City of Livermore
Storm Drain Master Plan
2022

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List of Abbreviations

Ac	Acres
BMP	Best Management Practices
CIP	Capital Improvement Program
CFS	Cubic Feet per Second
CMP	Corrugated Metal Pipe
CTP	Cooperating Technical Partnership
D/S	Downstream
EPA	Environmental Protection Agency
GIS	Geographic Information System
GPM	Gallons Per Minute
HDPE	High-Density Polyethylene
IDF	Intensity-Duration-Frequency
KW	Kinematic Wave
LiDAR	Light Detection and Ranging
MAP	Mean Annual Precipitation
MSL	Mean Sea Level
NAVD	National Adjusted Vertical Datum of 1988
NGVD	National Geodetic Vertical Datum of 1929
NPDES	National Pollutant Discharge Elimination System
NRCS	National Resource Conservation Service
RWQCB	San Francisco Regional Water Quality Control Board
SDMP	Storm Drain Master Plan
TASP	Transit Area Specific Plan
UH	Unit Hydrograph
U/S	Upstream

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1. Executive Summary

Livermore completed its first comprehensive Storm Drain Master Plan (SDMP) in 2004, which was updated in 2007 and 2009. The 2021 SDMP update represents a significant re-envisioning and has been undertaken to help guide the City of Livermore (City) to implement storm drain and flood control improvements.

The City has been incorporated for more than 140 years. It is experiencing the effects of aging storm drainage infrastructure, including the need to maintain and replace expensive equipment and facilities. This is complicated with significant planned and completed redevelopment and changing regulatory requirements. This SDMP identifies the capital projects needed to maintain acceptable levels of protection against local flooding. It also identifies the need for a revenue stream that will allow the improvements to be built and to keep the storm drain system maintained.

Storm Drainage and Flooding in Livermore

Flooding within Livermore is caused by two basic interrelated factors: 1) major creeks and channels that overflow due to limited capacity with flood flow and 2) inadequate local drainage infrastructure. The operation and maintenance of major creeks and channels are, for the most part, outside the City's control. Therefore, this document focuses on local storm drainage collection facilities owned and operated by the City of Livermore.

Urbanization tends to increase the rate of runoff generated from precipitation. Once primarily agricultural with an economy dominated by fruit and vegetable growers, the City has evolved into an urban community. Storm runoff in the City is collected through a system of underground pipes and a network of street gutters. Local runoff flows into creeks and channels that run through the city and ultimately into the San Francisco Bay. Drainage in the City is generally from the east to the west. The City currently owns and operates three stormwater pumping stations.

Regional Storm Water Coordination

Alameda County Zone 7 is the City’s primary partner in managing local flood control issues. Coordination with Zone 7 is integral to the SDMP’s success since all the City’s storm drainage systems eventually discharge into Zone 7-managed facilities. Zone 7 is keenly interested in any of the City’s storm drain projects that might impact one of their receiving creeks. In turn, the City has a vested interest in how Zone 7 manages its legislated flood protection responsibility.

This SDMP focuses on storm drainage and flood management, which are only two factors in the overall management of stormwater within the City. The City’s storm drain system must also consider other factors. These include new capital assets (Capital Improvement Program), finances (utility asset management), operations and maintenance, and regulatory compliance (San Francisco Regional Water Quality Control Board’s [RWQCB] Municipal Regional Storm Water Permit and National Pollutant Discharge Elimination System [NPDES] permit).

Basis of System Evaluation

Criteria used to design storm drain systems and evaluate their performance must be defensible yet simple to understand and apply. Ideally, the same criteria used to analyze system performance will continue for future infrastructure design. Storm drain design criteria set forth by the City of Livermore, in its 2015 standards and the Alameda County Hydrology and Hydraulic Manual (2017), are used in this SDMP.

Schaaf & Wheeler used data provided by the City and Zone 7 along with data gathered in the field to construct an integrated hydrologic and hydraulic InfoWorks ICM (Integrated Catchment Modeling) model. The model represents storm drain systems, creeks, and ground surfaces throughout the City. This model uses a design storm and land-use-based runoff coefficients to generate runoff to each collection system.

The hydraulic capacity of each drainage system component is calculated. Flows that exceed the system capacity are spilled onto the two-dimensional surface. These spills are reviewed to confirm if city drainage system performance criteria are being met. If the existing storm drainage system does not meet specific criteria, the model is then used to establish capital improvements.

Estimated Capital Costs and Annual Revenue Requirements

A prioritized capital improvement program (CIP) is established based on the analytical evaluation of the storm drainage system using the ICM model. Table 1–1 summarizes CIP costs.

Table 1-1: Capital Improvement Program Costs

Category	Number of Projects	Cost
High Priority CIP	9	$ 10,290,000
Moderate Priority CIP	11	$ 25,980,000
Low Priority CIP	19	$ 61,600,000
Total Budget	39	$ 97,870,000

Work Products

The updated SDMP intends to function at several levels. City planners and engineers responsible for capital improvements should find that this document contains sufficient background information and data to serve as a basis for CIP implementation or modification. For those City staff and other parties interested in a more in-depth examination of storm drain facilities within the City, the companion InfoWorks ICM model is available.

Comparison to Previous Master Plan

This SDMP and corresponding CIP differs from previous master plans due to the ICM model, which utilizes the County's updated hydrologic methodology. Additionally, the model accounts for surface storage within streets and open spaces along with the timing of coincident creek discharges. These updates generally result in less flooding and fewer CIP projects for the City. Figure 1-1 depicts the CIP from the 2004 master plan while Figure 1-2 shows the CIP projects suggested by this study. The figures show that significantly less projects are necessary now.

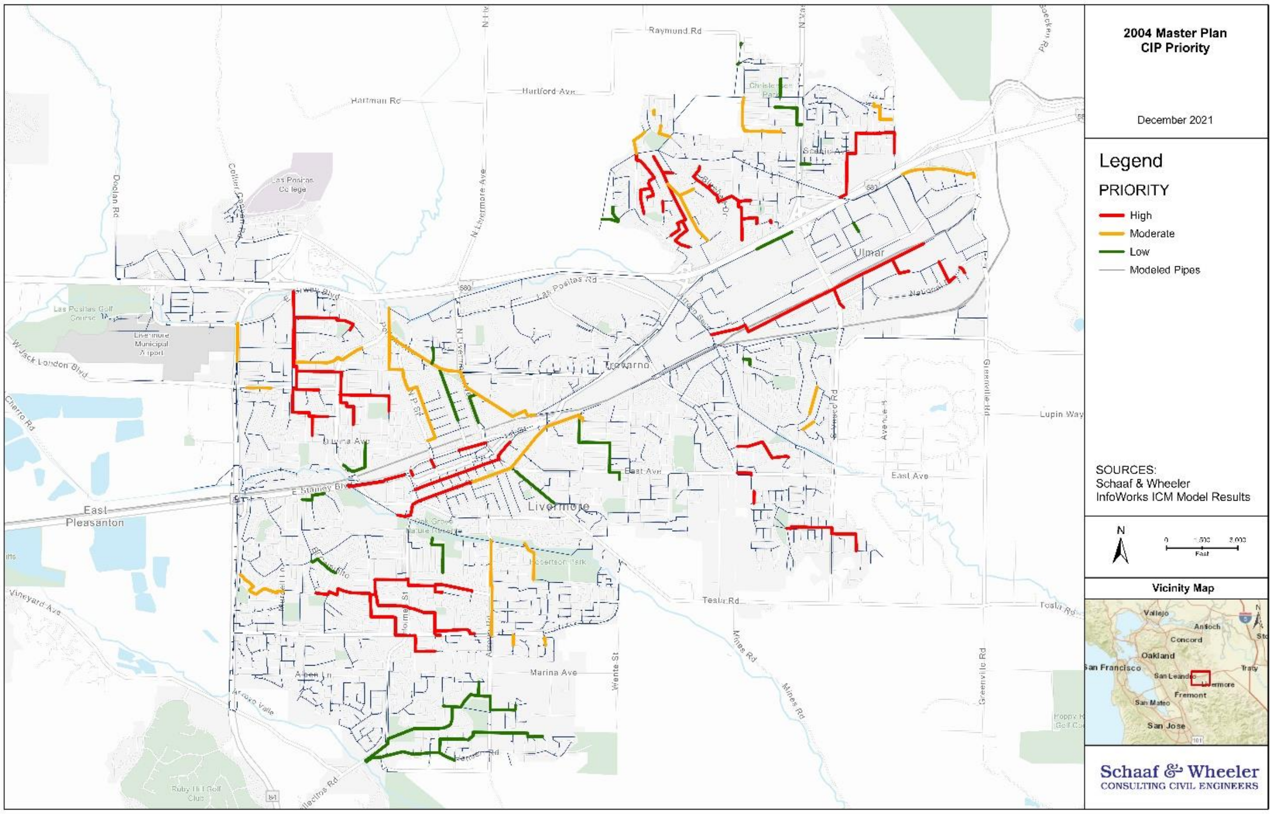

Figure 1-1: 2004 Master Plan CIP Priority

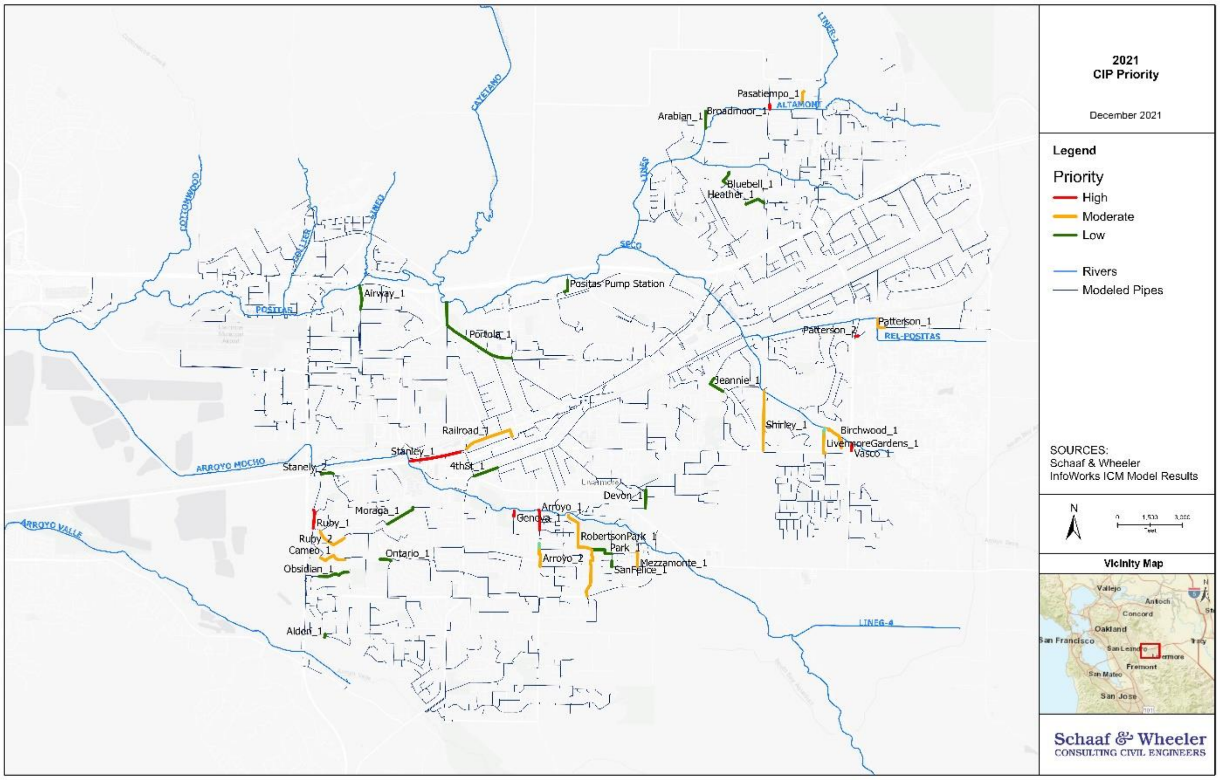

Figure 1-2: 2021 Master Plan CIP Priority

2. Introduction

The City completed the first comprehensive SDMP in 2004 and updated the plan in 2007 and 2009. This 2021 update represents a substantially new evaluation of the City's storm drain systems and floodplains. It incorporates creek modeling and floodplain evaluation completed by Zone 7 for the Stream Management Master Plan Update. This 2021 update focuses on storm drainage infrastructure and acknowledges that storm drain performance is fully intertwined with floodplain and creek behavior during stormwater runoff events.

