26	$2.95
4604_1	Public	25.3	0.45	4.78	$6.25	N/A	$10.45
4606_2	Private	37.2	0.72	7.63	$9.30	$1.72	$14.99
4607_1	Private	25.9	0.42	4.48	$5	$1.01	$8.57
4608_1114	Public	39.3	0.65	6.88	$8.19	N/A	$13.58
4608_20	Public	14.5	0.27	2.89	$3.76	N/A	$5.84
4608_24	Public	15.7	0.25	2.63	$2.82	N/A	$4.66
4702_1	Private	15.5	0.13	1.43	$1.80	$0.32	$3.57
4705_1215	Public	50.6	0.94	9.91	$10.64	N/A	$17.78
4705_1IS1	Public	12.6	0.23	2.46	$2.52	N/A	$4.27
4705_IS_2	Public	1.7	0.11	0.32[b]	$0.28	N/A	$0.50

MUTA ID	Ownership	TZn Load Reduction (lbs/yr)	MUTA Footprint (ac)	MUTA Volume (ac-ft)	CIP Cost ($ million)	Acquisition Cost ($ million)	Total 20-Year Cost ($ million)[a]
4705_23	Public	37.5	0.68	7.24	$8.30	N/A	$13.77
4803_15	Private	67.0	1.29	13.66	$14.43	$3.07	$26.16
4808_7	Public	23.5	0.52	5.55	$5.64	N/A	$8.52
4903_10	Private	32.5	0.54	5.70	$7.23	$1.28	$12.88
4903_2	Private	16.6	0.30	3.21	$3.85	$0.72	$6.72
4904_1	Public	38.4	0.52	5.47	$7	N/A	$11.26
Total		**508.3**	**9.03**	**94.5**	**$110.63**	**$9.4**	**$186.49**

Notes: ac = acres; ac-ft = acre-foot; lbs/yr = pounds per year.
[a] Total 20-year costs include CIP, acquisition, planning and design, and 20-year O&M costs.
[b] Surface MUTA volume includes the void space in the media and underdrain gravel.

Distributed GI Projects

There were 561 catch basin inlet drainage areas that had distributed GI opportunities selected as part of the optimal water quality solution. Within each catch basin, there was often more than one GI selected. Table 3-13 summarizes the type and magnitude of selected distributed GI projects across the entire watershed.

Table 3-13. Selected distributed GI characteristics

GI Type	GI Selected	Total GI Footprint (ac)	Average GI Footprint (sq. ft.)	Total GI Volume (ac-ft)	Total TZn Load Reduction (lbs/yr)	Total Cost ($ million)
Biofiltration	3,352	24.2	315	34.9	259.7	$58.3
Parcel-based GI	6	2.1	15,385	1.1	8.4	$1.5
Suspended Paving	165	6.1	1607	14.6	105.2	$24.2
Total	**3,523**	**32.5**	**401**	**50.6**	**371.3**	**$84.0**

Notes: ac = acres; ac-ft = acre-foot; lbs/yr = pounds per year.

Many of these GI opportunities were concentrated in high pollutant-generating areas or where there were significant opportunities for GI placement. Figure 3-21 illustrates the distribution of selected GI footprints within each of the selected catch basins, demonstrating that there are far more catch basins selected with smaller footprints and fewer with more concentrated GI implementation required.

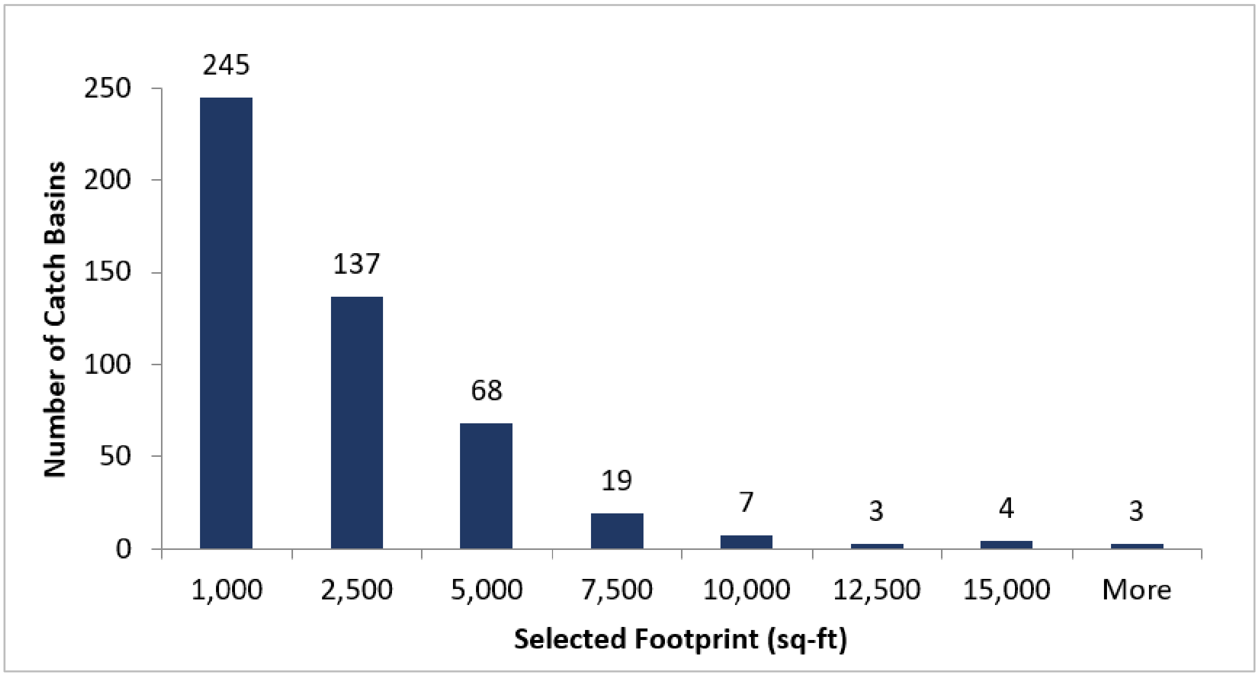

Figure 3-21. Histogram of GI projects recommended in selected catch basins.

This variability in the extent to which GI projects are selected within the watershed can be categorized into three overall levels of implementation: inlet scale, street scale, and neighborhood scale. Figure 3-22 demonstrates each of the primary implementation categories and highlights how implementation strategies can vary across each one (e.g., inlet-based biofiltration versus a complete green street).

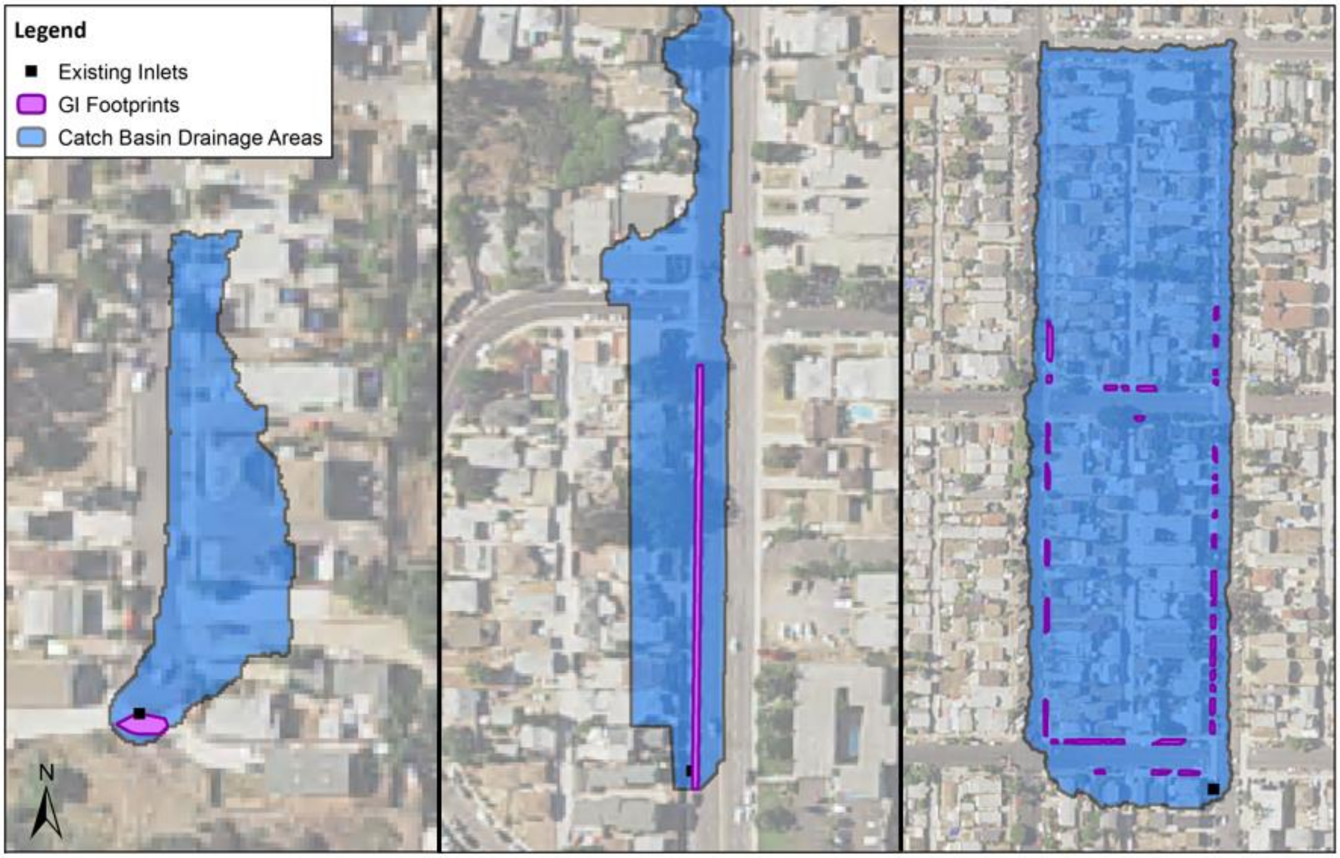

Figure 3-22. GI selection levels (inlet scale, street scale, and neighborhood scale).

Finally, the results indicate that the selection of GI projects is heavily impacted by the capacity and/or availability of the downstream MUTA to provide the required load reduction for the total area tributary to it. Of the catch basins that were selected for GI projects, nearly 93 percent (520 catch basins) were not tributary to a downstream selected MUTA, indicating that the GI projects within these catch basins were sufficient to provide the water quality benefits needed where there were no other opportunities downgradient or where a MUTA was not the most cost-effective solution. Of the distributed GI projects that were tributary to a downstream MUTA, approximately 89 percent were tributary to a MUTA that was limited in capacity for either the diversion rate or footprint area available.

The results from the optimization provide the City with specific placement of GI within each catch basin, as well as flexibility on design and implementation for each of these projects to account for potential site constraints and/or feasibility concerns. A comprehensive list of the distributed GI projects is included in the web application and in the results database provided with this report. The individual GI projects are grouped into bundles, which are presented in section 7.1.

4.0 Flood Control Assessment

Rick Engineering Company and sub-consultants created an existing condition H&H model that was used as the basis for proposed recommendations. The existing condition H&H model highlighted several areas where the existing drainage infrastructure (i.e., inlets, storm drain, culverts, and/or channels) would be considered deficient in terms of flood control.

This section presents the following:

- Details on the hydrologic methodology and modeling (section 4.1)
- Details on the hydraulic methodology and modeling (section 4.2)
- Existing condition H&H model results (section 4.3)
- Proposed condition results (section 4.4)

4.1 Hydrologic Methodology and Modeling

4.1.1 Rainfall

Point precipitation data for the Chollas Creek watershed was obtained from the National Oceanic and Atmospheric Administration (NOAA) Atlas 14 Precipitation Frequency Data Server (PFDS) (NOAA 2011). This data was selected because it has a longer period of record than the data presented in the *City of San Diego Drainage Design Manual* (1984) to best reflect the historical rainfall and flooding events specific to the study area. Data was obtained for three rain gages within the study area: Chollas Reservoir, San Diego NWS, and Sweetwater Reservoir (see Table 4-1).

Table 4-1. San Diego County local 24-Hour NOAA precipitation depth (inches)

Gage	Lat	Long	Period of Record	2-yr, 24-hr Precip. (in.)	10-yr, 24-hr Precip. (in.)	50-yr, 24-hr Precip. (in.)	100-yr, 24-hr Precip. (in.)
San Diego NWS	32.7136	-117.17	10/1850–12/2004	1.77	2.69	3.63	4.04
Sweetwater Reservoir	32.6833	-117	7/1888–7/2006	1.78	2.74	3.77	4.23
Chollas Reservoir	32.7333	-117.067	1/1926–1/2003	1.85	2.95	4.07	4.55

Source: NOAA 2011.
Notes: in. = inches; Lat = latitude; Long = longitude.

4.1.1.1 Rainfall Pattern

Setting up a storm simulation in EPA's Storm Water Management Model (SWMM) requires a hyetograph to distribute rainfall across the subcatchments over the storm duration. Two options were considered:

- SCS Type B distribution as presented in the *City of San Diego Drainage Design Manual* (1984). This is required for watershed hydrology studies larger than 1 sq. mi.
- Nested storm distribution based on USACE's guidance, *Hydrologic Analysis of Ungaged Watersheds Using HEC-1* (USACE 1982).

A 24-hour storm duration was selected for the study. The SCS Type B distribution was not suitable for the study because it underestimates the peak runoff generated and does not provide the critical peak intensities to evaluate potential deficiencies in drainage infrastructure for the subcatchments draining to inlets. The nested storm distribution was selected because it meets this study's goals. The nested storm provides the peak intensities necessary to assess drainage infrastructure at the inlet scale (up to 5-minute rainfall intensities) while preserving the total volume of runoff generated from the storm duration.

4.1.1.2 Rainfall Hyetograph Development

To develop the unit intensity duration relationship for the Chollas Creek study, NOAA precipitation depth data from three rain gage stations within the study area were obtained for the 2-, 10-, 50-, and 100-year, 24-hour storm events. Rainfall data obtained from the NOAA PFDS was used to generate an updated intensity-duration relationship for use within the Chollas Creek watershed. The 100-year precipitation depth data from these rain gages is shown in Figure 4-1 (NOAA 2011).

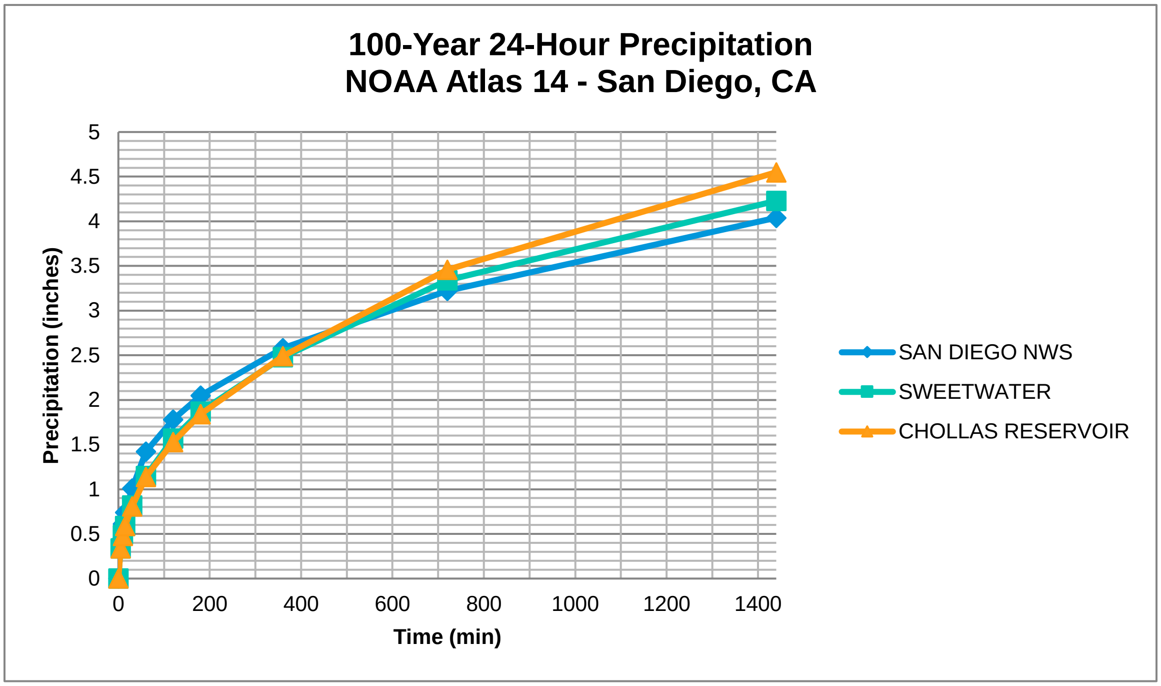

Figure 4-1. 100-year, 24-hour precipitation depth.

The rainfall intensity-duration data from NOAA were reviewed, and the resulting rainfall intensity-duration rainfall relationships were plotted for comparison (NOAA 2011). The results showed that the rainfall intensity-duration relationship yielded parallel lines for most gages (Figure 4-2).

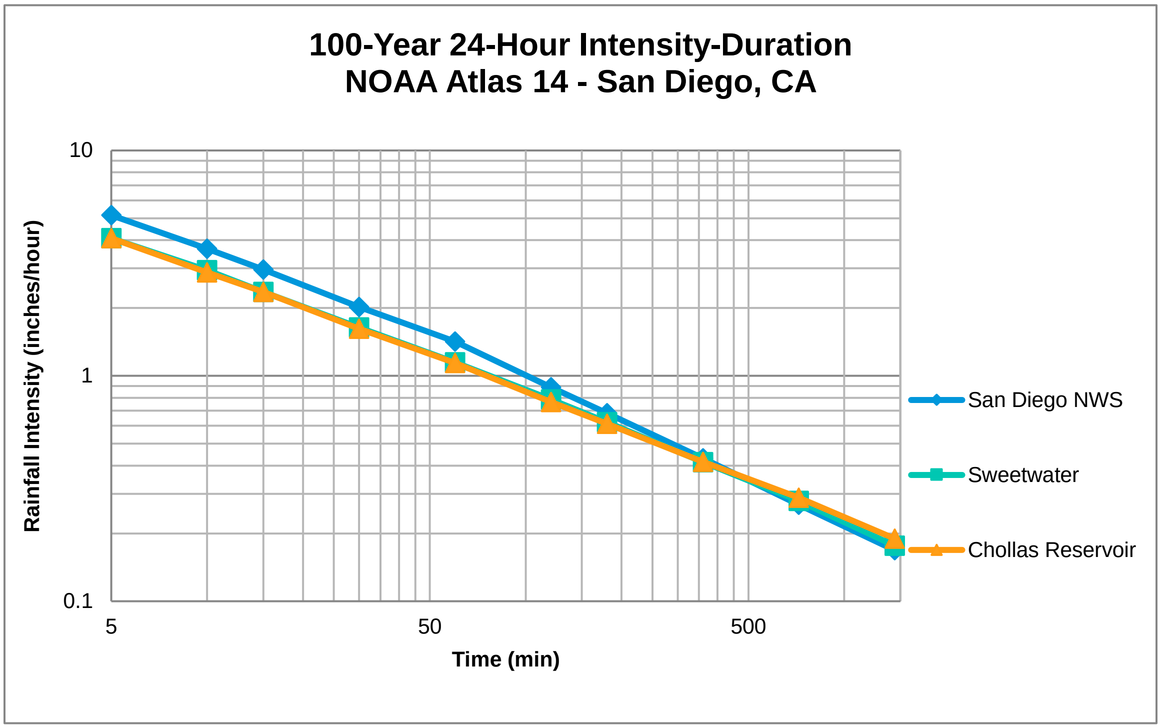

Figure 4-2. 100-year intensity-duration relationship.

Since the intensities plotted showed similar patterns for all three gages, it was determined that the Chollas Reservoir gage would be applied for the entire study area. The precipitation was entered in 5-minute increments. Certain durations were obtained directly from NOAA Atlas 14 as seen in the rainfall data shown in section B.4-2 in appendix B (NOAA 2011). Precipitation in between the given values was determined by log-log interpolation. A center-distributed hyetograph consistent with the City of San Diego standards was created, as seen in Figure 4-3.

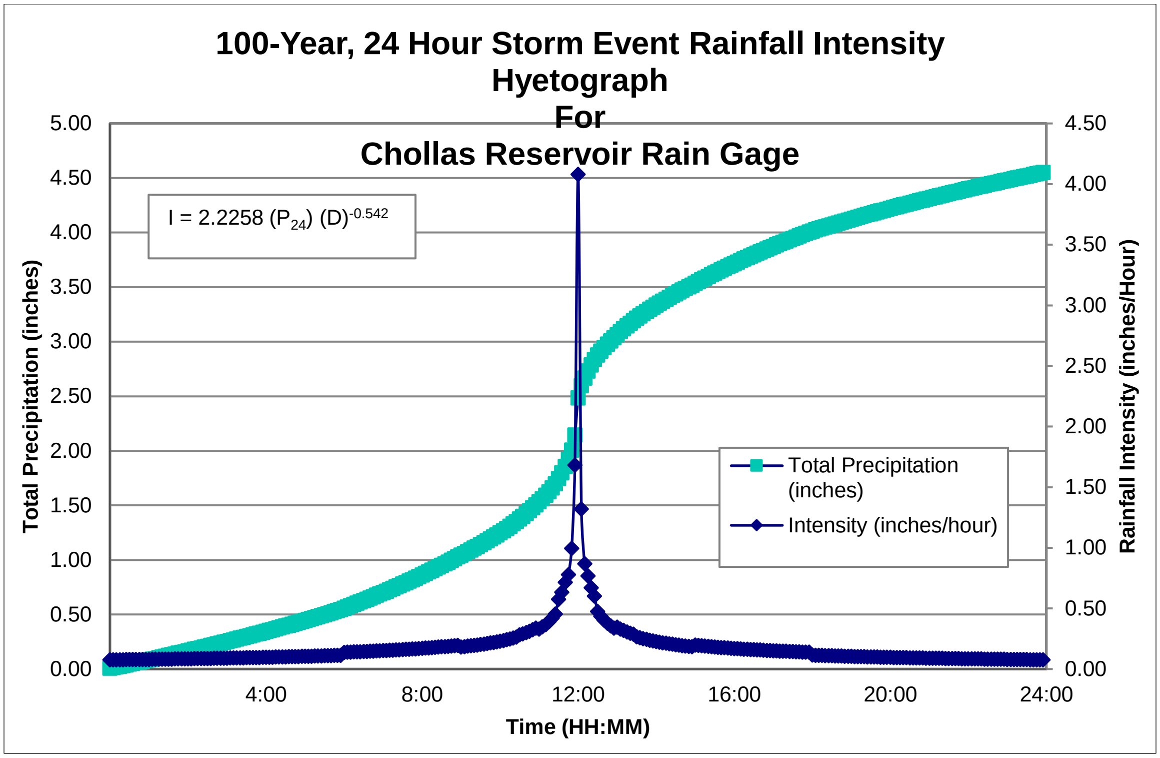

Figure 4-3. 100-year, 24-hour intensity hyetograph.

4.1.2 Hydrologic Modeling

The developed hyetographs were imported into PCSWMM as a DAT file with 5-minute time steps. Both the existing and proposed condition hydraulic models used the hyetographs to generate the runoff hydrographs for each subwatershed. See section 4.2 for more information regarding the hydraulic analysis methodology and modeling approach.

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

Each subcatchment is connected via a conveyance node and link network (e.g., inlets and pipes), which routes runoff generated towards the outlet of a subwatershed. See section 4.2 for more information regarding the hydraulic analysis methodology and modeling procedures.

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

Soil parameters were obtained using appendix G of the City of San Diego's *Storm Water Standards Manual* (San Diego 2016a). The distribution of hydrologic soil groups within the Chollas Creek watershed is based on SANDAG's ArcGIS feature class for National Resources Conservation Service hydrologic soil groups (see section B.4-2 in appendix B for a hydrologic soils group exhibit for the study area). Areas with an "unknown" soil classification were assumed to be type D soils for this analysis.

4.2 Hydraulic Methodology and Modeling

4.2.1 Flow Routing

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

Steady Flow routing was judged to be inappropriate for modeling this study area as it does not actually represent flow routing per a defined time step during the simulation. It is the simplest computation method that translates the inflow hydrographs directly downstream without any change in shape and simply uses the normal depth equations to relate flow rates, depths, and cross-sectional areas of the conveyance network. This method does not represent any backwater effects or pressurized flow, and does not take into account the user-defined computational time steps during the storm simulation.

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

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

4.2.2 Conveyance Material and Manning's Roughness Coefficients

In PCSWMM, the Manning roughness values are associated with a conveyance material database. Each channel, pipe, and conduit in the 1-D portion of the model must have a material code assigned to it; in that way, the resistance to flow and energy losses along the conduit length can be calculated. Table 4-2 lists the material types and the associated Manning's "n" value assigned to each material code in the models. The material codes were developed based on the material of construction defined in the storm water GIS data set provided by the City of San Diego. The Manning's roughness values were assigned based on the *City of San Diego Drainage Design Manual* (San Diego 1984). Manning's overland "n" values were selected using the *Storm Water Management Model Reference Manual Volume I - Hydrology* as reference (Rossman 2016).

Table 4-2. Conveyance material abbreviations and Manning's roughness coefficients

Material	Roughness	Description
ABM	0.018	Air Blown Mortar
ACP	0.013	Asbestos Cement Pipe
APC	0.013	Alternative Pipe Culvert
CAP	0.022	Corrugated Aluminum Pipe
CIPCP	0.015	Cast-in-Place Concrete Pipe
CMP	0.024	Corrugated Metal Pipe
CMPC	0.024	Corrugated Metal Pipe Coated
CONC	0.018	Concrete
CONCF	0.015	Concrete Finished
CP	0.015	Concrete Pipe
CPP	0.013	Corrugated Plastic Pipe
CSP	0.015	Corrugated Steel Pipe
EARTH	0.075	Earth
HDPE	0.01	High-Density Polyethylene
MASONRY	0.024	Masonry
PVC	0.012	Polyvinyl Chloride
PVCP	0.012	PVC Pipe
RC	0.013	Reinforced Concrete
RCP	0.013	Reinforced Concrete Pipe
ROCKOS	0.06	Rock Lining in Channel (assumed)
SPRIB	0.013	Spiral Rib (assumed to be RCP based on field inspection)
STEEL	0.017	Steel Pipe
SWALE	0.06	Swale
UNK	0.06	Unknown

While the model input information was being verified globally in a GIS environment, it became apparent to the Project Team that the inventory list provided by the City did not include all materials in the provided inventory files. Field inspections were conducted to identify material in certain areas, but it was infeasible to address every area because of time and physical constraints. An assumption of reinforced concrete pipe was applied to any remaining inventory fields that were not field-verified, had no as-built drawings, or were not included in the original GIS files.

4.2.3 Storm Water Inlet Modeling

The existing storm water conveyance system includes 3,062 inlet or catch basin structures for the collection of surface runoff from streets, ditches, swales, and overland flow. Undersized storm water inlets can limit the efficiency of the existing conveyance infrastructure to collect and convey runoff during storm events. The flow interception capacity of each inlet type was estimated based on the inlet structure type, location, street slope, and structure dimensions, following the 2014 *County of San Diego Hydraulic Design Manual* criteria (CSDDPW 2014). A 50-percent reduction factor was not applied for grated catch basin inlets. Flow interception at each inlet was included in the PCSWMM model with inflow rating curves as a function of street flow depth. The portion of storm water flows exceeding the capacity of the inlet was bypassed to the street conveyance in the 2-D models.

4.2.4 Coupled 1-D/2-D Model

The development of the 1-D hydraulic model includes the pipe/open channel drainage network for all pipes 18 inches and larger. Pertinent pipes having less than 18-inch diameters also were included in the model if they were judged to represent significant hydraulic connections or hydrologic loading points. Key hydraulic structures such as culverts, outfalls, and pipes also were included in the 1-D model, as were hydraulic structures that control the flow entering or discharging from the primary system.

The surface storage and conveyance represented by the streets and other surfaces are accounted for in the 2-D hydraulic model of the Chollas Creek watershed. The 2-D model was generated from an array of mesh (or grids) of varying resolution to represent the surface conveyance. A 10-ft resolution directional mesh was used to define the drainage patterns of streets and roads. A 10-ft resolution directional mesh was also used for open channel and canyon areas, and a 20-ft resolution hexagonal mesh was applied globally to the remaining sections of the watershed. The mesh was developed from a high-resolution DEM data set by sampling elevation data at points with a varying spatial resolution and was used to preserve the preferential flow paths and street conveyance that are part of the overall storm water conveyance system.

The two systems were coupled together at points where exchange of storm water between the surface conveyance system and the engineered storm water conveyance system could occur—typically at storm drain inlets, headwalls, and outlet structures. The models were linked between nodes in the 1-D minor system (subsurface) and the 2-D major system (surface). The coupled models were then run and solved simultaneously, representing the storm water conveyance and storage on the street and in the storm water collection and conveyance system. The coupling of the 1-D and 2-D models allowed for bidirectional exchange of volume between the 2-D surface conveyance system and the engineered 1-D storm water system. By coupling the models together and solving the hydraulics simultaneously, the dynamic exchange of runoff between the surface flow and storm water conveyance system facilities is described.

The coupled 1-D/2-D model was executed using the runoff hydrographs resulting from NOAA rainfalls for the 2-, 10-, 50-, and 100-year storm events based on existing land uses to assess the current system's deficiencies.

A GIS exhibit of the curb height data is included in section B.4-2 in appendix B, based on the results of a citywide sidewalk assessment (by others). A GIS exhibit of the surface DEM used to perform the 2-D analysis for the study area is also provided in section B.4-2 in appendix B.

4.3 Existing Condition

4.3.1 Existing Condition Model Methodology

Model results were obtained for the 24-hour storms at the 2-, 10-, 50-, and 100-year return period from the precipitation data obtained from NOAA Atlas 14 as discussed in section 4.1 of this report. The 24-hour storm events were judged to be the most pertinent storm events due to the volume of runoff generated and the peak flows observed at the main outfall of each subwatershed.

