SECTION 11
STORMWATER COLLECTION SYSTEMS

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SECTION 11
STORMWATER COLLECTION SYSTEMS

11.1 PURPOSE AND DEFINITIONS

11.1.1 Purpose
This Section provides minimum design standards and guidelines for the planning and design of public gravity Stormwater improvements in the City Service Area. This Section generally covers the size, layout, and placement of Mains as well as appurtenant Manholes, temporary storage facilities and Services. Section 12 addresses the design and construction of Stormwater pump stations and force Mains. These standards and guidelines may be amended periodically. It is the Designer's responsibility to check the City of Sacramento Department of Utilities (DOU) website or ask DOU representatives for amendments and to use the latest version of this Section. It is expected that all applicable Plates in the Appendix, and other Sections of this Manual will also be reviewed and utilized as determined to be appropriate by the Project owner and Designer.

Compliance with these standards does not relieve a Designer from the additional responsibility to apply conservative and sound professional judgment when designing public owned and maintained facilities. Designers are expected to consider related issues, such as environmental impacts, maintenance of pedestrian and vehicular traffic patterns, constructability, safety, system maintenance and sustainability principles. Designer shall submit a Variance for all proposed deviations from requirements contained herein. All Variances shall be reviewed and accepted by DOU prior to DOU review of affected portions of Plans or studies (Refer to Section 9.2.4).

11.1.2 DOU Stormwater System
The Department of Utilities is responsible for operating and maintaining the public Stormwater collection and conveyance system within the City of Sacramento, which includes a Combined Sewer System (CSS) in the older central areas of the City and a newer Separated Drainage System in the remaining City Service Area. Roadside ditches and culverts, streets, and gutters are maintained by the Department of Public Works. The design and construction of all drainage facilities shall be approved by the City department responsible for maintenance of said facilities.

The majority of the City Service Area is ultimately pumped into nearby rivers and channels maintained by others. Refer to Plate 11-1 DRAINAGE BASINS for a map showing the Sump Areas within the City, and boundaries of the Combined Sewer and Separated Drainage System Basins.

11.1.3 Definitions
Whenever the following terms or titles are used, the intent and meaning shall be as defined below. Words defined below are shown capitalized throughout this Section. Proper nouns are also capitalized, but not defined below. Refer to Plate 9-2 for utility abbreviations.

10 Year Event: Refer to Section 9.1.3

100 Year Event: Refer to Section 9.1.3

Basin: Refer to Section 9.1.3

Build-Out: Refer to Section 9.1.3

CFS: Refer to Section 9, Plate 9-2

City: Refer to Section 9.1.3

City Code: Refer to Section 9.1.3

City Service Area: Refer to Section 9.1.3

Clay Liner: An impermeable clay layer placed over a Detention Pond to prevent Groundwater Infiltration and/or surface water exfiltration. A clay liner must be carefully designed to prevent displacement due to buoyancy and may be required to be several feet thick. Clay Liners may also refer to manufactured Clay Liners consisting of bentonite and various types of fabrics which are usually installed by over-excavating the Pond, placing the liner, and covering it with a layer of fill to prevent displacement or damage.

Combined Sewer System (**CSS**): Refer to Section 9.1.3

Conditions of Approval: Refer to Section 9.1.3

Crown: Refer to Section 9.1.3

Culvert: A section of pipe that allows water to cross under a road, railroad, pedestrian crossing, bike path, trail or other channel obstruction

Customer: Refer to Section 9.1.3

Department of Utilities (**DOU**): Refer to Section 9.1.3

Designer: Refer to Section 9.1.3

Detention Pond: A low-lying area, either within the flow path of a channel or piped system (in-line), or connected thereto (off-line), which is positioned to allow for the storage of runoff during a storm, particularly during the peak of a storm, and the release of stored runoff after the peak of a storm. Detention Ponds may be utilized for a variety of secondary uses as appropriate, including support of natural habitat, recreational facilities and Stormwater quality treatment. Also see Wet & Dry Detention Pond and Stormwater Quality Pond. Refer to Section 11.9

Director: Refer to Section 9.1.3. Same as *City Code* Chapter 13.16.030

DOU Level Landscaping: All landscaping features, seeding, vegetation, planting, irrigation, controllers and the maintenance required for plant establishment, as required to prevent erosion.

Drainage Design Report: A report that analyzes the impact of a proposed Project to existing drainage systems, and the operation of proposed drainage facilities during specified storm events (Refer to Section 11.3.6)

Drain Inlet (**DI**): Refer to Section 9.1.3

Drain Rock: Clean crushed rock of specified size and consistency through which runoff is allowed to flow

Dry Detention Pond: A Detention Pond that remains dry, with the possible exception of a low-flow channel, until a storm occurs (Refer to Section 11.9)

Easement: Refer to Section 9.1.3

Existing Development: Roads, structures, drainage systems and other affected improvements that were constructed prior to Project. All Projects shall meet Existing Development criteria (Refer to Section 11.3.3).

Filter Fabric: A manufactured cloth product which prevents the passage of certain particles while allowing the passage of water

Final Map: Refer to Section 9.1.3

Finished Floor: The surface elevation on the top of a dwelling structure foundation

Flowing Freely: Refer to Section 9.1.3

Flow Line: Refer to Section 9.1.3

Freeboard: The height that a levee or other feature impacted by drainage extends above a designated water level

Grate: Refer to Section 9.1.3

Greenfield Development: A Project with new or extended public roads. All new improvements constructed as part of a Greenfield Development shall meet Greenfield Development drainage criteria (Refer to 11.3.1)

Groundwater: Water that collects or flows beneath the Earth's surface

Groundwater Infiltration: Refer to Section 9.1.3

Hydraulic Grade Line (**HGL**): Refer to Section 9.1.3

Infill Development: A Project that does not include new public road construction. All new improvements constructed as part of an Infill Development shall meet Infill Development drainage criteria (Refer to Section 11.3.2). Infill Development is a DOU specific term that is unrelated to "Infill Site" established in *City Code*.

Invert: Refer to Section 9.1.3

Junction Box: Refer to Section 9.1.3

Lead: A pipe that connects a Drain Inlet to a Main or other element of a receiving drainage system

Lined Channel: A channel in which a portion or all of its bottom and/or side slopes are covered with a layer of material intended to prevent erosion or seepage. A "Hard Lining" may consist of gunite, shotcrete, soil cement, mortared stone, or reinforced concrete as a protection against erosion. A "Flexible Lining" may consist of natural stone, riprap, gabions, and/or certain fabrics.

Main: Refer to Section 9.1.3

Manhole: Refer to Section 9.1.3. From bottom to top, a Manhole is generally comprised of the following components:

- **Base**: Refer to Section 9.1.3
- **Barrel**: Refer to Section 9.1.3
- **Cone**: Refer to Section 9.1.3
- **Grade Rings**: Refer to Section 9.1.3
- **Head and Cover**: Refer to Section 9.1.3

Master Parcel Map: A map that subdivides large tracts of land into smaller parcels for the purpose of selling or otherwise transferring the parcels for further Subdivision in accordance with specified procedures, or for the purpose of securing financing, together with planning and construction of infrastructure elements, but not for the purpose of creating individual Residential lots for sale to end-user homeowners, and not for the purpose of allowing construction or other improvements on non-Residential parcels pursuant to the provisions of *City Code* Chapter 16.32.160, Master parcel maps.

Nominal Capacity: The "firm capacity" of a Sump in CFS (capacity with the largest pump and low flow pump out of service) divided by the area of the cumulative upstream Basin(s) in acres.

On-Site: Refer to Section 9.1.3

Outfall: Refer to Section 9.1.3

Overland Release: A condition where Stormwater runoff that is unable to enter an inlet to the City drainage system due to a system failure or insufficient capacity, rises to the rim of the applicable surface depression and spills into an adjacent sub-Shed (refer to Plate 11-2 MASTER PLANNING CRITERIA EXHIBIT). Overland Release is most commonly caused by a plugged DI Grate, which causes the street to fill with Stormwater until the water surface reaches the lowest adjacent gutter Flow Line summit, and redirects the Stormwater to another DI.

Overland Release Point: The Flowline elevation of the controlling Overland Release spillway from the Shed of an inlet to the Separated Drainage or Combined Sewer Systems (e.g. gutter Flow Line summit elevation). A single Project may have a different ORP applicable to each structure depending on the grading design. Refer to Plate 11-2 MASTER PLANNING CRITERIA EXHIBIT.

Passover DI: A DI that is not located at a local low point in the street profile. Whenever gutter flow exceeds the ability of the DI to receive flow, the excess water passes over the DI and continues flowing downstream.

Plans: Refer to Section 9.1.3

Public Financing: A finance tool which allows a public agency (in this case the City of Sacramento) to establish a benefitting district (community facilities district or assessment district) and to sell bonds to pay for the design and construction of public drainage facilities required for development. Various types of bonds are available for this purpose: Mello Roos, 1913, and 1915 bonds.

Project: Refer to Section 9.1.3

Public Works: City of Sacramento Department of Public Works

Rational Method: A method of calculating a static peak flow rate throughout a drainage system without a dynamic analysis of runoff and routing over the time leading up to or following the peak. The Rational Method is utilized for Level 1 Drainage Design Reports (Refer to Section 11.3.6.5)

RD1000: Reclamation District No. 1000, created April 8, 1911 by a Special Act of the Legislature to provide agricultural drainage, flood control and levee maintenance. Situated on flat terrain in northwestern Sacramento, in Sacramento County, and Sutter County, RD1000 currently maintains approximately 53 miles of levees. The District is bounded on the west by the Sacramento River, on the north by the Natomas Cross Canal, on the east by the Pleasant Grove

Creek and Natomas East Main Drainage Canals, and on the south by the American and Sacramento Rivers. The stated mission and purpose of RD 1000 is to “operate and maintain the levees surrounding the Natomas basin and to operate and maintain the internal drainage system to evacuate agricultural and urban runoff.”

Regulated Stream/Channel: A stream or channel that is under the jurisdiction of the Central Valley Flood Protection Board

Residential: Refer to Section 9.1.3

Right-of-Way (**ROW**): Refer to Section 9.1.3

Rim: Refer to Section 9.1.3

Round Corner: Refer to Section 9.1.3

Separated Drainage System: Refer to Section 9.1.3

Shallow Groundwater: Refer to Section 9.1.3

Shed: Refer to Section 9.1.3

Springline: Refer to Section 9.1.3

SSWMM: The Sacramento Storm Water Management Model. SSWMM is a dynamic computer storm simulation model created for the City of Sacramento that is used for flood risk evaluation and drainage system analysis.

Standard Specifications: Refer to Section 9.1.3

Storm Drain Master Plan: A study that analyzes the existing drainage system and impacts from proposed Projects and capital improvements. Storm Drain Master Plans generally include the entire Basin. The Storm Drain Master Plan is generally prepared before and utilized by a Drainage Design Report to establish boundary conditions and/or existing flood elevations for comparison with flood elevations anticipated following specific improvements.

Stormwater: Refer to Section 9.1.3

Stormwater Quality Pond: A drainage facility that utilizes a Detention Pond configuration that primarily serves to remove pollutants from urban runoff (Refer to Section 11.9)

Subdivision: Refer to Section 9.1.3

Sump: Refer to Section 9.1.3

Tailwater: Refer to Section 9.1.3

Tentative Map: An exhibit prepared prior to a final map showing the anticipated improvements related to the proposed Subdivision and the existing conditions in and around it. "Tentative Map" includes a Tentative Map prepared in connection with a Parcel Map, Subdivision Map or Master Parcel Map pursuant to the provisions of *City Code* Chapter 16.24, Tentative Maps.

Under-drain: A subterranean drainage system consisting of a layer of permeable material with a perforated drainpipe sloped to drain

Wet Detention Pond: A Detention Pond which is always partially full of water but which has additional capacity and functions to store water during storm events to prevent flooding (Refer to Section 11.9)

XPSWMM ©: A dynamic computer storm simulation model that is used for flood risk evaluation and drainage system analysis created by XP Solutions ®

11.2 GENERAL REQUIREMENTS

City drainage improvements shall be designed to:

1. Meet the needs of a growing community,
2. Provide a minimum 100 Year Event protection to structures,
3. Provide a minimum 10 Year Event protection to streets,
4. Control urban runoff pollutants,
5. Avoid public safety hazards.

11.2.1 Authority and Responsibility

The Director is given the authority and responsibility to collect Stormwater from the public and convey it to receiving waters. The Designer is responsible for adherence to the design standards contained herein.

All improvements to the Separated Drainage and Combined Sewer Systems shall also be designed to meet the current applicable requirements of the following standards:

1. The Standard Specifications,
2. Title Chapter 13.08 and 13.16 of the Sacramento City Code,
3. Applicable provisions of the Uniform Plumbing Code.

In case of a conflict between the various standards, the design criteria presented herein shall govern.

11.2.2 Disclaimer, Acceptance and Variances

Refer to Sections 9.2.2 for disclaimer, 9.2.3, Plate 9-4 and Plate 11-5 for acceptance and 9.2.4 for variances

11.2.3 Drainage Facilities in the Combined Sewer System

Additional standards and criteria specifically relevant to design of drainage facilities within the Combined Sewer System may be found in Section 9.4.