This document is a guide for the City to implement a prioritized Capital Improvement Program (CIP). Key objectives of this SDMP update include:

- Updating the geographical information systems (GIS) to include pipelines 15 inches and greater in diameter throughout the entire city. This will reflect all storm drain projects and operational improvements completed by the end of 2020 and any changed land uses.
- Utilizing the ICM program to create an integrated hydrologic and hydraulic model that accounts for surface storage and routing and the coincident timing of water surface elevations within the major streams and drainage ways.
- Preparing an updated CIP that remediates identified system deficiencies.
- Updating projected capital improvement and costs.

Authorization

Schaaf & Wheeler Consulting Civil Engineers, Inc. prepared this updated SDMP for the City of Livermore in accordance with the provisions of an agreement executed by the City in March 2020.

Study Area

Livermore is in Alameda County, which is part of the San Francisco Bay area. Downtown Oakland is about 30 miles to the northwest. The bounding municipalities are the City of Pleasanton to the west, the City of Dublin to the northwest, and Alameda County at all other borders. Incorporated Livermore encompasses 25.2 square miles, all within the 50 square mile Arroyo Mocho watershed. Livermore and its vicinity are shown in Figure 2-1.

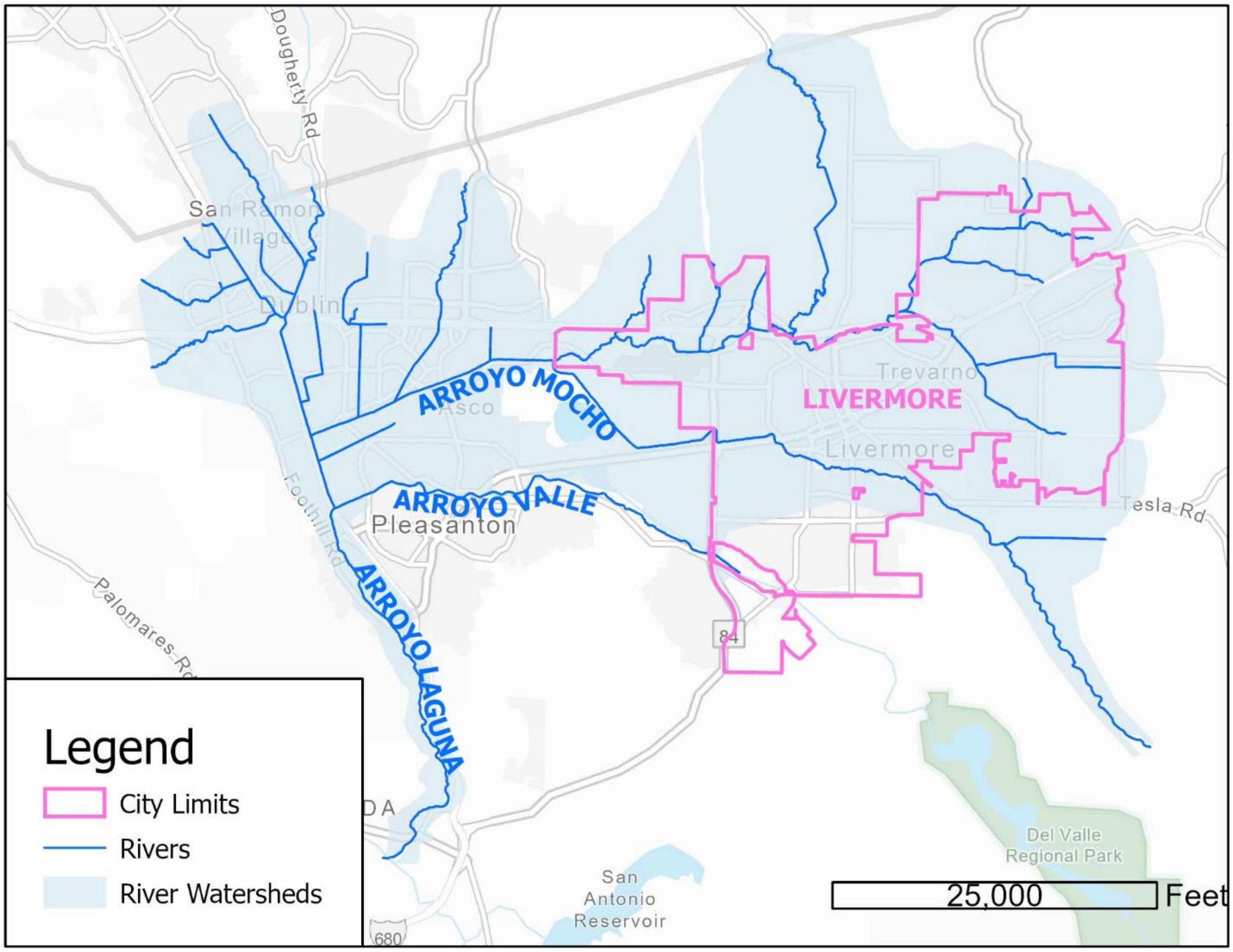

Figure 2-1: City of Livermore Vicinity

Climate

Livermore has a mild Mediterranean climate with average temperatures ranging from 39°F in the winter to 89°F in the summer. From May to October, there is minimal chance of precipitation within the area, but winters can be cool and moist. Rainfall is the only significant cause of stormwater runoff (significant snowfall is extremely rare), averaging 14 inches per year to the west and up to 16 inches annually to the east.

Most precipitation events in the Livermore area falls under one of two categories. They are either orographic, when moist air is lifted over the hills and then cools and condenses or cyclonic, where rain is caused by air mass movement from higher barometric pressure regions to lower pressure. Cyclonic events can also be caused by frontal activity. Warm fronts are generally associated with broad bands of low-intensity rainfall, while higher rainfall intensities are typical of cold fronts. Convective precipitation (e.g., thunderstorms) caused by air heating at the ground often leads to intense localized storms. However, this is not common in the City’s vicinity.

Physiography

The City lies 5 miles west of the second coastal range of foothills that surround the San Francisco Bay Area. The City generally slopes from the hills to the north, east, and south toward the Arroyo Mocho (and its tributaries). Arroyo Mocho intersects the City, exits to the west, and eventually confluences with Arroyo Laguna. Elevations range from 800 feet to 340 feet National Geodetic Vertical Datum (NGVD). The soil is primary gravel with excellent drainage.

Land Development and Drainage Characteristics

Urbanization tends to increase the rate of runoff generated from local precipitation. Once primarily range land, the City has evolved into a more urban community. It has developed as a mix of residential, commercial, and industrial development, with parks, schools, and greenbelts woven into the urban fabric. Future growth in the City will tend to be infill development, becoming denser as property values escalate.

A system of underground pipes and culverts and a network of street gutters collect storm runoff in the City. Local runoff flows into creeks and channels that run through the City. Drainage in the City generally is from the east to the west. Storm drain systems drain by gravity with three small pump stations that primarily drain underpasses.

Concurrent City Planning

The City has concurrent planning efforts focused on the Isabel Neighborhood Plan and Livermore Downtown Specific Plan areas. These plans are focused on the new BART station and downtown areas of the City where infill development has occurred or is planned.

Generally, impervious surface does not increase with infill development. The impacts of the plan areas would be based on realigned roads or identifying currently underserved areas where parcels drain by gravity to the street frontage. Improvements associated with these areas are described herein. At the time of this study, plans for new or re-routed city roadways had not been developed.

The City has developed a green stormwater infrastructure (GSI) plan as required under the National Pollutant Discharge Elimination System (NPDES) Municipal Regional Permit Section C.3.j. The plan relies on information produced in the Basin Stormwater Resource Plan. Opportunities to combine green infrastructure with capacity projects identified in this study can be considered as project planning develops.

Work Products

As discussed in subsequent sections, the following information is available via GIS:

1. ***Inventory of Drainage Facilities.*** Information pertaining to each system component may be accessed graphically through GIS or numerically using the ICM model.
2. ***Tributary Drainage Areas.*** Land areas used to generate local runoff are available in GIS and tabular format with tributary areas, runoff coefficients, and concentration times.

3. Methodologies

Criteria used to design storm drain systems and evaluate their performance must be defensible yet simple to understand and apply. Ideally, future infrastructure design will use the same criteria used to analyze system performance. As discussed in this chapter and the next, storm drain design criteria set forth by the City in its Design Standards and Guidelines dated 2015 are used in this master plan. Some additional provisions as discussed herein.

An integrated hydrologic and hydraulic InfoWorks ICM model representing storm drain systems, creeks, and ground surface throughout the City is constructed using existing data from the City and Zone 7 and new data gathered in the field and from as-built plans. This model uses a design storm event and land-use-based runoff coefficients to generate runoff from the surface areas tributary to each collection system.

The hydraulic capacity of each drainage system component is calculated and resulting overflows to the two-dimensional surface are reviewed to confirm whether city drainage system performance criteria are met. If the existing storm drainage system does not meet specific criteria, the model is then used to establish the capital improvement(s) needed. Those criteria are completed based on the capital improvement priority system described in the next chapter.

Data Sources

The comprehensive master plan model is built upon an integrated hydrologic and hydraulic InfoWorks ICM storm drain system model. The model is built using previous SDMP model data, Zone 7 Stream Management Master Plan model data, city GIS data, as-built plans, LiDAR and aerial surveys, photos, improvement plans, other data documents, and field investigations.

For the comprehensive master plan, Schaaf & Wheeler started with GIS shapefiles of the storm drain network provided by the City in May 2020. The shapefiles are updated using as-built and field investigation data. All elevations have been converted to the National Adjusted Vertical Datum of 1988 (NAVD) to conform to Zone 7 topography data.

The most common data transformation involves the conversion of the NGVD of 1929:

$$\text{NGVD} + 2.654 \text{ feet} = \text{NAVD (88)}$$

Sub catchment parameters of the model are based on the Existing General Plan land use data provided by the City in the form of GIS shapefiles. This is the most current available data for land use to characterize existing land surfaces. Aerial maps are used to assign land use of areas not defined by the City data or for recent development.

Information regarding pump station operation has been obtained from record drawings and conversations with city operations and maintenance staff in 2020.

Modeling Software

INFOWORKS ICM

InfoWorks ICM by Innovyze is a GIS-based, integrated modeling platform that incorporates both urban and river catchments. The integration of 1D- and 2D-hydrodynamic simulation techniques allows the modeling of both above- and below-ground elements of catchments to represent all flow paths accurately.

