RIVERBANK
STORM DRAIN SYSTEM
MASTER PLAN

VOLUME TWO

JUNE 2008

NOLTE

BEYOND ENGINEERING

CITY OF RIVERBANK
STORM DRAIN SYSTEM MASTER PLAN

REGISTERED PROFESSIONAL ENGINEER
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No. 33479
EXP. 6/30/10
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6-25-08

REGISTERED PROFESSIONAL ENGINEER
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STATE OF CALIFORNIA

6/25/08

Volume Two

June 2008

Submitted to:

City of Riverbank
Department of Public Works
6707 Third Street
Riverbank, CA 95367

Prepared by:

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CONTENTS

Volume Two

Appendices:

APPENDIX A

Technical Memorandum – City of Riverbank Meeting – Drainage Study

Technical Memorandum

Date: February 2, 2006

From: Joseph Fos
Engineering Technician

To: John Davids
Assistant, Engineer and
Support Services Manager

Re: **City of Riverbank Meeting - Drainage Study**

The City of Riverbank and Oakdale Irrigation District (OID) met January 30th at 10:00 am to review the ongoing issues of storm drainage, the responsibilities of new development and the impact on existing OID facilities located within the Riverbank sphere of influence. In attendance at the meeting were Community Development Director J. D. Hightower, Public Works Director Laurie Barton, another employee of the Riverbank Public Works Department whose name I did not get, City of Riverbank Engineer Bill Kull, OID Director Jack Alpers, OID General Manager Steve Knell, Assistant Watermaster Tom Laidlaw and myself.

We discussed the fact that Riverbank and OID have been tentatively involved in drainage studies for the past twelve (12) years and that the most recent meeting was held in late 2004. OID has not received any new information regarding the proposed drainage study since. We discussed the impacts of development occurring within the sphere of influence on the east side of Riverbank and drainage problems occurring in the Bruinville area.

The City of Riverbank would like to unite the small developments occurring in the Bruinville area to develop a drainage analysis and solution that all the developments could utilize. The Bruinville area Master Public Facilities Plan was briefly discussed and Laurie Barton recommended that the document be modified to include the concerns of OID regarding existing OID facilities located within the developments and how they should be addressed in planning a project.

Drainage issues regarding the OID Riverbank Drain were discussed. Tom Laidlaw explained the relationship between the Riverbank Drain, the Crane Drain and the Snedigar Lateral, and how a "bottleneck" that limits drainage exists at Central Avenue and California Street. A discussion of the volume of drainage in the Crane Drain and how a portion of that drainage is diverted to the Crane Lateral at the Stumph Pump was reviewed. Tom Laidlaw recommended increasing the capacity of the Stumph Pump to intercept more drainage from the Crane Drain before it is collected by the Snedigar Lateral. Steve Knell discussed the idea of also considering a reservoir along the Crane Drain at the Stumph Pump to collect drainage for discharge by the Stumph Pump.

I introduced the idea that it might be feasible for the Snedigar Lateral to be rerouted at Eleanor Avenue to connect to the Riverbank Lateral, located approximately 1,400 feet to the south, and that this connection could also intercept the Riverbank Drain. The discussion included the concept that if an engineering analysis of the Snedigar Lateral, Riverbank Lateral and Riverbank Drain concluded that connecting the facilities at Eleanor Avenue is feasible, then it might be possible for OID to quitclaim the Snedigar Lateral and Riverbank Drain to the City of Riverbank. This quitclaim could include the Snedigar Pond and pumps located along the east side of the Modesto Irrigation District (MID) Main Canal, where OID drainage currently discharges to the MID facility.

The City of Riverbank is in favor of determining if the OID modifications are feasible and asked Bill Kull if he could develop a proposal to the City to accomplish the work within sixty (60) days. Bill said he would provide the proposal.

The City of Riverbank asked if OID would install the proposed connector pipeline between the Snedigar and Riverbank Laterals. My initial response was that OID would not pay for any modifications to the Snedigar Lateral or Riverbank Drain; that it should be the responsibility of the developers and Riverbank to pay for the project. Steve Knell noted that if there is a benefit to OID in the project, including the development of the above-noted reservoir as part of the project, that OID could cost-share with the City of Riverbank and the developers.

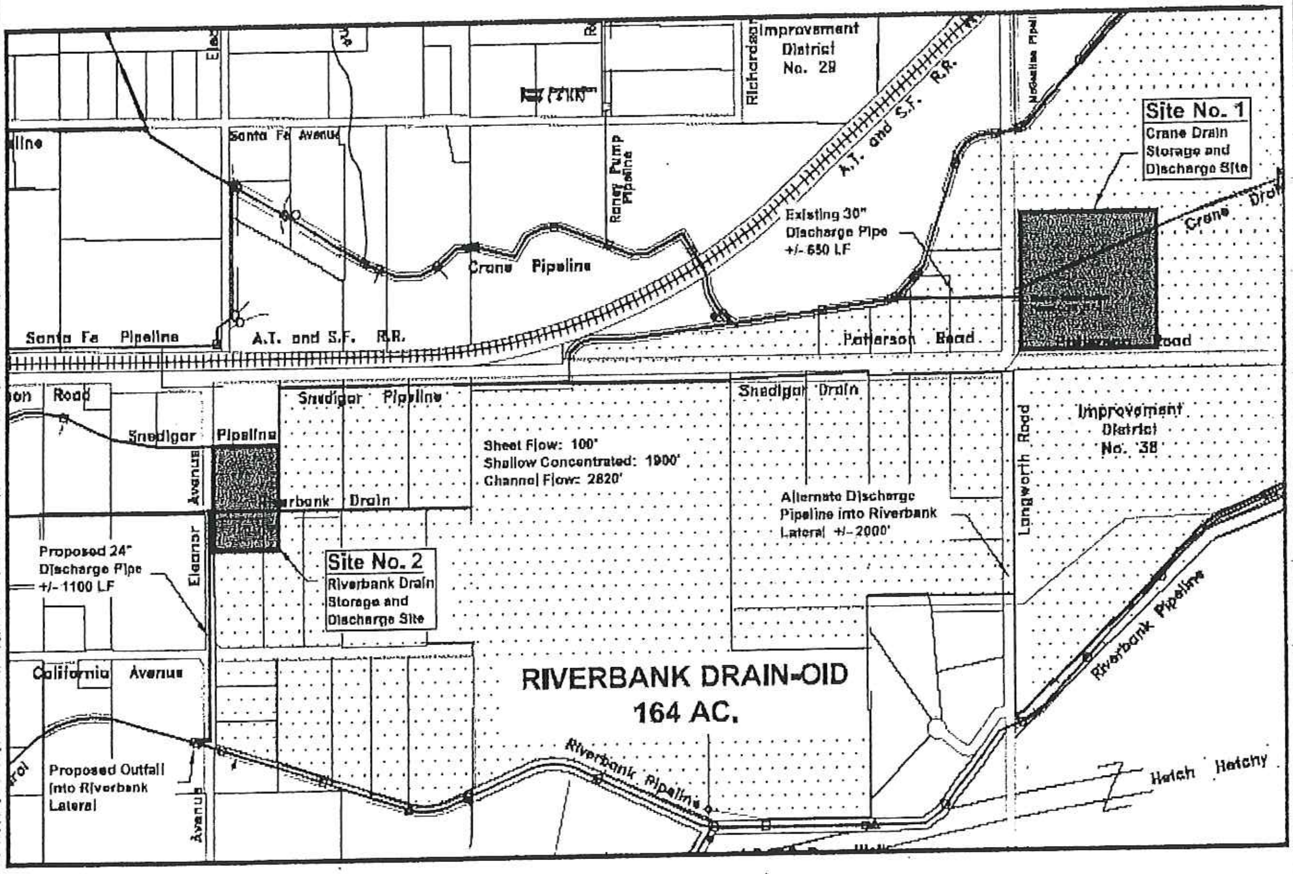
The meeting adjourned with the common agreement that Bill Kull's analysis if the proposal will be reviewed at the next meeting. In the interim, I was asked to attend a meeting Wednesday, February 1st, to review the proposed development on the north side of Van Dusen at Claus Road that impacts the Riverbank Lateral.

K:\Engineering\Joe Fos\Memos\RiverbankDrain.doc

APPENDIX B

East Riverbank Drainage Feasibility Study

EAST RIVERBANK DRAINAGE FEASIBILITY STUDY



Prepared by

Giuliani & Kull, Inc.
Engineers • Planners • Surveyors
440 S. Yosemite Ave, Suite A Oakdale, CA 95361
Phone (209) 847-8726 Fax (209) 847-7323
Auburn • San Jose • Oakdale

Giuliani & Kull, Inc.
Engineers • Planners • Surveyors
San Jose - Oakdale - Auburn

July 18, 2006

Laurie Barton
Public Works Director/City Engineer
City of Riverbank
6707 Third St.
Riverbank, CA 95367

Subject: Eastern Riverbank Drainage Study

Dear Ms. Barton:

At your request, Giuliani and Kull, Inc. has prepared the enclosed study to assess the feasibility of constructing a system which will have the capability of diverting agricultural and storm runoff from the Crane Drain and Riverbank Drain to the Oakdale Irrigation District's Crane Lateral and Riverbank Lateral, respectively. The ultimate goal is to reduce the runoff that enters the City of Riverbank's current and future storm drain system. Upon completion of the construction of the system the Oakdale Irrigation District would relinquish some its facilities lying West of Eleanor Avenue allowing the City to utilize the existing pipelines to be used for storm water conveyance. The study area is located on the East side of Riverbank near the intersections of Langworth Road and Patterson Road and Eleanor Avenue and Patterson Road in Stanislaus County.

Should you have any questions or comments please feel free to contact me or Bill Kull at our Oakdale Office.

Sincerely,

REGISTERED PROFESSIONAL ENGINEER
CHAD J. TIENKEN
C 68131
EXP. 6-30-07
CIVIL
STATE OF CALIFORNIA

Chad J. Tienken
Giuliani & Kull, Inc.

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Table of Contents

East Riverbank Drainage Study

Project Overview: Currently irrigation flow and storm flows from systems controlled by the Oakdale Irrigation District enter the City's sphere of influence at Eleanor Road. This water typically flows East to West and has the potential to impact future development of the properties that lie West of Eleanor Road. In an attempt to alleviate the future developed areas from having to become impacted from these flows it is practical to design a system that will divert the water around the future developed areas and discharge these flows into conveyance system presently in place and currently utilized by Oakdale Irrigation District.

The proposed system should be designed to collect runoff at two locations (See Figure 1). Site No. 1 is located at the northeast corner of Langworth Road and Patterson Road. Site No. 1 would capture runoff from the "Crane Drain" West of Crane Road and discharge that runoff into the Crane Lateral preventing flow into the Snedigar and Riverbank Drains. The recapture system would consist of a new pump and motor, pump house, basin, and pipeline. Current Oakdale Irrigation District facilities include a lift pump with a 15 Horsepower motor, pump house, discharge pipe, and small sump. The existing facility is referred to as the "Stumph Pump."

Site No. 2 is located just south of the intersection of Patterson Road and Eleanor Avenue at the point where the Riverbank Drain crosses Eleanor Avenue. The Riverbank Drain captures runoff from agricultural areas lying west of Langworth Road, South of Patterson Road, and North of the Riverbank Lateral. Site No. 2 would retain this runoff in a basin and pump it into the Riverbank Lateral via a 1400 feet discharge pipeline. The discharge pipeline would outfall into an existing control box on the Riverbank Lateral approximately 400 feet South of the intersection of California Avenue and Eleanor Avenue.

The Oakdale Irrigation District's existing facilities lying West of Eleanor Avenue include the Snedigar Pipeline and the Riverbank Drain. Due to urban development irrigation water demand has greatly decreased West of Eleanor Avenue. Consequently the District has expressed an interest in relinquishing the aforementioned facilities to the City of Riverbank. The City would have the ability to incorporate these facilities into their regional utility plan.

Assumptions: The watersheds for each site were defined through a combination of visual observation of existing drainage/irrigation patterns, verification through Oakdale Irrigation District personnel, and USGS quad maps. The watersheds are almost entirely made up of agricultural lands and have been graded to flood irrigate from the Oakdale Irrigation District Riverbank and Crane Laterals. Therefore, the watersheds are relatively well defined. Groundwater (subsurface) flows have not been incorporated as a part of this study.

Since flows from these watersheds are ungauged, no historical records are available to produce a unit hydrograph. Consequently, the watersheds were analyzed using the Natural Resources Conservation Service Technical Release 55 (TR-55), which presents simplified procedures to calculate storm runoff volume, peak rate of discharge, hydrographs, and storage volumes required for floodwater reservoirs. These procedures are applicable in small watersheds (up to 4000 acres), especially urbanizing watersheds, in the United States. The procedure produces a synthetic hydrograph, which can be used as a reasonable estimate.

Storage volumes were estimated based on 50-year 24-hour storm hydrographs. Design frequency criteria was established based on recommendations taken from the Stanislaus County Standards and Specifications (1998 Ed.) Section 4.4 *Drainage Retention*. The NRCS has developed four synthetic 24-hour rainfall distributions applicable to the United States. This study assumes a Type I rainfall distribution (see Exhibit F). Discharge capacities of retention basins are based on existing flow capacities of the Crane Lateral and Riverbank Lateral. It should be noted that storage volumes vary greatly with discharge capacities and future development should consider upgrading/enlarging these pipelines to lessen required storage.

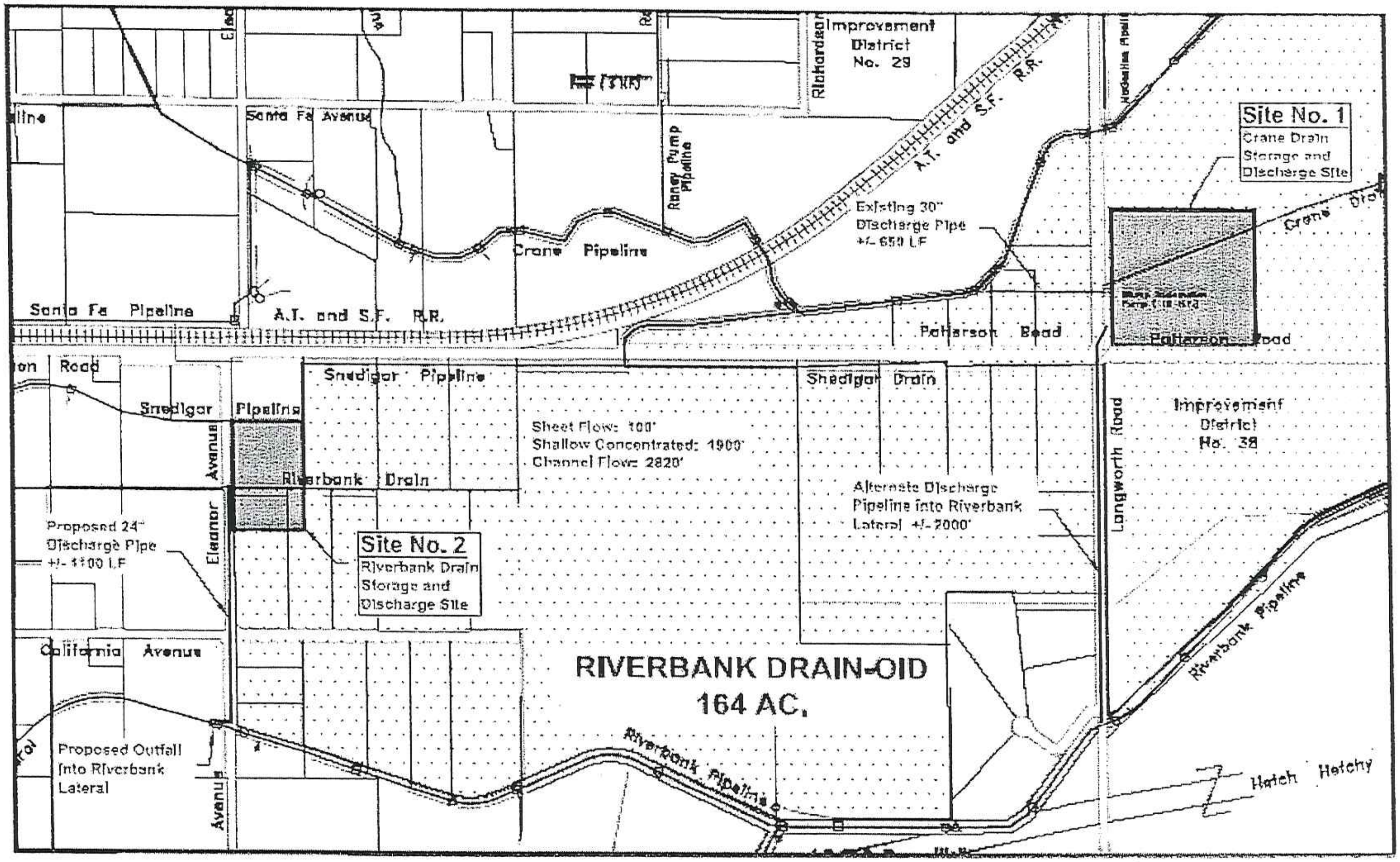


Figure 1. Proposed Storage and Discharge Sites

Calculations: Time of Concentration calculations are incorporated into the TR-55 program and consist of overland sheet flow, shallow concentrated overland flow and channel flow. Overland flows assume an average ground slope of 0.005 ft/ft and pasture grass as the cover. Channel flow assumed uniform channels with a 4 foot bottom width, 2:1 side slopes and an average depth of flow of 4'. The average channel slope for the Crane Drain was assumed to be 0.0015 ft/ft. The average channel slope for the Riverbank Drain was assumed to be 0.0035 ft/ft. The Time of Concentration for the Crane and Riverbank watersheds are 1.16 hr and 1.11 hr respectively.

The Crane Drain watershed is comprised of approximately 237 acres and consists of soils in the A, B, C, and D hydrologic groups (See Exhibit A). The Riverbank Drain watershed is comprised of approximately 164 acres and consists of soils in the B, C, and D hydrologic groups (See Exhibit B). The weighted Curve Numbers (CN) for the Crane and Riverbank watersheds are 78 and 83 respectively. An overall site plan is contained in Exhibit G.

The peak discharge for the Crane watershed was calculated to be 6.4 cfs (2-yr), 49 cfs (10-yr), and 89 cfs (50-yr). The synthetic runoff hydrograph for the Crane watershed is contained in Exhibit C. The peak discharge for the Riverbank watershed was calculated to be 12 cfs (2-yr), 56 cfs (10-yr), and 93 cfs (50-yr). The synthetic runoff hydrograph is contained in Exhibit D.

Based on the synthetic hydrographs and assumed discharge capacities the required storage was calculated at each location. Exhibits E and F illustrate the reservoir storage accounting for each watershed. Basin discharge for the Crane watershed would be accomplished by a pump station discharging to the Crane Lateral. The pump station was assumed to have a maximum capacity of 5 cfs. These design criteria result in a required storage of 25 acre-feet for a 50-year 24-hour storm event. Exhibit E also contains an alternate method of calculating detention storage volumes as outlined by Stanislaus County Public Works Standards and Specifications (1998).

The Riverbank storage facility would collect the Riverbank watershed runoff as illustrated in the reservoir storage accounting in Exhibit E. Basin discharge would be accomplished by pumping out of the proposed basin into an existing control box on the Riverbank Lateral approximately 400 feet South of the intersection of California Avenue and Eleanor Avenue. The discharge line would run parallel to Eleanor in a Southerly direction. Maximum basin discharge is estimated at 5 cfs and is based on interviews with Oakdale Irrigation District personnel as well as as-built drawings of the Riverbank Lateral. These design criteria result in a required storage of 20 acre feet for a 50-year 24-hour storm event.

Additional data, assumptions, and calculations are contained in the Appendix.

Conclusions and Findings: Our findings indicate the need for two storage facilities. It should be noted that storage volumes vary greatly with basin discharge capacities and future development should consider the potential for upgrading discharge pipelines (Crane Lateral and Riverbank Lateral) to reduce required storage volumes. The following table provides a summary of findings for the discharge scenario contain herein. Discharge rates are assumed to be, as stated above, 5 cfs for each pump station.

Examples of potential basin configurations are numerous. As an example we provide Tables 2 and 3 for illustration. The basin footprints in the example layout are square. These layouts provide the reader with an indication of the potential land area required for basin construction. All dimensions shown represent inside basin dimensions. Embankments and access roads are not included in area calculations.

Watershed Description	Contributing Area, (acres)[a]	Curve Number[b,e]	Time of Concentration, t_c (hr)[b,e]	Peak Flow (cfs)[b,c,e]	Estimated Basin Discharge (cfs)[d]	Storage Required (ac-ft)[c]
Riverbank Drain	164	83	1.11	93.11	5	20.0
Crane Drain	237	78	1.16	89.43	5	25.3

Footnotes:

a Estimated from field data and OID personnel

b See Attached Calculations (NRCS TR-55 Method)

c 50-year, 24-hr Storm Event

d Restricted by physical constraints of existing OID release facilities (Crane Lateral and Riverbank Lateral)

e NRCS TR-55 Method

Table 1. Findings Summary

We have calculated a required storage volume for the Crane Watershed of approximately 5.6 acres (See Table 2). The required storage for the Riverbank Watershed is estimated at 4.6 acres (See Table 3). Each basin is assumed to have an 6 feet total depth with 5 feet of effective storage. Side slope of the basin are assumed to be 3:1 (horizontal to vertical).