The GIS storm drain inventory provided was imported into PCSWMM and formed the basis of the 1-D conveyance portion of the watershed model. Rim elevations were sampled from the DEM, then extracted and processed from the LiDAR data to present storm drain profiles. Storm drain networks were visually inspected horizontally with reference to aerial imagery and vertically by viewing the storm drain profiles generated within the program to correct any erroneous data.

The DEM was also critical in developing the 2-D model surface to represent storm water flows in streets, channels, and canyon areas. A directional mesh was applied in these areas to represent the preferential direction of flow. This surface was coupled to the 1-D inventory to match the rim elevations at points of connection to the storm drain conveyance system.

The overall Chollas Creek watershed was divided into smaller study areas based on the subwatershed delineations from the WQIP to efficiently distribute the computational resources required for this scale of analysis. The inflow from portions of the subwatershed under the jurisdiction of other municipalities and agencies such as the City of La Mesa, the City of Lemon Grove, and Caltrans were conservatively estimated by a 1-D hydraulic model. This model included only the backbone pipe/open channel drainage system. Surface storage and overland flow were not quantified within these areas.

See section B-4.7 in appendix B for a summary of the hydrologic results of the single-storm model simulations at the main outfall location for each subwatershed.

The downstream portion of this study incorporated a potential impact analysis due to rising sea levels based on *California Coastal Commission Sea Level Rise Policy Guidance* adopted by the California Coastal Commission (CCC 2015). The integrated H&H model developed for the downstream subwatershed 4401 where Chollas Creek discharges into the San Diego Bay incorporated three scenario iterations for a 100-year storm event with tail water conditions reflective of rising sea levels projected for the year 2100. These scenarios include a tail water condition of 0 ft to represent the current mean sea level, a mid-range tail water condition of 5.6 ft, and a high-range tail water condition of 8.7 ft based on projected rise of 37 inches and 65 inches, respectively, at highest astronomical tide.

Refer to appendix B.4-2 for a more detailed description of the tail water conditions used in this study. For additional information on sea level rise, refer to the California Coastal Commission guidance document (CCC 2015).

4.3.2 Existing Condition Results

Modeling results highlight deficiencies in the LOS of the conveyance system within the study area. This is most obvious in the storm drain network, where a significant number of storm drain pipes identified in the inventory did not demonstrate capacity to convey the 100-year storm event. While reviewing the City's as-builts, the Project Team observed that a majority of the storm drain conveyance currently in place was designed in the early half of the 20th century, with some of the oldest as-built drawings dating to the 1920s. It is believed that those areas were not designed for the LOS currently required within the City of San Diego per drainage design standards.

Table 4-3 provides an overview of the results observed in the 100-year, 24-hour storm event and the capacity of the storm drain network.

Table 4-3. 100-yr, 24-hr storm summary of conveyance capacity

Storm Event: 100-yr, 24-hr			
	Pipe and Culvert		
Discharge vs. Capacity (%)	(Miles)	(Count)	%
<100	73.9	3,156	66%
100–150	26.6	776	24%
150–200	6.2	259	5%
> 200	5.6	214	5%
Total	**112.3**	**4,405**	**100%**

Refer to the maps in section B.4-5 of appendix B for more details on the 100-year model results.

4.4 Proposed Condition

4.4.1 Proposed Condition Methodology

The existing condition models were evaluated to highlight observed deficiencies in the conveyance network within the study area. All conveyance system improvements will be sized to convey the restricted 100-year storm flows present in the existing condition models. Previous modeling efforts had focused on increasing the conveyance capacity of the storm drain and channels in the study area to convey the unrestricted 100-year storm flows. During the initial modeling of Upper Chollas Creek, it became evident that upsizing all deficiencies throughout the system results in a significant increase in peak flow rates if not otherwise mitigated, resulting in a domino effect that would require upsizing all drainage conveyance infrastructure down to the San Diego Bay. Because of the significant impacts to downstream facilities that result from a traditional "unrestricted" approach, the methodology was revised in favor of a more balanced approach incorporating surface storage and detention to attenuate increases in the peak flow rates back to rates similar to existing conditions.

Subwatershed models were inspected to identify areas where flooding conditions were occurring to determine if it was because of inlet sizes, pipe sizes, or large tributary drainage areas without existing drainage facilities. Deficient inlets were addressed by proposing replacements with larger openings based on the amount of runoff on the surface calculated during the model simulations. Storm drain pipes identified as capacity-deficient based on the flow rate calculated during the simulation were upsized to accommodate the storm water flows in the system and to reduce surface ponding. Large tributary drainage areas flowing toward an inlet were mitigated by extending storm drain segments farther upstream and creating additional inlets to intercept additional surface flows. In addition, storm drain systems were shown to be realigned out from underneath private properties and structures, where feasible, and routed along the streets if positive drainage could still be achieved. Storm drain outfalls were also identified to be extended downstream to more defined low points, when applicable.

Detention locations were an integral part of the balanced approach to the flood control portion of this WMP, and these storage locations had potential to tie in with water quality MUTA locations. For the purposes of this project, detention volume was calculated by using the flow hydrographs generated at the identified areas during a proposed condition model simulation and mitigating the peak flow rate to a level comparable to those observed in the existing condition model where feasible.

To ensure the highest LOS of the storm drain system, emphasis must be placed on performing routine cleaning and maintenance on all storm drain inlets in the study area. This will ensure that trash and debris from the street, which could become lodged in grate and/or curb inlets, do not accumulate and interfere with storm water flows from entering the subsurface conveyance system for which these recommendations have been made.

4.4.2 Proposed Condition Results

Since portions of the existing storm drain system are severely undersized for the 100-year storm event, a traditional approach of upsizing existing facilities and installing new drainage facilities throughout the watershed would result in larger peak flow rates being delivered downstream and requiring further upsizing along the backbone systems (i.e., channels and culverts). Therefore, a balanced approach that integrates additional storage opportunities (i.e., detention) has been implemented, resulting in a reduction in the amount of storm drain facilities needing replacement, while also minimizing how much channel widening would be necessary throughout the numerous open channels within the watershed. The H&H modeling of the recommended improvements, including the benefits of additional storage being incorporated, are provided for each subwatershed within appendix B.

5.0 Restoration Assessment

5.1 Methodology

Two general stream restoration treatment types or scenarios were developed for the Chollas watershed based on the primary factors evaluated during initial selection and screening: Scenario 1 – Riparian/Wetland-Vegetated Channel; and Scenario 2 – Open Cobble Channel. The scenarios reflect two basic restoration types; one with a riparian-vegetated channel and embankments, and one with an open unvegetated cobble channel and riparian-vegetated embankments. Elements of freshwater marsh are also identified for the riparian-vegetated channel scenario, which apply to one of the candidate sites identified.

In assessing whether certain candidate sites could accept either one of the basic restoration treatment types, an emphasis is placed on the hydrogeomorphic factors of topography, hydrology, and substrate. These are perhaps the principal factors in determining the type of stream restoration that can be achieved in the Chollas watershed. Additional analysis will be required to determine the most appropriate restoration scenario for each of the 17 candidate restoration sites that were not removed from further analysis. Furthermore, the scenario may vary along the length of each restoration site. In general, the unvegetated cobble channel with riparian-vegetated embankments scenario is appropriate for most of the sites in the Chollas watershed due to the way water flows into and quickly through the watershed, much of which is influenced by topography.

Topography has a significant impact on the restoration treatment type, not only as an engineering constraint, in the case of steep-sloping and undercut banks, but also with respect to the overall gradient that affects the hydrology and substrate of the stream reach. General hydrologic factors considered in assessing stream restoration included frequency, duration, volume, and velocity of water entering and conveyed through the reach containing the candidate site. These factors were considered because they have an impact on channel configuration, scour potential, sediment transport, riparian habitat sustenance, and development of wetland conditions, among other issues. Substrate factors considered included general soil type and mapping unit, hydric rating, and substrate size.

5.2 Restoration Scenarios

5.2.1 Scenario 1–Riparian/Wetland-Vegetated Channel

The Riparian/Wetland-Vegetated Channel scenario generally consists of a trapezoidal-shaped channel with the potential to support riparian scrub, woodland, and forest habitat on the channel bottom and embankments, and wetland conditions within the channel bottom The scenario has a shallow gradient to promote lateral flooding and channel braiding, and a wider active floodplain area to promote sediment deposit and sorting, riparian vegetation recruitment and retention, and potentially, wetland conditions. This scenario is appropriate for the few candidate sites in Chollas where hydrology and soils are suitable, but also where there is lateral space available to widen the floodplain. In most cases, channel grading and the use of drop structures or other features would be required to dissipate flows and promote longer periods of inundation and saturation within the floodplain. Figure 5-1 provides a plan view and cross section of the basic riparian/wetland-vegetated channel scenario. Table 5-1 provides a summary of the plant palette considered for this scenario.

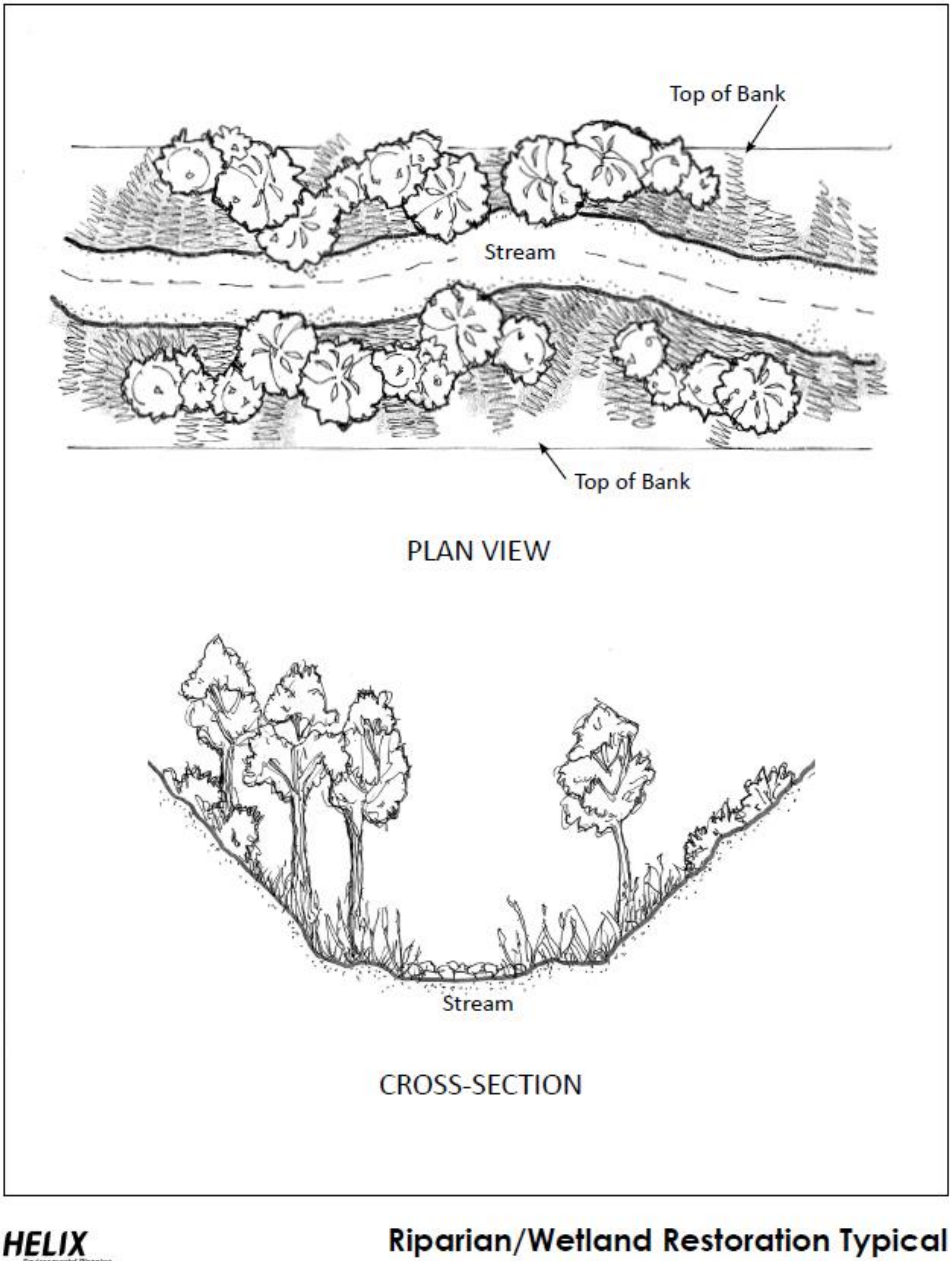

Figure 5-1. Riparian/wetland restoration typical.

Table 5-1. Riparian/wetland restoration planting palette

Scientific Name	Common Name
Ambrosia psilostachya	Western ragweed
Artemisia douglasiana	Douglas's mugwort
Artemisia palmeri	San Diego sagewort
Baccharis salicifolia	Mule fat
Baccharis sarothroides	Broom baccharis
Cyperus eragrostis	Tall flatsedge[a]
Eleocharis macrostachya	Pike rush[a]
Elymus triticoides	Beardless wild rye
Isocoma menziesii	Goldenbush
Iva hayesiana	San Diego marsh elder
Juncus acutus ssp. *leopoldii*	Southwestern spiny rush
Juncus bufonius	Toad rush
Leymus triticoides	Creeping wild rye
Platanus racemosa	California sycamore
Populus fremontii	Fremont cottonwood
Pluchea odorata	Salt marsh fleabane[a]
Salix exigua	Narrow-leaf willow
Salix gooddingii	Black willow
Salix laevigata	Red willow
Salix lasiolepis	Arroyo willow
Sambucus nigra	Blue elderberry
Scirpus californicus	California bulrush[a]
Typha latifolia	Broad-leaved cattail[a]

Note:
[a] Indicated species identified solely for freshwater marsh habitats.

5.2.2 Scenario 2–Open Cobble Channel

The Open Cobble Channel scenario generally consists of a trapezoidal-shaped channel with the potential to support riparian scrub habitat on the channel embankments only. The channel will retain an open, mostly unvegetated character supported by cobble substrate, with a very low potential to support wetland conditions because of the lack of suitable hydrology and soils. The scenario can withstand a steeper gradient with higher velocity, concentrated flows within a less dynamic and narrower floodplain. This scenario is well-suited for the majority of the Chollas Creek watershed where hydrology and soils are not as suitable for the establishment of dense riparian habitat and wetland conditions. Figure 5-2 provides a plan view and cross section of the basic cobble channel scenario. Table 5-2 provides a summary of the plant palette considered for this scenario.

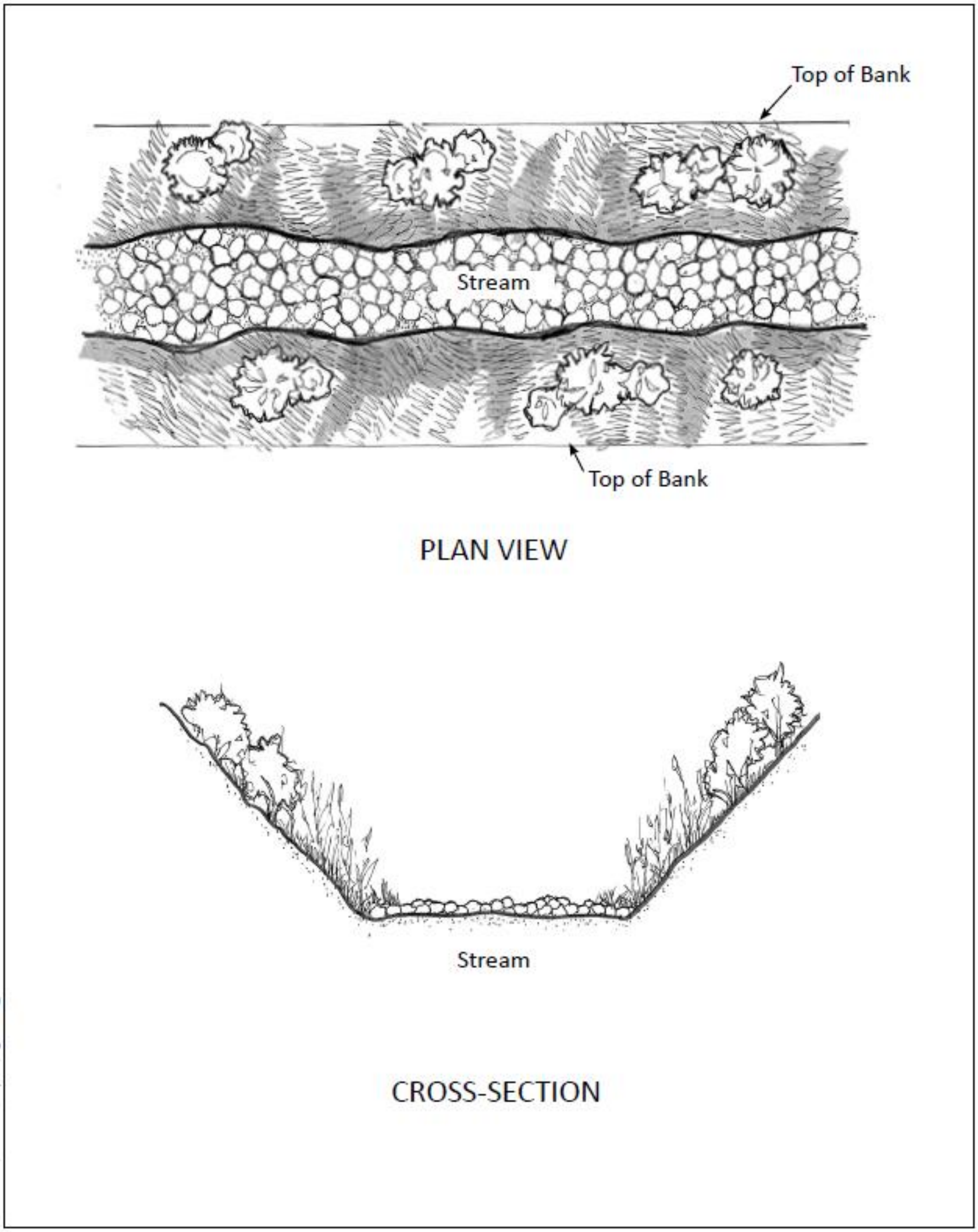

Figure 5-2. Open cobble restoration typical.

Table 5-2. Open cobble restoration planting palette

Scientific Name	Common Name
Acmispon americanus	Silver-leaf lotus
Acmispon glaber	Deerweed
Acmispon micranthus	Grab lotus
Ambrosia monogyra	Leafy burrowbush
Ambrosia psilostachya	Western ragweed
Artemisia californica	California sagebrush
Baccharis pilularis	Coyote brush
Baccharis salicifolia	Mule fat
Baccharis sarothroides	Broom baccharis
Elymus triticoides	Beardless wild rye
Eriogonum fasciculatum	California buckwheat
Eriophyllum confertiflorum	Golden yarrow
Heliotropum curvassavicum	Salt heliotrope
Heterotheca grandiflora	Telegraph weed
Isocoma menziesii	Goldenbush
Iva hayesiana	San Diego marsh elder
Juncus acutus ssp. leopoldii	Southwestern spiny rush
Plantago erecta	Dot seed plantain
Salix exigua	Narrow-leaf willow
Salix gooddingii	Black willow
Salix lasiolepis	Arroyo willow
Sambucus mexicana	Blue elderberry
Salvia mellifera	Black sage
Stipa pulchra	Purple needlegrass

6.0 Project Grouping and Prioritization

The results for each of the modeling and assessment efforts identify and characterize individual projects across the entire Chollas Creek watershed. The scale at which individual projects or assets were identified (e.g., catch basin inlet scale, specific storm conveyance, etc.) varies from the scale implemented for many CIP projects (e.g., neighborhood or street). Strategic synthesis of individual projects was completed to group projects together from an implementation, construction, and O&M standpoint. Cost (approximate bundled cost threshold of $5 million) and proximity were used to group projects together, at both the individual performance objective level and across IPs (see section 7.4). This section discusses the water quality project bundles (section 6.1) and flood control project bundles (section 6.3). Stream restoration projects were large enough individually that they were not bundled.

The model results generated by both the water quality assessment and the flood control assessment provide quantitative indicators (e.g., load removed and design storm flows) that drive project recommendations based on each respective water quality or design storm target. The stream restoration assessment provides proposed locations for stream restoration activities areas suited for classification using numeric criteria. These selection and design-related recommendations generated by the models and assessments are only one component of the overall CIP prioritization process completed for the WMP. Additional considerations and supplementary information—including (1) cost savings and capacity enhancements due to project synergies, (2) proximity to areas of concern (e.g., ESAs, contaminated soils, and flooding complaints), and (3) factors that impact ease of implementation and/or City access—were incorporated into each of the specific project prioritization rankings. Each of these components was assessed with regards to WMP project opportunities to provide the City with the key pieces of information needed to have a comprehensive understanding of the proposed improvements.

Three slightly different approaches were taken to prioritize the water quality projects (section 6.2), flood control projects (section 6.4), and stream restoration projects (section 6.5) due to the inherent incorporation of many prioritization components within the cost functions of the SUSTAIN model for water quality projects (section 3.2), as well as the diversity in specific prioritization criteria across the three assessment types. The flood control prioritization used a scoring matrix that incorporates the model results through conveyance characteristics and nonmodeled criteria, including land use impacts, environmental considerations, and ease of implementation. The stream restoration prioritization considered opportunities for environmental restoration and creation of new habitat, as well as hydrologic characteristics. Each of the prioritization methodologies accounts for potential synergies between water quality, flood control, and stream restoration projects, as IPs can lead to a reduction in overall costs, eased implementation challenges, and reduced impacts on citizens.

6.1 Water Quality Project Bundles

The results from the water quality optimization were designed at the catch basin inlet and MUTA scale to accurately reflect the hydrology and transport of pollutants in the watershed. However, these scales are not reflective of actual CIP projects that will be executed, which are often at the street or neighborhood level. Therefore, a method was developed to identify and group individually selected GI projects together in order to generate tangible water quality projects that can easily translate into a CIP. The following project characteristics were considered to assess whether catch basins and/or MUTAs could be grouped together:

- Total construction cost (more than $5 million). This total cost also assessed the flood control project recommendations to ensure that the ultimate IPs across performance objectives would not exceed the threshold of $5 million, where feasible. This was an iterative process as groupings would need to be revised across flood control, water quality, and stream restoration to generate a genuinely holistic solution.
- Proximity of projects to one another (e.g., located on either side of the same street or at an intersection, or small projects within a neighborhood or along a canyon).

Table 6-1 presents a summary of bundled projects types categorized into five main project types, and Figure 6-1 indicates the spatial distribution of these project types throughout the watershed.

Table 6-1. Water quality projects summary

Water Quality Project Type	Number of Projects	Total Construction Cost ($ million)	Average Construction Cost ($ million)	Total TZn Load Reduction (lbs/yr)	Average TZn Load Reduction (lbs/yr)	Average Footprint (ac)
Single Inlet GI	92	$3.6	$.04	16.64	0.18	0.01
Inlet GI Groups	40	$8.2	$0.2	37.87	0.95	0.05
Street-scale GI	160	$71.3	$0.3	311.49	1.95	0.13
GI and MUTA	3	$19.6	$6.5	84.6	28.2	0.49
Single MUTA	16	$92.0	$5.8	423.7	26.5	0.47
Total	**311**	**$194.7**	**$0.6**	**874.3**	**2.81**	**0.11**

Note: ac = acres.

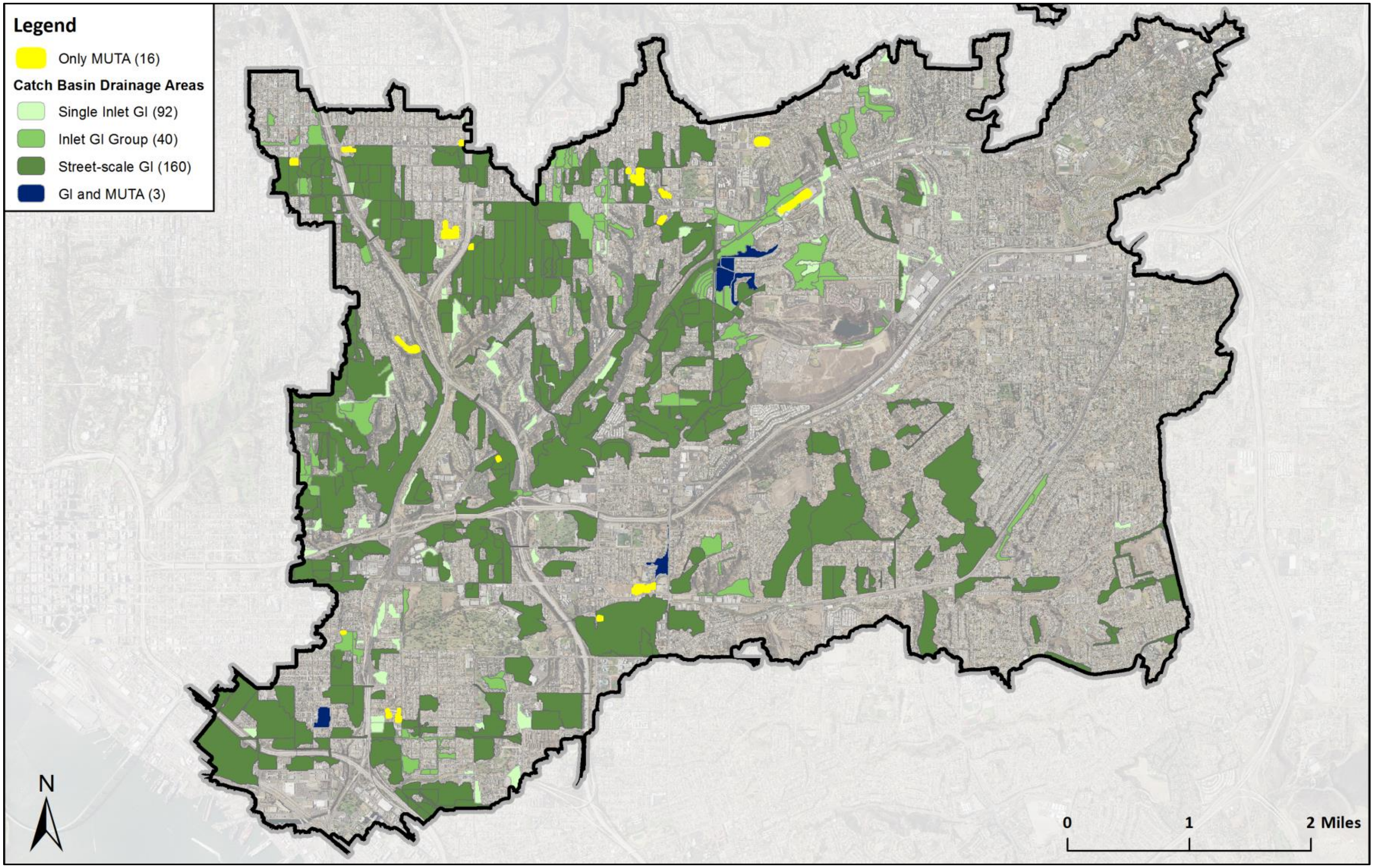

Figure 6-1. Distribution of water quality project types.

"Street-scale GI" projects indicate that the selected GI projects are located across one or more catch basin inlets, but are located along the same street, intersection, or neighborhood (Figure 6-2). These catch basin inlet drainage areas were grouped together to minimize disturbance to a particular street or neighborhood over the TMDL compliance timeline, as well as to account for the potential to integrate with other linear assets within the same ROW (e.g., flood control improvements, water utilities, bike lanes, and street improvements).

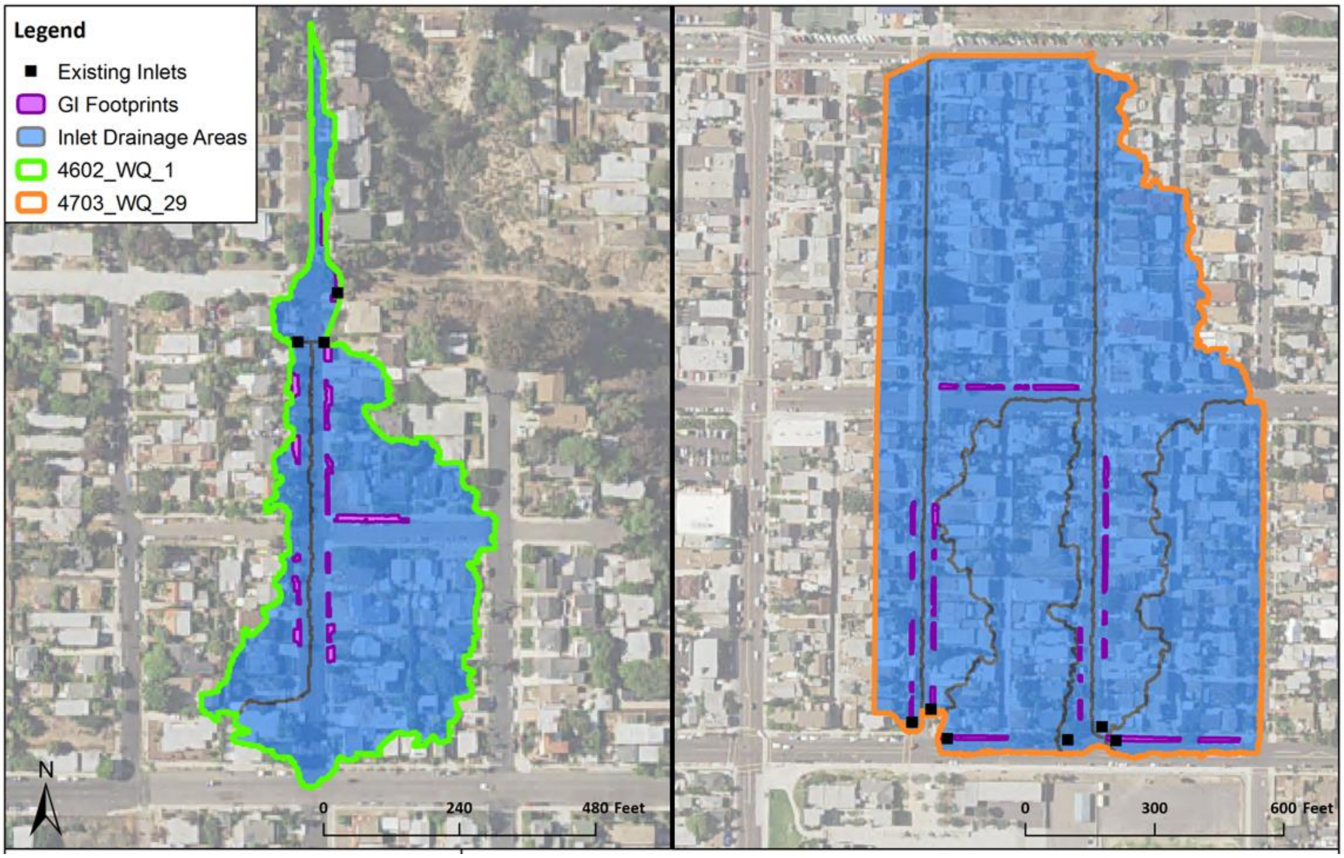

Figure 6-2. Street-scale GI project examples.