Hydrology

Design Storm Frequency

Flood frequency analyses are used to design facilities that control storm runoff since it is impossible to anticipate every conceivable storm's effect. Constructing a design storm is a common practice that both the City and Alameda County standards follow. A rainfall pattern is used in hydrologic models to estimate surface runoff and compare the surface runoff to the capacity of drainage systems designed to convey this runoff.

Precipitation-runoff frequency analyses are based on concepts of probability and statistics. Engineers generally assume that a rainfall event's frequency (probability) coincides with direct stormwater runoff frequency. However, the runoff generation depends on several factors not necessarily dependent upon the precipitation event, such as antecedent moisture conditions in the drainage basin.

The 10-year storm recurrence interval is used as the design storm to evaluate the flood control systems (i.e., storm drain pipes) for this master plan. It is worth noting that over the typical 30-year life of a home mortgage, the chance of experiencing at least one 10-year event is about 96 percent. The 2-year storm recurrence interval is used to check improvements recommended to ensure nuisance flooding is mitigated.

The 100-year storm recurrence interval is used as the design storm to evaluate if City-owned and maintained creek reaches have sufficient capacity. The 100-year event is a typical design storm for large facilities such as creeks and pump stations that receive stormwater from collection systems.

Design Storm Duration

A 24-hour storm duration determines the governing design storm event and the conservative operational conditions of the City's drainage facilities. This storm duration is used for the following reasons:

1. The 24-hour duration is a standard for many local, state, and federal agencies.
2. The 24-hour duration is short enough to be consistent with the watershed size and long enough to create volume-induced flood problems in the watershed. The 24-hour storm duration generally results in the most extensive floodplain relative to other storm durations within the local historical record.

Design Storm Rainfall Depths

Design rainfall depths are calculated using the following relationship from Alameda County Flood Control District (ACFCD):[1]

$$D_{ij} = (0.32665 + 0.091144\mathrm{P})(1 + \mathrm{K}_j CV)t_i^{0.43287}$$ (Equation 1)

Where:

D_{ij} Design rainfall depth (inches) for recurrence interval j and storm duration i

P Mean annual precipitation (inches)

K_j Frequency factor for recurrence interval j

CV Coefficient of variation

t_i Consecutive time (days)

A mean annual precipitation value of 15.5 inches is used for the City per ACFCD's isohyetal map. Rainfall depths for the 2-, 10-, and 100-yr 24-hour storms are calculated. The coefficients and resulting depths for each event are displayed below in Table 3-1.

Table 3-1: $A_{f,d}$ and $B_{f,d}$ Values for Design Rainfall Depth Equation

Frequency	K_j	CV	D_{ij} (in)
2-year	-0.21	0.404	1.59
10-yr	1.339	0.404	2.68
100-yr	3.211	0.404	3.99

Design Storm Temporal Distribution

The 24-hour design storm temporal distribution from the ACFCD Drainage Manual is displayed as Figure 3-1 below. The temporal rainfall distribution is for a 24-hour design storm with 15-minute intervals.

[1] ACFCD 2017: Alameda County Hydrology & Hydraulics Manual.

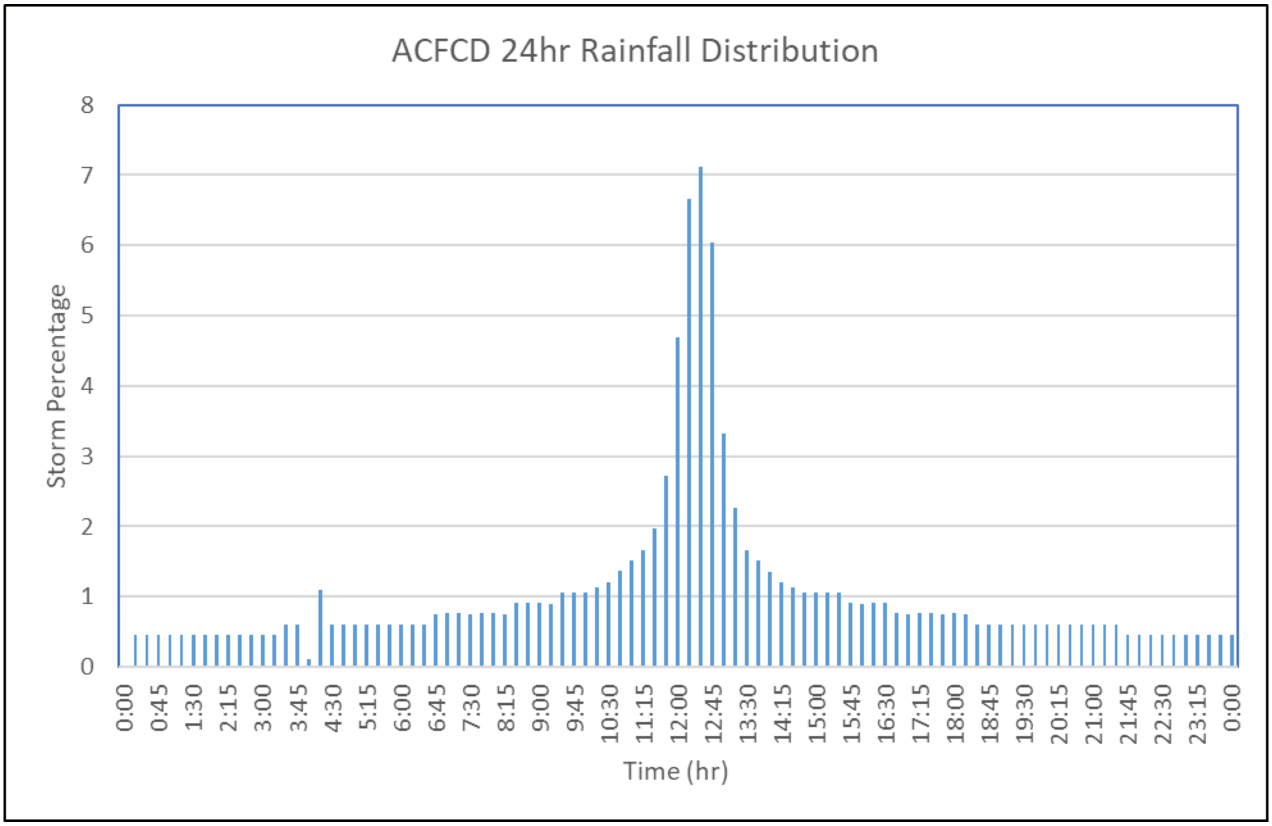

Figure 3-1: ACFCD 24-hour Storm Distribution

Rainfall/Runoff Transformation Method

The methodology for the transformation of the precipitation into stormwater runoff is described in this section. The general steps to transform rainfall into runoff are:

1. Apply a loss method to convert rainfall distributions into excess rainfall. This is done by accounting for the portion of rainfall lost to surface depressions, evaporation, and soil infiltration. The amount of precipitation that is lost will not result in direct runoff. Losses also vary over time during a storm. For example, as wetted soil becomes more saturated, losses decrease and more rainfall becomes surface runoff. Losses are a function of land use and soil conditions.

2. Transform the excess rainfall into surface runoff using the hydrograph methods subsequently described.

3. Route surface runoff hydrographs through the storm drain and creek systems. When stormwater flows exceed a storm drain or creek's hydraulic capacity, some portion of the runoff hydrograph will be carried over the ground surface. The timing and depth of this overland flow produce flood hazard mapping.

Hydrograph Method

The transformation of rainfall into runoff can be calculated in a model using various methods. ACFCD has adopted the Snyder unit hydrograph (UH) transformation method, which utilizes basin lag time and basin peaking factor input parameters.

Loss Method

The initial and constant loss rate method was utilized per ACFCD methodology. Loss rates are a function of soil conditions and land use. Losses are only applicable to the pervious portion of the drainage areas. The initial loss for all soil conditions and land uses for a 24-hour design storm is 1.0 inches. The uniform loss rates based on hydraulic soil group and land use type are shown in Table 3-2.

Table 3-2: Uniform Loss Rates[2]

Hydrologic Soil Group	Rural Coverage (in/hr)	New Urban Coverage (in/hr)	Existing Urban Coverage (in/hr)
A	0.45	0.45	0.45
B	0.35	0.37	0.40
C	0.14	0.19	0.25
D	0.05	0.07	0.09

The Horton Loss Rate Method can be used for both single-event design storms and continuous simulations with multiple intermittent storms since the initial loss capacity can be recovered. Antecedent soil moisture conditions and soil storages' saturation level before a storm are analyzed before determining the continuous storm simulation's appropriate initial loss rate.

Imperviousness

Table 3-3 shows the percentages of directly connecting impervious surface, non-directly touching impervious surface, and porous surface for each land-use. The percentages are taken from the ACFCD drainage manual.

Directly connected impervious surfaces (such as driveways, street pavements, and sidewalks) drain to the city storm drain system with limited surface attenuation. Non-directly connected impervious surfaces within a sub-basin experience greater peak-flow attenuation by flowing across pervious surfaces before entering the storm drain. These surfaces are generally roofs that drain to roof gutters which discharge to pervious lawns or landscaping.

[4] Alameda County Hydrology and Hydraulics Manual, ACFCD, 2017

Table 3-3: Land Use Percent Impervious

LAND USE TYPE	Impervious (%)		Pervious (%)
	Directly Connecting	Non-Directly Connecting	Area
Undeveloped Land, parks, open space, golf courses	0	0	100
Rural Residential (larger than 1 ac lot)	4	6	90
Residential 10,000 sf – 1 ac lot	15	12	73
Residential ¼ ac (8,000 – 10,000 sf lot)	22	18	60
Residential 1/8 ac (5,000 – 8,000 sf lot)	24	26	50
Residential (3,600 – 5,000 sf lot)	26	28	46
Residential (2,700 – 3,600 sf lot)	28	32	40
Zero Lot Line Residential & Less than 2,700 sf	35	0	65
Townhouse	50	30	20
Condominium	60	25	15
Industrial	70	20	10
Apartment	80	10	10
Commercial	85	5	10
Freeway	90	0	10
Mobile Home Park	17	37	46
Schools (large open space)	15-20	0	80-85
Schools (small open space)	40-50	0	50-60

Hydrograph Method Parameters

Snyder Unit Hydrograph Method

The two major input parameters of the method are Basin Lag Time and Basin Peaking Factor. The Basin Lag Time is a measure of the time elapsed between the occurrence of unit rainfall and the occurrence of unit runoff. It is based on the longest flow path length, slope, and basin roughness.