Basin Layout for Site No. 1 - Crane

Depth, ft =	6
Freeboard, ft =	1
Side Slopes, h:1 =	3

Volume = 1/3 h (a b + c d + SQROOT [a b c d])

Top Dimensions	Bottom Dimensions			Top Area	Bottom Area	Volume	Volume
a	b	c	d	ft^2	ft^2	ft^3	ac-ft
490	490	460	460	240,100	211,600	1,127,372	25.9

Basin Area, acres =	5.65
Time to Discharge, hr =	63

(based on Rate of Peak Outflow)

Table 2. Hypothetical Basin Layout – Site No. 1 (Crane Basin)

Additional potential for reduction of required storage volumes lie in the construction of an additional discharge pipeline that would run in a North-South direction and connect Site No. 1 (Crane Basin) to the Riverbank Lateral at its intersection with Langworth Road (see Figure 1). This would provide additional discharge capacity by allowing Crane Basin discharge flows to be directed down the Southwest Lateral. Capacities of the Southwest lateral were not explored as part of this study and the feasibility of this option requires additional investigation.

Basin Layout for Site No. 2 - Riverbank

Depth, ft =	6
Freeboard, ft =	1
Side Slopes, h:1 =	3

Volume = 1/3 h (a b + c d + SQROOT [a b c d])

Top Dimensions	Bottom Dimensions			Top Area	Bottom Area	Volume	Volume
a	b	c	d	ft^2	ft^2	ft^3	ac-ft
440	440	410	410	193,600	168,100	902,597	20.7

Basin Area, acres =	4.57
Time to Discharge, hr =	50

(based on Rate of Peak Outflow)

Table 3. Hypothetical Basin Layout – Site No. 2 (Riverbank Basin)

Cost Estimate: The following cost estimate is provided for budgeting purposes only as a detailed design was not included as a scope of this study.

Engineer's Estimate

Item	Description	Quantity	Unit	Unit Price	Cost
Crane Drain System					
1	Land Acquisition	1	LS	$300,000	$300,000
2	Earthwork - Basin Construction	1	LS	$35,000	$35,000
3	Pump Station & Discharge Piping	1	LS	$30,000	$30,000
				Subtotal:	**$365,000**
Riverbank Drain System					
1	Land Acquisition	1	LS	$300,000	$300,000
2	Earthwork - Basin Construction	1	LS	$25,000	$25,000
3	Pump Station	1	LS	$30,000	$30,000
4	Discharge Piping	1,084	LF	$60	$65,000
				Subtotal:	**$420,000**
				Total	**$785,000**

Table 4. Engineer's Estimate

Appendix

Exhibit A

HYDROLOGIC GROUP RATING FOR EASTERN STANISLAUS AREA, CALIFORNIA

Crane Drain Watershed

USDA Natural Resources Conservation Service

Web Soil Survey 1.1
National Cooperative Soil Survey

HYDROLOGIC GROUP RATING FOR EASTERN STANISLAUS AREA, CALIFORNIA

Crane Drain Watershed

MAP LEGEND

Hydrologic Group

{Dominant Condition, <}

- A
- A/D
- B
- B/D
- C
- C/D
- D
- Not rated or not available
- Soil Map Units
- Cities
- Detailed Counties
- Detailed States
- Interstate Highways
- Roads
- Rails
- Water
- Hydrography
- Oceans

MAP INFORMATION

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL: http://websoilsurvey.nrcs.usda.gov

Coordinate System: UTM Zone 10

Soil Survey Area: Eastern Stanislaus Area, California
Spatial Version of Data: 2
Soil Map Compilation Scale: 1:24000

Map comprised of aerial images photographed on these dates:
5/9/1993; 8/15/1998; 8/16/1998; 9/12/1998

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Tables - Hydrologic Group

Summary by Map Unit - Eastern Stanislaus Area, California

Soil Survey Area Map Unit Symbol	Map Unit Name	Rating	Total Acres in AOI	Percent of AOI
HdA	Hanford sandy loam, 0 to 3 percent slopes	B	9.8	3.6
HuA	Hopeton loam, 0 to 3 percent slopes	C	18.7	6.8
MdA	Madera sandy loam, 0 to 2 percent slopes	D	21.0	7.6
MtD2	Montpellier coarse sandy loam, 15 to 30 percent slopes, eroded	C	0.2	0.1
SaA	San Joaquin sandy loams, 0 to 3 percent slopes	D	206.1	74.9
SnA	Snelling sandy loam, 0 to 3 percent slopes	B	10.8	3.9
TuA	Tujunga loamy sand, 0 to 3 percent slopes	A	2.6	0.9
WmC	Whitney sandy loams, 8 to 15 percent slopes	C	3.0	1.1
WrB	Whitney and Rocklin sandy loams, 3 to 8 percent slopes	C	3.0	1.1

Description - Hydrologic Group

Hydrologic soil groups are based on estimates of runoff potential. Soils are assigned to one of four groups according to the rate of water infiltration when the soils are not protected by vegetation, are thoroughly wet, and receive precipitation from long-duration storms.

The soils in the United States are placed into four groups A, B, C, and D, and three dual classes, A/D, B/D, and C/D. Definitions of the classes are as follows:

The four hydrologic soil groups are:

Group A. Soils having a high infiltration rate (low runoff potential) when thoroughly wet. These consist mainly of deep, well drained to excessively drained sands or gravelly sands. These soils have a high rate of water transmission.

Group B. Soils having a moderate infiltration rate when thoroughly wet. These consist chiefly of moderately deep or deep, moderately well drained or well drained soils that have moderately fine texture to moderately coarse texture. These soils have a moderate rate of water transmission.

Group C. Soils having a slow infiltration rate when thoroughly wet. These consist chiefly of soils having a layer that impedes the downward movement of water or soils of moderately fine texture or fine texture. These soils have a slow rate of water transmission.

Group D. Soils having a very slow infiltration rate (high runoff potential) when thoroughly wet. These consist chiefly of clays that have a high shrink-swell potential, soils that have a high water table, soils that have a claypan or clay layer at or near the surface, and soils that are shallow over nearly impervious material. These soils have a very slow rate of water transmission.

If a soil is assigned to a dual hydrologic group (A/D, B/D, or C/D), the first letter is for drained areas and the second is for undrained areas. Only soils that are rated D in their natural condition are assigned to dual classes.

Parameter Summary - Hydrologic Group

Aggregation Method: Dominant Condition

Aggregation is the process by which a set of component attribute values is reduced to a single value that represents the map unit as a whole.

A map unit is typically composed of one or more "components". A component is either some type of soil or some nonsoil entity, e.g., rock outcrop. For the attribute being aggregated, the first step of the aggregation process is to derive one attribute value for each of a map unit's components. From this set of component attributes, the next step of the aggregation process derives a single value that represents the map unit as a whole. Once a single value for each map unit is derived, a thematic map for soil map units can be rendered. Aggregation must be done because, on any soil map, map units are delineated but components are not.

For each of a map unit's components, a corresponding percent composition is recorded. A percent composition of 60 indicates that the corresponding component typically makes up approximately 60% of the map unit. Percent composition is a critical factor in some, but not all, aggregation methods.

The aggregation method "Dominant Condition" first groups like attribute values for the components in a map unit. For each group, percent composition is set to the sum of the percent composition of all components participating in that group. These groups now represent "conditions" rather than components. The attribute value associated with the group with the highest cumulative percent composition is returned. If more than one group shares the highest cumulative percent composition, the corresponding "tie-break" rule determines which value should be returned. The "tie-break" rule indicates whether the lower or higher group value should be returned in the case of a percent composition tie.

The result returned by this aggregation method represents the dominant condition throughout the map unit only when no tie has occurred.

Component Percent Cutoff:

Components whose percent composition is below the cutoff value will not be considered. If no cutoff value is specified, all components in the database will be considered. The data for some contrasting soils of minor extent may not be in the database, and therefore are not considered.

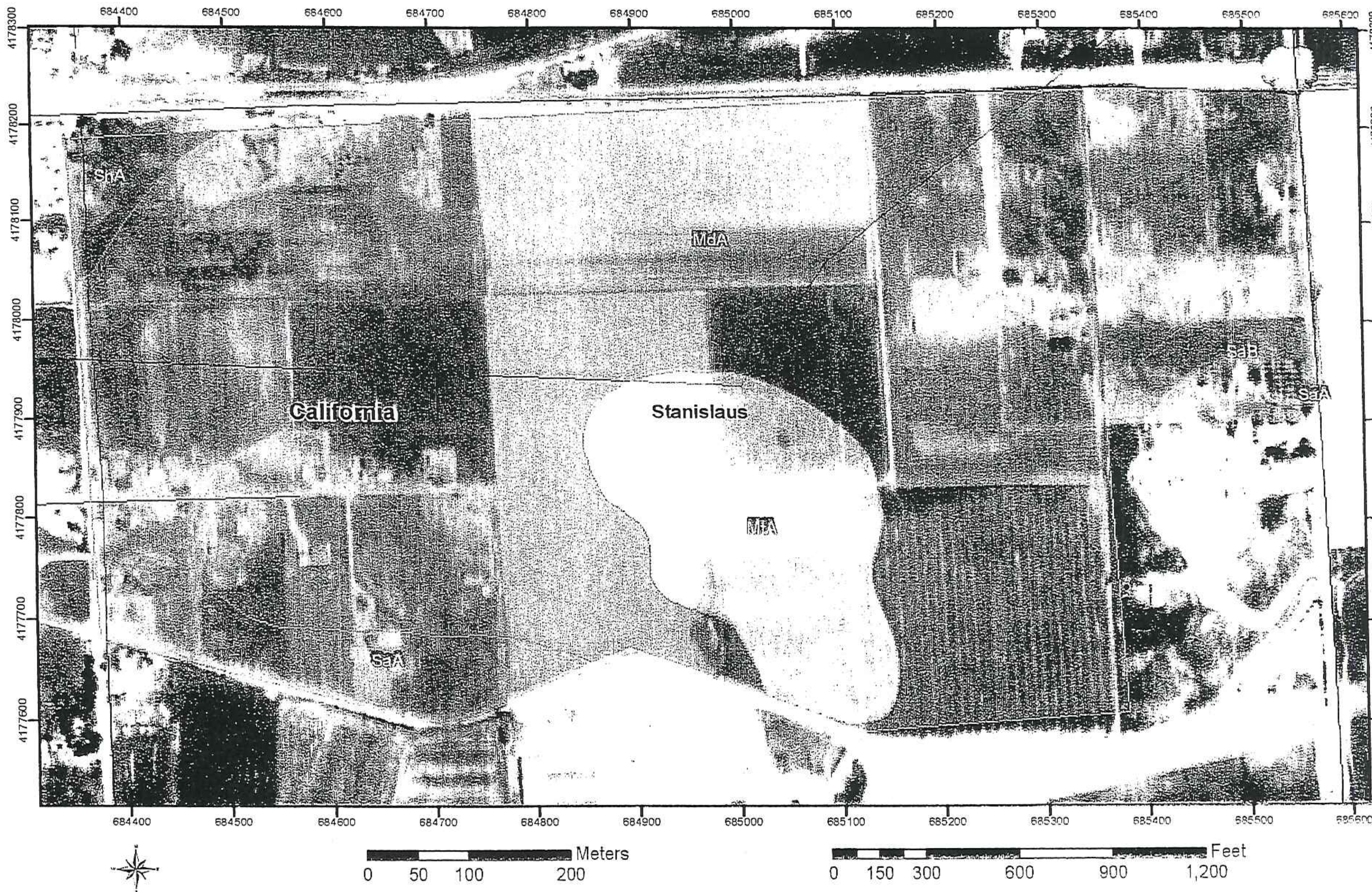
Tie-break Rule: Lower

The tie-break rule indicates which value should be selected from a set of multiple candidate values, or which value should be selected in the event of a percent composition tie.

Exhibit B

HYDROLOGIC GROUP RATING FOR EASTERN STANISLAUS AREA, CALIFORNIA

Riverbank Drain



HYDROLOGIC GROUP RATING FOR EASTERN STANISLAUS AREA, CALIFORNIA

Riverbank Drain

MAP LEGEND

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{Dominant Condition, <}

- A
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MAP INFORMATION

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MdA	Madera sandy loam, 0 to 2 percent slopes	D	129.6	79.2
MtA	Montpellier coarse sandy loam, 0 to 3 percent slopes	C	17.1	10.5
SaA	San Joaquin sandy loams, 0 to 3 percent slopes	D	9.1	5.5
SaB	San Joaquin sandy loams, 3 to 8 percent slopes	D	5.3	3.2
SnA	Snelling sandy loam, 0 to 3 percent slopes	B	2.6	1.6

Description - Hydrologic Group

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Tie-break Rule: Lower

The tie-break rule indicates which value should be selected from a set of multiple candidate values, or which value should be selected in the event of a percent composition tie.

Exhibit C

WinTR-55 Current Data Description

--- Identification Data ---

User:	CJT	Date:	7/12/2006
Project:	Riverbank - Crane	Units:	English
SubTitle:	Riverbank East Drainage Study	Areal Units:	Acres
State:	California		
County:	Stanislaus		
Filename:	C:\Documents and Settings\CTienken\Application Data\WinTR-55\Crane.w55		

--- Sub-Area Data ---

Name	Description	Reach	Area(ac)	RCN	Tc
Crane Pipe	Crane Drain Watershed	Crane Drn	237	78	1.163

Total area: 237 (ac)

--- Storm Data --

Rainfall Depth by Rainfall Return Period

2-Yr (in)	5-Yr (in)	10-Yr (in)	25-Yr (in)	50-Yr (in)	100-Yr (in)	1-Yr (in)
1.5	2.0	2.8	3.0	3.7	4.0	1.3

Storm Data Source: User-provided custom storm data
Rainfall Distribution Type: Type I
Dimensionless Unit Hydrograph: <standard>

CJT

Riverbank - Crane
Riverbank East Drainage Study
Stanislaus County, California

Sub-Area Time of Concentration Details

Sub-Area Identifier/	Flow Length (ft)	Slope (ft/ft)	Mannings's n	End Area (sq ft)	Wetted Perimeter (ft)	Velocity (ft/sec)	Travel Time (hr)
Crane Pipe							
SHEET	100	0.0050	0.150				0.415
SHALLOW	1300	0.0050	0.050				0.317
CHANNEL	4030					2.600	0.431
					Time of Concentration		1.163
							========

CJT

Riverbank - Crane
Riverbank East Drainage Study
Stanislaus County, California

Watershed Peak Table

Sub-Area or Reach Identifier	Peak Flow by Rainfall Return Period 2-Yr (cfs)	10-Yr (cfs)	50-Yr (cfs)
SUBAREAS			
Crane Pipe	7.09	57.16	104.73
REACHES			
Crane Drn	7.09	57.16	104.73
Down	6.39	48.84	89.43
OUTLET	6.39	48.84	89.43

WinTR-55 Output Hydrograph

Project: Riverbank - Crane

Subarea: (Outlet) Storms: 2-Yr, 10-Yr, 50-Yr

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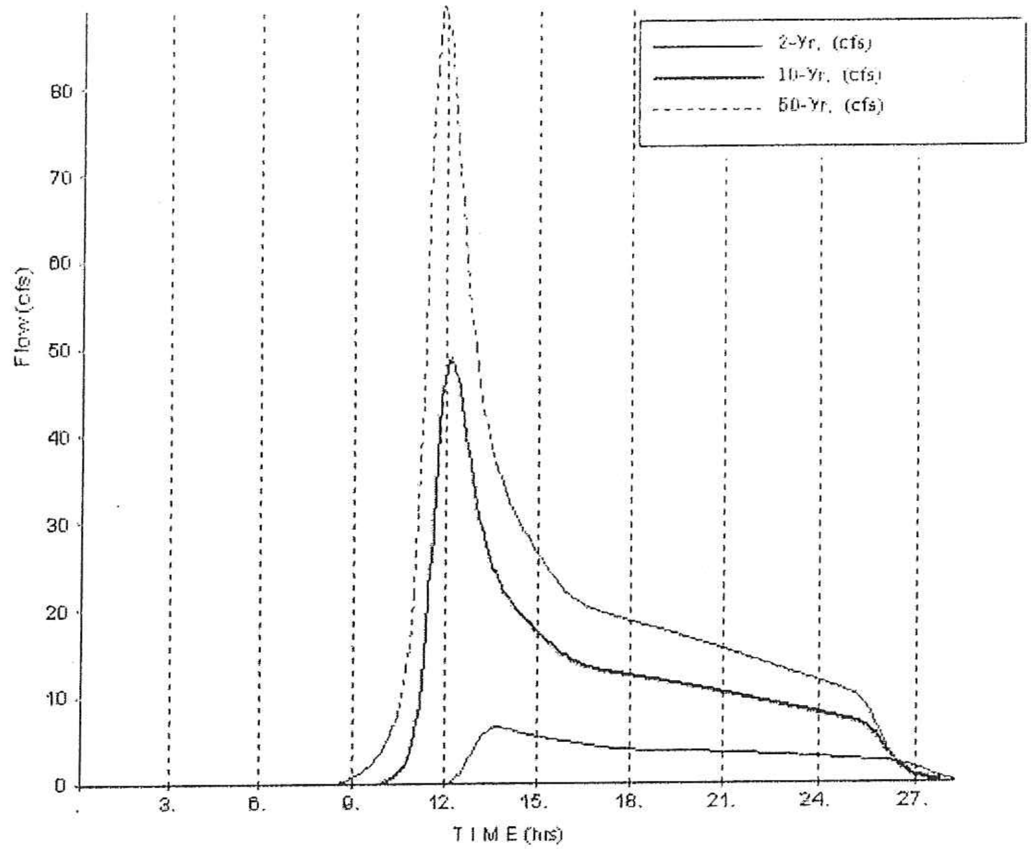
7/12/2006



Estimation of Time of Concentration (t_c) - Crane Drain

Location: Site No. 1 Crane Watershed

Overland Flow

1st 100 feet of Overland Flow is defined by Manning's Kinematic solution as follows:

t_c, hr = $0.007(nL)^{0.8}/(P_2)^{0.5}s^{0.4}$		t_c =	0.415276558
tc, hr = time, hr		P2 =	1.5
P2 = 2-yr, 24-hr rainfall, in.		L =	100
L = length, ft		n =	0.15
n = Mannings Coef., short grass = 0.15		s =	0.005

Remainder of Overland Flow is Shallow Concentrated

s, ft/ft =	0.005
Type of Terrain =	Short Grass/Pasture
Overland Flow Velocity[a] ft/s =	1.14
Length, ft =	1300
t_c =	0.32

Channel Flow

Given:	
Reach =	Crane Drain
Length, ft =	4030
Channel Geometry	
Bottom Width, ft =	4
Channel Depth, ft =	5
Side Slopes, h:1 =	2.00
Manning's n =	0.0375
slope, ft/ft =	0.0015
Depth of Flow, ft =	4.0000
Calculated:	
Top Width (Water Surf.), ft =	20.00
Area of Flow, ft =	48.00
Wetted Perimeter, ft =	21.89
Velocity, ft/s =	2.60
Q, cfs =	124.7
t_c, s =	1551.1
t_c, hr =	0.43

Total Time of Concentration	
t_c, hr =	1.16
t_c, min =	70

Notes:

Topography estimated from field observations and USGS Riverbank Quadrangle

[a] *Average Velocity of Overland Flow is taken from U.S. SCS, 1975b*

Exhibit D

WinTR-55 Current Data Description

--- Identification Data ---

User: CJT
Project: Riverbank Drain
SubTitle: Riverbank East Drainage Study
State: California
County: Stanislaus
Filename: C:\Documents and Settings\CTienken\Application Data\WinTR-55\Riverbank.w55

Date: 4/20/2006
Units: English
Areal Units: Acres

--- Sub-Area Data ---

Name	Description	Reach	Area(ac)	RCN	Tc
Riverbank	Riverbank Drain Watershed	Riverbank	163.7	83	1.113

Total area: 163.70 (ac)

--- Storm Data --

Rainfall Depth by Rainfall Return Period

2-Yr (in)	5-Yr (in)	10-Yr (in)	25-Yr (in)	50-Yr (in)	100-Yr (in)	1-Yr (in)
1.5	2.0	2.8	3.0	3.7	4.0	1.3

Storm Data Source: User-provided custom storm data
Rainfall Distribution Type: Type I
Dimensionless Unit Hydrograph: <standard>

Riverbank Drain
Riverbank East Drainage Study
Stanislaus County, California

Sub-Area Time of Concentration Details

Sub-Area Identifier/	Flow Length (ft)	Slope (ft/ft)	Mannings's n	End Area (sq ft)	Wetted Perimeter (ft)	Velocity (ft/sec)	Travel Time (hr)
Riverbank							
SHEET	100	0.0050	0.150				0.415
SHALLOW	1900	0.0050	0.050				0.463
CHANNEL	2820	0.0035	0.038	30.00	17.42	3.333	0.235
					Time of Concentration		1.113
							=======

Riverbank Drain
Riverbank East Drainage Study
Stanislaus County, California

Watershed Peak Table

Sub-Area or Reach Identifier	Peak Flow by Rainfall Return Period 2-Yr (cfs)	10-Yr (cfs)	50-Yr (cfs)
SUBAREAS			
Riverbank	12.73	58.44	96.68
REACHES			
Riverbank	12.73	58.44	96.68
Down	12.24	56.35	93.11
OUTLET	12.24	56.35	93.11

