City of East Palo Alto

Storm Drain Master Plan


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Chapter 1. Introduction

Overview

This chapter provides a general background of flood management issues currently affecting East Palo Alto. It also explains the criteria used to evaluate storm drain system performance and a summary of data acquired as part of the City's Storm Drain Master Plan (SDMP). Existing hydrologic and environmental settings of the City are described, along with flood protection and storm drain facilities. Historic flooding, a summary timeline of regulatory floodplain mapping efforts within the City, and Master Plan objectives are also discussed herein.

Setting

East Palo Alto encompasses many low lying areas and is bordered by the cities of Palo Alto and Menlo Park to the west and the San Francisco Bay to the east. It is relatively flat, with elevations ranging from 0 foot National Geodetic Vertical Datum (NGVD), to about 45 feet NGVD. Figure 1-1 shows the location of East Palo Alto.

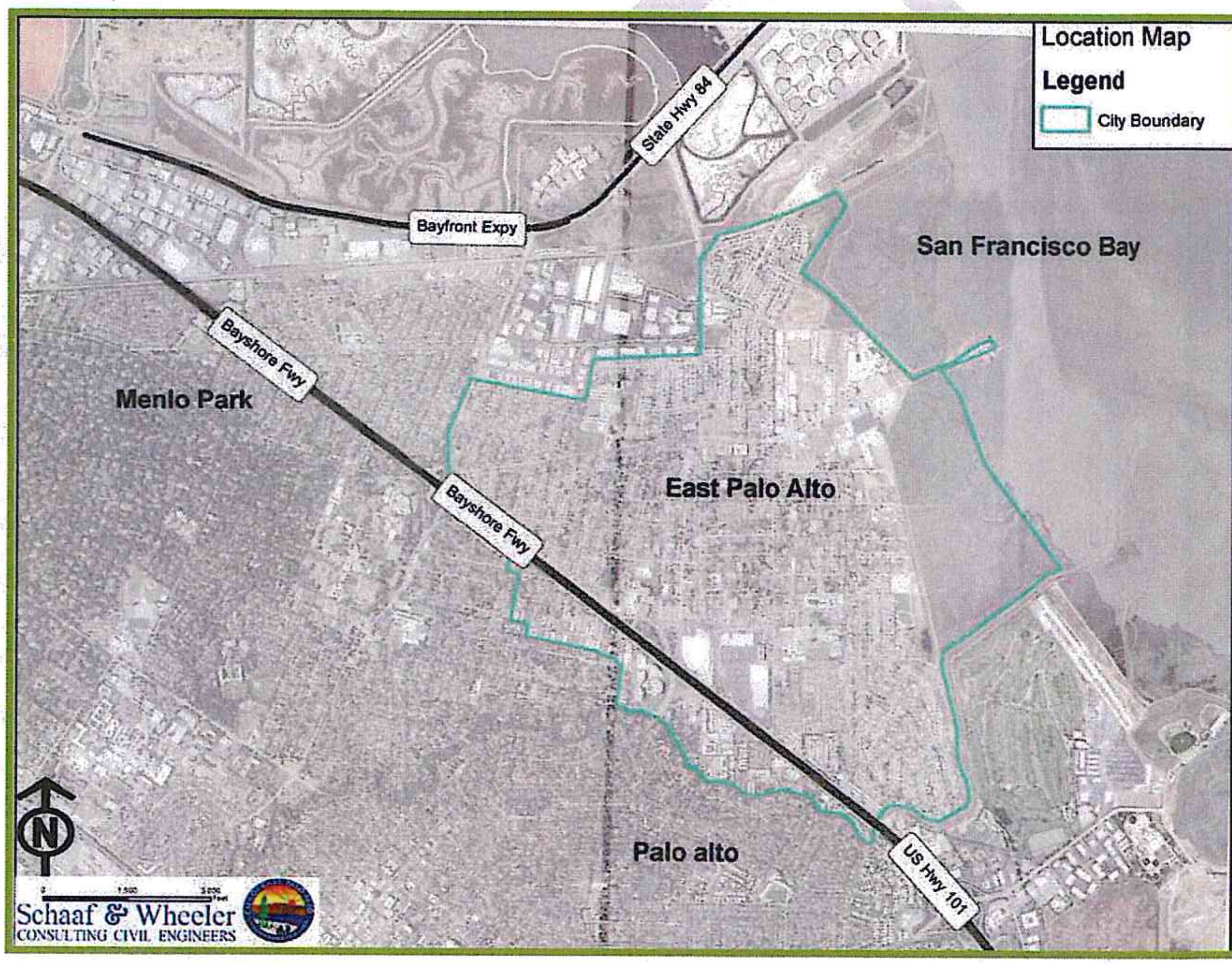

Figure 1-1: Location of East Palo Alto

Soils

The Natural Resources Conservation Service (NRCS) has classified soils into four hydrologic soil groups (A, B, C, and D) according to their infiltration rates. Figure 2-3 shows East Palo Alto has a combination of B and D soils.

Climate

East Palo Alto climate is marine-influenced with an average summertime high temperature of 80°F and an average low of 55°F, dropping to an average winter nighttime low temperature of 38°F and an average high of 59°F. Mean annual precipitation is 16 inches, with the majority of that precipitation falling from November through March. Precipitation occurs entirely as rainfall. Snowmelt is not a hydrologic process that significantly affects runoff in the City.

Flood Protection Facilities

Precipitation that falls within East Palo Alto generates storm water runoff. This runoff is conveyed into a number of manmade flood protection systems that discharge to the San Francisquito Creek and the San Francisco Bay. These systems can interact with one another, and potential improvements to one system may impact the performance of other systems. The total study area within the city limits is roughly 2.1 square miles (1,330 acres). It has been divided up into 9 drainage sub-areas which are shown in Figure 1-2 and detailed in Table 1-1. Most of the streets in East Palo Alto have traditional curb and are lined with gutters. This layout limits attenuation before runoff reaches a catch basin.

In addition to storm drains, flood protection is provided to East Palo Alto by the San Francisquito channel that conveys storm-generated runoff to the east into the San Francisco Bay.

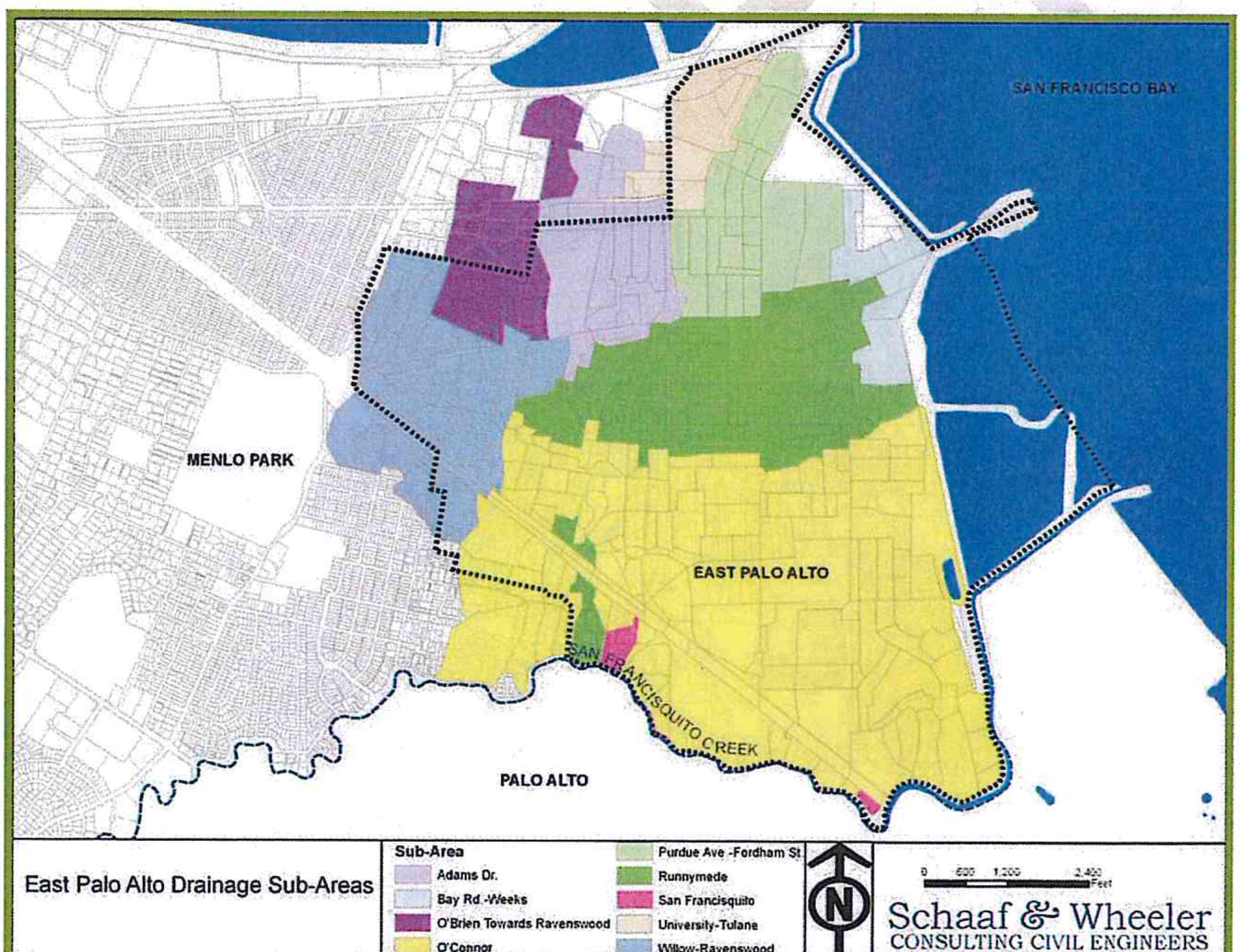

Figure 1-2: East Palo Alto Drainage Sub-Areas

Table 1-1: Watershed Areas and Length of Storm Drain Pipe

Drainage Area	Area (acres)	Pipe (miles)
Adam's Dr.	78	1.3
Bay Rd. - Weeks	42	.3
O'Brien Towards Ravenswood	36	.6
O'Connor	635	10.6
Purdue Ave. - Fordham St.	122	1.1
Runnymede	129	4.2
San Francisquito	8	.2
University - Tulane	43	.5
Willow - Ravenswood	136	2.4
TOTAL	**1,329**	**21.2**

History of Flooding Within East Palo Alto

Heavy rainfalls in the winter months have produced flood situations in East Palo Alto. Historical flooding information can be valuable in highlighting areas of recurring problems, and prioritizing future improvements. Areas with known flooding problems have been identified by Schaaf & Wheeler and City employees. Areas of known drainage issues are detailed in Chapter 2.

Flooding locations during a 100-year storm event were identified within the *2012 FEMA Flood Insurance Study* (FIS) for the City of East Palo Alto. Zones A and AE are 100-year floodplains. The largest contributors to 100-year flooding in East Palo Alto are spills from San Francisquito Creek and tidal inundation from San Francisco Bay. Figure 1-3 shows the FEMA flood zones in East Palo Alto.

The San Francisquito Joint Powers Authority is currently planning and designing large scale flood control improvements for East Palo Alto along San Francisquito Creek. These improvements should add improved flood protection along the south and west sides of East Palo Alto and decrease flood risk. The City of East Palo Alto has also begun plans for a channel improvement project from Runnymede Street to O'Connor Street, which should help the area from tidal flooding.

Recent Flood Protection Measures

The City of East Palo Alto recognizes inadequacies in the existing storm drain system. Therefore in an effort to alleviate problems, the City has begun making some system improvements. Some recent activity has focused on:

- Planning and Design of the Runnymede Storm Drain Improvements
- Assessing the O'Connor Street pump station
- Documentation and evaluation of problem areas within the storm drain network.

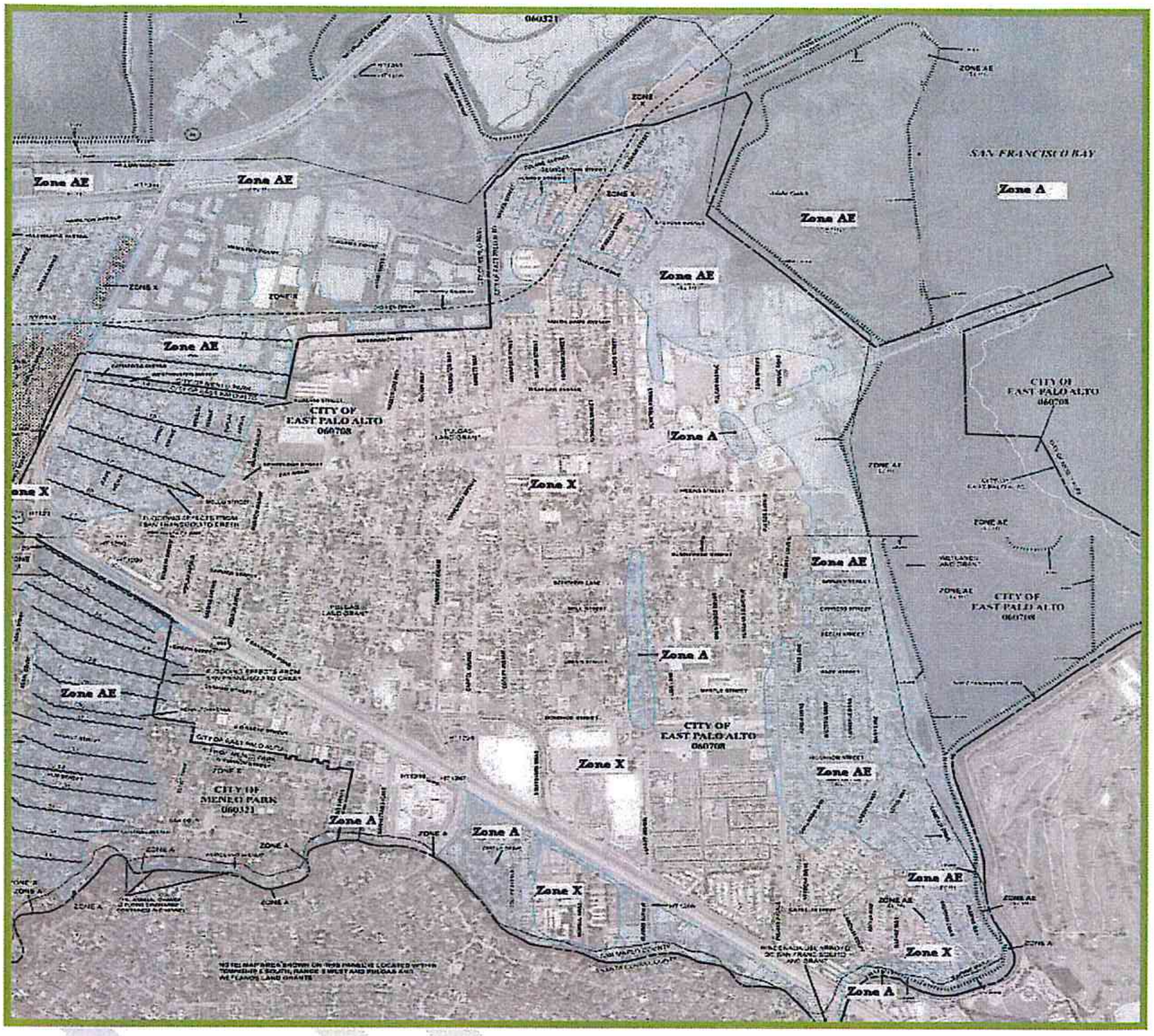

Figure 1-3: FEMA Flood Zones in East Palo Alto

Master Plan Process

The basic process to complete this master plan document is to analyze the current East Palo Alto storm drain system performance and operations procedures and determine necessary improvements. Several tasks were completed to reach this goal. The following list is a summary of steps taken:

1. Development of a geographical information system (GIS) storm drain system model includes: manhole invert and rim elevations, pipe length and diameter, and watershed runoff characteristics.
2. Establishment of storm drainage analysis methodologies and criteria with City staff.
3. Review of the City's regulatory requirements and preparation of an outline for the proposed actions.

4. Hydraulic analysis of the existing storm drains facilities throughout East Palo Alto to provide a 10-year level of service. System deficiencies are categorized in terms of the risk to public safety.
5. Identification of projects that will improve storm drain performance.
6. Preparation of the outline of a prioritized Capital Improvement Program (CIP).
7. Summarization of the projected capital improvement costs.

References

- General Construction Permit. State Water Resources Control Board: Division of Water Quality. (Order 2009-0009-DWQ as amended by 2010-0014-DWQ). (2010).
- Municipal Regional Stormwater NPDES Permit No. CAS612008. California Regional Water Quality Control Board: San Francisco Bay Region. (Order R2-2009-0074). (2009).
- Santa Clara County Drainage Manual. Santa Clara County Department of Planning and Development Services. Prepared by: Schaaf & Wheeler Consulting Civil Engineers. (2007). < http://www.sccgov.org/sites/dso/Land%20Development%20Engineering/Documents/Santa-Clara-County-Drainage-Manual-October-2007---Final.pdf >
- San Mateo County Flood Insurance Rate Map. Federal Emergency Management Agency (2012).
- East Palo Alto Zoning Map (2008) < http://www.ci.east-palo-alto.ca.us/DocumentCenter/View/6 >
- < http://www.valleywater.org >
- < http://www.ci.east-palo-alto.ca.us/index.aspx?NID=167 >

Chapter 2. Data

Overview

Schaaf & Wheeler reviewed and utilized readily available land use, topographic, geographical, and storm drain system data within the East Palo Alto Storm Drain Master Plan Area (study area). Available data was often missing information or was incorrect. Efforts were made to improve and add to the collective data. Where necessary, assumptions and engineering judgment were used to complete remaining data gaps. This chapter summarizes the findings and data acquired as part of the East Palo Alto Storm Drain Master Plan (SDMP). Data limitations, assumptions, and impacts are also summarized.

Data Sources

Topography and Aerial Imagery

All project data and results are in vertical datum NAVD88 (feet) and State Plane (California Zone III) coordinate system. Santa Clara County 1-foot contour LiDAR topography data (NAVD) with half foot accuracy (plus or minus 0.5 foot) is utilized for ground surface information. The data provided by the City is not on a consistent vertical datum; steps taken to convert data to a common datum are detailed in the Data Quality and Data Assumptions sections of this chapter. High resolution digital aerial imagery was obtained from the USGS using The National Map Seamless Server, the aerial image publication date is March 2011.

