CITY OF SEBASTOPOL

STORM DRAIN SYSTEM
UTILITY MASTER PLAN

December 2005

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List of Abbreviations

ACP	Asbestos Cement Pipe
CMP	Corrugated Metal Pipe
CP	Concrete Pipe
FEMA	Federal Emergency Management Agency
ft	Feet
GPS	Global Positioning System
HDPE	High-Density Polyethylene
HGL	Hydraulic Grade Line

in	Inches
LAFCO	Local Agency Formation Commission
lf	Linear feet
PVC	Polyvinyl Chloride
RCP	Reinforced Concrete Pipe
SCFC & WCD	Sonoma County Flood Control & Water Conservation District
SCWA	Sonoma County Water Agency
sf	Square feet
SMSDS	Sebastopol Municipal Storm Drain System
SOI	Sphere of Influence
UBG	Urban Growth Boundary
VCP	Vitrified Clay Pipe

Executive Summary

Coastland Civil Engineering Inc. was hired by the City of Sebastopol to complete a *Storm Drainage System Master Plan*. The Master Plan consists of:

- A study of the existing service area and land use plans;
- An assessment of existing and future storm drain flows by subhydrologic area;
- An explanation of storm drain system evaluation criteria;
- The development of a hydraulic computer model of the existing and future storm drain system;
- A recommendation for storm drain system improvements;
- An estimate of storm drain system improvement costs.

This *Storm Drainage System Master Plan,* is intended as an instrument for planning storm drain system improvements necessary to comply with current City zoning ordinances.

A hydraulic model was developed using the 10 year storm event, land use runoff values based on surface type and slope, times of concentration based on surface type and slope and length within subhydrologic areas.

The model indicates that for current conditions there are a few areas in the City where runoff will overtop the storm drain system in the 10 year storm event. Some of these areas are located in low lying portions of the town near the Laguna de Santa Rosa. These areas, which are below the 10-year and the 100-year floodplain, will flood regardless of any changes made to pipe size. Overtopping in many other areas can, however, be minimized by increasing pipe size and in some cases the configuration of the storm drain system.

The report recommends improvements to eight hydrologic areas to minimize overtopping. Estimates for each of these projects are also provided. These projects are summarized below by watershed title. The projects are listed in priority order, with numbers matching those on the map entitled “Proposed Improvements.”

1. Zimpher Creek

- (22) Replacing the existing 42" line with 590' of 54" RCP from Pitt Avenue to North Main;
- (22) Replacing the existing 48" line with 740' of 54" RCP from North Main to Petaluma Avenue;
- (23) Replacing the existing 48"line with 370' of 60" RCP from Petaluma Avenue to beginning of 54" storm drain;
- (23) Replacing the existing 54" line with 840' of 60" beginning at the existing 54" line to Morris Street.

- (8) Replacing the existing 30” and 24” on Valentine Avenue from Washington Avenue to the existing 36” at Brookhaven School with 1000' of 36” RCP.
- (9) Replacing the 24” storm drain line on Pleasant Hill Avenue North from Valentine Avenue to the 8” CP in Libby Park with 200' of 30" RCP.
- (13) Replacing the existing public 10” line in Pleasant Hill Avenue with 30' of 15” RCP.
- (10) Removing the existing 30” line at Patricia Court. intersection, running north-south and installing 150’ of 36” RCP connecting to the existing 36” between 401 and 411 Zimpher Drive.
- (11) Replacing the 15" RCP north of Brookside Avenue with 170' of 18" RCP.

2. Gravenstein Hwy South (Hazel Cotter Outfall)

- (29) Constructing a new 420 foot, 24” HDPE line from the corner of Fircrest Avenue and Gravenstein Hwy South to the 24” line on Hazel Cotter Court.
- (29) Abandoning the 18” line that currently runs from the corner of Fircrest Avenue and Gravenstein Hwy South to the corner of Lynch Road and Gravenstein Highway.
- (30) Replacing the 18” line south of Fircrest with a line that will provide a minimum slope of 0.0021 toward the new 24” HDPE line.
- (32) Replacing 80’ of 18” CMP line on the easterly end of Lynch Road with 24” HDPE.
- (31) Replacing 900’ of 24” CMP and RCP line running from the corner of Lynch Road and Gravenstein Highway to the Hazel Cotter outfall with 36” HDPE.
- (28) Replacing 1220’ of 15” storm drain line south of Redwood Avenue with a 24” HDPE storm drain line south of Redwood Avenue.

3. Palm Avenue

- (26) Replacing the existing 18” storm drain line starting on Palm Avenue and running to Petaluma Avenue and then to South Main with 470’ of 24” HDPE storm drain line.
- (27) Replacing the existing 15” storm drain line from Foster Lane to the inlet south of 970 South Highway 116 with 720’ of 24” HDPE storm drain line.

4. Calder Creek

- (12) Replacing the existing 380’ of 18” line running from Nelson Way to east of Virginia Avenue with 24” HDPE.
- (25) Removing 60’ of 30” RCP line and installing 45 feet of 32” HDPE to bypass the intermediate manhole in South Main.
- (24) Replacing the 530’ of 18” line from Bodega Avenue to upstream of the junction structure with 24” HDPE.

5. Healdsburg Avenue

- (17) Replacing the 48" line from Morris Street to the outfall with 80' of 54" RCP;
- (16) Replacing the 24" in Morris Street, north of Laguna Parkway, with 640' of 30" line,

- (18) Replacing the existing 15" line in Morris Street, at the intersection of Laguna Parkway, with 90' of 18" RCP;
- (21) Replacing the existing 42" line running from Flynn Street to Laguna Parkway with 220' of 48" RCP.
- (6) Replacing the existing 24" line with 290' of 30” HDPE in Healdsburg Avenue, north of the intersection with Live Oak Avenue.
- (7) Replacing the existing 18" line with 50' of 24" HDPE at the corner of Covert Lane and Healdsburg Avenue.
- (19 & 20) Replacing the existing 18" line in Laguna Parkway (between Flynn Street and Morris Street) with 60' of 30" and 60' of 24" HDPE.

6. Gravenstein Hwy North

- (3 & 4) Removing the two existing culverts on the west side of the highway and constructing 420’ of 24” storm drain line followed by 30’ of 27” storm drain line to the outfall north of Danmar Drive.
- (1 & 2) Replacing about 830’ of existing 18” ACP storm drain line on the east side of the highway with 570’ of 24” storm drain line followed by 260’ of 30” storm drain line.
- (5) Replacing the open channel in front of 885 Gravenstein Highway with 80’ of 18” closed storm drain line.

7. Atascadero Creek

- (15) Replacing 520’ of 15” RCP on Pleasant Hill Road with 18” HDPE.
- (14) Replacing 340’ of 18” RCP on Bodega Avenue starting at Pleasant Hill Road with 24” HDPE.

8. Witter Creek

- (33) Replacing 170’ of 15” diameter RCP on Meadowlark Drive with 18” diameter HDPE.
- (34 & 35) Replacing 650’ of 15” RCP on McFarlane and Lynch Roads starting at Meadowlark Drive with 24” diameter HDPE.
- (36) Replace the existing triple 18” culverts at the intersection of Jean Drive and Lynch Road with 46’ of 30” HDPE.
- (37) Install 200’ of 36” HDPE parallel to the existing 36” RCP in Beattie Lane.

The estimated costs of these projects are shown in the table below. The table includes estimated construction costs and total project costs including, design, environmental, administration and construction management.

Table ES-1: Estimated Costs of Projects to Bring Storm Drain System Up to Standards
Current Conditions

No.	Description	Construction Cost	Project Cost
1	Zimpher Creek	$1,282,883	$1,667,747
2	Gravenstein Hwy South (Hazel Cotter Outfall)	$484,190	$629,447
3	Palm Avenue	$223,905	$291,077
4	Calder Creek	$246,002	$319,803
5	Healdsburg Avenue	$404,398	$525,717
6	Gravenstein Hwy North	$285,840	$371,592
7	Atascadero Creek	$145,380	$188,994
8	Witter Creek	$201,446	$261,879
	Total	**$3,274,043**	**$4,256,256**

These are 2005 costs. Costs should be adjusted for inflation using the Engineering News Record 20 City Construction Cost Index, using 7,415 as the basis for 2005.

Future storm drain system needs were established based on the General Plan, The City Growth Ordinance and discussions with City Planning and Engineering Departments. Growth assumptions take into account projects currently in planning and the Northeast Area Specific Plan (Alternative B), and potential annexation of potential development in the areas in the sphere of influence outside current City boundaries, including the Gravenstein Highway South Study Area and Belmont Terrace.

The completion of the projects identified are for current conditions. No additional improvements will be required to accommodate future growth.

As areas within the Sphere of Influence (SOI) are annexed into the City additional storm drain infrastructure will be needed to meet the needs of these areas. A prior study, The South Gravenstein Study Area Utility Needs Study, provided three possible methods to meet the needs of that area when it is annexed.

