

Drainage System Master Plan

FINAL

February 2006





Los Angeles
Sacramento
San Francisco
San Jose
Walnut Creek

February 24, 2006

City of Waterford
Mr. Tony Marshall, P.E.
Consulting City Engineer
322 Sun West Place
Manteca, CA 95337

Subject: Final Storm Drain System Master Plan

Dear Mr. Marshall:

RMC is pleased to submit this final version of the Storm Drain System Master Plan for the City of Waterford. This Plan documents the following:

- Land use analyses, storm runoff estimates, and the development of a hydraulic model for the City's proposed annexation area;
- A Master Plan for the future storm drain system network for buildout expansion of the City within the study area boundary; and,
- A Capital Improvement Program (CIP) for storm drain improvements needed to serve this area

We greatly appreciate the support and guidance that we have received from the City throughout this process.

If you have any questions, please don't hesitate to contact us at (916) 273-1500.

Sincerely,
RMC Water and Environment

Glenn E. Hermanson, P.E.
Project Manager

Austin Peterson, P.E.
Project Engineer



2868 Prospect Park Drive
Suite 130
Rancho Cordova, CA 95670
ph: 916.273.1500
fax: 916.273.1501
www.rmcwater.com



City of Waterford Storm Drain Master Plan

Final Report

Prepared by:
RMC
Water and Environment

February 2006

Table of Contents

Chapter 1 Introduction	1-1
1.1 Background and Purpose	1-1
1.2 Study Area	1-1
Chapter 2 Study Area Characteristics	2-1
2.3 Land Use	2-1
2.4 Topography	2-2
2.5 Soils	2-2
2.6 Climate	2-3
Chapter 3 Analysis Methodology	3-1
3.1 Existing Conditions	3-1
3.1.1 Existing Drainage and Irrigation Facilities	3-1
3.1.2 Federal Emergency Management Agency Flood Insurance Rate Maps	3-2
3.2 Watershed and Subsheds	3-2
3.2.1 Overview of the Watershed and Subsheds	3-2
3.2.2 Planned Development within the Subsheds	3-3
3.3 Design Standards	3-4
3.4 Model Development	3-5
3.4.1 Modeling Software and Input Parameters	3-5
3.4.2 Modeling Approach	3-7
Chapter 4 Recommended Projects	4-1
4.5 Subshed A	4-2
4.6 Subsheds B and C	4-3
4.6.1 Subshed B	4-5
4.6.2 Subshed C	4-5
4.7 Subshed D and E	4-5
4.7.1 Subshed D	4-5
4.7.2 Subshed E	4-6
Chapter 5 Opinion of Probable Costs	5-1
Chapter 6 Permitting Requirements & Future Regulations	6-1
6.1 Storm Water Permitting	6-1
6.1.1 Construction Permit	6-1
6.1.2 Small MS4 General Permit	6-3
6.2 Future Regulatory Direction	6-4
Chapter 7 References	7-1
Appendix A	A-1
Appendix B	B-1

List of Tables

Table 1 - Proposed Land Uses	2-1
Table 2 - Climate Data	2-3
Table 3 - Design Criteria for Model	3-4
Table 4 - Allowable Pipe Materials	3-5
Table 5 - Design Storm Rainfall Totals	3-7
Table 6 - Subshed A Proposed Facilities Description	4-2
Table 7 – Proposed Detention Basins Descriptions	4-2
Table 8 - Subshed B and C Proposed Facilities Description	4-5
Table 9 - Subsheds D and E Proposed Facilities Description	4-6

Table 10 - Cost Criteria for Recommended Projects	5-1
Table 11 - Storm Drain System Cost Estimate	5-2

List of Figures

Figure 1 - Study Area	1-2
Figure 2 - Study Area Land Use.....	2-2
Figure 3 - MID Irrigation Infrastructure	3-1
Figure 4 - Watersheds and Subsheds	3-3
Figure 5 – Proposed Storm Drain Layout	3-8
Figure 6 - Detention Basins Schematic	3-10
Figure 7 – Proposed Storm Drain Systems Identification.....	4-1
Figure 8 - Profile for Subshed A Proposed Storm Drain System	4-3
Figure 9 - Profile for Subshed B Proposed Storm Drain System	4-4
Figure 10 - Profile for Subshed C Proposed Storm Drain System	4-4
Figure 11 – Profile 1 for Subsheds D and E Proposed Storm Drain System.....	4-7
Figure 12 - Profile 2 for Subsheds D Proposed Storm Drain System	4-7

Appendices

Appendix A	Storm Water Design and Maintenance Considerations
Appendix B	Stormwater Management Plan BMPs

Acknowledgements

The 2006 Storm Drain Master Plan represents a collaborative effort between RMC and the City of Waterford. We would like to thank the following key personnel from the City whose invaluable knowledge, experience, and contributions were instrumental in the preparation of this Master plan.

Tony Marshall – Consulting City Engineer, City of Waterford

Robert Borchard – Consulting City Planner, City of Waterford

List of Abbreviations

AF	Acre-feet
BMP	Best Management Practice
BOD	Biological Oxygen Demand
CFS	Cubic Feet per Second
CIMIS	California Irrigation Management Information System
CIP	Capital Improvement Plan/Program
CN	Curve Number
DU	Dwelling Unit
EO	Executive Officer
EPA	Environmental Protection Agency
FIRM	Flood Insurance Rate Map
FIS	Flood Insurance Study
GIS	Geographic Information System
GPD	Gallons per Day
GPM	Gallons per Minute
HGL	Hydraulic Grade Line
HSG	Hydrologic Soil Group
IDF	Intensity Duration Frequency
MCM	Minimum Control Measure
MEP	Maximum Extent Practicable
MGD	Million Gallons per Day
MID	Modesto Irrigation District
MS4	Small Municipal Separate Storm Sewer
NPDES	National Pollution Discharge Elimination System
NRCS	National Resource Conservation Service
SCADA	Supervisory Control Data Acquisition System
SCS	Soil Conservation Service
SWMP	Storm Water Management Plan
SWPPP	Storm Water Pollution Prevention Plan
SWRCB	State Water Resources Control Board
TOC	Time of Concentration
TR	Technical Resource
RWQCB	Regional Water Quality Control Board

Chapter 1 Introduction

This report presents the results of a study to develop a master plan for storm drains in the proposed areas of annexation (study area) to the City of Waterford (City). The report was prepared by RMC Water and Environment (RMC) under a contract with the City dated March 20, 2005.

The storm drain system facilities presented in this master plan were developed using information available at the time this report was drafted. This report shall act as the guiding document for design of storm drains in the study area; however, there may be circumstances in which it is necessary to deviate from the concepts presented in this master plan. Any deviations from the master plan shall only be allowed upon prior approval of the City Engineer.

1.1 Background and Purpose

The City is planning to annex approximately 1,610 acres of agricultural land surrounding the existing City boundary as shown in Figure 1. To help plan for the development of the study area, the City contracted with RMC to develop the following planning documents:

- Water Distribution Master Plan
- Sewer System Master Plan
- Storm Drainage Master Plan
- Urban Water Management Plan
- Wastewater Treatment Plant Master Plan

This Storm Drain Master Plan (Plan) provides information required for the City's planning and financial efforts, and defines the storm drain system improvements necessary to accommodate the City's future land use development plans. The scope of this Plan includes the following major tasks:

1. Create a computerized hydraulic model of the future storm drain system in the expansion area using HEC-HMS;
2. Create a Plan for the future storm drain system network for buildout expansion of the City within the study area boundary; and,
3. Develop a Capital Improvement Program (CIP) for storm drain improvements needed to serve this area.

1.2 Study Area

The City is located in the eastern portion of Stanislaus County, approximately 13 miles east of Modesto and 11 miles northeast of Turlock. The City is bordered on the south by the Tuolumne River, on the north by the Modesto Irrigation District (MID) Modesto Main Canal, on the west by Eucalyptus Avenue, and on the east by a parcel boundary south of MID Lateral Connection No. 8.

The study area for this Plan comprises approximately 1,610 acres of agricultural land surrounding the City's existing boundary to the north, east, and west. The study area forms a semicircular arc around the existing City, and is bounded by the Tuolumne River on the south and Dry Creek on the north. Figure 1 presents the geographical limits of the study area.

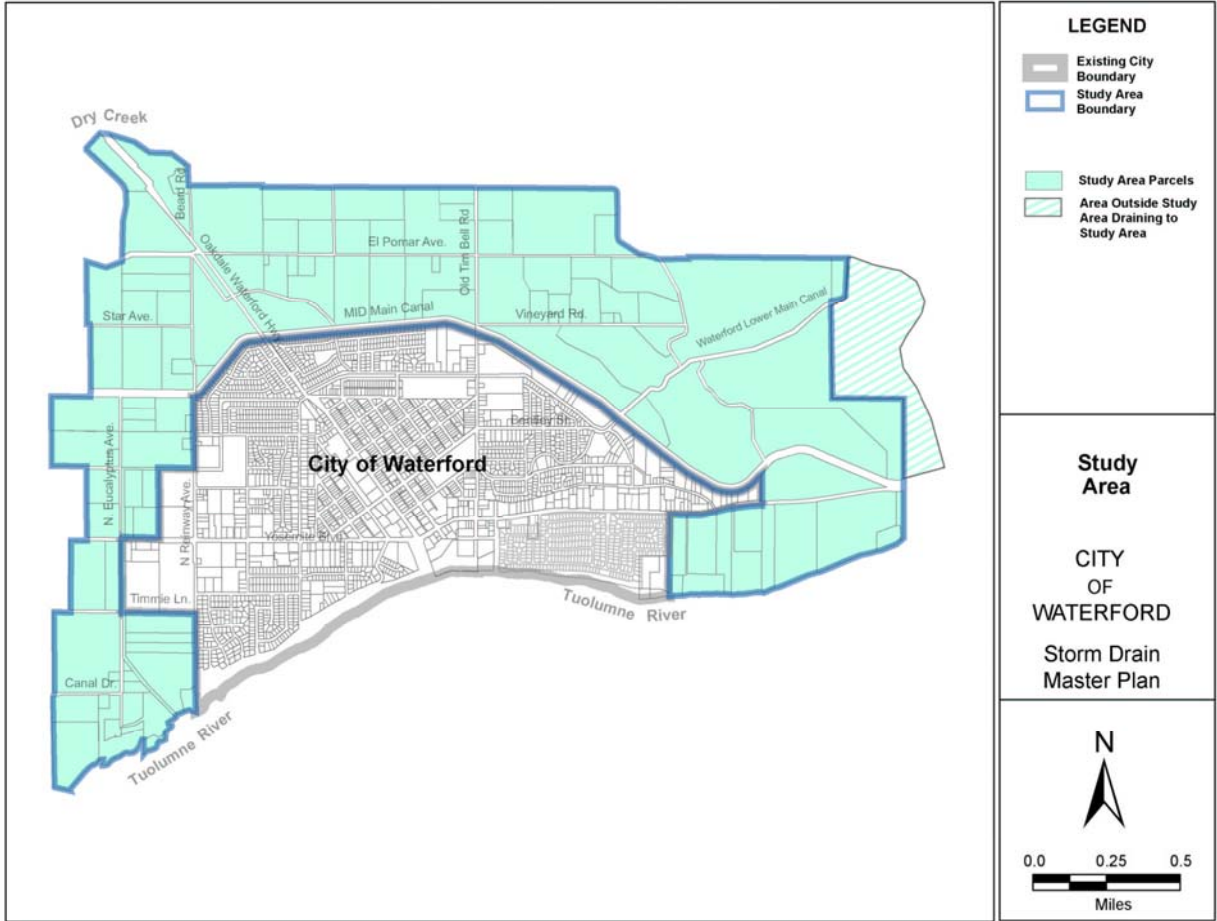


Figure 1 - Study Area

Chapter 2 Study Area Characteristics

This section provides a summary of the City's study area's characteristics including land use, terrain, climate and soils.

2.3 Land Use

The City's proposed annexation area consists primarily of agricultural lands surrounding the City's existing boundary. The study area's boundary, service area boundaries, land use maps, and databases were developed by incorporating the following information:

- GIS Parcel Map – Downloaded from the Stanislaus County GIS Library¹
- Annexation Area Map – Hard copy provided by MCR Engineering, Inc.
- River Pointe Development files – AutoCAD files provided by TKC Engineering
- Land Use Map – Hard copy provided by MCR Engineering, Inc.

A GIS (Geographic Information System) land use database was developed for each parcel by assigning the land use category from the paper map provided by MCR Engineering to the downloaded GIS parcel map. The proposed land uses associated with the study area are discussed and quantified below.

Table 1 presents a summary of the proposed buildout land use categories, their associated densities, and gross acreage developed as part of the land use evaluation task for this Master Plan.

Table 1 - Proposed Land Uses

Land Use Category	Residential Density (DU/acre)	Gross Acreage ¹	Percentage of Area
Low Density Residential	4.5	1,316	81%
Industrial	n/a	126	8%
General Commercial	n/a	48	3%
	Subtotal	1,490	92%
Major roads and canals	n/a	129	8%
	TOTAL	1,619	100%

1. Gross acreage includes future roadways, medians and sidewalks. Net acreage information is not available since the study area has not been subdivided into individual parcels and roadways. On average, net acreage is approximately 80 to 90 percent of the gross acreage.

As shown in Table 1, and illustrated in Figure 2, the majority of existing vacant land is planned for future low density residential development. At this time, the location and number of schools and parks have not been identified. Schools, parks, an artificial lake, and storm water detention basins will be located within the low density residential area. The light industrial area may also have storm water detention basins.