11.2.4 Geotechnical Design Report

Refer to Section 9.2.9

11.2.5 Phasing of Drainage Facilities

If phasing of drainage improvements is proposed, an accepted phasing plan is required prior to approval of Plans. The phasing plan shall provide sufficient detail to demonstrate the required drainage criteria has been met at all intermediate phases. The phasing plan shall clearly identify trigger mechanisms and proposed facilities for subsequent phasing and clearly define operation and maintenance requirements and responsibilities until the complete facilities are in place and functional. A financing plan which includes the construction of the interim and the ultimate drainage systems shall be completed and in place prior to acceptance of the Final Map.

11.2.6 Common Drainage Facilities

For the purpose of public financing of drainage infrastructure, the term “Common Drainage Facilities” shall be defined as follows:

1. Any pipe or other conveyance system whose capacity is equal to or greater than that of a 24" inch diameter pipe, including all appurtenances other than Drainage Inlets and Leads,
2. All channels, appurtenances, and Department of Utilities (DOU) Level Landscaping,
3. All Detention Ponds, Stormwater Quality Ponds, appurtenances, and DOU Level Landscaping,
4. All pump stations, appurtenances, and DOU Level Landscaping,
5. All property necessary for the maintenance of the above facilities which is not or will not be in a road Right-of-Way or other Easement which is dedicated to the public for purposes other than drainage.

Appurtenances for the above common facilities shall include but shall not necessarily be limited to the following:

1. Pipes and other conveyances: Manholes, Junction Boxes, weirs, floodgates, flap gates, and sluice gates,
2. Channels: concrete lining, concrete low flow channels, inlet structures, outlet structures, fencing, access roadways, berms, turnouts, pools, retaining walls, chutes, weirs, floodgates, flap gates, sluice gates, slope protection, earthen channels, ditches and DOU Level Landscaping,
3. Detention Ponds and Stormwater Quality Ponds: clay liners, Under-Drains, inlet structures, outlet structures, irrigation, low flow channels, weirs, sluice gates, flap gates, access roads, slope protection, fencing or masonry walls, and DOU Level Landscaping,
4. Pump Stations: Access roads, suitable flat areas, trash racks, mechanical and electrical systems, control buildings, masonry walls, gates, fencing, telemetry, pumps, Outfall pipes and structures, flap gates, sluice gates, lighting, On-Site backup power, On-Site maintenance equipment, On-Site drains, potable water infrastructure, irrigation, and DOU Level Landscaping.

An assessment district or community facilities district (An instrument to fund public improvements, such as Common Drainage Facilities, using public funds) or other funding mechanism shall be formed for construction of Common Drainage Facilities, prior to approval of Plans. Drainage agreements with other benefitting property owners must be submitted and approved by DOU prior to approval of Plans.

Construction cost estimates of all Common Drainage Facilities and all other facilities to be funded by the funding mechanism shall be included in the drainage agreement. Cost estimates associated with dewatering and various soil configurations in the construction of Detention Ponds may be reduced by more comprehensive geotechnical investigation. Cost estimates for Detention Ponds shall have appropriate contingencies.

Full improvement Plans and design calculations shall be submitted for all Common Drainage Facilities.

11.2.7 Groundwater Discharges

Temporary Groundwater discharges to the Separated Drainage System shall require approval per *City Code* Section 13.16.070.

The discharger shall demonstrate that there is available capacity in the Separated Drainage System. A system capable of terminating the discharge shall be provided.

Any Groundwater discharges to the Separated Drainage System must be secured with an individual National Pollutant Discharge Elimination System (NPDES) permit from the California Regional Water Quality Control Board (Water Board) and written approval from the City of Sacramento Department of Utilities. The NPDES permit must be received prior to the City issuing written approval to discharge to the City's storm drainage system.

Refer to Section 9.2.10 for groundwater discharges to the Separated and Combined Sewer Systems.

11.3 DRAINAGE STUDIES

The maximum allowable 10 and 100 Year Event water surface and Overland Release elevations are different for a Greenfield Development versus an Infill Development. All Projects must also meet Existing Development and public safety criteria. Refer to Plate 11-2 MASTER PLANNING CRITERIA EXHIBIT.

Drainage Studies include Storm Drain Master Plans and Drainage Design Reports (Levels 1 or 2). Some Projects may require acceptance of a Storm Drain Master Plan in conjunction with a Tentative Map or other entitlement. DOU will also require acceptance of a Drainage Design Report in conjunction with the Plans for most Projects proposing public drainage improvements.

All Drainage Studies shall be submitted with a Drainage Study Checklist, stamped by a registered civil engineer. If items on the Checklist are deficient, the Drainage Study may be returned for correction without review.

Existing 100 Year Event Stormwater detention volume to be removed by Project shall be accounted for in Drainage Study and replaced as necessary, in addition to other mitigation measures required herein. Typical minor losses shall be disregarded (Refer to Section 11.4.5).

Elevations for Separated Drainage studies shall be tied to a City benchmark, Datum NAVD 88. Elevations for Combined Sewer studies shall be tied to a City benchmark, Datum NGVD 29.

If a Project is required to comply with Stormwater quality standards, detailed analysis and sizing calculations shall be included with the Drainage Study (Refer to Section 11.11). Drainage Studies need not include on-site privately maintained drainage pipes and appurtenances, except as applicable to mitigate Project impacts to the public drainage system. Requirements for the design of such On-Site drainage facilities and sizing of drainage services are covered by the Onsite Design Manual.

11.3.1 Greenfield Development

The 10 Year Event HGL shall be a minimum of 6-inches below all new DI Grates. The Finished Floor of new structures shall be at least 12-inches above the 100 Year Event HGL, and 18-inches above the Overland Release Point (Refer to Section 11.7).

11.3.2 Infill Development

The 10 Year Event HGL shall be at or below all new DI Grates placed in gutters. Refer to 11.3.88 for inlets placed in roadside ditches. The Finished Floor of new structures shall be at least 6-inches above the 100 Year Event HGL and 12-inches above the Overland Release Point (Refer to Section 11.7).

11.3.3 Existing Development
Drainage Studies shall include existing On-Site, upstream and downstream facilities as determined by DOU to adequately assess impact of proposed improvements to Existing Development. Under no circumstances may a Project increase flooding in an Existing Development at any location such that:

1. The 10 Year Event HGL is 6-inches or more above an existing DI Grate located in a gutter. Refer to 11.3.88 for inlets located in roadside ditches,
2. The 100 Year Event HGL is at or above an existing affected building Finished Floor,
3. The Overland Release Point is 6-inches or less below an existing affected building Finished Floor.

Upgrades to existing drainage facilities shall be designed and constructed in accordance with standards for new drainage facilities, as outlined herein.

11.3.4 Development in a Special Flood Hazard Area or Magpie Creek Local Floodplain
For development in flood zones A, A99, AE, AR, AH, AO or the Magpie Creek Local Floodplain (as defined by the DOU), refer to Section 10 of the Onsite Design Manual for finished floor requirements.

11.3.5 Storm Drain Master Plan
Prior to Tentative Map approval, the DOU may require acceptance of a Storm Drain Master Plan. The Storm Drain Master Plan shall have sufficient information to determine the Right-of-Way requirements for proposed drainage facilities as well as the hydrology, hydraulics, pumping, and detention. Storm Drain Master Plans generally include all infrastructure key to a Basin and are prepared using XPSWMM. SSWMM may be used when modifying existing SSWMM models. All Storm Drain Master Plans shall utilize dynamic modeling, per Section 11.3.6.6.

11.3.6 Drainage Design Report
When required, a Drainage Design Report shall be completed and approved prior to acceptance of Plans. Drainage Design Reports may either utilize a static method (Level 1) or a dynamic method (Level 2) to analyze drainage, but not both. Refer to Plate 11-3 DRAINAGE DESIGN REPORT ALTERNATIVES for comparative flow chart. Refer to Plate 11-5 DRAINAGE STUDY CHECKLIST for a summary of items to be included in both studies.

Allowable report levels are primarily dependent on the total Project area:

- Projects with less than 10 acres: Level One or Two,
- Any Project size: Level Two only.

11.3.6.1 Research Past Studies
Contact DOU for the applicable 10 and 100 Year Event HGL, and to determine whether a current Drainage Study exists that encompasses Project. Note information for applicable existing or new Drainage Study on the Plans, including:

1. Title,
2. Date,
3. Basin number,
4. Starting 10 & 100 Year Event HGL elevations and locations for Project,
5. Existing storage volume anticipated On-Site during 100 Year Event.

11.3.6.2 Exemptions

A Drainage Design Report will not be required when:

1. An approved Drainage Study already exists that includes the Project, which is consistent with this Section as determined by DOU,
2. Project is consistent with site runoff and storage anticipated by existing Drainage Study,
3. All applicable public drainage improvements to be constructed by the Project are defined in existing Drainage Study and consistent with Project, and
4. All applicable improvements identified by existing Drainage Study to serve or mitigate for potential impacts from Project are in-place or will be constructed by Project.

   Or,
5. Project does not require public drainage improvements.

11.3.6.3 Conformance with Plans

Infrastructure in Drainage Design Report shall be based on existing improvements and those to be constructed by Project. During the course of Project design, if the Designer modifies the street alignment, lot configuration, impervious area, land use, length, size and alignment of the storm drain pipes, location of a Detention Pond or pump station, On-site storage volume, Stormwater quality measures, etc., the Drainage Design Report shall be revised to reflect these changes. In all cases, the accepted Plans shall match the current accepted Drainage Design Report.

11.3.6.4 Modification of Past Study

If the Project is included in, but does not conform to an existing Drainage Study, the existing Drainage Study must be updated to account for all changes, such as land use, imperviousness, slope, routing, etc.

1. If the Drainage Study utilizes the Rational Method, and the Designer elects to use the Rational Method, proceed to Section 11.3.6.5,
2. If the Drainage study utilizes a dynamic model, proceed to Section 11.3.6.6.

11.3.6.5 Level One - Rational Method

For Projects of less than 10 acres, Designer may elect to analyze Stormwater runoff and routing using the Rational Method. The Rational Method may not be used for Projects with public Detention Ponds or pump stations, or Projects consisting of more than 10 acres including all phases.

Downstream 10 and 100 Year Event HGLs shall be based on an existing Study, if available. If no Study exists for downstream connection, 10 and 100 Year Event HGLs shall be assumed as

0.5-feet and 1.0-feet, respectively above adjacent drain inlet at the most downstream point analyzed.

Level One Drainage Design Report calculations shall include the following:

1. Applicable runoff for sub sheds using Equations 11-1 & 11-2, and
2. 10 & 100 Year Event HGL throughout analyzed system utilizing Manning's equation

Equation 11-1 $$Q = CiA_S$$

Equation 11-2 $$i = at^b$$

Where:

Q = Peak flow rate to a particular node (CFS)
C = Runoff coefficient (*unit-less*, Refer to Table 11-1)
i = Rainfall intensity (inches/hour)
A_S = Shed area draining to a particular Node (acres)
a = Rainfall intensity coefficient = 8.10 (10 Year Event) and 14.465 (100 Year Event)
b = Rainfall intensity coefficient = -0.573 (10 Year Event) and -0.602 (100 Year Event)
t = Time of concentration (minutes) = Inlet Time + Time thru pipe/channel to a particular Node (Refer to Table 11-1 for Inlet Time)

Designer shall use a weighted average of pervious and impervious areas for calculating the C factor and Inlet Time.

The discharge Q for sites utilizing metered storage (refer to Onsite Design Manual) may be reduced to the peak discharge rate from the applicable Detention Ponds.

Table 11-1 Runoff Coefficients and Inlet Times

Imperviousness/ Land Use	Runoff Coefficient C	Inlet Time t_i
Proposed/Existing Development		
Impervious areas	0.95	5
Pervious areas	0.40	10

(use area weighted average)

11.3.6.6 Level Two – Dynamic Modeling

Designer shall analyze the Project Stormwater impact and any required mitigation using dynamic modeling for all Projects larger than 10 acres, and may elect to for smaller Projects. Model setup and report parameters shall be in accordance with applicable DOU model user guide. The latest version of the user guides may be obtained from DOU.

Drainage Design Reports in Basins that have a previously approved Storm Drain Master Plan shall utilize the model and software of the approved study. New drainage models shall use XPSWMM for the Separated Drainage System and InfoWorks for the Combined Sewer System. If only a portion of the Basin has been master planned using an older software, DOU may require the Designer to update the existing study to current software. All modifications to previously approved studies shall be documented in detail and included with the revised study. Prior to initiating the Drainage Design Report, the developer shall schedule a meeting with DOU to determine the model software and scope for the Drainage Study.

Downstream HGL shall be in accordance with a previously approved Storm Drain Master Plan or Drainage Design Report that includes the Project site. If the Project has not been included in a previously approved Storm Drain Master Plan or Drainage Design Report, the 10 and 100 Year Event HGLs at the discharge point(s) shall be assigned as illustrated in Table 11-2.

Table 11-2 Starting HGL

Fraction of Storm Duration	HGL location
Start	Invert of pipe
1/3	Crown of pipe
1/2	Maximum allowed Existing Development HGL (Refer to Section 11.3.3)
2/3	Gutter flowline
5/6	Crown of pipe
End	Invert of pipe

All models shall include 10 and 100-year events, utilizing 24-hour storm durations with rainfall in 5-minute increments in accordance with the *City/County Drainage Manual*. Refer to Plate 11-7 10 YEAR HYETOGRAPH and Plate 11-8 100 YEAR EVENT HYETOGRAPH for generated rainfall patterns. Simulations shall extend from the beginning of the storm until after all design storage has receded following the storm.