The Belmont Terrace area will also require a storm drain system prior to annexation. This report did not design that system, but only looked at the effect that system might have on the existing system. Since the Belmont Terrace system will mostly drain to the northwest, the affect of its storm drain system on the existing City Storm Drain system will be negligible.

These projects should be completed as development in the area flowing into the City storm drain system increases. Estimates are provided for the Gravenstein Highway South project is summarized below:

**Table ES-2: Estimated Costs of Projects to Bring Storm Drain System Up to Standards
Future Build-out Conditions**

No.	Description	Construction Cost	Project Cost
1	Gravenstein Hwy South	$1,527,300	$1,985,490
	Total	**$1,527,300**	**$1,985,490**

Included in the report are maps that show the proposed construction areas.

Along with the Master Plan a new electronic Base Map was developed as part of this project. It includes updated information consolidated from several sources and can be overlaid on a digital photo delivered as part of this project.

Section 1: Introduction

This report presents a comprehensive study of the City of Sebastopol's storm drain system. It is one of three master plan utility studies conducted by Coastland Civil Engineering, Inc. analyzing the City's water, sanitary sewer and storm drain facilities. It represents the latest in a series of studies conducted to establish the condition and effectiveness of existing and future drainage system needs.

This report includes an analysis of the major storm drain systems within the City of Sebastopol. An analysis of small-diameter pipes, private storm drain lines, creeks, and drainage ditches and swales is outside the scope of this report. In general, only publicly-maintained storm drain pipes 12 inches in diameter and larger, or pipes in areas known to have drainage problems have been analyzed. Culvert analysis was conducted only when it was necessary to evaluate the adequacy of their capacity.

The computer program StormCAD v5.5 by Haestad Methods was used to perform hydrologic and hydraulic calculations for the various watersheds, and to analyze storm drainage capacities, using the Rational Method. The program utilized precipitation information, tributary areas, C-values, Manning's coefficients, rainfall intensities, junction losses, pipe geometry, elevations, and other data. The storm drain system modeling is based on surface runoff conditions for both the existing condition and at ultimate growth development. This report assumes that areas outside of the City's Urban Growth Boundary (UBG) designated as Agricultural or Open Space will stay relatively undeveloped and that the drainage facilities serving these areas will continue to do so.

Background

Sebastopol was initially settled in the early 1850s serving primarily as a trade center for the predominately agricultural region. In 1902 the City was incorporated and had at that time established businesses such as canneries, mills, and wineries. Most of the original buildings were destroyed in the 1906 earthquake and were later rebuilt. Today, Sebastopol has a population of 7,782.

Flood control and drainage problems have existed in the City from its inception. The Laguna de Santa Rosa forms the eastern boundary of the City and is prone to flooding. Additionally, on the western edge of the City, flooding has occurred from Atascadero Creek and nuisance flooding is still a common occurrence within the City, especially during high-intensity, short-duration storm events. The first comprehensive study of local drainage problems was conducted in 1969[¥], and a Flood Insurance Study was later prepared for the City in 1979[£], and again in 1990[£].

[¥] Hogan, Schoch and Associates, Inc., "A Study of Local Storm Drain Needs for the City of Sebastopol", Report to the City of Sebastopol, Sonoma County, California, June 1969.

[£] Federal Emergency Management Agency, "Flood Insurance Study, City of Sebastopol, California, Sonoma County", Revised Report to The City of Sebastopol, Sonoma County, California, September 1990 – 1979 Report

[ϒ] Sonoma County Water Agency, "Flood Control Design Criteria Manual for Waterways, Channels and Closed Conduits", Manual for Sonoma County, California, November 1966, Revised April 1973, Revised August 1983.

The Sonoma County Water Agency (SCWA) has historically been the local agency with jurisdiction over flood control and drainage. Drainage design within Sonoma County since 1966 has generally been guided by the Water Agency's "Flood Control Design Manual", and most large-scale drainage improvements have been designed and funded by the Water Agency. To finance flood management projects, in 1958 the Sonoma County Water Agency Board of Directors created flood control zones, each representing major watersheds, to allow assessments for flood control projects.

Sebastopol lies within Sonoma County Water Agency Flood Control Zone 1A, which is comprised of all of the watershed area that drains into and includes the Laguna de Santa Rosa and Mark West Creek in central Sonoma County, and which ultimately discharges into the Russian River.

1.1 Objectives

This Storm Drainage Master Plan has been prepared to analyze the existing storm drain system in the City of Sebastopol, and develop a long-term plan for improving drainage facilities within the City. The primary purpose of the Master Plan is to ensure that the City's storm drain system can adequately drain runoff from existing development, and to identify storm drainage improvements that will be needed due to future development. In addition, this Master Plan provides cost estimates for recommended storm drainage improvements, in order to assist the City in establishing financing for capital improvements and development impact fees.

1.2 Scope of Services

The scope of Services of this phase of the three master plan studies is as follows:

- Update the 1993 Storm Drain System Base Map to existing conditions.
- Review and update existing hydrology studies, incorporating appropriate areas within the City Limits into this study.
- Compile and review available hydraulic analyses and develop new city-wide analyses.
- Identify needed projects based on existing and future demands.
- Prepare a report outlining recommended improvements to the storm drain system, incorporating preliminary cost estimates for these improvements.
- Prepare a Master Plan Base Map showing all needed improvements.

1.3 Conduct of Study

The information developed in this report is based on existing population figures, reports, as-built drawings, maps, utility information, and improvement plans provided by the City Engineering and Public Works Departments. The Public Works Department staff identified problem areas within the storm drain system that required attention, and allowed fine tuning of the base map.

Orthographic photography with airborne GPS control generated a digital orthographic surface from which photomaps with two foot contours were created. Surface elevations were obtained from these maps and transferred to a computer modeling program.

The Modified 1998 General Plan was used to determine projected land use generating runoff coefficients for each subhydrologic areas tributary to the City's storm drain system. Field investigation and topographic information was used to define the subhydrologic boundaries and from this total, runoff was calculated and modeled in the storm drain system. See Appendix A for a detailed explanation of the parameters used in developing the models.

Facility improvement projects with implementation plans required to meet current and future flows are recommended. The capital costs required for these improvements are presented as part of this report.

Section 2: Study Area

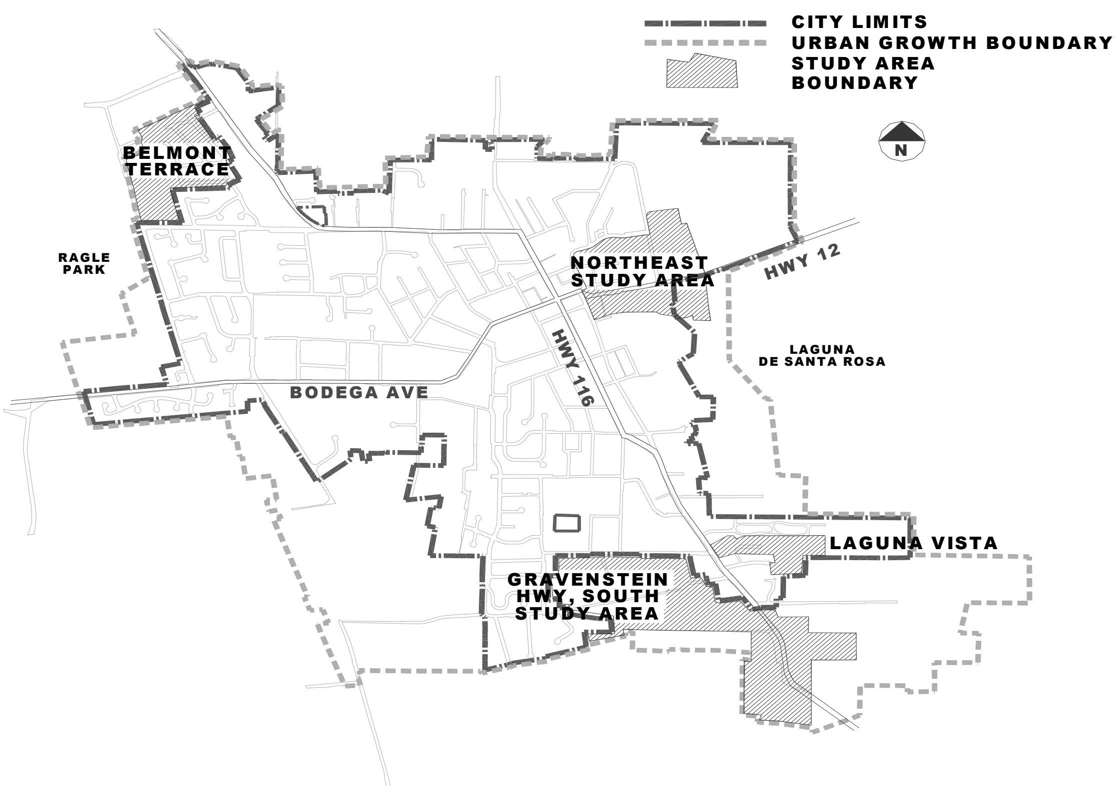
This section describes the Existing Service Area, plans for growth and the build-out methodology.