"Inlet GI" are individual inlets that are located either (1) near outlets to a canyon or (2) distributed within the watershed at a neighborhood scale and have a small water quality volume required (average volume is 0.027 acre-feet). Implementation of the individual GI areas in these projects can be streamlined through usage of standard biofiltration units or inserts at the catch basin and are grouped together in that manner (see Figure 6-3). Several of these projects are high-efficiency in terms of tributary load removal and are prime opportunities for near-term implementation.

Figure 6-3. Inlet GI project example.

"GI and MUTA" projects are MUTAs that have GI projects identified along adjacent streets or parcels (Figure 6-4). The assumption was that the ultimate design for the MUTA would be able to provide the water quality benefits of both the MUTA and adjacent GI to streamline costs and O&M burden. Design parameters that could be modified to enhance load removal include volume of the MUTA, diversion rate, and/or incorporation of real-time controls.

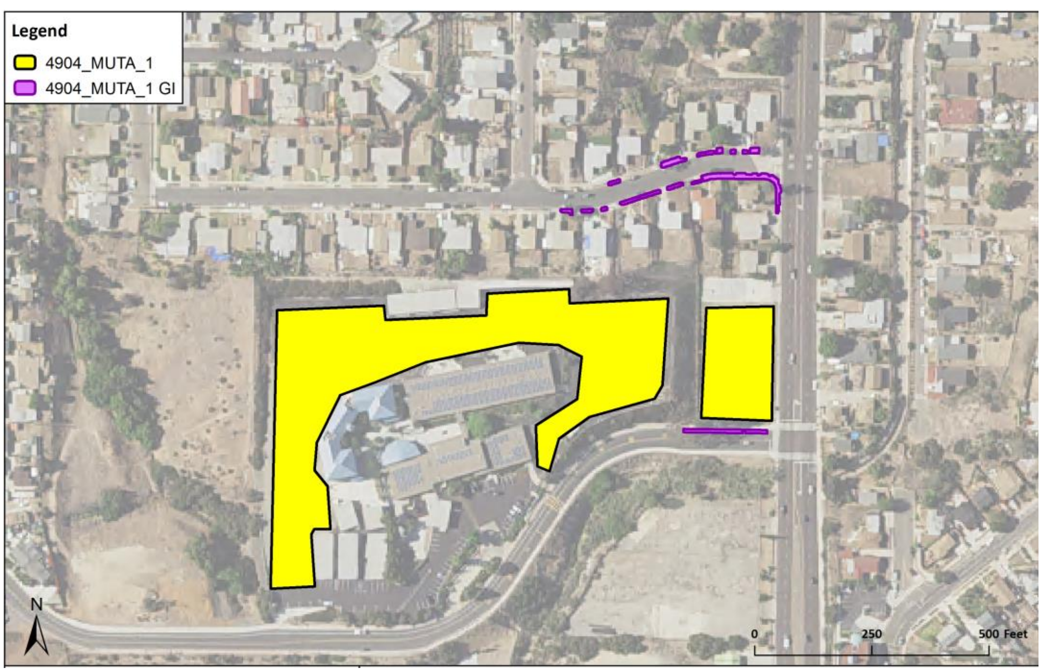

Figure 6-4. GI and MUTA project example.

"Single GI" and "Single MUTA" projects were not recommended as part of a larger bundle either due to proximity or extent of GI recommended.

Each water quality project bundle was assigned a new ID with the format "Subwatershed_WQ_Project Number" to clearly distinguish between individual water quality recommendations and bundled water quality projects. Table 6-2 presents the top 15 bundled projects by water quality rank (see section 6.2 for ranking methodology) with important project characteristics and cost data included. A complete list of projects is included in section 7.1.

Table 6-2. Top 15 water quality project bundles by water quality project rank

Water Quality Project ID	Project Type	Water Quality Project Rank	Construction Cost ($)	TZn Load Reduction (lbs/yr)	Efficiency ($/lb)
4702_MUTA_1[a]	MUTA	90.0	$1,795,249	15.5	$230,908
4608_MUTA_24	MUTA	86.3	$2,815,420	15.7	$297,567
4904_MUTA_1	MUTA & GI	85.6	$7,262,509	38.5	$306,412
4803_WQ_24	GI	81.4	$865,435	4.9	$311,067
4607_MUTA_1[a]	MUTA	81.2	$4,995,184	25.9	$331,181
4401_WQ_1	GI	80.8	$498,932	3.0	$298,002
4608_WQ_3	GI	80.0	$225,306	1.9	$226,464
4701_WQ_1	GI	79.1	$213,095	1.8	$223,379
4703_WQ_28	GI	78.4	$756,657	4.0	$320,657
4705_MUTA_1IS1	MUTA	78.1	$2,516,109	12.6	$338,341
4606_WQ_11	GI	78.1	$299,883	1.9	$273,396
4608_MUTA_1114	MUTA	77.6	$8,193,073	39.3	$345,941
4703_WQ_27	GI	77.3	$449,287	2.5	$307,592
4609_WQ_8	GI	77.1	$1,588,390	8.6	$341,836
4705_MUTA_1215	MUTA	77.0	$10,642,650	50.6	$351,570

Notes: $/lb = cost per pound.
[a]MUTAs are on private parcels.

6.2 Water Quality Prioritization Criteria

6.2.1 Water Quality Project Ranking

Grouping water quality projects based on proximity and constructability required a new prioritization and ranking methodology that extended beyond a singular metric. Simply ranking projects by the average efficiency (cost per pound of TZn removed) would not capture the overall load removed by each project bundle due to the grouping based on construction feasibility. A revised ranking methodology was developed that accounts for both *project efficiency* and *total project load removed*. The entire range of project efficiencies ($170,000 to $592,000) was normalized from 1 to 100. Similarly, the total project load removed by a project (0.1 lbs/yr to 67.0 lbs/yr) was normalized from 1 to 100. The geometric mean of the normalized efficiencies and total load removed was calculated to develop a power ranking that fully represents the impact of each project bundle in terms of effectiveness and overall progress towards the final TZn target. The result of the geometric mean was then normalized from 1 to 90 in order to be integrated into the comprehensive prioritization schema (see section 6.2.2).

$$\text{Normalized Attribute Rank} = 99 * \frac{\text{Attribute Value for Project} - \text{Minimium Value among all Projects}}{\text{Maximum Value} - \text{Maximum Value}} + 1$$

$$\text{Geometric Mean} = \sqrt{\text{Project Efficiency Rank} * \text{Project Load Removed Rank}}$$

$$\text{Normalized Project Rank} = 89 * \frac{\text{Attribute Value for Project} - \text{Minimium Value among all Projects}}{\text{Maximum Value} - \text{Maximum Value}} + 1$$

Figure 6-5 presents the distribution of projects by ranking, with the top project categories clearly indicated by color. The projects in the top right corner of the chart provide both the largest total load removal and have a relatively high removal efficiency. MUTAs, which are emphasized in purple, are concentrated at the top of the chart due to their relatively high load removal and capacity. In contrast, the projects that contain smaller, inlet-based GI are at the bottom of the chart due to their smaller required size. The efficiency varies, however, due to the footprint available, project drainage area, and pollutant loading.

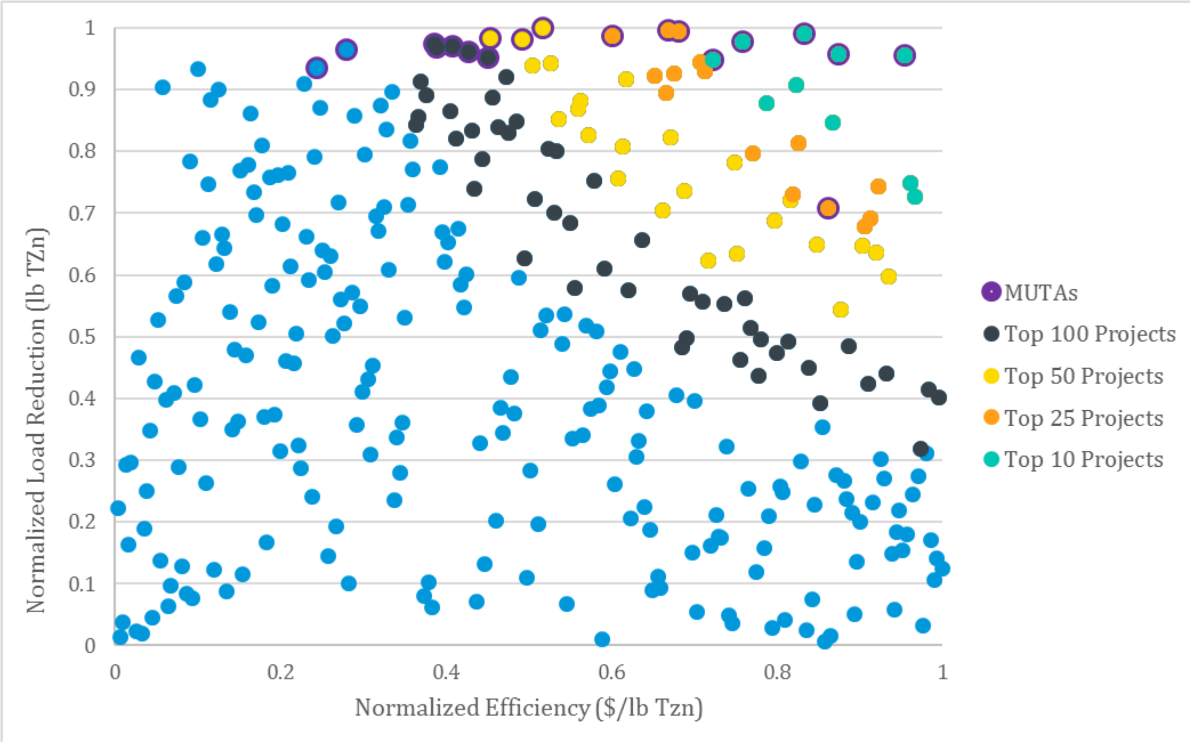

Figure 6-5. Water quality project ranking by load reduction and efficiency.

6.2.2 Nonmodeled Prioritization Criteria

While the modeling and ranking methodologies evaluate and synthesize all relevant technical and functional parameters, nonmodeled prioritization criteria provide additional information regarding program synergies and potential cost savings. Table 6-3 presents each of these criteria scores. Water quality projects may overlap with one or more flood control project type. The synergy criteria (and cost savings, where applicable) were applied only for the maximum flood control project type with each water quality project.

Table 6-3. Nonmodeled prioritization criteria scores

Nonmodeled Criteria	Individual Synergy Score
Synergy with Flood Control Projects	
Cost Sharing (MUTAs & Detention Facilities)	5
Cost Sharing (Water Quality GI & Pipe Facilities/Channels)	3
Cost Sharing (Water Quality GI & Street Improvements)	2
Cost Sharing (Water Quality GI & Curb Inlets)	1
Cost Sharing (Water Quality GI & Outfalls)	1

Nonmodeled Criteria	Individual Synergy Score
Synergy with Stream Restoration	
All Water Quality GI	5
Priority Trash Generation Area Tributary to GI	
Percentage of GI Drainage Area	0-5
GI Placement	
ESAs	-1
City Contaminated Sites	-1
Private Parcel	-5

The baseline water quality project ranking is indicative of the model results and is modified by the prioritization criteria through the following calculation:

$$CPS = BPR + SRS + FCS + TS - ESA - CSS$$

where:

CPS = Comprehensive WQ Project Score

BPR = Baseline WQ Project Rank

SRS = Stream Restoration Project Synergy Score

FCS = Flood Control Project Synergy Score

TS = Trash Generating Area Score

ESA = ESA Proximity Score

CSS = Contaminated Soils Score

Figure 6-6 presents an updated distribution of projects by ranking with the additional nonmodeled prioritization criteria, with the top project categories clearly indicated by color.

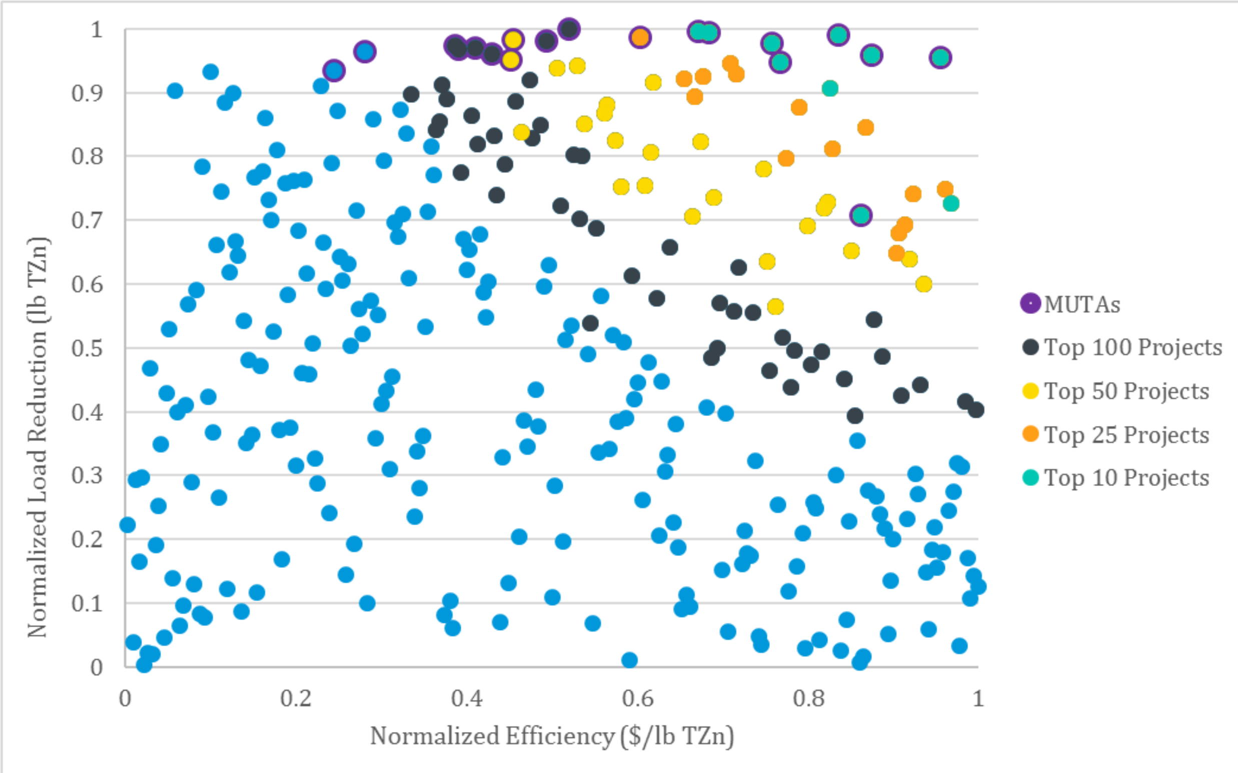

Figure 6-6. Water quality project ranking with prioritization criteria.

6.3 Flood Control Project Bundles

All flood control improvements are based on individual storm drain, inlets, channels, storages, and streets. For ease of implementation, these assets were bundled into flood control projects primarily based on geographical location. The assets were prioritized individually and then bundled together to form a project. The projects were then prioritized using a weighted priority ranking. Section 6.4.1 of this report further discusses the criteria of the bundled project prioritization.

6.4 Flood Control Prioritization Criteria

Prioritization criteria were established for the flood control recommendations to identify drainage projects that provide the highest comprehensive benefit to the community within the Chollas Creek watershed project study area. The criteria primarily consider flood-related factors, but also take into account public safety, environmental considerations, cost benefit, and cost savings synergies with water quality improvement projects to develop an inclusive project ranking that simultaneously considers both benefits and constraints of a proposed project. The Chollas Creek WMP prioritization matrix was developed for flood control facilities based on established prioritization best practices in which weighted scoring metrics are applied to a set of criteria factors. The criteria were further refined by City staff and Technical Review Committee input and comments on the initial Upper Chollas WMP submittal in June 2016.

6.4.1 Individual Asset Prioritization

Prioritization of the proposed flood control facilities was applied at two scales: (1) at the facility scale, by applying initial rating criteria values to each proposed segment; and (2) at the project scale, by bundling various facilities into a "project" and applying project synergy values to those flood control projects that are in relative proximity to identified water quality improvements and/or stream restoration projects, and could potentially achieve multi-benefit objectives. Each rating category is discussed further below.

Initial Flood Control Rating Criteria

First, each conveyance segment and drainage structure identified in Figure 6-7 was ranked based on flood control rating criteria, which assigned a raw score from -5 to 100 points to each facility through evaluation of the following categories:

1. Public Safety
    a. Land Use Impacts
    b. Conveyance Characteristics
2. Environmental Considerations
3. Ease of Implementation
4. Flood Control Synergy

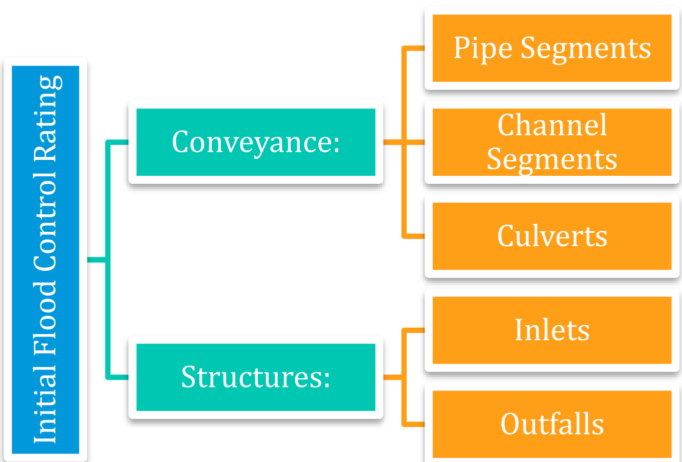

Figure 6-7. Flood control initial rating criteria.

Flood Control Synergy Rating Criteria

Once the facilities were ranked, they were bundled into projects and assigned a project ID. Each project was then given project synergy bonus points up to 20 additional points maximum based on its proximity to proposed water quality and stream restoration projects. The objective of the project synergy ranking was to correlate the additional cost-savings and integrated multi-project benefits that could be realized by synergized project implementation (see Figure 6-8). Section 7.4 of this report further discusses the benefits of integrated water resource projects.

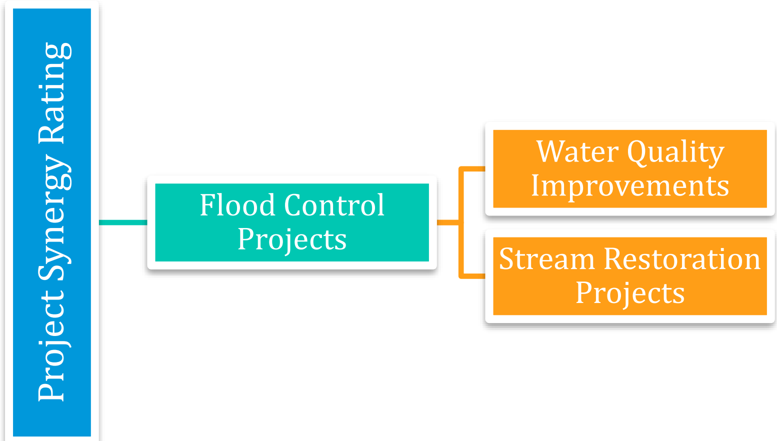

Figure 6-8. Flood control project synergy prioritization.

The following sections provide detailed descriptions of the criteria categories used in the prioritization analysis. Table 6-4 provides the overall prioritization criteria and scoring metrics used to develop the project rankings.

Table 6-4. Flood control priority-rating matrix

Rating Criteria	Max. Score	Subcriteria Score
Public Safety	**80**	
Land Use Impacts		**(0 to 15)**
Adjacent to high-priority land use		10
Adjacent to developed land use		5
Located within or adjacent to a major roadway		5
Conveyance Characteristics		**(0 to 65)**
Cost/Capacity Benefit (CCBI)		**(0 to 20)**
Highest Ranked 25% of facilities		20
Second Ranked 25% of facilities		10
Lowest Ranked 50% of facilities		0
IF: Existing Inlet - Inlet Capacity Ratio		**(0 to 30)**
All New Inlets; no drainage infrastructure previously existed		**20**
Max Flow @ Inlet /Existing Inlet Capacity @ 6-in head: Highest Ranked 25% of inlets		30
Max Flow @ Inlet /Existing Inlet Capacity @ 6-in head: Second Ranked 25% of inlets		20
Max Flow @ Inlet /Existing Inlet Capacity @ 6-in head: Lowest Ranked 50% of inlets		10
IF: Existing Culvert or Storm Drain - Conveyance Ratio		**(0 to 45)**
All New Pipes; no drainage infrastructure previously existed		30
100-year flow/Existing drainage facility capacity: 200% +		45
100-year flow/Existing drainage facility capacity: 150% to 200%		30
100-year flow/Existing drainage facility capacity: 100% to 150%		15

Rating Criteria	Max. Score	Subcriteria Score
IF: Detention Basin – Flow Ratio		**(0 to 30)**
Max. Total Inflow - Max. Outflow: Top 5 Detention Basins		30
Max. Total Inflow - Max. Outflow: Top 15 Detention Basins		20
Max. Total Inflow - Max. Outflow: All Other Detention Basins		10
IF: Open Channel - Conveyance Ratio		**(0 to 45)**
100-year flow/Existing channel capacity: 200% +		45
100-year flow/Existing channel capacity: 150% to 200%		30
100-year flow/Existing channel capacity: 100% to 150%		15
IF: Outfall - Conveyance Area Ratio & Erosive Conditions		**(0 to 25)**
Capacity Limitations		10
Existing Erosion Issues		10
Maintenance Accessibility and Ownership Alignments		5
IF: Street – (1) % Depth Over Curb Height and/or (2) Depth Exceeding Curb Height		**(0 to 30)**
Value 1 => 25% and/or Value 2=> 6 inches		30
Value 1 = 15-25% and/or Value 2 = 3-6 inches		20
Value 1 = 5-25% and/or Value 2 = 1-3 inches		10
Environmental Considerations	**-5**	
City Contaminated Sites		-5
Ease of Implementation	**10**	
Projects within existing City ownership, ROW, or easement		10
Projects located on Unimproved Property / Vacant		5
Flood Control Synergy	**10**	
CMP Replacement Program		10
Channel Maintenance Assessments		10
Raw Total	**100**	
Project Synergy Bonus Points	**0 to 20**	
Proximity to Water Quality Recommendations in WMP		10
Proximity to Stream Restoration Recommendations in WMP		10
Synergy Total	**20**	
Overall Project Score	***120***	

6.4.1.1 Initial Rating Criteria

Public Safety (80 points maximum)

Public safety was evaluated to determine community benefits based on land use impacts and conveyance characteristics of the existing and recommended drainage facilities.

Land Use Impacts

Spatial analysis using GIS was conducted to evaluate recommended flood control facilities in relation to adjacent land use types and roadway classification. The evaluated land use categories and roadway classifications and their corresponding point values are as follows:

- High Priority Land Use (10 points)
- Developed Land Use (5 points)
- Major Roadways (5 points)

All land uses were based on SanGIS 2016 existing land use data. The high-priority and vacant land uses are identified in Table 6-5 and Table 6-6, respectively. All other land use types were assumed to fall within the "developed land use" category. A 100-ft buffer around high-priority and vacant land uses was used to include proposed facilities that might be adjacent to each land use type. In instances in which a proposed facility intersecting more than one land use type was prevalent, points were assigned based on the highest scoring land use type.

All roadway classifications were based on SanGIS 2016 road data. Points were assigned to facilities that were located within a 40-ft buffer of any roadway with a functional classification of major road/4-lane major road.

Table 6-5. SANDAG high-priority land use definitions

Land Use Number	Land Use Definition
1400	Group Quarters Residential
6000	Office
6100	Public Services
6500	Hospitals
6800	Schools

Source: SanGIS LandUse Current.

Table 6-6. SANDAG vacant land use definitions

Land Use Number	Land Use Definition
7606	Landscape Open Space
8000	Agriculture
9100	Vacant and Undeveloped Land
9500	Under Construction
9600	Specific Plan Area

Source: SanGIS LandUse Current.

Conveyance Characteristics

The following subcriteria were evaluated under the conveyance characteristics category:

Cost/Capacity Benefit Index

The proposed cost for each facility was compared with the 100-year capacity benefits provided by that facility to evaluate the cost-effectiveness of the proposed improvements. The cost/capacity benefit index (CCBI) is modeled after a traditional cost-to-benefit ratio, which first calculates the *cost ratio* (CR) based on the flood control capacity and facility cost. The CR equation was unique for conveyance and structure facilities, since the benefit for conveyance facilities also is dependent on the length of the proposed conveyance. The following two equations were used to calculate the CR for conveyance and structure facilities, respectively:

$$CR_{Conveyance} = [Q_{100} * \text{Facility Length}] / \text{Facility Cost}$$

$$CR_{Structure} = [Q_{100}] / \text{Facility Cost}$$

Each facility's CR was normalized to provide CCBI values from 0 to 1 by dividing each CR by the largest CR as follows:

$$CCBI = CR/CR_{max}$$

The facilities/projects with the highest 25 percent of CCBI values were assigned a score of 20 points maximum. The second highest 25 percent of facilities received a score of 10 points; the remaining 50 percent of recommended facilities received 0 points.

Inlet Capacity

Proposed inlet facilities were evaluated through a percentage comparison of the existing inlet capacity to the existing maximum surface flow at the inlet. A formula was created to identify the inlet capacity based on its rating curve and inlet length for each existing inlet, allowing 6 inches of surface flow to pond at the inlet, consistent with the 2-D modeling methodology. Inlets were identified as deficient if the total max flow at the inlet, greater than 6 inches in head, exceeded the inlet capacity based on its rating curve. This assessment used the following equation to classify existing inlets' capacity deficiencies:

- *Inlet Capacity Ratio (%) = [Total Max Flow @ Inlet (cfs) / Inlet Capacity (cfs)*
- Inlet Capacity Ratio: Highest Ranked 25% of inlets (30 points)
- Inlet Capacity Ratio: Second Ranked 25% of inlets (20 points)
- Inlet Capacity Ratio: Lowest Ranked 50% of inlets (10 points)

All other inlets with capacity ratios less than 100 percent were assigned zero points.

New proposed inlets were assigned 20 points.

Culvert and Storm Drain Capacity

Proposed culverts and storm drains were evaluated through a percentage comparison of the existing drainage facility capacity to the proposed flow capacity based on the NOAA 100-year, 24-hour storm event scenario. This assessment used the following equation to classify existing inlets' capacity deficiencies:

- Culvert/Pipe Capacity Ratio > 200% (45 points)
- Culvert/Pipe Capacity Ratio ≤ 200% and > 150% (30 points)
- Culvert/Pipe Capacity Ratio ≤ 150% and > 100% (15 points)

All other culverts and pipes with capacity ratios less than 100 percent were assigned zero points.

New proposed inlets were assigned 30 points.

Open Channel Capacity

Proposed open channel conveyance facilities were evaluated using a method similar to that for culverts and pipes; however, the points were assigned to open channels as follows:

- Open Channel Capacity Ratio > 200% (45 points)
- Open Channel Capacity Ratio ≤ 200% and > 150% (30 points)
- Open Channel Capacity Ratio ≤ 150% and > 100% (15 points)

All other open channels segments with capacity ratios less than 100 percent were assigned zero points.

Detention Basin Assessment

Proposed detention basins were evaluated through reduction in flow from the proposed maximum total inflow entering the facility to the proposed maximum outflow exiting the facility. This comparison was also based on the NOAA 100-year, 24-hour storm event scenario. The assessment used the following criteria to classify detention basins:

- Max. Total Inflow - Max. Outflow: Top 5 Detention Basins (30 points)
- Max. Total Inflow - Max. Outflow: Top 6-15 Detention Basins (20 points)
- Max. Total Inflow - Max. Outflow: All Other Detention Basins (10 points)

Outfall Assessment

GIS spatial analysis was conducted to evaluate proposed outfall structures in comparison to the City's provided fiscal year (FY) 2013 Outfall Assessment Survey for Chollas Creek watershed, using the following criteria:

- Capacity Limitations—10 points were assigned to outfall facilities that were connected to conveyance facilities recommended for upsizing.
- Existing Erosion Issues—10 points were assigned to outfall facilities that were identified by the City's assessment data as "erosion," "repair," or "replacement."
- Maintenance, Accessibility, and Ownership Alignments—5 points were assigned to outfall facilities that were identified as beyond a 100-ft buffer from City ROW.

All other outfall facilities were assigned zero points.

