

## SECTION 4 STORM DRAINAGE

### 4.01 GENERAL

These Design Standards shall provide minimum requirements for the design of storm drainage and related appurtenances within the City of West Sacramento rights-of-way and easements. Design criteria of proposed improvements not included in these standards shall be subject to the approval of the City Engineer.

Specific documents to be referenced when preparing and completing the required hydrology and hydromodification calculations shall follow the document requirements:

- A. CITY OF WEST SACRAMENTO STORM WATER/Storm Drainage Master Plan Update, (SD/SW MP), April 2022 or latest approved update. ([Storm Water/Storm Drainage Master Plan Update](#))
- B. YOLO COUNTY CITY/County Drainage Manual, Revised 2010 or latest approved update. ([Drainage Manual](#))
- C. SACRAMENTO CITY/County Drainage Manual. Hydrology Standards, Volume II, December 1996 or latest approved update. ([Hydrology Standards](#))
- D. CITY OF WEST SACRAMENTO Post-Construction Standards Plan, 2014 or latest approved update. ([Post Construction Standards Plan](#))

### 4.02 HYDROLOGY AND HYDROMODIFICATION

- A. GENERAL HYDROLOGY CALCULATIONS
  1. The methods and storm recurrence intervals indicated below shall be used in determination of runoff quantities, assuming ultimate development of the upstream watershed.
  2. Hydrologic calculations shall be submitted to the City Engineer along with watershed maps, which indicate area distributions within the watershed and other information pertinent to the determination of storm runoff.
  3. Drainage facilities to be located within the City shall be designed in accordance with the SD/SW MP, April 2022, or the latest edition.
  4. These standards assume two categories of drainage facilities:

Type 1 Drainage Facilities	Storm	Analysis Method
Channels	100-yr	HEC-HMS
Culverts with associated channels	100-yr	HEC-HMS
Bridges	100-yr	HEC-HMS
Detention ponds	100-yr	HEC-HMS
Drainage pump stations	100-yr	HEC-HMS
Pipe Systems (large, for areas > 160 acres)	100-yr	HEC-HMS
Overland Conveyance Systems (for areas < 160 acres)	100-yr	Simplified 100-yr

Type 2 Drainage Facilities (for areas < 160 acres)	Storm	Analysis Method
Roadside ditches	10-yr, 100-yr	10-yr Peak, Simplified 100-yr
Culverts associated with roadside ditches	10-yr, 100-yr	10-yr Peak, Simplified 100-yr
Pipe Systems (small)	10-yr, 100-yr	10-yr Peak, Simplified 100-yr

## B. DESIGN CRITERIA

### 1. The Simplified 100-Year Method

- a. The *Simplified 100-Year Method* shall be used assuming a hundred-year (100-yr, 24-hr) storm event in the design of *Type 1 Overland Conveyance Facilities for areas one-hundred-sixty (160) acres or less*. At the discretion of the City Engineer, these facilities shall also be evaluated assuming a 10-year storm event.
- b. Computational Procedure Utilizing Simplified 100-Year Method
  - i. Delineate the subbasin contributing drainage to the point or node of interest.
  - ii. Calculate the *Simplified 100-Year Method* peak design flow using the equations below or read the *Simplified 100-Year Method* peak design flow from Chart A.

$$Q_{\text{Design100}} = 3.1604A^{0.7745}$$

Where:

$Q_{\text{Design100}}$  = peak flow (cfs)

A = cumulative drainage area (acres)

### 2. The HEC-HMS Method

- a. The HEC-HMS Method shall be applied in areas where storm volume (detention, storage and pumping) and/or dynamic tailwater conditions exist that invalidate peak-flow base evaluations. Under such dynamic flow conditions, this computer program or other comparable program shall be used at the design engineer's discretion. A copy of the HEC-HMS program is available online at the website for the Hydrologic Engineering Center in Davis, California ([Hydrologic Engineering Center](#)).
- b. Computational Procedure prior to Utilizing HEC-HMS.
  - i. Delineate the subbasin contributing drainage to the point or node of interest.
  - ii. Identify the area, by land use, within the subbasin.
  - iii. Determine the percentage impervious for the various land uses within the subbasin in accordance with Table 4-1.
  - iv. Calculate an area-weighted effective percent impervious for the subbasin.
  - v. Determine the Basin "n" for the various land uses within the subbasin in accordance with Table 4-4.