2.1 Existing Service Area and Land Use Plans

Sebastopol is a semi-urban incorporated community located in western Sonoma County approximately 50 miles north of San Francisco and 7 miles west of Santa Rosa. The area is bounded by the Laguna De Santa Rosa to the east and Atascadero Creek to the west. Highway 12 (Bodega Avenue, west of Main Street) is the main transportation corridor and bisects the community into north-south quadrants. Highway 116 bisects the community in east-west quadrants.

Figure 2-1 shows neighborhood areas and landmarks that may be referenced on occasion within the report. The commercial areas are generally located along the Hwy 116 corridor, with the majority of commercial and industrial space in the northeast quadrant of the City. The remaining areas are primarily residential with a scattering of parks and institutional land use for schools.

FIGURE 2-1
SEBASTOPOL NEIGHBORHOODS AND LANDMARKS



2.1.1 Status of Area Land Use Plans

Land use planning for the service area is performed under the auspices of the City's Planning Commission, the Design Review Board, citizen committees and the Sonoma County Local Agency Formation Commission (LAFCO), as detailed in the General Plan.

The officially recognized General Plan was adopted in 1994 with updates in 1995, 1996, 1998 and 2003. Consistent with the goals outlined in the General Plan, the City has adopted measures to limit urban sprawl by reducing the City's Sphere of Influence (SOI) and by encouraging infill; a means of concentrating new development within the City limits. The community, in agreement with these ideals, adopted the Urban Growth Boundary Measure (Measure O) in 1996. In essence, Measure O prohibits additions to the SOI by the City Council for a period of 20 years unless they are endorsed by voter approval.

In keeping with the General Plan, the City adopted a Growth Management Ordinance which establishes maximum allowable growth rates based on the community's ability to provide key resources (water, wastewater, roads, and schools, for example). Moreover, this ordinance limits the number of new residential units to 25 per year. If the annual limit is not met, the unused allocations become available for future years for a limited number of years.

2.1.2 Zoning and General Plan Land Use Designation

As mentioned in the previous section, the City of Sebastopol General Plan establishes land use designations for all areas within the SOI. These designations establish the City's zoning regulations as is described in the Zoning Ordinance and as illustrated in the Land Use Designations Map. The map in Appendix C reflects current zoning within the City's SOI. The 12 zones identified on this map include Open Space, Parks, Community Facilities, Very Low Density Residential, Medium Density Residential, High Density Residential, General Commercial, Office, Downtown Core, Light Industrial and Office/Light Industrial.

2.1.3 Build-out Development Methodology

The City of Sebastopol Growth Ordinance limits the net increase in residences to 575 over the life of the Plan. Second units, commonly known as "Granny Units" are not included in this figure.

In order to estimate future growth for the purposes of calculating the ultimate stormwater flows for each of the tributary areas, the following methodology was used:

1. Assume construction of 575 new residential housing units beginning in 1994. Use the existing residential units in 2004 and the planned units in 2004. Fill the remaining units using Alternative B of the Northeast Area Alternative Plan.

2. Assume the addition of 100 new second units beginning in 2005. Disperse these throughout the low and medium density housing land use areas.

3. Assume the commercial expansion from Alternative B in the Draft Northeast Area Alternative Report.

4. Assume an increase of 100,000 sf of commercial space along Gravenstein Highway North.

5. Assume any remaining capacity to be taken up by growth in the commercial zone in Gravenstein Highway South.

Consistent with the vision of Urban Growth Boundary measure, and subject to the constraints imposed by the Growth Management Ordinance, future build out development projects will shift and concentrate land use designations within the City limits, and potentially annex areas within the SOI. Table 2-1 lists locations where this expansion is estimated by City planners to occur. Appendix C contains a map outlining these areas.

Table 2-1 Build-out Land Use

Pending Residential Build Out	
Location	**Number of Additional Residential Units**
7991 Covert Lane	20
824 Gravenstein Hwy South	4
7385 Healdsburg Avenue	12
7770 Healdsburg Avenue	4
380 Jewell Avenue	1
Laguna Vista (net)	140
840 and 860 Litchfield Avenue	13
791 Norlee Street	3
333 North Main Street	6
501 Petaluma Avenue	39
406 Pitt Avenue	2
501 South Main Street	10
7590 Washington Avenue (net)	3
Additional Residential Build Out	
Location	**Number of Additional Residential Units**
Northeast Area	78
Second Units spread throughout City	100
Belmont Terrace	90
Belmont Terrace Second Units	27
Gravenstein Hwy South	117
Gravenstein Hwy South Second Units	35

Healdsburg Avenue	8
Bodega Avenue	7
First Street	7
Robinson Road	7
Zimpher Drive	7
South Main Street	7
Jewell Avenue	7

Commercial, Industrial and Community Facilities Build-out

Location	area (sq. ft)
Northeast Area	
light industrial (to be demolished)	150,000
commercial	350,000
community facilities	65,000
Gravenstein Hwy North (in City limits)	
commercial	100,000
Gravenstein Hwy South (in City limits)	
commercial	25,000
Gravenstein Hwy South (in SOI)	
light industrial	939,154
commercial	74,575
Downtown	
commercial	50,000

Section 3: Existing Storm Drainage System

This section describes the Sebastopol Municipal Storm Drain System (SMSDS) service area and the status of land use planning for the area.

3.1 Existing Infrastructure

Most of the stormwater runoff in Sebastopol drains in an easterly direction, from the higher elevations in the westerly portion of the City, through a series of creeks (including Zimpher, Calder and Witter Creeks) and drainage conduits ultimately discharging to the Laguna de Santa Rosa. A smaller drainage area lying westerly of Pleasant Hill Avenue North, discharges to Atascadero Creek, which flows along the City's west boundary.

A map of the existing storm drainage system is provided in Appendix D of this report. The area currently served by the existing storm drain system includes most of the developed properties within the City limits.

The existing storm drainage system consists of a variety of inlet structures and collection systems. The inlet structures include drop inlets and catch basins. The collection system consists of gravity flow pipes, ditches, channels, culverts, and creeks. The size of pipes in the publicly-maintained collection system ranges from 6 to 66 inches in diameter. Types of pipe materials include reinforced concrete, high-density polyethylene (HDPE), polyvinyl chloride (PVC), asbestos cement pipe (ACP), and vitrified clay pipe (VCP).

3.2 Drainage System Background Research

In order to best understand the existing condition of the City's storm drainage system, Coastland's Staff gathered and compiled data from record sources. Background information was gleaned to ensure that previous studies and development designs used similar hydrologic boundaries and that computations resulted in comparable hydraulic analysis. The City's Public Works Department, SCWA, and Coastland's Archive Files were the primary sources. Additionally, field reviews, as-builts, and improvement plans were utilized as necessary to verify record drainage improvements within the City Limits.

The following outline chronologically lists several key sources of background information, along with summaries of the key studies used in preparing this Master Plan:

Sonoma County Flood Control and Water Conservation District, "Zimpher Flood Control Project, Laguna-Mark West Zone 1A", Half-scale drawing set dated February 1st, 1967.

This plan set consists of four sheets of half-scale drawings for SCFC & WCD drainage improvements. The project consisted of installing approximately 880 lf of 42" RCP from

Zimpher Creek 150' west of Florence Avenue to connect into the existing 42" RCP storm drain line 180' east of West Street.

Sonoma County Flood Control and Water Conservation District, "Healdsburg Avenue Conduit, Laguna-Mark West Zone 1A", Half-scale drawing set dated November 6th, 1968.

This plan set consists of 14 sheets of half-scale drawings for SCFC & WCD drainage improvements. The project consisted of installing approximately 4400 lf of concrete pipe (beginning pipe diameter 27", ending diameter 48") beginning 100' west of Lyding Lane. at a temporary bulkhead, along Healdsburg Avenue and terminating at Morris Street.

Hogan, Schoch & Associates, Inc., "A Study of Storm Drain Needs for the City of Sebastopol", Report to the City of Sebastopol, Sonoma County, CA, June 1969.

This is the earliest and most comprehensive report found on record for the drainage system in the City of Sebastopol. The report is approximately 20 pages long and consists primarily of an introduction, a brief discussion of drainage law, and narrative descriptions of the most important drainage problem areas affecting the City at that time. The report concludes with a series of cost estimates for each problem area, and an itemized listing of proposed improvements, ranked by priority.

The report was a result of the exceptionally heavy rainfall that had occurred in the 1968-1969 season. Accordingly, some of the proposed improvements were recommended to be presented to the Zone 1-A Advisory Committee of the Sonoma County Flood Control and Water Conservation District for consideration.