¹ <http://regional.stangis.org/>

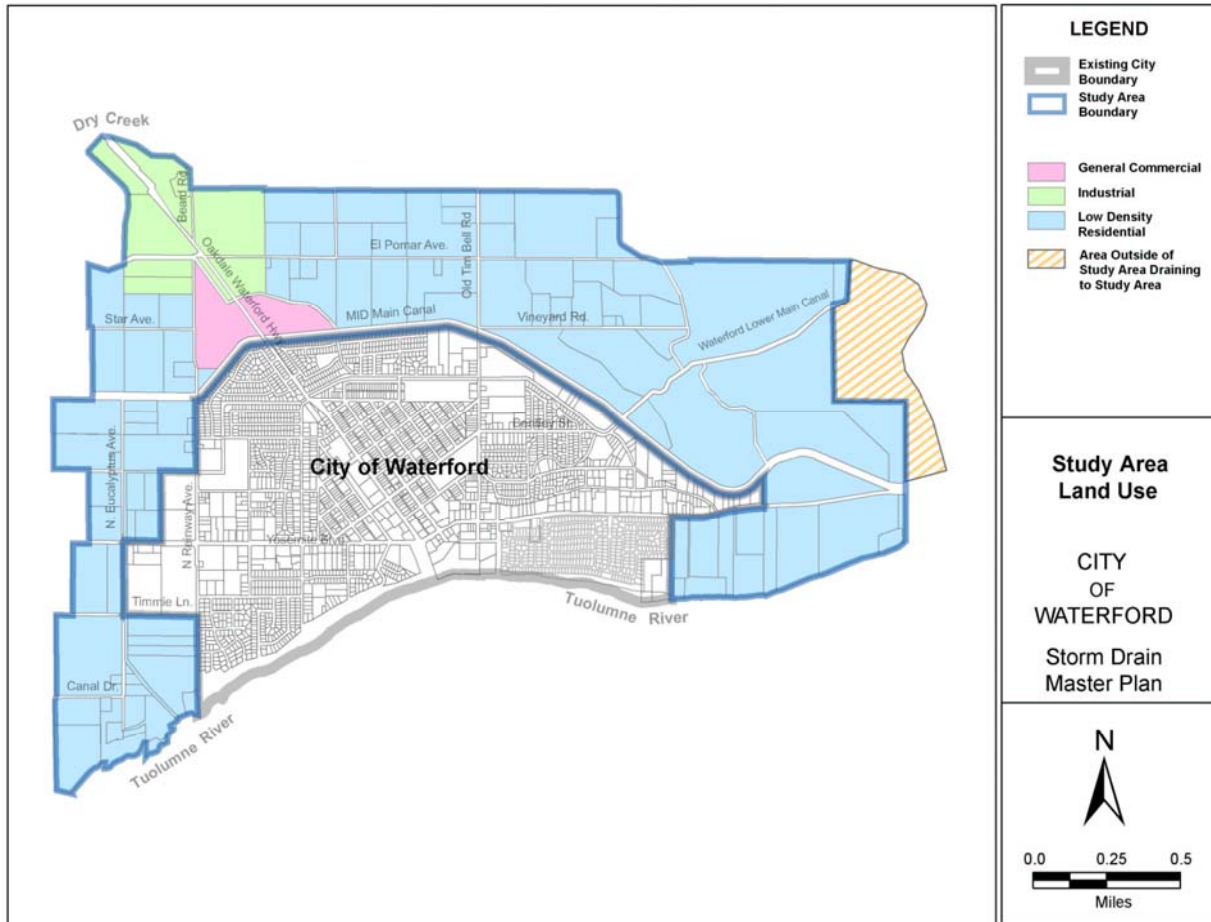


Figure 2 - Study Area Land Use

2.4 Topography

The terrain in the western half of the study area is very flat, with the exception of the southwestern corner of the study area that straddles the cliff north of the Tuolumne River. Terrain in the eastern half of the study area is more varied, rising from 160 feet above sea level to around 200 feet above sea level in the eastern and northeastern sections of the study area.

2.5 Soils

The Natural Resource Conservation Service classifies soils into four hydrologic soil groups based on the soil's runoff potential:

Group A is sand, loamy sand or sandy loam types of soils. These soils have low runoff potential and high infiltration rates even when thoroughly wetted. They consist chiefly of deep, well to excessively drained sands or gravels and have a high rate of water transmission.

Group B is silt loam or loam. These soils have a moderate infiltration rate when thoroughly wetted and primarily consist of moderately drained soils with moderately fine to moderately coarse textures.

Group C soils are sandy clay loam. These soils have low infiltration rates when thoroughly wetted and primarily consist of soils with a layer that impedes downward movement of water and soils with moderately fine to fine structure.

Group D soils are clay loam, silty clay loam, sandy clay, silty clay or clay. These soils have the highest runoff potential and very low infiltration rates when thoroughly wetted. They primarily consist of clay soils with a high swelling potential and/or soils with a permanent high water table.

Soils within the study area range from B-D, with Type C soils accounting for approximately 56 percent of the soils, Type B soils accounting for 42 percent of the soils and Type D soils accounting for approximately 4 percent of the soils².

2.6 Climate

Climate data including temperature and precipitation estimates used for the Waterford area were obtained from the Western Regional Climate Center near Modesto, California. The period of record was January 1, 1931 through December 31, 2004.

In general Waterford's climate is described as continental, characterized by moderate, wet winters and hot, dry summers. Table 2 shows the historic climate characteristics in the Waterford area. For this study, the more conservative mean annual precipitation of 12.7 inches presented in the Stanislaus County Standards and Specifications was used in the model development.

Table 2 - Climate Data

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Monthly Average ETo ⁽¹⁾ (in)	0.87	1.71	3.43	5.24	6.7	7.4	7.85	6.75	4.93	3.37	1.66	0.87	50.78
Average Total Precipitation ⁽²⁾ (in)	2.37	2.13	1.94	1.07	0.46	0.09	0.03	0.04	0.2	0.64	1.36	2.1	12.42
Average Max Temperature ⁽²⁾ (F)	53.7	60.8	66.9	73.4	81.1	88.2	94.1	92.1	87.7	78	64.4	54.2	74.5
Average Min Temperature ⁽²⁾ (F)	37.7	40.9	43.4	46.8	51.7	56.4	59.8	58.7	56	49.7	41.7	37.8	48.4

1. Data from CIMIS Station #71. The period of record is June 1987 to present.

2. Data from Western Regional Climate Center (<http://www.wrcc.dri.edu/cgi-bin/cliMAIN.pl?camode+nca>) for Modesto, CA. Period of record is 1/1/1931 through 12/31/04.

² Natural Resources Conservation Service website, <http://soildatamart.nrcs.usda.gov/>

Chapter 3 Analysis Methodology

This section presents the analysis methodology used to develop the Storm Drain Master Plan for the City of Waterford. As discussed below, the methodology involved (1) analyzing the existing conditions relating to drainage facilities and flood plains; (2) establishing subsheds for runoff; (3) defining all pertinent design criteria and assumptions; and (4) developing a model in order to define storm drain facility requirements and sizing.

3.1 Existing Conditions

The City’s study area consists primarily of agricultural lands surrounding the City’s existing boundary. The following sections describe the pertinent conditions in the area.

3.1.1 Existing Drainage and Irrigation Facilities

There are a number of MID irrigation canals and drainage ditches in the annexed area and City as shown in Figure 3. These facilities have historically been used for irrigation and drainage purposes. The MID Modesto Main canal acts as a natural drainage boundary because water cannot flow from one side to the other without being intercepted by the canal.

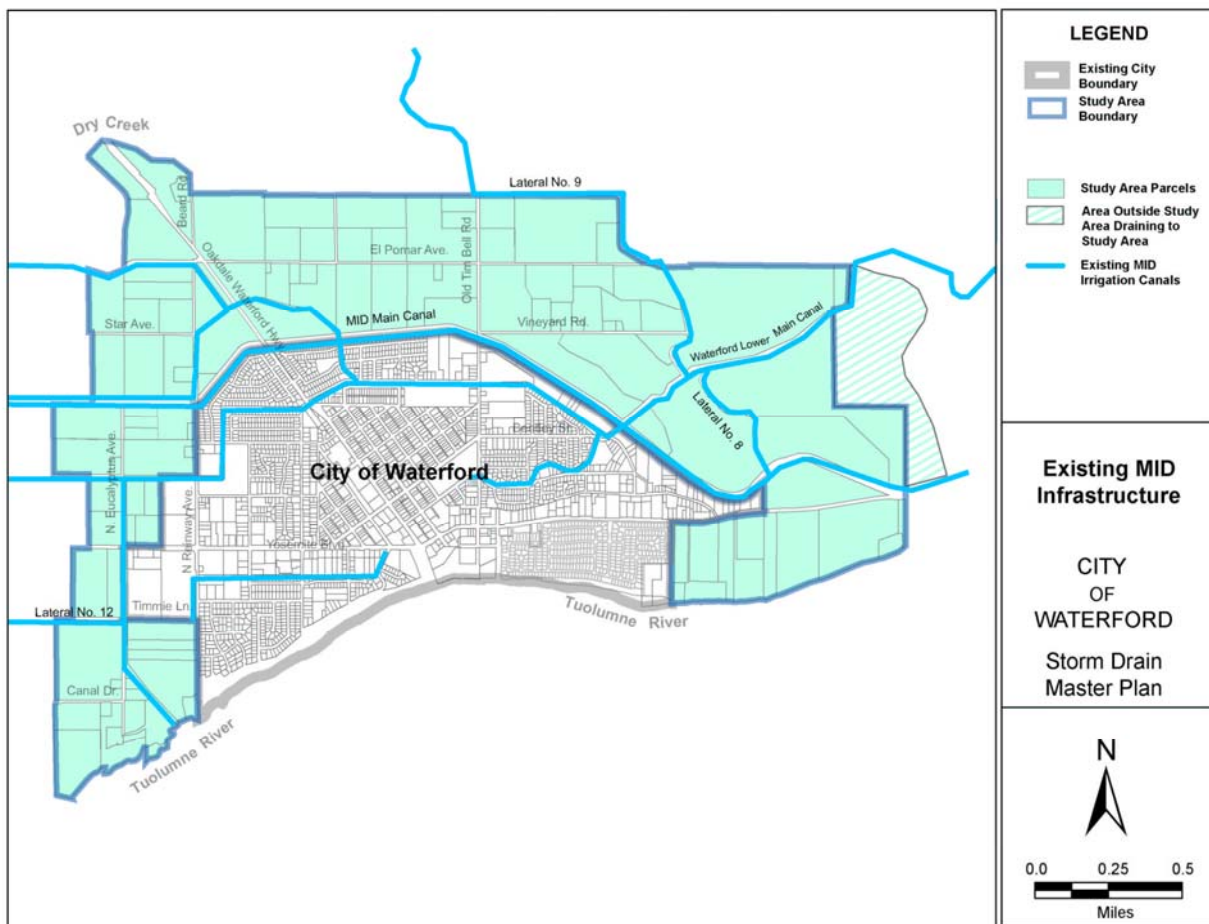


Figure 3 - MID Irrigation Infrastructure

It is anticipated that construction across the Modesto Main Canal will be accomplished by boring and jacking underneath the canal. With the exception of the Modesto Main Canal, all construction across the remainder of the MID canals and ditches will be completed using common construction methods. The following list provides some scenarios that may occur pending MID approval:

- 1) The canals/ditches remain in place and construction across them can be accomplished using open cut trenching methods,
- 2) The ditches may be replaced with pipe and covered, or
- 3) The ditches may be filled in and abandoned.

This study assumes that the MID irrigation canals will not be used to convey storm water for the following reasons:

1. *Inadequate Sizing of Canals.* Unlike storm water conveyance canals, irrigation canals tend to get smaller towards the end of the line. At the end of the line the canal only needs to be big enough to supply the end users. Some of the canals in the study area would need to be upsized to convey the storm water.
2. *Pending Regulations for Use of Canals.* The District is concerned that storm water would introduce pollutants such as heavy metals into the system, and that it would consume capacity needed for delivery of irrigation water. As such, the District is in the process of establishing criteria for use of their canals to convey storm water. The following potential requirements for use of their canals were identified during recent discussions:
 - a. 48-hour 100-year storage prior to discharge into the canal to allow settling of heavy metals.
 - b. Access to SCADA system for monitoring
 - c. Assessment fees
 - d. Sufficient notice, in the range of 48 hours, prior to each discharge into their canals

3.1.2 Federal Emergency Management Agency Flood Insurance Rate Maps

FEMA Flood Insurance Studies (FIS) and Flood Insurance Rate Maps (FIRM) for the area were analyzed to determine the 100-year floodplain elevations and flood categories for the area. The City and study area are predominately categorized as Zone C, which is defined as “areas of minimal flooding”. The local vicinity of Dry Creek and the Tuolumne River are categorized as Zone A and Zone B flood zones. Zone A is defined as “areas of 100-year flooding; base flood elevations and flood hazards not determined” and Zone B is defined as “areas between limits of the 100-year flood and 500-year flood; or certain areas subject to 100-year flooding with average depths less than (1) one foot or where the contributing drainage area is less than one square mile; or areas protected by levees from the base flood”.