- vi. Calculate an area-weighted Basin “n” for the subbasin.
  - vii. Determine the hydrologic soils groups and associated uniform infiltration rates for the various land uses within the subbasin in accordance with Table 4-3.
  - viii. Calculate an area-weighted uniform infiltration rate for the subbasin.
  - ix. Determine the initial loss based upon the storm recurrence in accordance with Table 4-2.
  - x. Determine the lag multiplication factor for overland release based upon the storm recurrence in accordance with Table 4-5.
  - xi. Determine the subbasin lag time based upon the following equation:
 
$$L_g = 1560nf(LL_c/S^{0.5})^{0.33}$$
 Where:
    - $L_g$  = Lag time (minutes)
    - L = Length of longest watercourse, measured as approximately 90% of the distance from the point of interest to the headwater divide of the basin (miles).
    - $LL_c$  = Length along the longest watercourse measured upstream from the point of interest to a point close to the centroid of the basin (miles)
    - S = Slope of 90% of the longest watercourse between the headwaters and concentration point, (ft/mi).
    - n = Basin “n” from Table 4-4
    - f = Lag frequency factor from Table 4-5 to account for flows exceeding pipe capacities causing temporary flooding in streets and thereby increasing lag times.
  - xii. Refer to SD/SW MP Appendix B for design rainfall.
3. Unsteady State Conditions
- a. Where unsteady state conditions exist, using an unsteady state model such as HEC RAS may be necessary to design “*Type 1 drainage facilities*” in lieu of the *Simplified 100-Year Method*. When HEC RAS is used to evaluate flooding, runoff hydrographs used within HEC-RAS should be developed using HEC-HMS or other methods as approved by the City Engineer.
4. The “10-Year Peak Method”
- a. The “10-Year Peak Method” shall be used in the design of Type 2 Drainage Facilities, for areas less than or equal to one-hundred-sixty (160) acres, except for overland conveyance systems which are based on 100-year flow. Generally, larger acreage development is more interdependent, draining into detention basins with dynamic tailwater conditions, requiring more complex analysis. However, infill areas less than one-hundred-sixty (160) acres in size that are tributary to existing pipe networks and are only constructing storm drains and overland release through streets, a simplified procedure has been developed for sizing storm drains. This simplified procedure is based on peak flow/conveyance only, and assuming circular reinforced concrete storm drainage pipes with a design

“n” value of 0.015. Alternative pipe materials with higher “n” values will require more detailed analysis.

- b. The 10-Year Design Charts included herein as Chart B and Chart C establish the parameters for sizing storm drains and conveyance facilities serving areas of one-hundred-sixty (160) acres or less. The 10-Year Peak Method is consistent with the dynamic 10-Year peak flow conditions in the City of West Sacramento using Yolo County rainfall when development is present.
- c. Computational Procedure
  - i. Contact the City Engineer to obtain the downstream hydraulic grade line (HGL) at the tie-in point to the system, to use as the starting conditions for upstream analysis. Assume full-flow conditions exist at the downstream end of the first conveyance facility being sized. Verify with the City Engineer that the proposed development is consistent with the City’s master planning and sufficiently mitigated downstream through downstream detention and pumping.
  - ii. Delineate the subbasin contributing drainage to the point or node of interest.
  - iii. Find the point on the curve corresponding to the estimated 10-Year peak flow from Chart B based on the drainage area from Step 2.
  - iv. Determine the physical longitudinal design slope (vertical ft/horizontal ft) of the drainage facility being sized, based on the site design grading constraints.
  - v. For storm drainpipe sizing, go to Chart C and locate the point on the chart corresponding to the 10-year peak flow from Step 3 and the physical design (pipe) slope from Step 4. Move down vertically from this point until the next closest line is reached, corresponding to the minimum design pipe size.

For designing a collection network of pipes, begin at the downstream end of the proposed system and work upstream for sizing tributary pipes. If connecting to an existing pipe diameter (downstream) that is smaller in diameter than the calculated diameter from the above procedure, the proposed pipe must be installed with a steeper slope, to match the existing pipe diameter. To determine the minimum required slope, move up on Chart C along the peak flow line to identify the required slope by selecting the line corresponding to the downstream pipe diameter. If using the required pipe size with a steeper slope is not feasible, consult with the City Engineer for alternatives that may involve dynamic analysis and onsite detention/pumping.