Sonoma County Water Agency, "Palm Avenue Conduit, Reach No. 2 South Main Street Through Litchfield Avenue, Laguna-Mark West Zone 1A", Half-scale drawing set dated June 12th, 1972.

This plan set consists of eight sheets of half-scale drawings for SCWA drainage improvements. The project consisted of installing approximately 1200 lf of concrete pipe (beginning pipe diameter 18", ending diameter 36") beginning approximately 150' west of Litchfield Avenue, near Hayden Avenue, and continuing easterly through a 10' drainage easement to the intersection of South Main Street and Petaluma Avenue.

Sonoma County Water Agency, "Washington-Bodega Conduit No. 2 Bodega Highway to 230' East of Golden Ridge Avenue and Palm Avenue Conduit No. 2, Main Street through Litchfield Avenue, Laguna-Mark West Zone 1A", Half-scale drawing set dated July 9th, 1974.

This plan set consists of 13 sheets of half-scale drawings for SCWA drainage improvements. The project consisted of installing two separate reaches of drainage conduit. The first being approximately 1600 lf of concrete pipe (beginning pipe diameter

18", ending diameter 30") beginning at a catch basin on Washington Avenue, 500' west of Virginia Avenue, then continuing easterly along Washington Avenue, and southerly along Nelson Way, to the manhole located at the intersection of Nelson Way and Bodega Avenue.

The second conduit is the Palm Avenue Conduit, Reach No. 2 as described above in the June 12th, 1972 SCWA plans.

Sonoma County Water Agency, "Washington-Bodega Conduit No. 1 Ives Park-West on Bodega Avenue to Nelson Way, Laguna-Mark West Zone 1A", Half-scale drawing set dated January 24th, 1975.

This plan set consists of eight sheets of half-scale drawings for SCWA drainage improvements. The project consisted of installing approximately 2200 lf of concrete pipe (beginning pipe diameter 30", ending diameter 42") beginning at the manhole located at the intersection of Nelson Way and Bodega Avenue, then continuing easterly along Bodega Avenue to an outfall at Calder Creek in Ives Park, approximately 100' north of the existing pedestrian bridge.

Sonoma County Water Agency, "Middle Zimpher Conduit, Laguna Mark West Zone 1A", Half-scale drawing set dated July 18th, 1990.

This plan set consists of eight sheets of half-scale drawings for SCWA drainage improvements. The project called for the removal of approximately 300 lf of 4'x3' RCP along McKinley Street just west of Petaluma Avenue, to be replaced with 48" RCP. The plans call for installing approximately 700 lf of 48" concrete pipe beginning at a collared connection to the 42" conduit at Keating Avenue, and continuing south along North Main Street and east along McKinley Street, terminating at the Johnson Street connection to an existing 54" RCP conduit.

Sonoma County Water Agency, "Palm Avenue/Petaluma Avenue/S. Main Street Conduits, Laguna-Mark West Zone 1A", Half-scale drawing set dated February 16th, 1996

This plan set consists of 19 sheets of half-scale drawings for SCWA drainage improvements. The project called for the installation of approximately 3800 lf of RCP along portions of Palm Avenue, Calder Avenue, Maple Avenue, South Main Street, and Petaluma Avenue. Installed pipe diameters range from 15" RCP to 42" RCP, and the project terminates at the existing 3'x6' concrete arch just east of Petaluma Avenue and approximately 300' north of Fannen Avenue

3.3 Existing Storm Drainage Problem Area

The City of Sebastopol Public Works Department indicated a problem area within the Calder Creek watershed between Swartz and Washington Avenues. The existing public storm drain system in Swartz Avenue outlets in a V-ditch north of Swartz Avenue in private property. From there it flows through two properties where it is again picked up by the public storm drain system. The City is responsible for maintaining this ditch that causes flow problems between systems. It is recommended that this ditch be replaced with a closed conduit.

3.4 Hydrology and Hydraulic Calculations

The storm drain systems within the City were divided into several smaller watershed areas as shown on the Watershed Boundary Map located in Appendix E. These different watersheds were analyzed using the criteria outlined in Appendix A.

Hydrology calculations were performed for each watershed using the Rational Method for the 10 year storm event, and design flow rates were determined and compared to the hydraulic capacity of existing storm drain facilities. The rainfall intensity-duration-frequency curve provided in the SCWA *Flood Control Design Criteria Manual* was adjusted using the appropriate K-factor to account for local precipitation. The runoff coefficients (C-values) corresponded to the current land and built-out land uses. The hydrology and hydraulic calculations for the existing storm drain system are shown in Appendix C.

The recommended modifications are listed in Section 5.2.

Section 4: Future Storm Drainage System

4.1 Future Development Potential

A number of areas throughout the City of Sebastopol are not fully developed to full General Plan build-out. It is anticipated that these open spaces will be built up with commercial or residential development in the future as indicated in the Land Use Element of the General Plan, and as limited by the Sebastopol Growth Ordinance.

4.2 Ultimate Buildout Methodology

As stated in Section 2, the Sebastopol General Plan and Modified Growth Ordinance limit the net increase in residences to 575 over the life of the Plan. Additionally, the City estimates capacity for 478,000 square feet of commercial development and 80,000 square feet of office space.

Table 2-1 provided the estimated future growth for the City of Sebastopol as estimated by the City Planning Department.

These areas, when built according to their Land Use designations, will have a higher proportion of impervious surfaces, such as roofs and paved areas. In areas with minor infill the change will be insignificant in proportion to the sub-hydrologic area, thus the C-value (runoff coefficient) and estimated runoff will not change.

Where changes are significant in relation to the subhydrologic area the C-values in that area can be expected to increase. This will have the effect of increasing storm runoff rates and volumes, which may necessitate larger drainage facilities.

In addition to infill development within the present City limits, two significant areas within the City's UGB may be expected to request annexation to the City at some point in the future. These include the Belmont Terrace subdivision on the northwesterly edge of Sebastopol, and the residential areas within the UGB, south of Fircrest Avenue and commercial properties fronting Gravenstein Highway South frontage south of town.

The Gravenstein Highway South Study Area Utility Needs Study completed in 1999 by Winzler and Kelly evaluated the storm drain system needs in the potential annexation areas south of town. The recommendations contained in Alternative 3 of that study (the preferred alternative of the City Council) were used in this report.

The Belmont Terrace subdivision does not presently have a storm drain system, and design of such a system is beyond the scope of this Master Plan. However, a watershed map was included this report, as a separate hydrologic area potentially tributary to the existing City storm drain system.

4.3 Hydrology and Hydraulic Calculations

In calculating future runoff rates and volumes for the City of Sebastopol, it was assumed that all areas in the City would be developed according to Table 2-1, increasing the occurrence of impervious surfaces. Where changes will be significant in relation to the subhydrologic area, the C-values were adjusted and the hydrology calculations were re-run to determine increases in runoff rates, volumes and ultimately whether the pipe required upsizing upon future construction. The hydrology calculations were based on the same major and sub watersheds used in analyzing existing drainage requirements (Section 3), with the same hydrologic criteria outlined in Appendix A.

Once hydrology was established for build-out conditions the future runoff rates and volumes were compared to the hydraulic capacity of storm drain facilities as modified per our recommendations to accommodate existing flows.

The analysis of the storm drain system due to future runoff is shown in Appendix C. Watershed areas are shown on the Watershed Boundary Map, which can be found in Appendix E.

Section 5: Recommended Drainage Improvements

5.1 General

Recommended improvements to the storm drainage system are shown in the Master Storm Drainage Plan (Fig. 2) located at the end of this report.

The improvements shown on the Master Plan can be separated into two general categories for scheduling and financing purposes. The first category includes improvements that are needed to correct deficiencies in the existing system. These improvements were determined by the calculation of existing drainage requirements as described in Section 3 of this report. The second category, includes projects needed to accommodate future development. These projects were determined by the calculation of future drainage requirements that was described in Section 4 of this report.

The timing and financing for these two categories are normally different. Projects to alleviate existing deficiencies should be completed at the earliest possible date utilizing funds generated primarily from within the established community. The timing for projects related to future growth will be largely dictated by the timing of new development. It is anticipated that the financing for projects required to accommodate growth will be borne by the developers.

5.2 Drainage Improvement Projects

5.2.1 Upgrades Required for Existing Conditions

The following upgrades are required to alleviate potential overtopping during the 10 year storm event with a 100 year starting HGL in the Laguna. Note that in some locations due to the flood level in the Laguna, parts of Sebastopol will experience flooding. Resizing the storm drain system alone cannot eliminate this flooding.

Witter Creek

Replace 170’ of 15” diameter RCP on Meadowlark Drive with 18” diameter HDPE. Starting at Meadowlark Drive, replace 650’ of 15” RCP on McFarlane and Lynch Roads with 24” diameter HDPE. Replace the existing triple 18” storm culvert the intersection of Lynch Road and Jean Drive with 46’ of 30” HDPE. Install 200’ of 36” RCP parallel to the existing 36” RCP in Beattie Lane.