The Flood Insurance Study completed in 1979 for the City of Waterford presents the 100-year floodplain elevation for the Tuolumne River at Hickman Road Bridge as 86 feet above mean sea level based on the Northern Geographic Vertical Datum. Dry Creek was not mapped as part of the City FIS or the Stanislaus County Unincorporated Area FIS.

3.2 Watershed and Subsheds

3.2.1 Overview of the Watershed and Subsheds

The storm drains must convey runoff from the study area and any tributary areas. The study area is predominately flat receiving little runoff from outside areas except for the eastern boundary. On the

eastern boundary of the study area there is some varied terrain outside of the boundary that is tributary to the study area.

As shown in Figure 4, the watershed was divided into subsheds and subbasins based on topographic barriers such as the Modesto Main Canal, planned development, parcel information and proximity to the two outlets, Tuolumne River and Dry Creek. Subshed boundaries are also based on regional topographic information collected from an aerial survey, aerial photography, and USGS maps. For the study area, there are 29 subsheds in total with an average area of 58 acres per subshed.

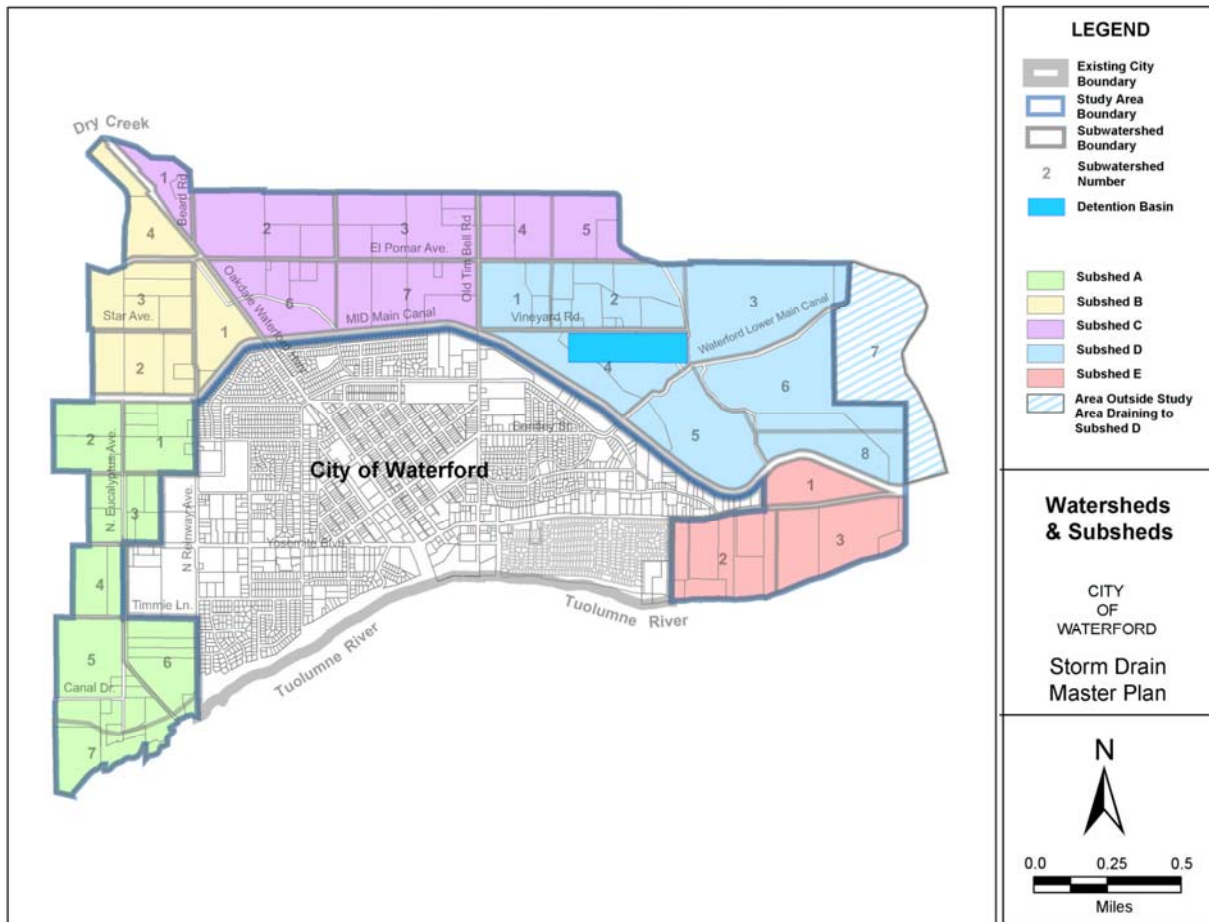


Figure 4 - Watersheds and Subsheds

3.2.2 Planned Development within the Subsheds

There is one planned residential development in the eastern study area. The development will occur in portions of subshed D, subbasins 1, 2, 3, 4, 5 and 8. There is a planned detention/retention basin located subbasin 4 and shown schematically in Figure 4 that was initially designed to contain all the storm runoff from the development. According to the developer, the total storage of the basin is approximately 129 acre-feet. The basin also functions as a recreation pond for the surrounding homes and has aesthetic benefits.

Operation of the basin shall be closely monitored throughout the year and especially during the winter months when there is a potential for flooding during heavier rainfall events. However, the basin still must provide recreational benefits as well as storm water storage.

3.3 Design Standards

The City of Waterford has not adopted storm drain facility design standards or specifications. This Plan establishes general design standards that shall be used in the design of future storm drains in the study area. Design standards presented in this Plan were compiled from a number of sources including:

- Stanislaus County Standards and Specifications
- City of Modesto Design Standards and Specifications
- Caltrans Standards and Specifications
- Modesto Irrigation District design criteria
- NPDES Phase II storm water permitting requirements
- Standard engineering practice

Design standards not addressed in this Plan shall conform to the minimum standards established by the City of Modesto. All designs failing to comply with the minimum standards established by the City of Modesto and this Plan shall be approved by the City Engineer prior to construction of said facilities. In addition, designs that deviate from the standards established in this Plan and the Modesto standards will be required to be approved by the City Engineer prior to construction. For example, best management practices that are not addressed in either of the documents will need to be approved prior to construction. It is recommended that the City of Waterford adopt design standards specific to their storm drain system so that the City will not have to rely on Modesto standards.

This Plan establishes certain design criterion superseding the standards presented in the aforementioned documents. These criteria are presented below for clarity and shall be used in the design of all future improvements. Table 3 presents additional design standards that should be adhered to during design.

1. The main trunk storm drain pipes presented and modeled as part of this master plan shall be designed to convey the 2-year 24- hour storm runoff without discharging to the detention basins. The main trunk storm drain pipes in conjunction with the operation of the detention basins shall be designed to convey the 50-year 24-hour storm event below the top of grate of the drainage inlets.
2. Laterals not presented in this master plan and connecting to the main trunk pipe shall be designed to meet the minimum standards presented in the City of Modesto Standards.
3. Drainage detention/retention facilities shall store a minimum of the 100-year, 24-hour storm with one foot of freeboard.

Table 3 - Design Criteria for Model

Criteria	Recommendation
Manning's "n"	0.013 for all materials
Minimum storm drain pipe diameter	12 inches
Minimum/maximum velocity	Conform to City of Modesto standards

Criteria	Recommendation
Minimum pipe depth	Maintain two feet of cover minimum from top of pipe to finished grade. At least 3 feet of separation between flow line of creeks and crown of pipe. Deviations from minimum requirements must be approved by City Engineer.
Increase in pipe size	Match crowns when increasing in pipe size.
Headloss in manholes	Deflections manholes with a deflection greater than 20 degrees shall be assigned a 0.1 foot drop. Deflections greater than 90 degrees are not allowed.

Table 4 presents a list of allowable pipe materials to be used in the construction of storm drains. Deviations from this list must be approved by the City Engineer.

Table 4 - Allowable Pipe Materials

Pipe Material	Diameter	Standard Designation
Precast Reinforced Concrete Pipe Class III minimum	12" – 60"	ASTM C76 (Pipe); Caltrans Standards Specifications Section 65 (Bell and Spigot joints)
Cast in Place Concrete Pipe	12" – 60"	Caltrans Standards Specifications Section 63 and 90. Concrete to be a minimum of 4000 psi.
Polyvinyl Chloride Pipe (PVC)	12" – 42"	ASTM D3034, SDR 35. All PVC pipe joints shall be integral wall bell and spigot configuration factory formed, all rubber rings shall conform to ASTM F477
PVC	48"	AWWA C905 SDR 41

3.4 Model Development

3.4.1 Modeling Software and Input Parameters

The modeling software used to design the storm water facilities includes HEC-HMS and spreadsheet calculations. A more sophisticated model such as EPA SWMM was not considered practical at this stage of the design. Although EPA SWMM has very powerful tools, those tools would be of little use at this preliminary stage of this study. HEC-HMS was developed by the US Army Corps of Engineers and is used in standard practice for developing watershed routing models. HEC-HMS provides routing of the runoff, calculates a hydrograph for detention/retention basin sizing, and calculates the peak discharges which are all applicable to this Plan. Many of the input parameters for the model can be calculated using the Natural Resources Conservation Service *Urban Hydrology for Small Watersheds, TR-55*.

HEC-HMS has three components: Basin Model, Metrologic Model, and Control Specifications. In the Basin Model, the user enters information on the subshed area and characteristics, loss rate, transform method, baseflow characteristics, and reach type. The user enters meteorological information such as the design storm event in the Metrologic Model. In the Control Specifications component, the user enters the date and duration of the storm event. The following characteristics were used in the model.

Loss Rate

For this study, the loss rate was calculated using the SCS Curve Number method, an empirical curve number method developed by the NRCS to estimate total excess precipitation for a storm based on cumulative precipitation, soil cover, land use, and antecedent moisture. Required parameters include the curve number (CN), which can range from 0 to 99, impervious area percentage, and initial loss.

Curve Number. CNs are categorized by the type of land use, such as agricultural lands with row crops, and are dependent on the hydrologic soil group (HSG) (i.e., soils A, B, C and D), cover type, treatment, hydrologic condition, and antecedent runoff condition. The model is based on curve numbers developed as part of TR-55 and includes the following assumptions:

- *Land Use Type:* This model assumes an open space land use category which is described as lawns, parks, golf courses, cemeteries, etc.
- *Cover Type:* The model is dependent on the condition (or quantity) of the grass cover, whether it be poor, fair, or good. For this model, the fair condition (grass cover 50% to 75%) category was used.
- *Hydrologic Soil Group:* As mentioned previously, fifty-six percent of the soils in the study area are Type C and 42 percent are Type B soils. A CN value of 75 was extrapolated between the two CNs for Type C and Type B soils based on the percentage of land of each soil.

Impervious Area. To account for the area that is covered by streets, driveways, and homes an impervious area of 50% was used. As a comparison, TR-55 recommends a 38% impervious area for residential districts of $\frac{1}{4}$ acre lots and a 65% impervious area for $\frac{1}{8}$ acre lots (i.e., town houses). Although the land use in the area is predominately $\frac{1}{4}$ acre lots, a higher percentage impervious area was used to account for the light industrial areas and the additional impervious areas provided by the transportation infrastructure that is not inherently incorporated into the estimates by TR-55.

Initial Loss. TR-55 presents a method for calculating initial abstraction, which is all losses before runoff begins (i.e., water detained in surface depressions, water intercepted by vegetation, evaporation, and infiltration). For the model, an initial loss of 0.15 inches was used assuming the ground was near saturation.

Transform Method

Using empirical data from small agricultural watersheds across the United States, the NRCS has developed a parametric unit hydrograph technique to compute the hydrograph peak and lag time. The time of concentration (TOC) and lag time were calculated using the SCS Unit Hydrograph method presented in TR-55 and assuming the following flow paths:

1. Sheet flow over grass at a residence assuming the slope of the yard is 1%, the length is 50 feet, and the manning's friction coefficient "n" is 0.24 (dense grass, such as bluegrass or buffalo grass). A precipitation depth of 1.3 inches corresponding to a two-year rainfall event (based on City of Modesto Standards and Specifications). This time was used for all the subsheds and equaled 0.28 hours or 16.8 minutes.
2. Gutter flow in the street was assumed to occur for 200 feet at a slope of 0.05 before entering a drainage inlet. From Figure 3-1 in TR-55 the velocity is approximately 4.6 ft/s and the total time is 0.012 hours or 0.72 minutes.
3. Lastly, water travels through the sublaterals in each subshed. The distance was calculated for each subshed and an assumed velocity of 5 ft/s was used. These travel times varied based on the length of the sublateral. Lag times varied but were in the range of 15 minutes.

Baseflow

Baseflow is groundwater flow that returns to the stream or channel from underground. Baseflow is typically a small percentage of the overall flow and for this study would be considered negligible compared to the storm water flow. As such, baseflow was not used in the model.

Reach

The reach element is used to represent the flow of water in open channels. Water requires a certain amount of time to travel down a reach and is attenuated by friction and channel storage. For this model, the Kinematic Wave method was used for the reach calculations. This method models flow with translation and attenuation by computing velocity from flow depth and channel parameters. The main storm drain system will be constructed with HDPE or concrete pipe with a typical manning's friction coefficient of 0.013. The pipe slope (and energy slope) varied but generally was set at 0.001 feet per foot.

Meteorological Method

The SCS Hypothetical Storm method was used due to the availability of the Intensity-Duration-Frequency (IDF) curves from the County and the City of Modesto. The method utilizes rainfall intensities arranged to maximize the peak runoff for a given total storm depth. The method uses four different rainfall distributions throughout the United States. The appropriate storm distribution for the City is a Type I storm.