WinTR-55 Output Hydrograph

Project: Riverbank Drain

4/20/2006

Subarea: (Outlet) Storms: 2-Yr, 10-Yr, 50-Yr

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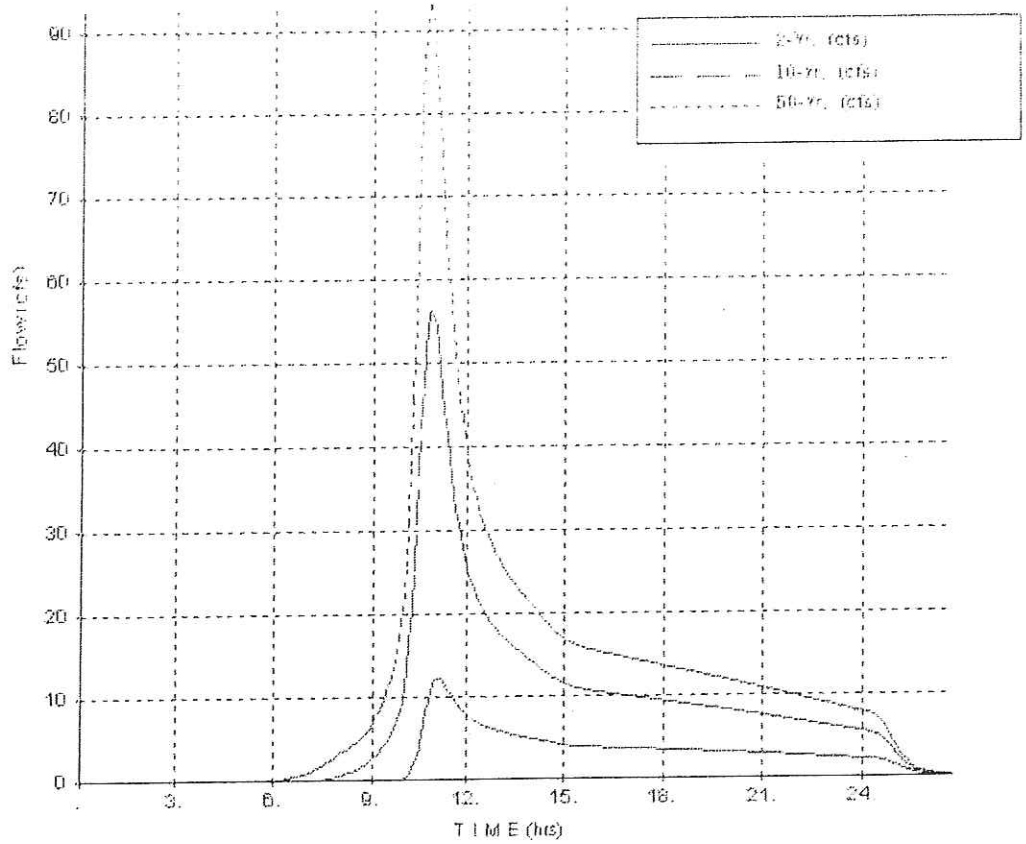


Estimation of Time of Concentration (t_c) - Riverbank Drain

Location: Site No. 2 Riverbank Watershed

Overland Flow

1st 100 feet of Overland Flow is defined by Manning's Kinematic solution as follows:

t_c, hr = $0.007(nL)^{0.8}/(P_2)^{0.5}s^{0.4}$		t_c =	0.415276558
t_c, hr = time, hr		P2 =	1.5
P2 = 2-yr, 24-hr rainfall, in.		L =	100
L = length, ft		n =	0.15
n = Mannings Coef., short grass = 0.15		s =	0.005

Remainder of Overland Flow is Shallow Concentrated

s, ft/ft =	0.005
Type of Terrain =	Short Grass/Pasture
Overland Flow Velocity[a] ft/s =	1.14
Length, ft =	1900
T =	0.46

Channel Flow

Given:	
Reach =	Riverbank Drain
Length, ft =	2820
Channel Geometry	
Bottom Width, ft =	4
Channel Depth, ft =	5
Side Slopes, h:1 =	2.00
Manning's n =	0.0380
slope, ft/ft =	0.0035
Depth of Flow, ft =	3.0000
Calculated:	
Top Width (Water Surf.), ft =	16.00
Area of Flow, ft =	30.00
Wetted Perimeter, ft =	17.42
Velocity, ft/s =	3.36
Q, cfs =	100.7
t_c, s =	840.3
t_c, hr =	0.23

Total Time of Concentration	
t_c, hr =	1.11
t_c, min =	67

Notes:

Topography estimated from field observations and USGS Riverbank Quadrangle

[a] *Average Velocity of Overland Flow is taken from U.S. SCS, 1975b*

Exhibit E

Hydrologic Summary

Estimation of Detention Basin Storage

Location: Southeast of Riverbank near the intersection of Patterson Road and Langworth Road

Watershed Description	Contributing Area, (acres)[a]	Curve Number[b,e]	Time of Concentration, t_c (hr)[b,e]	Peak Flow, (cfs)[b,c,e]	Estimated Basin Discharge, (cfs)[d]	Storage Required, (ac-ft)[c]
Riverbank Drain	164	83	1.11	93.11	5	20.0
Crane Drain	237	78	1.16	89.43	5	25.3

Footnotes:

a Estimated from field data and OID personnel
b See Attached Calculations (NRCS TR-55 Method)
c 50-year, 24-hr Storm Event
d Restricted by physical constraints of existing OID release facilities (Crane Lateral and Riverbank Lateral)
e NRCS TR-55 Method

Estimation of Detention Basin Storage

Location: Site No. 1 Crane Watershed (Langworth & Patterson)

Discharge: Crane Lateral

Initial Storage =	0 ac-ft	Starting Time =	0
Maximum Discharge[a] =	5	Time Increment, hr =	1

A Time hr	B Peak Inflow[b] cfs	C Outflow[a,c] cfs	D Inflow - Outflow[d] cfs	E Storage[e] cfs-hr	F Cumulative Storage cfs-hr	G Cumulative Storage[f] ac-ft
0	0.0	0.0	0.0			
				0.0	0.0	0 0
1	0.0	0.0	0.0			
				0.0	0.0	0.0
2	0.0	0.0	0.0			
				0.0	0.0	0.0
3	0.0	0.0	0.0			
				0.0	0.0	0.0
4	0.0	0.0	0.0			
				0.0	0.0	0.0
5	0.0	0.0	0.0			
				0.0	0.0	0.0
6	0.0	0.0	0.0			
				0.0	0.0	0.0
7	0.0	0.0	0.0			
				0.0	0.0	0.0
8	0.0	0.0	0.0			
				0.3	0.3	0.0
9	0.6	0.0	0.6			
				-0.2	0.1	0.0
10	4.1	5.0	-0.9			
				8.0	8.1	0.7
11	22.0	5.0	17.0			
				50.7	58.8	4.9
12	89.4	5.0	84.4			
				64.6	123.5	10.2
13	49.9	5.0	44.9			
				36.8	160.3	13.2
14	33.7	5.0	28.7			
				25.2	185.4	15.3
15	26.6	5.0	21.6			
				19.3	204.7	16.9
16	22.0	5.0	17.0			
				15.9	220.6	18.2
17	19.7	5.0	14.7			
				14.2	234.7	19.4
18	18.6	5.0	13.6			
				13.1	247.9	20.5
19	17.6	5.0	12.6			
				12.1	260.0	21.5
20	16.5	5.0	11.5			
				11.0	270.9	22.4
21	15.5	5.0	10.5			
				9.8	280.8	23.2
22	14.2	5.0	9.2			
				8.6	289.4	23.9
23	13.0	5.0	8.0			
				7.4	296.8	24.5
24	11.8	5.0	6.8			
				6.1	302.8	25.0
25	10.4	5.0	5.4			
				2.8	305.7	25.3
26	5.3	5.0	0.3			
				-2.0	303.7	25.1
27	0.8	5.0	-4.2			

A Time hr	B Peak Inflow[b] cfs	C Outflow[a,c] cfs	D Inflow - Outflow[d] cfs	E Storage[e] cfs-hr	F Cumulative Storage cfs-hr	G Cumulative Storage[f] ac-ft
				-4.6	299.1	24.7
28	0.0	5.0	-5.0			
				-5.0	294.1	24.3
29	0.0	5.0	-5.0			
				-5.0	289.1	23.9
30	0.0	5.0	-5.0			
				-5.0	284.1	23.5
31	0.0	5.0	-5.0			
				-5.0	279.1	23.1
32	0.0	5.0	-5.0			
				-5.0	274.1	22.7
33	0.0	5.0	-5.0			
				-5.0	269.1	22.2
34	0.0	5.0	-5.0			
				-5.0	264.1	21.8
35	0.0	5.0	-5.0			
				-5.0	259.1	21.4
36	0.0	5.0	-5.0			
				-5.0	254.1	21.0
37	0.0	5.0	-5.0			
				-5.0	249.1	20.6
38	0.0	5.0	-5.0			
				-5.0	244.1	20.2
39	0.0	5.0	-5.0			
				-5.0	239.1	19.8
40	0.0	5.0	-5.0			
				-5.0	234.1	19.4
41	0.0	5.0	-5.0			
				-5.0	229.1	18.9
42	0.0	5.0	-5.0			
				-5.0	224.1	18.5
43	0.0	5.0	-5.0			
				-5.0	219.1	18.1
44	0.0	5.0	-5.0			
				-5.0	214.1	17.7
45	0.0	5.0	-5.0			
				-5.0	209.1	17.3
46	0.0	5.0	-5.0			
				-5.0	204.1	16.9
47	0.0	5.0	-5.0			
				-5.0	199.1	16.5
48	0.0	5.0	-5.0			
				-5.0	194.1	16.0
49	0.0	5.0	-5.0			
				-5.0	189.1	15.6
50	0.0	5.0	-5.0			
				-5.0	184.1	15.2
51	0.0	5.0	-5.0			
				-5.0	179.1	14.8
52	0.0	5.0	-5.0			
				-5.0	174.1	14.4
53	0.0	5.0	-5.0			
				-5.0	169.1	14.0
54	0.0	5.0	-5.0			
				-5.0	164.1	13.6
55	0.0	5.0	-5.0			
				-5.0	159.1	13.2
56	0.0	5.0	-5.0			
				-5.0	154.1	12.7
57	0.0	5.0	-5.0			
				-5.0	149.1	12.3
58	0.0	5.0	-5.0			

Estimation of Detention Basin Storage

Location: Site No. 2 Riverbank Watershed (Eleanor & California)

Discharge: Riverbank Lateral

Initial Storage = 0 ac-ft Starting Time = 0 Inflow from Crane = 0

Maximum Discharge[a] = 5 Time Increment, hr = 1

A	B	C	D	E	F	G	H
Time hr	Peak Inflow[b] cfs	Inflow from Crane cfs	Outflow[a,c] cfs	Inflow - Outflow[d] cfs	Storage[e] cfs-hr	Cumulative Storage cfs-hr	Cumulative Storage[f] ac-ft
0	0.0	0.0	0.0	0.0			
					0.0	0.0	0.0
1	0.0	0.0	0.0	0.0			
					0.0	0.0	0.0
2	0.0	0.0	0.0	0.0			
					0.0	0.0	0.0
3	0.0	0.0	0.0	0.0			
					0.0	0.0	0.0
4	0.0	0.0	0.0	0.0			
					0.0	0.0	0.0
5	0.0	0.0	0.0	0.0			
					0.0	0.0	0.0
6	0.0	0.0	0.0	0.0			
					0.4	0.4	0.0
7	0.8	0.0	0.0	0.8			
					-0.6	0.0	0.0
8	2.9	0.0	5.0	-2.1			
					-0.4	0.0	0.0
9	6.4	0.0	5.0	1.4			
					7.7	7.7	0.6
10	19.0	0.0	5.0	14.0			
					48.8	56.5	4.7
11	88.7	0.0	5.0	83.7			
					59.1	115.5	9.5
12	39.5	0.0	5.0	34.5			
					28.0	143.6	11.9
13	26.5	0.0	5.0	21.5			
					18.8	162.4	13.4
14	21.1	0.0	5.0	16.1			
					14.0	176.4	14.6
15	16.9	0.0	5.0	11.9			
					11.1	187.5	15.5
16	15.4	0.0	5.0	10.4			
					9.9	197.4	16.3
17	14.5	0.0	5.0	9.5			
					9.1	206.4	17.1
18	13.6	0.0	5.0	8.6			
					8.2	214.6	17.7
19	12.7	0.0	5.0	7.7			
					7.2	221.8	18.3
20	11.8	0.0	5.0	6.8			
					6.3	228.2	18.9
21	10.9	0.0	5.0	5.9			
					5.4	233.5	19.3
22	9.9	0.0	5.0	4.9			
					4.4	237.9	19.7
23	8.9	0.0	5.0	3.9			
					3.4	241.4	19.9
24	7.9	0.0	5.0	2.9			
					0.9	242.2	20.0
25	3.8	0.0	5.0	-1.2			
					-2.9	239.3	19.8
26	0.4	0.0	5.0	-4.6			
					-4.8	234.5	19.4
27	0.0	0.0	5.0	-5.0			
					-5.0	229.5	19.0
28	0.0	0.0	5.0	-5.0			
					-5.0	224.5	18.6
29	0.0	0.0	5.0	-5.0			

A Time hr	B Peak Inflow[b] cfs	Inflow from Crane cfs	D Outflow[a,c] cfs	E Inflow - Outflow[d] cfs	F Storage[e] cfs-hr	G Cumulative Storage cfs-hr	H Cumulative Storage[f] ac-ft
					-5.0	219.5	18.1
30	0.0	0.0	5.0	-5.0			
					-5.0	214.5	17.7
31	0.0	0.0	5.0	-5.0			
					-5.0	209.5	17.3
32	0.0	0.0	5.0	-5.0			
					-5.0	204.5	16.9
33	0.0	0.0	5.0	-5.0			
					-5.0	199.5	16.5
34	0.0	0.0	5.0	-5.0			
					-5.0	194.5	16.1
35	0.0	0.0	5.0	-5.0			
					-5.0	189.5	15.7
36	0.0	0.0	5.0	-5.0			
					-5.0	184.5	15.2
37	0.0	0.0	5.0	-5.0			
					-5.0	179.5	14.8
38	0.0	0.0	5.0	-5.0			
					-5.0	174.5	14.4
39	0.0	0.0	5.0	-5.0			
					-5.0	169.5	14.0
40	0.0	0.0	5.0	-5.0			
					-5.0	164.5	13.6
41	0.0	0.0	5.0	-5.0			
					-5.0	159.5	13.2
42	0.0	0.0	5.0	-5.0			
					-5.0	154.5	12.8
43	0.0	0.0	5.0	-5.0			
					-5.0	149.5	12.4
44	0.0	0.0	5.0	-5.0			
					-5.0	144.5	11.9
45	0.0	0.0	5.0	-5.0			
					-5.0	139.5	11.5
46	0.0	0.0	5.0	-5.0			
					-5.0	134.5	11.1
47	0.0	0.0	5.0	-5.0			
					-5.0	129.5	10.7
48	0.0	0.0	5.0	-5.0			
					-5.0	124.5	10.3
49	0.0	0.0	5.0	-5.0			
					-5.0	119.5	9.9
50	0.0	0.0	5.0	-5.0			
					-5.0	114.5	9.5
51	0.0	0.0	5.0	-5.0			
					-5.0	109.5	9.1
52	0.0	0.0	5.0	-5.0			
					-5.0	104.5	8.6
53	0.0	0.0	5.0	-5.0			
					-5.0	99.5	8.2
54	0.0	0.0	5.0	-5.0			
					-5.0	94.5	7.8
55	0.0	0.0	5.0	-5.0			
					-5.0	89.5	7.4
56	0.0	0.0	5.0	-5.0			
					-5.0	84.5	7.0
57	0.0	0.0	5.0	-5.0			
					-5.0	79.5	6.6
58	0.0	0.0	5.0	-5.0			
					-5.0	74.5	6.2
59	0.0	0.0	5.0	-5.0			
					-5.0	69.5	5.7
60	0.0	0.0	5.0	-5.0			
					-5.0	64.5	5.3
61	0.0	0.0	5.0	-5.0			
					-5.0	59.5	4.9
62	0.0	0.0	5.0	-5.0			

A	B		D	E	F	G	H
Time hr	Peak Inflow[b] cfs	Inflow from Crane cfs	Outflow[a,c] cfs	Inflow - Outflow[d] cfs	Storage[e] cfs-hr	Cumulative Storage cfs-hr	Cumulative Storage[f] ac-ft
					Max Storage Required:		20.0 ac-ft

Basin Layout for Site No. 2 - Riverbank

Depth, ft = 6
Freeboard, ft = 1
Side Slopes, h:1 = 3
Volume = 1/3 h (a b + c d + SQROOT [a b c d])

Top Dimensions		Bottom Dimensions		Top Area	Bottom Area	Volume	Volume
a	b	c	d	ft^2	ft^2	ft^3	ac-ft
440	440	410	410	193,600	168,100	902,597	20.7

Basin Area, acres = 4.57
Time to Discharge, hr = 50
(based on Rate of Peak Outflow)

[a]5 cfs Pumping Facility discharging into the Riverbank Lateral near California Ave.
[b]Inflows are based on 50-year, 24-hour storm event
[c]Limited by Anticipated Pumping Facility (Assumed)
[d]Column E = Column B + Column C - Column D
[e]Column F = 1/2*(Column E1 + Column E2)*ΔTime
[f]12.1 cfs-hr = 1 ac-ft

Alternate Method for Estimation of Detention Basin Storage
Location: Site No. 1 Crane Watershed

Stanislaus County Standards for Drainage Retention
Drainage facilities shall have the capacity to hold the total runoff from a 50 year - 24 hour storm. Percolation, evaporation, and outlets shall be ignored.

V = CAR/12
V = Volume in ac-ft
C = Coef. Of Runoff = 0.3
A = Area in acres = 237
M.A.P. = 13
R = 2.33xM.A.P./10.9 (for M.A.P. see Plate 4-B)

V = $\boxed{16.5}$ acre-ft
V = 717214 ft^3
Q_{48} (Discharge req'd to empty in 48 hrs) = 4.15 ft^3/s

Basin Layout

Depth, ft = 6
Freeboard, ft = 1
Side Slopes, h:1 = 3
Volume = 1/3 h (a b + c d + SQROOT [a b c d])

Top Dimensions	Bottom Dimensions			Top Area	Bottom Area	Volume	Volume
a	b	c	d	ft^2	ft^2	ft^3	ac-ft
400	400	370	370	160,000	136,900	740,759	17.0

Basin Area, acres = 3.78
Time to Discharge, hr = 50

Exhibit F

Appendix B Synthetic Rainfall Distributions and Rainfall Data Sources

The highest peak discharges from small watersheds in the United States are usually caused by intense, brief rainfalls that may occur as distinct events or as part of a longer storm. These intense rainstorms do not usually extended over a large area and intensities vary greatly. One common practice in rainfall-runoff analysis is to develop a synthetic rainfall distribution to use in lieu of actual storm events. This distribution includes maximum rainfall intensities for the selected design frequency arranged in a sequence that is critical for producing peak runoff.

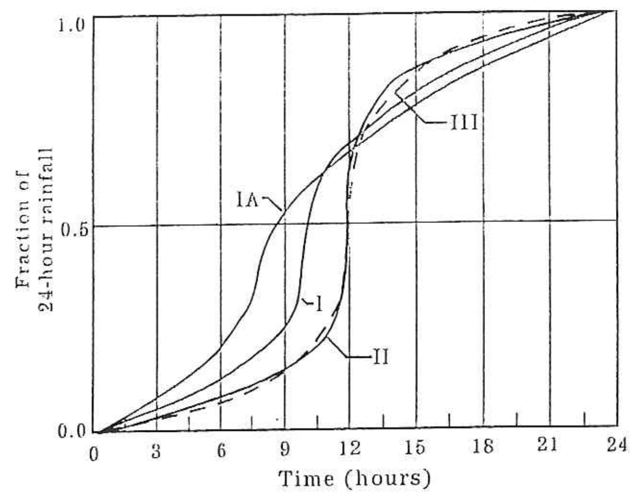
Synthetic rainfall distributions

The length of the most intense rainfall period contributing to the peak runoff rate is related to the time of concentration (T_c) for the watershed. In a hydrograph created with NRCS procedures, the duration of rainfall that directly contributes to the peak is about 170 percent of the T_c. For example, the most intense 8.5-minute rainfall period would contribute to the peak discharge for a watershed with a T_c of 5 minutes. The most intense 8.5-hour period would contribute to the peak for a watershed with a 5-hour T_c.

Different rainfall distributions can be developed for each of these watersheds to emphasize the critical rainfall duration for the peak discharges. However, to avoid the use of a different set of rainfall intensities for each drainage area size, a set of synthetic rainfall distributions having "nested" rainfall intensities was developed. The set "maximizes" the rainfall intensities by incorporating selected short duration intensities within those needed for longer durations at the same probability level.

For the size of the drainage areas for which NRCS usually provides assistance, a storm period of 24 hours was chosen the synthetic rainfall distributions. The 24-hour storm, while longer than that needed to determine peaks for these drainage areas, is appropriate for determining runoff volumes. Therefore, a single storm duration and associated synthetic rainfall distribution can be used to represent not only the peak discharges but also the runoff volumes for a range of drainage area sizes.