Street Flooding Inundation

Proposed street inundation was evaluated using a combination of two values. Value 1 represents the percentage of the total street area where the inundation depth exceeds the curb height. Value 2 represents the difference between the highest depth of inundations and curb height. Inundation depths accounting for less than 5 percent of the total street area were considered negligible. Assessments for street flooding inundation were made using the following criteria:

- *Value 1* > 25% and/or *Value 2* > 6 inches (30 points)
- *Value 1* > 15% and ≤ 25% and/or *Value 2* > 3 inches and ≤ 6 inches (20 points)
- *Value 1* ≥ 5% and ≤ 15% and/or *Value 2* ≥ 1 inch and ≤ 3 inches (10 points)

Flooding inundations that did not meet any of the above criteria were assigned zero points.

Environmental Considerations (-1 points maximum)

Environmental considerations are primarily being assessed as part of section 6.3 to this report. However, it is important to consider proposed project proximity to City-identified contaminated sites when evaluating the priority of new facilities. Therefore, the following subcriteria were evaluated to incorporate environmental considerations into the project ranking.

Contaminated Soil Sites (-1 points minimum)

Flood control projects that are located within a specific proximity to identified contaminated soil sites could incur additional project costs due to extraneous permitting and site clean-up. A proximity analysis was conducted using the City-provided contaminated soil site shapefile to identify flood control projects that might be impacted by contaminated soil sites. Drainage facilities located less than 100 ft from an identified site were assigned a score of -5; all other projects were assigned zero points.

Ease of Implementation (10 points maximum)

The prioritization incorporates ease of implementation for recommended drainage facilities through a GIS spatial analysis of drainage facility locations compared to two specific land use types.

City Ownership, ROW, or Easement

Projects within existing ROWs were assumed to be easiest to implement/construct due to simplified or lack of acquisition and permitting costs. GIS spatial analysis using the SanGIS 2016 Land_Ownersip_SG and the SanGIS Right_of_Way shapefiles was conducted to identify recommended drainage facilities that intersected with land identified as City-owned or City ROW parcels; those intersecting projects were assigned 10 points.

Vacant/Unimproved Property

Additionally, projects located on unimproved property or vacant land correlate with an opportunity for easier project implementation in comparison to developed/private land. GIS spatial analysis using the SanGIS 2016 parcels shapefile was conducted to identify recommended drainage facilities that intersected with land identified as vacant; those projects were assigned a value of 5 points.

All other project locations were assigned zero points.

Flood Control Synergy (5 points maximum)

The flood control synergy criteria discussed below incorporate additional weighting that correlates to cost-saving benefits that could be realized by combining the following project types.

Corrugated Metal Pipe Replacement

Recommended drainage facilities that propose to replace existing corrugated metal pipe are given an additional 5 points.

Channel Maintenance Assessments

Recommended drainage facilities that have an overlap with existing channel maintenance assessment activities, based on a spatial analysis with the channel maintenance assessment shapefile prepared by Rick Engineering as part of a separate project, were assigned 5 additional points.

6.4.1.2 Multiple Benefit Project Synergy Criteria

A raw score was developed for each structure and conveyance facility by applying the initial flood control rating values above. The conveyance segments and structure facilities were then grouped into projects and assigned a project ID in order to review proposed flood control improvements more comprehensively from both a cost and geographic perspective. Project synergy criteria were developed to assist the City in identifying flood control projects that might contribute to additional cost savings and achieving multi-benefit objectives by being integrated with water quality and /or stream restoration projects that are also proposed as part of this plan. The following criteria provide additional weighting to proposed flood control improvements at the project scale to develop a cumulative project score for each flood control project proposed.

Proximity to Chollas Creek WMP Water Quality Recommendations (10 points maximum)

A GIS spatial analysis was conducted to identify synergy opportunities between recommended flood control facilities and proposed water quality improvements. Proposed drainage facilities within a 100-ft radius of either GI or MUTA water quality projects were assigned 10 additional points.

Proximity to Chollas Creek Stream Restoration Recommendations (10 points maximum)

A GIS spatial analysis was conducted to identify synergy opportunities between recommended flood control facilities and proposed stream restoration projects. Proposed drainage facilities within a 100-ft radius of identified stream restoration opportunities were assigned 10 additional points.

6.4.1.3 Flood Control Priority Scoring

The initial criteria score assessed in section 6.4.1.1 was combined with the synergy criteria score described in section 6.4.1.2 to develop a comprehensive score for each facility. The resulting ranking of the proposed drainage facilities is included in the recommended drainage facilities summary table in section B.4-4 in appendix B.

6.4.2 Bundled Project Prioritization

Prioritization of the proposed flood control facilities was applied at two scales: (1) at the facility scale, by applying initial rating criteria values to each proposed segment; and (2) at the project scale, by bundling various facilities into a "project" and applying project synergy values to those flood control projects that are in relative proximity to identified water quality improvements and/or stream restoration projects, and could potentially achieve multi-benefit objectives. Each rating category is discussed further below.

For each "project" the total project priority score was calculated using a weighted sum of normalized priority scores for each type of recommendation such as conveyance, inlet, outlet, storage, or surface improvement recommendations.

The normalized priority scores for conveyance recommendations were calculated using the following equation, where "C_P" is the length-weighted priority score for conveyance facilities:

$$\text{Norm } C_P = [C_P / 100] * 85$$

The normalized priority scores for inlet recommendations were calculated using the following equation, where "I_P" is the average of inlet priority scores for the entire project:

$$\text{Norm } I_P = [I_P / 55] * 5$$

The normalized priority scores for outlet recommendations were calculated using the following equation, where "O_P" is the average of outlet priority scores for the entire project:

$$\text{Norm } O_P = [O_P / 50] * 5$$

The normalized priority scores for storage recommendations were calculated using the following equation, where "ST_P" is the average of storage priority scores for the entire project:

$$\text{Norm } ST_P = [ST_P / 55] * 85$$

The normalized priority scores for surface improvement recommendations were calculated using the following equation, where "SU_P" is the average of surface improvement priority scores for the entire project:

$$\text{Norm } SU_P = [SU_P / 30] * 5$$

The following equation was used to calculate a total project prioritization score that ranged from 0 to 100:

$$\text{Project } P_{Total} = \text{Greater value of } (\text{Norm } C_P \ \& \ \text{Norm } ST_P) + \text{Norm } I_P + \text{Norm } O_P + \text{Norm } SU_P$$

6.5 Stream Restoration Prioritization Criteria

6.5.1 Prioritization Approach and Methodology

The stream restoration prioritization component included an evaluation of the potential candidate restoration sites against additional screening criteria tailored to the watershed goals and the City's mitigation needs. The process included development of fine-screening criteria, running each site through the screening matrix, generating a weighted score, and prioritizing each site according the weighted score. Each site's score will be considered in the stream restoration component of the overall prioritization in the watershed.

6.5.2 Rating Criteria

Rating criteria considered in the fine-screening analysis included five main factors, each with categories and subcategories for which to assign a potential score. The factors and categories are summarized in Table 6-7 and discussed following the table.

Table 6-7. Stream restoration prioritization criteria

Factor	Condition	Potential Score
Jurisdictional Area		**(0-55)**
Opportunity for Creation (Establishment) or Restoration (Re-establishment)	Concrete Bed and Bank Removal and Bank Widening (USACE, RWQCB, CDFW, City)	30
	Concrete Bank-Only Removal and Bank Widening (CDFW, City)	25
	Earthen Bed and Bank Widening (USACE, RWQCB, CDFW, City)	15
	Earthen Bank Widening Only (CDFW, City)	10
Opportunity for Restoration (Rehabilitation)	Concrete Bed-Only Removal (USACE, RWQCB, CDFW, City)	20
	Earthen Bed or Bank Restoration (USACE, RWQCB, CDFW, City)	5
Opportunity for Enhancement	Earthen Bed and Bank Enhancement (USACE, RWQCB, CDFW, City)	5
Jurisdictional Area (Subtotal)		**55**

Factor	Condition	Potential Score
Riparian/Wetland Habitat Expansion		**(0-20)**
Runoff Frequency (0-6)	Perennial (High Potential to Support Wetland/Riparian Habitat)	6
	Intermittent (Low or Moderate Potential to Support Wetland/Riparian Habitat)	3
	Ephemeral (Not Likely to Support Wetland/Riparian Habitat)	0
Runoff Volume / Catchment Area (0-10)	>1 sq. mi.	10
	0.5-1 sq. mi.	5
	< 0.5 sq. mi.	0
Lateral Discharge Source (0-2)	Present	2
	Absent	0
Soils (Soil Texture)	Sand (Type A)	2
	Loam (Type B/C)	1
	Clay/Silt (Type D)	0
Riparian/Wetland Habitat Expansion (Subtotal)		**20**
Habitat Connectivity and Preserve Design		**(0-15)**
MSCP (0-5) and Dedicated Space	Within MHPA and/or Dedicated Open Space	7
	Within Dedicated Open Space	5
	Outside, but adjacent to MHPA and/or Dedicated Open Space	3
	Outside and not adjacent to MHPA and/or Dedicated Open Space	0
Adjacent Land Use (0-5)	Conserved Lands and/or Parks	3
	Development	0
Nonnative Invasive and Exotic Species Composition (0-5)	High (75-100%)	5
	Moderate (25-74%)	3
	Low (<25%)	0
Habitat Connectivity and Preserve Design (Subtotal)		**15**
Land Acquisition and Long-Term Preservation		**(-10-10)**
Ownership (-10-10)	City	10
	Other Public Agency	5
	Private	-5
Restrictive Easements (-5-0)	Present	-5
	Absent	0
Land Acquisition and Long-Term Preservation (Subtotal)		**10**

Factor	Condition	Potential Score
Other Mitigation Needs		**(0-10)**
Coastal Zone (0-10)	Within Coastal Zone Overlay	10
	Outside of Coastal Zone Overlay	0
Opportunity for City ESL Wetland Creation (Ability to Establish/Re-establish City Wetlands/Riparian Habitat) (0-5)	Present	5
	Absent	0
Immediate Mitigation Needs (Subtotal)		**10**
Total Score		**110**
Priority Ranking		**1-15**

Heavier weight is assigned to criteria categories that provide the most increase in wildlife value and increase in state and federal wetland jurisdictional area. The heaviest weight and highest category score of 25 points is assigned to candidates that are concrete-lined and provide an opportunity for establishment and/or re-establishment, i.e., creation of both channel bed and bank resources in upland areas.

Lower weight is assigned to criteria categories that would present a constraint on a restoration effort or provides a lower functional lift and minimal spatial gain. The lowest weight and lowest category score of -5 is assigned to a site that is primarily privately owned or when a restrictive easement such as an existing sewer or water easement is present within the candidate area.

Once the scores for each category are assigned to each candidate site or reach, the total weighted score is determined out of a maximum value of 110. The 17 sites are also assigned a priority ranking relative to one another based on their total score. The site with the highest total score is ranked number one; the lowest is ranked number 17.

Jurisdictional Area

The jurisdictional area criteria were established to help determine which stream restoration candidates result in the highest mitigation value with respect to general mitigation categories. The general mitigation categories value include creation (establishment), restoration (re-establishment), restoration (rehabilitation), and enhancement.

The preliminary jurisdictional delineation limits determined for the baseline condition were compared against engineering plan view and cross-section concepts and dimensions to determine which candidate sites would result in a spatial gain in channel bed and/or bank. Where a plan view concept was not available for a site, the cross-section dimensions and average widths were used. Spatial gain was considered for both acreage and linear feet.

For the jurisdictional area criteria, concrete removal in combination with widening the channel bed and banks resulted in the highest functional value and spatial gain with respect to all jurisdictional limits. Removing concrete and converting a concrete-lined channel to an earthen-lined channel provides for establishment or re-establishment of resources where they are absent under current conditions. Removing concrete and returning the natural substrate condition to the channel provides for substantial functional gains. Where the hydrogeomorphic conditions are appropriate, substantial functional gains are also achieved in candidate areas that can be planted with riparian vegetation and support wetland conditions.

USACE and RWQCB spatial gains were assessed at the conceptual level whenever the channel bed, generally taken from toe-of-slope to toe-of-slope, could be widened from the baseline condition. Although not assessed to site-specific levels for this WMP, additional USACE/RWQCB spatial gains in linear feet can be achieved with increased sinuosity in the channel. In addition to USACE/RWQCB spatial gains, increases in channel widths would also translate into spatial gains in CDFW jurisdictions at the channel bed. Where conditions are appropriate to support any of the City wetland habitat categories (e.g., natural flood channel, riparian, and marsh) as described in Tables 2A and 2B of the City's *Land Development Code–Biology Guidelines*, the removal of concrete and/or increase in channel widths would also translate into spatial gains in City Wetland habitat types (San Diego 1999).

Additional functional and spatial gains in CDFW jurisdiction and City wetlands were assessed at the conceptual level whenever the channel banks, as measured from the toe-of-slope to the top-of-slope, could be widened from the baseline condition. Many of the engineering concepts for candidate areas involve laying back the channel banks with a goal of achieving a 3:1 slope. Where conditions are appropriate, the widened channel banks could be planted with riparian habitat, thereby resulting in spatial gains in riparian-vegetated CDFW jurisdiction and City wetland habitat categories.

Riparian/Wetland Habitat Expansion

The riparian/wetland habitat expansion criteria were established to assess which candidate sites have the potential to result in functional gains where appropriate geomorphic conditions would be present. The primary criteria considered in this category was hydrology, and specifically, how much water is entering a reach and how often. In general, most of the conveyance features in the watershed are supported by ephemeral flows, so many of the candidate areas score evenly in the runoff frequency subcategory. If high-volume flows can be dissipated and slowed down through a particular reach, and if the substrate is appropriate, the concept is that the water can be dispersed over a larger floodplain area and retained longer to promote the establishment of riparian habitat and wetland conditions. The potential for a candidate site to support these processes under the post-project condition is assessed under this criterion. The highest score would be achieved in this category by a steep-gradient and narrow concrete-lined channel with a large watershed area being converted into a shallower gradient and wider earthen channel with riparian vegetation and potential wetland conditions.

Habitat Connectivity and Preserve Design

The habitat connectivity and preserve design criteria were established to give weight to candidate sites that would expand linear open space and riparian corridors, and improve the regional conservation and preserve design in the Chollas Creek watershed. MHPA overlays, open space configuration, and the presence of nonnative and invasive vegetation are the criteria considered. As described above, conserved lands are defined as areas conserved for the purpose of protecting the open space and natural habitats including lands inside and outside of NCCP areas. Conserved lands are those lands that are legal to conserve to protect natural habitats, species, and open space (including agricultural lands that are important components of the regional habitat preserve design), contribute to the existing and planned regional habitat preserve system, and are managed to protect the open space or natural resources into the future (SanGIS 2016). Candidate sites within these areas also infested with nonnative and invasive vegetation are also assigned a higher score for their potential to provide larger benefit to the watershed with enhancement actions (i.e., treatment and removal of key nonnative and invasive vegetation source areas).

Land Acquisition and Long-Term Preservation

The land acquisition and long-term preservation criteria were established to assess principal constraints related to protection and long-term management of a candidate site. Land ownership and uses can present a significant constraint on the ability to establish conservation easements and restrictive covenants; protect a site from trespass, vandalism, and other illegal activities; adequately access a site for maintenance and management actions; and ensure overall public safety. Existing utility and other easements can also present a significant constraint because the areas are subject to other uses such as maintenance uses that are incompatible with conservation goals for the site, and thereby, the areas cannot be counted toward the overall mitigation or preservation of the area. The highest score would be achieved in this category by a candidate site located within City-owned land and not encumbered by existing easements.

Other Mitigation Needs

The need to resolve relatively unique or site-specific mitigation obligations is also considered in the evaluation of candidate sites. In particular, the City is required to mitigate wetlands within the Coastal Overlay Zone to offset impacts related to maintaining the storm water conveyance capacity of channels that are also located within the Coastal Overlay Zone. However, only the extreme southwest portion of the Chollas watershed is located within the Coastal Overlay Zone. The majority of the City's mitigation obligations in the watershed are for areas that fall outside of the Coastal Overlay Zone, which can be mitigated both inside and outside of the Coastal Overlay Zone. Nevertheless, because the overall watershed area within the Coastal Overlay Zone is limited and the mitigation opportunity satisfies impacts both inside and outside of the Zone, the opportunity value is considered higher. The highest score would be achieved in this category when a candidate site can provide for establishment/re-establishment of City wetlands within the Coastal Overlay Zone.

6.5.3 Stream Restoration Priority Scoring

The total weighed scores were used to develop the stream restoration prioritization ranking; where scores were the same, the rank was based on the potential net gain in jurisdictional area expected. The candidate site with highest total score out of 110 is ranked first in priority, and the candidate site with the lowest score is ranked last in priority. Table 6-8 lists the total score and ranking for each candidate site. Table 6-9 provides a detailed breakdown of the scores and ranking for each candidate site.

Table 6-8. Restoration priority ranking summary

Site Name	Overall Rank[a]	Overall Score
Auburn – Auburn Wightman 3	**1**	93
Auburn - Fairmont Avenue	**2**	81
Chollas - Chollas Parkway	**3**	74
Chollas - Sunshine Berardini Park	**4**	67
Wabash - Interstate 15	**5**	65
Wabash - Juniper Canyon	**6**	64
South Chollas - Elwood Avenue	**7**	64
Chollas - National Avenue	**8**	64
Auburn – Spillman Drive	**9**	62
South Chollas - Castana Street	**10**	59
Encanto Branch - Merlin Drive	**11**	61
Auburn – Auburn Wightman 1	**12**	54
Chollas - 54th Street	**13**	53
Wabash - Ash & Delevan	**14**	50
Chollas - Federal & Home	**15**	47
Jamacha Branch Tributary - Cardiff Street	**16**	41
Auburn – Auburn Wightman 2	**17**	39

Note:
[a]For sites with the same overall scores, rank was assigned based on the potential net gain in jurisdictional area expected from each of the sites.

Table 6-9. Restoration priority ranking detail

Factor	Condition	Potential Score	54th	Auburn 1	Auburn 2	Auburn 3	Castana	Fairmont	Fed Home	I-15	Merlin	National	Spillman	Sunshine	Juniper	Cardiff	Elwood	Chollas	Ash
Jurisdictional Area		**(0-55)**																	
Opportunity for Creation (Establishment)/ Restoration (Re-establishment)	Concrete Bed and Bank Removal and Bank Widening (USACE, RWQCB, CDFW, City)	30	--	--	--	30	--	30	30	--	--	--	--	--	--	--	--	--	--
	Concrete Bank-Only Removal and Bank Widening (CDFW, City)	25	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	Earthen Bed and Bank Widening (USACE, RWQCB, CDFW, City)	15	15	15	15	15	--	15	--	15	--	--	15	15	15	--	--	15	15
	Earthen Bank Widening Only (CDFW, City)	10	--	--	--	--	10	--	--	10	10	10	10	--	--	--	10	10	--
Opportunity for Restoration (Rehabilitation)	Concrete Bed-Only Removal (USACE, RWQCB, CDFW, City)	20	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	Earthen Bed and Bank Restoration (USACE, RWQCB, CDFW, City)	10	10	10	10	10	10	10	--	10	10	10	10	10	10	10	10	10	10
	Earthen Bed or Bank Restoration (USACE, RWQCB, CDFW, City)	5	--	--	--	--	--	--	--	--	--	5	--	--	--	--	--	--	--
Opportunity for Enhancement	Earthen Bed and Bank Enhancement (USACE, RWQCB, CDFW, City)	5	--	--	--	--	5	--	--	5	5	5	5	--	--	5	5	--	--

Factor	Condition	Potential Score	54th	Auburn 1	Auburn 2	Auburn 3	Castana	Fairmont	Fed Home	I-15	Merlin	National	Spillman	Sunshine	Juniper	Cardiff	Elwood	Chollas	Ash
Jurisdictional Area (Subtotal)		**55**	**25**	**25**	**25**	**55**	**25**	**55**	**30**	**40**	**25**	**30**	**40**	**25**	**25**	**15**	**25**	**35**	**25**
Riparian/Wetland Habitat Expansion		**(0-20)**																	
Runoff Frequency	Perennial (High Potential to Support Wetland/Riparian Habitat)	6	6	6	6	6	6	6	6	6	--	6	6	6	6	--	6	6	6
	Intermittent (Low or Moderate Potential to Support Wetland/Riparian Habitat)	3	--	--	--	--	--	--	--	--	3	--	--	--	--	--	--	--	--
	Ephemeral (Not Likely to Support Wetland/Riparian Habitat)	0	--	--	--	--	--	--	--	--	--	--	--	--	--	0	--	--	--
Runoff Volume / Catchment Area	>1 square mile	10	10	10	10	10	10	10	10	10	10	10	10	10	10	--	10	10	10
	0.5-1 square mile	5	--	--	--	--	--	--	--	--	--	--	--	--	--	5	--	--	--
	< 0.5 square mile	0	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Lateral Discharge Source	Present	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
	Absent	0	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Soils (Soil Texture)	Sand (Type A)	2	2	--	--	--	--	--	--	2	--	--	--	--	--	--	--	--	--
	Loam (Type B/C)	1	--	1	1	1	1	1	1	--	1	1	1	1	1	1	1	1	1
	Clay/Silt (Type D)	0	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Riparian/Wetland Habitat Expansion (Subtotal)		**20**	**20**	**19**	**19**	**19**	**19**	**19**	**19**	**20**	**16**	**19**	**19**	**19**	**19**	**8**	**19**	**19**	**19**

Factor	Condition	Potential Score	54th	Auburn 1	Auburn 2	Auburn 3	Castana	Fairmont	Fed Home	I-15	Merlin	National	Spillman	Sunshine	Juniper	Cardiff	Elwood	Chollas	Ash
Habitat Connectivity and Preserve Design		**(0-15)**																	
MSCP (0-7)	Within MHPA/Dedicated Open Space	7	7	--	--	--	--	7	--	7	7	--	--	7	7	--	7	7	--
	Within Dedicated Open Space	5	--	--	--	--	--	--	--	--	--	--	--	--	--	5	--	--	--
	Outside, but adjacent to MHPA/Dedicated Open Space	3	--	--	--	3	--	--	--	--	--	--	--	--	--	--	--	--	3
	Outside and not adjacent to MHPA/Dedicated Open Space	0	--	0	0	--	0	--	0	--	--	0	0	--	--	--	--	--	--
Adjacent Land Use (0-3)	Conserved Lands/Park	3	3	--	--	3	--	--	--	3	3	--	3	3	3	3	3	3	3
	Development	0	--	0	0	--	0	0	0	--	--	0	--	--	--	--	--	--	--
Non-Native Invasive and Exotic Species Composition (0-5)	High (75-100%)	5	--	5	5	--	5	5	--	5	5	5	5	--	--	5	--	--	5
	Moderate (25-74%)	3	3	--	--	3	--	--	3	--	--	--	--	3	--	--	--	--	--
	Low (<25%)	0	--	--	--	--	--	--	--	--	--	--	--	--	0	--	0	0	--
Habitat Connectivity and Preserve Design (Subtotal)		**15**	**13**	**5**	**5**	**9**	**5**	**12**	**3**	**15**	**15**	**5**	**8**	**13**	**10**	**13**	**10**	**10**	**11**
Land Acquisition and Long-Term Preservation		**(-10-10)**																	
Ownership (-5-10)	City	10	--	10	--	10	10	--	--	--	10	--	--	10	10	10	10	10	--
	Other Public Agency	5	--	--	--	--	--	--	--	--	--	5	--	--	--	--	--	--	--
	Private	-5	-5	--	-5	--	--	-5	-5	-5	--	--	-5	--	--	--	--	--	-5
Restrictive Easements (-5-0)	Present	-5	--	-5	-5	--	--	--	--	-5	-5	-5	--	--	--	-5	--	--	--
	Absent	0	0	0	0	0	0	0	0	--	--	--	0	0	0	--	0	0	0
Land Acquisition and Long-Term Preservation (Subtotal)		**10**	**-5**	**5**	**-10**	**10**	**10**	**-5**	**-5**	**-10**	**5**	**0**	**-5**	**10**	**10**	**5**	**10**	**10**	**-5**
Other Mitigation Needs		**(0-10)**																	
Coastal Zone	Within Coastal Zone Overlay	10	--	--	--	--	--	--	--	--	--	10	--	--	--	--	--	--	--
	Outside of Coastal Zone Overlay	0	0	0	0	0	0	0	0	0	0	--	0	0	0	0	0	0	0

Factor	Condition	Potential Score	54th	Auburn 1	Auburn 2	Auburn 3	Castana	Fairmont	Fed Home	I-15	Merlin	National	Spillman	Sunshine	Juniper	Cardiff	Elwood	Chollas	Ash
Immediate Mitigation Needs (Subtotal)		10	0	0	0	0	0	0	0	0	0	10	0	0	0	0	0	0	0
Total Score		110	53	54	39	93	59	81	47	65	61	64	62	67	64	41	64	74	50
Priority Ranking		--	13	12	17	1	11	2	15	5	10	8	9	4	6	16	7	3	14

7.0 Recommendations

This section presents the prioritized projects for each of the individual performance categories addressed in the WMP (water quality, flood control, and stream restoration) as well as the IPs across two or more of the categories. The individual project recommendations highlight the applicable prioritization criteria, cost components, and respective benefits (e.g., water quality, mitigation credits, flood attenuation) attributed to each project and demonstrate how quantifiable progress towards the City's storm water initiatives and/or regulatory compliance can be achieved. Recommendations are also provided for the IPs that were identified as part of the master plan process, highlighting the opportunities for program synergies and cost sharing. The recommendations are summarized in section 7.1 (water quality and GI projects), section 7.2 (flood control projects), and section 7.3 (stream restoration projects). Section 7.4 identifies the types of integrated multi-benefit projects recommended as part of the WMP, highlights specific IP examples, and quantifies estimated cost savings that may be realized at the watershed scale. Each of these project recommendations is presented geospatially in the associated Chollas Creek WMP Web Mapping Application (https://gis.tetratech.com/Chollas_WMP/).

7.1 Water Quality Recommendations

The primary drivers for the water quality and GI projects are the impending regulatory milestones for TZn load reduction within the Chollas Creek watershed, as well as demonstrating progress in implementing the strategies identified in the WQIP. Section 3.3 identifies the comprehensive suite of water quality and GI projects that will achieve the required TZn load reduction at the most optimal cost based on high-resolution data sets and robust model assumptions. Section 6.1 presents the type and number of water quality projects that could be bundled together for implementation at the CIP level. The prioritization criteria specified in section 6.2 further characterize the projects through the identification of potential synergies with flood control projects and environmental restoration, as well as placement near contaminated sites, ESAs, and priority trash-generating land use areas.

A comprehensive summary of the water quality projects, including all priority criteria, is presented in Table 7-1 and indicates each project's water quality benefit, bundled characteristics (where applicable), total estimated costs, water quality project rank, and comprehensive project score (with additional prioritization criteria). All of this information will also be available geospatially within the FY 2018 web application and in the associated database provided.