The IDF curves used in the modeling are for 24-hour events and all infrastructure sizing was based on the 24-hour storm event. The rainfall events used in the model are shown in Table 5.

Table 5 - Design Storm Rainfall Totals

Design Storm Frequency	24-hour Rainfall Total (in)
2-year	1.2
10-year	2.2
50-year	2.8
100-year	3.4

Control

The 24-hour storm was modeled based on the duration of the IDF curves and County standards for sizing storm drain infrastructure.

3.4.2 Modeling Approach

The study area is characterized by a predominately flat terrain on the western side and a more varied terrain on the eastern side of the project. The area is located on a bluff almost 100 feet above the 100-year water surface elevation of the Tuolumne River. The proposed storm drain system, shown in Figure 5, was designed to take advantage of the elevation change by maximizing the use of gravity flow pipes.

The storm drain system will be comprised of main laterals, sublaterals, detention basins, and piping appurtenances. For this study, only the main laterals were modeled. As development takes place, the location of sublaterals will be better defined.

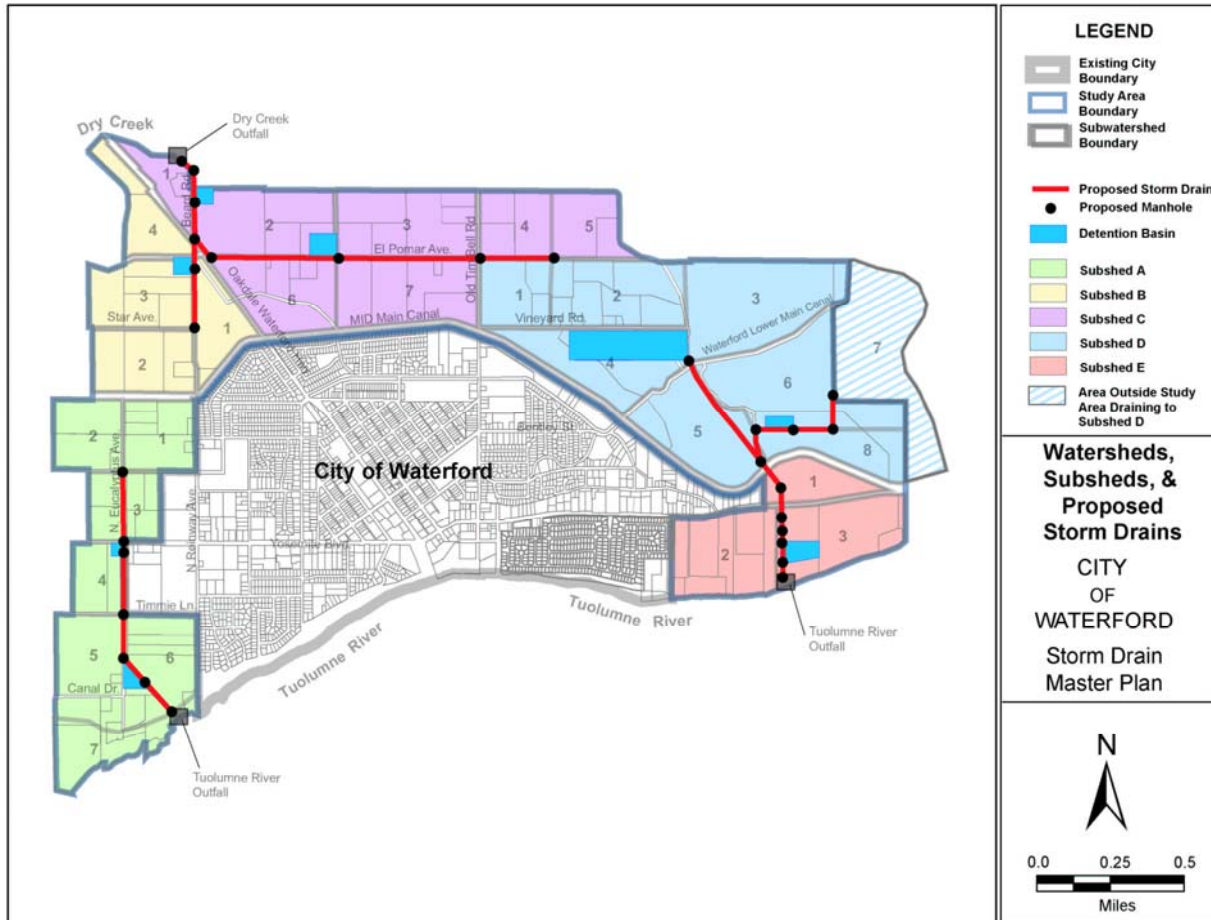


Figure 5 – Proposed Storm Drain Layout

Subsheds and Subbasins

The subsheds and subbasins were created not only based on topographic features, but so the runoff from the subbasin area was low enough to be conveyed by a main lateral with a diameter ranging between 3 to 6 feet in diameter. Each subshed has one to two main laterals and multiple detention basins.

Main Laterals

The main laterals were sized to convey runoff from the upstream subbasins. Most laterals were set at a slope of 0.001 in order to minimize the trenching depth throughout the system. Laterals were set at higher slopes where there was sufficient elevation change. At full flow, the velocity in each lateral exceeds the minimum City standard of 2 feet per second. At the upstream end, the lateral inverts were set at an elevation of 10 feet below ground surface to allow for elevation change in the upstream sublaterals.

Best Management Practices

As discussed in the chapter Permitting Requirements and Future Regulations presented later in this Plan, the City will have to reduce the discharge of pollutants to the maximum extent practicable (MEP) through implementation of Best Management Practices (BMPs) as part of their Storm Water Management Plan.

The State General Permit describes the MEP standard as “The MEP standard is an ever-evolving, flexible, and advancing concept, which considers technical and economic feasibility. As knowledge about controlling urban runoff continues to evolve, so does that which constitutes MEP.”

This Plan provides an overview of BMPs commonly used in Appendix B. There is a number of references readily available describing industry standard BMPs. Two good sources of information include the California Stormwater Quality Association Stormwater BMP Handbooks³ and the Caltrans Storm Water Quality Manuals and Handbooks⁴.

This Plan does recommend the installation of pollution prevention devices at the tail end of the main laterals (see Figure 7) prior to discharge into the receiving water bodies (i.e. Tuolumne River and Dry Creek). These devices should be designed to be either in-line or off-line units capable of handling flows in the range of a 25-year event. The devices should be able to operate given the following minimum standards:

- Gravity driven
- No moving parts
- Large sump storage capacity
- All metal shall be stainless steel
- 80% TSS removal, 90% floatables and neutrally buoyant material removal
- Have the ability to remove grease and oil

Detention Basins

Land development activities, including the construction of roads, convert natural pervious areas to impervious surfaces. These activities cause an increased volume of runoff because infiltration is reduced, surfaces are generally smoother allowing more rapid drainage, and depression storage is reduced. Construction of drainage systems help produce an increase in runoff volume and peak discharge, as well as a reduction in the time to peak of a runoff hydrograph.

The temporary storage or detention/retention of excess storm water runoff as a means of controlling the quantity and quality of storm water releases is a fundamental principle in storm water management. The storage of storm water can reduce the frequency and extent of downstream flooding, soil erosion, sedimentation, and water pollution. Detention basins also function as multi-use facilities such as parks, lakes, water quality treatment facilities, and nature areas (see Figure 6).

The proposed storm drain system incorporates detention basins at locations where the runoff exceeded the capacity of a reasonably sized main lateral. Although there is a corresponding loss of land associated with using detention basins, this is a more cost-effective alternative than using large diameter and dual pipe combinations. The detention/retention basins are strictly used for temporary storage of storm water in excess of the carrying capacity of the pipe network; however they can be planned to utilize recreation activities as well.

³ CASQA Stormwater BMP Handbooks can be found on their website at <http://www.cabmphandbooks.com/>.

⁴ Caltrans Storm Water Quality Manuals and Handbooks are available at <http://www.dot.ca.gov/hq/construc/stormwater/manuals.htm>

All proposed basins have been sized to detain the 100-year 24-hour storm with 1 foot of freeboard. The basin will have an inlet/outlet structure with a pipe connection to the main trunk manhole. The pipe and basin will be sloped towards the main trunk manhole so that water can drain by gravity back to the main collection system as the water level recedes. Appendix A presents design and maintenance considerations for storm water facilities.

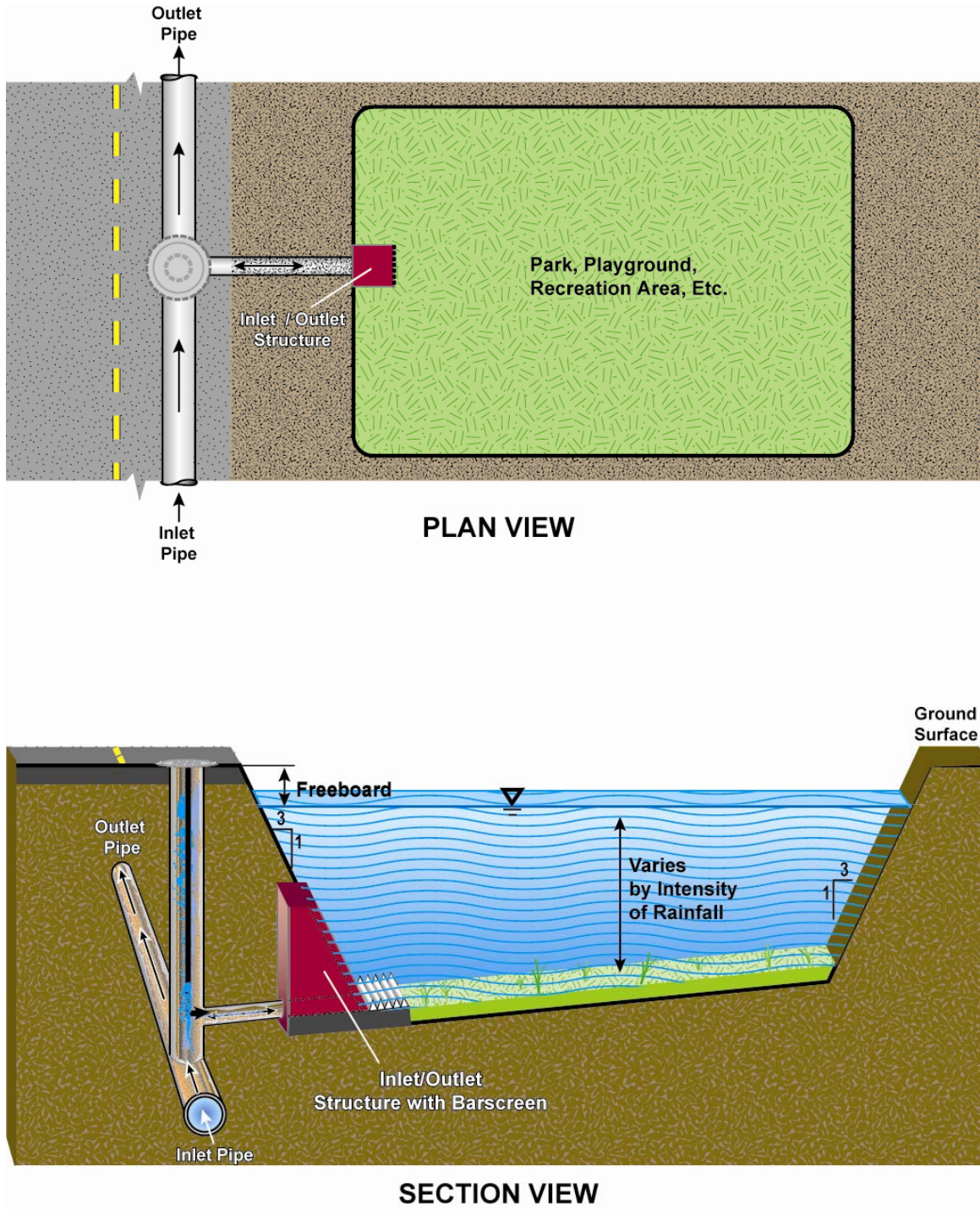


Figure 6 - Detention Basins Schematic

Outlet Structure

The outlet structure for the main laterals at Dry Creek and the Tuolumne River shall be designed and constructed to meet all applicable codes and standards. The structures shall be constructed with concrete and consist of a headwall, wingwalls, and footing. Sufficient rock slope protection (rip rap) shall be placed at the outlet to prevent erosion from the storm water. Where velocities are low enough, a grass swale shall be used to convey the discharge to the outlet water body.

Chapter 4 Recommended Projects

The recommended projects include main laterals and detention basins and are separated by subshed as shown in Figure 5. The storm drain laterals, detention basins and manholes are identified in Figure 7. The following sections discuss the recommended projects by subshed.

Elevations presented in this section are preliminary based on existing topography and are subject to change pending development. Elevations at manholes should be continuously reevaluated as development occurs. At discharge locations with pollution prevention devices, the elevation is subject to change pending headloss that will occur in the devices. Headloss should be in the range of 0.5 to 3 feet. For manholes hydraulically connected to off-line detention basins, an elevation drop across the manhole of 0.5 feet was used to account for headloss in the manhole.