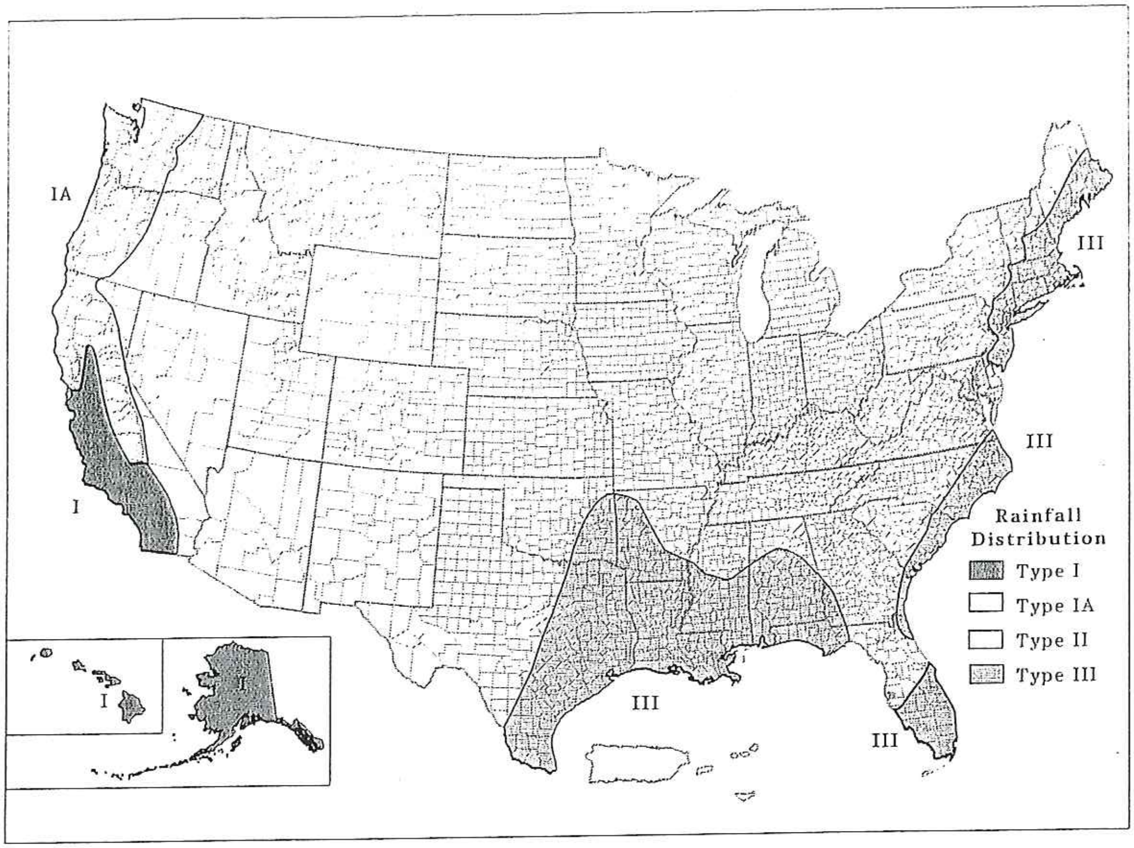
Figure B-1 SCS 24-hour rainfall distributions



The intensity of rainfall varies considerably during a storm as well as geographic regions. To represent various regions of the United States, NRCS developed four synthetic 24-hour rainfall distributions (I, IA, II, and III) from available National Weather Service (NWS) duration-frequency data (Hershfield 1061; Frederick et al., 1977) or local storm data. Type IA is the least intense and type II the most intense short duration rainfall. The four distributions are shown in figure B-1, and figure B-2 shows their approximate geographic boundaries.

Types I and IA represent the Pacific maritime climate with wet winters and dry summers. Type III represents Gulf of Mexico and Atlantic coastal areas where tropical storms bring large 24-hour rainfall amounts. Type II represents the rest of the country. For more precise distribution boundaries in a state having more than one type, contact the NRCS State Conservation Engineer.

Figure B-2 Approximate geographic boundaries for NRCS (SCS) rainfall distributions



Rainfall data sources

This section lists the most current 24-hour rainfall data published by the National Weather Service (NWS) for various parts of the country. Because NWS Technical Paper 40 (TP-40) is out of print, the 24-hour rainfall maps for areas east of the 105th meridian are included here as figures B-3 through B-8. For the area generally west of the 105th meridian, TP-40 has been superseded by NOAA Atlas 2, the Precipitation-Frequency Atlas of the Western United States, published by the National Ocean and Atmospheric Administration.

East of 105th meridian

Hershfield, D.M. 1961. Rainfall frequency atlas of the United States for durations from 30 minutes to 24 hours and return periods from 1 to 100 years. U.S. Dept. Commerce, Weather Bur. Tech. Pap. No. 40. Washington, DC. 155 p.

West of 105th meridian

Miller, J.F., R.H. Frederick, and R.J. Tracey. 1973. Precipitation-frequency atlas of the Western United States. Vol. I Montana; Vol. II, Wyoming; Vol III, Colorado; Vol. IV, New Mexico; Vol V, Idaho; Vol. VI, Utah; Vol. VII, Nevada; Vol. VIII, Arizona; Vol. IX, Washington; Vol. X, Oregon; Vol. XI, California. U.S. Dept. of Commerce, National Weather Service, NOAA Atlas 2. Silver Spring, MD.

Alaska

Miller, John F. 1963. Probable maximum precipitation and rainfall-frequency data for Alaska for areas to 400 square miles, durations to 24 hours and return periods from 1 to 100 years. U.S. Dept. of Commerce, Weather Bur. Tech. Pap. No. 47. Washington, DC. 69 p.

Hawaii

Weather Bureau. 1962. Rainfall-frequency atlas of the Hawaiian Islands for areas to 200 square miles, durations to 24 hours and return periods from 1 to 100 years. U.S. Dept. Commerce, Weather Bur. Tech. Pap. No. 43. Washington, DC. 60 p.

Puerto Rico and Virgin Islands

Weather Bureau. 1961. Generalized estimates of probable maximum precipitation and rainfall-frequency data for Puerto Rico and Virgin Islands for areas to 400 square miles, durations to 24 hours, and return periods from 1 to 100 years. U.S. Dept. Commerce, Weather Bur. Tech. Pap. No. 42. Washington, DC. 94 P.

Figure B-3 2-year, 24-hr rainfall

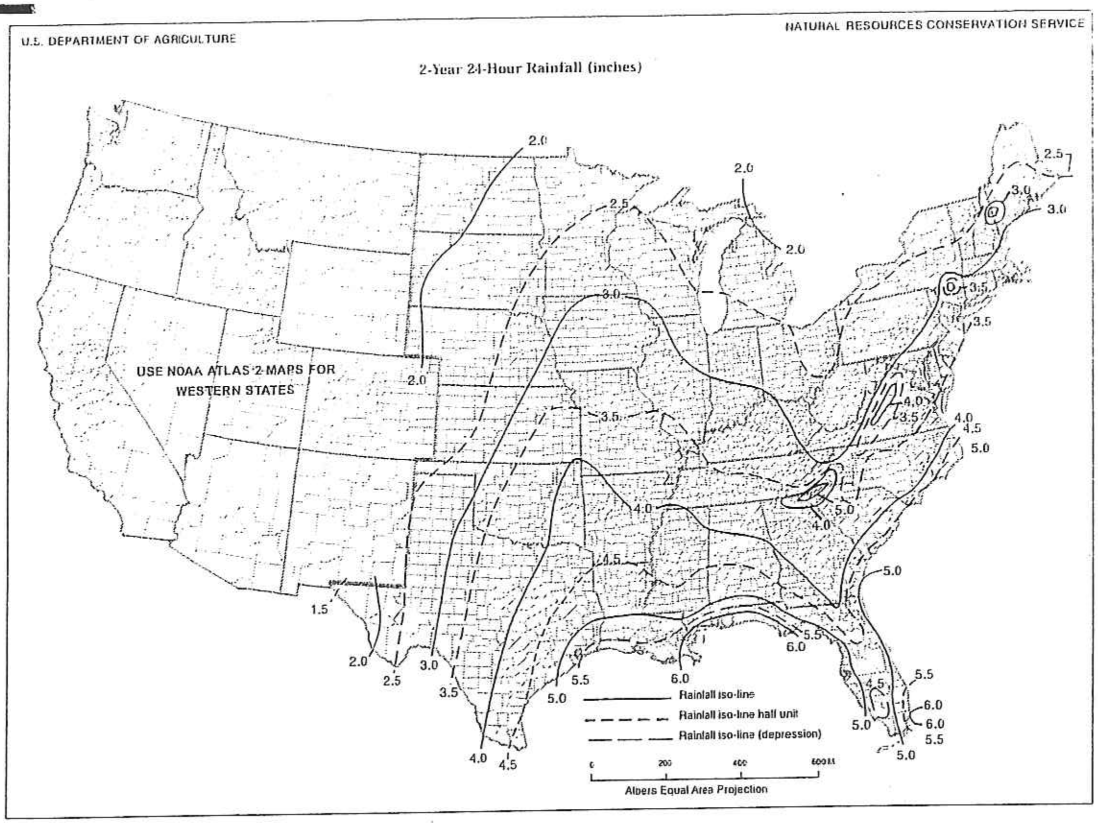


Figure B-4 5-year, 24-hour rainfall

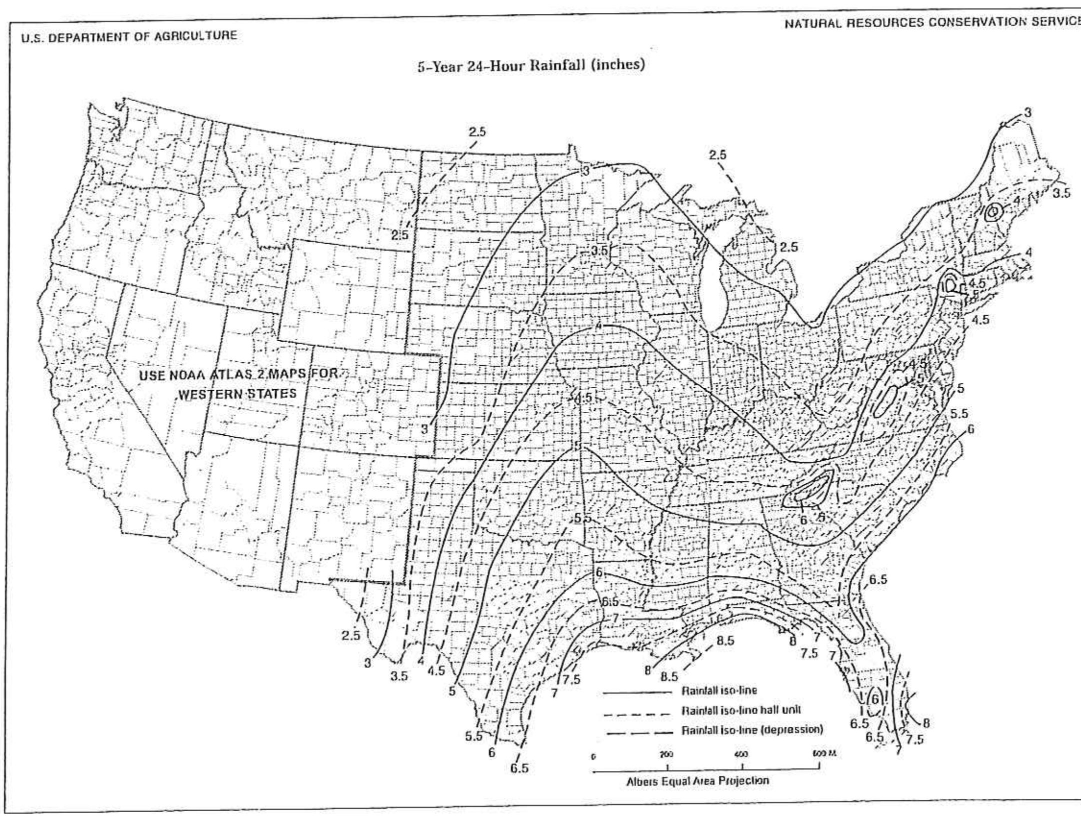


Figure B-5 10-year, 24-hour rainfall

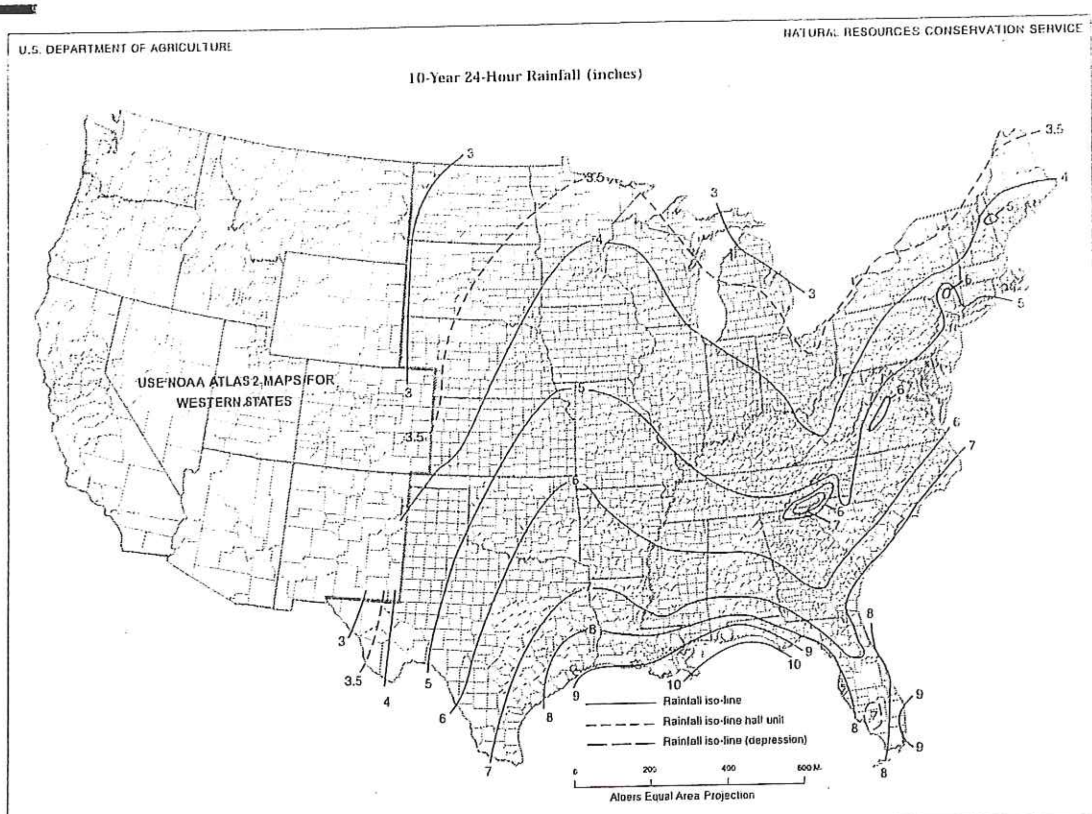


Figure B-6 25-year, 24-hour rainfall

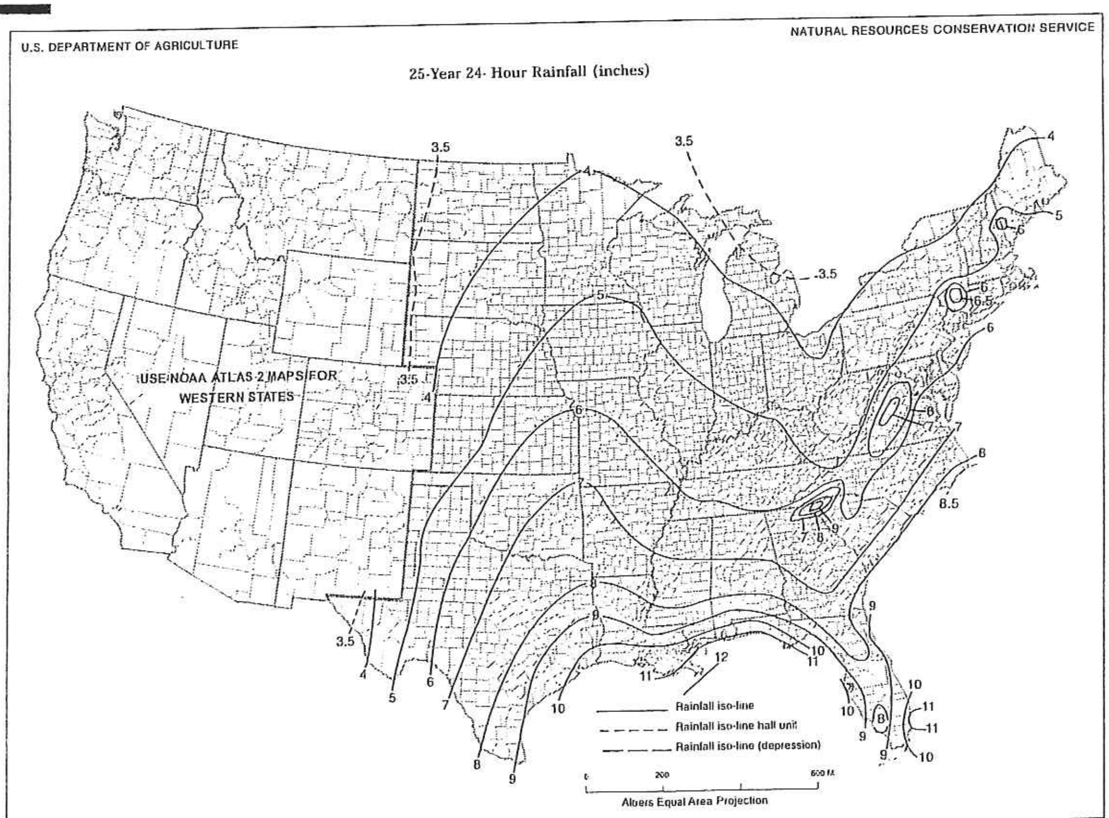


Figure B-7 50-year, 24-hour rainfall

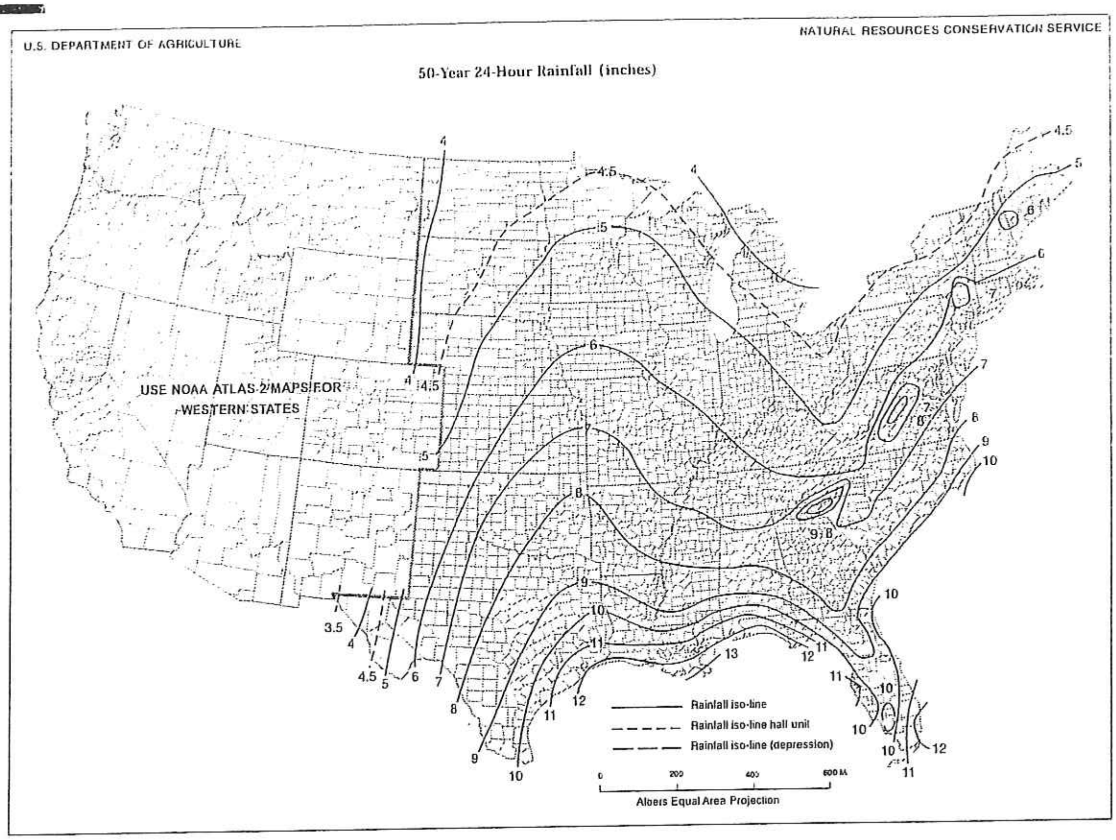
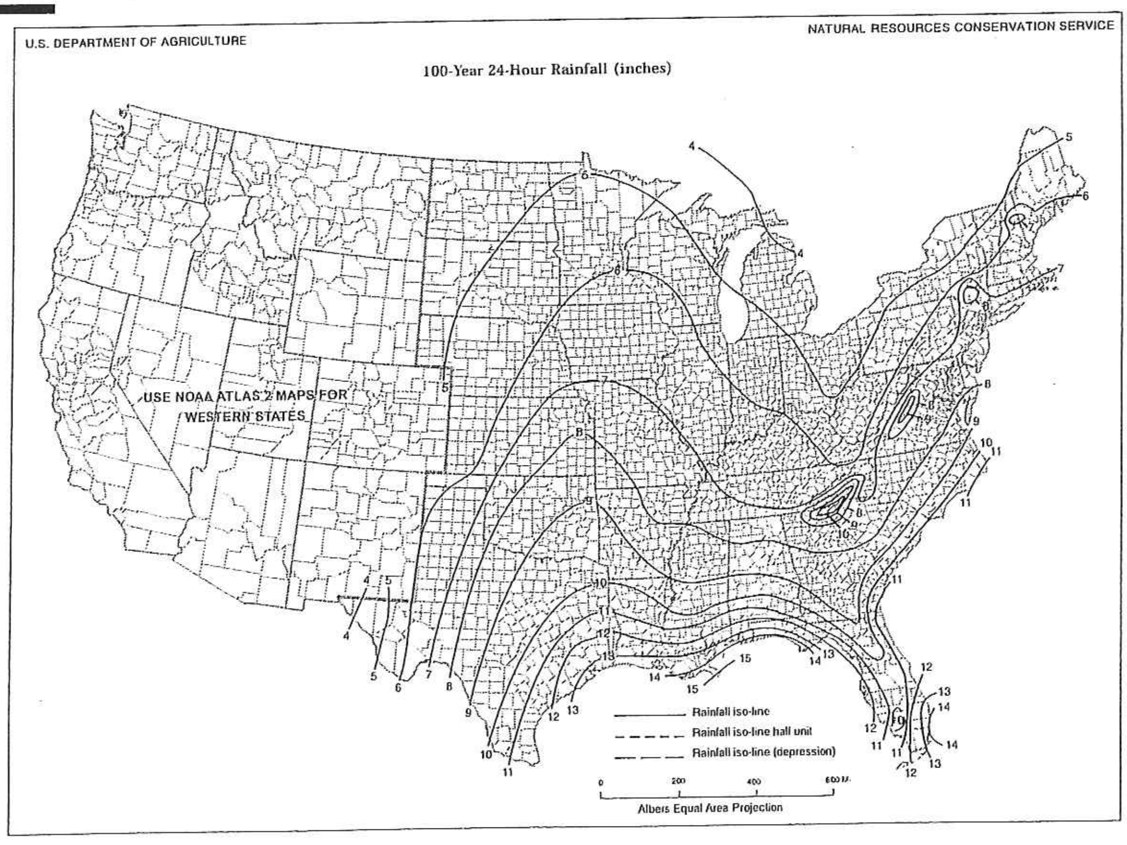


Figure B-8 100-year, 24-hour rainfall



Appendix E References

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Hershfield, D.M. 1961. Rainfall frequency atlas of the United States for durations from 30 minutes to 24 hours and return periods from 1 to 100 years. U.S. Dep. Commerce, Weather Bur. Tech. Pap. No. 40. Washington, DC. 115 p.