Our analysis indicated that the storm drain culverts on Elphick Road are undersized. Field investigations also revealed that these culverts are damaged and silted. These empty into private channels lined with corrugated metal and private culverts. While enlarging the culverts on Elphick Road will alleviate the problem with the culverts, it could increase problems in the private drainage downstream. One alternative to this would be to install a public storm drain system through this area.

Atascadero Creek

Replace 520’ of 15” diameter RCP on Pleasant Hill Road with 18” diameter HDPE. Replace 340’ of 18” RCP on Bodega Avenue starting at Pleasant Hill Road with 24” diameter HDPE.

Gravenstein Hwy South (Hazel Cotter Outfall)

Overtopping at Lynch and Gravenstein Highway South is predicted by our storm drain model. To alleviate this overtopping the storm drain system in this area needs to be reconfigured. We recommend constructing a new 420’, 24” HDPE line from the corner of Fircrest Avenue and Gravenstein Hwy South to the 24” line on Hazel Cotter Court. This will take the flows from Fircrest Avenue directly to the last pipe segment before the outfall. This project should include abandoning the 18” line that currently runs from the corner of Fircrest Avenue and Gravenstein Hwy South to the corner of Lynch Road and Gravenstein Highway. The 18” line south of Fircrest should be replaced with a line that will provide a minimum slope of 0.0021 toward the new line. Replace 80’ of 18” CMP line on the easterly end of Lynch Road with 24” HDPE. Replace 900 feet of 24” CMP and RCP line running from the corner of Lynch Road and Gravenstein Highway to the Hazel Cotter outfall with 36” diameter HDPE.

To alleviate overtopping on Redwood Avenue north of the Cotter property, we recommend replacing the existing 15” storm drain line with a 24” HDPE storm drain line.

Zimpher Creek

The storm drain system was analyzed using the 10-year storm with a 100-year starting HGL of 75' at the outfall. Flooding will occur from the outfall to between Brown Street and Petaluma Avenue in areas residing below elevations of 75’. Recommended pipe replacements from Petaluma Avenue to Morris Street will not diminish flooding in this area, but it will alleviate problems upstream of this point. For the system to work well, the main storm drain system beginning between West Street and Pitt Avenue and continuing to the outfall should be upgraded. This includes replacing the existing 42" line with 590' of 54" RCP from Pitt Avenue to North Main; replacing the existing 48" line with 740' of 54" RCP from North Main to Petaluma Avenue; replace the existing 48"line with 370' of 60" RCP from Petaluma Avenue to beginning of 54" storm drain; and replacing the existing 54" line with 840' of 60" beginning at the existing 54" line to Morris Street.

Other improvements must be made upstream to alleviate localized overtopping.

Recommended improvements include replacing the existing 30” and 24” in Valentine Avenue from Washington Avenue to the existing 36” at Brookhaven School with 1000' of 36” RCP. This will reduce overtopping on Valentine Avenue, Brookhaven Court and Washington Avenue.

Overtopping at Pleasant Hill Avenue North, can be alleviated by replacing the 24” storm drain line on Pleasant Avenue North from Valentine Avenue to the intersection with the 8” CP in Libby Park with 200' of 30" RCP.

Overtopping in the area of the Pleasant Hill Condos can be alleviated by replacing the existing public 10” line in Pleasant Hill Avenue with 30' of 15” RCP.

Overtopping at Zimpher Drive can be reduced by removing the existing 30” line at Patricia Court. intersection, running north-south and installing 150’ of 36” RCP connecting to the existing 36” between 401 and 411 Zimpher Drive.

Overtopping at Valentine Avenue from Loraine Court to Springdale Street and at Springdale Street from Valentine Avenue to Brookside Avenue can be minimized by replacing the 15" RCP north of Brookside Avenue with 170' of 18" RCP.

Healdsburg Avenue

The storm drain system was analyzed using the 10-year storm with a 100-year starting HGL of 75' at the Morris Street outfall. Flooding will occur in the lower reaches of the storm drain system due to the water level in the Laguna. Recommended pipe replacements in this area will not diminish flooding in this area, but it will alleviate overtopping problems upstream of this point. For the system to work well the Morris Street outfall and sections of the Morris Street storm drain system need to be replaced. This includes replacing the 48" line from Morris Street to the outfall with 80' of 54" RCP; replacing the 24" in Morris Street north of Laguna Parkway with 640' of 30" line, replacing the existing 15" line in Morris Street in the intersection of Laguna Parkway with 90' of 18" RCP; and replacing the existing 42" line running from Flynn Street to McKinley Way with 220' of 48" RCP.

Other improvements must be made upstream to alleviate localized overtopping.

Overtopping at the corner of Covert Lane and Healdsburg Avenue can be mitigated by replacing the existing 24" line with 290' of 30” HDPE and replacing the existing 18" line with 50' of 24" HDPE at the corner of Covert Lane and Healdsburg Avenue.

Overtopping at the end of Laguna Parkway from the headwall to the outfall can be reduced by replacing the existing 18" line with 60' of 30" and 60' of 24" HDPE.

Palm Avenue

To alleviate overtopping at the intersection of Palm, South Main and Petaluma Avenues we recommend replacing the existing 18” storm drain line starting in Palm Avenue and running to Petaluma Avenue and then to South Main with 470’ of 24” HDPE storm drain line.

Our model predicts overtopping on Highway 116 from Foster Lane to an inlet south of 970 South Highway 116. To alleviate this overtopping we recommend replacing the existing 15" storm drain line from Foster Lane to the inlet south of 970 South Highway 116 with 720' of 24" HDPE storm drain line.

Gravenstein Hwy North

Our model predicts overtopping on both sides of Highway 116 north from about 500 feet north of Tocchini Street. The storm drain system on both sides of North Highway 116 must be improved to alleviate this situation. On the west side of Highway 116 North we recommend removing the two existing culverts and 420' of 24" storm drain line followed by 30' of 30" storm drain line to the outfall. On the east side of Highway 116 North we recommend replacing about 830' of existing ACP storm drain line with 570' of 24" storm drain line followed by 260' of 30" storm drain line. We also recommend replacing the open channel in front of 885 Gravenstein Highway with 80' of18" closed storm drain line.

Calder Creek

Although Calder is the arguably the largest and most complex drainage system in Sebastopol, our analysis indicated few problems. There are three areas that require upgrading to manage storm drain flows at the existing density. To alleviate flooding on East Washington Street from Nelson Way to east of Virginia Avenue we recommend replacing the existing 380' of 18" line running from Nelson Way to east of Virginia Avenue with 24" HDPE.

To alleviate overtopping at the intersection of Calder Avenue and South Main Street, we recommend removing 60' of 30" RCP line and installing 45' of 32" HDPE to bypass the intermediate manhole in South Main.

To alleviate overtopping on South Main Street from Burnett Avenue to just upstream of the junction structure, we recommend replacing the 530' of 18" line from Bodega Avenue to upstream of the junction structure with 24" HDPE.

5.2.2 Upgrades Required for Future Growth Conditions

All the hydrologic zones above were modified to reflect changes in C-values resulting from future growth. All were modeled for future flows in the storm drain system with the modifications recommended above to accommodate the existing conditions. These calculations indicate that Witter Creek, Atascadero Creek, Hazel Cotter Outfall, Zimpher Creek, Healdsburg Avenue, Palm Avenue, Gravenstein Hwy North and Calder Creek watersheds will drain without overtopping during the design storm if the existing storm drain system is modified to accompany the design storm for the current conditions.

Additional construction and modifications will be needed in the Belmont Terrace Area and the Gravenstein Highway South Study Area.

The drainage in the Belmont Terrace area will need to be designed and installed when that area is annexed into the City. General drainage patterns for Belmont Terrace indicate the drainage should outlet to the northwest into an area that will not add additional flows into the City storm drain system. Therefore this annexation will not require upgrades to the existing City storm drain system.

Our model indicated that part of the storm drain line in Gravenstein Highway South is not sufficient when that area is developed and annexed into the City. However, the improvements recommended by the South Gravenstein Study Area should be sufficient to handle the increased flow.

Storm Drain Alternative 3 (in the Gravenstein Highway South Study Area) provides for carrying all stormwater through the Study Area in closed conduits. This storm drain system collects flow along the southerly side of Witter/Elphick Road. The storm drain system would begin with a 27 inch storm drain pipe along Witter Road. This would change to a 36 inch storm drain in Elphick Road. Manholes and drop inlets would be spaced every 300 feet and at each side street. At the intersection of Elphick Road and Highway 116, stormwater would flow through a culvert into the roadside drainage ditches. The storm drain along Highway 116, would be 48 inches in diameter.