Basin Lag Time is calculated using the following relationship from (ACFCD):

$$t_L = K * N \left(\frac{L * L_c}{\sqrt{S}} \right)^{0.38} \quad \text{(Equation 2)}$$

Where:

t_L Lag time (hr)

K Distance factor

for $L > 1.7$ mi, K = 24
for $L \le 1.7$ mi, $K = 15.22 + 2.15L + 8.7/L$

N Basin roughness factor (from Table 3-4 or Equation 3)

L Length of longest flow path

L_c Length of longest flow path measured from the point opposite the watershed centroid

S average stream slope (ft/mi)

Table 3-4: Basin Roughness Factors for Rural Watersheds

Basin Type	Basin Roughness Factor (N)
Rural watersheds with generally clear stream bed and minimal vegetation growth in the drainage reaches	0.05
Rural watersheds with moderate to high levels of vegetation growth, or rock and boulder deposits within the main drainage reaches	0.07
Rural watersheds with dense vegetation or high levels of boulder deposits within the main drainage reaches	0.08

The basin roughness factor can be calculated using the following relationship:

$$N = 0.52n^{0.79} \quad \text{(Equation 3)}$$

Where:

N Basin roughness factor

n Manning's roughness coefficient (from Table 3-5)

Table 3-5: Manning's Roughness Coefficient

Type of Facility	n
Reinforced Concrete Pipe	
Conduit > 36" diameter	0.012
Conduit ≤ 36" diameter	0.14
Corrugated Metal Pipe	
Annular	0.021
Helical	0.018

Concrete-Lined Channels	
Smooth-troweled	0.015
District Simulated Stone	0.017
Reinforced Concrete Box	
Cast-in-Place	0.015
Pre-Cast	0.014
Earth Channels	
Smooth Geometric	0.030-0.035
Irregular or Natural	0.045-0.050

The Peaking Factor is a function of overland basin storage. Large areas with flat slopes are associated with relatively high amounts of overland basin storage. Conversely, water that falls on steeply sloped areas will run off quickly with little overland basin storage. The lower the basin storage, the higher the corresponding peaking factor.

$$C_p = 0.6e^{0.06(S_{o/A})} \quad \text{(Equation 4)}$$

Where:

C_p Basin peaking factor ($C_p \leq 0.85$)

S_o Average watershed slope (%)

A Drainage area (mi^2)

Watershed Characteristics

To model the storm drain system and include all pipes that are 15-inches in diameter and larger, relatively small sub-watersheds have been developed for representation in the models.

The area that contributes runoff to a drainage line within these watersheds is referred to as a "Drainage Area." The smaller sub-watersheds within the Drainage Areas are noted as "Sub-Basins." Therefore, the hierarchy terminology for watersheds includes:

1. Watersheds – delineating the basin for each major creek system
2. Drainage Areas – delineating the basin for each named drainage line
3. Sub-Basins – delineating the smallest sub-basin for each drainage line

Sub-Basin Size

Sub-Basins are delineated based on the 2014 topographic LiDAR mapping furnished by the City, City of Livermore collector system locations, and overland release flow paths. The Sub-Basin size ranges from 0.003 acres in densely developed urban areas to approximately 2,200 acres in undeveloped hilly areas.

Sub-Basin Delineation

Sub-Basins are also delineated based on stream channels and storm drain networks. Where the overland flow path and the storm drain network flow path conflict, the storm drain flow path governs since it generally conveys the most flow.

ESRI ArcMap Hydrology tools condition the input terrain to include underground pipes and channels. This approach ensures that lateral pipes smaller than 12 inches can be routed to the modeled pipes hydrologically. The conditioned terrain creates sub-basins automatically. Sub-Basins are then further divided to model pipes that are 15-inches and greater in diameter. This approach provides consistent, reproducible watershed delineation results.

Sub-Basin Soils

The National Resource Conservation Service (NRCS) soil survey and map information identify soils in hydrologic soil groups based on their infiltration properties.

Hydrologic soil groups "A," "B," "C," "C/D," and "D" are present within the drainage system. Group "A" has a higher infiltration rate than Group "D." "C/D" soils indicate a duality of hydrologic soil conditions. When the groundwater table is seasonably high (less than 24" from the surface), the soil has a "D" type response. When the water table is well-drained (greater than 24" from the surface), the soil has a "C" type response. The open space areas in the eastern portion of the study area have more groups "C" and "D." Figure 3-7 presents the NRCS Soils Map.

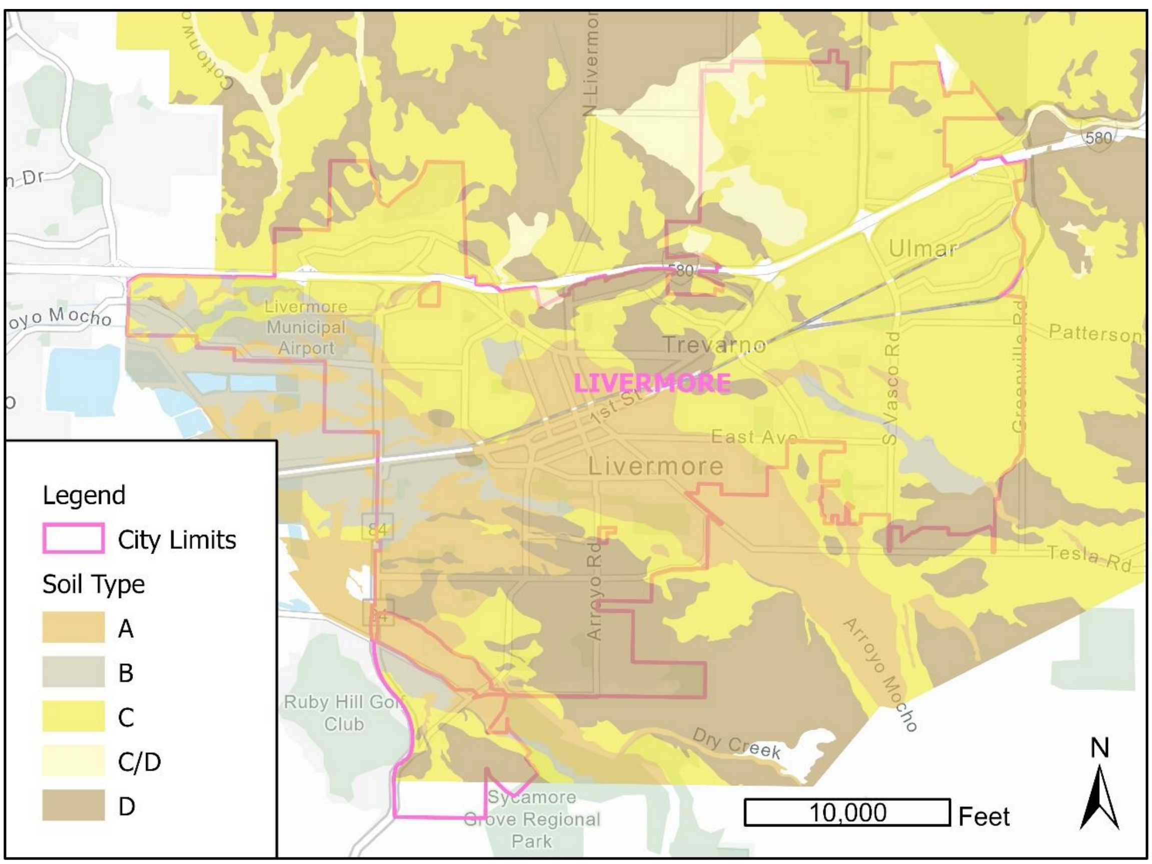

Figure 3-2: NRCS Soil Classification Map for the Livermore Watershed

Each soil type consists of a combination of seven soil groups: A, A/B, B, B/C, C, C/D, D. The NRCS assigns the dominant hydrologic soil group in the soil survey publication. In the event of an even split of percentages between two soil groups, the soil group with a lower infiltration rate is assigned.

Sub-Basin Land Use

The City provided a land-use GIS shapefile reflecting the level of development within the City boundary. Each land use category was assigned a value of relative imperviousness based upon Table 3-3. To develop Sub-Basin-specific hydrology parameters for the Snyder UH method, a combination of percent imperviousness and underlying soil infiltration regime are used.

Figure 3-3 shows the land use. Areas with no defined land use in the City's GIS are assigned sub-basin-specific hydrology parameters based on the Esri World Imagery Map.

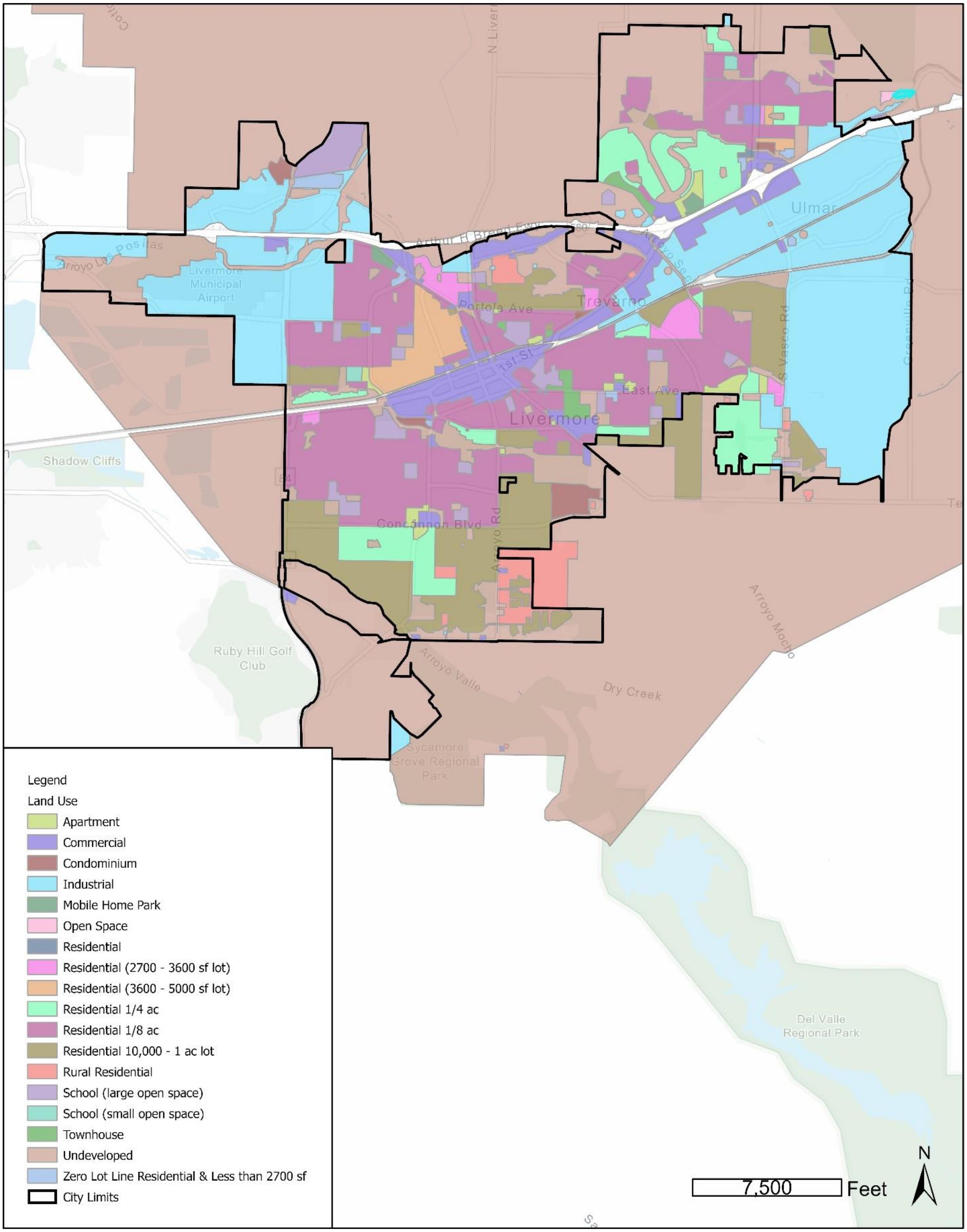

Figure 3-3: Livermore Land Use

Hydraulics

A detailed representation of both the "conduit and street" systems and the open channel systems is required in the model to evaluate the City's level of service goals. This representation accounts for both conveyance and storage in the streets, conduits, and open channels. The InfoWorks ICM modeling software preformed the hydraulic analysis.

Conduit and Street Systems

The conduit and street systems are modeled using parameters as discussed in the following sections.