Table 7-1. Water quality projects with characteristics and prioritization criteria

WQ Project ID	No. of CB/MUTAs	CIP Cost	Load Removed (lbs/year)	Raw WQ Score	ESA	Contaminated Soils	Trash Generating Area	Public/Private	Synergy with FC	Synergy with SR	Comprehensive WQ Score
4608_MUTA_24	1	$2,815,420	15.67	86.28	0	0	3	0	5	0	94.28
4705_MUTA_1IS1	1	$2,516,109	12.63	78.10	0	0	2	0	3	5	88.10
4904_MUTA_1	2	$7,262,509	38.45	85.60	0	0	1	0	0	0	86.60
4803_WQ_24	12	$865,435	4.90	81.44	-1	0	3	0	3	0	86.44
4702_MUTA_1	1	$1,795,249	15.45	90.00	0	0	1	-5	0	0	86.00
4705_MUTA_IS_2	1	$276,041	1.69	73.62	0	0	2	0	5	5	85.62
4608_MUTA_1114	1	$8,193,073	39.26	77.59	0	0	3	0	5	0	85.59
4607_MUTA_1	1	$4,995,184	25.93	81.19	0	0	3	-5	5	0	84.19
4705_MUTA_1215	1	$10,642,650	50.56	76.98	0	0	2	0	5	0	83.98
4701_WQ_1	2	$213,095	1.79	79.06	0	0	1	0	2	0	82.06
4606_WQ_11	4	$299,883	1.85	78.05	0	-1	2	0	3	0	82.05
4401_WQ_2	1	$1,110,752	5.75	76.79	0	-1	3	0	3	0	81.79
4401_WQ_1	3	$498,932	2.97	80.77	0	-1	2	0	0	0	81.77
4703_WQ_27	4	$449,287	2.49	77.30	0	0	1	0	3	0	81.30
4609_WQ_8	4	$1,588,390	8.60	77.10	0	-1	3	0	2	0	81.10
4608_WQ_3	2	$225,306	1.88	80.01	0	0	1	0	0	0	81.01
4607_WQ_1	2	$997,496	5.45	74.56	0	0	3	0	3	0	80.56
4703_WQ_31	2	$427,105	2.34	73.97	0	0	4	0	2	0	79.97
4705_MUTA_23	1	$8,295,660	37.53	72.65	0	0	2	0	5	0	79.65
4703_WQ_28	4	$756,657	3.96	78.40	0	0	1	0	0	0	79.40
4703_WQ_33	2	$214,831	1.43	73.95	0	0	2	0	3	0	78.95
4803_WQ_7	2	$250,921	1.54	74.91	0	0	1	0	3	0	78.91
4608_WQ_2	2	$849,577	4.59	72.73	0	-1	3	0	3	0	77.73
4903_WQ_1	3	$1,115,006	5.31	73.18	0	-1	3	0	2	0	77.18
4705_WQ_1	1	$198,837	1.29	72.06	0	0	2	0	3	0	77.06
4810_WQ_5	2	$406,898	2.18	72.15	0	0	0	0	3	0	75.15
4608_WQ_12	2	$992,722	5.10	70.93	0	0	1	0	3	0	74.93
4605_WQ_6	4	$482,590	2.59	70.14	0	0	2	0	2	0	74.14
4703_WQ_2	1	$209,013	1.31	70.02	0	0	1	0	3	0	74.02
4703_WQ_25	2	$317,786	1.81	72.94	0	0	1	0	0	0	73.94
4918_WQ_1	1	$186,453	1.19	70.54	0	0	3	0	0	0	73.54
4703_WQ_3	2	$187,326	1.26	72.15	0	0	1	0	0	0	73.15
4608_WQ_13	3	$380,660	1.82	67.13	0	0	1	0	5	0	73.13
4606_WQ_1	7	$911,371	4.10	66.41	0	0	3	0	3	0	72.41

WQ Project ID	No. of CB/MUTAs	CIP Cost	Load Removed (lbs/year)	Raw WQ Score	ESA	Contaminated Soils	Trash Generating Area	Public/Private	Synergy with FC	Synergy with SR	Comprehensive WQ Score
4809_WQ_3	1	$314,584	1.75	72.32	0	-1	1	0	0	0	72.32
4605_WQ_1	3	$728,065	3.55	65.74	0	0	2	0	3	0	70.74
4608_WQ_1	3	$1,500,818	6.85	66.48	0	0	1	0	3	0	70.48
4503_WQ_2	2	$350,914	1.66	64.42	0	-1	4	0	3	0	70.42
4607_WQ_2	4	$1,424,776	6.68	64.94	0	0	2	0	3	0	69.94
4605_WQ_7	1	$248,157	1.50	69.86	0	0	0	0	0	0	69.86
4607_WQ_6	3	$656,753	3.12	63.81	0	0	3	0	3	0	69.81
4608_MUTA_20	1	$3,757,870	14.51	61.75	0	0	3	0	5	0	69.75
4702_WQ_7	2	$596,446	2.60	64.87	0	0	1	0	3	0	68.87
4502_WQ_12	2	$474,945	2.39	66.40	0	0	1	0	0	0	67.40
4802_WQ_1	1	$251,213	1.25	65.12	-1	0	1	0	2	0	67.12
4606_MUTA_2	1	$9,303,780	37.21	63.00	0	0	3	-5	5	0	66.00
4602_WQ_3	3	$380,385	1.90	63.92	-1	0	0	0	3	0	65.92
4902_WQ_13	3	$686,335	2.82	58.82	0	0	2	0	5	0	65.82
4703_WQ_1	2	$205,908	1.06	61.78	0	0	1	0	3	0	65.78
4803_WQ_1	4	$384,517	1.90	62.25	0	0	0	0	3	0	65.25
4609_WQ_1	5	$1,168,804	5.27	62.20	-1	0	1	0	3	0	65.20
4905_WQ_2	2	$160,122	0.98	65.14	0	0	0	0	0	0	65.14
4503_WQ_3	2	$148,315	0.83	61.93	0	0	3	0	0	0	64.93
4502_WQ_3	2	$697,686	3.01	60.57	0	0	1	0	3	0	64.57
4502_WQ_10	6	$1,077,923	4.31	60.06	0	-1	2	0	3	0	64.06
4803_MUTA_15	1	$14,433,199	66.96	67.86	0	0	1	-5	0	0	63.86
4803_WQ_6	2	$106,713	0.73	60.47	0	-1	1	0	3	0	63.47
4803_WQ_2	4	$205,478	1.05	59.32	0	0	1	0	3	0	63.32
4801_WQ_9	2	$256,248	1.25	63.09	0	0	0	0	0	0	63.09
4703_WQ_6	4	$151,901	0.83	59.69	0	0	0	0	3	0	62.69
4902_WQ_11	1	$498,122	2.35	61.67	0	0	1	0	0	0	62.67
4503_WQ_6	1	$106,752	0.70	58.64	0	0	1	0	3	0	62.64
4802_WQ_4	2	$231,528	1.07	59.32	-1	0	1	0	3	0	62.32
4608_WQ_14	1	$88,100	0.68	60.27	0	0	2	0	0	0	62.27
4802_WQ_7	3	$558,892	2.39	61.24	0	0	1	0	0	0	62.24
4702_WQ_9	2	$260,016	1.34	60.97	0	0	1	0	0	0	61.97
4606_WQ_2	2	$561,059	2.25	55.80	0	0	3	0	3	0	61.80
4502_WQ_13	4	$360,156	1.61	57.54	0	0	1	0	3	0	61.54
4808_MUTA_7	6	$6,285,457	23.55	57.90	-1	0	1	0	3	0	60.90
4903_MUTA_10	1	$7,231,559	32.50	65.52	0	-1	1	-5	0	0	60.52

WQ Project ID	No. of CB/MUTAs	CIP Cost	Load Removed (lbs/year)	Raw WQ Score	ESA	Contaminated Soils	Trash Generating Area	Public/Private	Synergy with FC	Synergy with SR	Comprehensive WQ Score
4801_WQ_4	1	$210,167	1.11	56.40	0	0	1	0	3	0	60.40
4703_WQ_7	4	$169,719	0.90	59.33	0	0	1	0	0	0	60.33
4501_WQ_12	1	$618,947	2.64	59.28	0	0	1	0	0	0	60.28
4809_WQ_10	2	$430,768	1.79	57.21	0	0	1	0	2	0	60.21
4802_WQ_3	2	$317,035	1.50	57.90	-1	0	0	0	3	0	59.90
4609_WQ_2	2	$1,179,020	5.06	54.84	0	0	2	0	3	0	59.84
4602_WQ_2	4	$245,145	1.20	56.73	-1	0	1	0	3	0	59.73
4801_WQ_7	2	$73,914	0.65	59.72	0	0	0	0	0	0	59.72
4803_WQ_4	3	$153,234	0.84	58.69	0	0	1	0	0	0	59.69
4501_WQ_10	1	$102,872	0.64	54.57	0	0	5	0	0	0	59.57
4907_WQ_1	3	$190,572	1.03	60.21	-1	0	0	0	0	0	59.21
4803_WQ_3	1	$134,946	0.73	55.05	0	0	1	0	3	0	59.05
4803_WQ_8	2	$135,215	0.81	58.05	0	0	1	0	0	0	59.05
4401_WQ_5	4	$776,962	3.38	55.86	0	-1	2	0	2	0	58.86
4704_WQ_4	5	$743,648	3.17	52.85	0	0	3	0	3	0	58.85
4502_WQ_2	6	$603,779	2.50	54.83	0	-1	2	0	3	0	58.83
4503_WQ_8	3	$1,164,346	4.48	54.63	0	0	1	0	3	0	58.63
4703_WQ_29	6	$625,061	2.77	56.53	0	0	2	0	0	0	58.53
4906_WQ_3	3	$186,601	0.86	55.40	0	0	0	0	3	0	58.40
4801_WQ_8	2	$162,835	0.82	54.24	-1	0	2	0	3	0	58.24
4604_MUTA_1	1	$6,252,206	25.32	57.85	-1	0	1	0	0	0	57.85
4704_WQ_8	4	$440,252	1.82	53.48	0	0	2	0	2	0	57.48
4501_MUTA_5	1	$6,313,259	25.24	59.41	0	-1	1	-5	3	0	57.41
4705_WQ_4	3	$686,085	2.87	52.22	0	0	2	0	3	0	57.22
4606_WQ_9	3	$534,380	2.10	52.05	0	-1	3	0	3	0	57.05
4609_WQ_3	3	$125,144	0.76	58.00	-1	0	0	0	0	0	57.00
4903_MUTA_2	1	$3,845,263	16.59	60.50	0	0	1	-5	0	0	56.50
4703_WQ_32	4	$235,842	0.96	51.00	0	0	2	0	3	0	56.00
4703_WQ_4	4	$157,557	0.78	55.82	0	0	0	0	0	0	55.82
4609_WQ_7	3	$1,140,618	4.62	51.70	-1	0	2	0	3	0	55.70
4606_WQ_3	4	$274,011	1.25	52.60	0	0	3	0	0	0	55.60
4608_WQ_7	1	$47,027	0.41	52.21	0	0	1	0	2	0	55.21
4910_WQ_2	1	$309,494	1.41	48.56	0	0	1	0	5	0	54.56
4703_WQ_26	2	$583,430	2.50	50.97	-1	0	1	0	3	0	53.97
4606_WQ_4	1	$183,650	0.83	48.52	0	0	3	0	2	0	53.52
4802_WQ_2	1	$181,718	0.89	48.43	0	0	3	0	2	0	53.43

WQ Project ID	No. of CB/MUTAs	CIP Cost	Load Removed (lbs/year)	Raw WQ Score	ESA	Contaminated Soils	Trash Generating Area	Public/Private	Synergy with FC	Synergy with SR	Comprehensive WQ Score
4501_WQ_1	2	$197,895	0.91	51.24	0	-1	3	0	0	0	53.24
4910_WQ_3	7	$918,798	3.81	50.07	0	-1	1	0	3	0	53.07
4501_MUTA_1	2	$6,028,994	22.62	49.05	0	0	1	0	3	0	53.05
4609_WQ_9	1	$98,439	0.53	51.92	0	0	1	0	0	0	52.92
4605_WQ_3	3	$125,807	0.65	49.71	-1	0	1	0	3	0	52.71
4503_WQ_13	1	$52,130	0.45	52.57	0	0	0	0	0	0	52.57
4809_WQ_1	3	$243,069	1.14	53.56	-1	0	0	0	0	0	52.56
4502_WQ_1	1	$120,655	0.66	49.50	0	0	0	0	3	0	52.50
4803_WQ_20	1	$43,031	0.30	47.31	0	0	5	0	0	0	52.31
4608_WQ_10	2	$594,876	2.29	46.27	0	0	3	0	3	0	52.27
4907_WQ_3	3	$156,809	0.75	49.98	-1	0	1	0	2	0	51.98
4606_WQ_10	2	$285,813	1.15	46.71	-1	0	3	0	3	0	51.71
4503_WQ_15	2	$422,060	1.70	45.37	0	0	1	0	5	0	51.37
4904_WQ_1	1	$188,165	0.89	51.33	0	0	0	0	0	0	51.33
4503_WQ_4	1	$67,047	0.37	47.04	0	0	4	0	0	0	51.04
4801_WQ_2	3	$317,240	1.42	49.97	0	0	1	0	0	0	50.97
4502_WQ_7	1	$53,670	0.37	49.95	0	0	1	0	0	0	50.95
4802_WQ_9	3	$169,084	0.81	50.90	0	0	0	0	0	0	50.90
4502_WQ_4	6	$509,906	2.07	49.77	0	0	1	0	0	0	50.77
4809_WQ_6	1	$129,051	0.61	46.65	0	0	1	0	3	0	50.65
4701_WQ_6	2	$448,252	1.71	47.45	0	0	3	0	0	0	50.45
4802_WQ_10	3	$311,449	1.20	42.39	-1	0	1	0	3	5	50.39
4601_WQ_1	1	$933,601	3.21	47.07	-1	0	1	0	3	0	50.07
4802_WQ_8	5	$260,345	1.19	50.90	-1	0	0	0	0	0	49.90
4608_WQ_11	3	$286,086	1.19	47.70	0	-1	1	0	2	0	49.70
4902_WQ_8	3	$170,378	0.75	48.64	0	0	1	0	0	0	49.64
4917_WQ_4	3	$670,146	2.77	49.44	0	-1	1	0	0	0	49.44
4605_WQ_2	2	$316,009	1.33	48.36	0	-1	2	0	0	0	49.36
4602_WQ_4	1	$209,785	0.96	49.78	-1	0	0	0	0	0	48.78
4913_WQ_2	1	$359,221	1.54	44.19	0	0	1	0	3	0	48.19
4803_WQ_12	1	$32,105	0.27	45.85	0	0	2	0	0	0	47.85
4801_WQ_6	1	$40,856	0.30	48.64	-1	0	0	0	0	0	47.64
4704_WQ_3	1	$36,345	0.23	41.39	0	0	3	0	3	0	47.39
4608_WQ_6	1	$51,071	0.32	46.36	0	0	1	0	0	0	47.36
4704_WQ_7	3	$250,612	1.00	45.32	0	0	2	0	0	0	47.32
4808_WQ_1	2	$94,191	0.47	43.27	0	0	1	0	3	0	47.27

WQ Project ID	No. of CB/MUTAs	CIP Cost	Load Removed (lbs/year)	Raw WQ Score	ESA	Contaminated Soils	Trash Generating Area	Public/Private	Synergy with FC	Synergy with SR	Comprehensive WQ Score
4803_WQ_16	1	$24,699	0.19	39.26	0	0	3	0	5	0	47.26
4810_WQ_7	2	$320,203	1.23	46.97	0	0	0	0	0	0	46.97
4703_WQ_9	1	$49,492	0.28	42.96	0	0	1	0	3	0	46.96
4501_WQ_15	2	$893,658	3.59	43.88	-1	0	1	0	3	0	46.88
4808_WQ_6	2	$144,968	0.68	47.09	-1	0	0	0	0	0	46.09
4602_WQ_1	3	$126,968	0.63	45.07	0	0	1	0	0	0	46.07
4703_WQ_15	3	$93,916	0.46	46.05	0	0	0	0	0	0	46.05
4803_WQ_13	1	$46,672	0.29	45.80	0	0	0	0	0	0	45.80
4703_WQ_10	2	$43,038	0.25	41.52	0	0	1	0	3	0	45.52
4809_WQ_4	4	$639,545	2.26	41.27	0	0	1	0	3	0	45.27
4501_WQ_5	2	$156,015	0.63	40.08	0	0	2	0	3	0	45.08
4809_WQ_11	3	$174,393	0.72	43.08	0	0	2	0	0	0	45.08
4901_WQ_2	4	$1,235,058	4.98	43.06	-1	0	1	0	2	0	45.06
4703_WQ_13	1	$41,257	0.26	43.51	0	0	1	0	0	0	44.51
4503_WQ_11	1	$44,703	0.26	43.33	0	0	1	0	0	0	44.33
4913_WQ_1	3	$144,228	0.62	44.33	0	0	0	0	0	0	44.33
4809_WQ_12	2	$312,062	1.25	38.30	0	0	1	0	5	0	44.30
4702_WQ_3	1	$55,818	0.27	42.23	0	0	2	0	0	0	44.23
4810_WQ_4	1	$208,810	0.94	40.75	0	0	0	0	3	0	43.75
4606_WQ_5	1	$33,475	0.19	39.34	0	0	1	0	3	0	43.34
4803_WQ_10	1	$31,663	0.20	40.04	0	0	0	0	3	0	43.04
4602_WQ_10	1	$31,363	0.23	43.02	-1	0	1	0	0	0	43.02
4604_WQ_1	2	$353,724	1.41	43.69	0	-1	0	0	0	0	42.69
4905_WQ_4	2	$419,973	1.73	41.58	-1	0	0	0	2	0	42.58
4809_WQ_5	1	$174,444	0.76	35.56	0	0	2	0	5	0	42.56
4602_WQ_9	1	$118,186	0.49	41.50	-1	0	0	0	2	0	42.50
4502_MUTA_1	1	$1,369,242	6.65	45.16	0	0	2	-5	0	0	42.16
4503_WQ_1	2	$325,194	1.20	37.05	0	0	5	0	0	0	42.05
4502_WQ_6	1	$54,685	0.28	41.66	0	0	0	0	0	0	41.66
4703_WQ_30	3	$515,532	1.93	36.55	0	0	2	0	3	0	41.55
4810_WQ_6	1	$84,233	0.39	41.46	0	0	0	0	0	0	41.46
4801_WQ_5	1	$26,438	0.17	35.24	0	0	3	0	3	0	41.24
4701_WQ_5	2	$397,431	1.37	37.02	0	0	1	0	3	0	41.02
4902_WQ_10	1	$69,945	0.32	35.63	0	0	5	0	0	0	40.63
4902_WQ_6	3	$287,397	1.10	38.26	0	0	2	0	0	0	40.26
4503_WQ_5	1	$58,760	0.25	35.89	0	0	1	0	3	0	39.89

WQ Project ID	No. of CB/MUTAs	CIP Cost	Load Removed (lbs/year)	Raw WQ Score	ESA	Contaminated Soils	Trash Generating Area	Public/Private	Synergy with FC	Synergy with SR	Comprehensive WQ Score
4702_WQ_8	2	$320,666	1.26	37.87	0	0	2	0	0	0	39.87
4602_WQ_5	3	$530,575	1.98	37.81	-1	0	0	0	3	0	39.81
4602_WQ_8	3	$103,475	0.48	40.64	-1	0	0	0	0	0	39.64
4916_WQ_1	3	$865,376	3.33	35.55	0	0	1	0	3	0	39.55
4906_WQ_1	1	$59,784	0.29	37.51	0	0	2	0	0	0	39.51
4703_WQ_5	1	$133,446	0.58	40.26	-1	0	0	0	0	0	39.26
4902_WQ_5	3	$251,375	1.01	38.12	0	0	1	0	0	0	39.12
4501_WQ_6	1	$114,580	0.50	37.99	0	0	1	0	0	0	38.99
4908_WQ_2	1	$251,121	1.05	36.97	-1	0	1	0	2	0	38.97
4606_WQ_13	1	$101,848	0.46	35.94	0	0	3	0	0	0	38.94
4809_WQ_9	1	$20,817	0.19	38.77	0	0	0	0	0	0	38.77
4602_WQ_6	2	$528,176	1.91	35.57	0	-1	1	0	3	0	38.57
4606_WQ_6	2	$15,589	0.15	33.50	0	0	2	0	3	0	38.50
4902_WQ_1	1	$142,366	0.53	33.45	0	0	5	0	0	0	38.45
4808_WQ_2	1	$39,739	0.22	38.43	0	0	0	0	0	0	38.43
4918_WQ_2	2	$349,999	1.44	35.14	0	0	0	0	3	0	38.14
4502_WQ_5	1	$47,774	0.23	37.13	0	0	1	0	0	0	38.13
4902_WQ_12	1	$680,420	2.41	35.80	0	0	2	0	0	0	37.80
4704_WQ_5	7	$645,810	2.16	33.46	0	-1	3	0	2	0	37.46
4704_WQ_2	1	$33,784	0.17	33.26	0	0	2	0	2	0	37.26
4702_WQ_4	1	$23,569	0.17	36.24	0	0	1	0	0	0	37.24
4909_WQ_2	1	$49,179	0.22	33.89	0	0	0	0	3	0	36.89
4503_WQ_7	1	$406,348	1.56	32.63	0	0	1	0	3	0	36.63
4503_WQ_14	1	$18,608	0.16	35.46	0	0	1	0	0	0	36.46
4704_WQ_1	1	$186,241	0.71	34.31	0	0	2	0	0	0	36.31
4810_WQ_3	1	$231,568	0.91	35.89	0	0	0	0	0	0	35.89
4810_WQ_1	2	$243,195	0.87	34.40	0	0	1	0	0	0	35.40
4902_WQ_14	1	$34,092	0.19	33.98	0	0	1	0	0	0	34.98
4401_WQ_4	2	$1,243,393	4.66	31.80	0	0	1	0	2	0	34.80
4803_WQ_21	1	$33,264	0.19	33.75	0	0	1	0	0	0	34.75
4805_WQ_1	1	$14,865	0.13	30.68	0	0	1	0	3	0	34.68
4802_WQ_5	1	$315,108	1.19	35.24	-1	0	0	0	0	0	34.24
4701_WQ_2	1	$179,777	0.67	33.19	0	0	1	0	0	0	34.19
4917_WQ_3	3	$290,161	1.21	34.15	0	0	0	0	0	0	34.15
4907_WQ_4	1	$526,029	1.82	33.12	0	0	1	0	0	0	34.12
4608_WQ_5	1	$46,381	0.20	32.85	0	0	1	0	0	0	33.85

WQ Project ID	No. of CB/MUTAs	CIP Cost	Load Removed (lbs/year)	Raw WQ Score	ESA	Contaminated Soils	Trash Generating Area	Public/Private	Synergy with FC	Synergy with SR	Comprehensive WQ Score
4501_WQ_8	1	$74,639	0.32	29.37	0	0	1	0	3	0	33.37
4703_WQ_20	1	$25,362	0.15	32.93	0	0	0	0	0	0	32.93
4902_WQ_4	2	$317,481	1.15	31.45	0	0	1	0	0	0	32.45
4501_WQ_3	1	$208,001	0.88	31.44	0	0	1	0	0	0	32.44
4802_WQ_6	3	$571,523	1.99	32.25	-1	0	1	0	0	0	32.25
4808_WQ_3	1	$33,025	0.18	32.20	0	0	0	0	0	0	32.20
4905_WQ_3	1	$110,047	0.48	32.10	0	0	0	0	0	0	32.10
4911_WQ_3	1	$1,517,250	6.01	28.87	0	0	0	0	3	0	31.87
4606_WQ_7	1	$29,071	0.14	28.75	0	0	0	0	3	0	31.75
4601_WQ_2	1	$37,082	0.17	30.74	0	0	1	0	0	0	31.74
4603_WQ_1	1	$149,780	0.53	30.59	0	0	1	0	0	0	31.59
4902_WQ_15	1	$42,695	0.20	29.98	0	0	1	0	0	0	30.98
4911_WQ_1	2	$246,793	0.98	25.90	0	0	0	0	5	0	30.90
4906_WQ_9	1	$50,831	0.22	28.90	0	0	2	0	0	0	30.90
4917_WQ_1	2	$362,611	1.40	27.71	0	0	0	0	3	0	30.71
4702_WQ_2	1	$395,133	1.27	27.58	0	0	0	0	3	0	30.58
4902_WQ_9	2	$524,658	1.85	27.45	0	0	1	0	2	0	30.45
4912_WQ_1	1	$321,481	1.21	26.03	0	0	1	0	3	0	30.03
4704_WQ_6	3	$239,355	0.82	24.96	0	0	3	0	2	0	29.96
4809_WQ_2	1	$198,605	0.76	29.69	0	0	0	0	0	0	29.69
4908_WQ_3	1	$1,087,613	4.30	30.28	-1	0	0	0	0	0	29.28
4918_WQ_3	1	$103,795	0.41	29.23	0	0	0	0	0	0	29.23
4501_WQ_4	1	$693,595	2.24	25.19	0	0	1	0	3	0	29.19
4602_WQ_7	1	$210,901	0.77	29.13	-1	0	1	0	0	0	29.13
4803_WQ_11	1	$28,436	0.13	25.75	0	0	0	0	3	0	28.75
4909_WQ_1	1	$223,665	0.92	28.57	0	0	0	0	0	0	28.57
4902_WQ_2	2	$120,982	0.44	23.77	0	0	1	0	3	0	27.77
4501_WQ_7	1	$61,159	0.26	26.67	0	0	1	0	0	0	27.67
4801_WQ_1	1	$128,723	0.46	25.44	0	0	2	0	0	0	27.44
4910_WQ_1	1	$146,180	0.58	25.42	0	0	0	0	2	0	27.42
4803_WQ_9	1	$24,884	0.11	23.51	0	0	0	0	3	0	26.51
4905_WQ_5	1	$144,201	0.56	24.46	0	0	0	0	2	0	26.46
4501_WQ_9	1	$97,950	0.34	24.07	0	0	2	0	0	0	26.07
4803_WQ_22	1	$18,971	0.10	23.67	0	0	2	0	0	0	25.67
4906_WQ_7	1	$49,897	0.20	21.54	0	0	2	0	2	0	25.54
4805_WQ_3	1	$13,419	0.09	22.16	0	0	3	0	0	0	25.16

WQ Project ID	No. of CB/MUTAs	CIP Cost	Load Removed (lbs/year)	Raw WQ Score	ESA	Contaminated Soils	Trash Generating Area	Public/Private	Synergy with FC	Synergy with SR	Comprehensive WQ Score
4918_WQ_6	1	$343,474	1.35	25.07	0	0	0	0	0	0	25.07
4702_WQ_5	1	$37,937	0.15	23.03	0	0	2	0	0	0	25.03
4801_WQ_3	1	$229,250	0.80	25.77	-1	0	0	0	0	0	24.77
4401_WQ_3	1	$1,376,073	4.82	21.70	0	-1	2	0	2	0	24.70
4602_WQ_11	1	$13,635	0.08	17.51	0	0	4	0	3	0	24.51
4906_WQ_11	1	$31,013	0.13	22.15	0	0	0	0	2	0	24.15
4918_WQ_5	1	$300,705	1.17	21.06	0	0	0	0	3	0	24.06
4808_WQ_4	1	$24,173	0.11	22.94	0	0	1	0	0	0	23.94
4501_WQ_11	1	$27,515	0.12	18.78	0	0	3	0	2	0	23.78
4906_WQ_2	2	$145,928	0.55	22.00	0	0	1	0	0	0	23.00
4905_WQ_6	1	$65,265	0.26	22.73	0	0	0	0	0	0	22.73
4810_WQ_2	2	$169,576	0.56	18.46	0	0	0	0	3	0	21.46
4905_WQ_1	2	$311,086	1.06	19.44	0	0	0	0	2	0	21.44
4701_WQ_4	1	$14,256	0.09	20.37	0	0	1	0	0	0	21.37
4908_WQ_1	1	$134,704	0.53	21.14	0	0	0	0	0	0	21.14
4703_WQ_21	1	$22,728	0.10	18.27	-1	0	0	0	3	0	20.27
4901_WQ_1	1	$192,496	0.69	19.15	0	0	1	0	0	0	20.15
4705_WQ_5	1	$251,027	0.78	11.12	0	0	4	0	5	0	20.12
4803_WQ_14	1	$6,872	0.06	16.87	0	0	0	0	3	0	19.87
4503_WQ_12	1	$15,572	0.08	18.00	0	0	1	0	0	0	19.00
4501_WQ_2	1	$186,620	0.65	14.88	-1	0	3	0	2	0	18.88
4906_WQ_6	1	$27,100	0.10	16.74	-1	0	0	0	3	0	18.74
4603_WQ_2	1	$16,543	0.09	18.65	0	0	0	0	0	0	18.65
4902_WQ_16	1	$43,733	0.17	18.34	0	0	0	0	0	0	18.34
4906_WQ_5	1	$91,014	0.34	14.25	0	0	4	0	0	0	18.25
4602_WQ_12	1	$28,436	0.12	15.99	-1	0	3	0	0	0	17.99
4502_WQ_11	2	$328,134	0.93	15.69	0	-1	3	0	0	0	17.69
4503_WQ_10	1	$24,167	0.11	16.48	0	0	1	0	0	0	17.48
4902_WQ_3	1	$197,029	0.66	16.18	0	0	1	0	0	0	17.18
4501_WQ_13	1	$59,067	0.18	16.66	0	0	0	0	0	0	16.66
4906_WQ_4	1	$82,933	0.29	16.16	0	0	0	0	0	0	16.16
4502_WQ_8	1	$11,102	0.06	15.47	0	0	0	0	0	0	15.47
4703_WQ_12	1	$10,356	0.06	14.46	0	0	1	0	0	0	15.46
4502_WQ_9	1	$32,475	0.11	10.38	0	0	2	0	3	0	15.38
4904_WQ_3	2	$238,349	0.71	13.70	0	0	1	0	0	0	14.70
4908_WQ_4	1	$23,828	0.09	14.58	0	0	0	0	0	0	14.58

WQ Project ID	No. of CB/MUTAs	CIP Cost	Load Removed (lbs/year)	Raw WQ Score	ESA	Contaminated Soils	Trash Generating Area	Public/Private	Synergy with FC	Synergy with SR	Comprehensive WQ Score
4809_WQ_8	1	$8,791	0.05	13.99	0	0	0	0	0	0	13.99
4607_WQ_4	1	$40,403	0.14	12.77	0	0	1	0	0	0	13.77
4503_WQ_9	1	$38,111	0.14	11.54	0	0	2	0	0	0	13.54
4907_WQ_2	1	$167,793	0.51	11.53	0	0	2	0	0	0	13.53
4401_WQ_6	1	$53,952	0.15	8.37	0	0	2	0	2	0	12.37
4608_WQ_4	1	$43,501	0.15	9.76	0	0	2	0	0	0	11.76
4803_WQ_15	1	$8,320	0.04	11.29	0	0	0	0	0	0	11.29
4607_WQ_5	1	$40,486	0.12	7.79	0	0	3	0	0	0	10.79
4607_WQ_3	1	$69,919	0.18	5.03	0	0	2	0	3	0	10.03
4917_WQ_2	1	$62,165	0.20	7.90	0	0	0	0	2	0	9.90
4809_WQ_7	1	$98,260	0.28	9.45	0	0	0	0	0	0	9.45
4701_WQ_3	1	$28,784	0.08	4.43	0	0	4	0	0	0	8.43
4902_WQ_7	2	$141,210	0.37	7.30	0	0	1	0	0	0	8.30
4608_WQ_8	1	$37,281	0.11	8.21	0	0	0	0	0	0	8.21
4906_WQ_8	1	$5,895	0.04	7.19	0	-1	2	0	0	0	8.19
4608_WQ_9	1	$30,366	0.10	8.18	0	0	0	0	0	0	8.18
4805_WQ_2	1	$8,666	0.04	7.28	0	0	0	0	0	0	7.28
4702_WQ_1	1	$142,917	0.35	5.97	0	0	1	0	0	0	6.97
4918_WQ_4	1	$26,347	0.09	6.25	0	0	0	0	0	0	6.25
4609_WQ_4	1	$101,556	0.24	2.71	0	0	1	0	0	0	3.71
4902_WQ_18	1	$17,533	0.05	2.46	0	0	1	0	0	0	3.46
4906_WQ_10	1	$16,688	0.05	2.54	0	0	0	0	0	0	2.54
4902_WQ_17	1	$26,336	0.07	2.01	0	0	0	0	0	0	2.01
4705_WQ_3	1	$8,377	0.02	1.00	0	0	1	0	0	0	2.00
4705_WQ_2	1	$15,995	0.04	1.06	0	0	0	0	0	0	1.06

7.2 Flood Control Recommendations

The total Chollas Creek watershed spans 27 sq. mi. across the jurisdictions of the County of San Diego as well as the cities of San Diego, La Mesa, and Lemon Grove. The following sections present summaries of the various structures associated with the drainage infrastructure improvements within the City of San Diego's jurisdiction and a breakdown of the total anticipated costs of all improvements, which are estimated to be $223 million.