Because the area in subsheds A, B and C is predominately flat, it is not anticipated that development will result in a significant change from the existing ground surface elevations; hence the profiles in these subsheds should not change at the time of development. It is more likely that the area in subsheds D and E will face significant modifications to the existing terrain due to the undulating topography in that area. Fortunately there is plenty of elevation change between the upstream pipes and the outlet. As development occurs, the profile for this area will likely need to be adjusted.

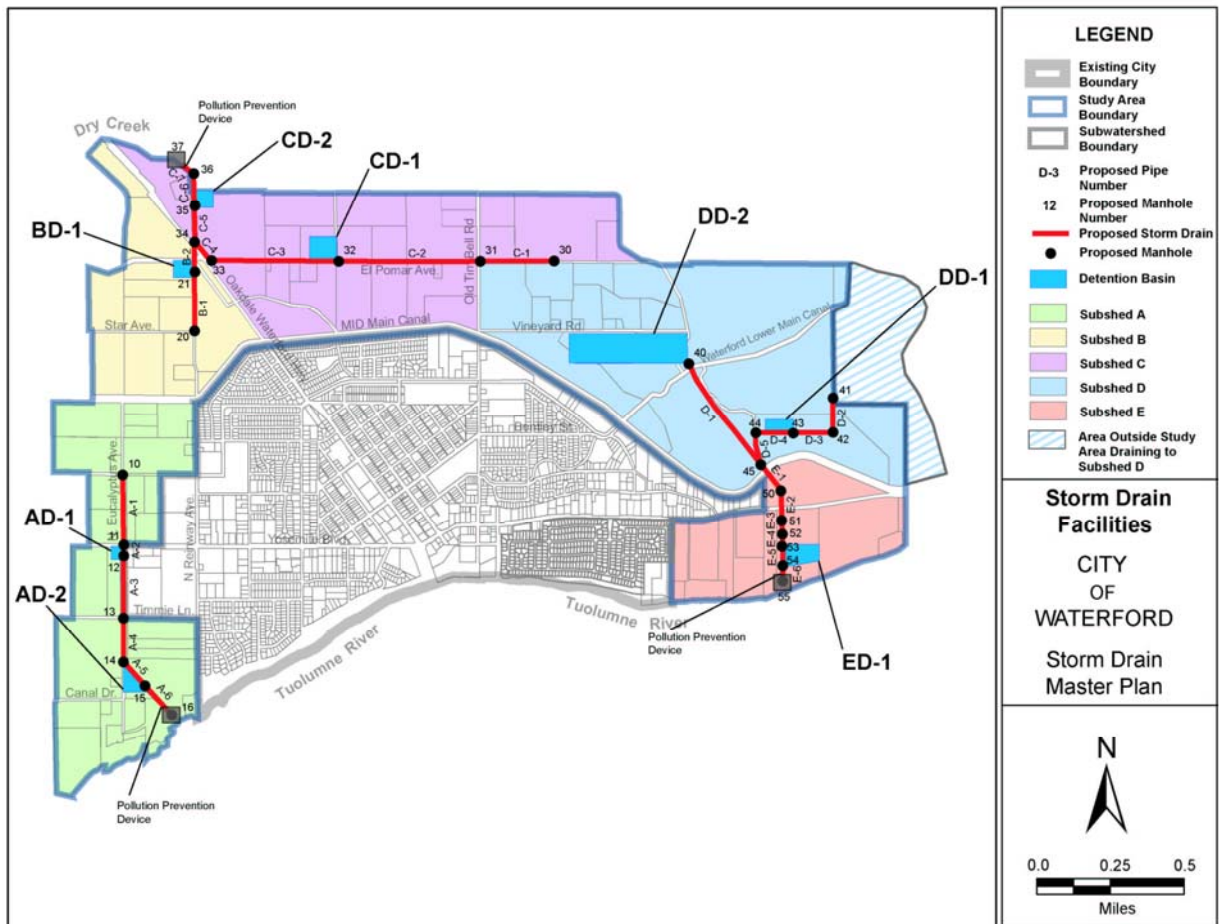


Figure 7 – Proposed Storm Drain Systems Identification

4.5 Subshed A

Proposed facilities for subshed A, which is comprised of 7 subbasins, are shown in plan layout in Figure 7 and profile view in Figure 8. The proposed facilities include two off-line detention basins, pipe segments and manholes.

Pipe segments A-1 through A-5 are described in Table 6.

Table 6 - Subshed A Proposed Facilities Description

Pipe Segment	Approximate Length (ft)	Slope (ft/ft)	Diameter (ft)	Approximate Ground Surface (ft)	Manholes	Invert Upstream (ft)	Invert Downstream (ft)
A-1	1250	0.001	5	161	10 - 11	151.0	149.8
A-2	1400	0.001	5	161	11 - 12	149.3	147.9
A-3	1500	0.001	5	160	12 - 13	147.9	146.4
A-4	200	0.002	5	160	13 - 14	145.9	145.5
A-5	400	0.002	5	159	14 - 15	145.5	144.7 ¹

1) The invert at this location will likely be lower pending the headloss in the pollution prevention device. The manhole/outlet structure at this location should be set at elevation 141.7 to account for the headloss.

Detention basin AD-1 is located at the corner of North Eucalyptus Avenue and Yosemite Blvd and will be used to detain storm runoff during larger storm events from subbasins 1 through 3. All storm water infrastructure in subbasin 3 should ultimately tie into manhole 11. Manhole 11 will also have an outlet to AD-1 that will be used to fill and drain the basin (see Figure 6).

AD-2 is located at the corner of North Eucalyptus Avenue and Canal Drive and will detain storm water from subbasins 1 through 6. All storm water infrastructure in subbasins 5 and 6 should ultimately tie into manhole 14. Detention basin criterion for the entire study area is presented in Table 7.

Table 7 – Proposed Detention Basins Descriptions

Detention Basin	Bottom Elevation (ft)	Top Elevation (ft)	Depth (ft)	Side Slopes (ft)	Top of Basin Area (acre)	Volume (AF)
AD-1	156	161	5	3:1	1.2	4.8
AD-2	155	159	4	3:1	2.9	11.0
BD-1	157	160	3	3:1	2.4	6.8
CD-1	157	162	5	3:1	5.0	22.9
CD-2	156	159	3	3:1	2.5	6.9
DD-1	175	179	4	3:1	3.6	13.3
DD-2	160	170	10	-	28	129
ED-1	121	126	5	3:1	5.6	25.7

1) All elevations and volumes subject to change pending development of the study area.

The storm drain system will discharge to the Tuolumne River. A pollution prevention device shall be installed prior to discharge to the Tuolumne River at the location identified in Figure 7.

Subbasin 7 is located below the bluff and is anticipated to have a disconnected drainage system separate from the rest of the subbasins. The storm drain system should be designed at the time of development of the subbasin.

During detailed design phase, additional analysis should be performed. It may be possible to eliminate detention basin AD-2.

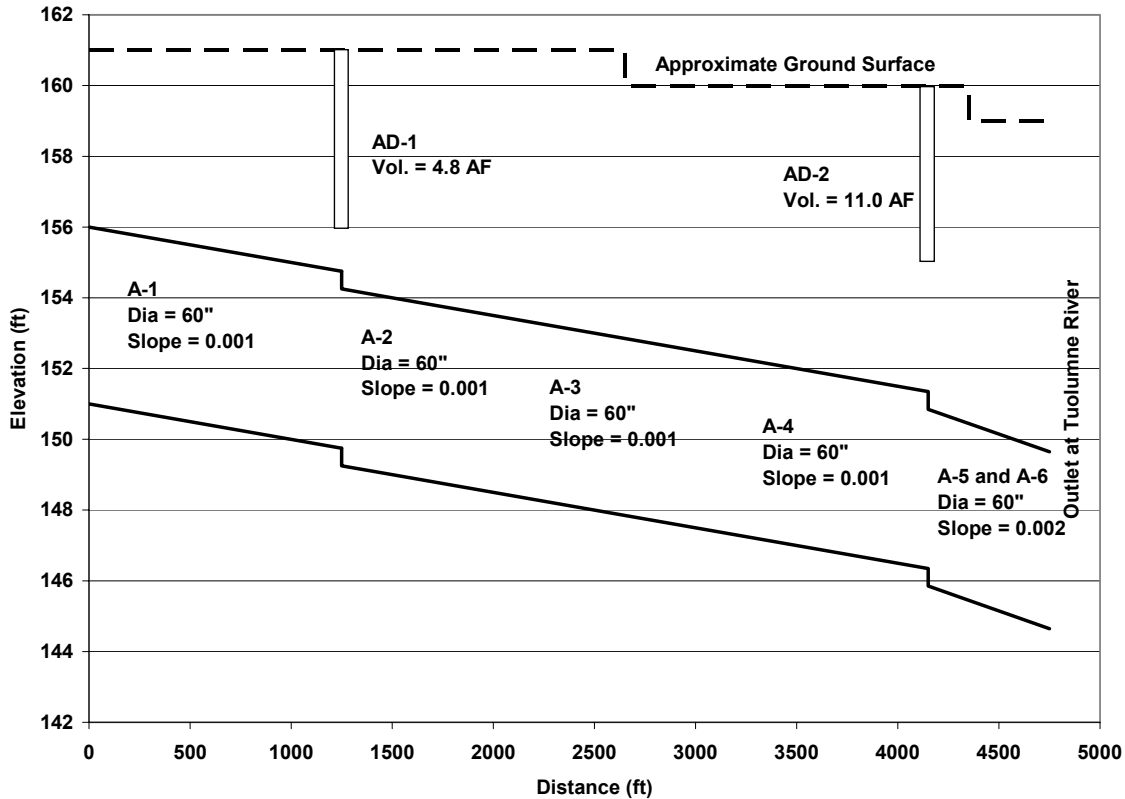


Figure 8 - Profile for Subshed A Proposed Storm Drain System

4.6 Subsheds B and C

Proposed facilities for subshed B, which is composed of subbasins 1 through 4, and subshed C, which is composed of subbasins 1 through 7, are shown in plan layout in Figure 7 and in profile views in Figure 9 and Figure 10. A pollution prevention device shall be installed prior to discharge to Dry Creek at the location shown in Figure 7.