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Appendix F Equations for figures and exhibits

This appendix presents the equations used in procedure applications to generate figures and exhibits in TR-55.

Figure 2-1 (runoff equation):

$$Q = \frac{\left[P - .2\left(\frac{1000}{CN} - 10\right)\right]^2}{P + 0.8\left(\frac{1000}{CN} - 10\right)}$$

where

Q = runoff (in)

P = rainfall (in)

CN = runoff curve number

Figure 2-3 (composite CN with connected impervious area):

$$CN_c = CN_p + \left(\frac{P_{imp}}{100}\right)(98 - CN_p)$$

where

CN_c = composite runoff curve number

CN_p = pervious runoff curve number

P_{imp} = percent imperviousness.

Figure 2-4 (composite CN with unconnected impervious areas and total impervious area less than 30%):

$$CN_c = CN_p + \left(\frac{P_{imp}}{100}\right)(98 - CN_p)(1 - 0.5R)$$

where

R = ratio of unconnected impervious area to total impervious area.

Figure 3-1 (average velocities for estimating travel time for shallow concentrated flow):

Unpaved $V = 16.1345\ (s)^{0.5}$

Paved $V = 20.3282\ (s)^{0.5}$

where

V = average velocity (ft/s)

s = slope of hydraulic grade line (watercourse slope, ft/ft)

These two equations are based on the solution of Manning's equation (eq. 3-4) with different assumptions for n (Manning's roughness coefficient) and r (hydraulic radius, ft). For unpaved areas, n is 0.05 and r is 0.4; for paved areas, n is 0.025 and r is 0.2.

Exhibit 4 (unit peak discharges for SCS type I, IA, II, and III distributions):

$$\log(q_u) = C_o + C_1 \log(T_c) + C_2\left[\log(T_c)\right]^2$$

where

q_u = unit peak discharge (csm/in)

T_c = time of concentration (hr) (minimum, 0.1; maximum, 10.0)

C_0, C_1, C_2 = coefficients from table F-1

Figure 6-1 (approximate detention basin routing through single- and multiple-stage structures for 24-hour rainfalls of the indicated type):

$$\frac{V_S}{V_r} = C_o + C_1\left(\frac{q_o}{q_1}\right) + C_2\left(\frac{q_o}{q_1}\right)^2 + C_3\left(\frac{q_o}{q_1}\right)^3$$

where

V_s/V_r = ratio of storage volume (V_s) to runoff volume (V_r)

q_o/q_i = ratio of peak outflow discharge (q_o) to peak inflow discharge (q_i)

C_0, C_1, C_2, C_3 = coefficients from table F-2

Table F-1 Coefficients for the equation used to generate exhibits 4-I through 4-III

Rainfall type	I_a/P	C_0	C_1	C_2
I	0.10	2.30550	-0.51429	-0.11750
	0.20	2.23537	-0.50387	-0.08929
	0.25	2.18219	-0.48488	-0.06589
	0.30	2.10624	-0.45695	-0.02835
	0.35	2.00303	-0.40769	0.01983
	0.40	1.87733	-0.32274	0.05754
	0.45	1.76312	-0.15644	0.00453
	0.50	1.67889	-0.06930	0.0
IA	0.10	2.03250	-0.31583	-0.13748
	0.20	1.91978	-0.28215	-0.07020
	0.25	1.83842	-0.25543	-0.02597
	0.30	1.72657	-0.19826	0.02633
	0.50	1.63417	-0.09100	0.0
II	0.10	2.55323	-0.61512	-0.16403
	0.30	2.46532	-0.62257	-0.11657
	0.35	2.41896	-0.61594	-0.08820
	0.40	2.36409	-0.59857	-0.05621
	0.45	2.29238	-0.57005	-0.02281
	0.50	2.20282	-0.51599	-0.01259
III	0.10	2.47317	-0.51848	-0.17083
	0.30	2.39628	-0.51202	-0.13245
	0.35	2.35477	-0.49735	-0.11985
	0.40	2.30726	-0.46541	-0.11094
	0.45	2.24876	-0.41314	-0.11508
	0.50	2.17772	-0.36803	-0.09525

Table F-2 Coefficients for the equation used to generate figure 6-1

Rainfall distribution (appendix B)	C_0	C_1	C_2	C_3
I, IA	0.660	-1.76	1.96	-0.730
II, III	0.682	-1.43	1.64	-0.804

APPENDIX C

NPDES Permit Design Standards Excerpt

Areas subject to high growth or serving a population of at least 50,000 must comply with the following provisions (for counties this threshold population applies to the population within the permit area).

A. RECEIVING WATER LIMITATIONS

1. Discharges shall not cause or contribute to an exceedance of water quality standards contained in a Statewide Water Quality Control Plan, the California Toxics Rule (CTR), or in the applicable RWQCB Basin Plan.

2. The permittees shall comply with Receiving Water Limitations A.1 through timely implementation of control measures and other actions to reduce pollutants in the discharges in accordance with the SWMP and other requirements of this permit including any modifications. The SWMP shall be designed to achieve compliance with Receiving Water Limitations A.1. If exceedance(s) of water quality objectives or water quality standards (collectively, WQS) persist notwithstanding implementation of the SWMP and other requirements of this permit, the permittees shall assure compliance with Receiving Water Limitations A.1 by complying with the following procedure:

   a. Upon a determination by either the permittees or the RWQCB that discharges are causing or contributing to an exceedance of an applicable WQS, the permittees shall promptly notify and thereafter submit a report to the RWQCB that describes BMPs that are currently being implemented and additional BMPs that will be implemented to prevent or reduce any pollutants that are causing or contributing to the exceedance of WQSs. The report may be incorporated in the annual update to the SWMP unless the RWQCB directs an earlier submittal. The report shall include an implementation schedule. The RWQCB may require modifications to the report.

   b. Submit any modifications to the report required by the RWQCB within 30 days of notification.

   c. Within 30 days following approval of the report described above by the RWQCB, the permittees shall revise the SWMP and monitoring program to incorporate the approved modified BMPs that have been and will be implemented, implementation schedule, and any additional monitoring required.

   d. Implement the revised SWMP and monitoring program in accordance with the approved schedule.

   So long as the permittees have complied with the procedures set forth above and are implementing the revised SWMP, the permittees do not have to repeat the same procedure for continuing or recurring exceedances of the same receiving water limitations unless directed by the RWQCB to develop additional BMPs.

B. DESIGN STANDARDS

Regulated Small MS4s subject to this requirement must adopt an ordinance or other document to ensure implementation of the Design Standards included herein or a functionally equivalent program that is acceptable to the appropriate RWQCB. The ordinance or other document must be adopted and effective prior to the expiration of this General Permit or, for Small MS4s designated subsequent to the Permit adoption, within five years of designation as a regulated Small MS4.

All discretionary development and redevelopment projects that fall into one of the following categories are subject to these Design Standards. These categories are:

- 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

1. Conflicts With Local Practices
   Where provisions of the Design Standards conflict with established local codes or other regulatory mechanism, (e.g., specific language of signage used on storm drain stenciling), the Permittee may continue the local practice and modify the Design Standards to be consistent with the code or other regulatory mechanism, except that to the extent that the standards in the Design Standards are more stringent than those under local codes or other regulatory mechanism, such more stringent standards shall apply.

2. Design Standards Applicable to All Categories

   a. Peak Storm Water Runoff Discharge Rates
      Post-development peak storm water runoff discharge rates shall not exceed the estimated pre-development rate for developments where the increased peak storm water discharge rate will result in increased potential for downstream erosion.

   b. Conserve Natural Areas
      If applicable, the following items are required and must be implemented in the site layout during the subdivision design and approval process, consistent with applicable General Plan and Local Area Plan policies:

      1) Concentrate or cluster Development on portions of a site while leaving the remaining land in a natural undisturbed condition.
      2) Limit clearing and grading of native vegetation at a site to the minimum amount needed to build lots, allow access, and provide fire protection.
      3) Maximize trees and other vegetation at each site by planting additional vegetation, clustering tree areas, and promoting the use of native and/or drought tolerant plants.

4) Promote natural vegetation by using parking lot islands and other landscaped areas.
5) Preserve riparian areas and wetlands.

c. Minimize Storm Water Pollutants of Concern
Storm water runoff from a site has the potential to contribute oil and grease, suspended solids, metals, gasoline, pesticides, and pathogens to the storm water conveyance system. The development must be designed so as to minimize, to the maximum extent practicable, the introduction of pollutants of concern that may result in significant impacts, generated from site runoff of directly connected impervious areas (DCIA), to the storm water conveyance system as approved by the building official. Pollutants of concern consist of any pollutants that exhibit one or more of the following characteristics: current loadings or historic deposits of the pollutant are impacting the beneficial uses of a receiving water, elevated levels of the pollutant are found in sediments of a receiving water and/or have the potential to bioaccumulate in organisms therein, or the detectable inputs of the pollutant are at concentrations or loads considered potentially toxic to humans and/or flora and fauna.

In meeting this specific requirement, "minimization of the pollutants of concern" will require the incorporation of a BMP or combination of BMPs best suited to maximize the reduction of pollutant loadings in that runoff to the Maximum Extent Practicable. Those BMPs best suited for that purpose are those listed in the *California Storm Water Best Management Practices Handbooks*; *Caltrans Storm Water Quality Handbook: Planning and Design Staff Guide*; *Manual for Storm Water Management in Washington State*; *The Maryland Stormwater Design Manual*; *Florida Development Manual: A Guide to Sound Land and Water Management*; Denver *Urban Storm Drainage Criteria Manual, Volume 3 – Best Management Practices* and *Guidance Specifying Management Measures for Sources of Nonpoint Pollution in Coastal Waters* , USEPA Report No. EPA-840-B-92-002, as "likely to have significant impact" beneficial to water quality for targeted pollutants that are of concern at the site in question. However, it is possible that a combination of BMPs not so designated, may in a particular circumstance, be better suited to maximize the reduction of the pollutants.

d. Protect Slopes and Channels
Project plans must include BMPs consistent with local codes, ordinances, or other regulatory mechanism and the Design Standards to decrease the potential of slopes and/or channels from eroding and impacting storm water runoff:

1) Convey runoff safely from the tops of slopes and stabilize disturbed slopes.
2) Utilize natural drainage systems to the maximum extent practicable.
3) Stabilize permanent channel crossings.
4) Vegetate slopes with native or drought tolerant vegetation, as appropriate.
5) Install energy dissipaters, such as riprap, at the outlets of new storm drains, culverts, conduits, or channels that enter unlined channels in accordance with applicable specifications to minimize erosion, with the approval of all agencies

with jurisdiction, e.g., the U.S. Army Corps of Engineers and the California Department of Fish and Game.

e. Provide Storm Drain System Stenciling and Signage
Storm drain stencils are highly visible source controls that are typically placed directly adjacent to storm drain inlets. The stencil contains a brief statement that prohibits the dumping of improper materials into the storm water conveyance system. Graphical icons, either illustrating anti-dumping symbols or images of receiving water fauna, are effective supplements to the anti-dumping message. All storm drain inlets and catch basins within the project area must be stenciled with prohibitive language (such as: "NO DUMPING – DRAINS TO OCEAN") and/or graphical icons to discourage illegal dumping.· Signs and prohibitive language and/or graphical icons, which prohibit illegal dumping, must be posted at public access points along channels and creeks within the project area.· Legibility of stencils and signs must be maintained.

f. Properly Design Outdoor Material Storage Areas
Outdoor material storage areas refer to storage areas or storage facilities solely for the storage of materials. Improper storage of materials outdoors may provide an opportunity for toxic compounds, oil and grease, heavy metals, nutrients, suspended solids, and other pollutants to enter the storm water conveyance system. Where proposed project plans include outdoor areas for storage of materials that may contribute pollutants to the storm water conveyance system, the following Structural or Treatment BMPs are required:

1) Materials with the potential to contaminate storm water must be: (1) placed in an enclosure such as, but not limited to, a cabinet, shed, or similar structure that prevents contact with runoff or spillage to the storm water conveyance system; or (2) protected by secondary containment structures such as berms, dikes, or curbs.
2) The storage area must be paved and sufficiently impervious to contain leaks and spills.
3) The storage area must have a roof or awning to minimize collection of storm water within the secondary containment area.

g. Properly Design Trash Storage Areas
A trash storage area refers to an area where a trash receptacle or receptacles (dumpsters) are located for use as a repository for solid wastes. Loose trash and debris can be easily transported by the forces of water or wind into nearby storm drain inlets, channels, and/or creeks. All trash container areas must meet the following Structural or Treatment Control BMP requirements (individual single family residences are exempt from these requirements):

1) Trash container areas must have drainage from adjoining roofs and pavement diverted around the area(s).
2) Trash container areas must be screened or walled to prevent off-site transport of trash.

h. Provide Proof of Ongoing BMP Maintenance

Improper maintenance is one of the most common reasons why water quality controls will not function as designed or which may cause the system to fail entirely. It is important to consider who will be responsible for maintenance of a permanent BMP, and what equipment is required to perform the maintenance properly. As part of project review, if a project applicant has included or is required to include, Structural or Treatment Control BMPs in project plans, the Permittee shall require that the applicant provide verification of maintenance provisions through such means as may be appropriate, including, but not limited to legal agreements, covenants, CEQA mitigation requirements and/or Conditional Use Permits.

For all properties, the verification will include the developer's signed statement, as part of the project application, accepting responsibility for all structural and treatment control BMP maintenance until the time the property is transferred and, where applicable, a signed agreement from the public entity assuming responsibility for Structural or Treatment Control BMP maintenance. The transfer of property to a private or public owner must have conditions requiring the recipient to assume responsibility for maintenance of any Structural or Treatment Control BMP to be included in the sales or lease agreement for that property, and will be the owner's responsibility. The condition of transfer shall include a provision that the property owners conduct maintenance inspection of all Structural or Treatment Control BMPs at least once a year and retain proof of inspection. For residential properties where the Structural or Treatment Control BMPs are located within a common area which will be maintained by a homeowner's association, language regarding the responsibility for maintenance must be included in the project's conditions, covenants and restrictions (CC&Rs). Printed educational materials will be required to accompany the first deed transfer to highlight the existence of the requirement and to provide information on what storm water management facilities are present, signs that maintenance is needed, how the necessary maintenance can be performed, and assistance that the Permittee can provide. The transfer of this information shall also be required with any subsequent sale of the property.

If Structural or Treatment Control BMPs are located within a public area proposed for transfer, they will be the responsibility of the developer until they are accepted for transfer by the County or other appropriate public agency. Structural or Treatment Control BMPs proposed for transfer must meet design standards adopted by the public entity for the BMP installed and should be approved by the County or other appropriate public agency prior to its installation.

i. Design Standards for Structural or Treatment Control BMPs
The Permittees shall require that post-construction treatment control BMPs incorporate, at a minimum, either a volumetric or flow based treatment control design standard, or both, as identified below to mitigate (infiltrate, filter or treat) storm water runoff:

1) Volumetric Treatment Control BMP

a) The 85th percentile 24-hour runoff event determined as the maximized capture storm water volume for the area, from the formula recommended in Urban Runoff Quality Management, WEF Manual of Practice No. 23/ ASCE Manual of Practice No. 87, (1998); or
b) The volume of annual runoff based on unit basin storage water quality volume, to achieve 80 percent or more volume treatment by the method recommended in California Stormwater Best Management Practices Handbook – Industrial/ Commercial, (2003); or
c) The volume of runoff produced from a historical-record based reference 24-hour rainfall criterion for "treatment" that achieves approximately the same reduction in pollutant loads achieved by the 85th percentile 24-hour runoff event.

2) Flow Based Treatment Control BMP
   a) The flow of runoff produced from a rain event equal to at least two times the 85th percentile hourly rainfall intensity for the area; or
   b) The flow of runoff produced from a rain event that will result in treatment of the same portion of runoff as treated using volumetric standards above.

Limited Exclusion
Restaurants and Retail Gasoline Outlets, where the land area for development or redevelopment is less than 5,000 square feet, are excluded from the numerical Structural or Treatment Control BMP design standard requirement only.

3. Provisions Applicable to Individual Priority Project Categories

   a. 100,000 Square Foot Commercial Developments

      1) Properly Design Loading/Unloading Dock Areas
      Loading/unloading dock areas have the potential for material spills to be quickly transported to the storm water conveyance system. To minimize this potential, the following design criteria are required:

         a) Cover loading dock areas or design drainage to minimize run-on and runoff of storm water.
         b) Direct connections to storm drains from depressed loading docks (truck wells) are prohibited.

      2) Properly Design Repair/Maintenance Bays
      Oil and grease, solvents, car battery acid, coolant and gasoline from the repair/maintenance bays can negatively impact storm water if allowed to come into contact with storm water runoff. Therefore, design plans for repair bays must include the following:

a) Repair/maintenance bays must be indoors or designed in such a way that doesn't allow storm water runon or contact with storm water runoff.
b) Design a repair/maintenance bay drainage system to capture all washwater, leaks and spills. Connect drains to a sump for collection and disposal. Direct connection of the repair/maintenance bays to the storm drain system is prohibited. If required by local jurisdiction, obtain an Industrial Waste Discharge Permit.

3) Properly Design Vehicle/Equipment Wash Areas
The activity of vehicle/equipment washing/steam cleaning has the potential to contribute metals, oil and grease, solvents, phosphates, and suspended solids to the storm water conveyance system. Include in the project plans an area for washing/steam cleaning of vehicles and equipment. The area in the site design must be:

a) Self-contained and/ or covered, equipped with a clarifier, or other pretreatment facility, and
b) Properly connected to a sanitary sewer or other appropriately permitted disposal facility.

b. Restaurants

1) Properly Design Equipment/Accessory Wash Areas
The activity of outdoor equipment/accessory washing/steam cleaning has the potential to contribute metals, oil and grease, solvents, phosphates, and suspended solids to the storm water conveyance system. Include in the project plans an area for the washing/steam cleaning of equipment and accessories. This area must be:

a) Self-contained, equipped with a grease trap, and properly connected to a sanitary sewer.
b) If the wash area is to be located outdoors, it must be covered, paved, have secondary containment, and be connected to the sanitary sewer or other appropriately permitted disposal facility.

c. Retail Gasoline Outlets

1) Properly Design Fueling Area
Fueling areas have the potential to contribute oil and grease, solvents, car battery acid, coolant and gasoline to the storm water conveyance system. The project plans must include the following BMPs:

a) The fuel dispensing area must be covered with an overhanging roof structure or canopy. The canopy's minimum dimensions must be equal to or greater than the area within the grade break. The canopy must not drain onto the fuel dispensing area, and the canopy downspouts must be routed to prevent drainage across the fueling area.

b) The fuel dispensing area must be paved with Portland cement concrete (or equivalent smooth impervious surface), and the use of asphalt concrete shall be prohibited.
c) The fuel dispensing area must have a 2% to 4% slope to prevent ponding, and must be separated from the rest of the site by a grade break that prevents run-on of storm water to the extent practicable.
d) At a minimum, the concrete fuel dispensing area must extend 6.5 feet (2.0 meters) from the corner of each fuel dispenser, or the length at which the hose and nozzle assembly may be operated plus 1 foot (0.3 meter), whichever is less.

d. Automotive Repair Shops

1) Properly Design Fueling Area
Fueling areas have the potential to contribute oil and grease, solvents, car battery acid, coolant and gasoline to the storm water conveyance system. Therefore, design plans, which include fueling areas, must contain the following BMPs:

a. The fuel dispensing area must be covered with an overhanging roof structure or canopy. The canopy's minimum dimensions must be equal to or greater than the area within the grade break. The canopy must not drain onto the fuel dispensing area, and the canopy downspouts must be routed to prevent drainage across the fueling area.
b. The fuel dispensing area must be paved with Portland cement concrete (or equivalent smooth impervious surface), and the use of asphalt concrete shall be prohibited.
c. The fuel dispensing area must have a 2% to 4% slope to prevent ponding, and must be separated from the rest of the site by a grade break that prevents run-on of storm water to the extent practicable.
d. At a minimum, the concrete fuel dispensing area must extend 6.5 feet (2.0 meters) from the corner of each fuel dispenser, or the length at which the hose and nozzle assembly may be operated plus 1 foot (0.3 meter), whichever is less.

2) Properly Design Repair/Maintenance Bays
Oil and grease, solvents, car battery acid, coolant and gasoline from the repair/maintenance bays can negatively impact storm water if allowed to come into contact with storm water runoff. Therefore, design plans for repair bays must include the following:

a) Repair/maintenance bays must be indoors or designed in such a way that doesn't allow storm water run-on or contact with storm water runoff.
b) Design a repair/maintenance bay drainage system to capture all wash-water, leaks and spills. Connect drains to a sump for collection and disposal. Direct connection of the repair/maintenance bays to the storm drain system is

prohibited. If required by local jurisdiction, obtain an Industrial Waste Discharge Permit.