GIS Data

The City provided AutoCAD drawings, GIS files, and the County Storm Drain map of East Palo Alto to the Schaaf & Wheeler team for use on this project. The City GIS data utilized for this project includes: storm drain pipes, storm drain manholes and inlets, existing zoning, and parcel data. The City's raw storm drain GIS data is missing a large quantity of information critical to accurately model the storm drain system. The data which is included in the GIS files is often of unknown accuracy or source (for example, elevation data based on an unknown vertical datum). Some of the routinely encountered examples include:

- missing pipes, manholes, inlets, and outfalls;
- missing pipe sizes;
- rim and/or invert elevations based on unknown datum;
- rim and/or invert elevations missing from manholes and inlets.

The original GIS data was compared with record drawings and improvement plans provided by the City. Data corrections or additions were manually entered into GIS with data source noted. Additional field information was collected by V&A Engineering (V&A), Schaaf & Wheeler's condition assessment sub-consultant and then added to the GIS. The GIS data includes:

- inlet and manhole locations;
- pipe diameters;
- manhole invert depths;
- standing water and sediment locations/depths.

The field data was used to verify pipe diameters, material, system layouts, assign invert depths at manholes and calculate sediment and standing water volumes in the existing system.

The City of Menlo Park also provided GIS data for the surrounding areas west of East Palo Alto. The storm drain GIS data provided by Menlo Park included: storm drain pipes, storm drain manholes and inlets. The data was fairly complete and provided the system layout and pipe diameters; however, most of the rim and invert information was missing from the manholes and inlets and were assumed.

The inadequacies of the GIS system data and steps taken to complete the data set to a master planning level of accuracy are detailed in the Data Quality and Data Assumptions sections of this chapter.

Pump Stations

There are two pump stations within the East Palo Alto study area. The O'Connor Street Pump Station is owned and operated by the City. The Ravenswood Pump Station serves East Palo Alto and Menlo Park, and is owned and operated by Caltrans. The O'Connor Street Pump Station was visited by Schaaf & Wheeler staff to visually inspect the condition of the station and document equipment and settings. The pump station's on and off levels were tied into the NAVD datum using as-built plans. Basic information obtained for both the pump stations by Schaaf & Wheeler is listed below:

- O'Connor Street Pump Station: As-Builts HUD No. WS-Calif.-315 dated Feb. 1984
- Ravenswood Pump Station: As-Builts Ravenswood Slough Pumping Plant dated 1/19/1981, and *Caltrans Pump Station & Tide Gates Operation Study, Rev 1, Dumbarton Bridge Approach, Menlo Park, CA* dated 3/12/1983

Historical Data

The 2003 *Draft East Palo Alto Storm Drainage Master Plan* prepared by BKF Engineers was reviewed for relevant data. Discussions with O&M staff also revealed several points of recent historical flooding on Ralmar Avenue and Garden Street. These locations were used to verify the accuracy of the Existing Conditions SDMP model results.

As-Builts

As-Builts and improvement plans provided by the City for developments in East Palo Alto were reviewed for relevant storm system data, to verify the City provided GIS data and to fill in data gaps. Caltrans plans for Highway 101 in East Palo Alto were reviewed for relevant data. The O'Connor and Ravenswood pump station As-Builts were reviewed for relevant pump data.

Field Measurements

V&A spent approximately 5 weeks in the field verifying key locations within the system, measuring missing pipe diameters, invert depths, sedimentation depths, and documenting the condition of storm water facilities. A map of the field locations visited by V&A is shown in Figure 2-1. Of these tasks, collecting accurate pipe diameters was the highest priority. Once pipes become surcharged, their invert elevations and slope become irrelevant to pipe flow calculations since the surcharged hydraulic grade line controls pipe capacities. Therefore, the pipe diameter and rim elevations are the most important values to verify when developing an accurate model of the system.

The data gathered by V&A was used to create maps showing locations of standing water and sedimentation within the East Palo Alto storm drain systems. The two maps are shown below in Figures 2-2 and 2-3.

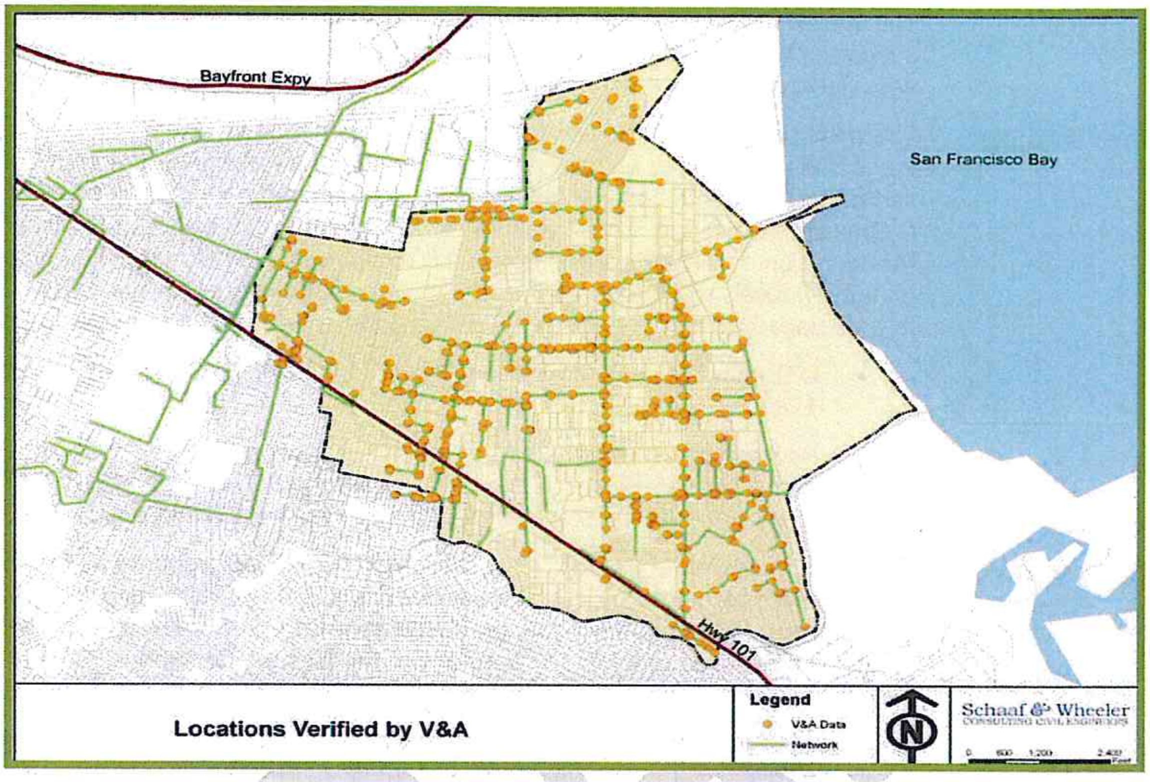

Figure 2-1: Locations Checked by V&A

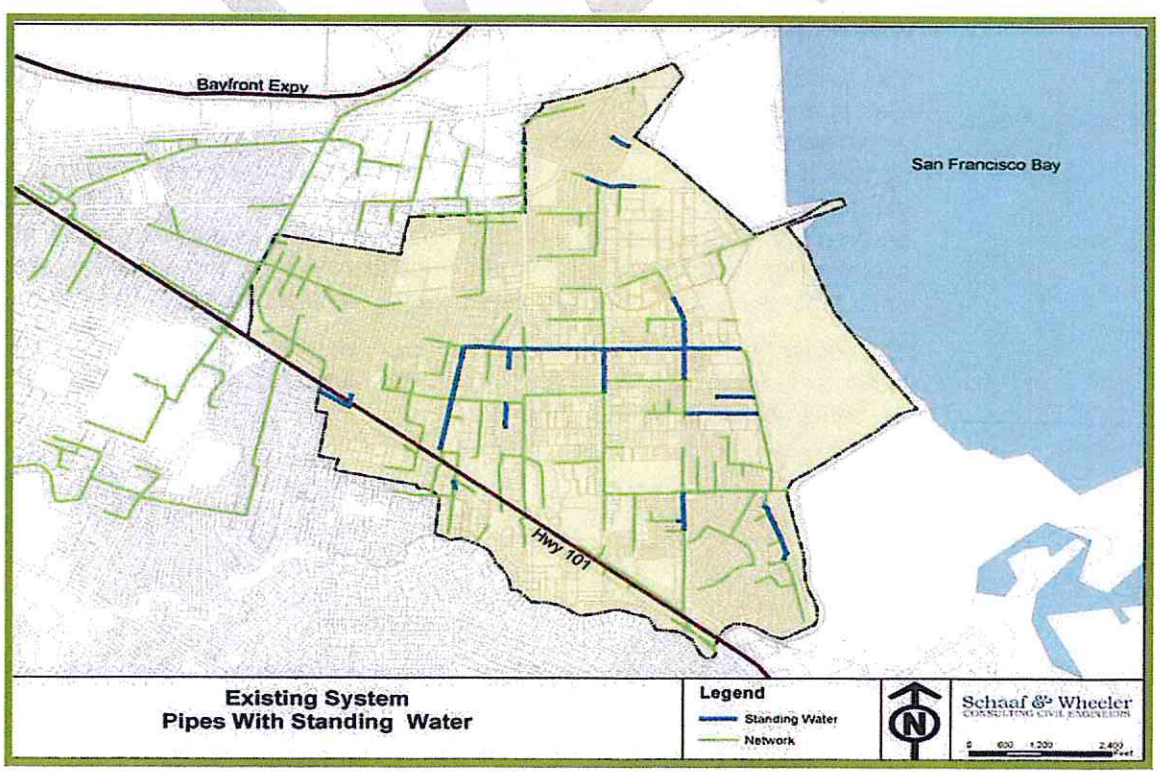

Figure 2-2: Pipes with Standing Water

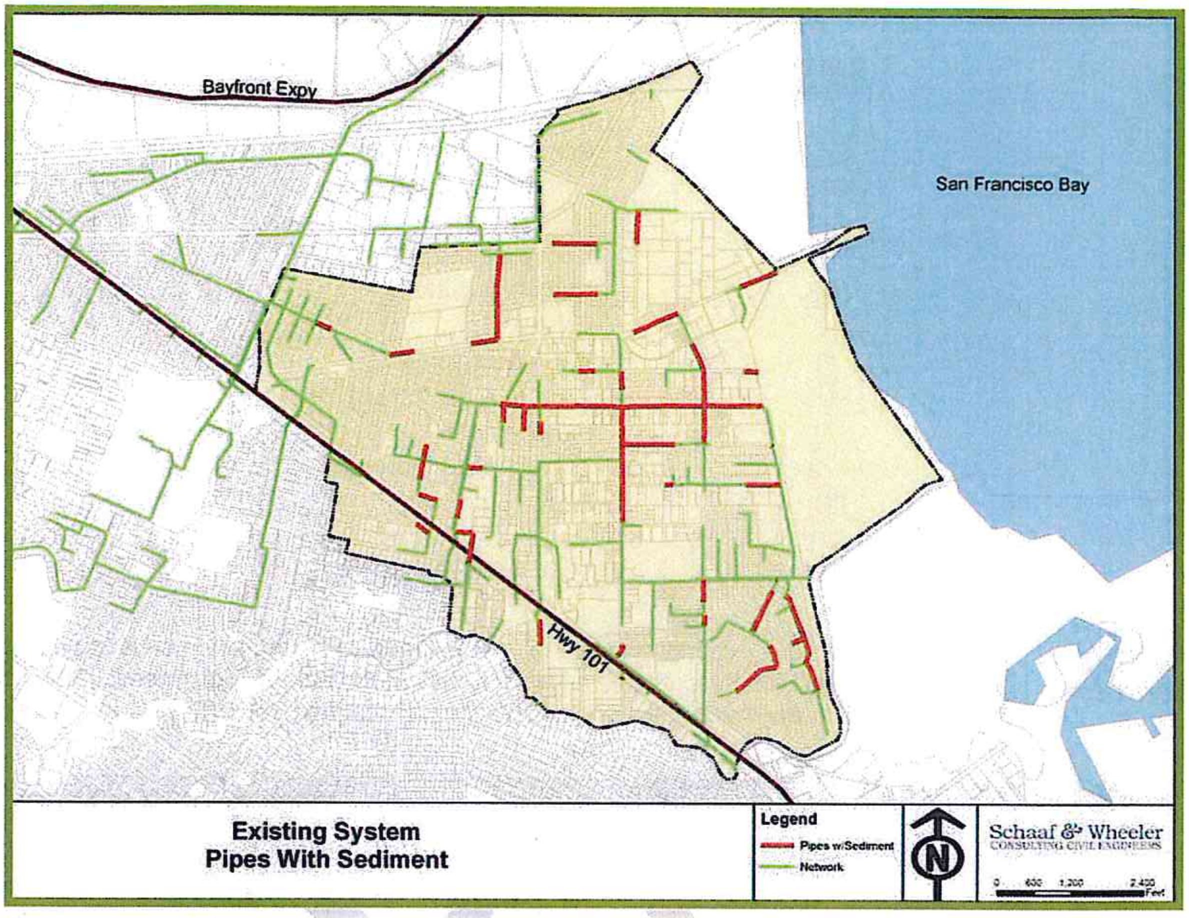

Figure 2-3: Pipes with Sediment

FEMA Data

FEMA reports were referenced for San Francisquito Creek water surface levels and were used to assign an existing water surface elevation at the fixed outfalls at the O'Connor Pump Station. Elevations were taken from FIRM Panel 0309E, effective October 16, 2012.

Regulatory

Key documents referenced for the regulatory review are the California Regional Water Quality Control Board San Francisco Region Municipal Regional Stormwater NPDES Permit, Order R2-2009-0074, NPDES Permit No. CAS612008, October 14, 2009.

Land Use Data and Runoff Characteristics

Two land use scenarios were analyzed for the SDMP: existing and future land use. The existing land use is based on the City's existing zoning from the General Plan and was updated in 2008. The land use was adjusted using aerial photography and the Vacant Lots GIS shapefile provided by city staff to account for the number of parcels that have a zoning designation but are currently open space. The various land use codes and descriptions found in the GIS database are summarized in Table 2-1.

Table 2-1: Land Use Codes and Descriptions

Land Use Code	Description
C-1	Neighborhood Business
C-2	General Commercial
COSC	Community Open Space
M-1	Light Industrial
M-2	Heavy Industrial
M-B	Industrial Buffer
O	Office
OR	Office/Residential
PUD	Planned Unit Development
R-1	Single-Family Residential
R-2	Two-Family Residential
RD	Road
RM	Resource Management
R-M	Multi-Family Residential

Existing Land Use

Figure 2-4 shows the existing land use in East Palo Alto. Existing land use is approximately 59% Residential, 17% Resource Management, 6% Industrial, 5% Commercial, 4% Road, 4% Planned Unit Development, 3% Community Open Space, and 1% Office.

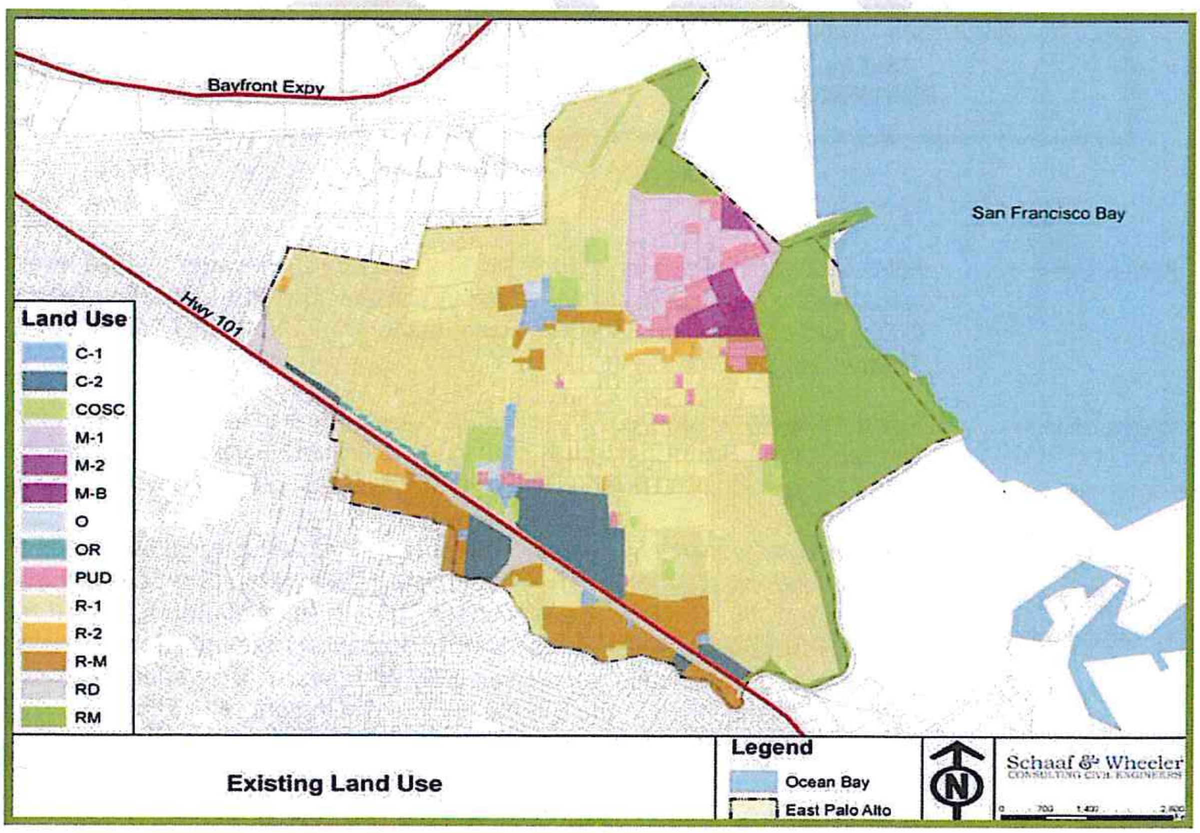

Figure 2-4: Existing Land Use of East Palo Alto

Future Land Use

The future land use condition is fully the developed existing zoning which consists of approximately 62% Residential, 17% Resource Management, 8% Industrial, 6% Commercial, 4% Roads, 2% Community Open Space and 1% Office. The future condition land uses in East Palo Alto are shown in Figure 2-5.