- vi. For Type 2 Drainage Facilities that are not pipes, use the Manning’s equation or a peak flow hydraulic computation program similar to

Bentley Flowmaster® to establish hydraulic conditions consistent with section 4.03.

- C. **STORMWATER QUALITY** - The Federal Clean Water Act provides regulations to manage stormwater discharges from new development and redevelopment projects. The Clean Water Act delegates authority to the States to issue National Pollutant Discharge Elimination System (NPDES) for discharges of stormwater to the Waters of the U.S. Small municipalities, like West Sacramento, are required to obtain coverage under the Phase II General NPDES Permit for Municipal Separate Stormwater & Sewer Systems (MS4). Phase II MS4 Municipalities are required to implement stormwater programs. The Post-Construction Standards Plan, latest approved edition provides guidance for stormwater design measures. Stormwater treatment design must comply with the latest version of this document and latest state Phase II MS4 permit.

**Table 4-1 - Effective Percent Impervious by Land Use**

<b>Land Use Description</b>	<b>Effective Percent Impervious</b>
Rural Estates	10
Rural Residential	15
Low Density Residential	55
Medium Density Residential	65
High Density Residential	70
High Rise Residential	80
Neighborhood Commercial	90
Community Commercial	90
Highway Service Commercial	90
Water-related Commercial	90
General Commercial	90
Office	90
Business Park	90
Neighborhood Mixed Use	80
Riverfront Mixed Use	90
Mixed Commercial/Industrial	85
Light Industrial	85
Heavy Industrial	85
Water-related Industrial	85
Public/Quasi-public	50
Recreation and Park	5
Open Space	2
Agriculture	2

Source: Sacramento City/County Drainage Manual, Hydrology Standards, Volume II, December 1996.

**Table 4-2 - Initial Loss by Recurrence Interval**

Recurrence Interval	Loss, in.
2	0.40
5	0.25
10	0.20
25	0.15
50	0.12
100	0.10
200	0.08
500	0.06

Source: Sacramento City/County Drainage Manual, Hydrology Standards, Volume II, December 1996.

**Table 4-3 - Infiltration Rates by Land Use and Hydrologic Soil Group**

Land Use Description	Effective Percent Impervious	Infiltration Rate, in/hr		
		Soil Group B	Soil Group C	Soil Group D
Rural Estates	10	0.18	0.10	0.07
Rural Residential	15	0.18	0.10	0.07
Low Density Residential	55	0.18	0.10	0.07
Medium Density Residential	65	0.18	0.10	0.07
High Density Residential	70	0.17	0.09	0.06
High Rise Residential	80	0.16	0.08	0.05
Neighborhood Commercial	90	0.14	0.07	0.04
Community Commercial	90	0.14	0.07	0.04
Highway Service Commercial	90	0.14	0.07	0.04
Water-related Commercial	90	0.14	0.07	0.04
General Commercial	90	0.14	0.07	0.04
Office	90	0.14	0.07	0.04
Business Park	90	0.14	0.07	0.04
Neighborhood Mixed Use	80	0.18	0.10	0.07
Riverfront Mixed Use	90	0.14	0.07	0.04
Mixed Commercial/Industrial	85	0.17	0.09	0.06
Light Industrial	85	0.17	0.09	0.06
Heavy Industrial	85	0.17	0.09	0.06
Water-related Industrial	85	0.17	0.09	0.06
Public/Quasi-public	50	0.19	0.11	0.75
Recreation and Park	5	0.16	0.09	0.07
Open Space	2	0.18	0.10	0.07
Agriculture	2	0.18	0.10	0.07

Sources: 1. Sacramento City/County Drainage Manual, Hydrology Standards, Volume II, December 1993.  
 2. Modifications in accordance with communications with Sacramento County Water Resources Division staff, August 12, 1994.