Additional dynamic model parameters:

1. Overland Flow “n” Factors
    a. Impervious areas: 0.016

b. Pervious areas: 0.250

2. Routing “n” Factors
   a. Pipes: 0.015 (Refer to Section 11.4.5)
   b. Road surface: 0.016
   c. Channels: Refer to Table 11-5 Channel “n” Factors (Section 11.8.6)
3. Pump Station
   a. The summer pump and one of the largest pumps shall remain off for each pump station throughout the simulation. If the pump station only includes a summer pump and or one primary pump, no pumps shall be accounted for in that station
   b. Flow rates shall be based on the corresponding head from the applicable pump curve, times a reduction factor to account for anticipated wear as follows:
      i. New and existing pump stations without flow meters: 75% of pump curve flow rates
      ii. New pump stations with flow meters: 90% of pump curve flow rates
      iii. Existing pump stations with flow meters: Reduction of pump curve flow rates shall be in accordance with meter data
4. Overland Release
   a. Runoff shall not be allowed to leave the simulation artificially due to incomplete surface modeling. Runoff may only leave the model through actual outfalls and Overland Release Points
   b. All Overland Release Points and surface storage areas that affect model results shall be included in the model
5. Minimum Runoff Slope: 1%
6. Basin Width: Refer to Equation 11-3, below
7. Infiltration:
   a. Horton method
   b. Impervious area depression storage: 0.10-inches
   c. Pervious area depression storage: 0.35-inches
   d. Area without detention: 25%[a]
   e. Maximum infiltration volume: None
   f. Refer to Table 11-3 below for infiltration rates

Equation 11-3 $$W = A/L$$

Where:

W = Shed Width (theoretical dimension)

L = Shed Length (feet) = overland (sheet) flow length = 150-feet for Residential, 200-feet for commercial

A = Shed Area (SF)

[a] Refer to Infoworks User Manual for means of accounting for area without detention in the Combined System

Table 11-3 Infiltration Rates

SCS Soil Type	Initial Infiltration Rate (in/hr)	Final Infiltration Rate (in/hr)	Decay Coefficient
A	1.00	0.35	0.0007
B	1.00	0.19	0.0018
C	1.00	0.11	0.0018
D	1.00	0.08	0.0018

11.3.7 Low Impact Development and Hydromodification Management Plan

Increased drainage flows from Projects 10 acres or less in disturbed area which are not utilizing a Level 2 Drainage Design Report may be partially or fully mitigated by implementing Low Impact Development (LID) features such as Stormwater planters and porous pavement, provided these features conform to the DOUs Hydromodification Management Plan (HMP) requirements. Designer shall utilize the latest edition of Sacramento Area Hydrology Model (SAHM) to illustrate mitigation of post project flows. Refer to http://www.beriverfriendly.net/Newdevelopment/ to download SAHM. The setup of SAHM shall be in accordance with the CSS Model User Guide.

In addition to flood mitigation, a Project may be required to implement LID and HMP requirements for Stormwater quality compliance.

11.3.8 Public Safety Hazards

All drainage systems shall be designed to minimize public safety hazards. The following guidelines shall be used in designing drainage systems based on a 100 Year Event. Depth (D) is in feet, and velocity (υ) is in feet per second (ft/sec):

1. Surface overflow depth multiplied by velocity shall be less than 6 ($D*\upsilon<6$) at all Overland Release Points and other accessible locations,
2. In front of facilities that predominantly serve children, surface overflow depth times velocity shall be less than 3 ($D*\upsilon<3$),
3. Bridge overtopping depth times velocity shall be less than 2 at the crown ($D*\upsilon<2$),
4. Emergency services shall not be disrupted or made inaccessible due to flooding deeper than 1-foot above a new lip of gutter for a Greenfield Development.

Additionally, the 10 Year Event HGL in roadside ditches shall not exceed the adjacent public road edge of pavement elevation.

11.4 DESIGN OF PIPELINES

11.4.1 Minimum Size

The minimum allowable pipe diameter in the Separated Drainage System shall be 12 inches.

Projects with pipes used for storage shall specify a minimum inside diameter on the Plans.

11.4.2 Velocity

The minimum design velocity in Separated Drainage System pipes shall be two feet-per-second (2 FPS) and the maximum velocity shall be 10 FPS utilizing the Manning equation:

1. Assuming the pipe is Flowing Freely at a depth of 0.8 times the inside diameter (80% full), and
2. During a 100 Year Event.

11.4.3 Cover

Minimum and maximum cover over Mains shall conform with Section 9.5.6. Refer to Section 11.6.2 for cover over DI Leads and Services

11.4.4 Placement

All storm drain lines shall be placed along the centerline within the public Right-of-Way.

11.4.5 Material and Roughness

Pipe Materials shall be in conformance with the *Standard Specifications* Section 26-4. Welded steel casing is also required under R/R tracks and in other high-risk areas to minimize damage and for ease of maintenance per Section 37 of the *Standard Specifications*.

Flows shall be analyzed using a Manning's "n" factor of 0.015 for all pipe types, which accounts for pipe friction and typical minor losses.

11.4.6 Removal or Replacement

When Plans indicate removing or replacing an existing pipe in an existing street, before saw cutting the pavement, the Contractor shall use a ferreting device or equivalent to determine the exact location of the existing Main and mark location on the pavement. A note to this affect shall be included on the Plans.

11.4.7 Access Control

Any pipe with a surface Outfall or inlet to or from a channel or Detention Pond shall require an access control structure with trash rack, and shall be provided with adequate vehicular access to the top of the structure to support H20 Loading. Structure shall be designed in conformance with Standard Specification Dwg. S-270, S-280, S-290, and S-300, as applicable.

11.4.8 Conflicts with Sewer and Water Lines

Conflicts with existing sewer or water lines shall be avoided by proper alignment selection and potholing when necessary (refer to Section 13.2.5). Where conflict with a water line cannot be avoided, relocation of the water line will be required (Refer to Section 13.2.7). It is not permitted to allow penetrations between Stormwater facilities and other utilities.

11.4.9 Tapping Existing Manholes

All existing manholes shall be tapped:

1. Above the Base bench,
2. Above the Springline of the existing outlet pipe,
3. With the Crown of the tap above the Crown of the existing outlet pipe,
4. Below the Cone.

Refer to Standard Specifications Section 10-19 and 25.

11.4.10 Drainage Services

A cleanout is required for all private drainage systems connecting to a public drainage system with an 8" or smaller diameter pipe in accordance with *Standard Specifications* DWG. NO. S-265. Refer to Section 11.6.2 for cover requirements.

A manhole is required for all private drainage systems connecting to a public drainage system with a 10" or larger diameter pipe located as follows:

1. Alleys: inside right-of-way and adjacent to right-of-way boundary,
2. Easement: inside easement and adjacent to easement boundary,
3. Public Street with sidewalk and Landscape strip: Inside landscape strip,
4. Public Street with sidewalk and without Landscape strip: behind and adjacent to the sidewalk,
5. Public Street without sidewalk: Inside property and adjacent to right-of-way.

11.5 MANHOLES

11.5.1 Location

Manholes shall be located at Main junction points, changes in gradient, changes in conduit size and at a maximum spacing of 500 feet.

11.5.2 Manhole Types

A Standard Manhole #3 shall be used for drain lines 24 inches or smaller in diameter with a depth of less than 8 feet, and shall conform to Section 25 and 38, and DWG. NO. S-70 of the *Standard Specifications.*

A Standard Manhole #3A with an eccentric cone shall be used for drain lines 24 inches or smaller where the depth to Flow Line is greater than 8 feet, and shall conform to Section 25 and Section 38, DWG. NO. S-80 of the *Standard Specifications*.

A Standard Manhole #4 shall be used for drain lines 27 through 42 inches in diameter and may be required at the intersection of three or more pipes, regardless of size and shall conform to Section 25 and DWG. NO. S-110 of the *Standard Specifications*.

A Saddle Type Manhole shall be used for drain lines larger than 42 inches in diameter in accordance with Section 9.6.3.

A reinforced concrete Junction Box shall be used where other Manhole types listed are not practical in accordance with Section 9.6.3.

11.5.3 Manhole Connections

Refer to Section 9.6.5

11.6 DROP INLETS AND GUTTER DRAINS

11.6.1 Types of Drop Inlets

A Type “B” Drop Inlet shall be utilized for all street inlet installations except where another type inlet is specifically required below and shall conform to Section 30 and Section 38, DWG. NO. S-10 of the *Standard Specifications*.

A Rolled Curb Transition Type “B” Drop Inlet shall be used within Curb & Gutter Type 1 and shall conform to Section 30 and to Section 38, DWG. NO. S-66 of the *Standard Specifications*.

A Ditch Box shall be used within roadside ditches, or where otherwise required and shall conform to Section 30 and to Section 38, DWG. NO. S-30 of the *Standard Specifications*.

In the Combined Sewer System:

1. A Modified Type “B” DI shall be used in streets per Section 30 and Section 38, DWG. NO. S-20 of the *Standard Specifications,*
2. A Gutter Drain No. 22 shall be used in alleys per Section 30 and Section 38, DWG. NO. S-50 of the *Standard Specifications.*

11.6.2 DI Leads

Each DI shall be connected directly to a manhole. Leads shall be a minimum of 12-inch diameter in the Separated Drainage System. DI Leads shall not be placed under curb & gutter for a length of more than 10-feet. DI leads more than 50-feet in length shall be a minimum 15-inch diameter.

Standard DI Leads and drainage services shall have a minimum of 18 inches of cover to the finished surface. Cover may be reduced to 12 inches by utilizing Class IV RCP or C-900 PVC, entirely backfilled with controlled density fill or concrete encased per the *Standard Specifications*.

11.6.3 Tributary Flow and Placement

Drop inlets shall be spaced so that gutter flow does not exceed a run of 400 feet before reaching a DI. The total length of run tributary to a DI from all directions shall not exceed 600 feet.

Drop inlets shall be placed adjacent to pedestrian ramps in high pedestrian traffic areas. A maximum of 100-feet of gutter may drain across the ramp. Drain Inlets shall not be placed within 3-feet of driveway sections, pedestrian ramps or Round Corners.

11.6.4 Taps to Drop Inlet

Taps to DIs are not allowed.

11.6.5 Passover Drop Inlet (DI)

The distance between pass over inlets shall not exceed 300 feet, with a maximum of 3 consecutive Passover DIs.

Where Passover DIs are approved, the downstream DI shall be sized to include flow calculated to pass over upstream Grates and corresponding runoff to Mains shall be accounted for accordingly.

11.6.6 Gutter Drains

Gutter Drains (No. 20, 21, 22 & 24 per the *Standard Specifications*) shall not be allowed in Separated Drainage Systems.

11.7 OVERLAND RELEASE

11.7.1 General

The controlling Overland Release Point (ORP) for a particular structure shall account for all Overland Release spillways from each structure to the extent of all Project improvements including:

1. Pump stations,
2. Detention Ponds,
3. Road Improvements,
4. All interim and complete Project phases.

Supporting documentation defining ORP, paths and inlets shall be included in Storm Drain Master Plans and Drainage Design Reports.

The Finished Floor shall be shown on Subdivision grading Plans with the applicable pad elevations.

11.7.2 Routing of Overland Releases

An Overland Release routing analysis shall be prepared by Designer based on complete inlet failure. Flows that cross an Overland Release Point due to insufficient capacity in a normally functioning Main and/or inlet shall also be accounted for in the hydraulic analysis for 10 and 100 Year Event HGLs.

11.7.3 Overland Release Easements

All Overland Releases shall be designed such that they can be contained within public Right-of-Ways.

11.7.4 Multi-Use of Overland Release Areas

Facilities may be constructed within Overland Release paths as long as they are not negatively impacted by, or create a restriction to flow. Affected terrain and multi-use facilities shall be designed such that the calculated Overland Release will not cause erosion or destruction.

11.8 OPEN CHANNELS

11.8.1 General Requirements

Open channels are not allowed for new designs, unless:

1. The surface water in the receiving body is at an elevation such that adequate cover cannot be obtained over the Outfall pipe (Refer to Section 11.4.3), or
2. The Stormwater runoff exceeds the capacity of a 72-inch diameter pipeline.

A trapezoidal, open, concrete Lined Channel is not an acceptable alternative for drainage conveyance. Open channel design shall provide an environmentally sensitive setting with natural landscaping, gently sloping sides, riffles, falls, sloughs, pools, and a variety of possible Stormwater quality features which support multi-use such as: bike trails, walking or jogging trails, etc.

11.8.2 Channel Design Criteria

Regulated Channels shall be designed in accordance with Central Valley Flood Protection Board requirements. All other channels shall be designed with a minimum of 1 foot of Freeboard.

The procedures in Federal Highway Administration Hydraulic Engineering Circular (HEC) No. 11 shall be utilized for protection of channels with flows of 50 CFS or above. The procedures in HEC No. 15 shall be utilized for the protection of channels carrying less than 50 CFS.

11.8.3 Dimensional Limitations

Channels shall not have an obvious geometric form, but shall approximate the centerline alignment of the integral channel with natural curves, and shall be as irregular in cross section as space constraints allow.

Side slopes shall vary from a maximum of 4:1 to flatter slopes to provide a more natural appearance. Service roads will be required along the slope at every 13 feet of depth (Refer to Section 11.8.8). A shallow, 8-foot wide concrete meandering low flow channel shall be incorporated into the design as illustrated in Section 11.9.10.