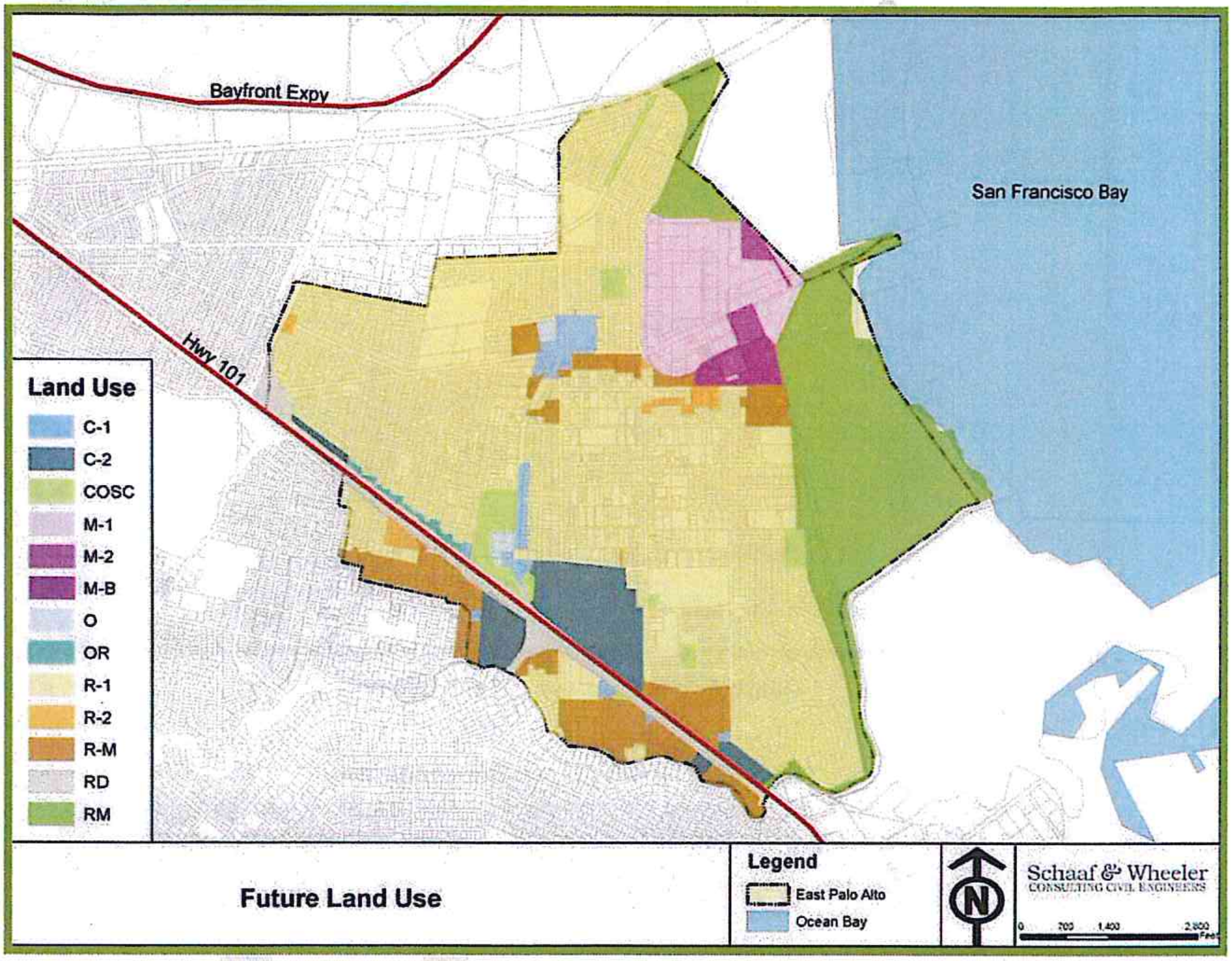

Figure 2-5: Future Land Use of East Palo Alto

Runoff Characteristics

Rainfall runoff is determined by soil classification, Curve Number, and percent impervious. Soils classification is based on hydraulic soil group (A, B, C, or D); this data is produced by the National Resource Conservation Service (NRCS), and its use in the master plan analysis is described in detail in Chapter 3 - Methodology. The Curve Number methodology, also described in Chapter 3, is used for surface runoff calculations. NRCS runoff Curve Numbers (CN) were assigned to various land uses based on hydraulic soil group using values published in Santa Clara County Drainage Manual. The soil groups found within East Palo Alto are shown in Figure 2-6. The percent impervious for each land use type is based on values published in the County Drainage Manual and validated using aerial photography. These values are presented in Table 2-2.

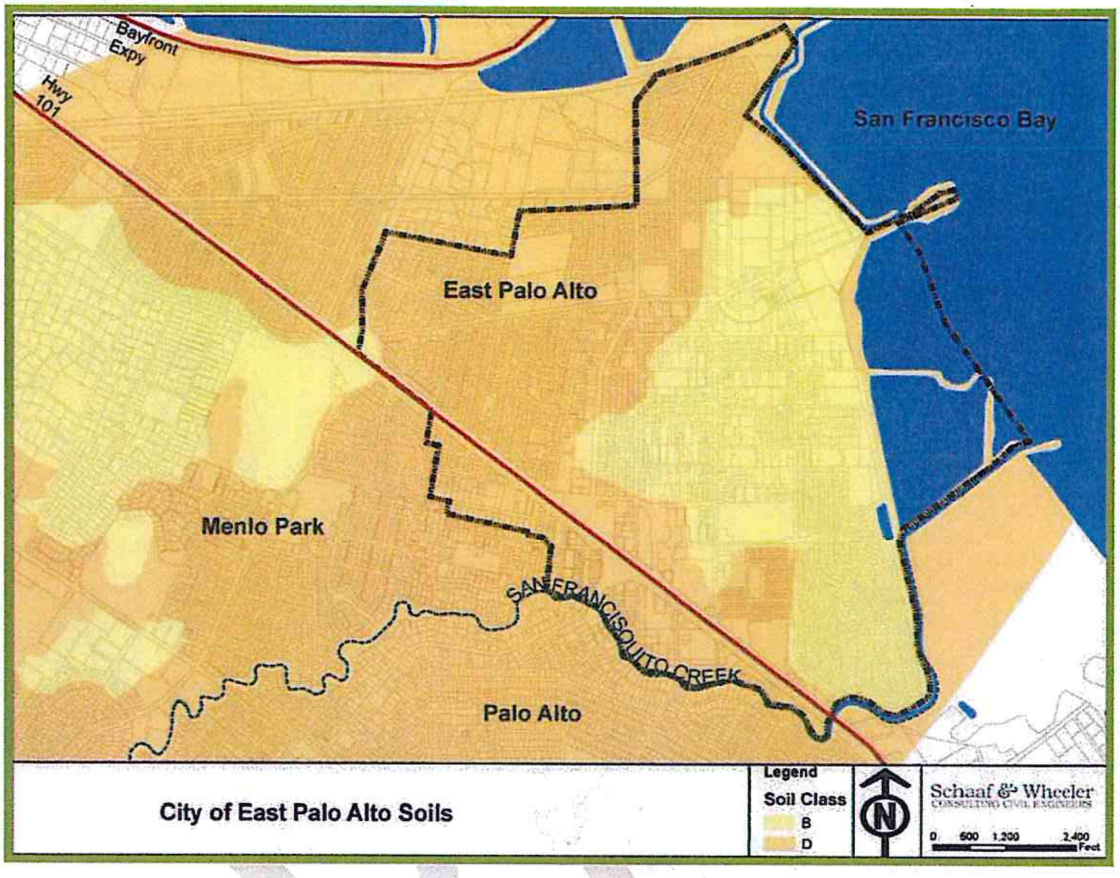

Figure 2-6: Soil Groups in East Palo Alto

Table 2-2: Soil Groups and Imperviousness

Description	Percent Impervious	Curve Number (AMC II 1/2)			
		Group A Soil	Group B Soil	Group C Soil	Group D Soil
Neighborhood Business	0.60	44	58	71	74
General Commercial	0.90	64	68	78	79
Community Open Space	0.20	44	58	71	74
Light Industrial	0.80	44	58	71	74
Heavy Industrial	0.95	64	68	78	79
Industrial Buffer	0.60	44	58	71	74
Office	0.75	44	58	71	74
Office/Residential	0.80	44	58	71	74
Planned Unit Development	0.15	44	60	74	80
Single-Family Residential	0.60	44	58	71	74
Two-Family Residential	0.75	44	58	71	74
Multi-Family Residential	0.90	64	68	78	79
Road	0.98	44	58	71	74
Resource Management	0.01	35	51	65	72

Data Quality

The quality and accuracy of the data obtained from the City for the East Palo Alto SDMP varies greatly. The City's GIS is generally spatially accurate but some attributed data is missing and/or un-sourced. Although some of the data in the GIS attributes may be traced to as-built plans, often those plans do not include all of the necessary information such as vertical datum. As such, even that information which is included in the GIS attribute files is of unknown accuracy.

Pipes with a diameter of 12-inches and greater and associated nodes were included in the model. There are a total of 93,292 linear feet of pipe, and 430 nodes (manholes and inlets) within East Palo Alto City limits, and a total of 160,200 linear feet of pipe and 759 nodes in the hydraulic model. The pipe shapefile has more than 85% of the total of pipe diameters identified, but the nodes shapefile is missing almost 30% of the invert depths.

Modeled Data Assumptions

Missing pipe diameters were assumed on a case by case basis and were typically assigned the same diameter as the pipe upstream, unless there was a valid reason for assuming a larger diameter. Larger pipe diameters were typically assumed where multiple laterals converged at a single node upstream or when large catchments drained to a single node.

As described previously, one of the significant shortcomings of the existing GIS database was that the elevation data, both for rims and inverts, was on unknown and inconsistent datums. The first step to complete the database for modeling purposes was to assign rim elevations to every node using the previously described LiDAR data. For nodes with invert and rim elevations, the depth to invert was calculated and subtracted from the newly assigned rim elevation. The remaining inverts were assigned based on either applying the field measured depth, or interpolating between points of known elevation using the MU Interpolation tool. Node invert elevations were assumed on a case by case basis when the interpolation tool could not be applied. The method of assigning data is preserved in the "Description" field of the final GIS database utilized by the model.

Chapter 3: Methodologies

Overview

The criteria used to evaluate storm drain system performance must be technically sound yet simple to understand and apply. Ideally, the methodology used to analyze system performance will continue to be used for future infrastructure design as well. Neither the City of East Palo Alto (City) nor County of San Mateo have published hydrology standards, so Schaaf & Wheeler is applying the County of Santa Clara's urban hydrology standards, as described in the Santa Clara County Drainage Manual (SCCDM) (Schaaf & Wheeler, 2007), to estimate storm runoff from current and future land uses for the East Palo Alto Storm Drain Master Plan. The County's method is being used along with MIKE-URBAN (MU) software, developed by DHI (Danish Hydraulic Institute) to determine storm drain system performance and necessary improvements. Physical parameters used in the model are based on the City's GIS data and other information detailed in Chapter 2, Data. Storm drain evaluation criteria have been developed with input from the City.

Evaluation Criteria

The SCCDM used to estimate storm runoff in East Palo Alto was developed in 2007 to provide consistent design and evaluation criteria for storm drainage throughout Santa Clara County. East Palo Alto is located on the border of Santa Clara County, so the manual's design and evaluation criteria is appropriate for the City and will provide results consistent with neighboring municipalities. The unit hydrograph method (described in Chapter 4 of the Drainage Manual) was used because it allows for the development of a flood hydrograph using a design storm, an appropriate infiltration technique, varying antecedent moisture conditions, storage within the watershed, and a synthetic unit hydrograph.

The standard storm duration for rainfall simulation is 24-hours. The storm pattern is based upon the three-day December 1955 rainfall event, considered to be the storm of record for northern California. The precipitation pattern has been adjusted to preserve the local rainfall statistics in Santa Clara County, and can be found in Appendix D of the SCCDM.

East Palo Alto's master plan effort included modeling the hydrology for the 10-year frequency storm/precipitation event. The 10-year storm event was used as the design event for the stormwater drainage system. The 10-year level-of-service standard is consistent with the design standards of neighboring cities and with the SCCDM.

GIS Based Modeling

The MIKE-URBAN software with SWMM solver was selected to model the East Palo Alto storm drain system and pump stations because it is a tested and reliable software with GIS interface. MIKE is a package of software programs designed by DHI for the analysis, design, and management of urban drainage systems, including storm water sewers and sanitary sewers. The MU model works within ArcMap GIS and can simulate runoff, open channel flow, pipe flow, water quality, and sediment transport. The program was chosen to model the East Palo Alto storm drain system because of its capabilities with overland flow, weirs, pumps, and storage areas; the incorporation of the Santa Clara County hydrology method; and the overall stability of the model. The modeling package consists of two interrelated products:

1. SWMM - This is a general purpose urban hydrology and conveyance system hydraulics software developed by the U.S. Environmental Protection Agency (EPA). It is a dynamic rainfall-runoff simulation model used for single event or long-term (continuous) simulation of runoff quantity and quality from primarily urban areas. The runoff component of SWMM operates on a collection of subcatchment areas that receive precipitation and generate runoff and pollutant loads. The routing portion of SWMM has the capability to route runoff through: pipe networks, open channels, storage/treatment devices, pumps, and control devices.

2. MIKE-URBAN (MU) is an ArcMap based program which includes tools specifically designed to develop urban drainage models. MU provides a graphical user interface for data input and editing and serves as a bridge between ArcMap GIS and the SWMM modeling program. Capabilities of MU include import and export of model data, network editing and gap-filling, catchment delineation, network simplification, and importation and presentation of model results. MU is also a graphical tool used for viewing and presentation of MU results. Capabilities include plan, longitudinal, and cross-section views; animation of results; presentation of flooding including water depth and pressure; and overlay of results on background graphics such as maps or aerial photos.

Though the models were developed using the proprietary MIKE-URBAN, the final models have been exported to SWMM 5, which is public domain software and is available for download from the EPA website.

The East Palo Alto storm drain system is modeled as two independent drainage regions based on outlet points and major drainage channels. These drainage regions are: East Palo Alto and Willow Avenue to Ravenswood. The East Palo Alto drainage area is mainly area within East Palo Alto and a small portion of area within Menlo Park. The Willow Avenue to Ravenswood drainage area is largely within Menlo Park, and has a small contributing area from East Palo Alto. Each drainage region system model is composed of a conveyance network (pipes, nodes, pump stations, etc.) and the urban catchments contributing runoff to the pipe network.

Operation

Two separate calculations are performed by MU for the East Palo Alto models: a runoff calculation estimating the amount of water entering the storm drain system during a design rainfall event; and the network flow calculation which replicates how the storm drain system will convey flows to outlet locations. Flows resulting from the runoff calculation are used as inflows for the subsequent network flow calculation. The MU runoff model offers a choice of three infiltration methods: Horton, Green Ampt, and Curve Number. The East Palo Alto storm drain models use the Curve Number method to calculate surface runoff. This method is in keeping with the SCCDM prescribed methodology. A simulation can be started at any point during the chosen design storm to assess surface runoff for any period of the design storm, with computations made based on a user-specified time step.

The MU network flow model offers a choice of three flow description approximations: Steady, Dynamic Wave, and Kinematic Wave; distinguished by the set of forces each takes into account. The East Palo Alto storm drain models use the most comprehensive flow description, Dynamic Wave, which incorporates the effects of gravitational, friction, pressure gradient and inertial forces. Because it accounts for all major forces affecting flow conditions, this equation allows the model to accurately simulate fast transients and backwater profiles. The simulation of flooding at a node is accommodated by the insertion of an artificial "basin" above the node which will store water when the water level rises above the ground level. The surface area of the "basin" gradually increases (up to a maximum of 1000 times the node surface area) with rising water levels at the node, replicating the effects of flooding.

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

Input and Output

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

MU pipe flow calculations require network data, operational data, and boundary data as input. Network data consists of the pipe network elements including nodes (manholes, outlets, and storage nodes) and links (pipes, culverts, and open channels). Parameters required to describe nodes include *x* and *y* coordinates of the node, a unique name, node type (junction, outlet or basin), depth and invert levels, and water levels at outlets.

Parameters required to describe links include the name of upstream and downstream nodes, shape and dimensions, material or roughness, and upstream and downstream inverts. Structural system elements including gates, pumps, and weirs are all modeled as functional relationships connecting two nodes in the system, or associated with one node in the case of free flow out of the system. Operational data consists of parameters which describe how these elements function in the network. Boundary data for the pipe flow computation can include any external loading, inflow discharges, water levels at interaction points with receiving waters, pump performance curves, as well as the results of a run-off calculation.

Output from the pipe flow computation includes the calculated water level at each node, pump discharges, weir discharges, water level in network branches, discharge in network branches, water velocity in network branches, water volume in the system, and time step data. Output is viewed using GIS, MU, or the MIKE-VIEW program. Results may be displayed in plan view or as a profile for a selected network section, and may be viewed as a temporal animation or at maximum or minimum values. Additional outputs which can be derived from MU pipe flow results using GIS and include: water depth, flooding level, pressure in closed conduits, percentage pipe filling, and the flow calculated for each link.

Surface Runoff Calculations

As described above, the first step of the MU model is to complete a stormwater runoff calculation that determines the amount of water entering the storm drain system from a specific rainfall event. Boundary and catchment data must be input to the model to complete this calculation.

Boundary Data

Methods used in this master plan to estimate peak storm water flow rates and volumes require the input of precipitation data. Since it is impossible to anticipate the impact of every conceivable storm, precipitation frequency analyses are often used to design facilities that control storm runoff. A common practice is to construct a design storm, which is a rainfall pattern used in hydrologic models to estimate surface runoff. A design storm is used in lieu of a single historic storm event to ensure that local rainfall statistics (i.e. depth, duration and frequency) are preserved. When combined with regional specific data for land use and loss rates, the model should produce runoff estimates that are consistent with frequency analyses of gauged stream-flow in the Santa Clara County area. In other words, the ten-year design storm pattern used for MU modeling creates results consistent with a ten-year storm runoff event.