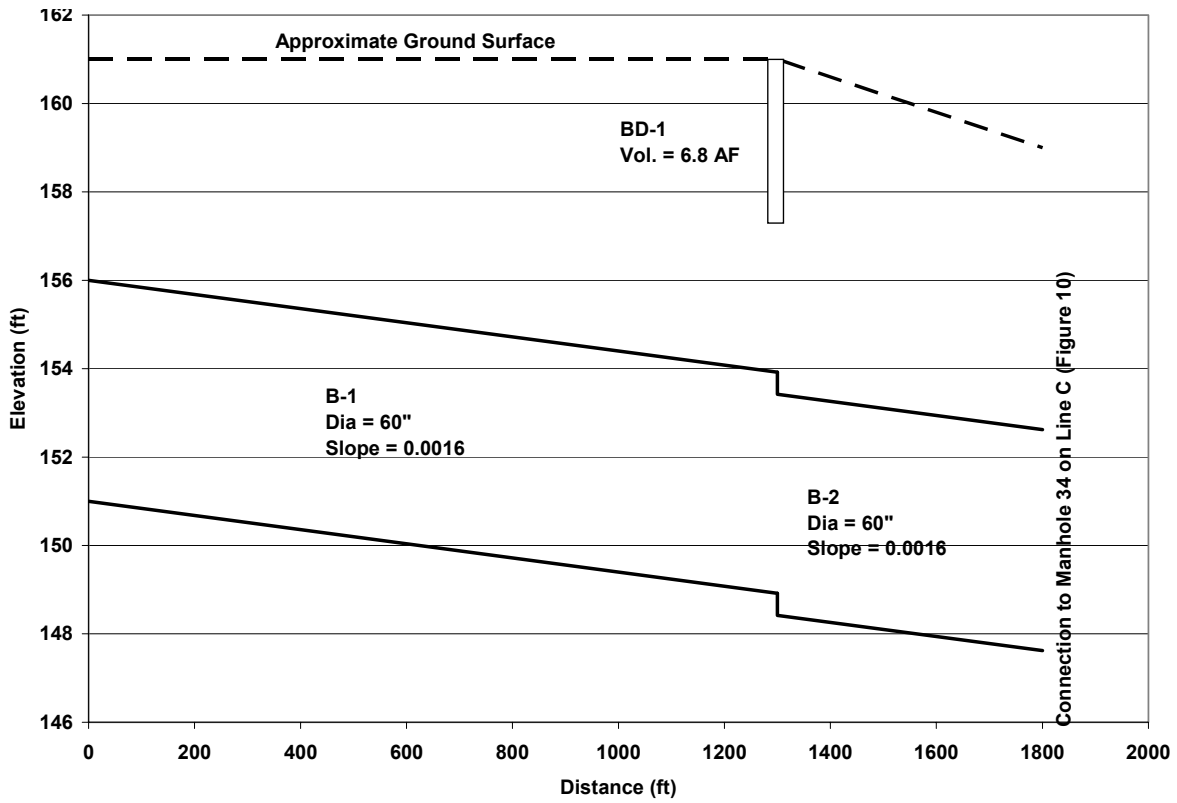


Figure 9 - Profile for Subshed B Proposed Storm Drain System

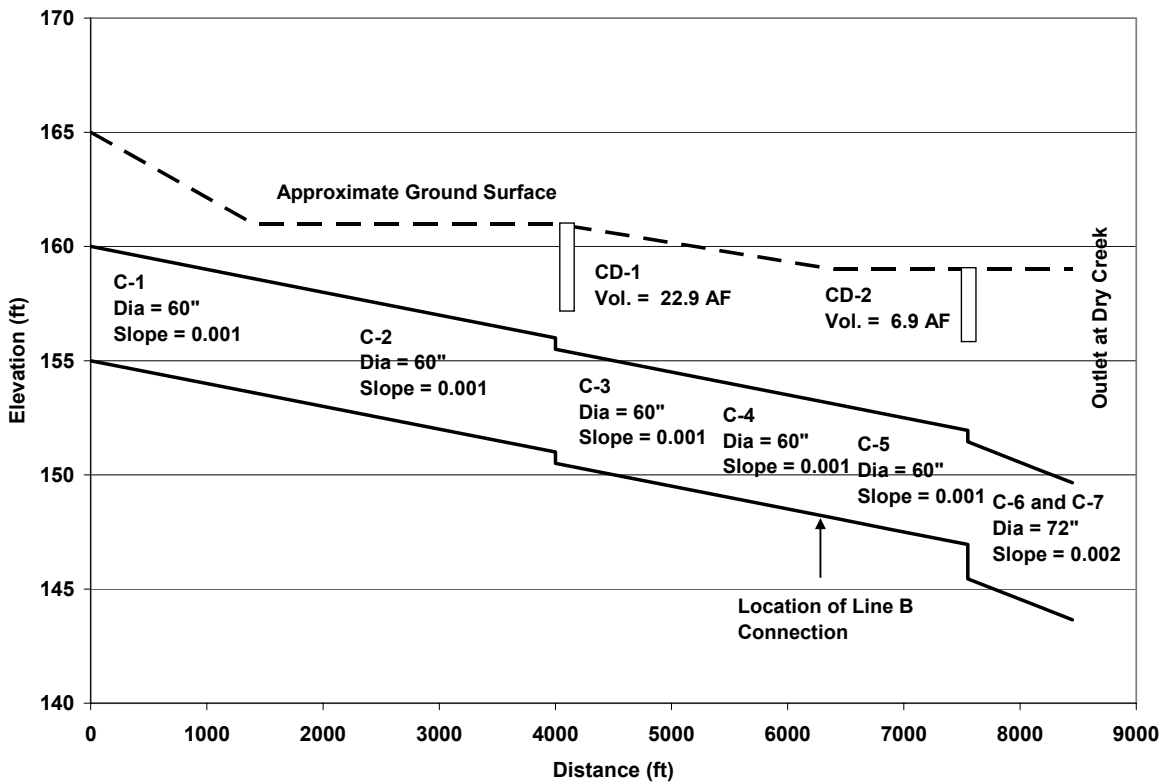


Figure 10 - Profile for Subshed C Proposed Storm Drain System

4.6.1 Subshed B

In subshed B, storm water flows from subbasins 1 and 2 shall be conveyed by B-1, and subbasin 3 shall tie into manhole 21. Subbasin 4 shall flow directly to an outlet at Dry Creek and all storm water infrastructure for this area shall be designed at the time of development. Pipe segment descriptions are provided in Table 8.

An off-line detention pond (BD-1), located at the corner of El Pomar Avenue and Beard Road, will be used to detain storm runoff during larger storm events from subbasins 1 through 3. Table 7 presents the design criteria for the detention basin.

4.6.2 Subshed C

In subshed C, subbasin 5 shall connect to manhole 30 and be conveyed by C-1. Subbasin 4 shall connect at manhole 31 and be conveyed by C-2 with the runoff from subbasin 5. Subbasins 3, 6 and 7 shall connect to the main laterals at manhole 32. Subbasin 2 shall connect at manhole 35. Subbasin 1 shall flow directly to an outlet at Dry Creek.

An off-line detention pond (CD-1), located at the intersection of El Pomar Avenue and Pleasant Avenue, will be used to detain storm runoff during larger storm events from subbasins 3 through 7. Detention basin CD-2 shall be located at Beard Road near the Dry Creek outfall and will collect runoff from subsheds B and C in excess of the downstream pipes. The storm drain system will discharge to Dry Creek.

Pipe segments for the two subsheds are described in Table 8.

Table 8 - Subshed B and C Proposed Facilities Description

Pipe Segment	Approximate Length (ft)	Slope (ft/ft)	Diameter (ft)	Approximate Ground Surface (ft)	Manholes	Invert Upstream (ft)	Invert Downstream (ft)
B-1	1300	0.0016	5	161	20 - 21	151.0	148.9
B-2	500	0.0016	5	161	21 - 34	148.4	147.6
C-1	1400	0.001	5	165	30 - 31	155.0	153.6
C-2	2600	0.001	5	161	31 - 32	153.6	151.0
C-3	2400	0.001	5	161	32 - 33	150.5	148.1
C-4	500	0.001	5	159	33 - 34	148.1	147.6
C-5	650	0.001	5	159	34 - 35	147.6	147.0
C-6	600	0.002	6	159	35 - 36	145.5	144.3
C-7	300	0.002	6	159	36 - 37	144.3	143.7 ¹

1) The invert at this location will likely be lower pending the headloss in the pollution prevention device. The manhole/outlet structure at this location should be set at elevation 140.7 to account for the headloss.

4.7 Subsheds D and E

Proposed facilities for subshed D, which is composed of subbasins 1 through 8, and subshed E, which is composed of subbasins 1 through 3, are shown in plan layout in Figure 7 and in profile views in Figure 11 and Figure 12. A pollution prevention device shall be installed prior to discharge to the Tuolumne River at the location shown in Figure 7.

4.7.1 Subshed D

In subshed D subbasins 1 through 5 shall discharge to the DD-2 detention reservoir. DD-2 shall store all the storm water for the 100-year 24-hour event. After the storm water has receded, the basin will be

emptied as appropriate using gravity flow through D-1. The downstream pipes have capacity to convey a limited quantity of runoff from DD-2 shall the need arise during a storm event. Operation of the reservoir shall be evaluated in future detailed hydraulic studies. There is sufficient elevation change in the downstream pipes should the need arise to lower the storm drain pipes.

Subbasin 7 shall be connect to manhole 41 and conveyed by D-2. Subbasin 6 and 8 shall connect to manhole 43.

An off-line detention pond (DD-1), located near the existing Lateral No. 8, will be used to detain storm runoff during larger storm events from subbasins 6 through 8. See Table 7 for the detention basin characteristics.

4.7.2 Subshed E

Lateral E-1 shall be pipe jacked underneath the MID Main Canal with at minimum of three feet of cover between the canal flowline and the pipe crown. The invert of the Main canal was not surveyed as part of this study and the estimated depth needs to be confirmed before downstream improvements are completed.

Subshed E subbasin 1 shall connect at manhole 50. Subbasins 2 and 3 shall connect at manhole 53. Detention basin ED-1 shall be constructed at the location shown in Figure 7. See Table 7 for the detention basin characteristics. The storm drain system will discharge to the Tuolumne River. Table 9 presents the pipeline design parameters.

Table 9 - Subsheds D and E Proposed Facilities Description

Pipe Segment	Approximate Length (ft)	Slope (ft/ft)	Diameter (ft)	Approximate Ground Surface (ft)	Manholes	Invert Upstream (ft)	Invert Downstream (ft)
D-2	650	0.003	4.5	183	41 - 42	173.0	171.1
D-3	750	0.003	4.5	197	42 - 43	171.1	168.8
D-4	700	0.003	4.5	175	43 - 44	168.3	166.2
D-5	600	0.003	4.5	181	44 - 45	166.2	164.4
D-1	2400	0.001	3.5	190	40 - 45	173.5	171.1
E-1	600	0.001	4	181	45 - 50	156.0	155.4
E-2	550	0.001	5	169	50 - 51	154.4	153.9
E-3	240	0.11	3	179	51 - 52	153.9	127.5
E-4	225	0.048	3	137	52 - 53	127.5	116.7
E-5	350	0.003	5	126	53 - 54	114.2	113.1
E-6	300	0.116	5	126	54 - 55	113.1	78.3 ¹

1) The invert at this location will likely be lower pending the headloss in the pollution prevention device. The manhole/outlet structure at this location should be set at elevation 75.3 to account for the headloss.

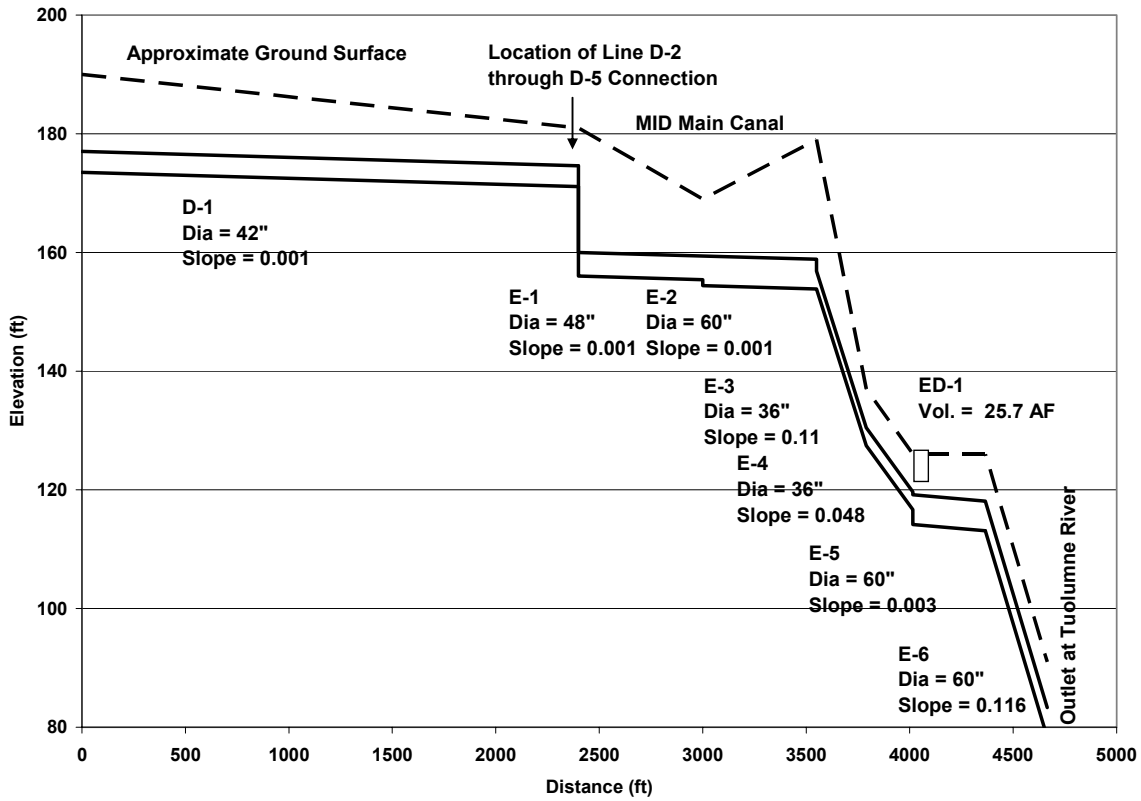


Figure 11 – Profile 1 for Subsheds D and E Proposed Storm Drain System

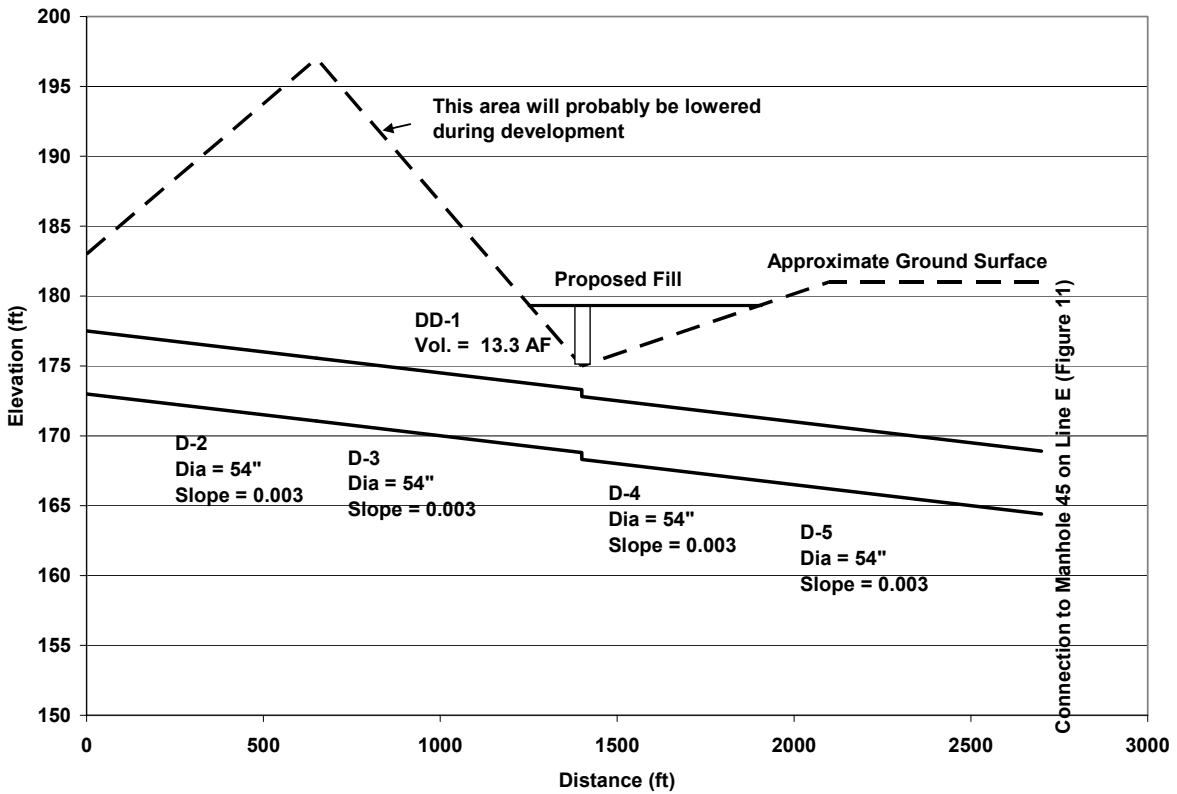


Figure 12 - Profile 2 for Subsheds D Proposed Storm Drain System

Chapter 5 Opinion of Probable Costs

Storm Drain installation costs vary according to many factors including pipe type, diameter, depth, material, soil and groundwater conditions, complexity of construction, and need for traffic control and surface restoration. The costs used in this Plan for installation of storm drain pipes includes mobilization, traffic control, trenching, dewatering, pipe installation and lateral connections, manholes, and pavement replacement.