5.3 Estimated Project Costs

This section provides the estimated costs for the improvement projects required to meet current and future needs. Estimated costs were averaged from a number of actual bid projects from 2003 to 2005, adjusted for inflation.

Each project estimate is based on the lineal feet of pipe, tie-ins, abandonments, resetting grades, culvert removal, catchbasins and manholes.

For each project, and included in the construction costs, an additional $10,000 is included for mobilization, $10,000 for traffic control and $5,000 for miscellaneous work. Larger values were used, especially for traffic control if those costs were warranted. Also, a 15% construction contingency was added. A 20% contingency was used for the South Gravenstein Highway project to match the contingency used in the Gravenstein Highway South Study Area Utility Needs Study.

Two estimates are provided for each project. The first is estimated construction cost. The second cost includes a 30% mark-up for legal, environmental, engineering, inspection, administration.

These costs are 2005 costs and should be adjusted for inflation using the Engineering Ness Record 20 City Construction Cost Index with a value of 7,415 used for 2005.

Estimated costs per unit are provided in Table 5.1:

Storm System Drain Unit Prices	
Size	**Unit Cost per Linear Foot ($/LF)**
12 in	**$65**
15 in	**$85**
18 in	**$100**
24 in	**$130**
27 in	**$140**
30 in	**$145**
32 in	**$147**
36 in	**$150**
48 in	**$240**
54 in	**$300**
60 in	**$350**
48 x 76	**$550**
Manholes	
48 in	**4000**
60 in	**6000**

Below are the costs of the modifications recommended in Section 5.3 above.

Table 5-2 **Witter Creek**

Location / Description	Diameter (in)	Length (ft) / unit count (ea)	Unit Cost	Estimated Cost
Meadowlark Dr	18	170	$100	$17,000
McFarlane/Lynch	24	650	$130	$84,500
Jean Dr/Lynch Rd intersection	30	46	$145	$6,670
Beattie Ln	36	200	$150	$30,000
Tie ins		12	$1,000	$12,000
Mobilization, Traffic Control and Miscellaneous work				$25,000
Contingency				$26,276
Construction Cost				$201,446
Total Replacement Cost				**$261,879**

Table 5-3 **Atascadero Creek**

Location / Description	Diameter (in)	Length (ft) / unit count (ea)	Unit Cost	Estimated Cost
Peasant Hill Rd	18	520	$100	$52,000
McFarlane/Lynch	24	340	$130	$44,200
Tie ins		6	$1,000	$6,000
Mobilization, Traffic Control and Miscellaneous work				$25,000
Contingency				$18,180
Construction Cost				$145,380
Total Replacement Cost				**$188,994**

Table 5-4 **Gravenstein Hwy South (Hazel Cotter Outfall)**

Location / Description	Diameter (in)	Length (ft) / unit count (ea)	Unit Cost	Estimated Cost
New line Fircrest to Hazel	24	420	$130	$54,600
Manhole		2	$6,000	$12,000
McFarlane/Lynch	36	900	$150	$135,000
Redwood Ave	24	1220	$130	$158,600
Abandonment		1	$4,000	$4,000
Grav Hwy S. at Fircrest Ave.: Raise invert of existing SD		1	$2,000	$2,000
Lynch Rd	24	80	$130	$10,400
Tie ins		14	$1,000	$14,000
Mobilization, Traffic Control and Miscellaneous work				$35,000
Contingency				$58,590
Construction Cost				$484,190
Total Replacement Cost**				**$629,447**

**Does not include possible land acquisition costs.

Table 5-5 **Zimpher Creek**

Location / Description	Diameter (in)	Length (ft) / unit count (ea)	Unit Cost	Estimated Cost
Pitt to No Main	54	590	$300	$177,000
No Main to Petaluma	54	740	$300	$222,000
Petaluma to Morris St	60	1210	$350	$423,500
Valentine to Brookhaven	36	1000	$150	$150,000
Pleasant Hill Avenue	30	200	$145	$29,000
Pleasant Hill Avenue	15	30	$85	$2,550
Patricia Ct	36	150	$150	$22,500
Loraine to Brookside	18	170	$100	$17,000
manholes	60	3	$6,000	$18,000
Abandonment		1	$3,000	$3,000
Tie ins		16	$1,000	$16,000
Mobilization, Traffic Control and Miscellaneous work				$35,000
Contingency				$167,333
Construction Cost				$1,282,883
Total Replacement Cost				**$1,667,747**

Table 5-6 **Healdsburg Avenue**

Location / Description	Diameter (in)	Length (ft) / unit count (ea)	Unit Cost	Estimated Cost
Morris St to outfall	54	80	$300	$24,000
No Morris	30	640	$145	$92,800
So Morris St	18	90	$100	$9,000
Flynn to Laguna Parkway	48	220	$240	$52,800
Healdsburg north of Live Oak	30	290	$145	$42,050
Covert & Healdsburg	24	50	$130	$6,500
Laguna Parkway	30	60	$145	$8,700
Laguna Parkway	24	60	$130	$7,800
manholes	60	11	$6,000	$66,000
Tie ins		7	$1,000	$7,000
Mobilization, Traffic Control and Miscellaneous work				$35,000
Contingency				$52,748
Construction Cost				$404,398
Total Replacement Cost				**$525,717**

Table 5-7 **Palm Avenue**

Location / Description	Diameter (in)	Length (ft) / unit count (ea)	Unit Cost	Estimated Cost
Palm to Petaluma to So Main	24	470	$130	$61,100
Gravenstein Hwy South, from Foster Lane to 970 S. Gravenstein Hwy	24	720	$130	$93,600
Tie ins		5	$1,000	$5,000
Mobilization, Traffic Control and Miscellaneous work				$35,000
Contingency				$29,205
Construction Cost				$223,905
Total Replacement Cost				**$291,077**

Table 5-8 **Gravenstein Hwy North**

Location / Description	Diameter (in)	Length (ft) / unit count (ea)	Unit Cost	Estimated Cost
West side of 116	24	420	$130	$54,600
West side of 116	27	30	$150	$4,500
1003 Grav Hwy to dbl 24	24	570	$130	$74,100
1003 Grav Hwy to dbl 24	30	260	$145	$37,700
885 Grav Hwy	18	80	$100	$8,000
manholes	48	7	$4,000	$28,000
Remove Existing Culverts		2	$500	$1,000
Tie ins		2	$1,000	$2,000
Mobilization, Traffic Control and Miscellaneous work				$55,000
Contingency				$20,940
Construction Cost				$285,840
Total Replacement Cost				**$371,592**

Table 5-9 **Calder Creek**

Location / Description	Diameter (in)	Length (ft) / unit count (ea)	Unit Cost	Estimated Cost
Nelson to Virginia	24	380	$130	$49,400
Abandonment		1	$4,000	$4,000
Calder at S. Main	32	45	$147	$6,615
South Main from Bodega	24	530	$130	$68,900
manholes	60	2	$6,000	$12,000
Tie ins		8	$1,000	$8,000
Mobilization, Traffic Control and Miscellaneous work				$65,000
Contingency				$32,087
Construction Cost				$246,002
Total Replacement Cost				**$319,803**

Table 5-10 **Gravenstein Hwy South (Alternative 3)**

Location / Description	Diameter (in)	Length (ft) / unit count (ea)	Unit Cost	Estimated Cost
Witter Road	27	650	$145	$94,250
Witter Road and Elphick Road	36	2100	$150	$315,000
South Main south of Fircrest	18	60	$100	$6,000
Gravenstein Hwy South	48	1500	$240	$360,000
manholes	60	14	$8,000	$112,000
catchbasins		23	$4,500	$103,500
Modify existing box culvert		1	$150,000	$150,000
Demo driveway culverts		18	$1,500	$27,000
Mobilization, Traffic Control and Miscellaneous work				$105,000
Contingency (20%)				$254,550
Construction Cost				$1,527,300
Total Replacement Cost				**$1,985,490**

5.4 Project Priorities and Timing

This section discusses improvement project priorities and timing.

Projects to accommodate future development are fairly easy to stage. In this case there are only two future projects. The first is the Belmont Terrace project, which is separate from, and will not affect, the existing storm drain system. The second project involves the Gravenstein Highway South drainage area. This will tie into the existing system on Gravenstein Highway South. Both of these projects should be completed prior to annexation, although in the case of the South Gravenstein area, the improvements could wait until the area is developed, if development occurs after annexation. This would allow the City to have developers supply the infrastructure related to their development.

The timing of projects required to meet existing needs is a little more difficult. Ideally, all projects necessary to carry drainage flows for the existing population density and construction should be completed as soon as possible. Funding restrictions, however, preclude this. Therefore, projects must be prioritized.

In developing the below prioritization list we took into account the positive effect each project might have in mitigating overtopping in the City as well as the cost of each project. Therefore, if two projects provided roughly the same benefit the project with the greater cost was ranked lower.