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

Rainfall

The rainfall distribution pattern for the East Palo Alto Storm Drain Master Plan was obtained from the SCCDM. The County's rainfall pattern is distributed in 5-minute time increments with a fraction of the total rainfall apportioned to each 5-minute increment. The resulting 24-hour rainfall pattern with 5-minute time steps is then prorated based on the Mean Annual Precipitation (MAP). The Santa Clara County manual provides the total rainfall depth for each MAP and storm frequency using the following equation:

$$x_{T,D} = A_{T,D} + (B_{T,D}\,MAP)$$

Where:
$x_{T,D}$ = precipitation depth for a specific return period and storm duration (inches)
T = return period (years)
D = storm duration (hours)
$A_{T,D}$, $B_{T,D}$ = dimensionless coefficients from Tables B-1 and B-2 in Appendix B of the SCCDM
MAP = Mean Annual Precipitation (inches).

The precipitation intensity, $i_{T,D}$ is given by:

$$i_{T,D} = \frac{x_{TD}}{D}$$

The Mean Annual Precipitation (MAP) within East Palo Alto is 16-inches based on the MAP Figure A-2 in Appendix A of the SCCDM. The rainfall total for a 24-hour 10-year event is 3.0 inches. The 10-year storm intensity graph for a MAP of 16-inches is shown in Figure 3-1. The distribution of rainfall is based on balancing the storm to shorter rainfall statistics (10-minute, 1-hour, etc).

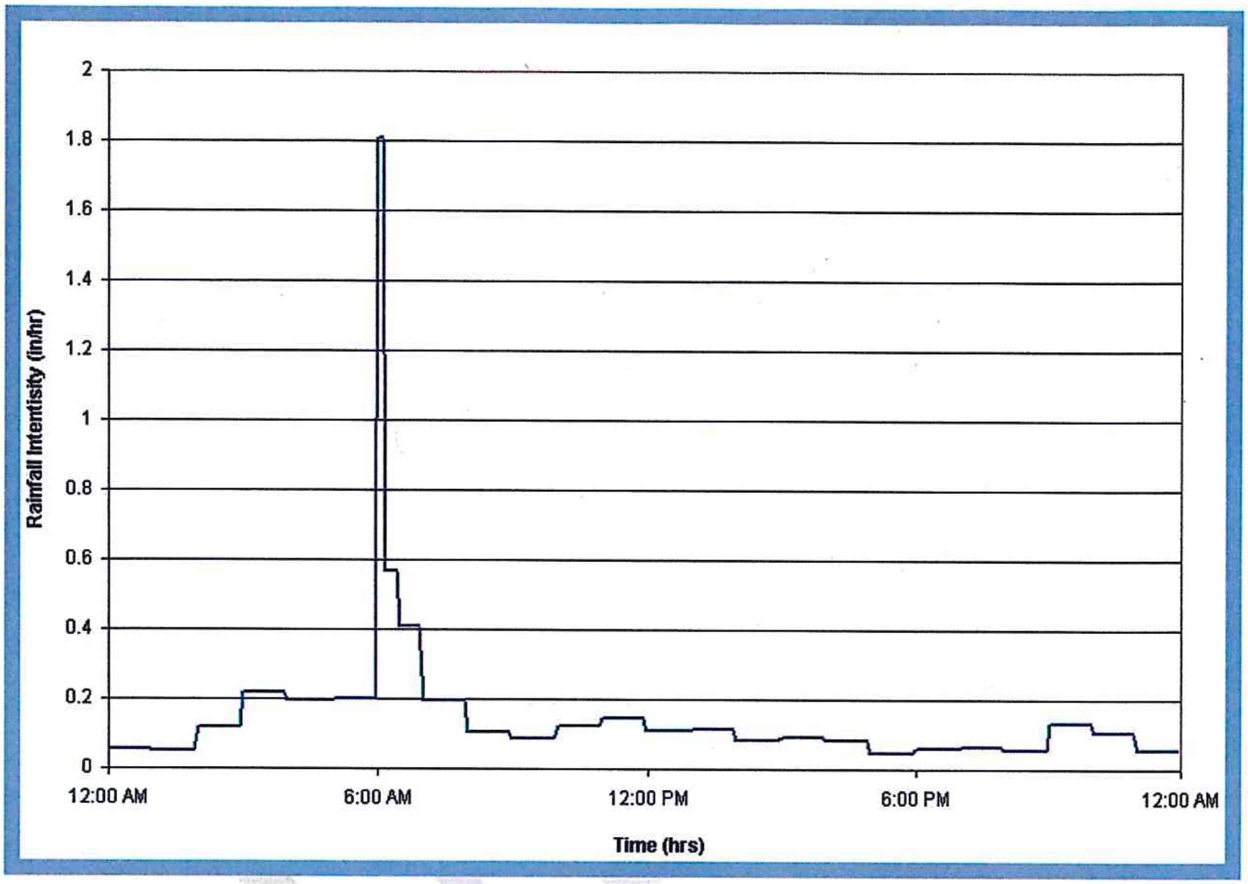

Figure 3-1: Santa Clara County 10-Year Storm Intensity Graph (MAP 16")

Catchment Data

Urban catchment data includes the boundaries of each drainage catchment, along with relevant physical and hydrologic parameters including surface area, land use characteristics, and parameters used to calculate basin lag times. East Palo Alto is divided into drainage areas, called catchments. Because this area is flat, use of automated delineation routines in MU was not appropriate. The delineations completed by Schaaf & Wheeler rely heavily on engineering judgment and experience using contours, lot lines, storm drainage system, and aerial imagery.

A unit hydrograph is a numerical representation of the time response of catchment runoff caused by one inch of excess rainfall applied uniformly over a unit of time. Many different techniques are available to estimate unit hydrographs. The NRCS-dimensionless unit hydrograph is used in the East Palo Alto storm drain models to be consistent with the County Drainage Manual. Direct runoff is estimated by subtracting soil infiltration and other losses from the rate of rainfall. Uniform loss, which accounts for constant infiltration of rainfall into the soil, is a function of both soil type and ground cover (i.e. vegetation type or land use). The Curve Number (CN) methodology uses the uniform loss rate to account for the various potential land uses and soil types within a basin.

East Palo Alto is mainly commercial, industrial, and high density residential developments. There are some undeveloped areas that are open space, parks or agriculture. The majority of the developed parcels have high concentrations of impervious surfaces that include buildings, roads, parking lots and sidewalks. Schaaf & Wheeler assigned impervious values to different land uses by reviewing aerial imagery and calculating the imperviousness for each given land use. There is a degree of uncertainty in applying standard values to all similar land uses; however, this is adequate at a master planning level. The impervious percentages for each land use category are shown in Table 2-2.

NRCS Curve Number

As mentioned previously, the NRCS Curve Number (CN) methodology was used to determine basin runoff. This methodology relies on the use of curve numbers to characterize basin infiltration and runoff potential. Curve numbers are based on a combination of land use, soil characteristics, and antecedent moisture condition. Two land use conditions are analyzed in East Palo Alto as discussed in detail in Chapter 2, Data. The NRCS has mapped soil types throughout the United States and has categorized each soil into Hydrologic Group (A, B, C, D). The portion of this map that covers the project area was obtained for this analysis. Type-A soils are well draining while Type-D soils are poor draining. East Palo Alto consists of D (63%) and B (37%) type soils.

Antecedent moisture condition (AMC) is defined as the moisture content of a soil prior to any precipitation event. AMC is characterized by the NRCS as:

AMC I	soils are dry
AMC II	average conditions
AMC III	heavy rainfall, saturated soil

The County Drainage Manual specifies a calibrated AMC value to properly convert the rainfall event's frequency of occurrence into the equivalent frequency of the runoff event. For a 10-year event the AMC is II1/2.

Curve numbers vary from 0 to 100, with 0 equating to no runoff from a basin and 100 indicating that all precipitation will run off. The County Drainage Manual was used to determine curve numbers for various land uses depending on soil type and AMC, as shown in Table 2-2. GIS techniques were used to calculate Curve Numbers for each catchment in East Palo Alto. Land use and soil hydrologic conditions were intersected and the appropriate CN was applied to each catchment.

Model Calibration, Basin Lag

SWMM includes limited hydrologic loss parameters. Basin lag, or lag time, is defined as the time elapsed between rainfall occurring within a basin and runoff occurring at an outlet point. SWMM uses basin slope (S), Manning's roughness coefficient (N), and basin width (W) to determine lag time. Slope is expressed in percent, roughness values for pervious (n-pervious) and impervious (n-impervious) are dimensionless and width is expressed in feet. SWMM does not provide detailed documentation of how basin width should be calculated. The SWMM manual defines it as:

Characteristic width of the overland flow path for sheet flow runoff (feet or meters)...Adjustments should be made to the width parameter to produce good fits to measured runoff hydrographs.

The basin width is assumed to be the total catchment area divided by the longest flowpath. This method has been used by Schaaf & Wheeler in previous studies involving SWMM and has proven to yield fairly accurate results.

Pipe Flow Calculations

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

Closed Conduits

Pipes are modeled as one-dimensional closed conduit links which connect two nodes in the models. The conduit link is described by a constant cross-section along its length, constant bottom slope, and straight alignment. Exit and entrance loss coefficients (Km, minor losses) are user specified and vary depending on the type of junction; nodes are assigned entrance and exit loss coefficients of 0.1, storage nodes are assigned loss coefficients of 0.5, and outfalls are assigned loss coefficients of 1. Unsteady flow in closed conduits is calculated using conservation of continuity and momentum equations, distinguishing between pipes flowing partially full (free surface flow), and those flowing full (pressurized flow). The pipes within the East Palo Alto models are modeled as reinforced concrete pipe (RCP) with a Manning's 'n' of 0.013. The channels are assigned a Manning's 'n' of 0.025.

Junction Losses

Hydraulic losses at junctions (manholes, inlets, intersections) can be significant in pressurized drainage systems. Losses can vary due to construction methods, condition, and shape. The junction losses are accounted for in the link parameters as user defined exit and entry loss coefficients.

Pump Stations

The drainage systems in East Palo Alto are largely dependent on pump stations. There are two pump stations within the study area and modeling their performance correctly is an important task. Pumps are modeled in MU as a functional relation between the water level of the inlet and outlet nodes. Pumps are characterized by starting and stopping water levels and a capacity curve of differential head vs. flow data for the pump.

Pump head vs. discharge curves, as provided by manufacturers, represent the flow through the pump itself only. It is difficult to accurately include the pump station piping and appurtenances within the model, so it's necessary to modify, or de-rate, the pump curve to account for the losses that occur between the inlet node (pump station wetwell) and the outlet node (beginning of forcemain or pump discharge manifold). This includes minor losses due to fittings, valves, expansions, contractions, and pipe spools.

The discharge velocity is calculated for each head value based on the manufacturer's pump curve flow rate (cfs) and the discharge outlet cross-sectional area (sf).

Velocity Equation

$V = Q/A$

Where: A = area of the discharge pipe (ft^2) = $\pi(D/2)^2$
Q = pump discharge from the manufacturer's curve (cfs)
D = diameter of the discharge pipe (ft)
V = velocity of discharge (ft/s)

The calculated velocity at each head level is used to calculate a corresponding friction head loss through the discharge piping using the Hazen-Williams friction loss equation. The discharge piping includes all elements not included in the model, which consists of piping between the pump outlet and the beginning of the force main or the pump discharge manifold, depending on the station layout. The Hazen-Williams friction loss equation is as follows:

Friction Loss Equation

$H_f = L\,(V^2/0.115*C*D^{0.63})^{1.5}$

Where: C = Hazen-Williams Discharge Coefficient =110 for concrete pipe
D = pump discharge pipe diameter (in)
L = length of pump discharge pipe (ft)
V = velocity of discharge (ft/s)
H_f = minor losses in head due to friction

The length of pipe and number of bends, tees, valves, reducers, etc is determined using pump station as-built drawings. The calculated discharge velocity at each head level is used to calculate the minor losses through each fixture based on the minor loss equation from the County Drainage Manual. The resulting friction and minor losses are summed and subtracted from the original head value to create the de-rated pump curve. The flow rates are not altered. The original and de-rated pump curve are plotted in Figure 3-2.

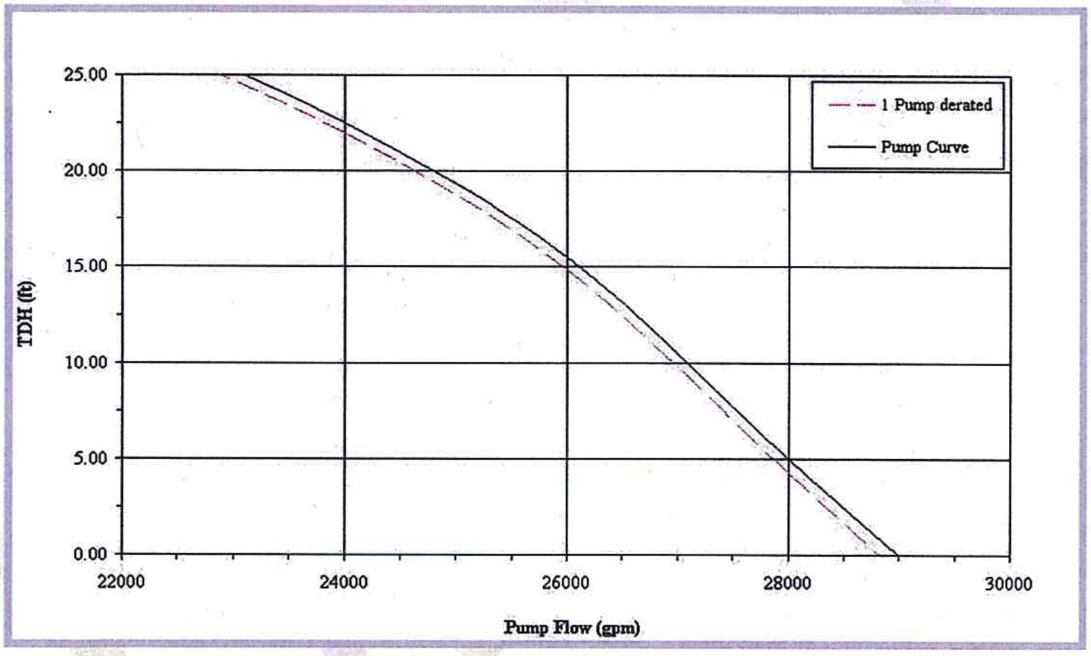

Figure 3-2: O'Connor De-Rated Pump Curve

Outlet Boundary Conditions

Pipe network outlets can be modeled with either a free outfall or a water surface elevation (fixed or variable with time) which captures backwater effects due to receiving water levels. The water surface elevation is set to the 100-year FEMA FIS level for the O'Connor pump station outfall in San Francisquito Creek. Because there is a high uncertainty of coincident peak timing, the channel level is set as a constant throughout the model simulation. The gravity flow outfalls all have FEMA 100-year flood elevations that would cause flooding at most associated nodes even without any rainfall. In order to assess the pipe capacity and restrict artificial flooding caused by the FEMA flood water elevations, the gravity outfalls at the north side of East Palo Alto were assigned water elevations equal to the Mean Sea Level of the San Francisco Bay. The remaining outlets were assigned constant water elevations equal to the ground level at the outfall.

Chapter 4. Storm Drain Collection Systems

Overview

The performance analysis of East Palo Alto's storm drain collection system forms the essential core of this master plan. This chapter describes major storm drain facilities, pump stations, and known drainage issues. Areas requiring system improvements are also identified and prioritized herein. This Chapter presents the 10-year predicted flooding depths for the existing land use condition with and without pipe sedimentation and projects that are required alleviating or minimizing flooding based on the 10-year standard. Improvements required to minimize flooding during a 10-year storm with the future land use condition are also presented in this chapter.

An evaluation of the O'Connor Street Pump Station was performed to gather more information and better assess the condition of the existing pump station. The pump station improvement is identified as part of the East Palo Alto improvements for Alternative 1 and 2. Apart from that, a detailed discussion of the O'Connor pump station deficiencies and improvements is included as a separate section later in this chapter.

Evaluation of the Storm Drain Capacity

Criteria

Each collection system has been analyzed for existing land use condition to determine its runoff during the design 10-year storm. Two scenarios were assessed for the existing land use; one assuming the pipes did not have any sedimentation and one using the field gathered sedimentation depths. Areas of significant flooding are recognized herein and recommended improvements to restore system performance in accordance with criteria outlined in Chapter 3, Methodology, are summarized. The improved collection systems were then analyzed with the future land use condition to determine whether further improvements are required to maintain the 10-year flood standard once future projects are built. Additional flow capacity requirements are determined by upsizing existing pipes in the MU model until flooding is reduced to acceptable levels. It is impossible to entirely remove predicted flooding throughout the project area, either due to local topography (for example, at minor 'bathtub' areas) or infeasibility of improvements, but the majority of model-predicted flooding can be mitigated to the previously described criteria with the capital improvements proposed herein.

Prioritizing Deficiencies and Needed Improvements

East Palo Alto's storm drain system conveys majority of the runoff towards the O'Connor street pump station for discharge into San Francisquito creek. There are multiple drainage systems that are shared with the City of Menlo Park. Schaaf & Wheeler obtained GIS data from the City of Menlo Park to complete the storm drain model; however, the drainage systems within the City of Menlo Park were not analyzed to the same measure of detail as those within East Palo Alto. It should be noted that neither private drainage systems nor site-specific drainage characteristics have been analyzed. Future refinement of the model could more precisely account for these site-specific drainage characteristics and more accurately represent the local drainage conditions.

Recommended master plan improvements are described in the following discussion. In some locations, the hydraulic grade line (HGL) predicted by the model at individual nodes in the system may be greater than actual water surface elevation during a storm event. This is due to limitations and assumptions inherent in the modeling software. In order to 'ground truth' predictive model results, Schaaf & Wheeler discussed model results with City staff and compared results to previously completed drainage studies where available. Locations for recommended system improvements are based on the results of this complete process. The recommended improvements were then prioritized based on the results of the above process, combined with consideration of the anticipated severity of flooding at each location and the benefit/cost relationship of proposed improvements. The following color code is used to highlight project prioritization:

Pipe Color	Improvement Priority	Priority Description
N/A	Urgent Priority	The projects under this category play a crucial role in the operation of the existing storm drain system. Completing these projects is necessary to maintain a functioning storm drain system.
Red	High Priority	Projects under this category have a large area of flooding where the 10-year maximum flood depth is greater than 12-inches. These projects improve locations with the deepest and longest flooding situations. They may also be located at the downstream end of many projects, as they would logically be constructed first. Areas of significant historical flooding fall into this category.
Yellow	Moderate Priority	This category has conditions similar to high priority, but has a smaller area affected by flooding. The length and depth of flooding is less than that of a high priority improvement.
Green	Low Priority	Low priority improvements are generally smaller projects that generally address nuisance flooding. The area of flooding is much smaller and/or briefer in duration than that of moderate and high priority projects.