**Table 4-4 - Basin "n" for Unit Hydrograph Lag Equation by Land Use and Effective Percent Impervious**

Sacramento County Land Use Description	Effective Percent Impervious	Basin "n"	
		Developed Pipe/Channel	Undeveloped Channel
Rural Estates	10	0.060	0.100
Rural Residential	15	0.056	0.096
Low Density Residential	55	0.046	0.088
Medium Density Residential	65	0.042	0.084
High Density Residential	70	0.035	0.073
High Rise Residential	80	0.032	0.070
Neighborhood Commercial	90	0.032	0.070
Community Commercial	90	0.032	0.070
Highway Service Commercial	90	0.032	0.070
Water-related Commercial	90	0.032	0.070
General Commercial	90	0.032	0.070
Office	90	0.032	0.070
Business Park	90	0.032	0.070
Neighborhood Mixed Use	80	0.037	0.076
Riverfront Mixed Use	90	0.037	0.076
Mixed Commercial/Industrial	85	0.032	0.070
Light Industrial	85	0.032	0.070
Heavy Industrial	85	0.032	0.070
Water-related Industrial	85	0.032	0.070
Public/Quasi-public	50	0.040	0.080
Recreation and Park	5	0.065	0.110
Open Space	2	0.075	0.120
Agriculture	2	0.075	0.120

Source: Sacramento City/County Drainage Manual, Hydrology Standards, Volume II, December 1993.

**Table 4-5 - Lag Multiplication Factors for Overland Release**

Frequency, Years	2	5	10	25	50	100	200	500
Multiplication Factor <sup>1</sup>	1.0	1.0	1.0	1.1	1.2	1.3	1.4	1.5

<sup>1</sup> Lag multiplication factors to be applied to the lag times for developed piped areas with overland release.

Source: Sacramento City/County Drainage Manual, Hydrology Standards, Volume II, December 1996.

**Table 4-6 - Manning's "n" By Conveyance System Type**

Conveyance Type	Manning's "n"
Concrete Pipe	0.015
Corrugated Metal Pipe	0.024
Concrete-lined Channels	0.015
Earth Channel (Straight/Smooth)	0.022
Earth Channel (Dredged)	0.028
Mowed Grass-lined Channel	0.035
Natural Channel (Clean/Some Pools)	0.040
Natural Channel (Winding/Some Vegetation)	0.048
Natural Channel (Winding/Stoney/Partial Vegetation)	0.060
Natural Channel (Debris/Pools/Rocks/Full Vegetation)	0.070
Floodplain (Isolated Trees/Mowed Grass)	0.040
Floodplain (Isolated Trees/High Grass)	0.050
Floodplain (Few Trees/Shrubs/Weeds)	0.080
Floodplain (Scattered Trees/Shrubs)	0.120
Floodplain (Numerous Trees/Dense Vines)	0.200

Source: Sacramento City/County Drainage Manual, Hydrology Standards, Volume II, December 1996.