The priorities below are by hydrologic drainage area. Recommended improvements to the storm drainage system are shown in the Storm Drain Proposed Improvements map located in Appendix F. Numbering corresponds to location on the map and not priority. The figure shows projects broken out by individual line length and diameter. This would allow the City to break out the hydrologic subareas into separate projects if required. If projects within a drainage area are split, there are two ways of prioritizing within a drainage area. The first method would be to solve immediate critical problems. Each project description in Section 5.2.1 describes the area that will be affected by the new construction. There were no problems within drainage areas that seemed to require being done ahead of the overall drainage area, but master plan level modeling cannot take into account localized deficiencies. The second method of prioritizing within a drainage area would be to start at the end nearest the outlet and work upstream. This avoids exacerbating problems downstream by fixing problems upstream.

1. Zimpher Creek

We prioritized Zimpher Creek as most urgent both because of the amount of area affected and the main thoroughfares affected by potential overtopping.

This project includes:

- (22) Replacing the existing 42" line with 590' of 54" RCP from Pitt Avenue to North Main;
- (22) Replacing the existing 48" line with 740' of 54" RCP from North Main to Petaluma Avenue;
- (23) Replacing the existing 48"line with 370' of 60" RCP from Petaluma Avenue to beginning of 54" storm drain;
- (23) Replacing the existing 54" line with 840' of 60" beginning at the existing 54" line to Morris Street.
- (8) Replacing the existing 30” and 24” in Valentine Avenue from Washington Avenue to the existing 36” at Brookhaven School with 1000' of 36” RCP.
- (9) Replacing the 24” storm drain line in Pleasant Hill Avenue North from Valentine Avenue to the 8” CP in Libby Park with 200' of 30" RCP.
- (13) Replacing the existing public 10” line in Pleasant Hill Avenue with 30' of 15” RCP.
- (10) Removing the existing 30” line at Patricia Court intersection, running north-south and installing 150’ of 36” RCP connecting to the existing 36” between 401 and 411 Zimpher Drive.
- (11) Replacing the 15" RCP north of Brookside Avenue with 170' of 18" RCP.

2. Gravenstein Hwy South (Hazel Cotter Outfall)

This was prioritized second because it has been a historic problem and it affects the main thoroughfare out of town to the south, a major commuter route. This project includes:

- (29) Constructing a new 420’, 24” HDPE line from the corner of Fircrest Avenue and Bodega Avenue to the 24” line on Hazel Cotter Court.
- (29) Abandoning the 18” line that currently runs from the corner of Fircrest Avenue and Bodega Avenue to the corner of Lynch Road and Gravenstein Highway.
- (30) Replacing the 18” line south of Fircrest with a line that will provide a minimum slope of 0.0021 toward the new line.
- (30) Replacing 80’ of 18” CMP line on the easterly end of Lynch Road with 24” HDPE.
- (31) Replacing 900’ of 24” CMP and RCP line running from the corner of Lynch Road and Gravenstein Highway to the Hazel Cotter outfall with 36” diameter HDPE.
- (28) Replacing the existing 1220’ of 15” storm drain line with a 24” HDPE storm drain line.

3. Palm Avenue

This was prioritized second because it affects the main thoroughfare out of town to the south, a major commuter route. This project includes:

- (26) Replacing the existing 18” storm drain line starting on Palm Avenue and running to Petaluma Avenue and then to South Main with 470’ of 24” HDPE storm drain line.
- (27) Replacing the existing 15” storm drain line from Foster Lane to the inlet south of 970 South Highway 116 with 720’ of 24” HDPE storm drain line.

4. Calder Creek

This drainage area is very large and our analysis indicated few problems that require upgrading. The project includes:

- (12) Replacing the existing 380’ of 18” line in Washington Avenue running from Nelson Way to east of Virginia Avenue with 24” HDPE.
- (25) Removing 60’ of 30” RCP line and installing 45’ of 32” HDPE to bypass the intermediate manhole in South Main.
- (24) Replacing the 530’ of 18” line in South Main Street from Bodega Avenue to upstream of the junction structure with 24” HDPE.

5. Healdsburg Avenue

This drainage area was prioritized next due to size of the area affected. This project includes:

- (17) Replacing the 48" line from Morris Street to the outfall with 80' of 54" RCP;
- (16) Replacing the 24" in Morris Street north of Laguna Parkway with 640' of 30" line,
- (18) Replacing the existing 15" line in Morris Street at the intersection of Laguna Parkway with 90' of 18" RCP;
- (21) Replacing the existing 42" line running from Flynn Street to Laguna Parkway with 220' of 48" RCP.
- (6) Replacing the existing 24" line with 290' of 30” HDPE in Healdsburg Avenue north of the intersection with Live Oak Lane.
- (7) Replacing the existing 18" line with 50' of 24" HDPE at the corner of Covert Lane and Healdsburg Avenue.
- (19&20) Replacing the existing 18" line in Laguna Parkway (between Flynn Street and Morris Street) with 60' of 30" and 60' of 24" HDPE.

6. Gravenstein Hwy North

Our model predicts overtopping in the ditches as the water leaves the City to the north. This project includes:

- (3&4) Removing the two existing culverts on the west side of the highway and constructing 420’ of 24” storm drain line followed by 30’ of 27” storm drain line to the outfall.

- (1&2) Replacing about 830’ of existing ACP storm drain line on the east side of the highway with 570’ of 24” storm drain line followed by 260’ of 30” storm drain line.
- (5) Replacing the open channel in front of 885 Gravenstein Highway with 80’ of 18” closed storm drain line.

7. Atascadero Creek

This project is a smaller area towards the outskirts of the City and therefore was prioritized below the projects above. This project includes:

- (15) Replacing 520’ of 15” diameter RCP on Pleasant Hill Road with 18” diameter HDPE.
- (14) Replacing 340’ of 18” RCP on Bodega Avenue starting at Pleasant Hill Road with 24” diameter HDPE.

8. Witter Creek

This was prioritized relatively low because it does not affect major thoroughfares or large developed areas. This project includes:

- (33) Replacing 170’ of 15” diameter RCP on Meadowlark Drive with 18” diameter HDPE.
- (34&35) Replacing 650’ of 15” RCP on McFarlane and Lynch Roads starting at Meadowlark Drive with 24” diameter HDPE.
- (36) Replace the existing triple 18” culverts at the intersection of Jean Drive and Lynch Road with 46’ of 30” HDPE.
- (37) Install 200’ of 36” HDPE parallel to the existing 36” RCP in Beattie Lane.

Errata / Clarifications

1. The subhydrologic watershed referred to as Gravenstein Hwy South in the text of this report, is labeled South Hwy 116 in the attached calculations and maps.

2. The subhydrologic watershed referred to as Gravenstein Hwy North in the text of this report, is labeled North Hwy 116 in the attached calculations and maps.

3. The Healdsburg Avenue watershed contains two points of discharge, “Outlet – North of Analy High,” and “Outlet – Morris Street,” as is seen in the calculations. Although these are two separate storm drain systems, for historical reference, they remain in the same watershed for this report.

Appendix A
Assumptions and Methodology

Rational Method Assumptions

There are a variety of methods used to generate the flow rates used in sizing a storm drain system. The Rational Method was chosen since it is an appropriate modeling method for the types and variety of drainage areas in the analysis. Additionally, since the Rational Method analysis is required by the Sonoma County Water Agency, subsequent drainage studies in the City and surrounding areas will most likely make use of the Rational Method as well. Providing information in compatible formats will allow this report to provide reference information for future designs.

Rational Method assumptions are:

- Drainage tributary areas are smaller than 300 acres.
- Peak flow occurs when the entire catchment area is contributing.
- Rainfall intensity is uniform over a duration of time at least equal to the time of concentration.
- Rational coefficients were independent of the intensity of the rainfall.

Hydrology and Hydraulics

The computer program StormCAD v5.5 was used to perform the hydrology and the hydraulic calculations. This computer program required the input of rainfall data, drainage areas, C-values, and elevations. Pipe geometry, pipe type, and other design assumptions were assigned from the Master Plan Base Map.

Runoff Coefficients

The following runoff coefficients (C-values) formed the basis for the hydrology calculations. These C-values represent an average that were adjusted based on the SCWA B-1 for variances in land use, density and ground slope. Where multiple land uses occurred, or in instances of higher imperviousness, nomograph, phase a revised C-value was used to more accurately reflect the condition. These coefficients were categorized according to the various Land Uses as shown on the General Plan.

Table A-1 – Average Runoff Coefficients for Various Land Uses

Land Use	Average Runoff Coefficient
Open Space	0.35
Parks	0.35
Community Facilities	0.8
Very Low Density Residential Up to 1 Unit/Acre	0.45
Low Density Residential 1.1 to 2.0 Units/Acre	0.5
Medium Density Residential 2.1 to 6.0 Units/Acre	0.6
High Density Residential 6.1 to 15 Units/Acre	0.75
General Commercial	0.9
Office	0.9
Downtown Core	0.9
Light Industrial	0.9
Office/ Light Industrial	0.9

Manning's Coefficient

Because of the age of the existing storm drain system and the variety of its materials, a Manning's coefficient of 0.014 was generally used for the pipes. In cases where the pipe was known to be CMP, a Manning's coefficient of 0.024 was used.