3) Properly Design Vehicle/Equipment Wash Areas
The activity of vehicle/equipment washing/steam cleaning has the potential to contribute metals, oil and grease, solvents, phosphates, and suspended solids to the storm water conveyance system. Include in the project plans an area for washing/steam cleaning of vehicles and equipment. This area must be:

   a) Self-contained and/or covered, equipped with a clarifier, or other pretreatment facility, and properly connected to a sanitary sewer or other appropriately permitted disposal facility.

4) Properly Design Loading/Unloading Dock Areas
Loading/unloading dock areas have the potential for material spills to be quickly transported to the storm water conveyance system. To minimize this potential, the following design criteria are required:

   a) Cover loading dock areas or design drainage to minimize run-on and runoff of storm water.
   b) Direct connections to storm drains from depressed loading docks (truck wells) are prohibited.

e. Parking Lots

1) Properly Design Parking Area
Parking lots contain pollutants such as heavy metals, oil and grease, and polycyclic aromatic hydrocarbons that are deposited on parking lot surfaces by motor-vehicles. These pollutants are directly transported to surface waters. To minimize the offsite transport of pollutants, the following design criteria are required:

   a) Reduce impervious land coverage of parking areas.
   b) Infiltrate or treat runoff.

2) Properly Design To Limit Oil Contamination and Perform Maintenance
Parking lots may accumulate oil, grease, and water insoluble hydrocarbons from vehicle drippings and engine system leaks:

   a) Treat to remove oil and petroleum hydrocarbons at parking lots that are heavily used (e.g. fast food outlets, lots with 25 or more parking spaces , sports event parking lots, shopping malls, grocery stores, discount warehouse stores).
   b) Ensure adequate operation and maintenance of treatment systems particularly sludge and oil removal, and system fouling and plugging prevention control.

4. Waiver

   A Permittee may, through adoption of an ordinance, code, or other regulatory mechanism incorporating the treatment requirements of the Design Standards, provide for a waiver from the requirement if impracticability for a specific property can be established. A waiver of impracticability shall be granted only when all other Structural or Treatment Control BMPs have been considered and rejected as infeasible. Recognized situations of impracticability include, (i) extreme limitations of space for treatment on a redevelopment project, (ii) unfavorable or unstable soil conditions at a site to attempt infiltration, and (iii) risk of ground water contamination because a known unconfined aquifer lies beneath the land surface or an existing or potential underground source of drinking water is less than 10 feet from the soil surface. Any other justification for impracticability must be separately petitioned by the Permittee and submitted to the appropriate RWQCB for consideration. The RWQCB may consider approval of the waiver justification or may delegate the authority to approve a class of waiver justifications to the RWQCB EO. The supplementary waiver justification becomes recognized and effective only after approval by the RWQCB or the RWQCB EO. A waiver granted by a Permittee to any development or redevelopment project may be revoked by the RWQCB EO for cause and with proper notice upon petition.

5. Limitation on Use of Infiltration BMPs

   Three factors significantly influence the potential for storm water to contaminate ground water. They are (i) pollutant mobility, (ii) pollutant abundance in storm water, (iii) and soluble fraction of pollutant. The risk of contamination of groundwater may be reduced by pretreatment of storm water. A discussion of limitations and guidance for infiltration practices is contained in, *Potential Groundwater Contamination from Intentional and Non-Intentional Stormwater Infiltration, Report No. EPA/600/R-94/051, USEPA (1994).*

   In addition, the distance of the groundwater table from the infiltration BMP may also be a factor determining the risk of contamination. A water table distance separation of ten feet depth in California presumptively poses negligible risk for storm water not associated with industrial activity or high vehicular traffic.

   Site specific conditions must be evaluated when determining the most appropriate BMP. Additionally, monitoring and maintenance must be provided to ensure groundwater is protected and the infiltration BMP is not rendered ineffective by overload. This is especially important for infiltration BMPs for areas of industrial activity or areas subject to high vehicular traffic [25,000 or greater average daily traffic (ADT) on main roadway or 15,000 or more ADT on any intersecting roadway]. In some cases pretreatment may be necessary.

6. Alternative Certification for Storm Water Treatment Mitigation

   In lieu of conducting detailed BMP review to verify Structural or Treatment Control BMP adequacy, a Permittee may elect to accept a signed certification from a Civil Engineer or a Licensed Architect registered in the State of California, that the plan meets the criteria established herein. The Permittee is encouraged to verify that certifying person(s) have been trained on BMP design for water quality, not more than two years prior to the signature date. Training conducted by an organization with storm water BMP design expertise (e.g., a University, American Society of Civil Engineers, American Society of Landscape Architects, American Public Works Association, or the California Water Environment Association) may be considered qualifying.

APPENDIX D

NPDES MS4 Best Management Practices Criteria Summary

NPDES MS4 Storm Water Quali ...rmanent Best Management Practices
Criteria Summary

Type of Practice	Management Practice	Description	Design Criteria	Environmental Considerations	Maintenance: Schedule	Maintenance: Activity
Infiltration Facilities	Infiltration Basin	A shallow, <u>open surface pond</u> with no outlet, which retains storm water a specified amount of time as it infiltrates into the soil. Believed to have a high pollutant removal efficiency, but can be problematic due to stringent soil requirements. Some studies have shown relatively high failure rates among infiltration basins.	• Tributary Area: < 5 acres typical, ≤ 50 acres w/ very permeable soils • Slope: mild ≤ 15% • at least 10 ft above seasonal high groundwater • ± 4 feet separation from bedrock • at least 100 ft from adjacent water supply wells • Retention Time: 40 hours recommended, 24- 40 hours range • Installation Area: refer to Appendix D, California Storm Water Best Management Practice Handbooks • Soil Conditions: sandy and loamy soils are ideal, low clay content, permeability between 0.5 and 3.0 in/hr • Side Slopes: 3:1 steepest, 4:1 to allow mowing and maintenance vehicle access • Pretreatment recommended to remove floatables and settleable solids, especially in finer soils • Freeboard: 1 ft min • Incorporate bypass or overflow for large events	• Potential groundwater contamination, may require monitoring • Wet season coincident with minimal plant growth, if not, supplement with irrigation	Annual or as needed	• Cleaning and removal of debris after major events • Sediment cleanout • Mowing and maintenance of upland vegetation areas
					3- to 5-year cycle	• Removal of sediment when 50% of original volume has been lost
					Annual Cost	• 1 - 10% of Construction Cost
	Trench / Rock Well	An underground, <u>horizontal chamber</u> filled with rock, with no outlet, in which storm water is retained in voids of the stones and is slowly allowed to infiltrate into the soil. An infiltration trench typically requires pretreatment measures to function efficiently and to increase life of system.	• Tributary Area: small areas, ± 3 acres • Slope: mild ≤ 15% • at least 10 ft above seasonal high groundwater • ± 4 feet separation from bedrock • at least 100 ft from adjacent water supply wells • Retention Time: 40 hours recommended, 24- 40 hours range • Installation Area: refer to Appendix D, California Storm Water Best Management Practice Handbooks • Observation well required to check for loss of infiltration • Incorporate bypass or overflow for large events • Pretreatment recommended due to difficult access	• Potential groundwater contamination, may require monitoring	Annual or as needed	• Cleaning and removal of debris after major events • Repair or replacement of stone aggregate • maintenance of inlets and outlets
					4-year cycle	• Removal of sediment when 50% of original volume has been lost
						• maintenance access limited, sometimes impossible
					Annual Cost	• 5 - 20% of Construction Cost

Type of Practice	Management Practice	Description	Design Criteria	Environmental Considerations	Maintenance Schedule	Maintenance Activity
Infiltration Facilities	Porous Paving (Concrete and Asphalt)	Storm water flows through a <u>permeable pavement surface</u> and into an underlaying stone subbase. Storm water is temporarily stored in the stone subbase which allows it to then infiltrate into the soil.	• Tributary Area: small areas, ± 3 acres • Installation Area: low traffic areas such as parking lots • Non-standard base and subase section, refer to Figure 1D, California Storm Water Best Management Practice • at least 2 to 5 ft above seasonal high groundwater • underlaying soil should have permeability between 0.5 and 3.0 in/hr, failing that, install subsurface / silt drains • at least 100 ft from adjacent water supply wells	• Potential groundwater contamination, may require monitoring	Quarterly or as needed	• cleaned by vacuum sweeping and high pressure wash • mow upland and adjacent areas • seed bare areas
					Annually	• inspect for surface deterioration or spalling
						• high potential for clogging
					Annual Cost	• 10 - 20% of Construction Cost
	Concrete Grid / Modular Pavement	Storm water passes through a <u>porous surface</u> and into a stone subbase, where it is temporarily stored and allowed to infiltrate into the soil. Typical installation is concrete blocks / pavers with turfgrass seeded in void spaces between pavers.	• Tributary Area: small areas, ± 3 acres • Installation Area: low traffic areas such as parking lots • at least 2 to 5 ft above seasonal high groundwater • at least 100 ft from adjacent water supply wells • underlaying soil should have permeability between 0.5 and 3.0 in/hr, failing that, install subsurface / silt drains • may limit handicap accessibility	• Potential groundwater contamination, may require monitoring	Quarterly or as needed	• mowing and removal surface debris/litter • maintain upland and adjacent areas • seed bare areas
					Annually	• inspect for surface deterioration
					Annual Cost	• 10 - 20% of Construction Cost

Type of Practice	Management Practice	Description	Design Criteria	Environmental Considerations	Maintenance Schedule	Maintenance Activity
Filtration Practices	Bioswales	A bioswale is a <u>vegetated open channel</u> with a specific geometry and features designed to treat and attenuate storm water runoff. The primary treatment is filtration through the vegetation and subsoil matrix. Some degree of infiltration occurs along the length of the channel as a secondary treatment.	• Tributary Area: small areas, ± 5 acres • Water Quality Volume: runoff from 2-year event (typical) • Residence Time: ≥ 5 min • Longitudinal Slope: 1% - 2% optimal, > 4% excessive • Velocity: 3 ft/sec max, 1.5 ft/sec min • Installation Area: approximately 1,200 sq. ft. of swale per 1 acre of impervious surface • Flow Depth: 4", such that runoff is in contact with vegetation • Cross Sectional Shape: trapezoidal most common • Bottom Channel Width: 2 ft min, 8 ft max • Side Slopes: 3:1 steepest, 5:1 to allow mowing • Freeboard: 6" min • Check Dams: spaced approximately 50 to 100 ft apart, reduces velocity, increases residence time • Incorporate bypass or overflow for large events	• Wet season coincident with minimal plant growth, if not, supplement with irrigation	Annual or as needed	• mowing and litter/debris removal • erosion repair • aeration of channel bottom • remove sediment when 25% of original volume has been lost
					5-year cycle	• scrap swale bottom and remove sediment to restore original cross section and infiltration rate
					Annual Cost	• 5 - 7% of Construction Cost
	Biostrips	Biostrips are <u>sloped pervious areas</u> (typically grass) placed adjacent to impervious areas and are design to treat the associated sheet flow storm runoff. They function by slowing runoff velocities such that filtration and infiltration can occur through the vegetation and subsoil.	• Tributary Area: small areas such that concentrated flow does not occur, max of 75 ft of impervious area • Water Quality Volume: runoff from 1" storm or 1/2" of runoff over entire drainage area (typical) • Slope: between 2% and 6% • Installation Area: large compared to tributary area • at least 2 to 4 ft above seasonal high groundwater • recent manuals do not consider this a treatment practice, more as pre-treatment	• Wet season coincident with minimal plant growth, if not, supplement with irrigation	Annual or as needed	• mowing and litter/debris removal • erosion repair • aeration • remove sediment when 25% of original volume has been lost
					Annual Cost	• $500 ± per acre (maintained)

Type of Practice	Management Practice	Description	Design Criteria	Environmental Considerations	Maintenance: Schedule	Maintenance: Activity
Detention / Retention Practices	Dry Extended Detention Basins	A constructed shallow basin, in which the outlet is sized to detain incoming storm water for a specified time, allowing for settlement of sediments and pollutants. The basin is dry between rainfall events.	• Tributary Area: regional, min of 10 acres (due to limitation of outlet size) • Retention Time: 40 hours recommended, 24- 40 hours range • Installation Area: refer to Appendix D, California Storm Water Best Management Practice Handbooks • Slope: mild ≤ 15% and stable • Side Slope: 2:1 typical and provide 4:1 for maintenance access • Freeboard: 1 ft min	• Wet season coincident with minimal plant growth, if not, supplement with irrigation	Annual or as needed	• cleaning and removal of debris after major events • repair of embankments
					5-year cycle	• removal of sediment from forebay or sediment storage areas when 60% of original volume has been lost
					20-year cycle	• Removal of sediment from main cell(s) of pond when 50% of original volume has been lost
					Annual Cost	• 1% ± of Construction Cost
Structural Control Measures	Media Filtration (Stormfilter™)	Storm water is treated as it flows through an underground vault which houses cylindrical filters or cartridges of various media. Typical media includes perlite, zeolite and granulated active charcoal.	• Tributary Area: ≤ 50 acres typical for develop area, ≤ 200 acres typical for undeveloped area • Water Quality Flow: max treatable capacity of largest unit is 11 cfs • Hydraulic Head: minimum of 2.4 ft • Installation Area: largest cast-in-place unit is 42.5 ft x 45 ft. • pretreatment recommended to extend the maintenance cycle	• sediments and water must be disposed in accordance with all applicable waste disposal regulations	Semi-annual or as needed	• removal of debris and litter within structure • general inspection of system
					Annual	• replacement of media cartridges • removal of accumulated sediment on structure floor
					Annual Cost	• 5 - 20% of Construction Cost
	Swirl Concentrator (Vortechs™ System)	Storm water passes through a vault which houses a swirl chamber and a series of flow control measures. A tangential inlet creates a swirling motion which allows solid to settle to the center of the chamber. Floatables are contained by a baffle.	• Tributary Area: ≤ 50 acres typical for develop area • Water Quality Flow: max treatable capacity of largest unit is 25 cfs • Installation Area: largest unit approximately 18 ft x 12 ft • Requires 3 ft minimum sump below inlet pipe • pretreatment recommended to extend the maintenance cycle	• sediments and water must be disposed in accordance with all applicable waste disposal regulations • standing water, potential mosquito habitat	Quarterly or as needed	• removal of accumulated sediment when grit chamber is 50% of original volume • general inspection of system
					Annual Cost	• ________of Construction Cost

Type of Practice	Management Practice	Description	Design Criteria	Environmental Considerations	Maintenance	
					Schedule	Activity
Structural Control Measures	Deflection Screen	Similar to swirl concentrators in that storm water enters structure through a tangential inlet to create a swirling motion. A circular filter then separates solids and the are settled to the sump of the structure.	• Water Quality Flow: max treatable capacity of largest cast-in-place unit is 300 cfs Hydraulic Head: up to 3 ft • pretreatment recommended to extend the maintenance cycle	• sediments and water must be disposed in accordance with all applicable waste disposal regulations • standing water, potential mosquito habitat	Quarterly or as needed	• removal of accumulated sediment when sump is 75% of original volume • general inspection of system
					Annual or as needed	• complete removal of sediments • inspection of sump basket for damage
					Annual Cost	• ______of Construction Cost

APPENDIX E

Hydrologic Calculations StormCAD Output

APPENDIX F

Basin Analyses
Pond Pack

Castleberg Basin Analysis

Type.... Vol: Elev-Area
Name.... POND 10

File.... N:\SA0154219\Calc\PondPack\Castleberg_01.ppw

Elevation (ft)	Planimeter (sq.in)	Area (acres)	A1+A2+sqr(A1*A2) (acres)	Volume (ac-ft)	Volume Sum (ac-ft)
129.86	-----	.0001	.0000	.000	.000
130.00	-----	.0080	.0090	.000	.000
131.00	-----	3.0920	3.2573	1.086	1.086
132.00	-----	5.3530	12.5134	4.171	5.257
133.00	-----	5.7350	16.6287	5.543	10.800
134.00	-----	6.0080	17.6129	5.871	16.671
135.00	-----	6.2860	18.4394	6.146	22.818
135.78	-----	6.5070	19.1886	4.989	27.807
136.00	-----	6.5690	19.6139	1.438	29.245

POND VOLUME EQUATIONS

* Incremental volume computed by the Conic Method for Reservoir Volumes.

Volume = (1/3) * (EL2-EL1) * (Area1 + Area2 + sq.rt.(Area1*Area2))

where: EL1, EL2 = Lower and upper elevations of the increment
Area1,Area2 = Areas computed for EL1, EL2, respectively
Volume = Incremental volume between EL1 and EL2

MASTER DESIGN STORM SUMMARY

Default Network Design Storm File, ID Riverbank1

Return Event	Rainfall Type	IDF ID
10	I-D-F Curve	I-D-F 10yr
50	I-D-F Curve	I-D-F 50yr
100	I-D-F Curve	I-D-F 100yr

MASTER NETWORK SUMMARY
Modified Rational Method Network

(*Node=Outfall; +Node=Diversion;)
(Trun= HYG Truncation: Blank=None; L=Left; R=Rt; LR=Left&Rt)

Node ID		Type	Return Event	HYG Vol ac-ft	Trun	Qpeak hrs	Qpeak cfs	Max WSEL ft	Max Pond Storage ac-ft
*OUT 10		JCT	10	.000		.0000	.00		
*OUT 10		JCT	50	.000		.0000	.00		
*OUT 10		JCT	100	.000		.0000	.00		
POND 10	IN	POND	10	.000		.0000	.00		
POND 10	IN	POND	50	.000		.0000	.00		
POND 10	IN	POND	100	.000		.0000	.00		
POND 10	OUT	POND	10	.000		.0000	.00		
POND 10	OUT	POND	50	.000		.0000	.00		
POND 10	OUT	POND	100	.000		.0000	.00		
SUBAREA 10		AREA	10	.000		.0000	.00		
SUBAREA 10		AREA	50	.000		.0000	.00		
SUBAREA 10		AREA	100	.000		.0000	.00		

0.76 hr

MASTER DESIGN STORM SUMMARY

Default Network Design Storm File, ID Riverbank1

Return Event	Rainfall Type	IDF ID
10	I-D-F Curve	I-D-F 10yr
50	I-D-F Curve	I-D-F 50yr
100	I-D-F Curve	I-D-F 100yr

MASTER NETWORK SUMMARY
Modified Rational Method Network

(*Node=Outfall; +Node=Diversion;)
(Trun= HYG Truncation: Blank=None; L=Left; R=Rt; LR=Left&Rt)

Node ID		Type	Return Event	HYG Vol ac-ft	Trun	Qpeak hrs	Qpeak cfs	Max WSEL ft	Max Pond Storage ac-ft	
OUT 10		JCT	10	5.090		.1500	6.75			
*OUT 10		JCT	50	6.799		.1200	6.75			
*OUT 10		JCT	100	8.161		.1200	6.75			
POND 10	IN	POND	10	5.090		.7600	73.90			
POND 10	IN	POND	50	6.799		.7600	98.72			
POND 10	IN	POND	100	8.161		.7600	98.75			
POND 10	OUT	POND	10	5.090		.1500	6.75	131.80	4.245	1 hr
POND 10	OUT	POND	50	6.799		.1200	6.75	132.13	5.946	
POND 10	OUT	POND	100	8.161		.1200	6.75	132.36	7.216	
SUBAREA 10		AREA	10	5.090		.7600	73.90			
SUBAREA 10		AREA	50	6.799		.7600	98.72			
SUBAREA 10		AREA	100	8.161		.7600	98.75			

Type.... Master Network Summary
Name.... Watershed
File.... N:\SA0154219\Calc\PondPack\Castleberg_01.ppw

MASTER DESIGN STORM SUMMARY

Default Network Design Storm File, ID Riverbank1

Return Event	Rainfall Type	IDF ID
10	I-D-F Curve	I-D-F 10yr
50	I-D-F Curve	I-D-F 50yr
100	I-D-F Curve	I-D-F 100yr

MASTER NETWORK SUMMARY
Modified Rational Method Network

(*Node=Outfall; +Node=Diversion;)
(Trun= HYG Truncation: Blank=None; L=Left; R=Rt; LR=Left&Rt)

Node ID		Type	Return Event	HYG Vol ac-ft	Trun	Qpeak hrs	Qpeak cfs	Max WSEL ft	Max Pond Storage ac-ft
OUT 10		JCT	10	6.418		.1800	6.75		
*OUT 10		JCT	50	8.345		.1400	6.75		
*OUT 10		JCT	100	9.137		.1300	6.75		
POND 10	IN	POND	10	6.418		.7600	56.83		
POND 10	IN	POND	50	8.345		.7600	74.80		
POND 10	IN	POND	100	9.137		.7600	87.29		
POND 10	OUT	POND	10	6.418		.1800	6.75	132.01	5.290 2 hr
POND 10	OUT	POND	50	8.345		.1400	6.75	132.36	7.215
POND 10	OUT	POND	100	9.137		.1300	6.75	132.51	8.047
SUBAREA 10		AREA	10	6.418		.7600	56.83		
SUBAREA 10		AREA	50	8.345		.7600	74.80		
SUBAREA 10		AREA	100	9.137		.7600	87.29		

MASTER DESIGN STORM SUMMARY

Default Network Design Storm File, ID Riverbank1

Return Event	Rainfall Type	IDF ID
10	I-D-F Curve	I-D-F 10yr
50	I-D-F Curve	I-D-F 50yr
100	I-D-F Curve	I-D-F 100yr

MASTER NETWORK SUMMARY
Modified Rational Method Network

(*Node=Outfall; +Node=Diversion;)
(Trun= HYG Truncation: Blank=None; L=Left; R=Rt; LR=Left&Rt)