11.8.4 Velocity Limitation

Channels shall have a sufficient average profile or longitudinal gradient to provide self-cleaning flow velocities (2.0 feet per second minimum during 100 Year Event while Flowing Freely), but not fast enough to create erosion. Maximum permissible velocities during 100 Year Event based on soil type are presented in the following table whether vegetated or not.

Table 11-4 Maximum Channel Velocities

Soil Type	Velocity (ft/sec)
Fine Sand (noncolloidal)	Not Allowed
Coarse Sand (noncolloidal)	4.0
Sandy Loam (noncolloidal)	2.5
Silt Loam (noncolloidal)	3.0
Ordinary Firm Loam	3.5
Silty Clay	3.5
Fine Gravel	5.0
Stiff Clay (very colloidal)	5.0
Graded, Loam to Cobbles (noncolloidal)	5.0
Graded, Silt to Cobbles (colloidal)	5.5
Alluvial Silts (noncolloidal)	3.5
Alluvial Silts (colloidal)	5.0
Coarse Gravel (noncolloidal)	6.0
Cobbles and Shingles	5.5
Hard Shales and Hard Pans	6.0
Soft Shales	3.5
Soft Sandstone	8.0
Sound rock (igneous or hard metamorphic)	20.0

11.8.5 Channel Curvature Limitation

For curved sections of channel, the centerline radius shall be a minimum of 35 feet or at least twice the channel bottom width, whichever is greater.

11.8.6 Manning's Roughness Coefficient

The Manning's coefficient of roughness to be used when designing a channel shall be as shown in the following Table.

Table 11-5 Channel "n" Factors

Type of Channel	Manning's "n"
Open channel with gunite lining (not acceptable for new channels)	0.018
Open channel not lined, with concrete low flow channel (composite "n" factor)	0.030
Earthen channel	0.035
Vegetated channel	0.040

11.8.7 Channel Improvement Plan Requirements

For all proposed channel improvements, the following items shall be incorporated into the Plans at a minimum:

1. All representative cross sections,
2. Profiles of the existing channel Flow Line and top of bank profile for a minimum of 1000 feet upstream and downstream of the proposed Project area in order to establish an average profile grade through the proposed development,
3. Plans shall be drawn at an appropriate scale showing all existing and proposed topography, all existing objects and features, all affected and adjacent property lines, Easements and Rights-of-Way, and all existing utilities,
4. All proposed improvements shall be defined with their sections, details, dimensions, notes and delineations necessary for their proper construction.

11.8.8 Access

For channels having side-slopes steeper than 4:1, access roads shall be provided on both sides parallel to channels including turn around areas as required (Refer to Plate 11-6 DOU ACCESS DRIVEWAYS). An all-weather surface shall be designed using the Caltrans gravel equivalency method, based on the minimum R-value of the underlying soil with H20 loading.

Paved access ramps shall be provided to the channel bottom at a minimum of two locations, to provide ingress and egress.

Bollards and/or post and cable fencing shall be provided as shown in *Standard Specification* DWG. NO. T-230 and T-330 to prevent unauthorized vehicular access to the maintenance roads and channel. Where pedestrian and bicycle access is prohibited, a pipe swing gate shall be used in lieu of removable bollards.

11.8.9 Levees

The design of channels that require levees shall comply with Federal Emergency Management Agency (FEMA), U.S. Army Corps of Engineer (USACE), Central Valley Flood Protection Board (CVFPB) and Department of Water Resources (DWR) requirements. The detailed design requirements for all channels with levees shall be determined on a case-by-case basis with consideration for existing soil profiles, Groundwater, quality of fill material, etc. At a minimum, the leveed channel shall be designed to accommodate the 200-year, 10-day storm with a minimum of 3 feet of Freeboard. After construction is completed, all levees shall be certified for flood protection by USACE or a Professional Engineer(s) and accredited by FEMA prior to acceptance by the City of Sacramento.

The design of channels with levees shall reference a levee structure report, surveys, certified soils reports, As-Built drawings of existing facilities, utility crossings, levee logs, other information required for certification, FEMA accreditation and compliance with DWR's "Urban Levee Design Criteria" (ULDC). All of these related items shall be submitted for acceptance with the channel design.

Levee slopes shall be free from non-essential structures, encroachments or vegetative growth that may interfere with maintenance, inspection or hamper flood-fighting activities.

11.8.10 Fencing

Access to channels with 4:1 and flatter side slopes shall be restricted with post-and-cable fencing and bollards, except for areas with an open space planning strategy.

Channels with sides slopes steeper than 4:1 shall be enclosed with a six-foot high chain link fence designed and constructed in conformance with Section 31 of the *Standard Specifications* along each side of the channel Easement. At all intersections between such channels and roads (bridge locations) fencing shall be provided to prevent public access. Locked access gates shall be provided for maintenance access from the roadway, recessed a minimum of 20 feet from the back of sidewalk or the edge of pavement, whichever is greater.

11.8.11 Utility Crossings

When water, sewer or storm drain lines cross open Regulated Channels or levees, the encroachment and crossing designs shall comply with Central Valley Flood Protection Board and DWR's "Urban Levee Design Criteria" (ULDC) requirements.

Minimum channel crossing requirements:

1. Existing and anticipated future channel bottom elevations shall be considered for design purposes. Crossing details of pipe, piers, anchorage, transition couplings, etc. shall be shown on a detail sheet of the Plans,
2. Design and construction shall be in accordance with the current requirements of the:
3. U.S. Army Corps of Engineers Engineer Manual (EM 1110-2-1913) "*Design and Construction of Levees*",
4. Sacramento District's Levee Design Guidance Standard Operating Procedure #3,
5. California Code of Regulations Title 23. Waters,
6. Division 1 Central Valley Flood Protection Board.
7. The proposed pipe shall be designed and constructed to prevent:
8. Flotation,
9. Scour or embankment erosion,

10. Damage from debris, particularly during flood flows,
11. Leakage,
12. Seepage along the proposed pipe,
13. Corrosion,
14. Damage from vehicular loads.
15. A clay cut-off wall shall be required at both sides of the channel. The clay cut-off wall shall:
16. Be a minimum of 4-feet in length,
17. Extend the full width of the excavated trench,
18. Extend 12-inches above and below the pipe.
19. Above-grade crossings are not permitted.

11.8.12 Culverts and Bridge Crossings

Hydraulic design information shall be provided for improvements related to DOU maintained Culverts and bridge crossings, including:

1. Ten and 100 Year Event HGL and channel profile at least 500 feet upstream and downstream,
2. Proposed abutments, piers, soffit height, head walls and bottom treatment,
3. Culvert size and type,
4. Grating to prevent unwanted access to Culvert pipes,
5. Erosion protection.

Culverts for Sheds smaller than 160 acres shall be designed in accordance with procedures outlined in the U.S. Department of Transportation “Hydraulic Design of Highway Culverts” utilizing HY-8 software provided by the Federal Highway Administration, or the dynamic modeling software used for the connecting system if applicable.

Culverts for Sheds larger than 160 acres shall be designed with HEC-RAS, or the dynamic modeling software used for the connecting system if applicable.

Culverts shall include a headwall or flared end section at the inlet and outlet (Refer to Section 11.4.7).

Hydraulic design information for Culverts crossing private driveways or other facilities not maintained by DOU are not required by DOU. Road crossings of Regulated Streams and Channels shall conform to the requirements of the Central Valley Flood Protection Board.

11.8.13 Outfall Structures

Where discharging Stormwater from a pipe to a surface drainage feature, the discharge pipe shall exit through a reinforced concrete Outfall structure. Outfall structures shall be equipped with a Trash rack when discharging above the 100 Year Event HGL, or a flap gate when discharging below the 100 Year Event HGL of the receiving waters. The flap gate shall be mounted to the concrete Outfall structure.

Erosion protection consisting of angular stone, reinforced shotcrete or other types of revetment shall be placed on the adjacent and, if appropriate, the opposite canal bank. The erosion protection shall extend a minimum of ten feet upstream, downstream, above and below the Outfall structure and shall have a suitable sized cut-off wall at all edges.

Angular stone shall be Facing Class as specified in Section 72 of the Caltrans Standard Specifications or an approved equal. A suitable woven geotextile fabric shall be placed between the angular stone and the earth. The minimum thickness of angular stone shall be 12-inches.

11.9 DETENTION PONDS

11.9.1 General

The primary purposes of a Detention Pond are to mitigate flooding by temporarily storing peak Stormwater flows and/or to improve Stormwater quality.

11.9.2 Required Capacity

Detention Ponds shall be sized in accordance with an accepted Drainage Design Report and when applicable a Storm Drain Master Plan. The Plans shall include a table listing 1-foot contour areas for detention ponds including:

1. The pond bottom and sides,
2. Permanent pools,
3. 10 Year and 100 Year Event water surfaces,
4. Surface of Stormwater Quality Ponds (if applicable),
5. A total volume to verify that the volume of available storage conforms to the Drainage Study.

Storage volume provided shall be in addition to any secondary improvements including: permanent pools, access ramps, storage used to control maximum Groundwater Infiltration, and volumes required for Stormwater quality as detailed in Section 11.9.11.

11.9.3 Maximum Allowed Discharge into Receiving Waters

Discharges into receiving waters shall conform to the requirements of the applicable governing body.

11.9.4 Low Flow Pumps for Detention Ponds

For pumped Detention Ponds, in addition to the primary pumps, a low flow pump shall be installed to convey low flows or dry weather flows, to accomplish Stormwater quality requirements, for energy efficiency and for maintenance purposes. Groundwater pumping shall be limited as indicated in Section 11.9.7.

11.9.5 Pump Operation at Detention Ponds

For pumped Detention Ponds, the first pump shall be turned on consistent with Stormwater Quality Pond requirements.

The second pump shall be turned on a minimum of one foot above the elevation required for Stormwater quality storage.

The third pump shall be turned on at the maximum water surface elevation of the 10 Year Event.

The pump "off" elevation shall not remove stored runoff at a faster rate than Stormwater quality requirements allow, when applicable (Refer to Section 11.11).

Pump on and off elevations shall be set at even six-inch intervals.

11.9.6 Pond Slope Configuration

Detention Ponds shall be designed with maximum side slopes of 4-feet horizontal to 1-foot vertical (4:1) and a minimum bottom slope of 1%, unless also utilized for Stormwater quality. For Ponds with Stormwater quality features, the configuration shall also conform to Stormwater quality requirements (Refer to Section 11.11).

Flatter side slopes may be required for areas intended for secondary use as determined by the party that will maintain the side slopes, but shall not be less than 1%.

11.9.7 Groundwater in Detention Ponds

The volume of Groundwater allowed to enter a Detention Pond or its contiguous pump station shall be limited. The Detention Pond shall be designed based on the following criteria:

The maximum allowable Groundwater inflow volume per year shall be 1.8 acre-feet per acre of tributary area.

The maximum allowable Groundwater Infiltration rates shall be:

1. 0.0009 CFS per tributary acre during periods of minimum Groundwater elevation, and
2. 0.015 CFS per tributary acre during periods of Shallow Groundwater.

The Geotechnical Design Report shall make recommendations for mitigating Groundwater Infiltration that does not conform to the above criteria and necessary measures shall be included in the Plans. During construction, actual volume and inflow rates shall be measured in the field and provided to the geotechnical engineer for adjustment of the Groundwater control measures. if in excess of that determined by the geotechnical report, revisions to the design and construction of the Detention Pond may be required.

11.9.8 Clay Liner

An impermeable Clay liner may be used to control Groundwater Infiltration. It may consist of:

1. A “thick clay liner” of suitable native material that meets the requirements of impermeability, or
2. Imported bentonite, or
3. A manufactured product approved by the Director.

The Clay Liner shall be designed to maintain Pond volume, to limit Groundwater Infiltration as described herein and to resist buoyancy. The Clay Liner may incorporate an Under-Drain system. The design shall incorporate the recommendations of the geotechnical report. “Thick clay liners” shall be a minimum of 1-foot thick.

An Under-drain system may be used in conjunction with a Clay Liner to reduce the thickness required of the Clay Liner and/or to mitigate buoyancy forces. The Under-Drain system shall adhere to the following:

1. Drain rock shall consist of durable, crushed stone having 100 percent passing the 1-inch sieve and less than 5 percent passing the No. 4 sieve. If a mineral filter/drain rock is proposed, it shall be compatible with formation material,
2. Synthetic Filter Fabric shall be a woven fabric with:
3. An equivalent opening size (EOS) US Standard Sieve of between 40 and 70,
4. A permeability of at least 0.02 centimeters per second,
5. A minimum flow rate of 50 gallons per minute per square foot of fabric,
6. A minimum puncture strength of 50 pounds
7. Synthetic Filter Fabric shall be placed in accordance with manufacturer's recommendations. Surfaces to receive Filter Fabric shall be free of loose or extraneous material and sharp objects that might damage the Filter Fabric during installation,
8. Trench depth and spacing shall be as recommended in the geotechnical report and may be adjusted in the field depending on the subsurface conditions as directed by the Project geotechnical engineer, who shall observe field conditions and confirm required depths and spacing during trench excavation,
9. Perforated drainpipe shall consist of schedule 40 PVC, 8 inches in diameter, with ¼-inch diameter (maximum) perforations, 12 to 24 inches on-center, placed down the center of trench. Pipe Invert shall be no more than 4 inches above trench bottom. Suitable drain rock shall be placed between the trench bottom and pipe bottom. Pipe drainage shall be collected in a solid conduit and directed to a sump or other location for disposal. Perforated and collector pipes shall be designed to gravity drain at a minimum slope of 0.35%. Supporting calculations for perforated and collector pipes shall be provided.