Conduit and Manhole Invert Elevations

The City's GIS file of the storm drain network provides inverts of conduits and manholes. If inverts are missing from these two data sources, as-builts have been referenced to fill in any data gaps. If data is still not found from these two data sources, an appropriate assumption is made by referencing upstream and downstream inverts and storm drain pipe cover.

Conduit Manning's n Roughness

Manning's n-values for conduit and street systems are estimated based on values specified in Table 3-5. All conduits of unknown material are assumed to be reinforced concrete pipe. For conduits with materials not listed in the table above, Manning's n values are referenced from other sources[3]. These materials and their associated Manning's n values are listed in Table 3-6.

Table 3-6: Conduit Manning's n Not Listed in Table 3-5

Material	Manning's n
Asbestos Cement (ACP)	0.011
Polyvinyl Chloride (PVC)	0.009
Cast Iron Pipe (CIP)	0.012
Ductile Iron Pipe (DIP)	0.012

All conduit material descriptions by pipe segment were obtained from the City.

Conduit Manhole Losses

Manhole losses are calculated in InfoWorks ICM using the Normal Headloss Method. This method does not account for bend, drop, contraction, and expansion losses. It does account for simple junction losses. However, storm drains are generally built on straight alignments of the same diameter from manhole to manhole without significant bends, drops, contractions, or expansions. Particularly for the larger pipe diameters, manholes provide periodic access to the top of continuous pipelines.

[3] Engineering ToolBox, (2004). Manning's Roughness Coefficients. [online] Available at: https://www.engineeringtoolbox.com/mannings-roughness-d_799.html [2020]

Conduit Boundary Conditions

The storm drain network's downstream boundary conditions are dynamically linked to either 1D open channels or directly to the 2D surface in the InfoWorks ICM model. Creek levees and/or floodwalls are assumed to hold their elevations if overtopped in a modeling scenario. Levees do not fail in the SDMP analyses as they might for a Federal Emergency Management Association (FEMA) flood hazard analysis.

Conduit Assumptions

All conduits are assumed to have their full conveyance available. In other words, all conduits are modeled with no silt or debris.

Pump Stations

The Livermore storm drain system does not rely heavily on pump stations to move runoff from pipe networks to creeks that flow to San Francisco Bay. There are three pump stations owned and operated by the City within the study area, as shown in Figure 3-4. The pump stations are used to drain roadway underpasses and outlet into the adjacent storm drain system.

The pump stations are input into the InfoWorks ICM model based on data obtained from as-builts and pump curves. There are no flooding issues reports at the pump station, so they have been simplified in the model to increase model stability. They are modeled as fixed discharge based on the design flow in the pump curve. Set levels and design discharge are shown in Table 3-7.

Table 3-7: Pump Station Data

	Murrieta	North Livermore	North P Street
Lead Start (ft)	5	5	5
Lead Stop (ft)	2	2.5	2.5
Both Start (ft)	5.5	5.5	5.5
Design Discharge (GPM)	1200	600	600

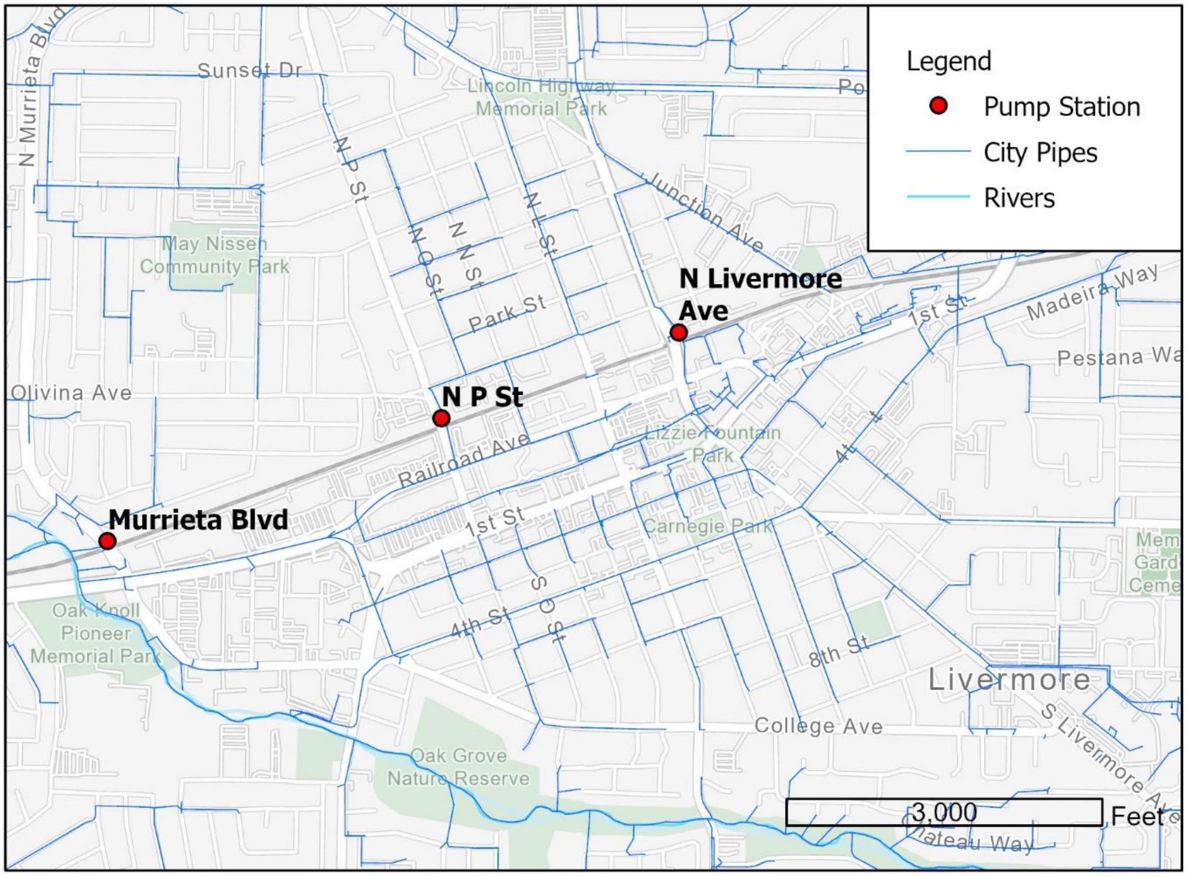

Figure 3-4: Pump Station Locations

River Systems

The modeled river systems include Arroyo Mocho, Arroyo Las Positas, Arroyo Valle, Altamont Creek, Line S, Rel Positas Creek, Collier Creek, Line O, Arroyo Seco, and Line R-1. The modeled river systems were imported directly into the Infoworks ICM model from the Zone 7 HEC-RAS model. River reaches in the Zone 7 model that don't interact with the City of Livermore's storm drain system are removed or truncated. Figure 3-5 displays the modeled river systems.

Imported river system features include cross section geometry, channel bank lines, bridges, and junctions. Channel bank lines connect channel overbanks to 2D floodplains hydraulically. These lines' ground elevations are sampled from the 2D terrain to ensure smooth transitions from channel overbanks to the 2D floodplains. Bridge opening data does not import directly into ICM and must be entered manually.

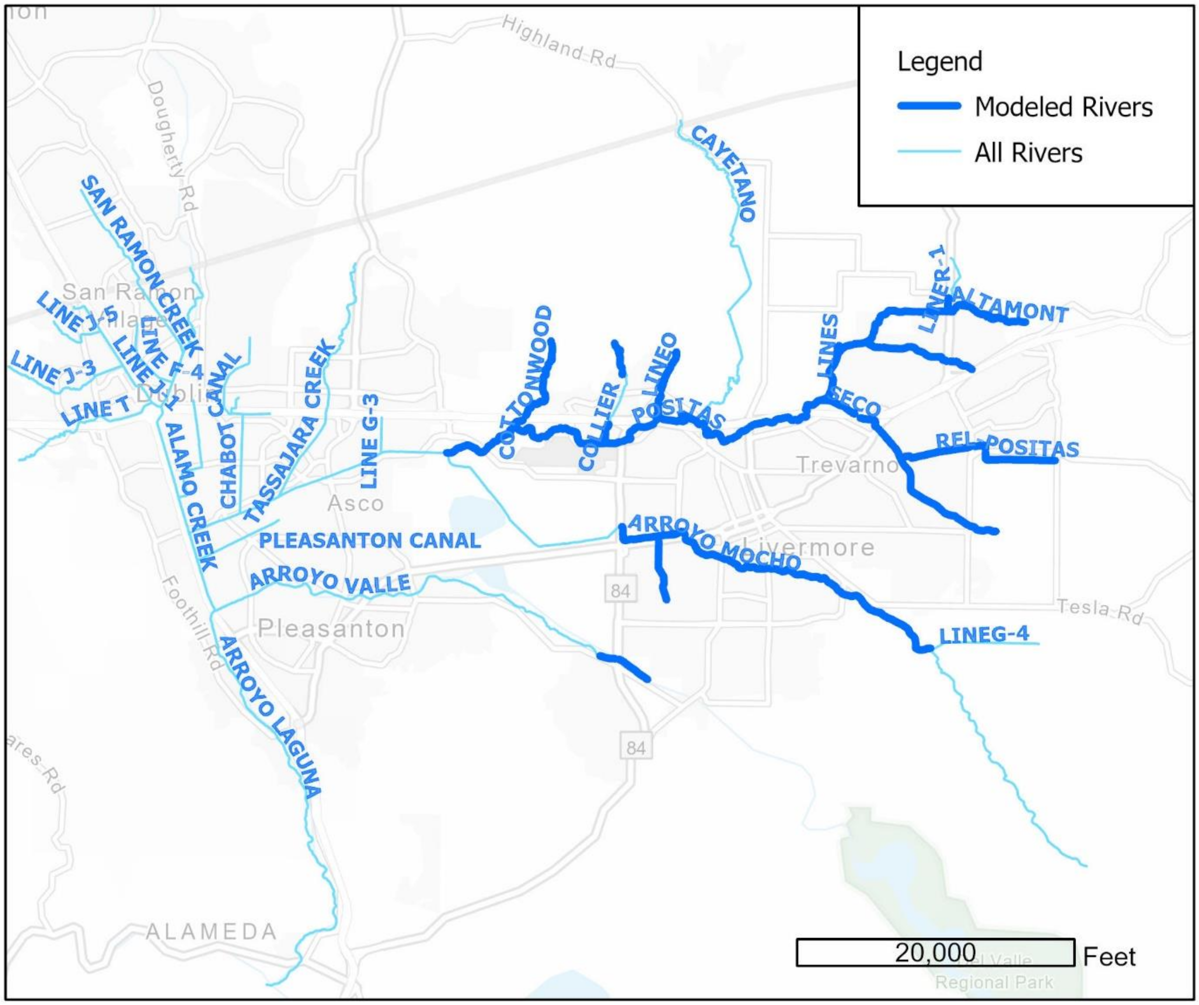

Figure 3-5: Map of Modeled Channels

Two-Dimensional Surface

A 2D surface is modeled and linked with pipe nodes to reflect flow exchanges and the hydraulic performance between different drainage facilities when pipe capacities exceed and flow spills to the 2D surface. The features that affect the predicted flooding extents with the spill to the 2D surface resolve the modeled 2D surface and surface roughness. The digital elevation model (DEM) that is used to create the 2D surface was obtained from the City. A shift of 12 feet in the x axis and 4 feet in the y axis is required to accurately position the surface on the network.