7.2.1 Inlet Recommendations

Table 7-2 presents the inlet recommendations in in the Chollas Creek watershed. A total of 213 new inlets have been proposed to mitigate large catch basin drainage areas in excess of approximately 8 acres or more, based on street conveyance, within the study area. Replacement of a total of 553 existing inlets with larger size openings was recommended to increase capture rate and mitigate the amount of surface flooding shown to occur within the models.

Table 7-2. Inlet recommendations summary table

Facility Type	Existing	Proposed	
	Total	Replaced	New
Inlet	2,599	553	213

7.2.2 Storm Drain Recommendations

The following tables are a brief summary of the proposed conveyance infrastructure improvements modeled in the proposed condition.

Table 7-3. Storm drain recommendations summary table

Facility Type	Existing	Proposed	
	Total	Replaced or Realigned	New
Storm Drain (miles)	107.3	19	21
Box Culvert (LF)	26,625	3,022	491

Installation of a total of 21 miles of new storm drain pipe segments has been identified as an effort to extend the conveyance network upstream to mitigate the amount of runoff being conveyed to inlet points located at the upstream end of the existing system. Nineteen miles of existing storm drain segments that were deficient in capacity and/or in need of realignment were identified to be replaced with a larger diameter storm drain pipe or realigned, as applicable. In areas where new storm drain segments were proposed, the alignments were proposed within the City's ROW and existing segments located in easements identified as undersized were upsized and realigned where feasible.

Note: Some of the existing segments identified for improvement were not shown with a new alignment due to horizontal and vertical constraints and the required pipe sizes were identified assuming the current alignment.

For a visual representation of the proposed storm drain improvements, see the map book provided in section B.4-6 of appendix B.

7.2.3 Outfall Recommendations

Several locations throughout the study area in the existing condition model exhibit discharges at or near the top of sloped areas towards the various canyons and valleys that form the topography of the region. In situations where replacement pipes have been proposed at these areas, a recommendation has been provided to relocate the discharge point to a more stable area located at or near the bottom of the slope.

The results of a previous outfall assessment conducted in 2013 by AMEC was incorporated into the prioritization effort per the City's direction taking into account existing capacity limitations, existing erosion issues, and maintenance accessibility and ownership alignments.

7.2.4 Channel Recommendations

This Chollas Creek WMP, along with the Chollas Creek Channel individual hydrologic and hydraulic assessment (IHHA) and Auburn Creek channel IHHA, identifies portions of open channel within the Chollas Creek watershed that potentially require maintenance to alleviate flooding risk and maximize flood control capacity. Recommended maintenance activities include either vegetation maintenance (removes vegetation down to the sediment layer) or sediment and vegetation removal, while minimizing vegetation removal whenever feasible. See the Channel Recommendations Map in section B-7.1 of appendix B for a visual representation of channel segments previously identified in an IHHA report as potentially requiring maintenance.

Note: Ongoing maintenance activities have been conducted as part of the El Niño Emergency Maintenance for 2015/2016 by the City of San Diego. Also, although maintenance activities will increase channel hydraulic capacity, the existing channel geometries are not sufficient to contain the 100-year flows.

In the proposed condition models, channels are modeled with cross-sectional geometry designed to convey the 100-year peak flows. The goal of strategically implementing regional storage locations was also important, wherever possible, in order not to exacerbate existing channel deficiencies. In areas with extreme physical constraints, recommendations included maintaining the current concrete-lined geometry of existing channels while performing maintenance activities to increase conveyance capacity.

Channels requiring an increase in capacity within the study area, including existing concrete segments, were reconfigured to contain the 100-year peak flows and maintain adequate freeboard, while attempting to maintain non-erosive velocities. These proposed channel recommendation areas are also potential stream restoration opportunities, including segments of existing concrete that could be restored to natural soft-bottom channels, dependent on available space adjacent to the channel.

Table 7-4 presents a brief summary of the total length of existing channel in the watershed, the length of channel replaced, and length of new channel created. Any new or replaced channel reaches will be naturally vegetated.

Table 7-4. Channel recommendations summary

Facility Type	Existing	Proposed	
	Total	Replaced or Widened	New
Channel (miles)	20.7	5	0

See section B-6.2 in appendix B for a more detailed channel recommendation summary and the associated map in section B-6.1 for a visual representation of these areas.

7.2.5 Detention Area Recommendations

As the ultimate destination of the storm drain discharges in the study area were channels, the proposed condition models showed a significant increase in peak flow rates in the channels after the storm drain pipes were upsized, with the end result being that the existing channels lack the capacity for the increased peak flows, unless additional storage to help reduce peak flow rates back to existing conditions.

In the process of identifying storage locations for the purposes of detention, preference was given to available aboveground areas, either in open space, parks, or undeveloped parcels. In some cases, the detention can be achieved by restricting flow upstream of culvert crossings to increase inundation and use of available open space without overtopping of the road and in many cases without requiring additional grading within the adjoining open space/canyon area. Due to the constraints of some of the more heavily developed regions within the watershed, other locations have been recommended for underground detention (e.g., below surface parking areas).

Fifty-five possible detention locations were identified. The locations were identified based on the aerial imagery, available footprint, and contributing areas. Table 7-5 presents a brief summary of the number of strategically identified detention areas and the total volume of storage required.

Table 7-5. Detention area recommendations summary

Detention Facility Type	Locations Identified	Total Detention Volume Required (ac-ft)
Above Ground Basin	37	254
Underground Vault	18	108
Street Storage	N/A	79
Total	**55**	**441**

7.2.6 Cost Estimates

Estimated construction costs were prepared for proposed drainage conveyance and structure facilities. Unit prices established for this master plan estimate were based on a review of current similar drainage projects within the region, as well as an evaluation of Caltrans (2016) and City of San Diego (2009) unit price lists. Unit prices for culvert and storm drain facilities were developed on a linear-foot basis. Unit prices for channel improvements were based on a function of linear feet and channel width (i.e., a change in volume from existing to proposed conditions was estimated specifically to excavation/export, while proposed length and top width was estimated specifically to area driven quantities). Unit prices for structure facilities were developed based on price per structure, relative to the size of the structure.

A miscellaneous lump sum cost of 40 percent of the estimated facility costs was applied as an add-on to all conveyance facilities. This add-on is intended to account for associated construction costs that could not be quantified on an individual facility level basis such as mobilization, pay and performance bonds, traffic control, water quality control plan compliance, and contingency. Furthermore, additional miscellaneous lump sum add-on costs were included for specific conveyance facilities that were identified during project review to have a potential to require additional costs such as land acquisition, channel stabilization, or energy dissipaters.

Total facility costs are arrived at by adding the initial facility cost with the miscellaneous lump sum and add-on costs; total project costs are equated through a summation of all coincident conveyance and structure facility costs associated with a specific identified project ID.

Assumptions

The following assumptions have been made to simplify both the calculations and understanding of the opinion of probable construction costs:

- The cost per unit of pipe, box culvert, channels, and structures includes work incidental to the installation such as excavation, backfill, and bedding material.
- Inlet structures are estimated at a maximum opening length of L=20 ft.
- Headwall structures are estimated for a maximum pipe diameter of D = 48 inches.
- Energy dissipaters are estimated to be per RSD D-40 and are costed based on influent pipe diameter or culvert height.

- Open channel conveyance estimates were calculated as follows:
- The proposed volume of channel creation was quantified by taking the difference in cross-sectional areas between the existing channel and the proposed channel, and multiplying this value by the length of proposed channel improvements. Surface area improvements such as clearing and grubbing, planting, and irrigation were based on the surface area of the proposed channel segment and were derived by multiplying the proposed top width of the channel by the proposed length. No environmental documentation or mitigation costs were included with this opinion.
- Relocation of utilities or other potential conflicts were not included in these costs.

The unit processes shown are for planning purposes only and are not guaranteed construction costs. Construction costs can vary greatly depending on project-specific factors, time of construction, field conditions, phasing, and other environmental conditions. Furthermore, although cost estimates are provided at the facility level, the intent of this opinion of probable cost is that structure and conveyance facilities will be constructed as a comprehensive project, and not as individual facilities. The facility costs presented herein are based on unit costs that are associated with drainage projects typically ranging from $250,000 to $4 million.

Note: Constructing smaller scale projects could result in higher unit costs for conveyance and structure facilities. Detailed construction costs estimates for each specific project improvement should be prepared at the time of project design and construction to account for these variables.

Table 7-6 presents a brief summary of the breakdown for the approximate costs for the flood control facility improvements recommended in this WMP.

Table 7-6. Facilities cost summary

Facility Type	Proposed (Replaced/Realigned/New)	
	Quantity	**Total Cost ($)**
Junctions		
Inlet (#)	766	$ 10,634,000
Cleanout (#)	267	$ 1,869,000
Headwall (#)	38	$ 387,000
Conveyance		
Storm Drain (miles)	40	$ 79,547,000
Culvert (LF)	3513	$ 4,172,000
Channel (miles)	5	$ 18,497,000
Storage (ac-ft)	362	$ 117,968,000
Total	**N/A**	**$ 223,074,000**

Note: ac-ft = acre-foot.

7.2.7 Flood Control Projects

The recommended drainage conveyance and structure facilities were grouped into project bundles and assigned a unique project ID to assist the City in evaluating proposed facility recommendations at the project scale. Recommended projects are provided in section B.5-1 in appendix B and include the necessary conveyance, including pipes, culverts, channels, and appurtenant structures such as inlets, cleanouts, and outfalls, that would be required to construct a project complete in place.

To group facilities into recommended projects, a heat map was prepared in GIS that highlighted recommended facilities based on their individual priority score as well as by proximity to adjacent facilities. The heat map provided the visual framework for identifying optimal project bundles; facilities were then assembled into projects with reference to overall project cost. At the City's direction, a primary objective of the project bundling was to compile cost-effective recommendations that equated to a total project construction cost of less than $4 million. Projects that exceeded the $4 million threshold were thus phased into multiple-project scenarios to maintain lower total project costs.

A summary of the compiled projects, including facility types and project costs, are included in section B.4-4 in appendix B.

7.3 Stream Restoration Recommendations

7.3.1 Stream Restoration Concepts

Appendix C contains detailed information including figures and acreages, for the recommended restoration concepts developed for each of the 17 recommended stream restoration candidate sites.

Restoration Treatment Types

Table 7-7 below provides a summary of the recommended treatment types assigned for each of the sites, with three of the sites recommended for both treatment types.

Table 7-7. Restoration Treatment Types

Name	Overall Rank	Restoration Treatment Type	
		Scenario 1 Riparian/Wetland-Vegetated Channel	Scenario 2 Open Cobble Channel
Auburn - Auburn/Wightman 3	1		X
Auburn - Fairmont Avenue	2		X
Chollas - Chollas Parkway	3		X
Chollas - Sunshine Berardini Park	4		X
Wabash - Interstate 15	5	X	X

Name	Overall Rank	Restoration Treatment Type	
		Scenario 1 Riparian/Wetland-Vegetated Channel	Scenario 2 Open Cobble Channel
Wabash - Juniper Canyon	6	X	
South Chollas – Elwood Avenue	7		X
Chollas - National Avenue	8		X
Auburn - Spillman Drive	9	X	
South Chollas - Castana Street	10		X
Encanto Branch - Merlin Drive	11	X	X
Auburn - Auburn/Wightman 1	12	X	
Chollas - 54th Street	13		X
Wabash - Ash & Delevan	14		X
Chollas - Federal & Home	15		X
Jamacha Branch Tributary – Cardiff Street	16		X
Auburn - Auburn/Wightman 2	17		X

As reflected in Table 7-7, thee sites that are recommended for the Scenario 1 – Riparian/Wetland-Vegetated Channel restoration treatment type, exclusively, include:

- Auburn - Auburn/Wightman 1,
- Auburn – Spillman Drive, and
- Wabash – Juniper Canyon

The sites that are recommended for the Scenario 2 – Open Cobble Channel restoration treatment type, exclusively, include:

- Auburn – Auburn/Wightman 2,
- Auburn – Auburn/Wightman 3,
- Auburn – Fairmont Avenue,
- Chollas – Chollas Parkway,
- Chollas – Sunshine Berardini Park,
- South Chollas – Elwood Avenue,
- Chollas – National Avenue,

- South Chollas – Castana,
- Chollas – 54th Street,
- Chollas – Federal & Home,
- Wabash – Ash & Delevan, and
- Jamacha Branch Tributary – Cardiff Street

The sites that are recommended for both Scenario 1 and Scenario 2 include:

- Wabash - Interstate 15, and
- Encanto Branch – Merlin Drive

The recommendations for restoration treatment types are preliminary and conceptual, but based on the site-specific information gathered within the scope of the WMP. It is expected that with more-detailed, project-level assessment of each site, the restoration treatments will be further refined.

Post-Restoration City Wetland Habitat Types

Table 7-8 provides a summary of the existing and expected post-restoration riparian/wetland habitat types and natural flood channel acreages for the 17 stream restoration candidate sites that are recommended for implementation.

Table 7-8. Approximate increase in riparian/wetland habitat and natural flood channel (based on City Biology Guidelines)

Name	Riparian/Wetland[a]			Natural Flood Channel[b]		
	Existing (ac)	With Restoration (ac)	Net Increase (ac)	Existing (ac)[c]	With Restoration (ac)	Net Increase (ac)[c]
Auburn - Auburn Wightman 1	0.39	0.99	*0.60*	0.00	0.09	*0.09*
Auburn - Auburn Wightman 2	0.77	2.50	*1.73*	0.40	0.42	*0.02*
Auburn - Auburn Wightman 3	0.50	1.93	*1.43*	1.06	0.32	*-0.75*
Auburn - Fairmont Avenue	0.24	1.53	*1.29*	0.44	0.14	*-0.30*
Auburn - Spillman Drive	0.80	2.48	*1.69*	0.03	0.10	*0.08*
Chollas - 54th Street	4.64	13.45	*8.81*	0.49	3.48	*2.99*
Chollas - Chollas Parkway	0.00	11.05	*11.05*	1.84	1.56	*-0.28*
Chollas - Federal & Home	0.00	6.56	*6.56*	3.08	0.66	*-2.43*
Chollas - National Avenue	0.86	3.95	*3.09*	3.53	2.62	*-0.91*
Chollas - Sunshine Berardini Park	0.41	5.40	*4.99*	0.96	0.62	*-0.34*
Encanto Branch - Merlin Drive	1.26	4.08	*2.82*	0.73	1.57	*0.84*
Jamacha Branch Tributary - Cardiff Street	0.00	1.20	*1.20*	0.00	0.09	*0.09*
South Chollas - Castana Street	1.33	2.55	*1.22*	0.66	0.18	*-0.48*
South Chollas - Elwood Avenue	0.43	7.27	*6.84*	0.68	0.31	*-0.37*
Wabash - Ash & Delevan	0.00	1.14	*1.14*	0.54	0.13	*-0.41*
Wabash - Interstate 15	0.31	5.46	*5.15*	1.20	0.75	*-0.45*
Wabash - Juniper Canyon	0.13	7.29	*7.17*	0.30	0.41	*0.12*
Total[d]	**12.07**	**78.86**	***66.79***	**15.94**	**13.43**	***-2.51***

Notes:

[a] According to riparian/wetland classifications provided in Tables 2A and 2B of the City's Biology Guidelines.

[b] May include acreage covering developed concrete-lined channel which is not a habitat-type; but will be removed and converted to natural flood channel with restoration.

[c] Acreage is reflective of gain or loss of habitat type. Negative values are the result of the conversion of natural flood channel into vegetated City wetland habitat types.

[d] Totals are the result of rounding.

Post-Restoration Jurisdictional Area

Table 7-9 illustrates the total increase in jurisdictional areas with implementation of all 17 restoration candidate sites.

Table 7-9. Approximate increase in City, state, and federal wetland jurisdictional area

Name	USACE/RWQCB			CDFW			City of San Diego[a]		
	Existing (ac)	With Restoration (ac)	Gain/Loss (ac)[b]	Existing (ac)	With Restoration (ac)	Gain/Loss (ac)[b]	Existing (ac)	With Restoration (ac)	Gain/Loss (ac)[b]
Auburn - Auburn Wightman 1	0.10	0.32	*0.22*	0.39	1.08	*0.69*	0.39	1.08	*0.69*
Auburn - Auburn Wightman 2	0.52	1.10	*0.58*	1.68	2.92	*1.24*	1.16	2.92	*1.76*
Auburn - Auburn Wightman 3	0.60	0.78	*0.19*	1.66	2.25	*0.59*	1.56	2.25	*0.68*
Auburn – Fairmount Avenue	0.37	0.39	*0.02*	0.91	1.67	*0.76*	0.69	1.67	*0.99*
Auburn – Spillman Drive	0.83	0.32	*-0.51*	1.76	2.59	*0.83*	0.83	2.59	*1.76*
Chollas – Federal & Home	2.18	1.96	*-0.22*	3.54	7.22	*3.68*	3.08	7.22	*4.13*
Chollas – 54th Street	3.12	9.10	*5.99*	7.32	16.92	*9.60*	5.08	16.92	*11.85*
Chollas – Chollas Parkway	2.14	4.57	*2.43*	6.30	12.61	*6.32*	1.84	12.61	*10.77*
Chollas – National Avenue	3.02	2.74	*-0.29*	5.63	6.57	*0.94*	4.39	6.57	*2.18*
Chollas – Sunshine Berardini Park	1.16	1.82	*0.66*	2.64	6.02	*3.38*	1.37	6.02	*4.65*
Encanto Branch – Merlin Drive	1.48	2.26	*0.78*	4.01	5.65	*1.63*	1.99	5.65	*3.66*
Jamacha Branch Tributary – Cardiff Street	0.26	0.27	*0.01*	0.56	1.29	*0.73*	0.00	1.29	*1.29*
South Chollas – Castana Street	0.81	0.48	*-0.33*	2.59	2.73	*0.15*	1.99	2.73	*0.74*
South Chollas – Elwood Avenue	0.83	0.91	*0.07*	2.94	7.58	*4.65*	1.11	7.58	*6.47*
Wabash – Ash & Delevan	0.37	0.34	*-0.03*	1.13	1.26	*0.14*	0.54	1.26	*0.73*
Wabash – Interstate 15	1.56	2.01	*0.45*	3.90	6.21	*2.31*	1.51	6.21	*4.70*
Wabash – Juniper Canyon	0.47	2.54	*2.07*	1.04	7.71	*6.67*	0.42	7.71	*7.28*
TOTAL[c]	19.82	31.91	*12.09*	47.99	92.29	*44.30*	27.96	92.29	*64.33*

Notes:
[a] According to riparian/wetland classifications provided in Tables 2A and 2B of the City's Biology Guidelines.
[b] Acreage is reflective of gain or loss of habitat type. Negative values are the result of the conversion of natural flood channel/streambed into vegetated City wetland habitat types.
[c] Totals are the result of rounding

7.3.2 Stream Restoration Prioritization with Flood Control Projects

The majority of the recommended stream restoration candidate sites are also recommended for flood control improvements under the WMP, thereby providing an opportunity for multiple benefits to the watershed and integration. Table 7-11 provides the prioritization for the recommended restoration sites that are also recommended for flood control improvements.

Surplus Mitigation Post-Restoration

Table 7-10 illustrates the surplus acreage of jurisdictional areas after fulfillment of on site City ESL Wetland restoration mitigation requirements.

Table 7-10. Approximate surplus/wetland habitat and natural flood channel (based on City Biology Guidelines) after mitigation

Rank	Name	Surplus Acreage after Mitigation(ac)
1	Chollas - Chollas Parkway	8.92
2	Chollas - Federal & Home	7.22
3	Wabash - Juniper Canyon	7.08
4	Chollas - 54th Street	6.78
5	South Chollas - Elwood Avenue	5.36
6	Encanto Branch - Merlin Drive	3.97
7	Chollas - Sunshine Berardini Park	3.79
8	Wabash - Interstate 15	3.58
9	Chollas - National Avenue	3.33
10	Auburn - Spillman Drive	2.22
11	Jamacha Branch Tributary - Cardiff Street	1.29
12	Auburn - Fairmount Avenue	1.18
13	Auburn - Auburn Wightman 2	1.12
14	South Chollas - Castana Street	0.65
15	Auburn - Auburn Wightman 3	0.57
16	Auburn - Auburn Wightman 1	0.29
17	Wabash - Ash & Delevan	0.19
Total		**57.55**

7.3.3 Stream Restoration Prioritization with Flood Control Projects

Most of the recommended stream restoration candidate sites are also recommended for flood control improvements under the WMP, thereby providing an opportunity for multiple benefits to the watershed and integration. Table 7-11 provides the prioritization for the recommended restoration sites that are also recommended for flood control improvements.

Table 7-11. Restoration priority ranking for sites with flood control recommendations

Name	Overall Rank[a]
Auburn- Auburn Wightman 3	1
Auburn - Fairmont Avenue	2
Chollas – Chollas Parkway	3
Chollas - Sunshine Berardini Park	4
Wabash - Interstate 15	5
Wabash - Juniper Canyon	6
Auburn - Spillman Drive	9
Auburn – Auburn Wightman 1	12
Chollas - 54th Street	13
Wabash - Ash & Delevan	14
Auburn – Auburn Wightman 2	16

[a]Rankings are reflective of overall score of all stream restoration candidate sites

Table 7-12 summarizes the prioritization for the recommended stream restoration candidate sites that are not recommended for flood control improvements.

Table 7-12. Restoration priority ranking for sites without flood control recommendations

Name	Overall Rank[a]
South Chollas – Elwood Avenue	7
Chollas – National Avenue	8
South Chollas – Castana Street	10
Encanto Branch – Merlin Drive	11
Chollas – Federal & Home	14
Jamacha Branch Tributary – Cardiff Street	15

[a]Rankings are reflective of overall score of all stream restoration candidate sites.

Using the values in Table 7-8 and Table 7-9, if all of the restorations sites *with* flood control recommendations from Table 7-11 are implemented pursuant to the identified restoration scenario, then the riparian/wetland habitat within the Chollas Watershed would increase by approximately 45.10 acres, the natural flood channel (i.e., unvegetated streambed) would increase by 0.79 acre, and the total amount of City Wetland habitat types would increase by 45.89 acres.

Similarly, and also using the values in Table 7-8 and Table 7-9, if all of the restoration sites *without* flood control recommendations from Table 7-12 are implemented pursuant to the identified restoration scenario, then the riparian/wetland habitat within the Chollas Watershed would increase by approximately 21.74 acres, the natural flood channel would decrease by 3.27 acres due to expected gain in vegetated channel area within areas that are currently unvegetated, and the total amount of City Wetland habitat types would increase by 18.47 acres.

In comparing the restoration candidate sites with and without flood control recommendations, the sites with flood control recommendations are afforded higher overall rankings, would provide both stream restoration and flood control benefits, and offer the greatest increases in City Wetland habitat types and jurisdictional area.

7.3.4 Stream Restoration Costs

Restoration cost estimates were determined for the two general restoration scenarios (i.e., Scenario 1 – Riparian/Wetland-Vegetated Channel and Scenario 2 – Open Cobble Channel) based on real costs encountered for similar efforts in the region. The values reflect basic per acre and unit costs for the major restoration tasks assuming a 5-year restoration effort, including site preparation, grading, temporary irrigation, seeding and planting, maintenance, and monitoring. In general, the costs provided are conservative soft costs and not based on project-level information. The cost of property acquisition, conservation easement, and long-term management, for example, was not considered in the scope of this study.

Table 7-13 through Table 7-16 below provide a cost estimate summary for each scenario, which can be applied to each of the 17 recommended restoration candidate sites based on the information from Table 7-8 through Table 7-12.

Table 7-13. Riparian/wetland with grading (flood control improvements) restoration cost

Riparian/Wetland Restoration with Grading	Estimated Costs
Project Design	
Biology /Landscape	$3,000
Irrigation	$3,500
Subtotal	***$6,500***
Biological Monitoring	
Biological Installation Monitoring	$4,500
Biological Maintenance Monitoring	$25,000
Biological Annual Monitoring and Reporting	$30,000
Subtotal	***$59,500***
Construction Option	
Vegetated Bottom and Slopes	
Site Preparation	$217,800
Temporary Irrigation	$47,900
Planting and Hydroseed	$43,600
Maintenance	
Year 1	$36,000
Year 2	$27,000
Year 3	$24,000
Year 4	$18,000
Year 5	$18,000
Subtotal	***$432,300***
TOTAL	**$498,300**

Table 7-14. Riparian/wetland without grading (flood control improvements) restoration cost

Riparian/Wetland Restoration without Grading	Estimated Costs
Project Design	
Biology /Landscape	$3,000
Irrigation	$3,500
Subtotal	***$6,500***
Biological Monitoring	
Biological Installation Monitoring	$4,500
Biological Maintenance Monitoring	$25,000
Biological Annual Monitoring and Reporting	$30,000
Subtotal	***$59,500***
Construction Option	
Vegetated Bottom and Slopes	
Site Preparation	$87,120
Temporary Irrigation	$47,900
Planting and Hydroseed	$43,600
Maintenance	
Year 1	$36,000
Year 2	$27,000
Year 3	$24,000
Year 4	$18,000
Year 5	$18,000
Subtotal	***$301,620***
TOTAL	**$367,620**

Table 7-15. Open cobble with grading (flood control improvements) restoration cost

Open Cobble Restoration with Grading	Estimated Costs
Project Design	
Biology /Landscape	$3,000
Irrigation	$3,500
Subtotal	***$6,500***
Biological Monitoring	
Biological Installation Monitoring	$4,500
Biological Maintenance Monitoring	$25,000
Biological Annual Monitoring and Reporting	$30,000
Subtotal	***$59,500***
Construction Option	
Cobble Bottom / Vegetated Slopes	
Site Preparation	$217,800
Temporary Irrigation	$47,900
Planting and Hydroseed	$39,200
Maintenance	
Year 1	$24,000
Year 2	$18,000
Year 3	$16,000
Year 4	$12,000
Year 5	$12,000
Subtotal	***$386,900***
TOTAL	**$452,900**

Table 7-16. Open cobble without grading (flood control improvements) restoration cost

Open Cobble Restoration without Grading	Estimated Costs
Project Design	
Biology /Landscape	$3,000
Irrigation	$3,500
Subtotal	***$6,500***
Biological Monitoring	
Biological Installation Monitoring	$4,500
Biological Maintenance Monitoring	$25,000
Biological Annual Monitoring and Reporting	$30,000
Subtotal	***$59,500***
Construction Option	
Cobble Bottom / Vegetated Slopes	
Site Preparation	$87,120
Temporary Irrigation	$47,900
Planting and Hydroseed	$39,200
Maintenance	
Year 1	$24,000
Year 2	$18,000
Year 3	$16,000
Year 4	$12,000
Year 5	$12,000
Subtotal	***$256,220***
TOTAL	**$322,220**

7.3.5 General Site Constraints, Opportunities, and Recommendations

The discussion below highlights the general constraints initially identified for each potential candidate restoration site. General constraints include property ownership, proximity to MHPA and conserved lands, occupancy of sensitive species, impacts to sensitive native habitat, existing utilities and easements, and steep slopes and rugged terrain. Direct or indirect impacts to sensitive upland and wetland habitat types may need to be mitigated appropriately. Enhancement-related mitigation for impacts to City Wetland ESL habitat types are expected to be mitigated entirely or largely on site. To meet the resources agencies' no net-loss of wetlands policy requirements and where impacts to City Wetland ESL cannot be mitigated on site, mitigation would be achieved by off-site means, such as at another stream restoration site or an approved mitigation bank. Project-level evaluations for each site may determine additional constraints not readily apparent at the programmatic-level assessment provided in this document.

Auburn – Auburn Wightman 1

The most significant constraint associated with this site is that it is primarily located within privately-owned parcels, which would require multiple party involvement during City acquisition or recordation of a conservation easement or equivalent over portions of the parcels used for restoration mitigation. Direct impacts to City Wetland ESL habitats for channel widening would require compensatory mitigation. As currently planned, enhancement required for impacts to City Wetland ESL habitat types is expected to be entirely on-site. To meet the resources agencies' no net-loss of wetlands policy requirements and where impacts to City Wetland ESL cannot be mitigated on site, mitigation would be achieved by off-site means, such as at another stream restoration site or an approved mitigation bank. The existing steep slope to the northwest and surrounding development further present constraints on the ability to widen the channel and access it during monitoring and maintenance. Several utility lines occur within the middle of the site and have the potential to limit the restoration potential.

Some of the more noteworthy opportunities of the site is that it is partially City owned, supports a large watershed area, and supports relatively high flows. These opportunities would reduce acquisition constraints, provide suitable hydrology for the establishment of City wetlands, among other benefits.

This site is also being recommended for flood control improvements, which presents an opportunity to integrate and achieve multiple benefits from a single project.

Auburn – Auburn Wightman 2

The most significant constraint associated with this site is that it is primarily located within privately-owned parcels, which would require multiple party involvement during City acquisition or recordation of a conservation easement or equivalent over portions of the parcels used for restoration mitigation. As currently planned, enhancement required for impacts to City Wetland ESL habitat types is expected to be entirely on-site. To meet the resources agencies' no net-loss of wetlands policy requirements and where impacts to City Wetland ESL cannot be mitigated on site, mitigation would be achieved by off-site means, such as at another stream restoration site or an approved mitigation bank. The existing steep slopes and surrounding development further present constraints on the ability to widen the channel and access it during monitoring and maintenance. Several utility lines occur throughout the site and have the potential to limit the restoration potential.

Some of the more noteworthy opportunities of the site is that the site supports a large watershed area and supports relatively high flows. These opportunities would provide suitable hydrology for the establishment of City Wetlands, among other benefits.

This site is also being recommended for flood control improvements, which presents an opportunity to integrate and achieve multiple benefits from a single project.