Node ID	Type	Return Event	HYG Vol ac-ft	Trun	Qpeak hrs	Qpeak cfs	Max WSEL ft	Max Pond Storage ac-ft	
*OUT 10	JCT	10	8.608		.2300	6.75			
*OUT 10	JCT	50	11.121	R	.1900	6.75			
*OUT 10	JCT	100	11.123	R	.1700	6.75			
POND 10 IN	POND	10	8.608		.7600	40.32			
POND 10 IN	POND	50	11.168		.7600	52.65			
POND 10 IN	POND	100	12.422		.7600	57.08			
POND 10 OUT	POND	10	8.608		.2300	6.75	132.29	6.823	4 hr
POND 10 OUT	POND	50	11.121	R	.1900	6.75	132.75	9.376	
POND 10 OUT	POND	100	11.123	R	.1700	6.75	132.96	10.588	
SUBAREA 10	AREA	10	8.608		.7600	40.32			
SUBAREA 10	AREA	50	11.168		.7600	52.65			
SUBAREA 10	AREA	100	12.422		.7600	57.08			

MASTER DESIGN STORM SUMMARY

Default Network Design Storm File, ID Riverbank1

Return Event	Rainfall Type	IDF ID
10	I-D-F Curve	I-D-F 10yr
50	I-D-F Curve	I-D-F 50yr
100	I-D-F Curve	I-D-F 100yr

MASTER NETWORK SUMMARY
Modified Rational Method Network

(*Node=Outfall; +Node=Diversion;)
(Trun= HYG Truncation: Blank=None; L=Left; R=Rt; LR=Left&Rt)

Node ID		Type	Return Event	HYG Vol ac-ft	Trun	Qpeak hrs	Qpeak cfs	Max WSEL ft	Max Pond Storage ac-ft
·OUT 10		JCT	10	8.788		.2300	6.75		
*OUT 10		JCT	50	11.119	R	.1900	6.75		
*OUT 10		JCT	100	11.114	R	.2200	6.75		
POND 10	IN	POND	10	8.788		.7600	38.67		
POND 10	IN	POND	50	11.430		.7600	50.29		
POND 10	IN	POND	100	14.482		.7600	42.91		
POND 10	OUT	POND	10	8.788		.2300	6.75	132.31	6.913 6 hw
POND 10	OUT	POND	50	11.119	R	.1900	6.75	132.78	9.538
POND 10	OUT	POND	100	11.114	R	.2200	6.75	133.18	11.856
SUBAREA 10		AREA	10	8.788		.7600	38.67		
SUBAREA 10		AREA	50	11.430		.7600	50.29		
SUBAREA 10		AREA	100	14.482		.7600	42.91		

MASTER DESIGN STORM SUMMARY

Default Network Design Storm File, ID Riverbank1

Return Event	Rainfall Type	IDF ID
10	I-D-F Curve	I-D-F 10yr
50	I-D-F Curve	I-D-F 50yr
100	I-D-F Curve	I-D-F 100yr

MASTER NETWORK SUMMARY
Modified Rational Method Network

(*Node=Outfall; +Node=Diversion;)
(Trun= HYG Truncation: Blank=None; L=Left; R=Rt; LR=Left&Rt)

Node ID		Type	Return Event	HYG Vol ac-ft	Trun	Qpeak hrs	Qpeak cfs	Max WSEL ft	Max Pond Storage ac-ft
OUT 10		JCT	10	11.079	R	.3600	6.75		
*OUT 10		JCT	50	11.108	R	.2400	6.75		
*OUT 10		JCT	100	11.105	R	.2500	6.75		
POND 10	IN	POND	10	12.139		.7600	21.55		
POND 10	IN	POND	50	13.171		.7600	37.06		
POND 10	IN	POND	100	16.276		.7600	34.25		
POND 10	OUT	POND	10	11.079	R	.3600	6.75	132.51	8.056 8hr
POND 10	OUT	POND	50	11.108	R	.2400	6.75	132.94	10.435
POND 10	OUT	POND	100	11.105	R	.2500	6.75	133.34	12.738
SUBAREA 10		AREA	10	12.139		.7600	21.55		
SUBAREA 10		AREA	50	13.171		.7600	37.06		
SUBAREA 10		AREA	100	16.276		.7600	34.25		

MASTER DESIGN STORM SUMMARY

Default Network Design Storm File, ID Riverbank1

Return Event	Rainfall Type	IDF ID
10	I-D-F Curve	I-D-F 10yr
50	I-D-F Curve	I-D-F 50yr
100	I-D-F Curve	I-D-F 100yr

MASTER NETWORK SUMMARY
Modified Rational Method Network

(*Node=Outfall; +Node=Diversion;)
(Trun= HYG Truncation: Blank=None; L=Left; R=Rt; LR=Left&Rt)

Node ID		Type	Return Event	HYG Vol ac-ft	Trun	Qpeak hrs	Qpeak cfs	Max WSEL ft	Max Pond Storage ac-ft	
·OUT 10		JCT	10	11.077	R	.3700	6.75			
*OUT 10		JCT	50	11.098	R	.2800	6.75			
*OUT 10		JCT	100	11.104	R	.2600	6.75			
POND 10	IN	POND	10	12.392		.7600	20.97			
POND 10	IN	POND	50	14.759		.7600	29.60			
POND 10	IN	POND	100	16.494		.7600	33.45			
POND 10	OUT	POND	10	11.077	R	.3700	6.75	132.53	8.128	10 hr
POND 10	OUT	POND	50	11.098	R	.2800	6.75	133.05	11.077	
POND 10	OUT	POND	100	11.104	R	.2600	6.75	133.35	12.837	
SUBAREA 10		AREA	10	12.392		.7600	20.97			
SUBAREA 10		AREA	50	14.759		.7600	29.60			
SUBAREA 10		AREA	100	16.494		.7600	33.45			

Type.... Master Network Summary
Name.... Watershed
File.... N:\SA0154219\Calc\PondPack\Castleberg_01.ppw

MASTER DESIGN STORM SUMMARY

Default Network Design Storm File, ID Riverbank1

Return Event	Rainfall Type	IDF ID
10	I-D-F Curve	I-D-F 10yr
50	I-D-F Curve	I-D-F 50yr
100	I-D-F Curve	I-D-F 100yr

MASTER NETWORK SUMMARY
Modified Rational Method Network

(*Node=Outfall; +Node=Diversion;)
(Trun= HYG Truncation: Blank=None; L=Left; R=Rt; LR=Left&Rt)

Node ID		Type	Return Event	HYG Vol ac-ft	Trun	Qpeak hrs	Qpeak cfs	Max WSEL ft	Max Pond Storage ac-ft	
*OUT 10		JCT	10	11.062	R	.4300	6.75			
*OUT 10		JCT	50	11.097	R	.2900	6.75			
*OUT 10		JCT	100	11.103	R	.2600	6.75			
POND 10	IN	POND	10	14.199		.7600	17.41			
POND 10	IN	POND	50	14.893		.7600	29.06			
POND 10	IN	POND	100	16.627		.7600	32.89			
POND 10	OUT	POND	10	11.062	R	.4300	6.75	132.58	8.447	12 hr
POND 10	OUT	POND	50	11.097	R	.2900	6.75	133.06	11.119	
POND 10	OUT	POND	100	11.103	R	.2600	6.75	133.36	12.888	
SUBAREA 10		AREA	10	14.199		.7600	17.41			
SUBAREA 10		AREA	50	14.893		.7600	29.06			
SUBAREA 10		AREA	100	16.627		.7600	32.89			

Type.... Master Network Summary
Name.... Watershed
File.... N:\SA0154219\Calc\PondPack\Castleberg_01.ppw

MASTER DESIGN STORM SUMMARY

Default Network Design Storm File, ID Riverbank1

Return Event	Rainfall Type	IDF ID
10	I-D-F Curve	I-D-F 10yr
50	I-D-F Curve	I-D-F 50yr
100	I-D-F Curve	I-D-F 100yr

MASTER NETWORK SUMMARY
Modified Rational Method Network

(*Node=Outfall; +Node=Diversion;)
(Trun= HYG Truncation: Blank=None; L=Left; R=Rt; LR=Left&Rt)

Node ID		Type	Return Event	HYG Vol ac-ft	Trun	Qpeak hrs	Qpeak cfs	Max WSEL ft	Max Pond Storage ac-ft	
OUT 10		JCT	10	11.060	R	.4400	6.75			
*OUT 10		JCT	50	11.096	R	.2900	6.75			
*OUT 10		JCT	100	11.102	R	.2700	6.75			
POND 10	IN	POND	10	14.505		.7600	16.90			
POND 10	IN	POND	50	15.000		.7600	28.58			
POND 10	IN	POND	100	16.759		.7600	32.27			
POND 10	OUT	POND	10	11.060	R	.4400	6.75	132.59	8.470	14 hr
POND 10	OUT	POND	50	11.096	R	.2900	6.75	133.06	11.145	
POND 10	OUT	POND	100	11.102	R	.2700	6.75	133.37	12.929	
SUBAREA 10		AREA	10	14.505		.7600	16.90			
SUBAREA 10		AREA	50	15.000		.7600	28.58			
SUBAREA 10		AREA	100	16.759		.7600	32.27			

MASTER DESIGN STORM SUMMARY

Default Network Design Storm File, ID Riverbank1

Return Event	Rainfall Type	IDF ID
10	I-D-F Curve	I-D-F 10yr
50	I-D-F Curve	I-D-F 50yr
100	I-D-F Curve	I-D-F 100yr

MASTER NETWORK SUMMARY
Modified Rational Method Network

(*Node=Outfall; +Node=Diversion;)
(Trun= HYG Truncation: Blank=None; L=Left; R=Rt; LR=Left&Rt)

Node ID		Type	Return Event	HYG Vol ac-ft	Trun	Qpeak hrs	Qpeak cfs	Max WSEL ft	Max Pond Storage ac-ft	
*OUT 10		JCT	10	11.059	R	.4400	6.75			
*OUT 10		JCT	50	11.096	R	.2900	6.75			
*OUT 10		JCT	100	11.102	R	.2700	6.75			
POND 10	IN	POND	10	14.567		.7600	16.79			
POND 10	IN	POND	50	15.034		.7600	28.42			
POND 10	IN	POND	100	16.784		.7600	32.15			
POND 10	OUT	POND	10	11.059	R	.4400	6.75	132.59	8.469	14.5hr
POND 10	OUT	POND	50	11.096	R	.2900	6.75	133.06	11.151	
POND 10	OUT	POND	100	11.102	R	.2700	6.75	133.37	12.935	
SUBAREA 10		AREA	10	14.567		.7600	16.79			
SUBAREA 10		AREA	50	15.034		.7600	28.42			
SUBAREA 10		AREA	100	16.784		.7600	32.15			

Type.... Master Network Summary
Name.... Watershed
File.... N:\SA0154219\Calc\PondPack\Castleberg_01.ppw

MASTER DESIGN STORM SUMMARY

Default Network Design Storm File, ID Riverbank1

Return Event	Rainfall Type	IDF ID
10	I-D-F Curve	I-D-F 10yr
50	I-D-F Curve	I-D-F 50yr
100	I-D-F Curve	I-D-F 100yr

MASTER NETWORK SUMMARY
Modified Rational Method Network

(*Node=Outfall; +Node=Diversion;)
(Trun= HYG Truncation: Blank=None; L=Left; R=Rt; LR=Left&Rt)

Node ID		Type	Return Event	HYG Vol ac-ft	Trun	Qpeak hrs	Qpeak cfs	Max WSEL ft	Max Pond Storage ac-ft
*OUT 10		JCT	10	11.059	R	.4500	6.75		
*OUT 10		JCT	50	11.096	R	.2900	6.75		
*OUT 10		JCT	100	11.102	R	.2700	6.75		
POND 10	IN	POND	10	14.637		.7600	16.66		
POND 10	IN	POND	50	15.055		.7600	28.32		
POND 10	IN	POND	100	16.819		.7600	31.96		
POND 10	OUT	POND	10	11.059	R	.4500	6.75	132.59	8.465
POND 10	OUT	POND	50	11.096	R	.2900	6.75	133.06	11.154
POND 10	OUT	POND	100	11.102	R	.2700	6.75	133.37	12.943
SUBAREA 10		AREA	10	14.637		.7600	16.66		
SUBAREA 10		AREA	50	15.055		.7600	28.32		
SUBAREA 10		AREA	100	16.819		.7600	31.96		

15 hr

First Street Basin Analysis

Type.... Vol: Elev-Area
Name.... POND 10

File.... N:\SA0154219\Calc\PondPack\First_Street_02.ppw

Elevation (ft)	Planimeter (sq.in)	Area (acres)	A1+A2+sqr(A1*A2) (acres)	Volume (ac-ft)	Volume Sum (ac-ft)
127.69	-----	.0000	.0000	.000	.000
128.00	-----	.0590	.0590	.006	.006
129.00	-----	1.0340	1.3400	.447	.453
130.00	-----	1.2320	3.3947	1.132	1.584
130.29	-----	1.2770	3.7633	.364	1.948
131.00	-----	1.3870	3.9949	.945	2.894
132.00	-----	1.4950	4.3220	1.441	4.334
133.00	-----	1.5940	4.6327	1.544	5.878
134.00	-----	1.6920	4.9283	1.643	7.521
135.00	-----	1.7920	5.2253	1.742	9.263
136.00	-----	1.8930	5.5268	1.842	11.105

POND VOLUME EQUATIONS

* Incremental volume computed by the Conic Method for Reservoir Volumes.

Volume = (1/3) * (EL2-EL1) * (Area1 + Area2 + sq.rt.(Area1*Area2))

where: EL1, EL2 = Lower and upper elevations of the increment
Area1,Area2 = Areas computed for EL1, EL2, respectively
Volume = Incremental volume between EL1 and EL2

MASTER DESIGN STORM SUMMARY

Default Network Design Storm File, ID Riverbank1

Return Event	Rainfall Type	IDF ID
10	I-D-F Curve	I-D-F 10yr
50	I-D-F Curve	I-D-F 50yr
100	I-D-F Curve	I-D-F 100yr

MASTER NETWORK SUMMARY
Modified Rational Method Network

(*Node=Outfall; +Node=Diversion;)
(Trun= HYG Truncation: Blank=None; L=Left; R=Rt; LR=Left&Rt)

Node ID		Type	Return Event	HYG Vol ac-ft	Trun --	Qpeak hrs	Qpeak cfs	Max WSEL ft	Max Pond Storage ac-ft
OUT 10		JCT	10	.000		.0000	.00		
*OUT 10		JCT	50	.000		.0000	.00		
*OUT 10		JCT	100	.000		.0000	.00		
POND 10	IN	POND	10	.000		.0000	.00		
POND 10	IN	POND	50	.000		.0000	.00		
POND 10	IN	POND	100	.000		.0000	.00		
POND 10	OUT	POND	10	.000		.0000	.00		
POND 10	OUT	POND	50	.000		.0000	.00		
POND 10	OUT	POND	100	.000		.0000	.00		
SUBAREA 10		AREA	10	.000		.0000	.00		
SUBAREA 10		AREA	50	.000		.0000	.00		
SUBAREA 10		AREA	100	.000		.0000	.00		

Outlet low

MASTER DESIGN STORM SUMMARY

Default Network Design Storm File, ID Riverbank1

Return Event	Rainfall Type	IDF ID
10	I-D-F Curve	I-D-F 10yr
50	I-D-F Curve	I-D-F 50yr
100	I-D-F Curve	I-D-F 100yr

MASTER NETWORK SUMMARY
Modified Rational Method Network

(*Node=Outfall; +Node=Diversion;)
(Trun= HYG Truncation: Blank=None; L=Left; R=Rt; LR=Left&Rt)

Node ID		Type	Return Event	HYG Vol ac-ft	Trun	Qpeak hrs	Qpeak cfs	Max WSEL ft	Max Pond Storage ac-ft
OUT 10		JCT	10	2.626		.1000	2.85		
*OUT 10		JCT	50	3.499		.0800	2.85		
*OUT 10		JCT	100	3.859		.0800	2.85		
POND 10	IN	POND	10	2.626		.6400	47.66		
POND 10	IN	POND	50	3.499		.6400	63.51		
POND 10	IN	POND	100	3.859		.6400	70.04		
POND 10	OUT	POND	10	2.626		.1000	2.85	130.58	2.331
POND 10	OUT	POND	50	3.499		.0800	2.85	131.22	3.201
POND 10	OUT	POND	100	3.859		.0800	2.85	131.47	3.561
SUBAREA 10		AREA	10	2.626		.6400	47.66		
SUBAREA 10		AREA	50	3.499		.6400	63.51		
SUBAREA 10		AREA	100	3.859		.6400	70.04		

1 hr

Type.... Master Network Summary
Name.... Watershed
File.... N:\SA0154219\Calc\PondPack\First_Street_02.ppw

MASTER DESIGN STORM SUMMARY

Default Network Design Storm File, ID Riverbank1

Return Event	Rainfall Type	IDF ID
10	I-D-F Curve	I-D-F 10yr
50	I-D-F Curve	I-D-F 50yr
100	I-D-F Curve	I-D-F 100yr

MASTER NETWORK SUMMARY
Modified Rational Method Network

(*Node=Outfall; +Node=Diversion;)
(Trun= HYG Truncation: Blank=None; L=Left; R=Rt; LR=Left&Rt)

Node ID		Type	Return Event	HYG Vol ac-ft	Trun	Qpeak hrs	Qpeak cfs	Max WSEL ft	Max Pond Storage ac-ft
*OUT 10		JCT	10	2.626		.1000	2.85		
*OUT 10		JCT	50	3.499		.0800	2.85		
*OUT 10		JCT	100	3.859		.0800	2.85		
POND 10	IN	POND	10	2.626		.6400	47.66		
POND 10	IN	POND	50	3.499		.6400	63.51		
POND 10	IN	POND	100	3.859		.6400	70.04		
POND 10	OUT	POND	10	2.626		.1000	2.85	130.58	2.331 ✓ W
POND 10	OUT	POND	50	3.499		.0800	2.85	131.22	3.201
POND 10	OUT	POND	100	3.859		.0800	2.85	131.47	3.561
SUBAREA 10		AREA	10	2.626		.6400	47.66		
SUBAREA 10		AREA	50	3.499		.6400	63.51		
SUBAREA 10		AREA	100	3.859		.6400	70.04		

Type.... Master Network Summary
Name.... Watershed
File.... N:\SA0154219\Calc\PondPack\First_Street_02.ppw

MASTER DESIGN STORM SUMMARY

Default Network Design Storm File, ID Riverbank1

Return Event	Rainfall Type	IDF ID
10	I-D-F Curve	I-D-F 10yr
50	I-D-F Curve	I-D-F 50yr
100	I-D-F Curve	I-D-F 100yr

MASTER NETWORK SUMMARY
Modified Rational Method Network

(*Node=Outfall; +Node=Diversion;)
(Trun= HYG Truncation: Blank=None; L=Left; R=Rt; LR=Left&Rt)

Node ID		Type	Return Event	HYG Vol ac-ft	Trun	Qpeak hrs	Qpeak cfs	Max WSEL ft	Max Pond Storage ac-ft
*OUT 10		JCT	10	4.696	R	.1600	2.85		
*OUT 10		JCT	50	4.699	R	.1400	2.85		
*OUT 10		JCT	100	4.700	R	.1300	2.85		
POND 10	IN	POND	10	4.726		.6400	22.13		
POND 10	IN	POND	50	6.131		.6400	28.90		
POND 10	IN	POND	100	6.819		.6400	31.33		
POND 10	OUT	POND	10	4.696	R	.1600	2.85	131.77	3.990 4 bw
POND 10	OUT	POND	50	4.699	R	.1400	2.85	132.69	5.395
POND 10	OUT	POND	100	4.700	R	.1300	2.85	133.12	6.066
SUBAREA 10		AREA	10	4.726		.6400	22.13		
SUBAREA 10		AREA	50	6.131		.6400	28.90		
SUBAREA 10		AREA	100	6.819		.6400	31.33		

Type.... Master Network Summary
Name.... Watershed
File.... N:\SA0154219\Calc\PondPack\First_Street_02.ppw

MASTER DESIGN STORM SUMMARY

Default Network Design Storm File, ID Riverbank1

Return Event	Rainfall Type	IDF ID
10	I-D-F Curve	I-D-F 10yr
50	I-D-F Curve	I-D-F 50yr
100	I-D-F Curve	I-D-F 100yr

MASTER NETWORK SUMMARY
Modified Rational Method Network

(*Node=Outfall; +Node=Diversion;)
(Trun= HYG Truncation: Blank=None; L=Left; R=Rt; LR=Left&Rt)

Node ID		Type	Return Event	HYG Vol ac-ft	Trun	Qpeak hrs	Qpeak cfs	Max WSEL ft	Max Pond Storage ac-ft
*OUT 10		JCT	10	4.687	R	.2600	2.85		
*OUT 10		JCT	50	4.695	R	.1700	2.85		
*OUT 10		JCT	100	4.694	R	.1800	2.85		
POND 10	IN	POND	10	6.664		.6400	11.83		
POND 10	IN	POND	50	7.231		.6400	20.35		
POND 10	IN	POND	100	8.935		.6400	18.80		
POND 10	OUT	POND	10	4.687	R	.2600	2.85	132.41	4.950
POND 10	OUT	POND	50	4.695	R	.1700	2.85	133.13	6.093
POND 10	OUT	POND	100	4.694	R	.1800	2.85	133.96	7.458
SUBAREA 10		AREA	10	6.664		.6400	11.83		
SUBAREA 10		AREA	50	7.231		.6400	20.35		
SUBAREA 10		AREA	100	8.935		.6400	18.80		

8 hr

MASTER DESIGN STORM SUMMARY

Default Network Design Storm File, ID Riverbank1

Return Event	Rainfall Type	IDF ID
10	I-D-F Curve	I-D-F 10yr
50	I-D-F Curve	I-D-F 50yr
100	I-D-F Curve	I-D-F 100yr

MASTER NETWORK SUMMARY
Modified Rational Method Network

(*Node=Outfall; +Node=Diversion;)
(Trun= HYG Truncation: Blank=None; L=Left; R=Rt; LR=Left&Rt)