The 2D surface is modeled as a triangular flexible mesh. The program selects the appropriate triangle size based on changes in DEM elevation. For example, flat areas will have larger triangles sizes while areas with varied elevations in a small area will have smaller triangles. This type of mesh provides a high level of accuracy with a smaller file size and model run time.

A surface roughness value of 0.03 is used. This value is consistent with the roughness value used in the Zone 7 model. It is appropriate for roads and grassland which is most of the surface type that conveys overland flow.

4. Collection System Capital Improvement Program

This chapter describes deficiencies in the piped collection system, historical problem areas, and other known flood hazards. Detailed descriptions of necessary capital improvement projects and their prioritization are provided in this chapter.

Existing Conditions Flooding

The master plan evaluates the existing storm drain system performance for the 2-year and 10-year design storms. The maximum flood depths that occur during the 2-year and 10-year storms are shown in Appendix A. In this flood study, the SDMP proposes CIP projects that can eliminate or ameliorate the identified inundation.

Improvement Projects

Improvements have been developed that reduce 10-year flooding to a maximum depth of 0.5 feet. These improvements are then checked with the 2-year design storm to ensure nuisance flooding is eliminated. Recommended CIP projects are identified graphically, and general project routes are given. CIP priorities are assigned based on the consequence of flooding in the existing 10-year storm condition, elimination of existing 2-year storm flooding, and number of parcels removed from the 10-year floodplain.

- High-priority CIP projects address the following issues:
    - extensive 10-year flooding on residential or commercial properties that spreads across several streets and can widely disrupt traffic, residential, and commercial activities.
    - 2-year flooding.
    - Remove a large number of parcels from the 10-year floodplain.
    - Are located downstream of moderate and/or low priority CIP projects.
- Moderate-priority CIP project address the flowing issues:
    - Moderate flooding on residential or commercial properties.
    - Remove a moderate number of parcels from the 10-year floodplain,
    - Are located downstream of low priority CIP projects.
- A low-priority CIP project manages 10-year flooding that occurs only in streets, minor flooding on properties, or flooding that can only be partially alleviated.

City-owned storm drainpipes 15 inches and larger in diameter are evaluated. Pipes that act as laterals are not included in the mainline analysis but are treated to be part of the system that delivers flow into the main drainage lines.

Alternative Improvement Projects

To increase storm drain system capacity, two types of projects are available. A new relief storm drain parallel to the system lacking capacity can be installed, or the overloaded pipe can be replaced with a larger diameter pipe in the same alignment. The two alternatives can be made equivalent to one another using the following formula, assuming that pipe material and length are equal:

$$D_R = \left(D_e^{2.63} + D_p^{2.63} \right)^{0.38}$$

where D_R = diameter of replacement pipe

D_e = diameter of overloaded pipe

D_p = diameter of parallel relief drain

The City's selection of a capacity improvement strategy will vary from project to project. It will be governed by construction constraints, including available rights-of-way and existing utilities. Most likely, the storm drain CIP for the City will utilize parallel relief drains unless right-of-way and utility constraints appear to favor the pipe's actual replacement, which is more costly.

Installing new parallel drains should be more cost-effective than replacing pipes in most cases since the required pipe size is smaller, and the existing pipe can stay in place. In order to be conservative on the cost estimate, pipe replacement, the more expensive method is used as the default project.

Collection System Capital Improvement Program

CIP projects for the piped collection system are identified in Table 4-1 and are shown in Appendix B. Existing and proposed condition impacted parcels are shown in Appendix C. Detailed figures, descriptions, and cost estimates for each high priority CIP project are included in Appendix D.

Table 4-1: Capital Improvement Projects

Project	Priority	Replacement Option
Arroyo_1	High	Replace approximately 920 LF of existing 36-inch RCP with 745 LF of 42-inch RCP and 175 LF of 48-inch RCP on Arroyo Rd between Rivers Bend Cir and the Arroyo Mocho outfall. Arroyo_1 should be constructed before Arroyo_2.
Broadmoor_1	High	Replace approximately 205 LF of existing 30-inch RCP with 36-inch RCP on Broadmoor St at Bridgeport Cir.
Geneva_1	High	Replace approximately 245 LF of existing 18-inch RCP with 24-inch RCP on Geneva St between Peary Way and the Arroyo Mocho outfall.
Patterson_2	High	Replace approximately 140 LF of existing 18-inch RCP with 24-inch RCP on Patterson Pass Rd at Vasco Rd.
Ruby_1	High	Replace approximately 860 LF of 54-inch RCP with 60-inch RCP adjacent to Ruby Rd between Ruby Ct and Pearl Dr. Ruby_1 should be constructed before Ruby_2 and Cameo_1 are construction.
Stanley_1	High	Replace approximately 2350 LF of existing 54-inch RCP with 60-inch RCP on Stanley Blvd between S St and the Arroyo Mocho outfall. Stanley_1 should be constructed before Railroad_1.
Vasco_1	High	Replace approximately 315 LF of existing 24-inch RCP with 30-inch RCP on Vasco Rd between East Ave and the Arroyo Seco outfall.
Arroyo_2	Moderate	Replace approximately 1135 LF of existing 33-inch RCP with 36-inch RCP on Arroyo Rd between Chardonnay Way and Cabernet Way. Arroyo_1 should be constructed before Arroyo_2.
Birchwood_1	Moderate	Replace approximately 1260 LF of existing 30-inch RCP with 36-inch RCP on Birchwood Cmn and Holly Cmn between Wildood Comn and the Arroyo Seco outfall.
Cameo_1	Moderate	Replace approximately 1135 LF of existing 21-inch and 18-inch RCP with 24-inch RCP on Topaz Way and Cameo Dr between Onyx Rd and Diamond Dr. Ruby_1 should be constructed before Cameo_1.
LivermoreGardens_1	Moderate	Replace approximately 1245 LF of existing 24-inch and 30-inch RCP with 36-inch RCP on the Livermore Gardens Apartments driveway from East Ave to the Arroyo Seco outfall.
Mezzamonte_1	Moderate	Replace approximately 710 LF of existing 240-inch and 30-inch RCP with 455 LF of 30-inch RCP and 255 LF of 42-inch RCP on Mezzamonte Dr between Caldeira Dr and Roberson Park Rd.
Pasatiempo_1	Moderate	Replace approximately 590 LF of existing 60-inch RCP with 66-inch RCP on Pasatiempo St between Cypress Point Dr and Skylinks Way.
Patterson_1	Moderate	Replace approximately 725 LF of existing 60-inch RCP with 66-inch RCP on Patterson Pass Rd at the Rel-Positas outfall.
Railroad_1	Moderate	Replace approximately 2510 LF of existing 30-inch RCP with 36-inch RCP on Railroad Ave between Mill Springs Cmn and S Street. Stanley_1 should be constructed before Railroad_1. The portion of RobertsonPark_1 located downstream of Park_1 should be constructed before Park_1.

Project	Priority	Replacement Option
Robertson Park_1	Moderate	Replace approximately 4720 LF of existing 42-inch RCP with 60-inch RCP on Normandy Way, Bobwhite Rd, and Robertson Park Rd between Concannon Blvd and the Arroyo Mocho outfall.
Ruby_2	Moderate	Replace approximately 1480 LF of existing 27-inch RCP with 30-inch RCP on Diamond Dr and Ruby Rd between Onyx Rd and Ruby Ct. Ruby_1 should be constructed before Ruby_2.
Shirley_1	Moderate	Replace approximately 2720 LF of existing 54-inch RCP with 60-inch RCP adjacent to Lucille St between East Ave and the Arroyo Seco outfall.
4th St_1	Low	Replace approximately 1150 LF of existing 48-inch RCP with 54-inch RCP on 4th St between P St and College Ave.
Ariway_1	Low	Replace approximately 1100 LF of existing 48-inch RCP with 54-inch RCP at Airway Blvd between Modoc Pl and the Arroyo Las Positas outfall.
Alden_1	Low	Replace approximately 170 LF of existing 18-inch RCP with 24-inch RCP at Alden Ln near Old Oak Rd.
Arabian_1	Low	Replace approximately 790 LF of existing 15-inch RCP with 18-inch RCP between Arabian Rd and the Altamont Creek outfall.
Bluebell_1	Low	Replace approximately 695 LF of existing 42-inch RCP with 48-inch RCP adjacent to Bluebell Ave between Marigold Ct and the Arroyo Las Positas outfall.
Devon_1	Low	Replace approximately 830 LF of existing 42-inch RCP with 48-inch RCP at Devon Pl.
Heather_1	Low	Replace approximately 935 LF of existing 33-inch and 36-inch RCP with 42-inch RCP on Heather Ln between Wisteria Way and Bluebell Dr.
Jeannie_1	Low	Replace approximately 1010 LF of existing 42-inch and 48-inch RCP with 54-inch RCP on Jeannie Way between Audry St and Kyle Cmn.
Moraga_1	Low	Replace approximately 1455 LF of existing 24-inch RCP with 30-inch RCP on Moraga Dr between Alexander St and Caliente Ave.
Obsidian_1	Low	Replace approximately 1425 LF of existing 24-inch, 27-inch, and 33-inch RCP with 36-inch RCP on Obsidian Way between Murdell Ln and Peridot Dr.
Ontario_1	Low	Replace approximately 525 LF of existing 54-inch RCP with 60-inch RCP on Ontario Dr at El Padro Dr.
Park_1	Low	Replace approximately 1110 LF of existing 33-inch RCP with 36-inch RCP on Lucca Ct and Park Ct between San Felice Dr and Bobwhite Rd. The portion of RobertsonPark_1 located downstream of Park_1 should be constructed before Park_1.
Portola_1	Low	Replace approximately 4480 LF of existing 54-inch and 60-inch RCP with 3420 LF of 60-inch RCP and 1060 LF of 72-inch RCP on Portola Ave between N Livermore Ave and the Arroyo Las Positas outfall.
Positas Pump Station	Low	Construct a 11,200 gpm pump station at Las Positas Rd near Mines Rd that pumps from the City's collection system into Arroyo Las Positas.
SanFelice_1	Low	Replace approximately 280 LF of existing 24-inch RCP with 30-inch RCP on San Felice Dr between Caldeira Dr and Vernazza Dr.

Project	Priority	Replacement Option
Stanley_2	Low	Replace approximately 575 LF of existing 24-inch RCP with 30-inch RCP on Stanley Blvd between Murdell Ln and Isabel Ave.

Storage Facilities

Two basic categories of stormwater storage are commonly used: detention and retention. Some facilities blur the distinction between the two but, in general:

> Detention refers to the temporary storage of incoming runoff that exceeds the permissible release. After the storm event, the facility empties and returns to its natural function (e.g., a parking lot or park).
>
> Retention facilities, on the other hand, hold on to the excess runoff for an indefinite period. Natural ponds and lakes exemplify retention facilities where water levels change only through evaporation, infiltration, and additional storm runoff.

With the gravel that underlies much of the City, true retention facilities may be advantageous. Several storage facilities in the City serve a dual role for both stormwater detention and retention, reducing the peak flows that enter the pipes system.

Properly designed, constructed, and maintained, stormwater storage facilities could reduce peak flows. This would better utilize the capacity of downstream conveyance facilities. Such facilities can also potentially mitigate the need for system upgrades.