Table 10 presents the cost criteria used to develop cost estimates for the recommended storm drain system projects for the study area.

Table 10 - Cost Criteria for Recommended Projects

Facility Type	Diameter (in)	In Existing Street (\$/LF)	Not in Existing Street (\$/LF)
Storm Drain Pipeline	8	\$85	\$60
	10	\$85	\$70
	12	\$105	\$90
	15	\$125	\$110
	18	\$125	\$120
	21	\$160	\$135
	24	\$150	\$150
	30	\$180	\$190
	36	\$235	\$205
	42	\$250	\$220
	48	\$265	\$235
	54	\$220	\$250
	60	\$295	\$265
	72	\$325	\$295
Pipe Jacking	48	\$1000/LF	
Excavation	\$6.07/CY		

Table 11 presents the preliminary cost estimate for the proposed Storm Drain System facilities. It should be noted that the estimated capital costs presented in this table are considered conceptual planning level costs, and have an expected accuracy of -30% to +50%.

Table 11 - Storm Drain System Cost Estimate

Description	Diameter (in)	Length (ft)	Estimated Construction Cost
<i>Watershed A Storm Drains</i>			
A-1	60	1,250	\$368,750
A-2	60	200	\$59,000
A-3	60	1,200	\$354,000
A-4	60	1,500	\$442,500
A-5	60	200	\$59,000
A-6	60	400	\$118,000
Off-line Detention Basin AD-1	4.8 AF		\$92,000
Off-line Detention Basin AD-2	11.0 AF		\$152,600
Pollution Prevention Device	200 cfs		\$700,000
<i>Subtotal</i>			<i>\$2,346,000</i>
<i>Watershed B and C Storm Drains</i>			
C-1	60	1,400	\$413,000
C-2	60	2,600	\$767,000
C-3	60	2,400	\$708,000
C-4	60	500	\$147,500
C-5	60	650	\$191,750
C-6	72	600	\$195,000
C-7	72	300	\$97,500
B-1	60	1,300	\$383,500
B-2	60	500	\$147,500
Off-line Detention Basin CD-1	22.9 AF		\$269,000
Off-line Detention Basin CD-2	6.9 AF		\$112,500
Off-line Detention Basin BD-1	6.8 AF		\$111,500
Pollution Prevention Device	200 cfs		\$700,000
<i>Subtotal</i>			<i>\$4,244,000</i>
<i>Watershed D and E Storm Drains</i>			
D-1	42	2,400	\$528,000
D-2	54	650	\$162,500
D-3	54	750	\$187,500
D-4	54	700	\$175,000
D-5	54	600	\$150,000
E-1	48	600	\$695,000
E-2	60	550	\$145,750
E-3	36	240	\$49,200
E-4	36	225	\$46,125
E-5	60	350	\$92,750
E-6	60	300	\$79,500
Off-line Detention Basin DD-1	13.3 AF		\$175,000
Detention/Retention Basin DD-2	129 AF		\$1,307,000
Off-line Detention Basin ED-1	25.7 AF		\$296,000
Pollution Prevention Device	200 cfs		\$700,000
<i>Subtotal</i>			<i>\$4,789,000</i>
<i>TOTAL</i>			<i>\$11,275,000</i>

These baseline construction costs are based on installation costs for development recent northern California bids and cost estimates on similar projects.

The costs for pipe jacking under the MID Main Canal consist of three main items, the jacking pit, the receiving shaft, and the pipe jacking. Costs for Pipe Jacking have been developed from actual construction bid data from across the country and include \$60,000 for the jacking pit, \$35,000 for the receiving shaft and \$1,000 per unit foot of pipe.

It is assumed that all other major crossings such as those across Highway 132 can be accomplished using open cut trench methods. If this is not possible, the costs for boring and jacking beneath the Highway will be similar to those stated above.

A construction contingency and project implementation multiplier of 1.625⁵ was applied to each potential improvement project's estimated baseline construction cost. This allowance is assumed to include:

- Potential construction issues unforeseen at the planning level
- Administration costs
- Environmental assessments and permits
- Planning and engineering design
- Construction administration and management
- Legal fees

⁵ The 1.625 multiplier is based on a 30% construction cost contingency plus a 25% engineering and administration factor to calculate the capital cost. Hence, for budgeting purposes, it is assumed that the contingency and project implementation multiplier is 1.625 ($1.00 \times 1.25 \times 1.30 = 1.625$).

Chapter 6 Permitting Requirements & Future Regulations

This section presents an overview of storm water permitting requirements as well as future regulations that may impact the City. Detailed information and permits can be found on the SWRCB and RWQCB websites.⁶

6.1 Storm Water Permitting

Storm water permitting dates back to 1972 when the federal Water Pollution Control Act (also known as the Clean Water Act [CWA]) was amended to provide that the discharge of pollutants to waters of the United States from any point source is unlawful unless the discharge is in compliance with a NPDES permit. The 1987 amendments to CWA added section 402(p), which established a framework for regulating storm water discharges under the NPDES Program. Subsequently, in 1990, the U.S. Environmental Protection Agency (U.S. EPA) promulgated regulations for permitting storm water discharges from industrial sites (including construction sites that disturb five acres or more) and from municipal separate storm sewer systems (MS4s) serving a population of 100,000 people or more. These regulations, known as the Phase I regulations, require operators of medium and large MS4s to obtain storm water permits. On December 8, 1999, U.S. EPA promulgated regulations, known as Phase II, requiring permits for storm water discharges from Small MS4s and from construction sites disturbing between one and five acres of land.

An “MS4” is a conveyance or system of conveyances (including roads with drainage systems, municipal streets, catch basins, curbs, gutters, ditches, man-made channels, or storm drains): (i) designed or used for collecting or conveying storm water; (ii) which is not a combined sewer; and (iii) which is not part of a Publicly Owned Treatment Works (POTW). [See Title 40, Code of Federal Regulations (40 CFR) §122.26(b)(8).]

A “Small MS4” is an MS4 that is not permitted under the municipal Phase I regulations, and which is “owned or operated by the United States, a State, city, town, borough, county, parish, district, association, or other public body (created by or pursuant to State law) having jurisdiction over disposal of sewage, industrial wastes, storm water, or other wastes, including special districts under State law such as a sewer district, flood control district or drainage district, or similar entity....” (40 CFR §122.26(b)(16)).⁷

Federal regulations allow two permitting options for storm water discharges (individual permits and general permits). SWRCB elected to adopt a statewide general permit for Small MS4s in order to efficiently regulate numerous storm water discharges under a single permit. If the City of Waterford decides to be covered by the State General Permit they will have to submit a Notice of Intent (NOI) to comply with the terms of this General Permit.

At this time, the City is not on the SWRCB’s list of entities subject to regulation as an MS4. This will change as the City grows and becomes subject to the regulations set forth by the NPDES program. Close coordination with the Central Valley Regional Water Quality Control Board (RWQCB) will facilitate storm water permitting. In general, the City will likely require two types of permit: a construction permit and a Small Municipal Separate Storm Sewer Systems (MS4) General Permit.

6.1.1 Construction Permit

A construction permit must be secured prior to breaking ground on construction that will disturb more than one acre of land. The General Permit for Storm Water Discharges Associated with Construction

⁶ SWRCB website (<http://www.waterboards.ca.gov/>). Central Valley RWQCB website (<http://www.waterboards.ca.gov/centralvalley/>)

⁷ Fact Sheet for State Water Resources Control Board (SWRCB) Water Quality Order No. 2003-0005-DWQ (http://www.waterboards.ca.gov/stormwtr/phase_ii_municipal.html)

Activity WQO No. 99-08-DWQ (General Construction Permit) requires all dischargers where construction activity disturbs one acre or more to:

1. Develop and implement a Storm Water Pollution Prevention Plan (SWPPP) which specifies Best Management Practices (BMPs) that will prevent all construction pollutants from contacting storm water and with the intent of keeping all products of erosion from moving off site into receiving waters.
2. Eliminate or reduce non-storm water discharges to storm sewer systems and other waters of the nation.
3. Develop and implement a monitoring program.
4. Perform inspections of all BMPs.

Storm Water Pollution Prevention Plan

According to the General Construction Permit, the SWPPP shall emphasize the use of appropriately selected, correctly installed and maintained pollution reduction BMPs. All dischargers are required to prepare and implement a SWPPP prior to disturbing a site, and the SWPPP shall remain on the site at all times and shall be implemented to protect water quality at all times throughout the life of the project. Non-storm water BMPs must be implemented year-round.

The SWPPP has two major objectives: (1) to help identify the sources of sediment and other pollutants that affect the quality of storm water discharges and (2) to describe and ensure the implementation of BMPs to reduce or eliminate sediment and other pollutants in storm water as well as non-storm water discharges.

The SWPPP shall include BMPs which address source control and, if necessary, shall also include BMPs which address pollutant control.

The following elements are required in a SWPPP:

1. Site description addressing the elements and characteristics specific to the site
2. Descriptions of BMPs for erosion and sediment controls
3. BMPs for construction waste handling and disposal,
4. Implementation of approved local plans
5. Proposed post-construction controls, including description of local post-construction erosion and sediment control requirements
6. Non-storm water management

Monitoring Program

The General Construction Permit requires development and implementation of a monitoring program. Dischargers are required to inspect the construction site prior to anticipated storm events and after actual storm events. During extended storm events, inspections must be made during each 24-hour period. Inspections will identify areas contributing to a storm water discharge and evaluate whether measures to reduce pollutant loadings identified in the SWPPP are adequate and properly installed and functioning in accordance with the terms of the General Permit. In addition, inspections will determine whether additional control practices or corrective maintenance activities are needed.

6.1.2 Small MS4 General Permit

Upon completion of development, or at an appropriate time as determined through communications with RWQCB staff, the City will likely require a municipal permit. Small MS4s may be identified through the following methods:

1. Automatically designated by U.S. EPA pursuant to 40 CFR section 122.32(a)(1) because it is located within an urbanized area defined by the Bureau of the Census.
2. Traditional Small MS4s that serve cities, counties, and unincorporated areas that are designated by SWRCB or RWQCB after consideration of the following factors:
 - b. High population density – an area with greater than 1,000 residents per square mile, potentially created by a non-residential population, such as tourists or commuters.
 - c. High growth or growth potential – Growth of more than 25 percent between 1990 and 2000, or anticipated growth of more than 25 percent over a 10-year period ending prior to the end of the first permit term.
 - d. Significant contributor of pollutants to an interconnected permitted MS4.
 - e. Discharge to sensitive water bodies
 - f. Significant contributor of pollutants to waters of the U.S.

Based on criterion 2.b., the City is anticipated to be designated as a regulated small MS4.

The MS4 permit requires dischargers to develop and implement a Storm Water Management Program (SWMP) that describes the best management practices, measurable goals, and time schedules of implementation as well as assigns responsibility of each task. Also, as required by the Small MS4 General Permit, the SWMP must be available for public review and must be approved by the appropriate Regional Water Quality Control Board (RWQCB), or its Executive Officer (EO), prior to permit coverage commencing. This information is provided to facilitate the process of an MS4 obtaining Small MS4 General Permit coverage.

Storm Water Management Plan

The General Permit requires permittees to develop and implement a SWMP designed to reduce the discharge of pollutants through their MS4s to the Maximum Extent Practicable (MEP). The General Permit requires the SWMP to be fully implemented by the end of the permit term (or five years after designation for those designated subsequent to General Permit adoption). Once RWQCB staff has reviewed a SWMP and, in light of meeting the MEP standard, recommends approval of coverage, the public may review the SWMP and request a public hearing if necessary. The SWMP will be made available for public review for a minimum of 60 days.

Federal and State regulations require operators of MS4s to develop a five-year workplan with associated performance measures and budgeting to address six Minimum Control Measures (MCMs). The MCMs to be addressed include:

1. Public Outreach and Education
2. Public Participation and Involvement
3. Illicit Discharge Elimination
4. Construction Site BMPs Over 1 Acre
5. Post-Construction BMPs
6. Municipal Activities

For each MCM, measurable BMPs should be developed, and a schedule and budget provided for completion of the BMP. Additional information on BMPs is provided in Appendix B.