The Immediate O'Connor Pump Station Improvement has been categorized as an urgent improvement. There are no pipes associated with the improvement and was therefore not assigned a color.

This section outlines the ultimate improvements needed to achieve a 10-year level of service by alleviating or minimizing predicted flooding throughout the City. Each improvement was grouped with nearby improvements that could be undertaken simultaneously and named using a major street or intersection, generally the most downstream, within the group of improvements. The naming convention is used to identify the improvements in maps and tables. A complete CIP with tables detailing storm drain network improvement projects including existing pipe size, recommended pipe size, and costs for each improvement is available in Chapter 6, Capital Improvements.

East Palo Alto System

Overview

The modeled East Palo Alto drainage area is approximately 2.1 square miles. The modeled collection system within East Palo Alto city limits consists of 430 nodes, 15 outlets, and one pump station. The project area has a total of 101,400 linear feet (19.2 miles) of modeled storm drain pipe equal to or greater than 12 inches in diameter. In general, the East Palo Alto area drains North to the San Francisco Bay and East into San Francisquito Creek.

An evaluation of the O'Connor Street pump Station was performed as part of this SDMP, a more detailed section for the pump station is included later on in this chapter.

Identified Deficiencies

MU analysis of the East Palo Alto systems for the 10-year storm event with sedimentation shows some flooding (HGL above the rim elevation of the node) occurring at 68 of the 430 nodes. MU predicts a flooding depth of less than 0.5 foot at 19 nodes. Depths between 0.5 and 1.0 foot above the street occur at 16 nodes, and a flooding depth greater than one foot occurs at 33 nodes. Maps of the 10-year flooding depths predicted by the 1D MU analyses with no improvements are presented in Figures 4-1 and 4-2. Figure 4-1 shows flooding without any sedimentation; Figure 4-2 shows flooding with the field gathered sediment depths.

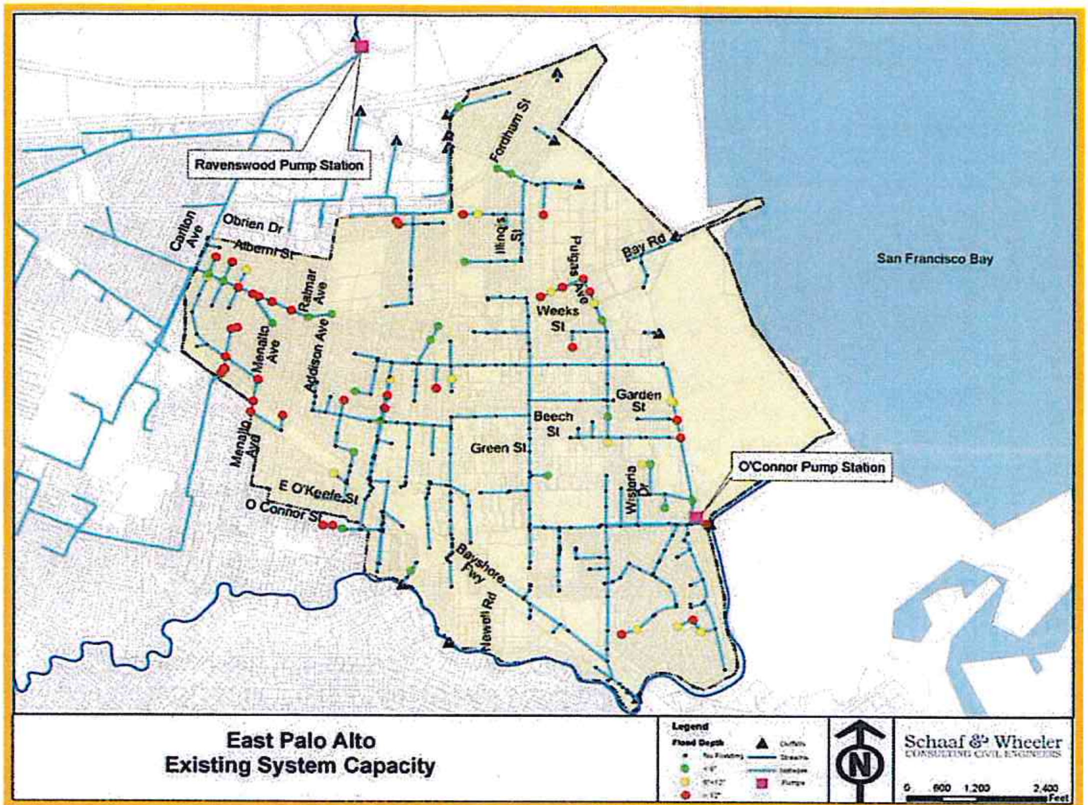

Figure 4-1: East Palo Alto 10-Year System Capacity

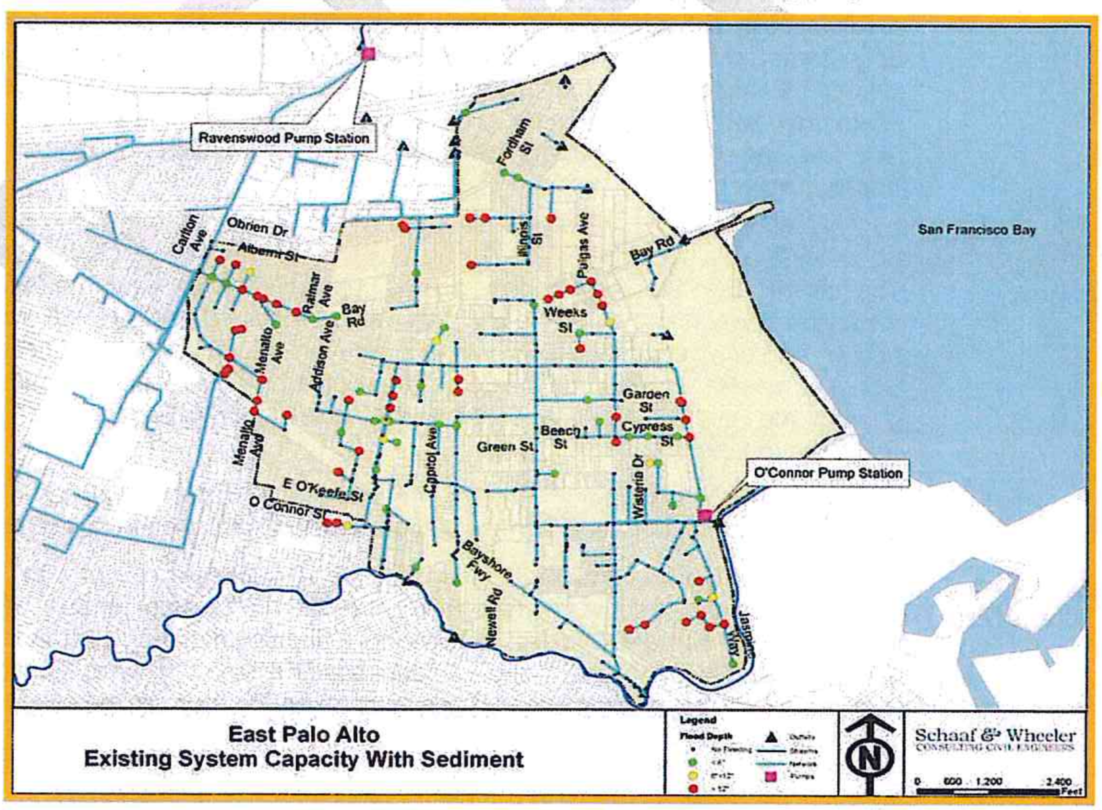

Figure 4-2: East Palo Alto 10-Year System Capacity with Sediment

Prioritized Improvements

Alternative 1

Two alternatives for prioritized improvements were developed for the City of East Palo Alto to alleviate or minimize flooding during a 10-year storm event. Alternative 1, the preferred alternative, is shown in Figure 4-3. Alternative 1 centers on connecting the northern drainage systems to either a new outfall on Purdue Avenue in the City of Menlo Park or to the existing Runnymede trunk line. Most of the high priority improvements work in conjunction with the proposed new system; these consist of: a channel rehabilitation project that conveys stormwater from Runnymede to the O'Connor Street pump station; the O'Connor pump station replacement; and increasing pipe diameters along Bell Street, Willow Road, Newbridge Street, Saratoga Avenue, Holland Street and O'Connor Street south of Highway 101. The improvements on Bell Street and Holland Street do not significantly reduce node flooding themselves; however, these improvements are necessary to prevent node surcharging from increased peak flows due to projects upstream.

Moderate priority improvements are recommended to provide a 10-year level of service at nine locations. These projects range from upsizing small sections of pipe to large projects requiring significant pipe improvements and outfall removals. The City may need to re-prioritize these projects based on funding, other utility improvements, and land use changes.

Low priority improvements are recommended at thirteen locations in Alternative 1. These projects would eliminate nuisance flooding and may only get built if there are significant changes to land use, roadway or redevelopment projects in the area.

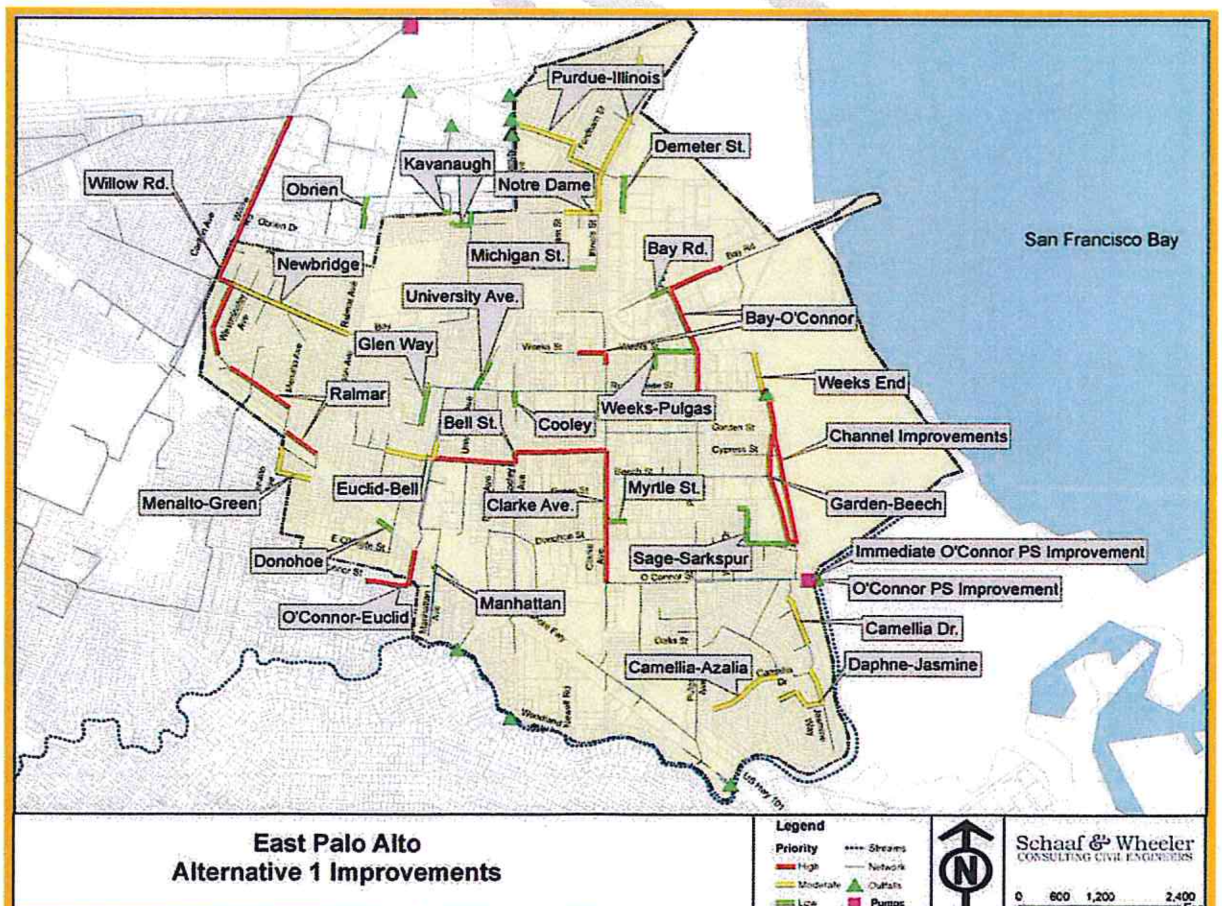

Figure 4-3: East Palo Alto System Improvements — Alternative 1

Prioritized Improvements

Alternative 2

Alternative 2, shown in Figure 4-4, centers around connecting the northern drainage systems to the Runnymede Street trunk line through a pump station on the corner of Bay Rd. and Pulgas Avenue and offering an alternative solution to the Clarke Avenue improvement in Alternative 1. The Illinois-O'Connor improvement is based on the assumption that an outfall at the end of Purdue Avenue in the City of Menlo Park is not possible. A portion of the drainage system on Bay Road and Pulgas Avenue will be replaced and an entirely new trunk line will be constructed on Demeter Street from Purdue Avenue to Bay Road. This alternative is not preferred because of high construction costs and increased maintenance costs associated with a new pump station. The Bell-Clarke improvement offers an alternative that does not require the existing Clarke Avenue system to be replaced as it is in Alternative 1. However, multiple improvements to smaller systems and an improvement to the Runnymede system are required to prevent node surcharging. High priority improvements that work in conjunction with the proposed pump station consist of the channel improvement project designed by Wilsey Ham (Runnymede Storm Drain Improvements 30% Plans, November, 2012), the O'Connor pump station replacement, upsizing a portion of the Bell Street system, and adding a trunk line between Runnymede and Bell to increase the amount of stormwater that can be routed through the Bell Street system.

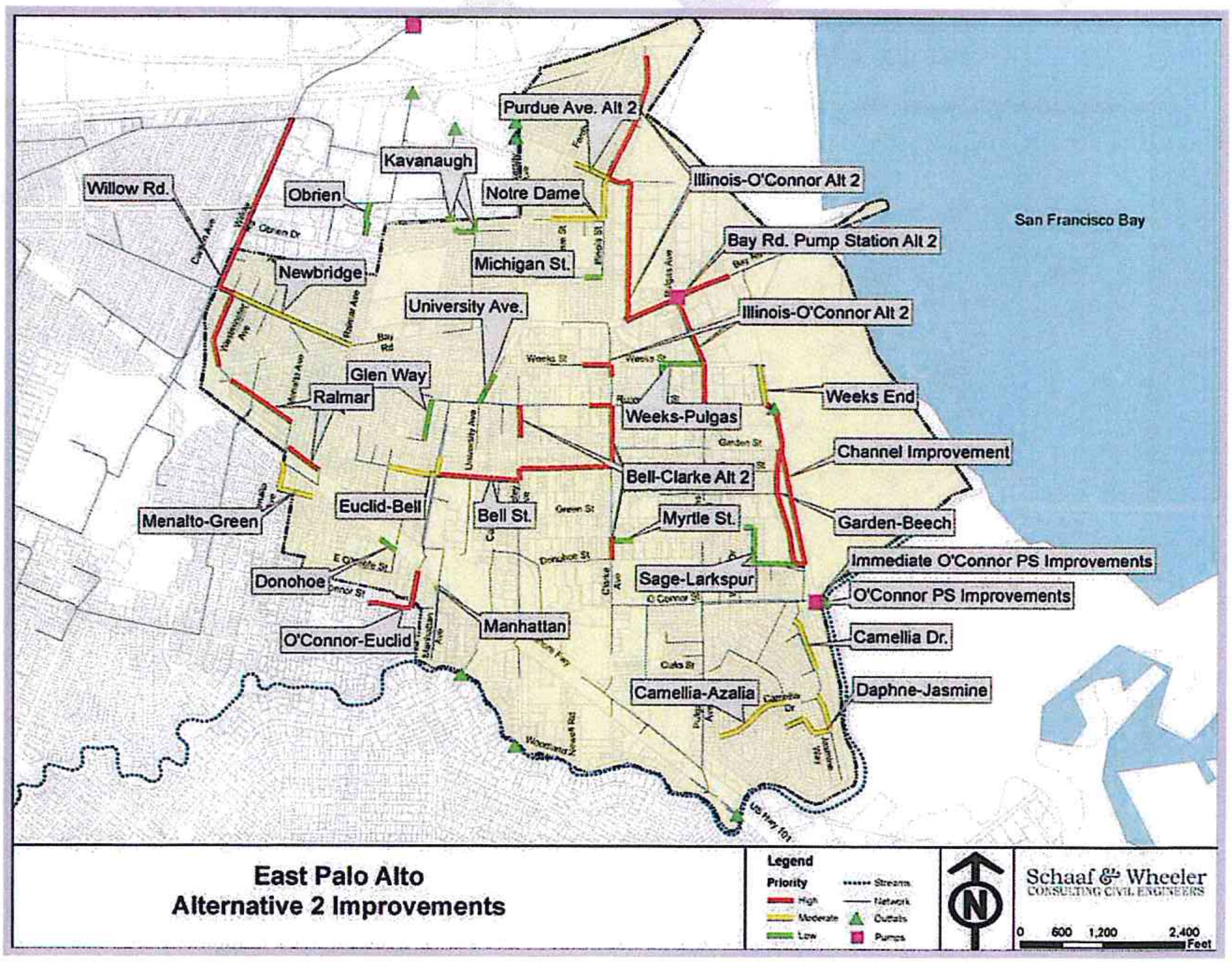

Figure 4-4: East Palo Alto System Improvements — Alternative 2

Future Land Use Improvements

Future land uses in the industrial area of East Palo Alto near Bay Road pose a potential need for increased storm drain capacity due to increased impervious areas. To analyze the potential need for increased demand, Schaaf & Wheeler developed a future land use model of the East Palo Alto storm drain system. In the future land use model the existing land uses were replaced with land uses for the planned urban developments. It was found that the East Palo Alto improvements that are required to alleviate or minimize flooding during a 10-year storm event with the existing land use are sufficient to handle the flows for the new developments. No further improvements are required for the storm drain system as a result of the 2013 approved planned urban development projects.