The efficacy of any detention facility and ancillary improvements in the quality of storm runoff to receive waters will need to be evaluated on a case-by-case basis. However, some general design criteria need to be applied to every basin:

1. Basins should be sized so that their output does not exceed the downstream facilities' design capacity.
2. There must be an overflow section capable of safely discharging the 100-year peak inflow (should outlet works become clogged) without causing property damage.
3. At least one foot of freeboard over the maximum 100-year water surface elevation should be provided for excavated basins. Three feet of freeboard (minimum) must be provided where berms or levees create basins.
4. Infiltration capacity shall not be considered when designing basins, unless percolation rates are determined by on-site soil testing certified by a civil or geotechnical engineer.
5. Debris and sediment loading must be considered in design (see below).
6. Ponds and basins need to be designed with shallow side slopes (5:1 minimum) so that people and animals may extricate themselves from the water should the need arise. A safety shelf may also be considered. Facilities that pose an inordinate risk to the public should be fenced off. Openings larger than six inches in diameter must be screened to protect children and animals.
7. A mechanism for draining the basin should be provided. If the basin also serves as a pumping forebay, the pumping facilities must fully dewater the basin.
8. Facilities designed for the permanent (or semi-permanent) retention of water should be deep enough to avoid eutrophication (accumulation of excess nutrients that stimulates plant growth) and breeding insects. Pond surface areas should be at least one-half acre, with a minimum depth

of 10 feet over at least a quarter of the area. The average depth over the rest of the pond needs to be at least five feet. Basin outlets should be positioned opposite the inlet to promote circulation. Stocking permanent ponds with fish also promote good water quality.

9. Underdrain systems to minimize wetness should be considered for detention facilities not intended as permanent water features. This helps prevent the facility from encouraging insect populations and provides for a quicker return to its dry weather function.
10. Basin bottoms and sides should be stabilized with vegetation to withstand periodic flooding and prevent erosion. Basin outlets need to be provided with erosion protection, such as riprap.

Debris Loading

Detention and retention basins will eventually fill up with sediment and other debris, reducing their storage capacity until they will not operate as designed. Therefore, consideration of debris loading must be made for each basin. Depending on the desired frequency of maintenance, some allowance for “dead” storage should be made to handle sediment and debris. Based on work by Schaaf & Wheeler for the Santa Clara Valley Water District, the following empirical relationships (debris load per unit drainage area) are used to evaluate debris loading:

Highly urban areas	0.1 acre-feet/mi^2/year
Hillside open space	0.4 acre-feet/mi^2/year

5. Creek System Capital Improvement Program

This chapter describes deficiencies in City owned and maintained reaches of the creek system. Detailed descriptions of necessary capital improvement projects and their prioritization are provided in this chapter. Creek ownership in the Livermore area is shown in Figure 5-1.

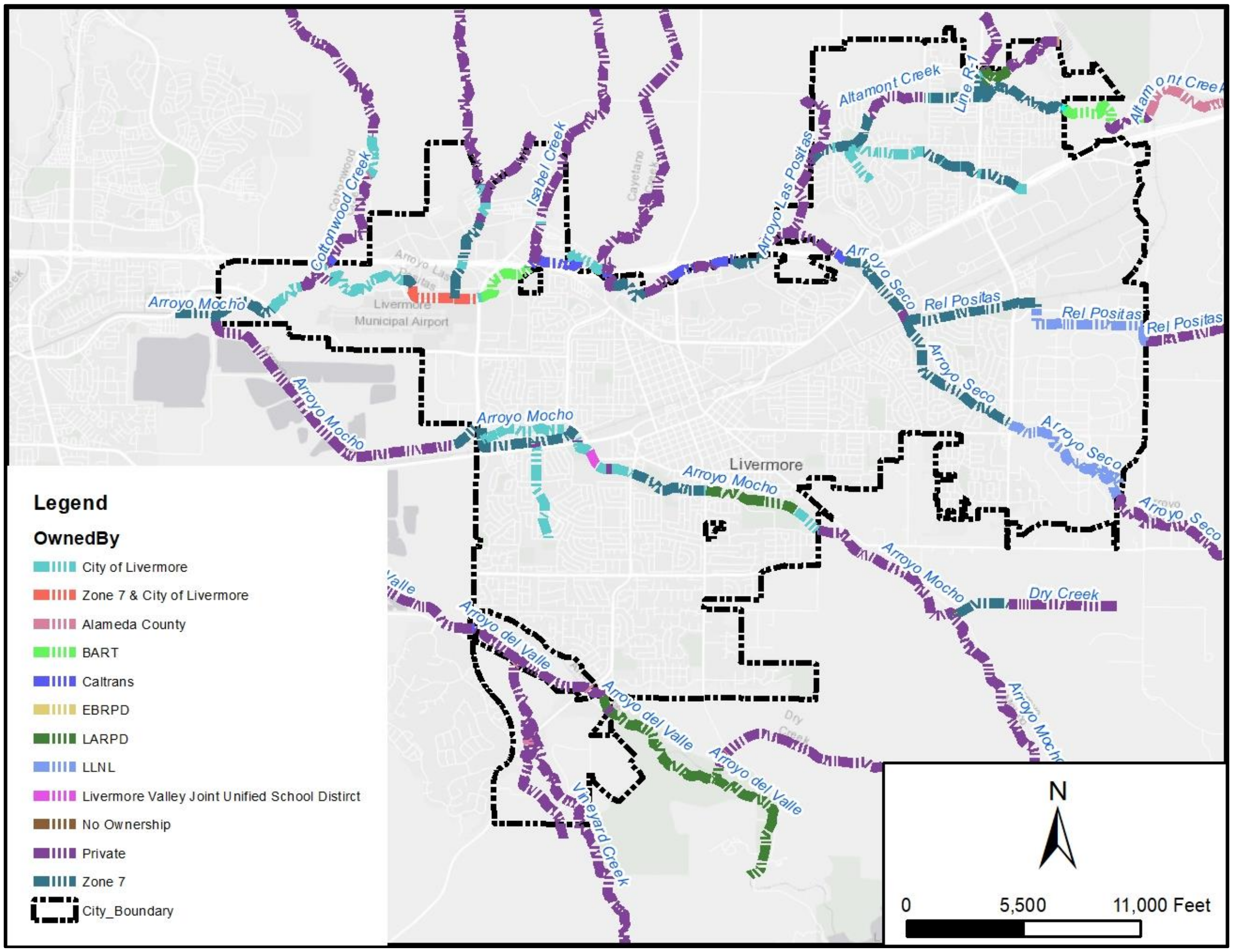

Figure 5-1: Creek Reach Ownership Map

Existing Conditions Flooding

The SDMP evaluates the existing creek system performance for the 100-year design storm. The maximum flood depths that occur during the 100-year storm is shown in Appendix E. In this flood study, the SDMP proposes CIP projects that can eliminate or ameliorate the identified inundation.

Known Problem Areas

The City is aware of several areas that experience creek flooding on a regular basis. Impacts of this flooding include residential, commercial, and municipal property damage; closed roads; and debris buildup.

Collier Canyon

Collier Canyon Creek enters the City system near the intersection of Collier Canyon Road and Mirtage Common. It crosses under Collier Canyon Road through a series of culverts. The trash racks at these culverts may become clogged by sediment and debris during high flow events, causing creek overtopping and flooding along Collier Canyon Road.

The City currently has a grant to design and build a debris basin upstream of the Collier Canyon Road culverts, which will mitigate this flood risk. Since this project is currently funded, it is not included in the CIP.

Las Positas Golf Course

Arroyo Las Positas enters the Las Positas Golf Course as Airway Boulevard. It overflows its banks during high flow events which causes damage to the parking lot, golf course greens and sandpits. The cost to repair the damage is compounded by the fact that golfers cannot use the course until repairs are made.

The City currently has a grant to design and improve the reach of Arroyo Las Positas through the golf course, which will mitigate this flood risk. Since this project is currently funded it is not included in the CIP.

Heather Lane and Bluebell Drive Culverts

Arroyo Las Positas crosses under Heather Lane and Bluebell Drive in the Springtown area of the City. The culverts are undersized which causes flooding in the adjacent neighborhoods, particularly along Quince Court. The limited capacity of the Heather Lane culvert also causes debris buildup around the culvert headwall.

Improvement Projects

Improvements have been developed that reduce 100-year creek flooding to a maximum depth of 1 foot to align with FEMA guidelines. Recommended CIP projects are identified graphically, and general project routes are given. CIP priorities are assigned based on reports of nuisance flooding due to creek overflows, the consequence of flooding in the existing 100-year storm condition, and the cost of the improvement.

Creek System Capital Improvement Program

CIP projects for the creek system are identified in Table 5-1 and are shown in Appendix E. Detailed figures, descriptions, and cost estimates for each high priority CIP project are included in Appendix D.

Table 5-1: Creek System Capital Improvement Projects

Project	Priority	Replacement Option
Heather Ln Culvert	High	Replace an approximately 25 feet long double 6 feet by 6 feet culvert which crosses Arroyo Las Positas under Heather Lane.
Bluebell Dr Culvert	High	Replace an approximately 80 feet long culvert with five 10 feet wide by 4.5 feet high openings which crosses Arroyo Las Positas under Bluebell Drive.

Project	Priority	Replacement Option
Murrieta Blvd Floodwall	Low	Construct a 2100 foot long 6 feet high floodwall along the north bank of Arroyo Mocho adjacent to Murrieta Blvd and the Arroyo Bike Trail from Stanley Blvd toward Holmes St. Should be constructed concurrently with the Holmes St Floodwall.
Holmes St Floodwall	Low	Construct a 2600 foot long 5 feet high floodwall along the south bank of Arroyo Mocho behind Granada High School, the Holy Cross Lutheran Church, and the senior living facilities at Holmes St. Should be constructed concurrently with the Murrieta Blvd Floodwall.
Airway Blvd Floodwall	Low	Construct a 86,100 foot long 7 feet high floodwall along both banks of Arroyo Las Positas between Airway Blvd and Isabel Ave.

6. Operations, Maintenance, and Replacement

The intent of this SDMP is not to focus on storm drain system operations and maintenance requirements or techniques. Rather, some foresight is provided into anticipated ongoing maintenance schedules, including periodic replacement of major storm drain system components. The City needs to set aside sufficient funds for annual facility maintenance and a systematic, long-term replacement program since some of its older storm drainage infrastructure is reaching the end of its useful life.

General Maintenance Regimen

Table 6-1 presents general criteria that can be useful in establishing a routine maintenance regimen. Again, city staff will have the best experience with necessary frequency and extent of ongoing maintenance on a system-by-system basis. Also, maintenance needs will fluctuate depending on seasonal and annual factors, particularly the amount of precipitation and, to a lesser extent, the general climate.

It is vitally important that all collection, storage, and pumping systems be in working order prior to the start of the wet season, which is near the end of October. Due to limited staff resources, certain items will have higher priority than others.

Table 6-1: Storm System Maintenance Guidelines

Category	Schedule
Inlet Inspection	annually (summer-fall)
Inlet Cleaning	as required (ongoing)
Storm Drainpipe Cleaning	continuous if possible (ongoing)
Channel Cleaning/Desilting	annually (fall)
Culvert Cleaning/Desilting	annually (fall)
Detention Basin Dredging	every 10 years
Pump Exercising	monthly (year-round)
Engine Exercising	monthly at full load (year-round)
Equipment Lubrication	per manufacturers' recommendations
Drain and fill diesel fuel tank	every six months
Motor/Engine Control Testing	annually (fall)

Collection System Maintenance

The storm drain and channel system cannot function if one of its components is plugged. Even though hydraulic analyses show criteria are met, blocked inlets, pipes, or channels will cause flooding. Lagoons and pumping forebays need to be monitored and periodically dredged to preserve design capacities.