Times of Concentration

For initial areas, where the subhydrologic areas were less than 2 acres, the time of concentration used in the calculations was 15 minutes for undeveloped and grassy areas, 10 minutes for medium-density development and 7 minutes for commercial, industrial, and high-density areas.

To obtain times of concentration for initial areas greater than 2 acres, overland drainage was calculated using the SCWA's *Overland Flow Time* Nomograph. Because there exists instances where an initial area will drain to one or more subhydrologic areas prior to entering the storm drain system, times of concentration were adjusted assuming sheet flow, or Manning's equation for irregular channels. These calculated times of concentration were entered into the StormCAD software.

Pipe Cover and Slope

Pipe cover, slope, and invert elevations were taken from improvement plans, as-builts, and through field verification, where possible. Where invert elevations and pipe slope information was not known, a three foot minimum depth of cover and or a minimum cleanout velocity was used. The invert information will not be reflected on the Base Maps.

Future pipe sections were assigned a minimum cleanout velocity slope where possible. Water Agency design criteria requires that publicly-maintained storm drain conduits be able to achieve a self-cleaning velocity that is a function of pipe type, size and slope to prevent sediment build-up. During design storm events, backwater conditions will often cause the velocity to drop below this level. Once the water level has receded, the velocity will often increase. The lower water level can be expected at the beginning and end of a storm event.

In locations where the existing drainage system is surcharged such that the hydraulic grade line exceeds the ground surface elevation, recommendations for improvements were made. This recommendation is based on SCWA drainage design criteria to ensure free flow into the drainage system inlet structures during the design storm.

Inlet and Manhole Losses

The losses within the storm drain system were assumed to consist of junction losses and friction losses.

Junction headlosses were calculated using the HEC-22 Energy Method. This method, taken from the Federal Highway Administration's *Urban Drainage Design Manual* correlates structure headloss to the velocity head in the outlet pipe using an experimentally-determined coefficient. There are numerous corrections to the coefficient which take into account structure geometry, pipe diameter, flow depth, relative flow, plunging flow, and benching. The total loss at each structure is the product of the exit pipe's velocity head and the HEC-22 headloss coefficient.

Friction losses were computed based on the average rate of friction loss along a pipe segment (The average friction slope of a segment multiplied by its length). Using the direct step method of analysis, we were able to generate the gradually varied flow profiles for individual reaches of the storm drain system, taking friction losses into account. The water surface elevation profiles were then compared to the existing surface elevations to pinpoint locations in the storm drain system which may be prone to localized overtopping during the 10-year storm event.

Starting Hydraulic Grade Lines

At outfall locations discharging to major waterways, (those with a tributary area of more than four square miles, or about 1300 acres) the 100-year storm event starting HGL in the major waterway was used. The starting HGL for outfalls to the Laguna de Santa Rosa was assumed per the *1990 Federal Emergency Management Agency (FEMA) Flood Insurance Study for the City of Sebastopol* as the 75 foot contour line. In order to best represent the Laguna's starting 100-year HGL, elevation information was taken from the 2004 Orthophoto 2 foot contours provided by Delta Geomatics rather than directly from the FEMA study.

For outfalls discharging to a minor waterway, (less than 1 square mile) the starting HGL was taken from SCWA documented HGLs or by assuming crown elevations.

Table A-3 provides the initial water surface elevation used in the hydraulic calculations for each watershed. Table A-3 shows the approximate locations of each of the outfalls, and precise locations can be found on the updated Storm Water System Base Map.

Table A-2 – Water Surface Elevations at Outfall

Watershed Area	Water Surface Elevation at Outfall	Outfall Location
Zimpher Creek	75	Zimpher Creek
Zimpher Creek	164.74	Lower Zimpher Creek & Brookside Avenue
Zimpher Creek	161.50	Upper Zimpher Creek
Zimpher Creek	132.00	Zimpher Creek @ Murray Avenue
Atascadero Creek	134.95	Atascadero Creek from Bodega Avenue
Atascadero Creek	139.00	Atascadero Creek South of Bodega Avenue
Atascadero Creek	138.00	North Side of Bodega Avenue
Atascadero Creek	162.10	Ragle Road
Calder Creek	105.00	Calder Creek - First St.
Calder Creek	91.50	Ives Memorial Park from Bodega Avenue
Calder Creek	88.00	Ives Memorial Park from Dutton Avenue
Calder Creek	91.00	Ives Memorial Park from Jewell Avenue (Outlet
Calder Creek	104.00	Calder Creek – 60” Outlet

Watershed Area	Water Surface Elevation at Outfall	Outfall Location
Calder Creek	110.98	Calder Creek – Leland Avenue
Calder Creek	125.21	Calder Creek – 18” CMP Outlet
Calder Creek	116.50	Calder Creek near Stefenoni Court
Calder Creek	75.00	Calder Creek
Calder Creek	75.00	Calder Creek 6’x3’ Conc Arch
Calder Creek	151.00	Calder Creek West of Shaun Court
Calder Creek	145.45	Calder Creek - West of Jewel Avenue
Witter Creek	149.00	Witter Creek
South Hwy 116	92.22	Gravenstein HWY South
South Hwy 116	95.19	Outlet West of Redwood Avenue
South Hwy 116	102.00	Hazel Cotter Court
Palm Avenue	75.00	East of Sebastopol Health Care on Palm Avenue
Ragle Ranch	188.23	Ragle Ranch Park
Healdsburg Avenue	75.00	Morris Street
Healdsburg Avenue	91.84	North of Analy High
North Hwy 116	181.33	Gravenstein HWY North Outfall

Rainfall Data

The following rainfall intensity data was calculated from the SCWA Flood Control Design Criteria Manual, Plate No. B-2. Combined rainfall data of various rainfall gauges throughout Sonoma County were used to establish the intensity-duration-frequency curve equation shown below. The rainfall information was obtained from the California Department of Water Resources and the Sonoma County Water Agency. Since the curve is a statistical representation of rainfall intensity County-wide, adjustments to the Rational Method to account for localized precipitation must be taken into account. The

SCWA Manual Plate No. B-32 provides an isoheytal map of the mean seasonal precipitation in Sonoma County. The "K-factor" is used to make this adjustment. K is the mean annual precipitation value taken from the map, divided by 30. The watershed areas in Sebastopol were assigned a K-factor of 1.17, to reflect a mean annual precipitation of 35 inches per year. The program used this rainfall intensity information to develop the intensity-frequency-duration (IDF) curves used in the hydrology calculations.

$$i = K5.12y^{0.1469} \bullet t^{-0.528}$$

K = mean annual precipitation % 30 (unitless)
i = rainfall intensity (inches/hour)
y = return period (in years, 10, 25, 100, etc.)
t = time (minutes)

Table A-3 – Sebastopol Rainfall Data

Return Period (years)	**5-Minute** (inches/hr)	**15-Minute** (inches/hr)	**30-Minute** (inches/hr)	**60-Minute** (inches/hr)
2	2.83	1.59	1.10	0.76
5	3.24	1.81	1.26	0.88
10	3.59	2.01	1.39	0.97
25	4.1	2.30	1.59	1.11
50	4.55	2.55	1.77	1.23
100	5.04	2.82	1.95	1.36

Appendix B
Watershed Area Details, Hydrology and Hydraulic Calculations

The Sebastopol drainage area has been divided into a number of individual watershed areas for hydrologic and hydraulic calculation purposes. Each major storm drainage system in the City which drains into an open-channel waterway has been classified and analyzed separately.

The following output was generated by the StormCAD Haestad Methods computer program. This program was used for both the Hydrology and Hydraulic calculations of the storm drainage system. For assumptions and methodology used in the calculations, see Appendix A.

The existing storm drainage system, updated to reflect the current condition is shown on the City of Sebastopol Storm Drain Master Plan Base Map. In areas where the existing storm drainage system was inadequate as currently sized, pipes were upsized as necessary, and the analysis was re-run and labeled as existing with improvements. In areas that were expected to experience development according to the Land Use Plan, the runoff coefficients were changed to the built-out values, and the analysis was run again and labeled as build out according to General Plan.

Note that the proposed analysis was only performed for areas where the storm drainage system is *currently undersized*, and the Future analysis was only performed for areas that were *expected to be developed* in the future according to the City's General Plan.

Appendix C
Existing Land Use Designations Map

Appendix D
Existing Storm Drain System Map

Appendix E
Watershed Boundary Map

Appendix F
Storm Drain Proposed Improvements Maps

Appendix G
Gravenstein Hwy South Utility Needs Study