O'Connor Pump Station

Overview

The City of East Palo Alto currently operates one storm water pumping facility located on O'Connor Street adjacent to San Francisquito Creek. A portion of the stormwater from the northern part of East Palo Alto is routed through the Ravenswood pump station, which is owned and operated by Caltrans. The O'Connor pump station was originally constructed in 1984 by the County of San Mateo. It was owned and operated by the County until 2005, and was then taken over by the City. Besides some minor repairs and recent overhauling of the diesel engines, the equipment and operations of the station are largely the same as when it was originally constructed. As a part of the City's Storm Drain Master Plan, Schaaf & Wheeler evaluated the condition and functionality of the pump station. The findings are detailed here below. Dimensions used within this assessment report are taken from the pump station as-built drawings from 1984.

The station consists of a concrete wetwell below a CMU building, which houses the pumps and electrical controls. The station is equipped with four 225-horsepower diesel-engine-driven axial-flow pumps and one 40-horsepower electric motor-driven low flow pump. Each pump individually discharges to a common discharge box located within the bank of San Francisquito Creek. Pump discharge pipes are equipped with flap gates to prevent back flow into the station. Access to the wetwell, both inside and outside of the pump station building is possible by access grating installed in the wetwell top slabs. Fuel to power the diesel engines is stored in a 2,000 gallon capacity storage tank located at below grade level. The station is shown in Figure 4-5.

Figure 4-5: O'Connor Pump Station

Operations

Currently, the operational 40 HP pump serves as the primary pump, keeping the station dewatered under dry conditions. In the event of storm flows larger than the 40 HP pump can convey, the first of the engine-driven pumps starts automatically. As station inflows increase, each remaining engine-driven pump starts in succession, based on wet well levels. The pump station set levels are listed in Table 4-1. Pump controls and alarm communications are coordinated using a recently installed Programmable Logic Controller (PLC) as shown in Figure 4-6.

Table 4-1: O'Connor Pump Station Set Levels

Pump Set Levels	Wet Well Depth	
	Start	Stop
Sump Pump	9'	3.5'
Pump 1	10'	5'
Pump 2	11'	5'
Pump 3	12'	5'
Pump 4*	N/A	N/A

**Pump 4 was un-operational during field inspection*

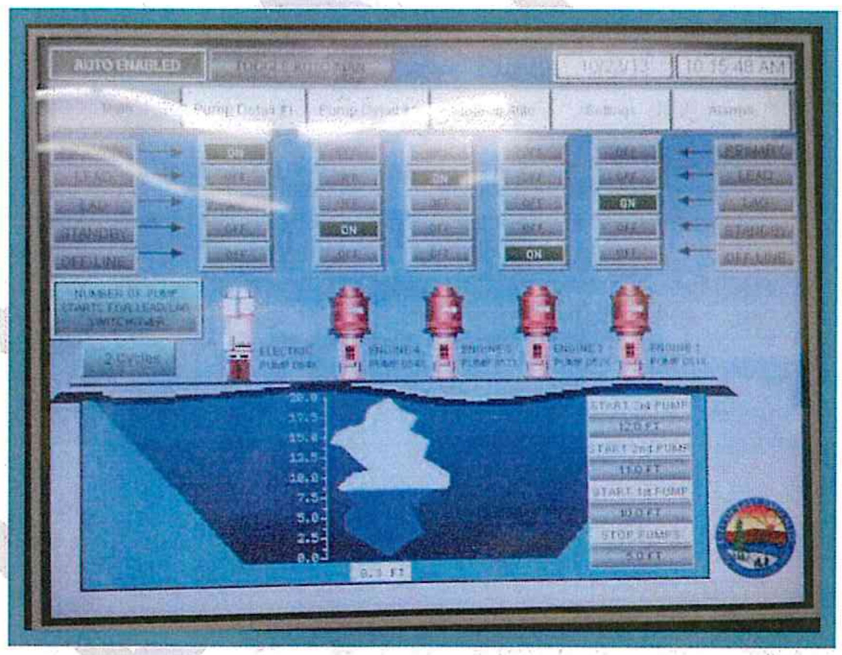

Figure 4-6: PLC Control Screen

Conversations with City O&M staff revealed several operational issues at the station that should be addressed in order to provide a functional and reliable pump station. Operational issues include:

1. Large amount of sediment on the wetwell floor (Approximately 2' according to O&M.) reduces the overall capacity of the wetwell and could impede flow for the pump intakes.

2. Engine-mounted fuel transfer pumps are too small, and do not provide enough fuel to the engines while running
3. Engine-mounted fuel transfer pumps cannot draw fuel from diesel storage tank when the fuel level goes lower than the 1,500 gallons mark.
4. High creek water levels submerge significant portions of the station, including the engine batteries and would prevent the engines from running during a high creek level scenario.
5. Trash rack spacing is too large and allows large items to pass.
6. Current operations budget includes rebuilding of one diesel engine per year and is excessive for operating a single pump station

Wet Well

Originally the wetwell was designed and constructed with two pipe inlets - 54-inch and 60-inch RCP. However, only the Southern, 60-inch pipe was fully constructed and has flow entering the station. From the pipe inlets, the station walls expand from 6 feet wide to 41 feet wide over a distance of approximately 33 feet. After the expansion, the wetwell continues for approximately 23 feet. The engine-driven pumps are spaced 8'-8" apart and the motor-driven pump is located 6'-6" south of the first large pump. The large pumps have suction umbrellas approximately 5-feet in diameter while the small pump has a suction umbrella approximately 3-feet in diameter. The pumps are not separated by divider walls. Divider walls help distribute the inflow and reduce the potential for vortex formation. In general the existing wetwell does not conform to the current Hydraulic Institute guidelines for wetwell dimensions, as shown in Table 4-2 below.

Table 4-2: O'Connor Pump Station Hydraulic Dimensions

Dimension	Hydraulic Institute	O'Connor Station
Wetwell Approach Wall Angle	20° Max	24°
Wetwell Approach Floor Angle	10° Max	26°
Pump Divider Wall Length (Proportional to pump inlet diameter, D)	25' (5D)	None
Wetwell Floor Length (Proportional to D, measured from pump CL)	25' (5D)	27'±
Pump Spacing (Proportional to D, measured from pump CL)	10' (2D)	8'-8"
Dimensions/Requirements taken from ANSI/HI 9.8-1998 (Pump Intake Design)		

In addition to the deficiencies listed above, the small size of the station's wetwell does not allow for proper pump cycling time. Currently, under critical cycling conditions (station inflow equal to half of single pump capacity) the pump station starts 12 to 14 times per hour. Typically, on large storm water stations, Schaaf & Wheeler recommends no more than 6 starts per hour. For engine driven pumps with minimum engine cool-down periods, increasing the number of starts per hour is less of a concern, however it is still not recommended.

Pump Capacity

The required station capacity to meet the 10-year storm event is 230 CFS and the 100-year storm event is 290 CFS. Schaaf & Wheeler obtained manufacturer pump performance curves for the four large pumps. These curves were then coupled with discharge pipe lengths obtained from the station as-built plans, to estimate the approximate pump capacity for each of the pumps. As shown in Figure 4-7, each of the large pumps has a capacity of approximately 49 CFS, for a station capacity of approximately 200 CFS.

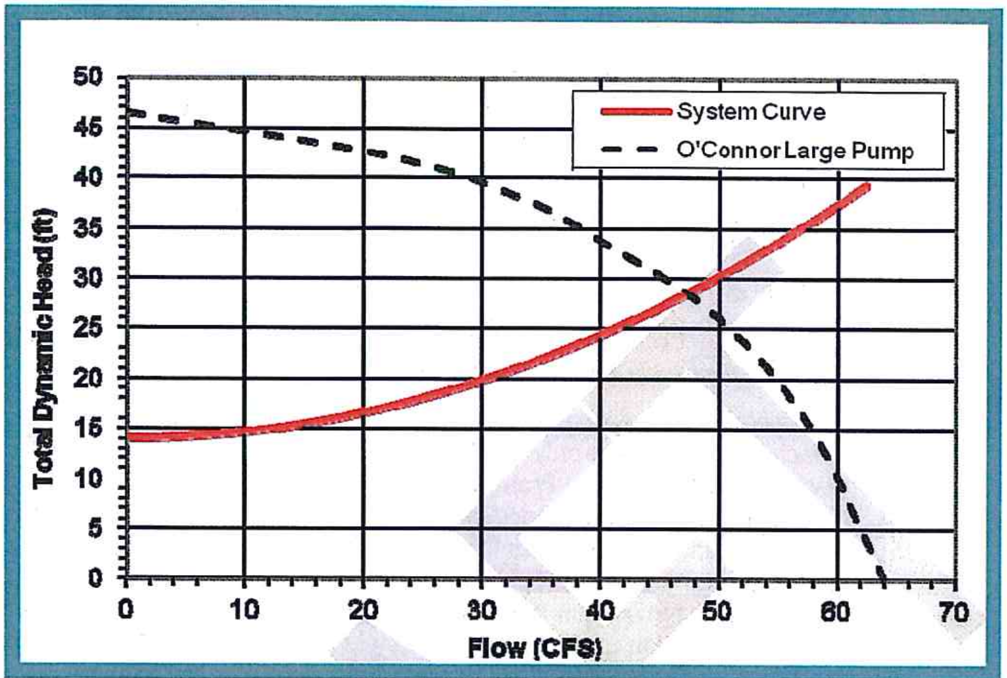

Figure 4-7: O'Connor Pump System Curve

Per conversations with City staff, the pumps have not been pulled or inspected for maintenance since the City took ownership of the station in 2005. Lack of maintenance and servicing is also apparent on the right-angle gear drives that couple the diesel engines to the pumps. The observation made on the oil level indicating glass also reveals that all four of the right-angle drives do not have any lubricating oil in them. Lack of oil can decrease the efficiency and increase the wear on the components, shortening the life of the drives and the diesel engines.

It is likely that the lack of upkeep on the pumps has resulted in diminished capacity compared to the factory pump curves. However, quantifying the capacity reduction is not feasible without detailed testing and investigation.

Electrical

The O'Connor pump station is currently served by PG&E with a 240V, 3-phase, 4-wire electrical service rated at 200 amps. Power to the original pump station control panel is fed from the PG&E service point (located within the pump station). As observed, this service point has been decommissioned with the exception of the 240V power panel and the electric pump motor starter. The 240V power panel supplies power to the recently installed pump control PLC as well as lighting and electrical outlets throughout the pump building. The existing PG&E service is sufficient to power current pump station loads, and any significant additional loads (i.e. new electric motors) should not be installed at the pump station without upgrading the electrical service.

The pump station building floor contains grating that links the building directly to the wetwell, making it a Class 1, Division 1 location per the California Electric Code. As such, all electrical equipment located within the pump station including control panels, electric motors, light fixtures and outlets are required to be rated (typically with an explosion-proof rating) for use in Class 1, Division 1 hazardous locations. Though every piece of electrical equipment within the building was not specifically inspected, those observed were not rated for use in hazardous locations. Figure 4-8 shows an example of a non-rated electrical outlet, which is typical throughout the station.

Figure 4-8: Non-Rated Electrical Outlet

Lastly, City O&M staff has indicated a preference to replace Diesel Engine No. 3 with an electric motor. In order to accomplish this, a new PG&E transformer and electrical service to the station is required. Additionally, as currently configured, the electric motor and all associated equipment will need to be rated for use within a hazardous location. This will increase costs and complexities in construction significantly.

Recommendations

Immediate Improvements

Based on the deficiencies identified herein, complete rehabilitation or replacement of the O'Connor Street pump station is recommended. In order to maintain a safe and functional station until its replacement or rehabilitation, there are improvements that should be implemented as soon as funding allows. These improvements are detailed in Table 4-3.

Table 4-3: Immediate Improvements

Improvement	Cause/Reasoning
Rebuild Diesel Engine No. 3	O&M identify engine as needing rebuild
Inspect/Maintain Pump and Drive Units	Unknown Condition/Lack of Maintenance
Replace Fuel Pumps (4)	Insufficient Capacity
Relocate (E) Electrical Equipment	Electrical Equipment Not Rated for Hazardous Location
Replace (E) 40 HP Motor w/ Explosion Proof Motor	Motor Not Rated for Hazardous Location
Replace (E) Light Fixtures and Outlets w/ Explosion Proof Equipment	Electrical Equipment Not Rated for Hazardous Location

Long Term Improvements

Due to the hydraulic deficiencies of the existing station wetwell, it is assumed that a new station will ultimately be constructed to replace the existing O'Connor Street pump station. It may be possible to use computational fluid dynamics (CFD) models to develop a hydraulically acceptable rehabilitation plan for the existing station; however that is beyond the scope of this assessment. The improvements listed in Table 4-4 are based on constructing a new pump station. It should also be noted that all improvements associated with the O'Connor Street pump station are High priority.

Table 4-4: Pump Station Replacement

Improvement
Construct (N) Concrete Pump Station Structure
(N) 200 HP High Flow Pumps (4)
(N) 40 HP Low Flow Pump
(N) Electrical Control Panels and MCC
(N) Standby Engine Generator and Fuel Tank
(N) PG&E Transformer and Electrical Service

Chapter 5. Regulatory Requirements

Overview

The City is responsible for ensuring compliance with national, regional and local regulatory requirements in the following areas:

- Floodplain management
- Riparian and wetland protection
- Surface water and groundwater protection
- Stormwater management

The San Francisquito Creek flows through the City and is prone to flooding. The City is a member of the San Francisquito Creek Joint Powers Authority (SFCJPA) which works to plan, design, and implement flood protection projects from the upper watershed to coastal wetlands, for the mutual benefit of its member jurisdictions. The City hosts information regarding floodplain management on its website and is a part of the FEMA National Flood Insurance Program.

City and private projects within the riparian corridor or near a wetland may also be required to have environmental and water quality permits from San Mateo County, San Francisco Bay Area Regional Water Quality Control Board, California Department of Fish and Game, and the United States Army Corps of Engineers (USACE). The "Guide to Creek and Wetland Project Permitting" developed by the San Mateo Countywide Stormwater Pollution Prevention Program (SMCWPPP) details the necessary permits related to water quality and environmental protection in these areas.

The most significant regulatory requirements for stormwater management in the City of East Palo Alto are found in the State of California's Construction General Permit (CGP) and the San Francisco Bay Municipal Regional Stormwater Permit (MRP) under the National Pollutant Discharge Elimination System (NPDES). This chapter provides a general outline of the various legal and regulatory requirements for floodplain management, riparian and wetland protection, surface water and groundwater protection, and stormwater management.

FEMA Regulations

Flooding is not covered by a standard homeowner's insurance policy. A separate flood insurance policy is required to cover damages incurred by flooding. Coverage is available for the building itself as well as for the contents of the building. The City of East Palo Alto participates in the National Flood Insurance Program (NFIP) that makes available federally backed flood insurance for all structures, whether or not they are located within the floodplain. The City maintains records of all elevation certificates that have been created for properties within the City. The City's floodplain regulations are outlined within Chapter 15.52 of the East Palo Alto Municipal Code.

San Mateo County Flood Control District

The District is empowered to study flood conditions and to construct facilities after the formation of zones consisting of the particular watersheds to be served. San Mateo County has flood control zones in the following areas: Colma Creek, Ravenswood, San Bruno Creek, and San Francisquito Creek - which run through East Palo Alto. The District is responsible for property and facilities which it owns and maintains, generally consisting of walls and levees. Any proposed work involving property and facilities owned by the Flood Control District will require an Encroachment Permit. In addition, regulations of construction have been adopted in San Francisquito Creek for the stretch between its confluence with Los Trancos Creek and San Francisco Bay.

USACE

Under Section 404 of Clean Water Act (CWA), the United States Army Corps of Engineers (USACE) regulates certain activities that "discharge dredged or fill material into waters of the United States". Waters of the U.S. are defined to generally include such resources as tidal waters, most rivers, lakes, and streams, and certain types of wetlands. Channel stabilization and stream maintenance activities that propose to place fill, e.g. culverts, gabions, rock rip rap, logs, etc., in the channel must obtain a permit from USACE. It is important to note that, in streams, waters of the U.S. include the bed and banks of the channel only up to ordinary high water (OHW) or the 2.33-year flood event. Formal wetland delineations are often conducted to determine the specific bank elevation of OHW, as well as the limit of Waters of the U.S. where streams become intermittent or ephemeral. Clear wetland delineation becomes very important when assessing the area of impact of a proposed stream maintenance activity in order to determine what type of USACE permit will be required.

USACE issues two types of permits under Section 404: general permits and standard (individual) permits. General permits are issued by USACE to streamline the permit process, while individual permits are more rigorously reviewed and are reserved for projects that impact more than 1/3 acre of tidal waters or non-tidal waters greater than ½ acre. Specifically, the USACE Nationwide Permit (NWP) program authorizes 43 different categories of activities, each of which is governed by specific conditions for the particular NWP, as well as 27 general conditions that apply to all NWPs. There are eight NWPs that can be used individually, or stacked in combination, for channel stabilization and stream maintenance activities. They are listed as follows:

NWP 3 Maintenance – the repair, rehabilitation, or replacement of any previously authorized, currently serviceable structure or fill, provided that the structure or fill is not to be put to uses differing from those uses specified in the original permit. This NWP authorizes the repair, rehabilitation, or replacement of those structures or fills damaged by storms or floods provided the work commences within two years of the date of their damage.

NWP 7 Outfall Structures and Maintenance – permits activities related to construction of outfall structures and associated intake structures where the effluent from the outfall is authorized or in compliance with the National Pollutant Discharge Elimination System (NPDES) program. Under this permit maintenance excavation, including dredging, to remove accumulated sediments blocking or restricting outfall and intake structures.

NWP 18 Minor Discharges – permits minor discharges of dredged or fill material in waters of the U.S. below the plane of the OHW mark or high tide line, provided it is less than 25 cubic yards and does not cause the loss of more than 1/10 acre of wetlands.