Maintaining the more natural drainage features, such as non-creek open channels and basins, as drainage features is also important. This will prevent them from becoming jurisdictional. Extensive regulatory permits will not be required to perform what should be routine maintenance.

Based on system history, the most significant problems occur at the base of the foothills, where sediment- and debris-laden runoffs are easily carried within the steeper pipes and streets. The sediment and debris are deposited as the topography flattens out within the City limit. Some of this sediment and debris originate outside of the City limits in unincorporated Alameda County.

Municipal Regional Stormwater Permit Requirements

Livermore participates in the Alameda County Clean Water Program as a co-permittee under the California Regional Water Quality Control Board San Francisco Bay Region (Water Board) Municipal Regional Stormwater NPDES Permit (Order No. R2-2015-0049). Also referred to as the "MS4 Permit" or "MRP", it became effective on November 19, 2015. Requirements outlined in the City's MS4 Permit are subject to change.

This SDMP does not intend to document specific NPDES requirements or their implementation. Rather, it intends to provide a brief background regarding the requirements likely to affect system-wide operation and maintenance. An allowance is made in the next chapter for typical annual costs to satisfy system-wide permit requirements. A permit update (MRP3.0) is in the draft form currently and is anticipated to be adopted in 2021.

Regulatory Background

The Water Board has found that stormwater runoff from urban and developing areas within the San Francisco Bay region contains significant sources of pollutants that contribute to water quality impairment in the waters of the region. In the City, these could include: creeks, streams, and San Francisco Bay. In conformance with the Clean Water Act, the Water Board has established total maximum daily loading limits (TMDLs) for various pollutants to gradually eliminate the water bodies' impairment and attain water quality standards.

As a co-permittee, the City is required to effectively prohibit the discharge of anything other than stormwater into storm drain systems and watercourses. It is specifically prohibited from discharging rubbish, refuse, sediment, or other solid wastes into surface waters or anywhere such trash will eventually transport to surface waters, including floodplain areas.

Routine Practices

The City shall implement best management practices (BMP) to control and reduce polluted stormwater and non-stormwater discharges to storm drains and watercourses. BMP shall be implemented during operation, inspection, and routine repair and maintenance activities of municipal facilities and infrastructure. These practices apply to:

- Road repair and maintenance
- Sidewalk and other hardscape repairs, maintenance, and cleaning
- Structural maintenance (e.g., bridge repair) and graffiti removal
- Stormwater pump station operation and maintenance
- Corporation yard activities
- Construction sites
- Pesticide toxicity control

The City must implement an industrial and commercial site control program at all sites that could reasonably be considered to cause storm water runoff pollution. Routine inspections and enforcement to abate actual or potential pollution sources need to be consistent with an Enforcement Response Plan (Plan). The Plan is prepared to confirm the implementation of appropriate and effective pollutant controls by industrial and commercial site operators.

In addition, the City is responsible for detecting and eliminating illicit discharges by any parties within its jurisdiction. An illicit discharge program shall be developed and implemented to include active surveillance, a centralized point of contact for complaints, a tracking system, and reporting. Public outreach and water quality monitoring, which can be collaborative with other co-permittees, such as Alameda County, are also permit requirements.

New Development and Redevelopment

The City administers the implementation of new development and redevelopment projects to comply with the Municipal Regional Stormwater Permit requirements. Project administration includes project review and permitting in the areas of: site design, onsite stormwater treatment, hydro-modification management, landscaping, trash enclosures, plumbing, swimming pool water disposal, and fire test water disposal.

The MS4 Permit allows the City to consider the construction of regional stormwater treatment facilities in lieu of treatment on individual building sites. Such regional stormwater treatment facilities are not factored into capital planning for the stormwater system described in this SDMP.

Green Infrastructure

The City's Green Infrastructure Plan (GI Plan) aims to gradually transform the urban landscape and storm drainage systems from "gray" to "green." It involves shifting from having stormwater flow directly off impervious surfaces into the storm drainage system to having runoff flow into a local, sustainable system.

Options include: draining into vegetated areas for infiltration and evaporation, collecting runoff for non-potable uses, using permeable pavements, and treating runoff with biotreatment. This green infrastructure will help limit the transport of pollutants in stormwater by reducing runoff. Coordinating the proposed CIP projects with street greening can lower the marginal cost of stormwater management.

Trash Capture

The City must capture all trash originating from the City's Municipal Separate Sewer System (MS4) before it enters the waterways by the year 2022 (a draft permit may revise the deadline to 2023). The City is accomplishing this through full trash capture systems on the storm drain trunk lines and in the storm drain inlets.

One example is the screening device at Southfront Road. It is outside the scope of the SDMP to identify and model these devices. However, the design and operation of these devices may result in impediments to flow and the potential to cause localized flooding. This needs consideration during the locating and design of these devices as well as during ongoing operations and maintenance.

7. Storm Drainage Funding Requirements

Cost Basis of Capital Improvement Program

Chapters 4 and 5 discuss evaluation criteria used to prioritize improvements. Based on hydrologic and hydraulic analyses of stormwater collection and pumping facilities, SDMP improvements will bring systems into compliance with performance criteria. This is a master plan-level effort. Hence, many of the practical constraints that will govern the detailed design and construction of actual infrastructure improvements are unknown at this time, such as:

- Utility interference and relocation
- Right-of-way and/or easement availability
- Traffic control requirements
- Geotechnical and hazardous waste conditions
- Archaeological discoveries and environmental impacts
- Regulatory and permitting requirements

Table 7-1 provides unit cost information for storm drain collection systems. Costs are based on bids from past storm drain projects adjusted to the current ENR index. Unit costs assume and excavation and backfill of up to 5 feet of depth. The estimate does not specifically include surface restoration, utility protection/relocation, and other site-specific factors that will impact the cost of the projects. It is assumed that the 40% contingency will cover those costs. Detailed project costs are included in the project sheets that have been created for each high priority CIP project in Appendix D.

The Heather Lane and Bluebell Drive culvert replacement project costs are lump sum costs based on similar culvert replacement projects Schaaf & Wheeler has worked on in the Bay Area. A construction subtotal cost of $550,000 is used for both culvert replacement.

Table 7-1: Direct Unit Cost of Storm Drain Pipes and Manholes

(All costs in 2021 dollars)

Diameter	18"	24"	30"	36"	42"	48"	54"	60"	72"
Pipe (per foot)	$283	$350	$447	$516	$614	$692	$789	$898	$1,171
Manhole (each)	$13,369	$13,655	$13,941	$14,228	$14,514	$14,801	$16,080	$16,406	$18,268

An example is shown below for the calculation of individual project cost. Detailed project costs are included in the project sheets that have been created for each high priority CIP project in Appendix D.

Table 7-2: Individual Detailed Project Cost Example

Project Name: Broadmoor_1	Diameter	Unit Cost	Quantity (LF or EA)	Total Cost
Pipe	36	$ 516	204	$ 105,500
Manhole		$ 14,228	1	$ 144,228
Direct Cost Subtotal				**$ 164,700**
Mobilization/Demobilization		10%		$ 16,500
Traffic Control		5%		$ 8,200
Contingency		40%		$ 65,900
Construction Cost Total				**$ 255,300**
Engineering/Inspection		20%		$ 51,100
Total Capital Cost				$ **306,400**

Capital Improvement Program Cost

Table 7-3 summarizes budget requirements to fund CIP projects described in Chapters 4 and 5. In general, high priority projects should be completed first, especially high priority projects that need to be constructed before upstream moderate or low priority projects.

Moderate and low priority projects should be considered when other types of construction are taking place in the project areas. Bundling these projects with other types of CIPs, which may already be funded, can lead to potential cost savings.

Table 7-3: Comprehensive Master Plan CIP Projects

CIP Project	Priority	Cost
Heather Ln Culvert	High	$ 1,023,000
Bluebell Dr Culvert	High	$ 1,023,000
Arroyo_1	High	$ 1,320,000
Broadmoor_1	High	$ 310,000
Geneva_1	High	$ 270,000
Patterson_2	High	$ 120,000
Ruby_1	High	$ 1,490,000
Stanley_1	High	$ 4,370,000
Vasco_1	High	$ 370,000
Arroyo_2	Moderate	$ 1,350,000
Birchwood_1	Moderate	$ 1,640,000
Cameo_1	Moderate	$ 1,020,000
LivermoreGardens_1	Moderate	$ 1,520,000
Mezzamonte_1	Moderate	$ 830,000
Pasatiempo_1	Moderate	$ 410,000
Patterson_1	Moderate	$ 1,580,000
Railroad_1	Moderate	$ 2,620,000
RobertsonPark_1	Moderate	$ 8,730,000
Ruby_2	Moderate	$ 1,410,000
Shirley_1	Moderate	$ 4,870,000
Murrieta Blvd Floodwall	Low	$ 722,600
Holmes St Floodwall	Low	$ 822,000
Airway Blvd Floodwall	Low	$ 33,631,000
4thSt_1	Low	$ 1,770,000
Airway_1	Low	$ 1,720,000
Alden_1	Low	$ 240,000
Arabian_1	Low	$ 650,000
Bluebell_1	Low	$ 1,110,000

CIP Project	Priority	Cost
Devon_1	Low	$ 1,180,000
Heather_1	Low	$ 1,200,000
Jeannie_1	Low	$ 1,600,000
Moraga_1	Low	$ 1,370,000
Obsidian_1	Low	$ 1,600,000
Ontario_1	Low	$ 990,000
Park_1	Low	$ 1,200,000
Portola_1	Low	$ 8,760,000
Positas Pump Station	Low	$ 2,180,000
SanFelice_1	Low	$ 290,000
Stanley_2	Low	$ 560,000

Table 7-4 summarizes the calculation of estimated CIP cost by SDMP improvement priority.

Table 7-4: Storm Drain Capital Improvements Costs
(All costs in 2021 dollars)

Category	Cost
High Priority CIP	$ 10,290,000
Moderate Priority CIP	$ 25,980,000
Low Priority CIP	$ 61,600,000
Total Budget	$ 97,870,000

Development-Related Impacts

Future land use changes in Livermore from development could impact the drainage network. Increased runoff, even with NPDES requirements, from new impervious surfaces has the potential to create new drainage issues or further exacerbate existing system limitations. The existing General Plan land use designations were applied to the 10-year CIP model (existing land uses) to identify potential impacts. Table 7-5 summarizes the changes in model results based on increases in spills from the network. Appendix E shows the locations of these impacts.

Table 7-5: Development Impacts
(10-year)

Impact	Number of Nodes
Increased Spills	43
No Increases	6229

Additional capital projects to mitigate the impacts of future development were identified and costed. Table 7-6 lists the costs of each project while Appendix E shows the location of each CIP.

Table 7-6: Development-Related CIPs
(10-year)

CIP Project	Cost
1st	$ 690,000
2nd	$ 310,000
Alden	$ 860,000
Bellflower 1	$ 710,000
Bellflower 2	$ 70,000
Bobby	$ 90,000
Cedar	$ 1,350,000
Chardonnay	$ 1,240,000
E Jack London 1	$ 770,000
E Jack London 2	$ 740,000
Gamay	$ 380,000
Heather	$ 140,000
Hollice	$ 4,810,000
Jillana	$ 250,000
Lagiss	$ 380,000
Lincoln	$ 540,000
N Mines 1	$ 190,000
N Mines 2	$ 240,000
Pine	$ 250,000
Yellowstone	$ 740,000
Total	**$ 14,750,000**