11.9.9 Outfall/Inlet Structures

All pipes conveying flow into or out of the Pond shall be provided with a reinforced concrete Outfall or inlet structure, in accordance with *Standard Specifications* Sections 10, 20, 21, and 38, DWG. NO. 270, 280, 290 and 300. These structures shall be equipped with trash racks, flap gates and/or sluice gates as required. Wooden stop logs are not allowed. Structures shall be designed to prevent public access into pipes. Alternative designs for structures may be approved by the Director. Plans and structural calculations signed and stamped by a professional engineer currently registered in the State of California shall be submitted to DOU for review.

Suitable slope and erosion protection shall be provided around these structures. At a minimum, No.2 Backing as specified by Caltrans shall be required with synthetic woven Filter Fabric and cutoff walls on all sides.

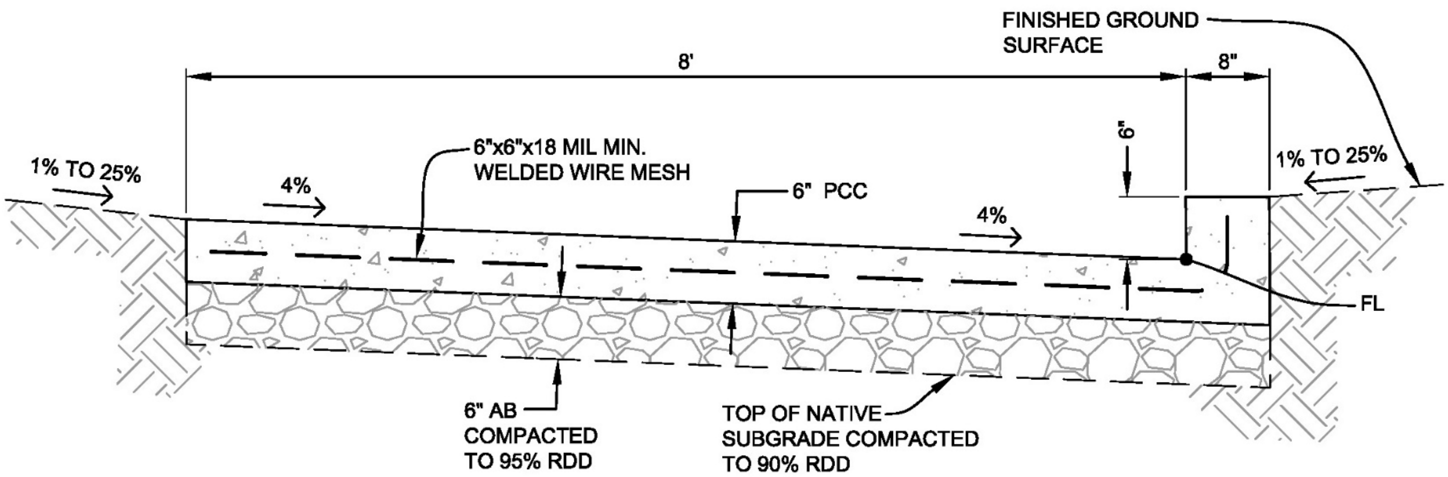
An all-weather vehicle access road shall be provided to the top of each such structure above the 100 Year Event water surface elevation in accordance with Plate 11-6 DOU ACCESS DRIVEWAYS.

Refer to Section 11.11 for additional requirements related to Stormwater Quality Ponds.

11.9.10 Concrete Low Flow Channel

If the Pond will be subject to year-round, summer, or nuisance flow, a concrete low flow channel shall be incorporated per Section 11.8.3 and the detail below.

Figure 11-1 Concrete Low Flow Channel



11.9.11 Water Quality of Permanent Pools

To maintain acceptable water quality in detention Ponds (water relatively free from algae blooms, offensive odor, or other noticeable adverse conditions), design of permanent pools shall conform to the requirements of the *Stormwater Quality Design Manual* (Refer to Section 11.11).

11.9.12 Fencing

Consistent with the multi-use concept, fencing will be minimal and typically limited to post and cable. Bollards and post and cable fencing will be constructed as required to control pedestrian, bicycle and vehicular access. A three-foot chain link fence may be required in certain areas to restrict human access and keep domestic animals out of nature areas.

11.9.13 Landscaping and Irrigation

Landscaping and irrigation may be required for a Detention Pond in addition to planting associated with Stormwater quality requirements. All planting and irrigation shall be in accordance with the *Standard Specifications*.

11.9.14 Maintenance

An access road shall be provided to the top of all pipe inlets and outlets. An access ramp or ramps shall be provided to the Pond bottom. All access roads and ramps shall conform to Plate 11-6 DOU ACCESS DRIVEWAYS.

Control of vegetation will require periodic harvesting in the Stormwater quality areas and along the banks of permanent ponds. Vehicular access shall be provided for these functions. Adjacent to the permanent pool or other feature, a suitable flat area shall be provided for harvesting.

A maintenance plan shall be submitted and approved by the Director prior to approving the design of the facilities. The maintenance plan shall include, but shall not be limited to the following:

1. A map showing:
2. Areas to be mowed,
3. Areas not to be mowed,
4. Areas where herbicides may be used,
5. Tree plantings and watering schedules,
6. Drainage inlet facilities including stilling ponds,
7. The 10/100 Year Event water surface elevations for both the detention pond and any influent channels,
8. Permanent pool elevations for wet detention ponds.
9. A description of how the areas that are not to be mowed are to be maintained (e.g. weed and algae control practices),
10. A description and annual schedule for maintaining environmentally sensitive areas,
11. A list of appropriate herbicides to be used to control weeds, etc.,
12. An itemized list of any facilities that require specific maintenance procedures including, but not limited to, the following:
13. Sedimentation basins,
14. Recreational facilities,
15. Trail access roads,
16. Pond recirculation aeration facilities.
17. List of maintenance equipment requirements,
18. Estimate of annual maintenance costs,
19. Master calendar for seasonal/periodic activities and inspections.

The DOU will provide “Utility Level Maintenance” of Detention Ponds on properties owned by or in easements granted to the City. This will include mowing twice annually, removing surface debris following major storms, clearing inlet/outlet structures of debris and assuring that conveyance pipes and low flow channels are functioning. DOU will maintain access roads and pump stations associated with Detention Ponds. The cost of maintaining retention ponds and any other Detention Pond features such as sports fields, Stormwater quality features, irrigation, landscaping, and facilities associated with other secondary uses is beyond the expertise and budget of the DOU. Developers shall provide funds for maintenance of these special and secondary uses by formation of a Maintenance District or other financial instrument that is approved by the Director.

11.9.15 Retention Pond

A Retention Pond is a Detention Pond with a zero normal release rate. All runoff that enters the

Pond is captured and stored in the Pond until it soaks into the earth, evaporates or is manually pumped-out. Retention ponds are strongly discouraged and may only be used as a temporary solution for drainage problems. Prior to design of a Retention Pond, the applicant shall obtain written approval from the DOU for the temporary use of a Retention Pond and shall execute an agreement with the City and provide a letter of credit for the ultimate, permanent drainage facilities. The agreement shall be to the satisfaction of the DOU and the City Attorney, and shall address at a minimum vector control, access, security and maintenance.

Retention Ponds shall be sized to hold 1.5 times the average yearly rainfall plus one 1-foot of Freeboard.

11.9.16 On-Site Storage

Floodwater may be temporarily stored in parking lots, planters, private Detention Ponds, structures and other On-Site areas as allowed by On-Site design criteria.

11.9.17 Underground Detention

Publicly maintained underground storage will not be allowed in the Separated Drainage System.

11.9.18 Secondary Uses

Detention Ponds allow for a number of beneficial secondary uses such as bicycle and walking/jogging paths, nature areas, species habitat, bird sanctuaries and a variety of recreational uses that may increase the value of surrounding homes and businesses and provide for a more desirable life style.

Detention Ponds shall be designed as an amenity to the neighborhood where they are located and may be integral to a park, habitat, open space, a landscape buffer or lake (secondary uses). The design of secondary uses may require coordination with one or more of the following City departments: Neighborhood Services, Planning, Development Services, Parks and Recreation and Utilities.

11.10 PIPELINES IN LEVEES

11.10.1 General

The various levees within the City of Sacramento, as shown in Plate 11-4 LEVEE MAINTENANCE MAP, are regulated by the Central Valley Flood Protection Board (CVFPB), Department of Water Resources Maintenance Area 9 (MA9), Reclamation District 1000 (RD1000), the American River Flood Control District (ARFCD) and/or the City of Sacramento. The U.S. Army Corps of Engineers (USACE) also has jurisdiction over the levees on the Sacramento and American rivers and other major streams. Pipelines, conduits, utility lines and appurtenant structures within a levee section must comply with all standards and regulations required by the maintaining agency and/or the USACE. Stormwater facilities placed in levees maintained by CVFPB and RD1000 shall comply with California Code of Regulations (CCR) Title 23, Waters Division 1, Reclamation Board Section 123 (Reclamation Board Standards for encroachment through Project levees).

An encroachment permit must be obtained from the appropriate agencies prior to construction in any levee section. The following Section includes some of the general requirements for construction within a levee.

11.10.2 Flow Line

The Flow Line of any discharge pipe shall be installed above the 100 Year Event flood elevation within the levee crown.

11.10.3 Discharge pipe

Discharge pipe within the levee section shall be welded steel or solid wall High Density Polyethylene Pipe (HDPE).

All welded steel discharge pipe within a levee section shall conform to the requirements of AWWA Standard C200 as modified herein. Pipe shall have a fusion bonded epoxy lining and coating per the requirements of AWWA C213. The joints of the steel pipe shall be welded.

Joints in the HDPE pipe shall be made by the thermal butt fusion process where the joints develop the full tensile capability of the pipe.

11.11 STORMWATER QUALITY

11.11.1 Construction Requirements

Projects constructed in the City shall comply with the City's Grading, Erosion and Sediment Control Ordinance which requires the applicant to incorporate construction measures to control urban runoff pollution from the project site during construction. Construction measures' selection and installation shall be in accordance with the latest edition of "Administrative and Technical Procedures Manual for Grading and Erosion and Sediment Control", which can be downloaded at http://www.cityofsacramento.org/-/media/Corporate/Files/DOU/Specs-Drawings/Sediment-control-manual.pdf?la=en.

Projects that disturb one or more acre of land shall comply with the State's "Construction General Permit", which requires project applicants to file a Notice of Intent (NOI) through the State's Storm Water Multiple Application and Report Tracking System (SMARTS). A valid WDID number must be obtained and provided to the DOU prior to the issuance of any grading permits.

11.11.2 Post Construction Requirements

New Development and redevelopment Projects constructed in the City of Sacramento shall comply with the City's Stormwater quality standards. Post construction Stormwater quality measures' design, construction and maintenance shall be in accordance with the latest edition of the "Stormwater Quality Design Manual for the Sacramento Region" (SQDM), which can be downloaded at http://www.beriverfriendly.net. The SQDM is periodically updated and the most recent version of the SQDM shall apply.

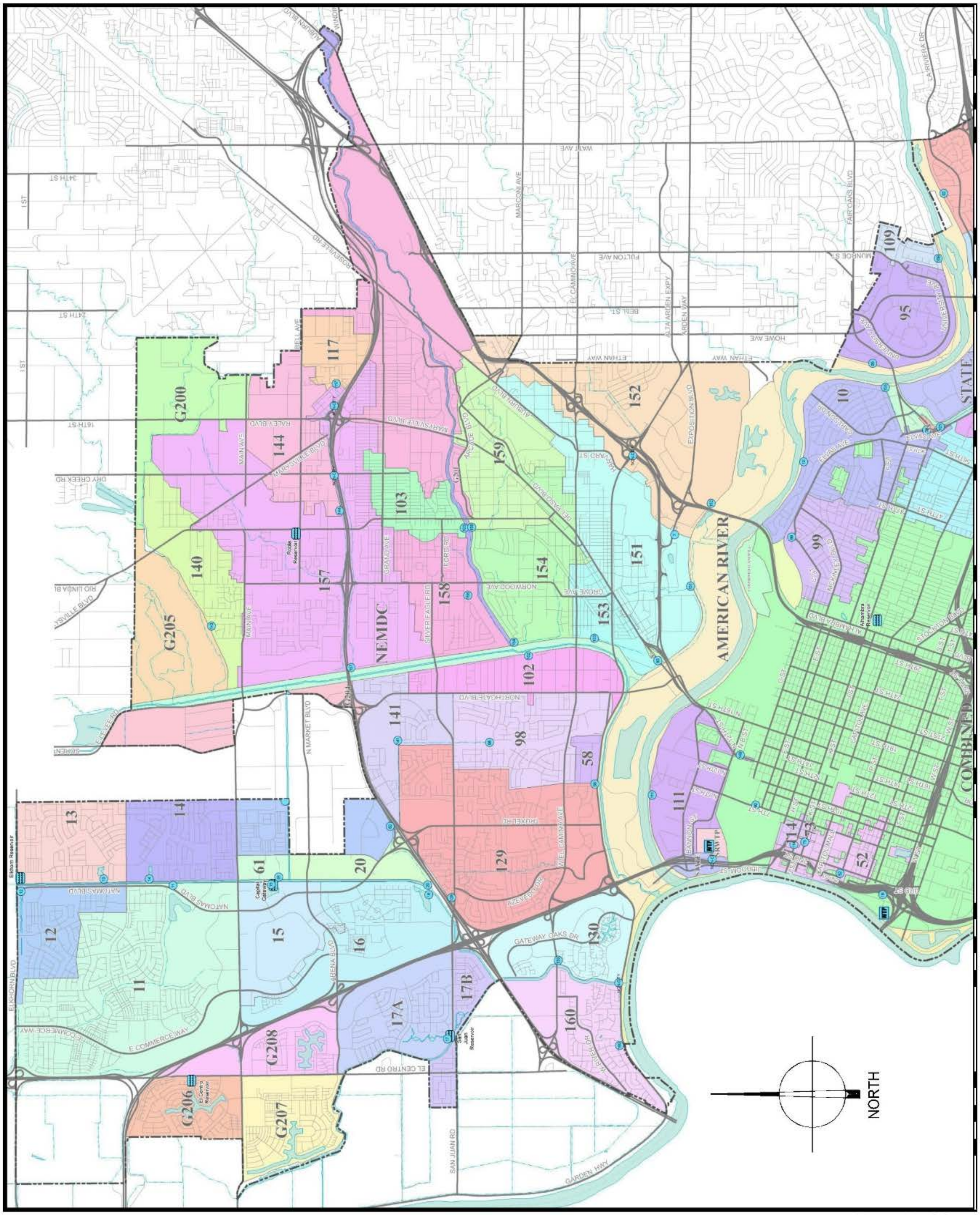
The measures identified in the SQDM are for reducing urban runoff pollution to the maximum extent practicable and shall be designed and constructed under the supervision of a California licensed professional engineer and other specialists as required.