NWP 27 Stream and Wetland Restoration Activities – permits activities in waters of the U.S. associated with restoration of former waters, the enhancement of degraded wetlands and riparian areas, the creation of new wetland and riparian areas, and the restoration and enhancement of open water habitats. The main provision requires that the project reach be in non-federal public or private ownership.

NWP 33 Temporary Construction, Access and Dewatering – permits temporary structures, work and discharges, including cofferdams for dewatering channel stabilization and stream maintenance sites provided the associated primary activity is authorized by USACE.

San Francisco Bay Conservation and Development Commission

On a regional level, the San Francisco Bay Conservation and Development Commission regulates projects proposing to fill, extract materials, or change the use of water, land, or structures in or around San Francisco Bay. Fill is very broadly defined to include (1) solid fill, such as dirt, concrete, wood, and structures, (2) pile-supported fill, such as fixed boat piers and docks, (3) floating fill, such as floating docks, houseboats, and vessels moored for extended periods of time, and even (4) structures cantilevered over the Commission's jurisdiction. The Commission's permit jurisdiction includes San Francisco Bay which is defined as any area within the greater San Francisco Bay up to mean high tide (except in areas of tidal marsh where the Commission's jurisdiction extends to 5 feet above mean sea level) and a "shoreline band" that extends 100 feet inland from areas subject to tidal action.

San Francisco Bay Area Regional Water Quality Control Board

The San Francisco Bay Area Regional Water Quality Control Board's overall mission is to protect surface and ground waters of the San Francisco Bay region. The Regional Board reviews and waives Section 401 Water Quality Certification for projects requiring Corps of Engineers Section 404 permits. Section 401 refers to the section of the Clean Water Act that gives states the authority to issue, waive or deny certification that the proposed activity is in conformance with State water quality standards.

US Fish and Wildlife

The U. S. Fish and Wildlife Service reviews and comments on projects pursuant to the Fish and Wildlife Coordination Act, the Clean Water Act, and the National Environmental Policy Act. The Service's comments focus on the effects of projects on all fish and wildlife resources and the habitats that support those resources. Such projects may be, but are not limited to, flood control, urban and industrial development, habitat restoration activities, etc. The Service also reviews projects for their affects pursuant to the Federal Endangered Species Act (Act). The Act, through Section 9, prohibits the take of any species listed as threatened or endangered pursuant to the Act without a specific exemption. The term "take" is broadly defined and if "take" is going to occur a permit from the Service is required. If there is another Federal Agency involved then exemption from the "take" provisions of the Act can be achieved through a Section 7 process.

California Department of Fish and Game

The California Department of Fish and Game requires a Streambed Alteration Agreement (SAA) for projects that will divert or obstruct the natural flow of water, change the bed, channel or bank of any stream, or propose to use any material from a streambed. The SAA basically is a contract between the applicant and the Department of Fish and Game regarding what will and will not be done in the riparian zone and stream course. The Department is interested in any work that occurs anywhere (in, on, over, or under the creek) between the streambed sloping upwards to the top of the bank.

Construction General Permit (CGP)

The State of California requires that dischargers obtain permit coverage for projects with construction activities that disturb one or more acres in accordance with Construction General Permit Order 2009-0009-DWQ. Construction activity subject to this permit includes clearing, grading, and land disturbances such as stockpiling or excavation. The permit excludes certain regular maintenance activities from obtaining coverage. The CGP requires the development and implementation of a Storm Water Pollution Prevention Plan (SWPPP). The SWPPP includes a Water Pollution Prevention Drawing that identifies and locates Best Management Practices (BMPs) within the limits of work, and stormwater discharge monitoring and sampling requirements.

Municipal Regional Permit (MRP)

The City of East Palo Alto is part of San Mateo Countywide Water Pollution Prevention Program (SMCWPPP), an association of twenty-two jurisdictions in San Mateo County that share a common MRP to discharge stormwater to the San Francisco Bay. Figure 5-1 shows the organizational structure and meeting schedule for SMCWPPP.

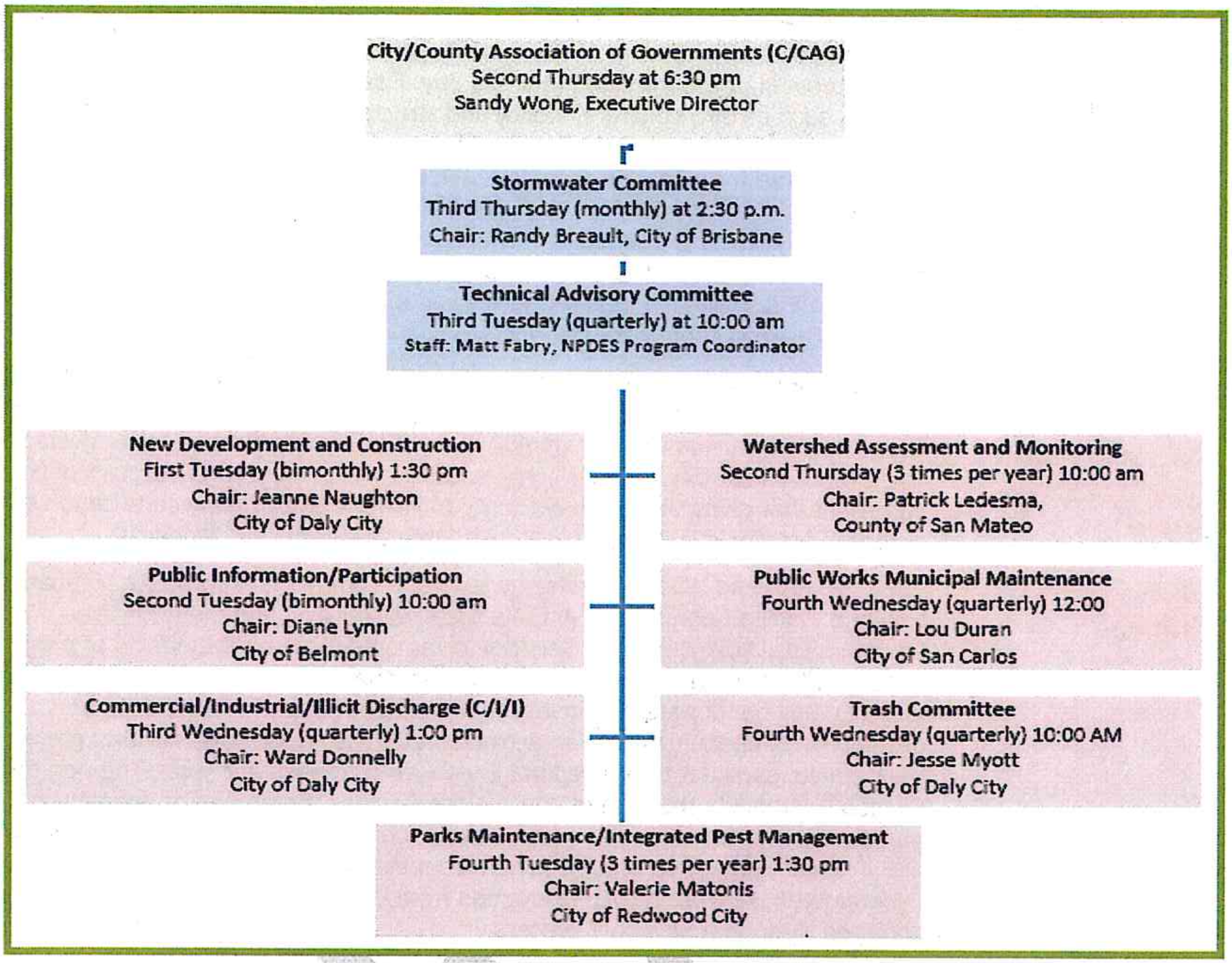

Figure 5-1. SMCWPPP Organizational Chart

Municipal Regional Permit (MRP)

The City is required to meet all stormwater management practices required by the MRP. The City funds stormwater regulatory practices from a small Storm Drainage Assessment District that covers the Gardens Neighborhood. In addition, the city collects in-lieu fees from private development projects. Beyond these two resources, the city funds most of its regulatory work through general funds or grants (such as the US Environmental Protection Agency State and Tribal Assistance Grants and Department of Water Resources Proposition 1E). The MRP was adopted October 14, 2009 (Order no. R2-2009-0074), and is effective as of December 1, 2009.

The MRP outlines the State's requirements for municipal agencies in the San Francisco Bay Area to address the water quality and flow-related impacts of stormwater runoff. Some of these requirements are implemented directly by municipalities while others are addressed by the SMCWPPP on behalf of all the municipalities. The MRP is a comprehensive permit that requires activities related to construction sites, industrial sites, illegal discharges and illicit connections, new development, and municipal operations. The permit also requires a public education program, implementing targeted pollutant reduction strategies, and a monitoring program to help characterize local water quality conditions and to begin evaluating the overall effectiveness of the permit's implementation. Table 5-1 summarizes the sixteen provisions in the MRP with the associated resources available to the City of East Palo Alto.

Table 5-1: 16 Provisions in Municipal Regional Permit

MRP Provision	Description	Regional Efforts/Resources
C1: Compliance with Discharge Prohibitions and Receiving Water Limitations	Describes the process by which Permittees must respond to a determination that discharges are causing or contributing to an exceedance of an applicable WQS.	SMCWPPP Stormwater Committee
C2: Municipal Operations	Sets forth requirements which Permittees must meet for municipal projects and property, including activities such as street and sidewalk repair and maintenance.	BASMAA Operational Permits Committee SMCWPPP Operational Permits Committee
C3: New Development and Redevelopment	Requires Permittees to use their planning authorities to include appropriate source control, site design, and stormwater treatment in all development projects to address stormwater runoff pollutant discharges.	BASMAA New Development Committee SMCWPPP New Development (ND) Subcommittee SMCWPPP C.3 Stormwater Technical Guidance, Version 3.2 CASQA Stormwater Best Management Practice (BMP) Handbooks / Portal http://www.cabmphandbooks.com/ CASQA LID Portal https://www.casqa.org/LID/tabid/240/Default.aspx
C4: Industrial and Commercial Site Controls	Sets forth requirements for industrial and commercial site control implementation including inspections, annual reporting, and follow-up of non-compliance.	SMCWPPP CII Subcommittee (CII) Agreement with San Mateo Center for Environmental Health (CEH) to conduct stormwater inspections of businesses
C5: Illicit Discharge Detection and Elimination	Sets forth the requirements to detect and control illicit discharges.	SMCWPPP CII Subcommittee Center for Watershed Protection "Illicit Discharge Detection and Elimination: A Guidance Manual for Program Development and Technical Assessment"
C6: Construction Site Control	Sets forth the requirements for a construction site inspection and control program, including follow-up and enforcement, at construction sites to prevent construction site discharges of pollutants to receiving waters.	SMCWPPP New Development (ND) Subcommittee BASMAA Development Committee
C7: Public Information and Outreach	Sets forth requirements for public information and outreach to reduce and mitigate impacts of stormwater pollution on receiving waters.	BASMAA Public Information/Participation Committee SMCWPPP's Public Information and Participation (PIP) Subcommittee SMCWPPP website www.flowstobay.org

MRP Provision	Description	Regional Efforts/Resources
C8: Water Quality Monitoring	Sets forth the requirements for water quality monitoring.	SMCWPPP Watershed Assessment and Monitoring Subcommittee (WAM) BASMAA Monitoring/POCs Committee
C9: Pesticides Toxicity Control	Sets forth the requirements for the development of a pesticides toxicity control program that address both City and others users of pesticides within the City jurisdiction.	SMCWPPP Integrated Monitoring Report (IMR) Parks Maintenance and Integrated Pest Management (IPM) Work Group CASQA Pesticide Committee BASMAA Municipal Operations Committee SMCWPPP Pest Control Portal http://www.flowstobay.org/pestcontrol
C10: Trash Load Reduction	Sets forth the requirements for trash load reduction.	SMCWPPP Trash Committee BASMAA Regional Trash Committee Trash Assessment "Pilot Study to Identify Trash Sources and Management Measures at an In-stream Trash Accumulation Area San Mateo County, California " Survey on Existing Municipal Trash Management Practices and Known Trash Problem Areas in San Mateo County, California SCVURPPP and SMSTOPPP Pilot Implementation and Testing of RWQCB Rapid Trash Assessment
C11: Mercury Controls	Outlines notable activities specific to Mercury controls required in the effective NPDES permit.	BASMAA Regional Pollutants of Concern Report for FY 2012-2013 SMCWPPP Integrated Monitoring Report BASMAA Monitoring/POCs Committee SMCWPPP Watershed Assessment and Monitoring Subcommittee (WAM)
C12: PCB Controls	Outlines notable activities specific to PCB controls required in the effective NPDES permit.	BASMAA Regional Pollutants of Concern Report for FY 2012-2013 SMCWPPP Integrated Monitoring Report (IMR) SMCWPPP Watershed Assessment and Monitoring Subcommittee (WAM)
C13: Copper Controls	Outlines notable activities specific to Copper controls required in the effective NPDES permit.	California Building Inspectors Group (CALBIG) SMCWPPP's CII Subcommittee SMCWPPP's PIP Subcommittee Brake Pad Partnership (BPP)
C14: PBDE, Legacy Pesticides, and Selenium	Sets forth the control program requirements for PBDEs, legacy pesticides, and selenium.	BASMAA Regional Pollutants of Concern Report for FY 2012-2013
C15: Exempted and Conditionally Exempted Discharges	Provides information for the exemption of non-stormwater discharges from Discharge Prohibition A.14 and conditionally	SMCWPPP CII Subcommittee SMCWPPP Water Utility Work Group
C16: Annual Reports	Sets forth the annual report requirements for Permittees.	Technical Advisory Committee (TAC) workshop on Annual Reports

The LID Movement

As of December 1, 2011, the MRP include LID treatment requirements for all new development and redevelopment projects. The term LID refers to practices that reduce water quality impacts by preserving and re-creating natural landscape features, minimizing imperviousness, and using stormwater as a resource, rather than a waste product. These measures include rainwater harvesting/reuse, infiltration, and evapotranspiration. If these measures are deemed infeasible, then biotreatment can be used. It is believed that in the future more and more emphasis will be placed on using the following technologies on construction sites recommended by the Water Board:

1. Bioretention & Rain Gardens
2. Rooftop Gardens
3. Sidewalk Storage
4. Vegetated Swales, Buffers & Strips; Tree Preservation
5. Roof Leader Disconnection
6. Rain Barrels and Cisterns
7. Permeable Pavers
8. Soil Amendments
9. Impervious Surface Reduction & Disconnection
10. Pollution Prevention & good Housekeeping

Because of the emphasis that the MRP puts towards using LID, there are numerous regional groups tracking the most up to date technologies on LID and the corresponding NPDES regulations. The following sites contain useful information for municipal staff, developers, general public, and elected officials to keep abreast with trends and policies in the often changing arena.

CASQA
http://www.casqa.org/LID/tabid/240/Default.aspx

California State Water Resources Control Board
http://www.waterboards.ca.gov/water_issues/programs/low_impact_development/

SMCWPPP
http://www.flowstobay.org/newdevelopment

SCVURPPP
http://www.scvurppp-w2k.com/nd_wp.shtml#lid

U.C. Davis
http://extension.ucdavis.edu/unit/center_for_water_and_land_use/low_impact.asp

BASMAA Development Committee
http://basmaa.org/BoardandCommittees/Development.aspx

Urban Design Tool
http://lid-stormwater.net/index.html

Adopting Green Infrastructure Practices

Beyond the compulsory use of LID on construction site projects, the city stands to gain environmental, social and economic benefits from the use of green infrastructure practices (also termed "sustainable stormwater design"). Green infrastructure (GI) is a comprehensive approach to water quality protection defined by a range of natural and built systems that can occur at the regional, community and site scales. Linkages between sites and between practices within one site ensure that stormwater is slowed, infiltrated where possible and managed with consideration for natural hydrologic processes. Comprehensive stormwater management with green infrastructure must consider:

1. How to protect and preserve existing natural resources,
2. Where to direct development in the community, and
3. How to develop on individual sites.

The SMCWPPP has developed the "San Mateo County Sustainable Green Streets and Parking Lots Design Guidebook" to help jurisdictions and private developers identify and realize green street and parking lot site design opportunities, provide solutions to common implementation barriers, and provide guidance on how to best design, construct, and maintain successful projects.

Economic Benefits of LID/GI

While the initial costs of LID and GI infrastructure may be high, overtime studies have shown significant benefits to local governments such as:

- Protecting water quality helps protect real estate values, which protects tax revenues.
- Reduced inflow and infiltration – less stormwater leaking into sanitary sewers means less volume of water reaching sewage treatment plant.
- Reduced public expenditures on stormwater infrastructure including expensive retrofits.
- Reduced system-wide operations and maintenance costs of pipe infrastructure.
- Extension of the useful life of central pipe infrastructure as populations in-crease.
- Reduced regulatory costs associated with water-quality impacts, such as threats to sensitive species, TMDL compliance, etc.

In addition to the benefits to local government, there are also benefits to the community such as:

- Improved water quality, increased groundwater recharge, improved air quality, enhanced aesthetics, enhanced property values, increased open space, and carbon sequestration.
- Protecting water quality through LID maintains the value of clean water, which is usually less expensive than cleaning contaminated water. Not having to clean contaminated water is an avoided cost.
- Clean water is a quality of life benefit: although difficult to quantify, its value may rival or exceed more tangible benefits. For example, protecting human health is the driving force behind the nation's water supply protection program.
- Reduced flooding, reduced stream erosion, and reduced pollutant loading to downstream waters.
- Preserving open space.

Chapter 6. Capital Improvements

Overview

This chapter provides a Capital Improvement Program (CIP) that recognizes prioritized improvements recommended to address East Palo Alto's storm drain collection system's deficiencies in Chapter 4. The CIP provides an overall guideline for the City to use as a tool in preparing annual budgets. Exigent circumstances and future in-field experiences may necessitate deviations from the Storm Drain CIP. A master plan is intended to be a tool for planning. Capital improvement priorities are not intended to be hard and fast.

The CIP does not include the cost of new facilities related to new development (e.g., pipeline extensions to serve areas that are currently undeveloped). These new facilities may be constructed as part of the new developments, and are not included in the CIP.