Node ID		Type	Return Event	HYG Vol ac-ft	Trun	Qpeak hrs	Qpeak cfs	Max WSEL ft	Max Pond Storage ac-ft	
*OUT 10		JCT	10	4.686	R	.2600	2.85			
*OUT 10		JCT	50	4.692	R	.2000	2.85			
*OUT 10		JCT	100	4.694	R	.1900	2.85			
POND 10	IN	POND	10	6.803		.6400	11.51			
POND 10	IN	POND	50	8.102		.6400	16.25			
POND 10	IN	POND	100	9.055		.6400	18.36			
POND 10	OUT	POND	10	4.686	R	.2600	2.85	132.45	5.011	10 hr
POND 10	OUT	POND	50	4.692	R	.2000	2.85	133.42	6.562	
POND 10	OUT	POND	100	4.694	R	.1900	2.85	134.00	7.527	
SUBAREA 10		AREA	10	6.803		.6400	11.51			
SUBAREA 10		AREA	50	8.102		.6400	16.25			
SUBAREA 10		AREA	100	9.055		.6400	18.36			

MASTER DESIGN STORM SUMMARY

Default Network Design Storm File, ID Riverbank1

Return Event	Rainfall Type	IDF ID
10	I-D-F Curve	I-D-F 10yr
50	I-D-F Curve	I-D-F 50yr
100	I-D-F Curve	I-D-F 100yr

MASTER NETWORK SUMMARY
Modified Rational Method Network

(*Node=Outfall; +Node=Diversion;)
(Trun= HYG Truncation: Blank=None; L=Left; R=Rt; LR=Left&Rt)

Node ID		Type	Return Event	HYG Vol ac-ft	Trun	Qpeak hrs	Qpeak cfs	Max WSEL ft	Max Pond Storage ac-ft
*OUT 10		JCT	10	4.681	R	.3100	2.85		
*OUT 10		JCT	50	4.692	R	.2100	2.85		
*OUT 10		JCT	100	4.693	R	.1900	2.85		
POND 10	IN	POND	10	7.957		.6400	9.29		
POND 10	IN	POND	50	8.235		.6400	15.69		
POND 10	IN	POND	100	9.200		.6400	17.72		
POND 10	OUT	POND	10	4.681	R	.3100	2.85	132.71	5.417
POND 10	OUT	POND	50	4.692	R	.2100	2.85	133.46	6.621 14 hr
POND 10	OUT	POND	100	4.693	R	.1900	2.85	134.05	7.599
SUBAREA 10		AREA	10	7.957		.6400	9.29		
SUBAREA 10		AREA	50	8.235		.6400	15.69		
SUBAREA 10		AREA	100	9.200		.6400	17.72		

Type.... Master Network Summary
Name.... Watershed
File.... N:\SA0154219\Calc\PondPack\First_Street_02.ppw

MASTER DESIGN STORM SUMMARY

Default Network Design Storm File, ID Riverbank1

Return Event	Rainfall Type	IDF ID
10	I-D-F Curve	I-D-F 10yr
50	I-D-F Curve	I-D-F 50yr
100	I-D-F Curve	I-D-F 100yr

MASTER NETWORK SUMMARY
Modified Rational Method Network

(*Node=Outfall; +Node=Diversion;)
(Trun= HYG Truncation: Blank=None; L=Left; R=Rt; LR=Left&Rt)

Node ID		Type	Return Event	HYG Vol ac-ft	Trun	Qpeak hrs	Qpeak cfs	Max WSEL ft	Max Pond Storage ac-ft
*OUT 10		JCT	10	4.681	R	.3100	2.85		
*OUT 10		JCT	50	4.692	R	.2100	2.85		
*OUT 10		JCT	100	4.693	R	.1900	2.85		
POND 10	IN	POND	10	8.030		.6400	9.15		
POND 10	IN	POND	50	8.265		.6400	15.54		
POND 10	IN	POND	100	9.233		.6400	17.55		
POND 10	OUT	POND	10	4.681	R	.3100	2.85	132.72	5.432
POND 10	OUT	POND	50	4.692	R	.2100	2.85	133.47	6.631
POND 10	OUT	POND	100	4.693	R	.1900	2.85	134.05	7.612
SUBAREA 10		AREA	10	8.030		.6400	9.15		
SUBAREA 10		AREA	50	8.265		.6400	15.54		
SUBAREA 10		AREA	100	9.233		.6400	17.55		

15 hr

Type.... Master Network Summary
Name.... Watershed
File.... N:\SA0154219\Calc\PondPack\First_Street_02.ppw

MASTER DESIGN STORM SUMMARY

Default Network Design Storm File, ID Riverbank1

Return Event	Rainfall Type	IDF ID
10	I-D-F Curve	I-D-F 10yr
50	I-D-F Curve	I-D-F 50yr
100	I-D-F Curve	I-D-F 100yr

MASTER NETWORK SUMMARY
Modified Rational Method Network

(*Node=Outfall; +Node=Diversion;)
(Trun= HYG Truncation: Blank=None; L=Left; R=Rt; LR=Left&Rt)

Node ID		Type	Return Event	HYG Vol ac-ft	Trun	Qpeak hrs	Qpeak cfs	Max WSEL ft	Max Pond Storage ac-ft	
*OUT 10		JCT	10	4.681	R	.3200	2.85			
*OUT 10		JCT	50	4.691	R	.2100	2.85			
*OUT 10		JCT	100	4.693	R	.1900	2.85			
POND 10	IN	POND	10	8.102		.6400	9.01			
POND 10	IN	POND	50	8.293		.6400	15.40			
POND 10	IN	POND	100	9.264		.6400	17.38			
POND 10	OUT	POND	10	4.681	R	.3200	2.85	132.72	5.442	16 hr
POND 10	OUT	POND	50	4.691	R	.2100	2.85	133.47	6.640	
POND 10	OUT	POND	100	4.693	R	.1900	2.85	134.06	7.623	
SUBAREA 10		AREA	10	8.102		.6400	9.01			
SUBAREA 10		AREA	50	8.293		.6400	15.40			
SUBAREA 10		AREA	100	9.264		.6400	17.38			

Type.... Master Network Summary
Name.... Watershed
File.... N:\SA0154219\Calc\PondPack\First_Street_02.ppw

MASTER DESIGN STORM SUMMARY

Default Network Design Storm File, ID Riverbank1

Return Event	Rainfall Type	IDF ID
10	I-D-F Curve	I-D-F 10yr
50	I-D-F Curve	I-D-F 50yr
100	I-D-F Curve	I-D-F 100yr

MASTER NETWORK SUMMARY
Modified Rational Method Network

(*Node=Outfall; +Node=Diversion;)
(Trun= HYG Truncation: Blank=None; L=Left; R=Rt; LR=Left&Rt)

Node ID		Type	Return Event	HYG Vol ac-ft	Trun	Qpeak hrs	Qpeak cfs	Max WSEL ft	Max Pond Storage ac-ft
*OUT 10		JCT	10	4.680	R	.3200	2.85		
*OUT 10		JCT	50	4.684	R	.2900	2.85		
*OUT 10		JCT	100	4.686	R	.2600	2.85		
POND 10	IN	POND	10	8.148		.6400	8.91		
POND 10	IN	POND	50	9.926		.6400	10.31		
POND 10	IN	POND	100	10.921		.6400	11.49		
POND 10	OUT	POND	10	4.680	R	.3200	2.85	132.73	5.445
POND 10	OUT	POND	50	4.684	R	.2900	2.85	133.74	7.079
POND 10	OUT	POND	100	4.686	R	.2600	2.85	134.34	8.105
SUBAREA 10		AREA	10	8.148		.6400	8.91		
SUBAREA 10		AREA	50	9.926		.6400	10.31		
SUBAREA 10		AREA	100	10.921		.6400	11.49		

17 hr

Type.... Master Network Summary
Name.... Watershed
File.... N:\SA0154219\Calc\PondPack\First_Street_02.ppw

MASTER DESIGN STORM SUMMARY

Default Network Design Storm File, ID Riverbank1

Return Event	Rainfall Type	IDF ID
10	I-D-F Curve	I-D-F 10yr
50	I-D-F Curve	I-D-F 50yr
100	I-D-F Curve	I-D-F 100yr

MASTER NETWORK SUMMARY
Modified Rational Method Network

(*Node=Outfall; +Node=Diversion;)
(Trun= HYG Truncation: Blank=None; L=Left; R=Rt; LR=Left&Rt)

Node ID		Type	Return Event	HYG Vol ac-ft	Trun	Qpeak hrs	Qpeak cfs	Max WSEL ft	Max Pond Storage ac-ft
*OUT 10		JCT	10	4.680	R	.3200	2.85		
*OUT 10		JCT	50	4.684	R	.2900	2.85		
*OUT 10		JCT	100	4.686	R	.2600	2.85		
POND 10	IN	POND	10	8.171		.6400	8.85		
POND 10	IN	POND	50	9.961		.6400	10.24		
POND 10	IN	POND	100	10.960		.6400	11.42		
POND 10	OUT	POND	10	4.680	R	.3200	2.85	132.73	5.445
POND 10	OUT	POND	50	4.684	R	.2900	2.85	133.74	7.086
POND 10	OUT	POND	100	4.686	R	.2600	2.85	134.35	8.116
SUBAREA 10		AREA	10	8.171		.6400	8.85		
SUBAREA 10		AREA	50	9.961		.6400	10.24		
SUBAREA 10		AREA	100	10.960		.6400	11.42		

18 [illegible]

Type.... Master Network Summary
Name.... Watershed
File.... N:\SA0154219\Calc\PondPack\First_Street_02.ppw

MASTER DESIGN STORM SUMMARY

Default Network Design Storm File, ID Riverbank1

Return Event	Rainfall Type	IDF ID
10	I-D-F Curve	I-D-F 10yr
50	I-D-F Curve	I-D-F 50yr
100	I-D-F Curve	I-D-F 100yr

MASTER NETWORK SUMMARY
Modified Rational Method Network

(*Node=Outfall; +Node=Diversion;)
(Trun= HYG Truncation: Blank=None; L=Left; R=Rt; LR=Left&Rt)

Node ID		Type	Return Event	HYG Vol ac-ft	Trun	Qpeak hrs	Qpeak cfs	Max WSEL ft	Max Pond Storage ac-ft
*OUT 10		JCT	10	4.680	R	.3200	2.85		
*OUT 10		JCT	50	4.684	R	.2900	2.85		
*OUT 10		JCT	100	4.686	R	.2700	2.85		
POND 10	IN	POND	10	8.194		.6400	8.80		
POND 10	IN	POND	50	9.994		.6400	10.18		
POND 10	IN	POND	100	10.996		.6400	11.34		
POND 10	OUT	POND	10	4.680	R	.3200	2.85	132.73	5.444
POND 10	OUT	POND	50	4.684	R	.2900	2.85	133.74	7.093
POND 10	OUT	POND	100	4.686	R	.2700	2.85	134.35	8.125
SUBAREA 10		AREA	10	8.194		.6400	8.80		
SUBAREA 10		AREA	50	9.994		.6400	10.18		
SUBAREA 10		AREA	100	10.996		.6400	11.34		

19 [illegible]

APPENDIX G

Hydrogeologic Calculations

Runoff Coefficient
Time of Concentration

City c. .iverbank
Storm Drain System Master Plan
Runoff Coefficients

Surface Type	Total Area	Total Area		Commercial		Area x C-Value		Residential		Area x C-Value		Residential with big lots		Area x C-Value		Park		Area x C-Value	Total Areas x C-Values	Total Areas x C-Values / Total Area Weighted Runoff Coefficient, C
C-value				0.9				0.6				0.5				0.35				
Areas	Acres	sq.ft.		Acres	sq.ft.	sq.ft.		Acres	sq.ft.	sq.ft.		Acres	sq.ft.	sq.ft.		Acres	sq.ft.	sq.ft.	sq.ft.	
8th Street																				
B4-573	8.98	391170.33	0.9	3.1	135037	121532.9	0.6	5.88	256134	153680.28	0.5		0	0	0.35		0	0	275213.2	0.704
B4-572	23.35	1017130	0.9		0	0	0.6	3.99	173805	104283.047	0.5	19.36	843325	421662.4	0.35		0	0	525945.5	0.517
B4-570	26.93	1173075.4	0.9		0	0	0.6	16.65	725277	435166.098	0.5	10.28	447799	223899.3	0.35		0	0	659065.4	0.562
B4-566	11.41	497021.54	0.9		0	0	0.6	10.51	457817	274690.432	0.5		0	0	0.35	0.9	39204	13721.45	288411.9	0.580
C4-563	37.6	1637862.4	0.9		0	0	0.6	37.6	1637862	982717.435	0.5		0	0	0.35		0	0	982717.4	0.600
C4-562	15.84	689993.09	0.9		0	0	0.6	13.64	594161	356496.431	0.5		0	0	0.35	2.2	95832	33541.33	390037.8	0.565
C4-561	13.65	594596.32	0.9		0	0	0.6	9.91	431681	259008.771	0.5		0	0	0.35	3.74	162915	57020.26	316029.0	0.532
C4-559	28.7	1250176.9	0.9	6.7	291853	262667.8	0.6		0	0	0.5		0	0	0.35	22	958324	335413.3	598081.1	0.478
C4-556	2.68	116741.26	0.9		0	0	0.6	2.68	116741	70044.7534	0.5		0	0	0.35		0	0	70044.8	0.600
C4-553	17.85	777549.03	0.9		0	0	0.6	17.85	777549	466529.421	0.5		0	0	0.35		0	0	466529.4	0.600
D4-550	6.41	279220.69	0.9		0	0	0.6	4.2	182953	109771.628	0.5		0	0	0.35	2.21	96268	33693.79	143465.4	0.514
Virginia Street																				
D4-522	1.63	71003.077	0.9		0	0	0.6	1.63	71003	42601.8463	0.5		0	0	0.35		0	0	42601.8	0.600
D4-516	4.03	175547.49	0.9		0	0	0.6	4.03	175547	105328.491	0.5		0	0	0.35		0	0	105328.5	0.600
D4-517	11.55	503119.96	0.9		0	0	0.6	11.55	503120	301871.978	0.5		0	0	0.35		0	0	301872.0	0.600
Townsend Avenue																				
D4-533	0.79	34412.534	0.9		0	0	0.6	0.79	34413	20647.5206	0.5		0	0	0.35		0	0	20647.5	0.600
D4-534	0.75	32670.128	0.9		0	0	0.6	0.75	32670	19602.0765	0.5		0	0	0.35		0	0	19602.1	0.600
D4-537	0.76	33105.729	0.9		0	0	0.6	0.76	33106	19863.4375	0.5		0	0	0.35		0	0	19863.4	0.600
D4-538	0.75	32670.128	0.9		0	0	0.6	0.75	32670	19602.0765	0.5		0	0	0.35		0	0	19602.1	0.600
D4-541	0.61	26571.704	0.9		0	0	0.6	0.61	26572	15943.0222	0.5		0	0	0.35		0	0	15943.0	0.600
D4-531	12.43	541452.91	0.9		0	0	0.6	12.43	541453	324871.748	0.5		0	0	0.35		0	0	324871.7	0.600
Candlewood Place																				
B1-501	7.85	341947.33	0.9		0	0	0.6	7.85	341947	205168.401	0.5		0	0	0.35		0	0	205168.4	0.600
B1-508	5.54	241323.34	0.9		0	0	0.6	5.54	241323	144794.005	0.5		0	0	0.35		0	0	144794.0	0.600
B1-504	2.36	102802	0.9		0	0	0.6	2.36	102802	61681.2007	0.5		0	0	0.35		0	0	61681.2	0.600
B1-506	1.91	83199.925	0.9		0	0	0.6	1.91	83200	49919.9548	0.5		0	0	0.35		0	0	49920.0	0.600
B1-510	63.33	2758665.6	0.9	11.72	510525	459472.7	0.6	51.61	2248140	1348884.22	0.5		0	0	0.35		0	0	1808356.9	0.656
B2-513	20.14	877301.82	0.9	4.85	211267	190140.1	0.6	12.44	541889	325133.109	0.5		0	0	0.35	2.85	124146	43451.27	558724.5	0.637
B2-579	4.51	196456.37	0.9		0	0	0.6	4.51	196456	117873.82	0.5		0	0	0.35		0	0	117873.8	0.600
A2-514	4.34	189051.14	0.9		0	0		4.34	189051	0	0.5		0	0	0.35		0	0	0.0	0.000
A2-515	9.37	408159	0.9		0	0		9.37	408159	0	0.5		0	0	0.35		0	0	0.0	0.000

City c verbank
Storm Drain System Master Plan
Time of Concentration by Drainage Area

Area Identification	Overland Time				Gutter Time			Pipe Time					Total Time of Concentration (minutes) $T_{overland} + T_{gutter} + T_{pipe}$
	Parcel Type			Minimum Travel Time (minutes)	Gutter Length (ft)	Velocity (ft/s)	Gutter Time (minutes)	Pipe Length (ft)	Assumed Slope (ft/ft)	Avg Pipe Diameter (in)	Velocity*, V $= {}^{0.59}/_{n} * D^{0.67} * S^{0.5}$ (ft/s)	Time, T_s = L/V (min)	
	Single Family (>0.5 Ac)	Single Family (<0.5 Ac) or Multi-Family	Commercial or Industrial										
TOWNSEND AVE													
D4-531		X		20	450	1.0	7.5	1940	0.005	12	3.21	10.1	37.6
D4-533		X		20	130	1.0	2.2	0	0.005	0	0.00	0.0	22.2
D4-534		X		20	130	1.0	2.2	0	0.005		0.00	0.0	22.2
D4-537		X		20	130	1.0	2.2	0	0.005		0.00	0.0	22.2
D4-538		X		20	130	1.0	2.2	0	0.005		0.00	0.0	22.2
D4-541		X		20		1.0	0.0	0	0.005		0.00	0.0	20.0
TERMINAL													
D4-522		X		20	260	1.0	4.3	20	0.005	12	3.21	0.1	24.4
D4-516		X		20	365	1.0	6.1	170	0.005	12	3.21	0.9	27.0
D4-517		X		20	350	1.0	5.8	1280	0.005	12	3.21	6.6	32.5
8TH STREET													
D4-550		X		20	605	1.0	10.1		0.005		0.00	0.0	30.1
C4-553		X		20	570	1.0	9.5	1590	0.005	15	3.73	7.1	36.6
C4-556	X			30	145	1.0	2.4		0.005		0.00	0.0	32.4
C4-559	X			30	230	1.0	3.8	1055	0.005	15	3.73	4.7	38.6
C4-561		X		20	255	1.0	4.3	1043	0.005	12	3.21	5.4	29.7
C4-563		X		20	1177	1.0	19.6	1625	0.005	12	3.21	8.4	48.1
C4-562		X		20	615	1.0	10.3	1385	0.005	12	3.21	7.2	37.4
B4-566	X			30	850	1.0	14.2		0.005		0.00	0.0	44.2
B4-570		X		20	1650	1.0	27.5	0	0.005	18	4.21	0.0	47.5
B4-572	X			30	1270	1.0	21.2		0.005		0.00	0.0	51.2
B4-573	X			30	901	1.0	15.0	425	0.005	12	3.21	2.2	47.2
CANDLEWOOD													
B1-501		X		20	865	1.0	14.4		0.005		0.00	0.0	34.4
B1-504		X		20	400	1.0	6.7		0.005		0.00	0.0	26.7
B1-506		X		20	460	1.0	7.7		0.005		0.00	0.0	27.7
B1-508		X		20	730	1.0	12.2	260	0.005	18	4.21	1.0	33.2
B1-510		X		20	430	1.0	7.2	1330	0.005	21	4.67	4.7	31.9
B2-513		X		20	480	1.0	8.0	885	0.005	24	5.11	2.9	30.9
A2-514		X		20	460	1.0	7.7	230	0.005	12	3.21	1.2	28.9
B2-579		X		20	310	1.0	5.2	330	0.005	12	3.21	1.7	26.9
A2-515	X			30	410	1.0	6.8		0.005		0.00	0.0	36.8

* Velocity assumes full pipe flow in concrete pipe.
\\sjs1\Project\SA0154219\Gen\Calc\TimeOfConcentration.xls

6/24/2008

City o. .verbank
Storm Drain System Master Plan
Time of Concentration by Drainage Area

Area Identification	Overland Time				Gutter Time			Pipe Time					Total Time of Concentration (minutes) $T_{overland} + T_{gutter} + T_{pipe}$
	Parcel Type			Minimum Travel Time (minutes)	Gutter Length (ft)	Velocity (ft/s)	Gutter Time (minutes)	Pipe Length (ft)	Assumed Slope (ft/ft)	Avg Pipe Diameter (in)	Velocity*, V $= {}^{0.59}/_{n} * D^{0.67} * S^{0.5}$ (ft/s)	Time, T_s = L/V (min)	
	Single Family (>0.5 Ac)	Single Family (<0.5 Ac) or Multi-Family	Commercial or Industrial										
CASTLEBERG BASIN													
A		X		20	1270	1.0	21.16667	1300	0.005	24	5.11	4.2	45.4
B		X		20	730	1.0	12.16667	960	0.005	15	3.73	4.3	36.5
C		X		20	630	1.0	10.5	1510	0.005	18	4.21	6.0	36.5
D	Per Townsend Avenue Model Information												41.2
E	Per Virginia Avenue Model Information												38.8
FIRST STREET BASIN													
A			X	10		4.0	0	2000	0.005	18	4.21	7.9	17.9
B		X		20	340	5.0	1.133333	3360	0.005	12	3.21	17.4	38.6
C			X	10	860	6.0	2.388889	640	0.005	12	3.21	3.3	15.7
D		X		20	700	7.0	1.666667	425	0.005	12	3.21	2.2	23.9

* Velocity assumes full pipe flow in concrete pipe.