Table 3-3 of the SQDM indicates the types of Projects and associated thresholds that are subject to the requirements of the SQDM and which measures are to be applied.

All developer financed Stormwater quality facilities shall include provisions for funding all on-going maintenance in perpetuity and in a manner that is acceptable to the Director. Stormwater quality maintenance agreements shall be accepted by DOU prior to approval of Plans.

APPENDIX

Plate 11-1 DRAINAGE BASINS



Page 1 of 2

SEE PAGE 1 OF 2

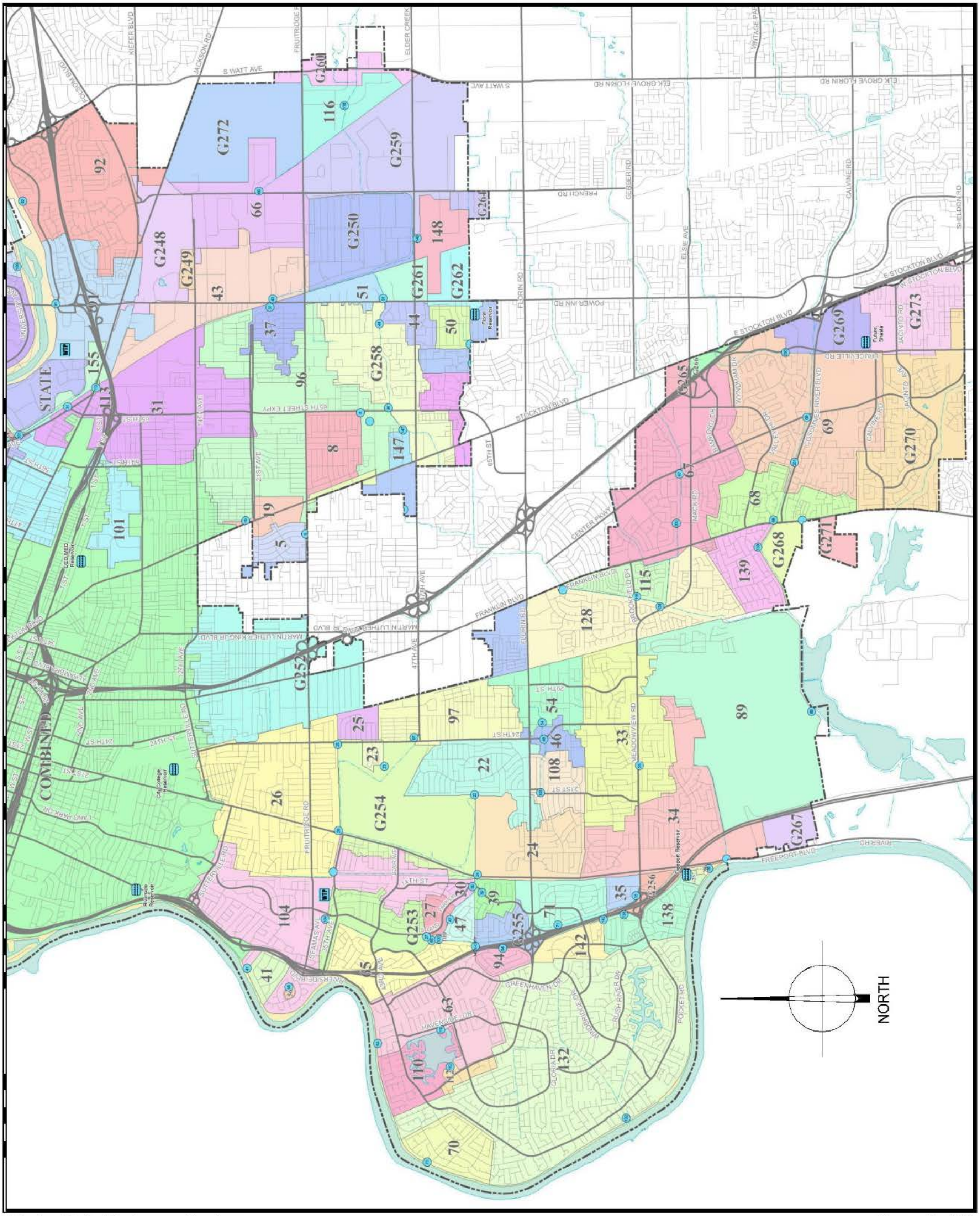


Plate 11-1 Drainage Basins

Plate 11-2 MASTER PLANNING CRITERIA EXHIBIT

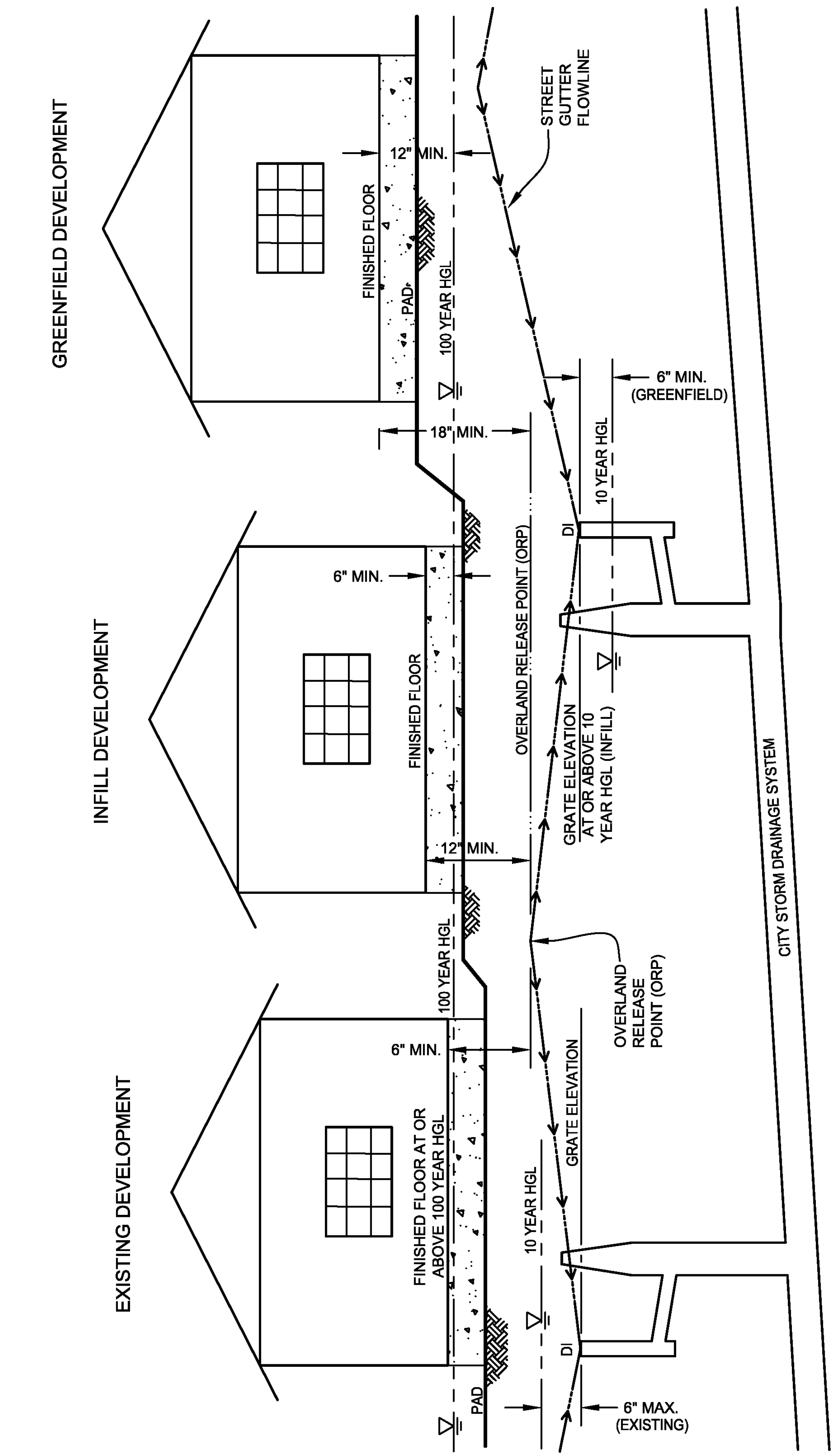


Plate 11-3 DRAINAGE DESIGN REPORT ALTERNATIVES

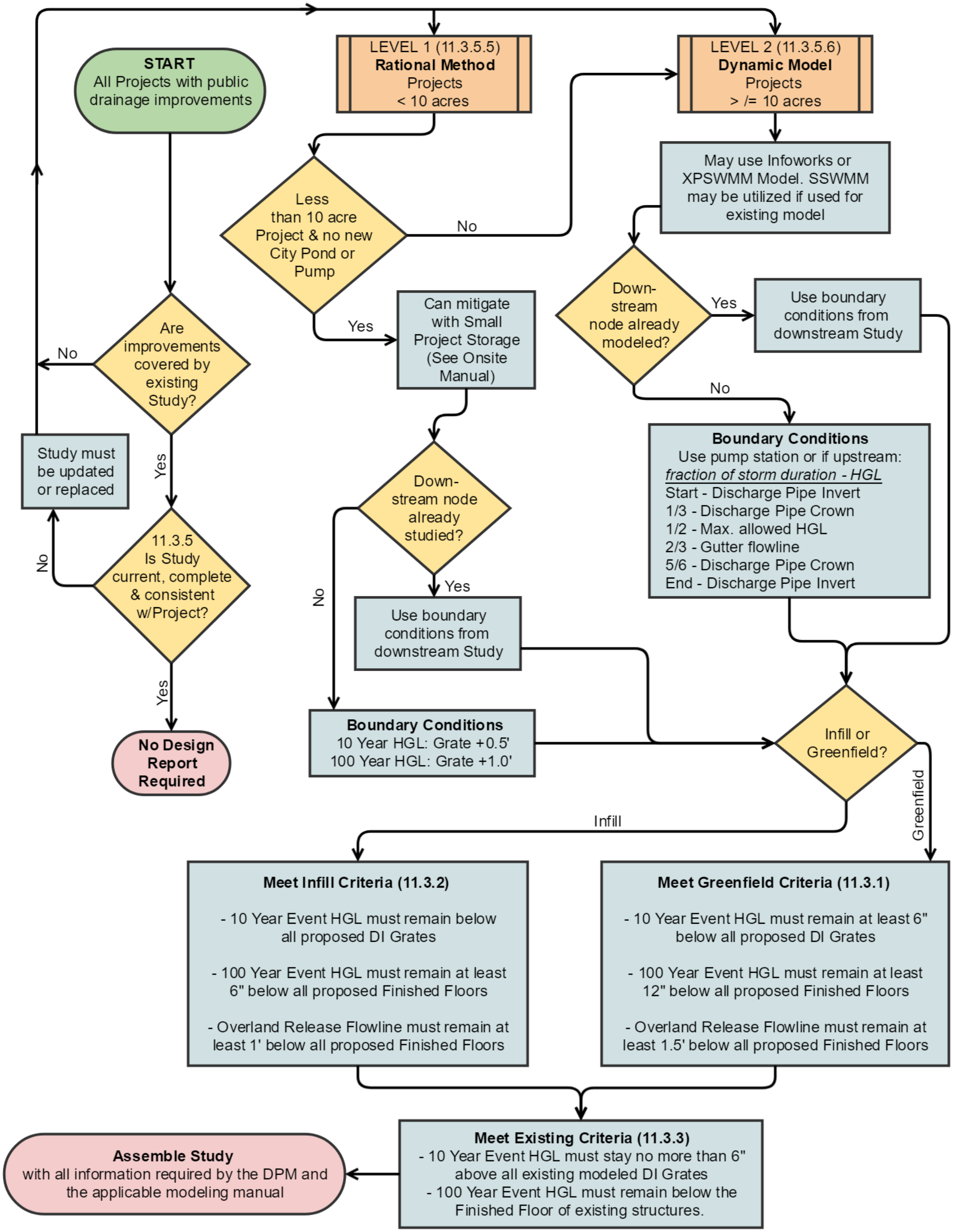


Plate 11-4 LEVEE MAINTENANCE MAP

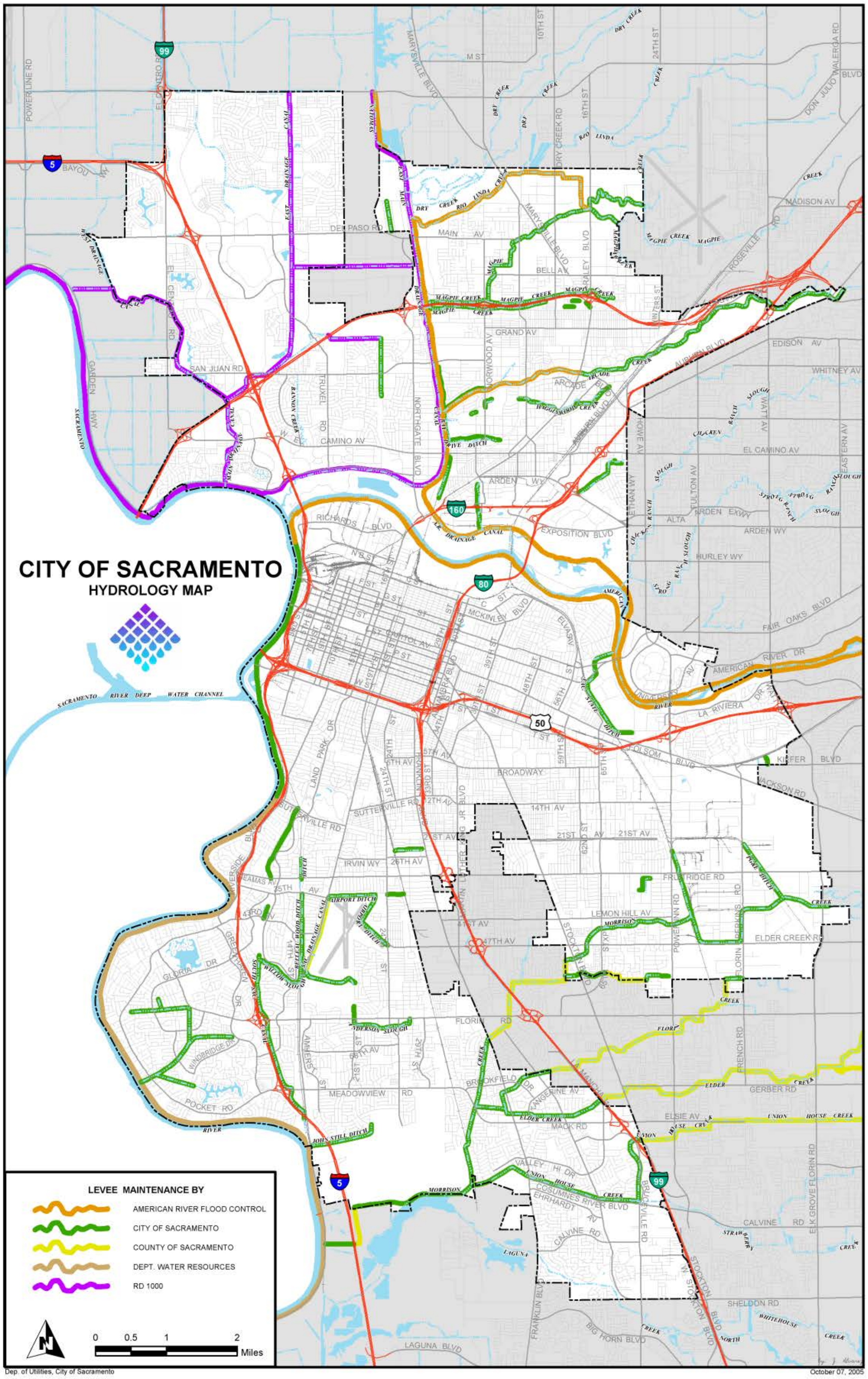


Plate 11-5 DRAINAGE STUDY CHECKLIST

City of SACRAMENTO
Department of Utilities

Note to Consultant: The checklist was developed to aid the Designer in the development of drainage studies for submittal to the City of Sacramento Department of Utilities (DOU). The intent is to expedite review by reducing the number of incomplete or unclear submittals. Completion of this checklist does not imply approval of the submitted Drainage Design Report or Plans. See City of Sacramento Design and Procedures Manual (DPM) Section 11 and 9.4. Please include the completed checklist with your Drainage Design Report submittals. This will ensure the study is routed in an expeditious manner.

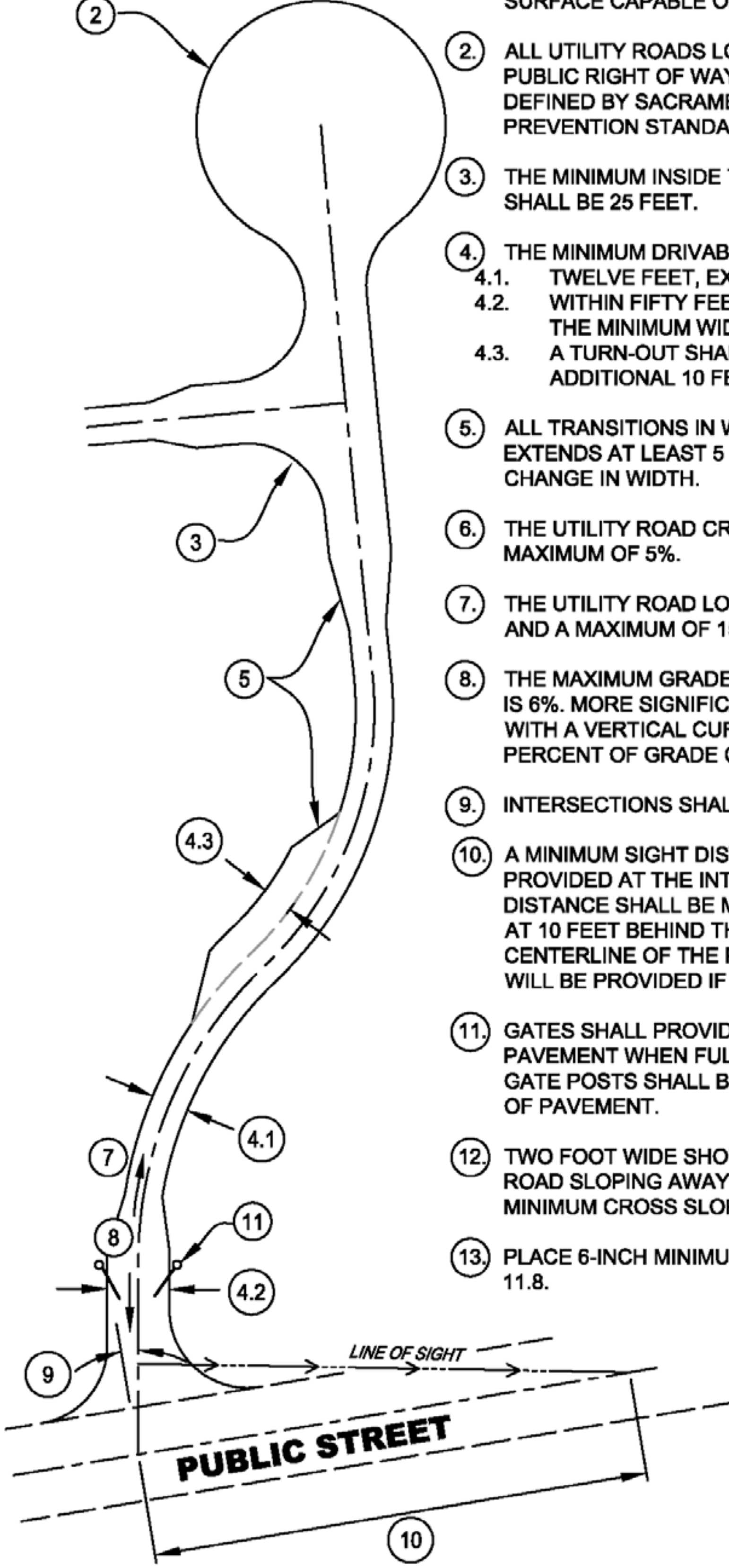
Storm Drain Master Plan (SDMP) and Drainage Design Reports (Level 1 & Level 2)

Level 1	Level 2	SDMP	Report Requirements	DPM Section	DOU Acceptance
I. COVER SHEET AND TABLE OF CONTENTS					
			A.Name of Project		
			B. Address		
			C. Owner		
			D. Developer		
			E. Engineer - Signed and Stamped	11.3	
			F. Submittal date and revision dates as applicable		
			G. Table of Contents		
II. SITE LOCATION AND DESCRIPTION					
			A. Site Location		
			1. Vicinity Map		
			2. Assessor parcel number and address, if applicable		
			3. Sewer Book page numbers and drainage Basin number		
			4. Streets, roadways, and highways adjacent to the proposed development, or within the area served by the proposed drainage improvements		
			5. Names of surrounding or adjacent developments		
			B. Narrative description of property		
			1. Existing ground cover, vegetation, and percent of impervious cover		
N/A			2. Existing soils hydrological group(s)		
			3. Existing site topography and slopes		
			4. Major and minor drainageways		
			5. Existing irrigation canals or ditches		
			6. Significant geologic features		
			7. Proposed land use & site activities		
			8. Site area(s) in acres		
			9. Groundwater depths		
III. DRAINAGE BASIN					
			A. Decribe overall drainage Basin containing site		
			1. On-site and off-site major drainage basin characteristics and flow patterns and paths		
			2. Existing and proposed land uses within the basins		
			3. Reference all drainage planning studies and floodplain delineation		
			4. Discussion of the impacts of the off-site flow patterns and paths, under fully developed conditions		
IV. EXISTING STORMWATER FACILITIES					
			A. Narrative of existing stormwater conveyance facilities		
			1. Existing conveyance facilities that will be incorporated into the design		
			2. Existing conveyance facilities that will be incorporated into the design with modifications		
			3. Existing conveyance facilities that will be rebuilt or abandoned		

			B. Narrative of existing stormwater storage facilities		
			1. Existing storage facilities that will be incorporated into the design		