Auburn – Auburn Wightman 3

The most significant constraint associated with this site is that it is located adjacent to MHPA and Tier II DCSS potentially occupied by special-status species, including the coastal California gnatcatcher (*Polioptila californica californica*; CAGN). Direct impacts to Tier I- IIIB and City Wetland ESL habitats for channel widening would require compensatory mitigation and is expected to be achieved by off-site means, such as through the City's Habitat Acquisition Fund (HAF) program. As currently planned, enhancement required for impacts to City Wetland ESL habitat types is expected to be entirely on-site. To meet the resources agencies' no net-loss of wetlands policy requirements and where impacts to City Wetland ESL cannot be mitigated on site, mitigation would be achieved by off-site means, such as at another stream restoration site or an approved mitigation bank. In addition, the site is partially located within privately-owned parcels, which would require multiple party involvement during City acquisition or recordation of a conservation easement or equivalent over portions of the parcels used for restoration mitigation. The existing steep slope to the southeast and surrounding development further present constraints on the ability to widen the channel and access it during monitoring and maintenance.

Some of the more noteworthy opportunities of the site is the creation potential as a result of removing concrete from portions of the channel, although it is acknowledged that there is a very long reach of existing concrete-lined channel that is not being recommended for removal or restoration between Auburn – Auburn Wightman 2 and Auburn – Auburn Wightman 3. In addition, the site is primarily City owned, is not constrained by incompatible uses, supports a large watershed area, and supports relatively high flows. These opportunities would reduce acquisition constraints, alleviate the easement recordation process, provide suitable hydrology for the establishment of City wetlands, among other benefits.

This site is also being recommended for flood control improvements, which presents an opportunity to integrate and achieve multiple benefits from a single project.

Auburn – Fairmont Avenue

The most significant constraint associated with this site is that the entirety is located within privately-owned parcels, which would require multiple party involvement during City acquisition or recordation of a conservation easement or equivalent over portions of the parcels used for restoration mitigation. In addition, the site is located immediately adjacent to MHPA and Tier II DCSS potentially occupied by special-status species, including the CAGN. Direct impacts to Tier I-IIIB and City Wetland ESL habitats for channel widening would require compensatory mitigation and is expected to be achieved by off-site means, such as through the City's HAF program. As currently planned, enhancement required for impacts to City Wetland ESL habitat types is expected to be entirely on-site. To meet the resources agencies' no net-loss of wetlands policy requirements and where impacts to City Wetland ESL cannot be mitigated on site, mitigation would be achieved by off-site means, such as at another stream restoration site or an approved mitigation bank.. The existing steep slope to the southeast and development to the northwest further present constraints on the ability to widen the channel and access it during monitoring and maintenance. A single sewer utility line and associated easement traverses a short section at the very downstream end of the site.

Some of the more noteworthy opportunities of the site is the creation potential as a result of removing concrete from portions of the channel. In addition, the site is not constrained by incompatible uses, supports a large watershed area, and supports relatively high flows. These opportunities would provide suitable hydrology for the establishment of City Wetlands, among other benefits.

This site is also being recommended for flood control improvements, which presents an opportunity to integrate and achieve multiple benefits from a single project.

Auburn – Spillman Drive

The most significant constraint associated with this site is that it is entirely located within privately-owned parcels, which would require multiple party involvement during City acquisition or recordation of a conservation easement or equivalent over portions of the parcels used for restoration mitigation. In addition, the site is located immediately adjacent to MHPA and Tier II DCSS potentially occupied by special-status species, including the CAGN. Direct impacts to Tier I-IIIB and City Wetland ESL habitats for channel widening would require compensatory mitigation and is expected to be achieved by off-site means, such as through the City's HAF program. As currently planned, enhancement required for impacts to City Wetland ESL habitat types is expected to be entirely on-site. To meet the resources agencies' no net-loss of wetlands policy requirements and where impacts to City Wetland ESL cannot be mitigated on site, mitigation would be achieved by off-site means, such as at another stream restoration site or an approved mitigation bank. The existing steep slope to the south constrains the ability to widen the channel and access it during monitoring and maintenance.

Some of the more noteworthy opportunities of the site is that it has no known utility or easement restrictions, is not constrained by incompatible uses, supports a large watershed area, and supports relatively high flows. These opportunities would provide suitable hydrology for the establishment of City wetlands, among other benefits.

This site is also being recommended for flood control improvements, which presents an opportunity to integrate and achieve multiple benefits from a single project.

Chollas – 54th Street

The most significant constraint associated with this site is that it is located within MHPA and adjacent to Tier II DCSS potentially occupied by special-status species, including the CAGN. Direct impacts to Tier I-IIIB and City Wetland ESL habitats for channel widening would require compensatory mitigation and is expected to be achieved by off-site means, such as through the City's HAF program. As currently planned, enhancement required for impacts to City Wetland ESL habitat types is expected to be entirely on-site. To meet the resources agencies' no net-loss of wetlands policy requirements and where impacts to City Wetland ESL cannot be mitigated on site, mitigation would be achieved by off-site means, such as at another stream restoration site or an approved mitigation bank. The existing development surrounding the northern half present constraints on the ability to widen the channel; however, the southern portion of the site is unconstrained.

Some of the more noteworthy opportunities of the site is that it is primarily City owned, is not constrained by incompatible uses, supports a large watershed area, and supports relatively high flows. These opportunities would reduce acquisition constraints, alleviate the easement recordation process, provide suitable hydrology for the establishment of City wetlands, among other benefits.

This site is also being recommended for flood control improvements, which presents an opportunity to integrate and achieve multiple benefits from a single project.

Chollas – Chollas Parkway

The most significant constraint associated with this site is that it is located within MHPA and adjacent to Tier II DCSS potentially occupied by special-status species, including the CAGN. Direct impacts to Tier I-IIIB and City Wetland ESL habitats for channel widening would require compensatory mitigationand is expected to be achieved by off-site means, such as through the City's HAF program. As currently planned, enhancement required for impacts to City Wetland ESL habitat types is expected to be entirely on-site. To meet the resources agencies' no net-loss of wetlands policy requirements and where impacts to City Wetland ESL cannot be mitigated on site, mitigation would be achieved by off-site means, such as at another stream restoration site or an approved mitigation bank. The existing steep slope to the north further present constraints on the ability to widen the channel.

Some of the more noteworthy opportunities of the site is that it is primarily City owned, is not constrained by incompatible uses, supports a large watershed area, and supports relatively high flows. These opportunities would eliminate acquisition constraints, alleviate the easement recordation process, and provide suitable hydrology for the establishment of City wetlands, among other benefits.

This site is also being recommended for flood control improvements, which presents an opportunity to integrate and achieve multiple benefits from a single project.

Chollas – Federal & Home

The most significant constraint associated with this site is that it is primarily located within public-owned parcels. The site is also bounded by existing roads, which would limit the potential mitigation acreage.

Some of the more noteworthy opportunities of the site is its creation potential as a result of removing concrete from portions of the channel, although this channel was not recommended for flood control improvements. In addition, the site is not constrained by incompatible uses, supports a large watershed area, and supports relatively high flows. These opportunities would provide suitable hydrology for the creation and establishment of City Wetlands, among other benefits.

Chollas – National Avenue

The most significant constraint associated with this site is partially owned by City and the U.S. government, but is primarily located within privately-owned parcels, which would require multiple party involvement during City acquisition or recordation of a conservation easement or equivalent over portions of the parcels used for restoration mitigation. Several utility lines occur within the northern end of the site and have the potential to limit the restoration potential. The site is bordered by existing roads and development, limiting the extent of channel widening. In addition, portions of the site are concrete-lined and concrete removal is not recommended which would further present constraints on the ability to widen the channel.

Some of the more noteworthy opportunities of the site is that a portion of the site is located within the Coastal Zone Overlay. In addition, the site is not constrained by incompatible uses, supports a large watershed area, and supports high flows. These opportunities would provide suitable hydrology for the establishment of City Wetlands, among other benefits.

Chollas – Sunshine Berardini Park

The most significant or noteworthy constraint associated with this site is that it is located within and adjacent to MHPA and Tier II DCSS potentially occupied by special-status species, including CAGN. Direct impacts to Tier I-IIIB and City Wetland ESL habitats for channel widening would require compensatory mitigation and is expected to be achieved by off-site means, such as through the City's HAF program. As currently planned, enhancement required for impacts to City Wetland ESL habitat types is expected to be entirely on-site. To meet the resources agencies' no net-loss of wetlands policy requirements and where impacts to City Wetland ESL cannot be mitigated on site, mitigation would be achieved by off-site means, such as at another stream restoration site or an approved mitigation bank. In addition, there are sewer utility lines and associated easements that intersect the site perpendicularly at two locations: one in the upper reach and one in the middle reach. The utility easements are spaced from one another and should not preclude the ability for the remaining site outside of any utility easements to be restored and generate riparian/wetland compensatory mitigation credit. In the upper reach and further upstream toward Fairmount Avenue, the sewer utility is consolidated as a single main line that runs parallel with and adjacent to the channel on the north side. In these areas, restoration would be restricted to the south to keep the utility and associated easement outside of the mitigation areas.

Some of the more noteworthy opportunities of the site is that it is entirely City owned, is not constrained by incompatible uses, supports a large watershed area, and supports relatively high flows. These opportunities would eliminate acquisition constraints, alleviate the easement recordation process, and provide suitable hydrology for the establishment of City Wetlands, among other benefits.

This site is also being recommended for flood control improvements, which presents an opportunity to integrate and achieve multiple benefits from a single project.

Encanto Branch – Merlin Drive

The most significant constraint associated with this site is that it is located immediately adjacent to MHPA and Tier II DCSS potentially occupied by special-status species, including the CAGN. Direct impacts to Tier I-IIIB and City Wetland ESL habitats for channel widening would require compensatory mitigation and is expected to be achieved by off-site means, such as through the City's HAF program. As currently planned, enhancement required for impacts to City Wetland ESL habitat types is expected to be entirely on-site. To meet the resources agencies' no net-loss of wetlands policy requirements and where impacts to City Wetland ESL cannot be mitigated on site, mitigation would be achieved by off-site means, such as at another stream restoration site or an approved mitigation bank. The southern half of the site is bordered by existing roads, railways, and development, limiting the extent of channel widening. In addition, portions of the site are concrete-lined and concrete removal is not recommended which would further present constraints on the ability to widen the channel. The City performed enhancement, in the form of non-native plant removal, in the southern portion of this site in 2016. In addition, Dudek identified restoration potential in the northern portion of this site; however, restoration has not been initiated.

Some of the more noteworthy opportunities of the site is that it is primarily City owned, supports a large watershed area, and supports relatively high flows. These opportunities would reduce acquisition constraints, alleviate the easement recordation process, and provide suitable hydrology for the establishment of City Wetlands, among other benefits.

Jamacha Branch Tributary – Cardiff Street

The most significant constraint associated with this site is that it does not support a large watershed area and it might not receive flows large enough to support wetland vegetation. The site is currently characterized by round-bottom swale features that traverse non-native upland habitat types. In addition, a single sewer utility line and associated easement traverses the entire northern length of the site; however, the existing utility should not preclude the site from being restored and generating riparian/wetland compensatory mitigation credit. The site also is entirely City owned, which would reduce acquisition constraints.

South Chollas – Castana Street

The most significant constraint associated with this site is that it is constrained by existing development and the Jacobs Channel Reconfiguration & Restoration (2000) mitigation site upstream, which would limit the restoration potential (Figure 2-7). Non-native vegetation, specifically arundo, was removed concurrently with the development of the park, to the south, in 2014. In addition, direct impacts to Tier I-IIIB and City Wetland ESL habitats for channel widening would require compensatory mitigation and is expected to be achieved by off-site means, such as through the City's HAF program. As currently planned, enhancement required for impacts to City Wetland ESL habitat types is expected to be entirely on-site. To meet the resources agencies' no net-loss of wetlands policy requirements and where impacts to City Wetland ESL cannot be mitigated on site, mitigation would be achieved by off-site means, such as at another stream restoration site or an approved mitigation bank. Some of the more noteworthy opportunities of the site is that it is entirely City owned, is not constrained by utility easements or incompatible uses, supports a large watershed area, and supports relatively high flows. These opportunities would reduce acquisition constraints, alleviate the easement recordation process, and provide suitable hydrology for the establishment of City Wetlands, among other benefits.

South Chollas - Elwood and Lenox

The most significant constraint associated with this site is that it is located adjacent to MHPA and within Tier II DCSS potentially occupied by special-status species, including CAGN. Direct impacts to Tier I-IIIB and City Wetland ESL habitats for channel widening would require compensatory mitigation and is expected to be achieved by off-site means, such as through the City's HAF program. As currently planned, enhancement required for impacts to City Wetland ESL habitat types is expected to be entirely on-site. To meet the resources agencies' no net-loss of wetlands policy requirements and where impacts to City Wetland ESL cannot be mitigated on site, mitigation would be achieved by off-site means, such as at another stream restoration site or an approved mitigation bank. A single, existing sewer utility line and associated easement parallels the entire length and crosses the channel once.

Some of the more noteworthy opportunities of the site is that it is primarily City owned, is not significantly constrained by utility easements or incompatible uses, supports a large watershed area, and supports relatively high flows. These opportunities would eliminate acquisition constraints, alleviate the easement recordation process, and provide suitable hydrology for the establishment of City Wetlands, among other benefits.

Wabash – Ash & Delevan

The most significant constraint associated with this site is that it is entirely located within privately-owned parcels, which would require multiple party involvement during City acquisition or recordation of a conservation easement or equivalent over portions of the parcels used for restoration mitigation. In addition, the site is located adjacent to MHPA and Tier II DCSS potentially occupied by special-status species, including CAGN. Direct impacts to Tier I-IIIB and City Wetland ESL habitats for channel widening would require compensatory mitigation and is expected to be achieved by off-site means, such as through the City's HAF program. As currently planned, enhancement required for impacts to City Wetland ESL habitat types is expected to be entirely on-site. To meet the resources agencies' no net-loss of wetlands policy requirements and where impacts to City Wetland ESL cannot be mitigated on site, mitigation would be achieved by off-site means, such as at another stream restoration site or an approved mitigation bank. A single sewer utility line and water main and associated easements traverses the length of the site at the top of the bank. The utility lines are within 20 feet of the channel; therefore, restoration and flood control improvements would likely require the relocation of the utility lines.

This site is also being recommended for flood control improvements, which presents an opportunity to integrate and achieve multiple benefits from a single project.

Wabash – Interstate 15

The most significant constraint associated with this site is that it is primarily located within privately-owned parcels, which would require multiple party involvement during City acquisition or recordation of a conservation easement or equivalent over portions of the parcels used for restoration mitigation. In addition, the site is located adjacent to MHPA and within Tier II DCSS potentially occupied by special-status species, including CAGN. Direct impacts to Tier I-IIIB and City Wetland ESL habitats for channel widening would require compensatory mitigation and is expected to be achieved by off-site means, such as through the City's HAF program. As currently planned, enhancement required for impacts to City Wetland ESL habitat types is expected to be entirely on-site. To meet the resources agencies' no net-loss of wetlands policy requirements and where impacts to City Wetland ESL cannot be mitigated on site, mitigation would be achieved by off-site means, such as at another stream restoration site or an approved mitigation bank. The northern half of the site is bounded by residential development and Interstate 15, which would limit the mitigation potential. A sewer utility line and associated easement traverses the length at the southern end of the site as well as multiple utility lines that traverse the very northern portion.

Some of the more noteworthy opportunities of the site is that it supports a large watershed area and supports relatively high flows. These opportunities would provide suitable hydrology for the establishment of City Wetlands, among other benefits.

Portions of this site are also being recommended for flood control improvements, which presents an opportunity to integrate and achieve multiple benefits from a single project.

Wabash – Juniper Canyon

The most significant constraint associated with this site is that it is located within MHPA and Tier II DCSS potentially occupied by special-status species, including CAGN. Direct impacts to Tier I-IIIB and City Wetland ESL habitats for channel widening would require compensatory mitigation and is expected to be achieved by off-site means, such as through the City's HAF program. As currently planned, enhancement required for impacts to City Wetland ESL habitat types is expected to be entirely on-site. To meet the resources agencies' no net-loss of wetlands policy requirements and where impacts to City Wetland ESL cannot be mitigated on site, mitigation would be achieved by off-site means, such as at another stream restoration site or an approved mitigation bank. A single sewer utility line and associated easement traverses the length of the east side of the site; however, the existing utility should not preclude the ability for the site to be restored and generate riparian/wetland compensatory mitigation credit.

Some of the more noteworthy opportunities of the site is that it is entirely City owned, is not constrained by incompatible uses, supports a large watershed area, and supports relatively high flows. These opportunities would eliminate acquisition constraints, alleviate the easement recordation process, and provide suitable hydrology for the establishment of City Wetlands, among other benefits.

This site is also being recommended for flood control improvements, which presents an opportunity to integrate and achieve multiple benefits from a single project.

7.4 Integrated Multi-benefit Projects

There are a multitude of advantages that can be achieved by combining independent flood control improvements, water quality projects, and stream restoration efforts within the same drainage area into a comprehensive improvement strategy. Integrating watershed improvements provides a way for the City to simultaneously address multiple objectives, including:

- Flood Risk Reduction—by constructing drainage improvements to reduce flooding impacts.
- Improved Water Quality—by installing GI and MUTAs that treat surface runoff.
- Improved Ecological Systems—by using intelligently located flood control and water quality improvements to create stream restoration and enhancement opportunities in the community.
- Community Enhancement—by implementing an integrated watershed management solution to provide the community with a single project that simultaneously reduces flooding, improves water quality, and enhances the natural environment. It can also reduce the community's exposure and duration to more unfavorable impacts resulting from construction such as noise, traffic delays, equipment staging, reduced parking, and other construction-related disturbances that occur during project implementation.

Integrated watershed improvements accomplish a holistic storm water strategy by addressing flood control, water quality, habitat restoration, and community issues

In addition to meeting the City's storm water program objectives, a multi-benefit project can offer significant cost savings when the preliminary, design, and construction phases of work are executed comprehensively. The WMP analyses indicated that an estimated $72.1 million (20 percent) total cost savings can be realized through the planning, design, construction, and maintenance of IPs. The following sections present the benefits of furthering the multi-benefit project planning process through the quantification of potential cost savings and design integration (section 7.4.1) and the additional flood control capacity that can be provided by enhanced water quality project implementation (section 7.4.2).

7.4.1 IP Types

One significant benefit of the coordinated assessments completed as part of this WMP was the identification of IPs that can meet one or more City objective (water quality, flood control, and/or environmental restoration). Traditionally, planning and implementation for each of these objectives has been executed with limited coordination due to the sheer number of potential project opportunities and the high-level of feasibility criteria applied for previous watershed-scale efforts. This WMP has identified specific project types (e.g., MUTAs and large-scale detention facilities, stream restoration opportunities, and channel widening) and unique watershed conditions (e.g., limited detention opportunities and constrained infiltration capacity) that necessitate innovative, synergistic solutions.

The project bundling and prioritization methodologies for each of the individual project types (section 6.0) provide the preliminary information needed to identify specific types of IP opportunities. The methodology for generating IPs is outlined in section 7.4.1.1, with detailed cost sharing estimates and descriptions of the three main IP types provided in the following sections:

- GI and Flood Control Conveyance/Street Improvements (section 7.4.1.2)
- MUTAs and Flood Control (FC) Detention (section 7.4.1.3)
- Stream Restoration and Channel/Outfall Improvements (section 7.4.1.4)
- Stream Restoration, Flood Control, and MUTAs (section 7.4.1.5)

A summary of the IP types and quantities are provided in Table 7-17.

Table 7-17. IP summary table

Integration Type	Number of Projects	Construction Savings	Planning and Design Savings	Total Percent Cost Savings
Stream Restoration & Channel Improvements	8	• 100% of the Standalone SR Cost (not including monitoring or maintenance)	No Cost Savings[a]	50%
Distributed GI & FC Storm Drain/ Street Improvements	107	No Cost Savings	50% of the Total Planning and Design Costs	9%
MUTA & Flood Control Detention Storage	7	• See Table 7-19	50% of the Total Planning and Design Costs	21%
Stream Restoration, Flood Control Improvement, and Water Quality	3	• 100% of the Standalone SR Cost (not including monitoring or maintenance) • See Table 7-19 for FC and WQ	• 50% of the Total Planning and Design Costs for Bundled Distributed GI & FC Storm Drain • 50% of the Total Planning and Design Costs for Bundled MUTA & FC Storage	35%

Note:
[a] Stream restoration planning and design costs were included as part of the flood control channel improvements due to their inherent synergy.

7.4.1.1 IP Ranking Methodology

The ranking methodology used for each of the IP types is consistent to ensure that each of the different project types are evaluated comparatively. Each of the individual groups of projects and rankings outlined in section 6.0 were compiled for each of the 125 IPs and normalized to a maximum score of 100. The three project scores were then averaged together to yield comprehensive scores with a maximum value of 300. The highest score was 239.0, which corresponds to the Auburn Creek IP (4505_IP_3_B), and the lowest was 33.9, which corresponds to a distributed GI and a flood control inlet improvement. Ranking scores for an alternative method are also included, where the normalized scores for each performance objective (0-100) were averaged together. A complete list of the integrated projects are included in Table 7-18. Each of these IPs are also presented in detail in the web application and database provided in conjunction with this report.

Table 7-18. IP ranking and scores.

IP ID	IP Type	IP Score (Sum)	IP Score (Average)	FC ID 1	FC ID 2	FC ID 3	FC ID 4	WQ ID 1	WQ ID 2	SR IDs	IP CIP Cost	IP Planning & Design Cost	IP O&M Cost	IP Acquisition Cost
4705_IP_3_B	WQ MUTA, Stream Restoration, FC Channel Improvements	79.67	239.00	4705_FC_1_5	4705_FC_1_3	4705_FC_1_1	4705_FC_1_7	4705_MUTA_1IS1		4703_SR_3	$3,578,121	$831,220	$1,217,976	
4705_IP_3_A	WQ MUTA, Stream Restoration, FC Culvert Improvements & Storage	63.40	190.19	4705_FC_1_6	4705_FC_4			4705_MUTA_IS_2		4705_SR_1	$1,405,301	$288,142	$168,198	
4608_IP_2	WQ MUTA & FC Storage	79.29	158.58	4608_FC_5_1[a]				4608_MUTA_24			$2,752,477	$602,787	$1,243,624	
4910_IP_1	WQ BMP & FC Street/Storm Drain Improvement	78.12	156.23	4910_FC_3_1	4910_FC_6_1	4910_FC_10_1	4910_FC_1_2	4910_WQ_3			$1,621,786	$170,333	$506,781	
4802_IP_2	WQ GI, FC Channel Improvements & Storage, Stream Restoration	51.41	154.22	4802_FC_1_1	4802_FC_9_1	4802_FC_7_1		4802_WQ_10		4802_SR_1	$8,398,757	$2,289,223	$130,504	
4705_IP_2	WQ MUTA & FC Storage	73.12	146.25	4705_FC_5_1[a]				4705_MUTA_1215			$10,783,062	$2,132,816	$4,851,947	
4606_IP_3	WQ MUTA, FC Storm Drain Improvement & Storage	72.62	145.23	4606_FC_4_3				4606_MUTA_2			$10,481,237	$1,790,963	$1,973,463	$1,715,839
4608_IP_9	WQ MUTA & FC Storage	70.70	141.40	4608_FC_3_1				4608_MUTA_1114			$8,142,977	$930,095	$3,633,263	
4607_IP_2	WQ MUTA & FC Storage	69.96	139.91	4607_FC_4_3[a]				4607_MUTA_1			$4,209,291	$732,290	$1,513,461	$1,007,063
4602_IP_101	Flood Control Storage & Channel Improvement and Stream Restoration	69.91	139.82	4602_FC_1				N/A		4602_SR_1 & 4603_SR_1	$7,342,722	$2,176,267		
4803_IP_1	WQ BMP & FC Street/Storm Drain Improvement	69.88	139.77	4803_FC_3_1	4803_FC_2_1			4803_WQ_24			$2,974,435	$402,600	$473,371	
4606_IP_2	WQ BMP & FC Street/Storm Drain Improvement	68.46	136.92	4606_FC_4_4	4606_FC_4_2_2			4606_WQ_11			$1,089,823	$114,947	$140,508	
4607_IP_3	WQ BMP & FC Street/Storm Drain Improvement	68.03	136.06	4607_FC_4_3[b]	4607_FC_4_2			4607_WQ_1			$1,690,284	$349,511	$690,688	
4916_IP_1	WQ BMP & FC Street/Storm Drain Improvement	66.76	133.51	4916_FC_1_1	4916_FC_6_1			4916_WQ_1			$1,217,941	$131,877	$507,163	
4803_IP_2	WQ BMP & FC Street/Storm Drain Improvement	64.58	129.16	4803_FC_10_2				4803_WQ_7			$379,893	$46,230	$129,006	
4608_IP_4	WQ MUTA, FC Storm Drain Improvement & Storage	63.56	127.11	4608_FC_4_1				4608_MUTA_20			$4,758,411	$566,360	$1,281,035	

IP ID	IP Type	IP Score (Sum)	IP Score (Average)	FC ID 1	FC ID 2	FC ID 3	FC ID 4	WQ ID 1	WQ ID 2	SR IDs	IP CIP Cost	IP Planning & Design Cost	IP O&M Cost	IP Acquisition Cost
4801_IP_1	WQ BMP & FC Street/Storm Drain Improvement	62.76	125.52	4801_FC_2				4701_WQ_5			$512,564	$59,852	$128,491	
4802_IP_1	WQ BMP & FC Street/Storm Drain Improvement	62.58	125.16	4802_FC_12_1				4802_WQ_4			$277,721	$31,736	$87,708	
4606_IP_1	WQ BMP & FC Street/Storm Drain Improvement	62.47	124.95	4606_FC_4_2_1				4606_WQ_1			$1,330,547	$143,160	$443,444	
4608_IP_6	WQ BMP & FC Street/Storm Drain Improvement	62.29	124.59	4608_FC_5_1b				4608_WQ_14			$1,903,104	$310,574	$37,822	
4809_IP_3	WQ BMP & FC Street/Storm Drain Improvement	59.65	119.30	4809_FC_7_1				4809_WQ_12			$719,666	$94,576	$168,978	
4502_IP_3	WQ BMP & FC Street/Storm Drain Improvement	59.28	118.56	4502_FC_3_7				4502_WQ_13			$399,207	$39,661	$185,144	
4705_IP_5	WQ MUTA, FC Storm Drain Improvement & Storage	59.27	118.53	4705_FC_6_5				4705_MUTA_23			$8,985,351	$1,061,518	$3,700,718	
4703_IP_1	WQ BMP & FC Street/Storm Drain Improvement	58.77	117.54	4703_FC_2_1				4703_WQ_27			$2,719,353	$151,758	$221,329	
4801_IP_102	Flood Control Channel Improvement and Stream Restoration	57.82	115.64	4801_FC_1_2				N/A		4801_SR_2	$3,779,723	$1,107,367		
4503_IP_1	WQ BMP & FC Street/Storm Drain Improvement	57.60	115.20	4503_FC_7_2	4703_FC_7_1			4503_WQ_15	4503_WQ_7		$2,148,631	$304,206	$438,490	
4608_IP_1	WQ BMP & FC Street/Storm Drain Improvement	57.47	114.93	4608_FC_4_2				4608_WQ_2			$1,332,363	$152,422	$581,366	
4910_IP_2	WQ BMP & FC Street/Storm Drain Improvement	56.91	113.82	4910_FC_9_1				4910_WQ_2			$7,319,728	$1,084,695	$201,976	
4703_IP_101	Flood Control Channel Improvement and Stream Restoration	55.96	111.91	4703_FC_1_1				N/A		4703_SR_1	$1,156,049	$320,265		
4917_IP_1	WQ BMP & FC Street/Storm Drain Improvement	55.58	111.17	4917_FC_3_1				4917_WQ_1			$624,867	$78,190	$227,952	
4502_IP_1	WQ BMP & FC Street/Storm Drain Improvement	54.70	109.40	4502_FC_3_3				4502_WQ_3			$769,458	$85,518	$346,848	
4608_IP_3	WQ BMP & FC Street/Storm Drain Improvement	54.22	108.44	4608_FC_1_1				4608_WQ_13			$2,238,991	$319,535	$165,636	
4802_IP_3	WQ BMP & FC Street/Storm Drain Improvement	53.71	107.42	4802_FC_5_1				4802_WQ_3			$368,272	$41,654	$188,096	