Capital Improvement Priorities

The proposed CIP for storm drainage in East Palo Alto is broken into four priority levels for the purpose of funding and implementation. The total cost summary for all CIP projects including pipe and pump station improvements and sediment removal is shown for each priority level below in Table 6-1.

Table 6-1: Summary of CIP Costs Based on Priority Level

Priority Level	Cost
Urgent Priority Capital Improvements	$580,000
High Priority Capital Improvements	$30,620,000
Moderate Priority Capital Improvements	$5,200,000
Low Priority Capital Improvements	$2,900,000
Total Capital Improvement Program	**$39,200,000**

The above costs include a 40% increase in construction cost estimates to include design, administration, and contingency costs. It should be noted that the Channel Improvement costs were taken from for the 30% Runnymede Storm Drain Improvements (Wilsey Ham, 2012) and do not include a 40% cost increase.

Alternative Improvement Projects

Two essential types of projects are traditionally utilized to increase storm drain system capacity:

- install a new relief storm drain parallel to the system lacking capacity, or
- replace the overloaded pipe with 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:

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

where D_R = diameter of replacement pipe;

D_e = diameter of overloaded pipe; and

D_p = diameter of parallel relief drain.

Assuming the existing pipe is adequate in terms of condition, the installation of a new parallel pipe is typically more cost effective than pipe replacement since the required pipe size is smaller and the existing pipe does not need to be removed. This does not take into account the long term maintenance associated with a parallel system. The selection of a capacity improvement strategy will vary from project to project, and be governed by field constraints such as conflicting utilities, rights-of-way, environmental concerns, permit requirements and traffic control.

Traditional cut and cover methods of construction will be employed for most storm drain construction. However, the utilization of trenchless methods such as bore and jack, directional drilling, cured-in-place pipe (CIPP), slip-lining, and others, may increasingly find application in special circumstances where existing development encroaches upon the pipe alignment, or disruption of other services and land uses is too costly.

Cost of Improvements

Costs have been estimated using information from other projects, cost estimating guides (*2013 Current Construction Costs,* Saylor Publications, Inc.), and engineering judgment. All estimates are based on the ENR May 2013 index of 9515. The cost per linear foot of improvement used for the pipe cost estimates are given in Table 6-2 *(note that these costs do not include the 40% increase for design, administration, and contingency included in all other tables).*

As per our estimates, connection (manhole or catch basin) replacement cost estimates ranged from $11,850 to $22,000 depending on connecting pipe diameters. Pipe costs include open trenching in the roadway up to ten feet in depth. New outfall costs for are estimated to be $25,000 per new outfall. It should be noted that wide variations in actual outfall costs are expected. Since most of these improvement projects are expected to qualify for negative declarations from permitting agencies, these costs do not include permitting or any environmental documentation.

Table 6-2: Storm Drain Unit Costs

Diameter (inches)	2013 Dollar per Linear foot of Pipe	2013 Dollar per Connection
15	$250	$11,850
18	$270	$11,930
21	$290	$12,010
24	$325	$12,080
27	$350	$12,155
30	$375	$12,230
33	$400	$12,305
36	$425	$12,380
42	$475	$12,530
48	$525	$12,680
54	$575	$12,830
60	$625	$12,970
66	$675	$13,120
72	$725	$13,270
78	$780	$13,360
84	$830	$13,570

Note: These costs do not include the 40% increase for design, administration, and contingency included in all other tables.

Drainage neighborhoods were created in order to associate a drainage area with an individual system. The neighborhoods were generally created based on outfall location with some smaller systems grouped together to form a single drainage neighborhood. Figure 6-1 shows the neighborhoods along with the Alternative 1 improvements. These improvements were used to calculate the cost per acre for each neighborhood. The total cost and cost per acre for each neighborhood is summarized in Table 6-3

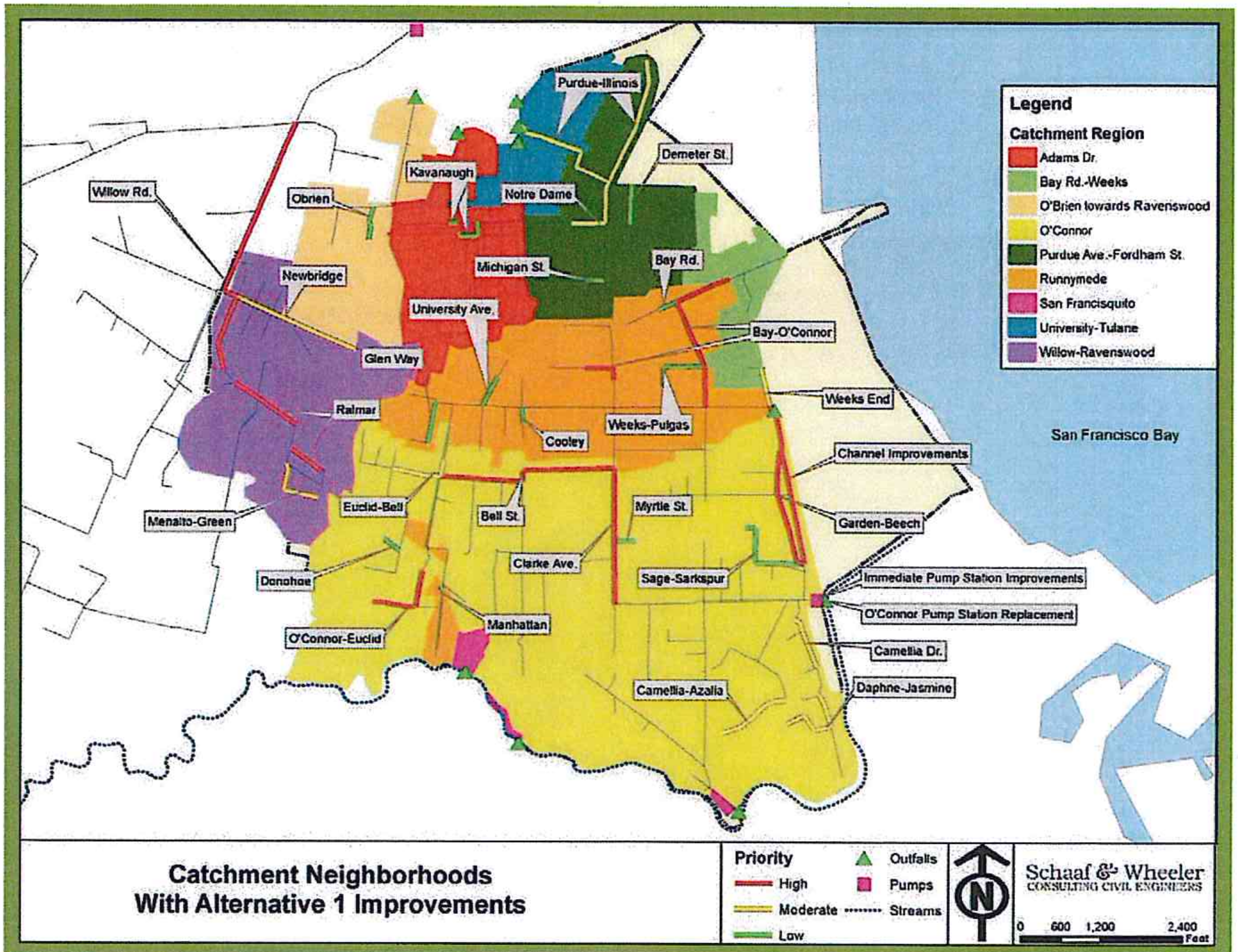

Figure 6-1: East Palo Alto Drainage Neighborhoods

Table 6-3: Neighborhood Cost Summary

Catchment Area	Total Cost/Neighborhood	Cost/Acre
Adams Dr.	$460,000	$5,900
Bay Rd.-Weeks	$940,000	$22,400
Obrien-Ravenswood	$280,000	$7,800
O'Connor	$17,200,000	$27,100
Purdue Ave.-Fordham St.	$2,130,000	$17,400
Runnymede	$4,270,000	$18,700
San Francisquito	-	-
University-Tulane	$1,240,000	$28,600
Willow-Ravenswood	$1,240,000	$9,100

Capital Improvement Program

Storm Drain Improvement CIP

The CIP costs and pipe lengths based on priority level are summarized in Table 6-4. Tables 6-5 and 6-6 detail the CIP cost by alternative and project name. All cost estimates prepared by Schaaf & Wheeler with the exception of the O'Connor pump station improvements and Channel Improvements include an additional 40% for design, administration, and contingency costs. The O'Connor pump station improvements include a 55% contingency to account for higher variability in actual costs. Maps of the improvement priorities with pipe diameters are shown in Chapter 4.

Table 6-4: Summary of Prioritized 10-Year CIP - Pipeline Project Costs

System	High Priority		Moderate Priority		Low Priority	
	Length	Cost	Length	Cost	Length	Cost
Alternative 1	18,100	$22,700,000	9,800	$6,900,000	7,100	$3,800,000
Alternative 2	23,400	$31,200,000	7,500	$5,200,000	5,600	$2,900,000

Table 6-5: Alternative 1 - 10-Year Storm Protection CIP

Project	Pipe Length	Connections	Outfalls	Cost	Priority	Cost w/Contingency
Immediate O'Connor PS Improvements	-	-	-	$380,000	Urgent	$580,000
Bay Rd to O'connor	3,030	12	-	$1,400,000	High	$1,960,000
Bell St.	2,677	12	-	$1,710,000	High	$2,390,000
*Channel Improvements	-	3	-	$1,090,000	High	$1,250,000
Clarke Ave.	1,986	8	1	$1,140,000	High	$1,600,000
Garden to Beech	1,773	4	-	$780,000	High	$1,090,000
Newbridge	1,855	7	-	$750,000	High	$1,050,000
O'connor & Euclid	1,164	6	-	$520,000	High	$730,000
**O'Connor PS Improvement	-	6	-	$4,240,000	High	$6,570,000
Ralmar	1,238	4	-	$490,000	High	$690,000
Willow Rd.	4,386	14	1	$3,430,000	High	$4,800,000
Camellia Dr.	780	3	-	$330,000	Moderate	$460,000
Camelia to Azalia	1,088	4	-	$390,000	Moderate	$550,000
Menalto and Green	886	3	-	$360,000	Moderate	$500,000
Daphne to Jasmine	1,311	5	-	$470,000	Moderate	$660,000
Euclid-Bell	957	4	-	$430,000	Moderate	$600,000
Notre Dame	1,091	4	-	$450,000	Moderate	$630,000
Purdue and Illinois	3,713	14	-	$1,770,000	Moderate	$2,480,000
System Cleaning	-	-	-	$730,000	Moderate	$1,030,000
Bay Rd	292	1	-	$90,000	Low	$130,000
Cooley	237	1	-	$90,000	Low	$130,000
Demeter St.	567	2	1	$250,000	Low	$350,000
Donohoe	282	2	-	$120,000	Low	$170,000
Glen Way	605	2	-	$190,000	Low	$270,000
Kavanaugh	648	4	-	$330,000	Low	$460,000
Manhattan	71	1	-	$30,000	Low	$40,000
Michigan St	252	1	-	$90,000	Low	$130,000
Myrtle St.	345	2	-	$140,000	Low	$200,000
Obrien	501	3	-	$200,000	Low	$280,000
Sage and Larkspur	1,395	5	-	$460,000	Low	$640,000
University Ave	481	1	-	$150,000	Low	$210,000
Weeks End	565	2	-	$210,000	Low	$290,000
Weeks to Pulgas	870	3	-	$320,000	Low	$450,000

**Cost Estimate by Wilsey Ham **Assumed Pump Station Replacement*

Table 6-6: Alternative 2 - 10-Year Storm Protection CIP

Project	Pipe Length	Connections	Outfalls	Cost	Priority	Cost w/Contingency
Immediate O'Connor PS Improvements	-	-	-	$380,000	Urgent	$580,000
Illinois-O'Connor Alt 2	8,060	33	-	$3,960,000	High	$5,540,000
Bay Rd. Pump Station	-	3	-	$4,800,000	High	$4,800,000
*Channel Improvement (Wilsey Ham)	-	3	1	$1,090,000	High	$1,250,000
Bell-Clarke Alt 2	3,315	12	-	$1,860,000	High	$2,600,000
Garden to Beech	1,856	4	-	$1,010,000	High	$1,410,000
Newbridge	1,855	7	-	$750,000	High	$1,050,000
O'connor and Euclid	1,164	6	-	$520,000	High	$730,000
**O'Connor PS Improvement	-	6	1	$4,240,000	High	$6,570,000
Willow Rd.	4,379	14	-	$3,420,000	High	$4,790,000
Ralmar	1,349	4	-	$520,000	High	$730,000
Euclid-Bell	932	4	-	$420,000	Moderate	$590,000
Weeks End	571	2	-	$210,000	Moderate	$290,000
Menalto and Green	981	4	-	$410,000	Moderate	$570,000
Purdue Ave. Alt 2	523	2	-	$230,000	Moderate	$320,000
Camellia Dr.	779	3	-	$330,000	Moderate	$460,000
Camellia to Azalia	1,084	4	-	$390,000	Moderate	$550,000
Daphne to Jasmine	1,311	3	-	$470,000	Moderate	$660,000
Notre Dame	1,360	5	-	$500,000	Moderate	$700,000
System Cleaning	-	-	-	$730,000	Moderate	$1,030,000
Kavanaugh Dr.	648	4	-	$330,000	Low	$460,000
Donohoe	282	2	-	$120,000	Low	$170,000
Glen Way	605	2	-	$200,000	Low	$280,000
Manhattan	71	1	-	$30,000	Low	$40,000
Michigane Ave.	252	1	-	$80,000	Low	$110,000
Myrtle St.	345	2	-	$140,000	Low	$200,000
Obrien	685	3	-	$260,000	Low	$360,000
Sage Larkspur	1,399	5	-	$460,000	Low	$640,000
University Ave.	481	1	-	$150,000	Low	$210,000
Weeks to Pulgas	868	3	-	$320,000	Low	$450,000

**Costs by Wilsey Ham **Assumed Pump Station Replacement*

The pipe improvements recommended in the above tables are a combination of capacity related improvements and system realignments to reduce the number of outfalls to the San Francisco Bay. A number of the smaller existing systems in the north of East Palo Alto are currently undersized. Providing system realignments and adding new connections decreases flooding on the streets of East Palo Alto and at the same time lowers the outfall maintenance costs.

System Cleaning Costs

Sediment removal has been categorized as a moderate priority project and is included as part to this CIP. Costs for removing the sediment in the systems have been calculated based on the observed levels of sediment and water documented by V&A in the Storm Drain Condition Assessment report. The sediment map (Figure 2-3) shows the locations of sediment in the various systems. Cleaning costs are included in the CIP Tables (6-5 and 6-6) and account for dewatering, sediment removal, and waste disposal; a more detailed breakdown is included below in Table 6-7.

Table 6-7. Storm Drain Cleaning Costs

Item	Unit Cost	Units	Cost (Approx.)	Costs w/Contingency
Dewatering of Runnymede System				
Adler/Baker Tank Rental	$2,500/tank/wk.	30 takns,1 wk.	$75,000	$105,000
Sump Pump Rental	$1,500/pump/wk.	2 pumps, 1 wk.	$3,000	$4,000
Labor	$800/day/worker	5 days, 4-person crew	$16,000	$22,000
Mobilization/Demobilization	-	-	$10,000	$14,000
Dewatering of Separate Storm Drain Systems				
Water truck for transport	$700/day	5 days, 2 trucks	$7,000	$10,000
Vactor truck and operators	$2000/day	5 days	$10,000	$14,000
Pipe Plugs	$1,000	2	$2,000	$3,000
Sump Pump Rental	$1,500/pump/wk.	2 pumps, 1 wk.	$3,000	$4,000
Labor	$800/day/worker	5 days, 4-person crew	$16,000	$22,000
Mobilization/Demobilization	-	-	$10,000	$14,000
Sediment Removal				
Bucket Machine (pipes up to 36 inches)	$5/linear foot	25,200 linear ft.	$126,000	$176,000
Bucket Machine with Manned Entry (pipes larger than 36 inches)	$15/linear foot	5,750 linear ft.	$86,000	$120,000
			Transportation and Disposal	
Transportation and Disposal (1,830 cu. Yd. of material)	$130/ton	2,841 tons	$370,000	$518,000
Total			$734,000	$1,028,000

Costs for dewatering the Runnymede system are calculated based on the assumption that water will be pumped into storage tanks and then released into the sewer main at the east end of Runnymede Street during off peak hours.

O'Connor Pump Station Improvements

Based on the deficiencies identified in Chapter 4, immediate improvements are recommended as urgent priority, and a complete rehabilitation or replacement of the O'Connor Street pump station is recommended as a high priority improvement. The improvement costs for the O'Connor Pump Station have been included in the CIP Tables (6-5 and 6-6) for both Alternatives 1 and 2. A detailed breakdown of the improvement costs for immediate improvements and the pump station replacement is presented in Table 6-8 and Table 6-9 respectively. Individual site constraints for pump replacements and rehabilitations are difficult to determine until the design phase of a project and can create high variations in actual construction costs. To account for this a 55% contingency is used for all O'Connor pump station improvement cost estimates.

Table 6-8: Immediate Improvements

Improvements	Cost (Dollars)
Rebuild Diesel Engine No. 3	$30,000
Inspect/Maintain Pump and Dive Units	$150,000
Replace Fuel Pumps (4)	$10,000
Relocate (E) Electrical Equipment	$100,000
Replace (E) 40 HP Motor w/ Explosion Proof Motor	$60,000
Replace (E) Light Fixtures and Outlets w/ Explosion Proof Equipment	$25,000
Subtotal	$375,000
Contingency (55%)	$206,000
Total	**$581,000**

Table 6-9: Pump Station Replacement

Improvement	Cost (Dollars)
Construct (N) Concrete Pump Station Structure	$1,250,000
(N) 200 HP High Flow Pumps (4)	$1,000,000
(N) 40 HP Low Flow Pump	$60,000
(N) Electrical Control Panels and MCC	$1,000,000
(N) Standby Engine Generator and Fuel Tank	$750,000
(N) PG&E Transformer and Electrical Service	$75,000
Miscellaneous Equipment and Construction	$100,000
Subtotal	$4,235,000
Contingency (55%)	$2,330,000
Total	**$6,565,000**