			2. Existing storage facilities that will be incorporated into the design with modifications		
			3. Existing storage facilities that will be rebuilt or abandoned		
			C. Narrative of existing stormwater pumping facilities		
			1. Existing pumping facilities that will be incorporated into the design		
			2. Existing pumping facilities that will be incorporated into the design with modifications		
			3. Existing pumping facilities that will be rebuilt or abandoned		
V. PROPOSED STORMWATER CONVEYANCE OR STORAGE FACILITIES					
			A. Narrative of proposed stormwater conveyance facilities		
			1. Conceptual discussion of proposed drainage patterns and describe differences from historic patterns		
			2. Conveyance of off-site runoff		
			3. Discuss the content of any pertinent tables, charts, figures, graphs, drawings, etc. that are presented in the report		
			4. Discussion of anticipated conveyance problems and potential solutions		
			5. Discuss the anticipated major drainageway improvements		
			6. Discuss the maintenance and access aspects of the design		
			B. Narrative of proposed stormwater storage facilities		
			1. Detention storage locations and conceptual outlet structure design		
			2. Discuss anticipated storage problems and potential solutions		
			3. Discuss the maintenance and access aspects of the design		
			C. Narative of Proposed Stormwater Pumping Facilities		
			1.Discuss pump station location and conceptual layout		
			2. Discuss anticipated problems and potential solutions		
			3. Discuss the maintenance and access aspects of the design		
			D. Describe proposed phasing plan if the project will be divided into several phases.	11.2.5	
			E. Describe and attach a financing plan, if applicable		
			F. Discuss any needs for a variance from DPM standards	9.2.4	
VI. APPENDIX A - CALCULATIONS					
			A. Calculation of existing and post project drainage flows	11.3	
			B. Demonstrate project meets 10yr and 100yr HGL criteria	11.2.1	
			C. Demonstrate that overland flow release has been met	11.8	
N/A			D. Complete & provide Modeling Checklist (SSWMM, InfoWorks or XPSWMM as applicable)	Plate 11-5	
			E. Demonstrate that public safety hazards do not exist	11.2.1.9	
			F. Mitigate increased drainage flows if necessary (storage w/restricted outlet, fee, CIP and/or HMP)	9.4, 11.2, 11.3, 11.10	
			G. Demonstrate that pipe velocity requirements are met	11.4.2	
			H. Account for removal of existing storage	11.3	
	N/A	N/A	I. Small Project Storage calculations for onsite ponds	11.3.5.1	
			J. Additional requirements for Projects in the Combined Sewer System (CSS)	9.4	
		N/A	1. Demonstrate no increase in flooding		
		N/A	2. Demonstrate no increase in outflows		
		N/A	3. Demonstrate no increase in sewage on the street		
		N/A	4. Demonstrate no increase in treated and untreated CSS overflows to the river		
		N/A	5. Calculation of existing and post project sewer flows		
		N/A	6. Mitigate increased sewer flows (fee and/or CIP)		
		N/A	7. Calculate available capacity in existing CSS mains from the Project's point of service to the nearest 18-inch main and determine whether any mains need to be upsized		
			K. Verify that calculations match plans and maps		
			1. Areas match map and overall parcel		
			2. Pipe lengths match map/improvement plans		
			3. Pipe slopes match improvement plans		
			4. Pipe Diameters match map/improvement plans		
			5. Pipe roughness = 0.015	11.4.5	
			6. Overland flow segments match overland release map	11.8	
			7. Note City benchmark number, datum and elevation difference from Plan datum. CSS studies shall utilize NGVD 1929, and Separated Studies shal utilize NAVD 88 datums.	11.3	