IP ID	IP Type	IP Score (Sum)	IP Score (Average)	FC ID 1	FC ID 2	FC ID 3	FC ID 4	WQ ID 1	WQ ID 2	SR IDs	IP CIP Cost	IP Planning & Design Cost	IP O&M Cost	IP Acquisition Cost
4605_IP_1	WQ BMP & FC Street/Storm Drain Improvement	53.50	107.00	4605_FC_1				4605_WQ_3			$139,383	$15,516	$68,954	
4503_IP_4	WQ BMP & FC Street/Storm Drain Improvement	53.37	106.75	4503_FC_3				4503_WQ_2			$884,480	$117,633	$156,621	
4803_IP_4	WQ BMP & FC Street/Storm Drain Improvement	53.33	106.66	4803_FC_9_3				4803_WQ_16			$2,469,160	$369,315	$13,054	
4808_IP_2	WQ BMP & FC Street/Storm Drain Improvement	53.23	106.45	4808_FC_1_1				4808_MUTA_7			$10,742,505	$1,309,408	$2,064,106	
4801_IP_101	Flood Control Channel Improvement and Stream Restoration	53.21	106.42	4801_FC_1_1				N/A		4801_SR_1	$2,135,786	$614,186		
4502_IP_2	WQ BMP & FC Street/Storm Drain Improvement	52.97	105.93	4502_FC_3_1				4502_WQ_10			$1,874,650	$235,001	$428,286	
4501_IP_3	WQ BMP & FC Street/Storm Drain Improvement	52.72	105.45	4501_FC_3_2				4501_MUTA_1			$6,854,520	$760,213	$2,498,156	
4803_IP_7	WQ BMP & FC Street/Storm Drain Improvement	52.72	105.44	4803_FC_21_1				4803_WQ_10			$164,040	$11,084	$20,661	
4803_IP_5	WQ BMP & FC Street/Storm Drain Improvement	52.38	104.77	4803_FC_19_2				4803_WQ_1			$609,943	$56,461	$241,493	
4909_IP_1	WQ BMP & FC Street/Storm Drain Improvement	52.27	104.53	4909_FC_2_1				4909_WQ_2			$130,154	$17,415	$20,634	
4601_IP_1	WQ BMP & FC Street/Storm Drain Improvement	51.41	102.82	4601_FC_2				4601_WQ_1			$1,342,616	$110,960	$256,721	
4705_IP_1	WQ BMP & FC Street/Storm Drain Improvement	51.10	102.21	4705_FC_2				4705_WQ_1			$525,201	$70,259	$128,218	
4704_IP_1	WQ BMP & FC Street/Storm Drain Improvement	51.10	102.20	4704_FC_2_3				4704_WQ_4			$1,927,285	$212,945	$408,791	
4801_IP_2	WQ BMP & FC Street/Storm Drain Improvement	51.04	102.07	4801_FC_6				4801_WQ_8			$516,436	$60,673	$85,841	
4401_IP_1	WQ BMP & FC Street/Storm Drain Improvement	50.94	101.89	4404_FC_1				4401_WQ_2			$1,204,735	$133,107	$608,509	
4810_IP_1	WQ BMP & FC Street/Storm Drain Improvement	50.47	100.93	4810_FC_3				4810_WQ_5			$2,084,903	$234,149	$230,913	
4503_IP_2	WQ BMP & FC Street/Storm Drain Improvement	50.33	100.66	4503_FC_5_1				4503_WQ_6			$647,203	$71,437	$69,713	
4902_IP_1	WQ BMP & FC Street/Storm Drain Improvement	50.07	100.13	4902_FC_2_1				4902_WQ_13			$1,354,827	$173,810	$299,030	

IP ID	IP Type	IP Score (Sum)	IP Score (Average)	FC ID 1	FC ID 2	FC ID 3	FC ID 4	WQ ID 1	WQ ID 2	SR IDs	IP CIP Cost	IP Planning & Design Cost	IP O&M Cost	IP Acquisition Cost
4703_IP_3	WQ BMP & FC Street/Storm Drain Improvement	49.86	99.72	4703_FC_3_4	4703_FC_3_3			4703_WQ_33			$1,660,422	$220,322	$147,433	
4803_IP_3	WQ BMP & FC Street/Storm Drain Improvement	49.43	98.85	4803_FC_2_3				4803_WQ_6			$677,906	$97,113	$61,149	
4607_IP_1	WQ BMP & FC Street/Storm Drain Improvement	48.72	97.43	4607_FC_4_1				4607_WQ_2			$1,743,430	$200,453	$889,736	
4704_IP_2	WQ BMP & FC Street/Storm Drain Improvement	48.25	96.50	4704_FC_2_2				4704_WQ_3			$1,061,173	$151,349	$23,009	
4809_IP_4	WQ BMP & FC Street/Storm Drain Improvement	47.67	95.33	4809_FC_5_1				4809_WQ_5			$227,800	$27,660	$112,725	
4911_IP_1	WQ BMP & FC Street/Storm Drain Improvement	47.44	94.88	4911_FC_1_1				4911_WQ_1			$775,633	$103,935	$166,649	
4703_IP_6	WQ BMP & FC Street/Storm Drain Improvement	47.16	94.32	4703_FC_8_1	4703_FC_8_1			4703_WQ_6			$4,598,527	$638,828	$77,398	
4502_IP_4	WQ BMP & FC Street/Storm Drain Improvement	47.14	94.28	4502_FC_3_9_3				4502_WQ_2			$1,164,972	$135,038	$285,308	
4913_IP_1	WQ BMP & FC Street/Storm Drain Improvement	46.78	93.56	4913_FC_3_1				4913_WQ_2			$409,741	$46,066	$221,994	
4602_IP_1	WQ BMP & FC Street/Storm Drain Improvement	46.52	93.03	4602_FC_5_2				4602_WQ_3			$423,884	$47,280	$233,742	
4501_IP_2	WQ BMP & FC Street/Storm Drain Improvement	46.39	92.79	4501_FC_7_2				4501_WQ_5			$275,964	$31,956	$62,177	
4918_IP_1	WQ BMP & FC Street/Storm Drain Improvement	46.01	92.03	4918_FC_3_2				4918_WQ_2			$1,201,776	$165,266	$229,735	
4608_IP_7	WQ BMP & FC Street/Storm Drain Improvement	45.89	91.78	4606_FC_1_2				4608_WQ_12			$1,277,247	$136,561	$646,625	
4503_IP_3	WQ BMP & FC Street/Storm Drain Improvement	45.49	90.98	4503_FC_4_2				4503_WQ_8			$1,950,107	$199,389	$439,628	
4705_IP_4	WQ BMP & FC Street/Storm Drain Improvement	45.47	90.94	4705_FC_6_2				4705_WQ_4			$1,842,904	$247,032	$356,130	
4501_IP_5	WQ BMP & FC Street/Storm Drain Improvement	45.38	90.77	4501_FC_7_1				4501_WQ_4			$864,701	$99,980	$252,817	
4703_IP_2	WQ BMP & FC Street/Storm Drain Improvement	44.71	89.42	4703_FC_3_1				4703_WQ_2			$576,030	$77,447	$140,912	
4810_IP_2	WQ BMP & FC Street/Storm Drain Improvement	43.60	87.20	4810_FC_2				4810_WQ_4			$558,216	$61,674	$137,768	

IP ID	IP Type	IP Score (Sum)	IP Score (Average)	FC ID 1	FC ID 2	FC ID 3	FC ID 4	WQ ID 1	WQ ID 2	SR IDs	IP CIP Cost	IP Planning & Design Cost	IP O&M Cost	IP Acquisition Cost
4703_IP_4	WQ BMP & FC Street/Storm Drain Improvement	43.41	86.82	4703_FC_6				4703_WQ_1			$694,064	$95,285	$100,568	
4705_IP_6	WQ BMP & FC Street/Storm Drain Improvement	43.39	86.78	4705_FC_6_3				4705_WQ_5			$7,409,364	$1,100,646	$111,586	
4602_IP_3	WQ BMP & FC Street/Storm Drain Improvement	41.82	83.65	4602_FC_5_1	4602_FC_4_3			4602_WQ_2			$311,327	$36,193	$145,150	
4801_IP_3	WQ BMP & FC Street/Storm Drain Improvement	41.57	83.13	4801_FC_5				4801_WQ_4			$419,037	$53,848	$145,908	
4608_IP_5	WQ BMP & FC Street/Storm Drain Improvement	41.26	82.52	4608_FC_4_4				4608_WQ_10			$1,225,254	$131,277	$264,444	
4906_IP_1	WQ BMP & FC Street/Storm Drain Improvement	41.18	82.37	4906_FC_1_1				4906_WQ_3			$357,362	$45,607	$68,511	
4703_IP_5	WQ BMP & FC Street/Storm Drain Improvement	41.16	82.33	4703_FC_8_3	4703_FC_9_2			4703_WQ_32			$1,623,520	$203,919	$82,518	
4606_IP_8	WQ BMP & FC Street/Storm Drain Improvement	41.03	82.05	4606_FC_1	4606_FC_2_1			4606_WQ_10			$1,669,668	$197,007	$120,505	
4606_IP_4	WQ BMP & FC Street/Storm Drain Improvement	40.61	81.22	4606_FC_3				4606_WQ_2			$589,927	$64,444	$227,843	
4803_IP_8	WQ BMP & FC Street/Storm Drain Improvement	40.56	81.12	4803_FC_12_2				4803_WQ_2			$298,619	$35,987	$108,930	
4809_IP_1	WQ BMP & FC Street/Storm Drain Improvement	40.17	80.34	4809_FC_2_1				4809_WQ_6			$306,898	$34,299	$62,034	
4608_IP_8	WQ BMP & FC Street/Storm Drain Improvement	40.11	80.22	4608_FC_2				4608_WQ_1			$1,892,862	$219,608	$834,081	
4605_IP_2	WQ BMP & FC Street/Storm Drain Improvement	39.79	79.57	4605_FC_4				4605_WQ_1			$859,910	$97,784	$457,276	
4803_IP_6	WQ BMP & FC Street/Storm Drain Improvement	39.69	79.38	4803_FC_11_1				4803_WQ_3			$450,441	$61,783	$69,985	
4606_IP_6	WQ BMP & FC Street/Storm Drain Improvement	38.69	77.38	4606_FC_2_2				4606_WQ_9			$788,043	$95,304	$211,727	
4609_IP_3	WQ BMP & FC Street/Storm Drain Improvement	37.94	75.87	4609_FC_3				4609_WQ_1			$1,554,326	$158,374	$679,792	
4501_IP_4	WQ BMP & FC Street/Storm Drain Improvement	37.75	75.50	4501_FC_3_1				4501_WQ_15			$2,471,642	$332,447	$504,716	
4607_IP_4	WQ BMP & FC Street/Storm Drain Improvement	37.50	75.01	4607_FC_2				4607_WQ_6			$848,475	$99,125	$404,381	

IP ID	IP Type	IP Score (Sum)	IP Score (Average)	FC ID 1	FC ID 2	FC ID 3	FC ID 4	WQ ID 1	WQ ID 2	SR IDs	IP CIP Cost	IP Planning & Design Cost	IP O&M Cost	IP Acquisition Cost
4609_IP_2	WQ BMP & FC Street/Storm Drain Improvement	37.45	74.90	4609_FC_5_2	4609_FC_5_1			4609_WQ_7			$2,700,509	$256,379	$568,058	
4805_IP_1	WQ BMP & FC Street/Storm Drain Improvement	36.60	73.19	4804_FC_3_1				4805_WQ_1			$71,782	$10,130	$8,205	
4609_IP_1	WQ BMP & FC Street/Storm Drain Improvement	36.19	72.37	4609_FC_4_1				4609_WQ_2			$1,638,966	$184,368	$664,038	
4808_IP_1	WQ BMP & FC Street/Storm Drain Improvement	35.71	71.42	4808_FC_4_1				4808_WQ_1			$733,721	$106,021	$56,003	
4501_IP_6	WQ BMP & FC Street/Storm Drain Improvement	35.37	70.73	4501_FC_6				4501_WQ_8			$126,296	$15,746	$44,513	
4902_IP_2	WQ BMP & FC Street/Storm Drain Improvement	34.68	69.37	4902_FC_4_1				4902_WQ_2			$163,111	$19,282	$56,347	
4918_IP_2	WQ BMP & FC Street/Storm Drain Improvement	34.37	68.74	4918_FC_3_1				4918_WQ_5			$1,389,809	$195,584	$209,293	
4502_IP_5	WQ BMP & FC Street/Storm Drain Improvement	33.89	67.77	4502_FC_3_5				4502_WQ_1			$140,551	$15,912	$81,572	
4703_IP_8	WQ BMP & FC Street/Storm Drain Improvement	33.25	66.50	4703_FC_5_3	4703_FC_5_2			4703_WQ_15			$157,372	$19,581	$40,953	
4917_IP_101	Flood Control Channel Improvement and Stream Restoration	32.72	65.43	4916_FC_1_4				N/A		4917_SR_2	$1,882,281	$538,134		
4606_IP_7	WQ BMP & FC Street/Storm Drain Improvement	32.64	65.28	4606_FC_4_1				4606_WQ_7			$665,907	$98,640	$9,784	
4702_IP_102	Flood Control Channel Improvement and Stream Restoration	32.59	65.18	4702_FC_1_2				N/A		4702_SR_2	$970,509	$264,603		
4703_IP_7	WQ BMP & FC Street/Storm Drain Improvement	32.36	64.72	4703_FC_5_4				4703_WQ_30			$1,359,669	$149,199	$255,261	
4703_IP_10	WQ BMP & FC Street/Storm Drain Improvement	31.47	62.94	4703_FC_2_3				4703_WQ_26			$752,084	$87,809	$331,279	
4803_IP_9	WQ BMP & FC Street/Storm Drain Improvement	31.16	62.32	4803_FC_20_1				4803_WQ_9			$190,421	$27,497	$10,134	
4602_IP_2	WQ BMP & FC Street/Storm Drain Improvement	30.59	61.18	4602_FC_4_2	4602_FC_4_4			4602_WQ_6			$584,757	$65,077	$232,992	
4703_IP_11	WQ BMP & FC Street/Storm Drain Improvement	30.42	60.84	4703_FC_2_2				4703_WQ_9			$357,866	$51,559	$27,989	

IP ID	IP Type	IP Score (Sum)	IP Score (Average)	FC ID 1	FC ID 2	FC ID 3	FC ID 4	WQ ID 1	WQ ID 2	SR IDs	IP CIP Cost	IP Planning & Design Cost	IP O&M Cost	IP Acquisition Cost
4503_IP_6	WQ BMP & FC Street/Storm Drain Improvement	29.94	59.88	4503_FC_4_1				4503_WQ_5			$921,168	$135,657	$17,382	
4912_IP_1	WQ BMP & FC Street/Storm Drain Improvement	29.81	59.62	4912_FC_2_1				4912_WQ_1			$1,004,247	$118,959	$190,935	
4705_IP_7	WQ BMP & FC Street/Storm Drain Improvement	29.09	58.19	4705_FC_5_1[b]				4705_WQ_2			$1,481,880	$994,245	$3,679	
4606_IP_5	WQ BMP & FC Street/Storm Drain Improvement	28.14	56.29	4606_FC_4_6				4606_WQ_5			$405,981	$59,463	$8,780	
4801_IP_4	WQ BMP & FC Street/Storm Drain Improvement	28.05	56.09	4801_FC_3				4801_WQ_5			$68,905	$9,203	$12,625	
4809_IP_2	WQ BMP & FC Street/Storm Drain Improvement	27.78	55.56	4809_FC_4_1				4809_WQ_4			$920,344	$110,642	$227,114	
4606_IP_9	WQ BMP & FC Street/Storm Drain Improvement	27.37	54.75	4606_FC_4_7_1				4606_WQ_6			$419,686	$62,285	$6,745	
4911_IP_2	WQ BMP & FC Street/Storm Drain Improvement	26.28	52.56	4911_FC_3_2	4911_FC_3_1			4911_WQ_3			$2,221,841	$245,627	$1,060,606	
4602_IP_5	WQ BMP & FC Street/Storm Drain Improvement	25.71	51.42	4602_FC_5_3				4602_WQ_5			$858,062	$105,970	$249,030	
4607_IP_5	WQ BMP & FC Street/Storm Drain Improvement	24.91	49.82	4607_FC_3				4607_WQ_3			$87,279	$10,095	$16,152	
4803_IP_10	WQ BMP & FC Street/Storm Drain Improvement	24.72	49.43	4803_FC_23_1				4803_WQ_11			$97,572	$13,417	$12,828	
4703_IP_14	WQ BMP & FC Street/Storm Drain Improvement	24.61	49.21	4703_FC_9_1				4703_WQ_10			$133,695	$18,210	$22,873	
4601_IP_101	Flood Control Channel Improvement and Stream Restoration	24.00	48.01	4601_FC_1				N/A		4601_SR_1	$561,677	$141,953		
4810_IP_3	WQ BMP & FC Street/Storm Drain Improvement	21.97	43.94	4810_FC_1				4810_WQ_2			$303,420	$28,255	$62,692	
4703_IP_9	WQ BMP & FC Street/Storm Drain Improvement	21.15	42.29	4703_FC_4				4703_WQ_21			$425,287	$24,415	$8,924	
4803_IP_11	WQ BMP & FC Street/Storm Drain Improvement	20.66	41.32	4803_FC_18_1				4803_WQ_14			$142,183	$21,033	$4,583	
4602_IP_4	WQ BMP & FC Street/Storm Drain Improvement	20.33	40.67	4602_FC_2				4602_WQ_11			$64,640	$9,112	$7,510	
4906_IP_2	WQ BMP & FC Street/Storm Drain Improvement	20.02	40.03	4906_FC_1_2				4906_WQ_6			$730,030	$100,007	$6,186	

IP ID	IP Type	IP Score (Sum)	IP Score (Average)	FC ID 1	FC ID 2	FC ID 3	FC ID 4	WQ ID 1	WQ ID 2	SR IDs	IP CIP Cost	IP Planning & Design Cost	IP O&M Cost	IP Acquisition Cost
4702_IP_2	WQ BMP & FC Street/Storm Drain Improvement	18.23	36.45	4702_FC_5				4702_WQ_2			$579,121	$69,934	$125,761	
4705_IP_3_C	Stream Restoration & FC Channel Improvements	18.19	36.38	4703_FC_1_4						4703_SR_2	$837,939	$224,832		
4502_IP_6	WQ BMP & FC Street/Storm Drain Improvement	16.92	33.84	4502_FC_3_2_3				4502_WQ_9		4703_SR_3	$87,744	$11,770	$14,448	

[a] IP is flood control storage based; other flood control components within the flood control bundled project are included in other IPs.

[b] IP is flood control conveyance based; flood control storage component is included in other IPs.

7.4.1.2 GI and Flood Control Conveyance/Street Improvements

Distributed GI projects and flood control improvements located within City ROW provide multiple opportunities for integration due to their close proximity and connection to the same backbone infrastructure. Where water quality distributed GI projects were identified adjacent to linear conveyance, catch basin inlet, or street improvements, an IP was considered to be advantageous. An example of an integrated street-based flood control and distributed GI IP is shown in Figure 7-1.

Figure 7-1. GI and flood control conveyance/street improvement IP example.

There was a total of 107 IPs of this type identified in the watershed, ranging in cost from $65,000 to $11 million. Cost savings for these IPs were negligible for construction costs due to the different infrastructure needed for each project component. For example, storm drain conveyances are typically located underneath the street and are a larger diameter than those needed for a GI underdrain; whereas GI projects are located adjacent to the street and set back in the ROW. Where cost sharing can be realized is in the mobilization, traffic control costs, planning and design, and long-term O&M. Overall, these components can contribute up to 9 percent savings of the total 20-year project cost, which is estimated at $17.3 million watershed-wide.

7.4.1.3 MUTAs and Flood Control Detention

MUTAs opportunities that were designed on the same parcel or adjacent to a parcel where flood control detention facilities were identified were bundled together as an IP. There was a total of seven integrated MUTA and flood control detention projects identified; an example is shown in Figure 7-2.

Figure 7-2. MUTA and flood control detention IP example.

These IPs provide the most opportunity for synergy and cost sharing for water quality-based improvements due to the fundamental need for similar construction activities (e.g., top excavation, grading, planting, and so forth) and design components (e.g., diversion structure, pump station or sump pump, storage units, pretreatment, and so forth). Comprehensive planning and design for these facilities can yield significant reductions in the total storage volume needed (see section 7.4.2), especially with the incorporation of real time controls and predictive storage management. Cost-sharing components for these projects are included in Table 7-19. The overall cost savings watershed-wide is estimated to be $20.7 million or 21 percent of the total costs without integration.

Table 7-19. Cost-sharing components for MUTAs and flood detention facilities

Synergized Project Elements	Cost Savings (% reduction)
Storage Volume Costs	37.5% savings for duplicate storage infrastructure
Project Footprint Costs	37.5% savings on excavation costs, site preparation, and duplicate storage infrastructure
Diversion Structure Cost	Water quality inflow diversion structure cost used (site-specific)
Pipe Diversion Cost	Water quality inflow pipe cost used (site-specific)
Markup Cost	Recalculated as 40% of total new integrated construction cost

7.4.1.4 Stream Restoration and Channel/Outfall Improvements

The integration of stream restoration and flood control improvements is inherent in most of the stream restoration projects. After evaluating each of the initial stream restoration candidate sites, the Project Team recommended a total of 17 sites as viable projects, while the remaining sites were not recommended due to severe physical constraints. Of the 17 sites, a total of 11 overlap with recommended channel widening efforts to accommodate for and provide additional flood control benefits in conjunction with the stream restoration benefits (three have additional water quality components are described in detail in section 7.4.1.5. The multi-benefit aspect of these 11 projects resulted in them being designated as IPs. While the remaining four stream restoration projects did not specifically require widening to improve flood control conveyance, future design of those segments should still consider adjusting the longitudinal slope, channel side slopes, and potential widening to provide non-erosive conditions and improve long-term establishment of plants along the side slopes and to ensure frequent channel maintenance is not required (i.e., design for a higher Manning's n-value than what might exist in the channel today).

For cost estimating purposes, the saving associated with the integrated approach is already reflected in the flood control project cost, which incorporates the various cost components specific to grading, planting, temporary irrigation, and so forth. To quantify the saving associated with the integrated approach, it can be approximated by considering that a restoration effort could have occurred in a separate location and the flood control improvements could have occurred without incorporating stream restoration concepts and plant establishment, in which case the costs would have been nearly double, excluding storm drain-related elements of the flood control project. Other significant savings are realized as a result of the integrated approach that long-term channel maintenance and associated mitigation costs are avoided by incorporated design parameters that provide conveyance for the 100-year storm event assuming a fully vegetated condition.

7.4.1.5 Stream Restoration, Flood Control, and Water Quality Projects

Three of the stream restoration and channel improvement projects had the potential for incorporating water quality improvements off-line from the channel, focusing on capturing and treating runoff from adjacent neighborhoods and lateral storm drain systems prior to discharging into the channel (Auburn Creek [4705_IP_3_A], Auburn Creek [4705_IP_3_B], and Chollas Creek [4802_IP_2]). Water quality MUTAs or distributed GI that were selected in the optimization model to provide load removal either in the watershed upstream from the project site (Chollas Creek) or directly downstream (Auburn Creek) were grouped with these IPs.

For cost estimating purposes, the construction savings for the flood control channel and stream restoration is consistent with all other such projects. Additional construction cost savings was estimated for the structural components of the water quality facility as indicated in Table 7-19. Planning and design cost savings were estimated as a 50% cost savings for flood control and water quality components as compared to costs when designed separately; stream restoration planning and design costs are incorporated in the flood control costs to begin with. The total cost savings associated with these IPs is estimated to be $9.9 million, or 3% of the total costs without integration.

Further integration of water quality with stream restoration and flood control might also be possible pending future coordination with various stakeholders and RWQCB staff, including locating aboveground MUTAs at existing storm drain outfalls in the headwaters of smaller tributary canyons or within remaining upstream fragments of open channels.

7.4.2 Flood Control Benefits from Water Quality Projects

H&H model results have indicated that substantial detention storage might be needed to alleviate flooding and relieve stressed downstream storm drains in the Chollas Creek watershed. Coupled with the highly built-out nature of the watershed and the severely limited traditional flood detention opportunities available, a creative approach to identifying and capitalizing on additional storage capacity was needed. The City is required to implement GI and MUTA opportunities to meet water quality regulations; therefore, there exists an opportunity to use the capacity created by these projects to address flooding and LOS needs. Tetra Tech developed a process to synthesize the results from the PCSWMM model (H&H), SUSTAIN model (water quality), and a rule-based real-time control (RTC) model (predictive controls) for a pilot subwatershed (4705) to assess the potential flood control benefits that could be realized by coordinating with planned water quality projects. The rule-based RTC model includes a system of rules and logic that integrates real-time precipitation forecasts into the design and operations of a MUTA in order to meet multiple objectives (e.g., maximize residence time for water quality between storm events and strategic release of storm water prior to forecast wet weather to create capacity). A number of long-term (continuous period of record) and short-term (design storm) simulation durations were developed to quantify the magnitude of flood management improvement by GI and MUTA. The performance metrics used for this analysis were focused on the neighborhood-scale surface flooding reductions, as well as on peak flow reduction at the outlet of the subwatershed.

Results of this analysis demonstrate that strategic implementation of water quality projects in coordination with targeting flood management deficiencies can significantly reduce both neighborhood-scale surface flooding and peak flows at the watershed scale Figure 7-3). Both traditional design storm-based analyses and long-term simulations showed categorical improvements beyond the existing condition. MUTAs, especially those designed with RTC capabilities, were demonstrated to be the most effective at reducing design storm-based peak flows. GI & MUTAs were demonstrated to have a significant impact on neighborhood-scale nuisance flooding as well as on peak flow for moderate and smaller storms, especially when evaluated over a long-term precipitation record (see Table 7-20). Therefore, a combination of GI and MUTAs outfitted with RTC technology could offset even further the improvements needed to address flood management concerns within the Chollas Creek watershed. This analysis provides the City with the means to strategically address local drainage needs (e.g., nuisance flooding, undersized infrastructure, lack of detention) in tandem with required water quality projects to quantify potential synergies and capitalize on true multiuse project opportunities.

A complete summary of the modeling approach, scenarios analyzed (e.g., design storm-based approach, and long-term simulation), innovations modeled (e.g., RTC), and model results is presented in appendix D of this report.

Table 7-20. Percent reduction in neighborhood-scale flooding due to GI and MUTAs

Flood Severity	Depth (in)	Existing Condition, Acres Flooded (% flooded)	Decrease in Flooding from Water Quality GI & MUTA (%)
Nuisance	1-6	8.65 (1.29%)	18%
Minor	6-12	0.87 (0.13%)	29%
Major	12+	0.78 (0.12%)	28%

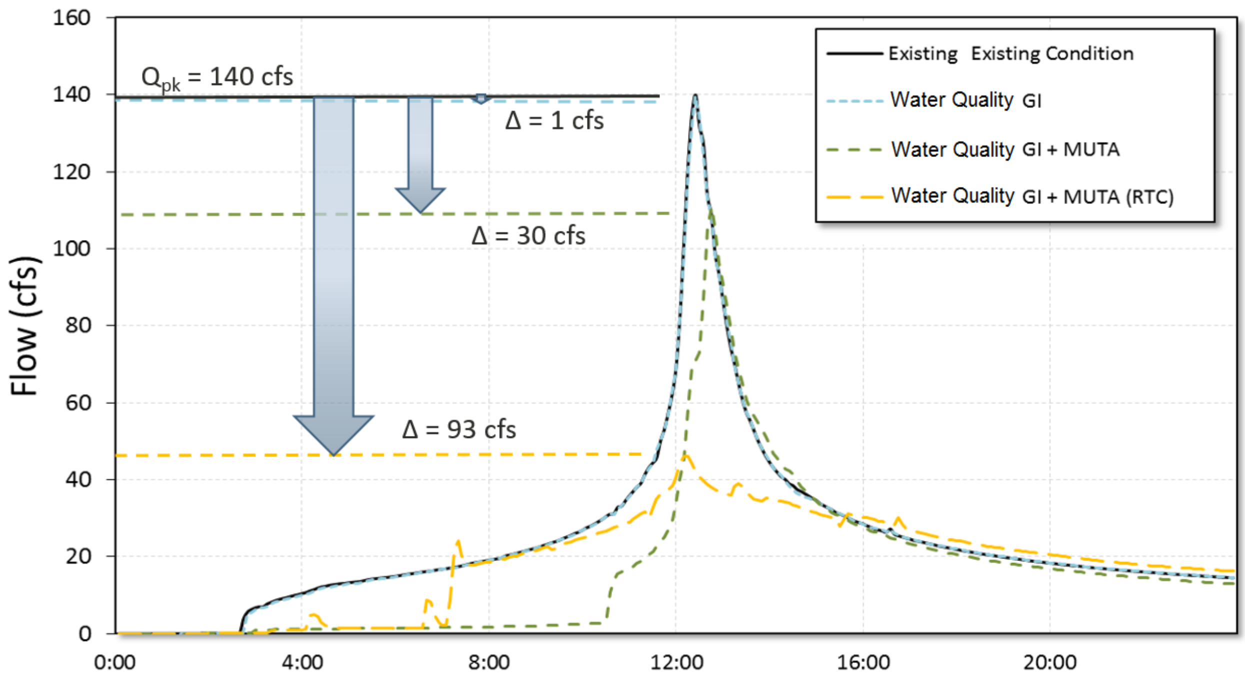

Figure 7-3. Impact of GI and MUTAs on the peak flows from the 1-yr, 24-hour design storm.

8.0 Conclusions

This WMP successfully used high-resolution data and high-powered computing tools to identify, optimize, and prioritize storm water management solutions for water quality, flood control, and stream restoration. This effort has provided the City with a project-by-project roadmap for meeting regulatory and LOS requirements with an unprecedented level of supporting detail and engineering analyses.

The water quality modeling and results (sections 3.0, 6.1, 6.2, and 7.1) can effectively replace the structural GI portions of the WQIP by increasing the resolution and modeling accuracy of GI placement and performance in the watershed. A total of 311 integrated water quality projects with capital costs of approximately $195 million is proposed to meet the structural GI load reduction requirements, reflecting the improved watershed characterization and representation of GI included in the WMP.

The overall flood control improvements include inlets, storm drains, outfalls, channels, detention, and street improvements and are estimated to cost $223 million. The development of this solution was a highly iterative process to ensure that impacts of upsizing or generating new conveyance infrastructure did not propagate downstream and overwhelm the receiving waters. The identification of deficiencies in street conveyance capacity provides the opportunity to coordinate with the City's Street Division and reclaim available storage capacity in the constrained watershed.

Stream restoration opportunities throughout the Chollas Creek watershed are subject to numerous constraints; however, the WMP provides the information needed to pursue restoration opportunities to the maximum extent feasible. The 17 identified stream restoration sites have the potential to provide significant enhancement to the City's riparian/wetland habitat (66.85 acres) and City wetlands (64.38 acres).

The development of numerous IP types (section 7.4.1) demonstrates how the strategic identification and planning of storm water projects can provide substantial cost savings and identify new, innovative project opportunities. The 125 IPs have the potential to save the City approximately $72.1 million (or 20 percent of total implementation costs) when compared to parallel, non-integrated implementation efforts.

9.0 References

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A. Water Quality and Green Infrastructure Modeling

B. Flood Control Modeling

C. Biological Resource

D. Water Quality and Flood Control Integration Model