6.2 Future Regulatory Direction

Regulating storm water discharge will continue to evolve likely resulting in more stringent and specific regulations that demand increased levels of treatment, monitoring, and control measures. The City should continue to look forward and plan for adoption of these increased standards. It is recommended that City planners remain in constant communication with the RWQCB in order to facilitate their efforts. The City should also familiarize themselves with the various grant programs.

Other RWQCB's are already in the process of implementing more stringent storm water regulations. The San Francisco Bay Area RWQCB has amended their Phase I NPDES permitting for large dischargers to include increased regulation of discharges to the San Francisco Bay region. Specifically, Provision C.3 was added to the NPDES storm water permits issued to the municipalities in its jurisdiction in February of 2003. Provision C.3 affects the requirements for new developments and significant redevelopment by reducing the threshold for applicability and increasing the onsite treatment requirements. Previously, the requirements for new and significant redevelopment applied to development projects that would create or modify one acre or more of impervious surfaces. Effective February 15, 2005, the threshold for area created or modified was reduced from one acre to 10,000 square feet. The revised provision requires affected dischargers to capture and treat all storm water onsite prior to discharge.

While this revised requirement does not apply to the City, which is neither a large Phase I discharger, nor located in the San Francisco Bay region, this revised provision indicates that storm water regulations are continually becoming more restrictive. Though this provision does not directly apply to the City, considering the potential future incorporation of similar provisions in the MS4 permit requirements allows storm water management programs to be designed for longevity and consistency with anticipated future regulatory direction.

Chapter 7 References

1. DeLorme, Waterford Annexation Area 3-D Topoquad, 2002.
2. MCR Engineering, City of Waterford Proposed Sphere of Influence Map, January 2005.
3. MCR Engineering, Waterford Land Use Map.
4. MCR Engineering, Waterford Annexation Area Map.
5. National Resources Conservation District (June, 1986). Urban Hydrology for Small Watersheds TR-55
6. Stanislaus County, Waterford GIS Parcel Map.
7. The Grupe Company, River Pointe CAD files, May 2005.
8. TKC Engineering, River Pointe CAD files.
9. Tri State Photogrammetry, Waterford Study Area Ortho Photos.
10. U.S. Department of Transportation, Federal Highway Administration (August, 2001). Hydraulic Engineering Circular No. 22, Second Edition Urban Drainage Design Manual.
11. Fact Sheet for State Water Resources Control Board (SWRCB) Water Quality Order No. 2003-0005-DWQ (http://www.waterboards.ca.gov/stormwtr/phase_ii_municipal.html)

**Appendix A Storm Water Design and Maintenance
Considerations**

Appendix A

Temporary Detention/Retention Ponds

There are a number of issues to consider in the design of temporary detention/retention ponds. The ponds are used to temporarily store drainage exceeding the capacity of the storm drain system. The following design criteria should be adhered to during design of the facilities:

Overall Design

- Detention basins should be off-line.
- The discharge pipe to the detention basins should be set at or above the soffit of the main trunk conveyance pipe in a manhole.
- The discharge pipe shall be constructed such that the pipe slopes towards the manhole with the main trunk pipeline in order to provide gravity flow from the detention basin back into the main trunk pipe.
- An inlet/outlet structure shall be constructed in the basin. The structure shall be constructed out of concrete with steel bar racks.
- The detention basin shall be sloped to drain towards the discharge structure.

Public Safety

- Promote public safety such as warning signs, outreach via radio and/or television announcements, flyers, and education of school children.
- Prevent public trespass where applicable at the detention basin, provide emergency escape aids, and eliminate hazards.
- Construct inlets and outlets with bar racks to prevent ingress to the pipe. Ensure surface area at bar rack is many times larger than the outlet pipe to reduce velocities across the bar rack. Allow a clear opening of 9 to 12 inches at the bottom of the bar rack to permit smaller debris to pass at low flows. Spacing between vertical bar racks should be approximately 4 to 5 inches.
- Enclose ponds with a fence where applicable.
- Construct basins with mild slopes.
- Design inlets and outlets that result in mild velocities.

Operation and Maintenance

Storm water management facilities should be properly maintained if they are to function as intended over a long period of time. The following tasks should be performed periodically to ensure the storm water facilities function properly:

- Inspections – Storm water facilities should be inspected periodically for a few months after construction is complete and on a bi-annual basis thereafter. In addition, the facilities should be inspected during and after a major storm event to guarantee they are working properly and nothing is clogged with debris.
- Mowing – Impoundments should be mowed at least twice a year to eliminate woody debris and control weeds. Some facilities such as parks and sports fields will have to be mowed weekly.

- Sediment, Debris, and Litter Control – Accumulated sediment, debris, and litter should be removed from the site at least twice a year. Particular attention should be paid to the inlet and outlet structures to make sure there is no debris blocking the entrance and exits to the pipes.
- Structural Repairs and Replacement – All components that have been damaged or destroyed shall be replaced immediately.

Appendix B Stormwater Management Plan BMPs

Appendix B

Best Management Practices

Best Management Practices are measures that may yield a significant result while being implemented at a relatively low cost and low level of effort. Various sources have compiled recommended storm water BMPs, including the Model Urban Runoff Program (MURP), a guide developed by a small municipality for other small municipalities developing urban runoff and storm water management programs. In addition, EPA has compiled several example BMPs to achieve each MCM. Example BMPs for each MCM selected from recommendations set forth by the MURP, EPA, and recent SWMPs completed by local municipalities are listed below. Additional BMP alternatives may be found on the EPA's National Menu of Best Management Practices for NPDES Storm water Phase II website: (http://cfpub.epa.gov/npdes/stormwater/menuofbmps/bmp_files.cfm).

MCM: Public Outreach and Education

Public education is a key component to any effective storm water management program. Inclusion of some or all of these BMPs in the SWMP workplan will assist municipalities in achieving public support for storm water protection measures. The Public Outreach and Education MCM is aimed at identifying measures to be implemented to increase general knowledge and awareness of storm water impacts. The MURP identifies common practices that can be undertaken by residents and businesses to reduce potential for storm water contamination from a variety of public and private activities. These recommended BMPs are summarized in Appendix A of this document.

To comply with the requirements of the MS4 permit, Waterford will be required to implement a public education program to distribute educational materials to the community or conduct equivalent outreach related to the impacts of storm water discharges on water bodies and actions that the public can take to reduce pollutants in storm water runoff.

Example BMPs related to achieving the Public Outreach and Education MCM include:

- Public education radio campaign on storm water
- Storm water education program for school children
- Storm water education materials for restaurant owners
- Develop and distribute bilingual brochures, posters, magnets, coloring books for public information
- Educate restaurants and auto repair shops about BMPs
- Distribute educational materials at point-of-sale and additional venues

MCM: Public Participation and Involvement

The Public Participation and Involvement MCM is included in recognition of the fact that an involved public will be more likely to support a storm water program. Addressing this MCM will facilitate storm water program implementation as well as financing. Example BMPs to address this MCM include the following:

- Establish a NPDES storm water steering committee
- Hold public meetings to receive input on the proposed program
- Enlist volunteers to mark storm drains and do community cleanups
- Conduct public workshop on the proposed Storm water Pollution Prevention Plan
- Write a draft of or revise the existing storm water quality ordinance
- Institute an annual community cleanup with volunteers

The MS4 permit requires the permittee to comply with State and local public notice requirements when implementing public involvement/participation programs.

MCM: Illicit Discharge Elimination

Illicit discharges are defined by EPA as wastes and wastewaters that are not from storm water runoff and are not otherwise authorized by a NPDES permit. These illicit discharges can enter the storm water system through direct connections, such as via a combined wastewater/storm water system. Alternatively, illicit discharges can enter through indirect means such as infiltration from leaky wastewater systems, spills, dumping into the storm drain, etc. This MCM involves identification and stoppage of illicit discharges.

The MS4 permit requires permittees to implement the following minimum actions to identify and eliminate illicit discharges:

1. Develop, implement, and enforce a program to detect and eliminate illicit discharges (as defined at 40 CFR §122.26(b)(2))
2. Develop a storm sewer system map with locations of all outfalls and names and locations of all waters of the U.S. receiving discharges from those outfalls
3. Develop and implement an ordinance or other regulatory mechanism to prohibit non-storm water discharges and implement appropriate enforcement procedures and actions
4. Develop and implement a plan to detect and address non-storm water discharges to the system that are not authorized by the NPDES permit, including illegal dumping
5. Inform public employees, businesses, and the general public of the hazards associated with illegal discharges and improper waste disposal
6. Address any of the following categories of non-storm water discharges or flows that are identified as significant contributors of pollutants:
 - a. Water line flushing
 - b. Landscape irrigation
 - c. Diverted stream flows
 - d. Rising ground waters
 - e. Uncontaminated ground water infiltration (as defined at 40 CFR §35.2005(20)) to separate storm sewers
 - f. Uncontaminated pumped ground water
 - g. Discharges from potable water sources
 - h. Foundation drains
 - i. Air conditioning condensation
 - j. Irrigation water
 - k. Springs
 - l. Water from crawl space pumps
 - m. Footing drains
 - n. Lawn watering
 - o. Individual residential car washing
 - p. Flows from riparian habitats and wetlands
 - q. Dechlorinated swimming pool discharges

Discharges or flows from fire fighting activities are excluded from the prohibition against non-storm water. These flows should only be addressed if they are identified as significant sources of pollutants to waters of the U.S. The RWQCB may require the permittees to monitor and submit a report and to implement BMPs on discharges from the above flows if it is determined that they are significant sources of pollution to U.S. waters.

Additional example BMPs to address this MCM include:

- Identify illicit connections through dry weather screening and targeted video inspection
- Implement an illicit discharge/illegal dumping hotline
- Conduct pilot surveillance for illicit discharge detection and elimination
- Conduct annual survey of city for illicit discharges

MCM: Construction Site BMPs Over 1 Acre

Construction sites can be a significant source of sediment discharge, especially when installation and maintenance of erosion and sediment controls are not required or adequately enforced. This MCM is intended to institute BMPs to minimize sediment discharge from construction sites larger than one acre.

The MS4 permit requires the permittee to develop, implement, and enforce a program to reduce pollutants in storm water runoff resulting from construction activities generating a land disturbance of greater than or equal to one acre. If the land disturbance is less than one acre, but the construction is part of a larger activity that will ultimately disturb one acre or more, reduction of storm water discharges that activity must be included.

To comply with MS4 requirements, Waterford will be required to develop and implement a storm water quality control program for construction sites over one acre that includes the following minimum elements:

1. An ordinance or other regulatory mechanism to require erosion and sediment controls, as well as sanctions, or other effective mechanisms, to ensure compliance
2. Requirements for construction site operators to implement appropriate erosion and sediment control BMPs
3. Requirements for construction site operators to control waste such as discarded building materials, concrete truck washout, chemicals, litter, and sanitary waste at the construction site
4. Procedures for site plan review considering potential water quality impacts
5. Procedures for receipt and consideration of information submitted by the public
6. Procedures for site inspection and enforcement of control measures

Additional example BMPs for this MCM are:

- Require Erosion and Sediment Control plans
- Require the use of appropriate perimeter controls on construction sites
- Develop a certification program for contractors
- Educate local developers, construction firms and Building Department on BMP requirements
- Require Storm water Pollution Prevention Plans for all construction over 1 acre
- Conduct training for building inspectors, plan review engineers on requirements

MCM: Post-Construction BMPs

This MCM targets reductions in discharges from new development and significant redevelopment. These projects offer significant opportunities to install structural runoff controls on both the site and regional scales.

To comply with the provisions of the MS4 permit, Waterford will be required to:

1. Develop, implement, and enforce a program to address storm water runoff from new development and redevelopment projects that disturb greater than or equal to one acre, including projects less than one acre that are part of a larger common plan
2. Develop and implement strategies combining appropriate structural and/or non-structural BMPs
3. Use an ordinance or other regulatory mechanism to address post construction runoff from new development and redevelopment projects
4. Ensure adequate long-term operation and maintenance of BMPs.

Because Waterford's projected MS4 eligibility is based on future high population growth, additional provisions of the MS4 permit would require Waterford to adopt an ordinance to ensure implementation of design standards for the following categories of discretionary development and redevelopment projects:

- Single-Family Hillside Residences
- 100,000 Square Foot Commercial Developments
- Automotive Repair Shops
- Retail Gasoline Outlets
- Restaurants
- Home Subdivisions with 10 or more housing units
- Parking lots 5,000 square feet or more or with 25 or more parking spaces and potentially exposed to storm water runoff

MCM: Municipal Activities

Municipal operations may contribute to discharge of pollutants in a variety of ways. By educating municipal employees on the potential impacts of their own operations on storm water quality, municipal crews can learn to set a good example for other citizens.

At a minimum, MS4 permit compliance will require the City of Waterford to develop and implement an operation and maintenance program including a training component. The program goal shall be to prevent or reduce pollutant runoff from municipal operations. Training materials are available from several sources, including the U.S. EPA, the State of California, and other organizations. The employee training program will be designed to prevent and reduce storm water pollution from activities such as park and open space maintenance, fleet building maintenance, new construction and land disturbances, and storm water system maintenance.

Potential additional BMPs that may be implemented to address this MCM include:

- Develop spill prevention and control plans for municipal facilities
- Incorporate the use of road salt alternatives for roadway deicing
- Inspect and assess cleanliness of municipal activities
- Participate in regional water quality initiatives
- Develop or revise standard operating procedures (SOPs) for street or storm drain spills
- Assess street sweeping effectiveness
- Conduct pilot metals testing on storm water detention basins