VII. APPENDIX B - Maps & Plans (8.5"x11" or 11"x17")					
			A. Project Title Sheet with legend, notes, abbreviations, etc.		
			B. Project Site Plan		
			C. Title Block – include name and address of proposed Project/development, submittal date, title of drawing, and page number		
			D. General drawing information (north arrow, appropriate drawing scale, etc.)		
			E. Project site and abutting property topographic map with land cover and land use		
			F. Offsite drainage to the property; creeks, lakes, ponds, wetlands and other environmentally sensitive areas on or adjacent to the project site.		
			G. Existing natural and manmade drainage facilities within and immediately adjacent to the project site with points of drainage discharge from site		
			H. Overall shed and drainage system map ("bubble map")		
			1. 1' Countours		
			2. Existing and proposed ground elevations (pads, gutters, street high & low points)		
			3. Structures, geographical features, property lines, rights of way and easements		
			4. Sub sheds with impervious percent		
			5. Water surface elevations and design flows: (10-year and 100-year) at key analysis points with corresponding tributary areas		
			I. Current Tentative Map, if applicable		
		N/A	J. Current Plans		
			K. Points of discharge for drainage from the Project site		
VIII. APPENDIX C - Details					
			A. Pump station	11.3.5.6	
N/A		N/A	1. Pump curves		
N/A			2. Pump settings		
N/A			3. Pump station layout		
			B. Proposed Detention Ponds	11.10	
		N/A	1. 1' Contours		
		N/A	2. 1% minimum bottom slope (2% for WQ basin)		
		N/A	3. 3:1 Max. Side slopes		
		N/A	4. All weather acess road		
		N/A	5. All weather acces ramp		
		N/A	B. Outlet structures		
IX. APPENDIX D - Variances					
			A. Attach approved Variances for all deviations from DPM requirements	9.2.4	
X. APPENDIX E - Electronic Copies and Attachments					
			A. Modeling files		
			B. Geotechinical Design Report	9.2.9	
			C. Dedication or irrevocable offer of dedication for all applicable easements and right-of-way		
			D. Report and all Appendices (Submitted in Microsoft Word with all edits from previous version shown using "Track Changes")		
XI. APPENDIX F - Additional Requirements for Dynamic Model					
			A. Runoff Parameters	11.3.5.6	
N/A			1. Shed Width - Calculated overland flow length of 150' for residential and 200' for commercial		
N/A			2. Slope - minimum of 1%		
N/A			3. Infiltration rates match soil type per manual		
N/A			4. Roughness coefficients per manual		
N/A			5. Storm		
N/A			6. Impervious Percent		
			B. Extran Parameters	11.3.5.6	
N/A			1. Pump setting match report		
N/A			2. Redundant Pump off		
N/A			3. Pump service factor applied		
N/A			4. Basin storage curve matches basin details		
N/A			5. Boundary conditions		
			C. Model results		
N/A			1. Continuity		

Plate 11-6 DOU ACCESS DRIVEWAYS



1. ALL UTILITY ROADS SHALL BE PAVED WITH AN APPROVED ALL WEATHER SURFACE CAPABLE OF WITHSTANDING H20 LOADING.

2. ALL UTILITY ROADS LONGER THAN 150 FEET MEASURED FROM THE PUBLIC RIGHT OF WAY SHALL TERMINATE WITH A TURNAROUND AS DEFINED BY SACRAMENTO METROPOLITAN FIRE DISTRICT FIRE PREVENTION STANDARD, FIGURE 1.

3. THE MINIMUM INSIDE TURNING RADIUS AT THE EDGE OF PAVEMENT SHALL BE 25 FEET.

4. THE MINIMUM DRIVABLE PAVEMENT WIDTH SHALL BE:
   - 4.1. TWELVE FEET, EXCEPT
   - 4.2. WITHIN FIFTY FEET OF ALL INTERSECTIONS AND TURNAROUNDS THE MINIMUM WIDTH SHALL BE TWENTY FEET, AND
   - 4.3. A TURN-OUT SHALL BE PROVIDED EVERY 400 FEET THAT IS AN ADDITIONAL 10 FEET WIDE BY 30 FEET LONG ON ONE SIDE.

5. ALL TRANSITIONS IN WIDTH SHALL BE MADE WITH A TAPER THAT EXTENDS AT LEAST 5 FEET LONGITUDINALLY FOR EVERY 1 FOOT CHANGE IN WIDTH.

6. THE UTILITY ROAD CROSS SLOPE SHALL BE A MINIMUM OF 1% AND A MAXIMUM OF 5%.

7. THE UTILITY ROAD LONGITUDINAL SLOPE SHALL BE A MINIMUM OF 1% AND A MAXIMUM OF 15%.

8. THE MAXIMUM GRADE BREAK DIFFERENCE AT A VERTICAL ANGLE POINT IS 6%. MORE SIGNIFICANT GRADE BREAKS SHALL BE ACCOMMODATED WITH A VERTICAL CURVE WITH A MINIMUM LENGTH OF 3 FEET PER PERCENT OF GRADE CHANGE.

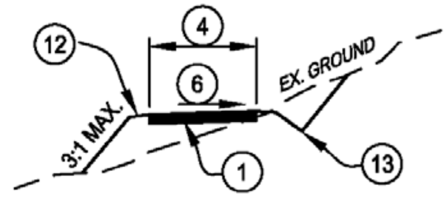
9. INTERSECTIONS SHALL BE WITHIN 20 DEGREES OF PERPENDICULAR.

10. A MINIMUM SIGHT DISTANCE OF 8 TIMES THE SPEED LIMIT SHALL BE PROVIDED AT THE INTERSECTION WITH ALL PUBLIC ROADS. THE SIGHT DISTANCE SHALL BE MEASURED FROM THE UTILITY ROAD CENTERLINE AT 10 FEET BEHIND THE EDGE OF PUBLIC ROAD PAVEMENT TO THE CENTERLINE OF THE PUBLIC ROAD IN BOTH DIRECTIONS. EASEMENTS WILL BE PROVIDED IF NECESSARY TO MAINTAIN LINE OF SIGHT.

11. GATES SHALL PROVIDE A MINIMUM OF 20 FEET FROM THE PUBLIC ROAD PAVEMENT WHEN FULLY OPENED FOR A VEHICLE STOPPING AREA. GATE POSTS SHALL BE PLACED A MINIMUM OF 1 FOOT FROM THE EDGE OF PAVEMENT.

12. TWO FOOT WIDE SHOULDERS SHALL BE PROVIDED ON BOTH SIDES OF ROAD SLOPING AWAY FROM PAVEMENT. SHOULDERS SHALL HAVE A MINIMUM CROSS SLOPE OF 1% AND MAXIMUM CROSS SLOPE OF 5%.

13. PLACE 6-INCH MINIMUM DEPTH DITCHES FOR CUT SLOPES PER SECTION 11.8.



TYPICAL SECTION

Plate 11-7 10 YEAR HYETOGRAPH

Hours 1-3	Hours 4-6	Hours 7-9	Hours 10-12	Hours 13-15	Hours 16-18	Hours 19-21	Hours 22-24
0.005	0.005	0.008	0.012	0.07	0.008	0.005	0.005
0.005	0.005	0.008	0.012	0.05	0.008	0.005	0.005
0.005	0.005	0.008	0.012	0.05	0.008	0.005	0.005
0.005	0.005	0.008	0.012	0.04	0.008	0.005	0.005
0.005	0.005	0.008	0.012	0.04	0.008	0.005	0.005
0.005	0.005	0.008	0.012	0.03	0.008	0.005	0.005
0.005	0.005	0.008	0.012	0.021	0.008	0.005	0.005
0.005	0.005	0.008	0.012	0.021	0.008	0.005	0.005
0.005	0.005	0.008	0.012	0.021	0.008	0.005	0.005
0.005	0.005	0.008	0.012	0.021	0.008	0.005	0.005
0.005	0.005	0.008	0.012	0.021	0.008	0.005	0.005
0.005	0.005	0.008	0.012	0.021	0.008	0.005	0.005
0.005	0.005	0.008	0.012	0.016	0.008	0.005	0.005
0.005	0.005	0.008	0.012	0.016	0.008	0.005	0.005
0.005	0.005	0.008	0.012	0.016	0.008	0.005	0.005
0.005	0.005	0.008	0.012	0.016	0.008	0.005	0.005
0.005	0.005	0.008	0.012	0.016	0.008	0.005	0.005
0.005	0.005	0.008	0.012	0.016	0.008	0.005	0.005
0.005	0.005	0.008	0.016	0.012	0.008	0.005	0.005
0.005	0.005	0.008	0.016	0.012	0.008	0.005	0.005
0.005	0.005	0.008	0.016	0.012	0.008	0.005	0.005
0.005	0.005	0.008	0.016	0.012	0.008	0.005	0.005
0.005	0.005	0.008	0.016	0.012	0.008	0.005	0.005
0.005	0.005	0.008	0.016	0.012	0.008	0.005	0.005
0.005	0.005	0.008	0.021	0.012	0.008	0.005	0.005
0.005	0.005	0.008	0.021	0.012	0.008	0.005	0.005
0.005	0.005	0.008	0.021	0.012	0.008	0.005	0.005
0.005	0.005	0.008	0.021	0.012	0.008	0.005	0.005
0.005	0.005	0.008	0.021	0.012	0.008	0.005	0.005
0.005	0.005	0.008	0.03	0.012	0.008	0.005	0.005
0.005	0.005	0.008	0.03	0.012	0.008	0.005	0.005
0.005	0.005	0.008	0.04	0.012	0.008	0.005	0.005
0.005	0.005	0.008	0.04	0.012	0.008	0.005	0.005
0.005	0.005	0.008	0.05	0.012	0.008	0.005	0.005
0.005	0.005	0.008	0.11	0.012	0.008	0.005	0.005
0.005	0.005	0.008	**0.25**	0.012	0.008	0.005	0.005

Rainfall depth in inches over (288) consecutive 5-minute increments (2.98-inches over 24-hours total)

Plate 11-8 100 YEAR EVENT HYETOGRAPH

Hours 1-3	Hours 4-6	Hours 7-9	Hours 10-12	Hours 13-15	Hours 16-18	Hours 19-21	Hours 22-24
0.007	0.007	0.011	0.018	0.18	0.011	0.007	0.007
0.007	0.007	0.011	0.018	0.07	0.011	0.007	0.007
0.007	0.007	0.011	0.018	0.07	0.011	0.007	0.007
0.007	0.007	0.011	0.018	0.045	0.011	0.007	0.007
0.007	0.007	0.011	0.018	0.045	0.011	0.007	0.007
0.007	0.007	0.011	0.018	0.045	0.011	0.007	0.007
0.007	0.007	0.011	0.018	0.032	0.011	0.007	0.007
0.007	0.007	0.011	0.018	0.032	0.011	0.007	0.007
0.007	0.007	0.011	0.018	0.032	0.011	0.007	0.007
0.007	0.007	0.011	0.018	0.032	0.011	0.007	0.007
0.007	0.007	0.011	0.018	0.032	0.011	0.007	0.007
0.007	0.007	0.011	0.018	0.032	0.011	0.007	0.007
0.007	0.007	0.011	0.018	0.022	0.011	0.007	0.007
0.007	0.007	0.011	0.018	0.022	0.011	0.007	0.007
0.007	0.007	0.011	0.018	0.022	0.011	0.007	0.007
0.007	0.007	0.011	0.018	0.022	0.011	0.007	0.007
0.007	0.007	0.011	0.018	0.022	0.011	0.007	0.007
0.007	0.007	0.011	0.018	0.022	0.011	0.007	0.007
0.007	0.007	0.011	0.022	0.018	0.011	0.007	0.007
0.007	0.007	0.011	0.022	0.018	0.011	0.007	0.007
0.007	0.007	0.011	0.022	0.018	0.011	0.007	0.007
0.007	0.007	0.011	0.022	0.018	0.011	0.007	0.007
0.007	0.007	0.011	0.022	0.018	0.011	0.007	0.007
0.007	0.007	0.011	0.022	0.018	0.011	0.007	0.007
0.007	0.007	0.011	0.032	0.018	0.011	0.007	0.007
0.007	0.007	0.011	0.032	0.018	0.011	0.007	0.007
0.007	0.007	0.011	0.032	0.018	0.011	0.007	0.007
0.007	0.007	0.011	0.032	0.018	0.011	0.007	0.007
0.007	0.007	0.011	0.032	0.018	0.011	0.007	0.007
0.007	0.007	0.011	0.032	0.018	0.011	0.007	0.007
0.007	0.007	0.011	0.045	0.018	0.011	0.007	0.007
0.007	0.007	0.011	0.045	0.018	0.011	0.007	0.007
0.007	0.007	0.011	0.045	0.018	0.011	0.007	0.007
0.007	0.007	0.011	0.07	0.018	0.011	0.007	0.007
0.007	0.007	0.011	0.11	0.018	0.011	0.007	0.007
0.007	0.007	0.011	**0.44**	0.018	0.011	0.007	0.007

Rainfall depth in inches over (288) consecutive 5-minute increments (4.31-inches over 24-hours total)