**Figure 4-1 - Drainage Area vs 100-Year Flow**

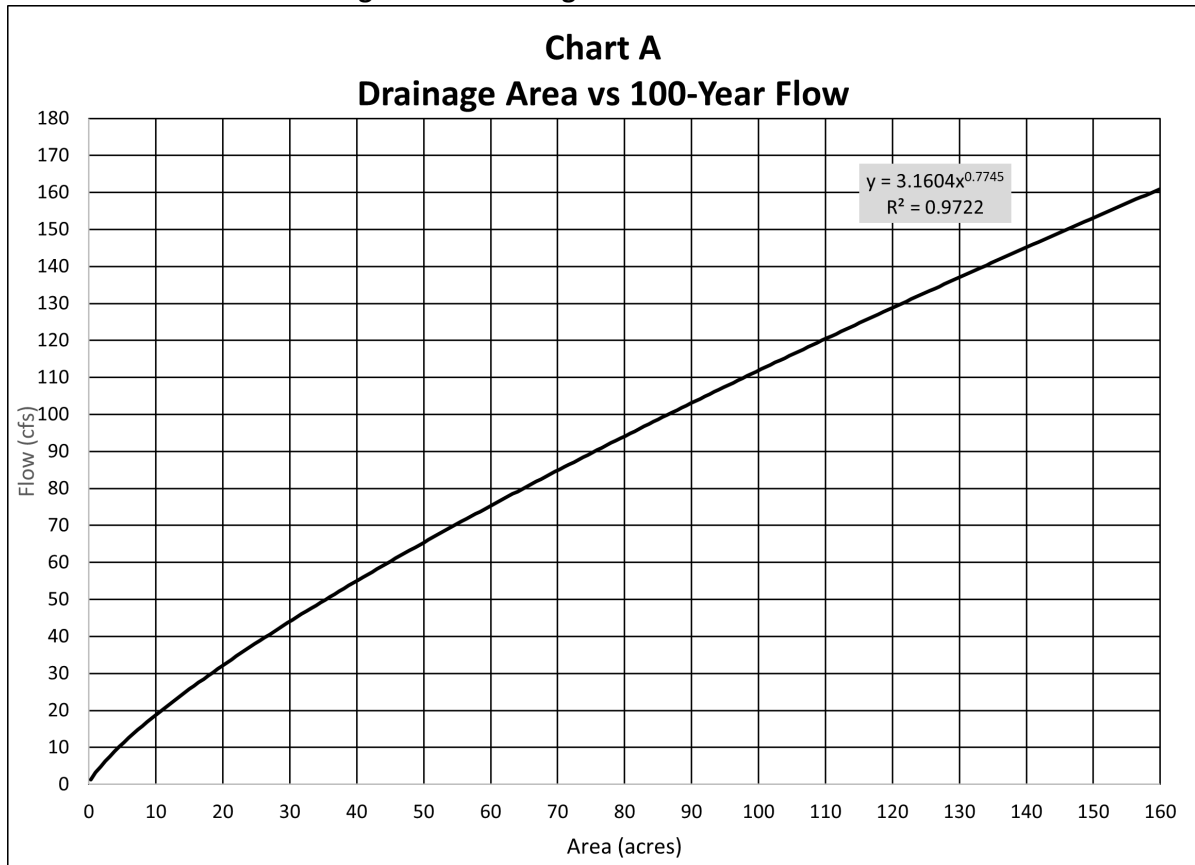


Figure 4-2 - Drainage Area vs 10-Year Peak Flow

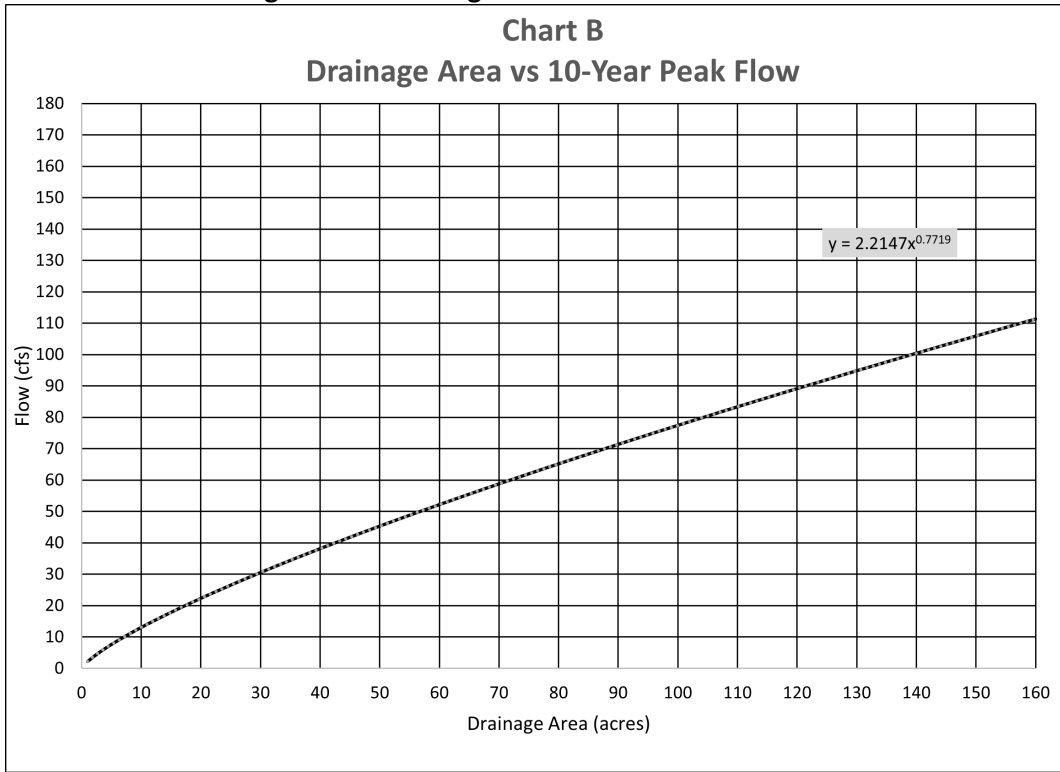
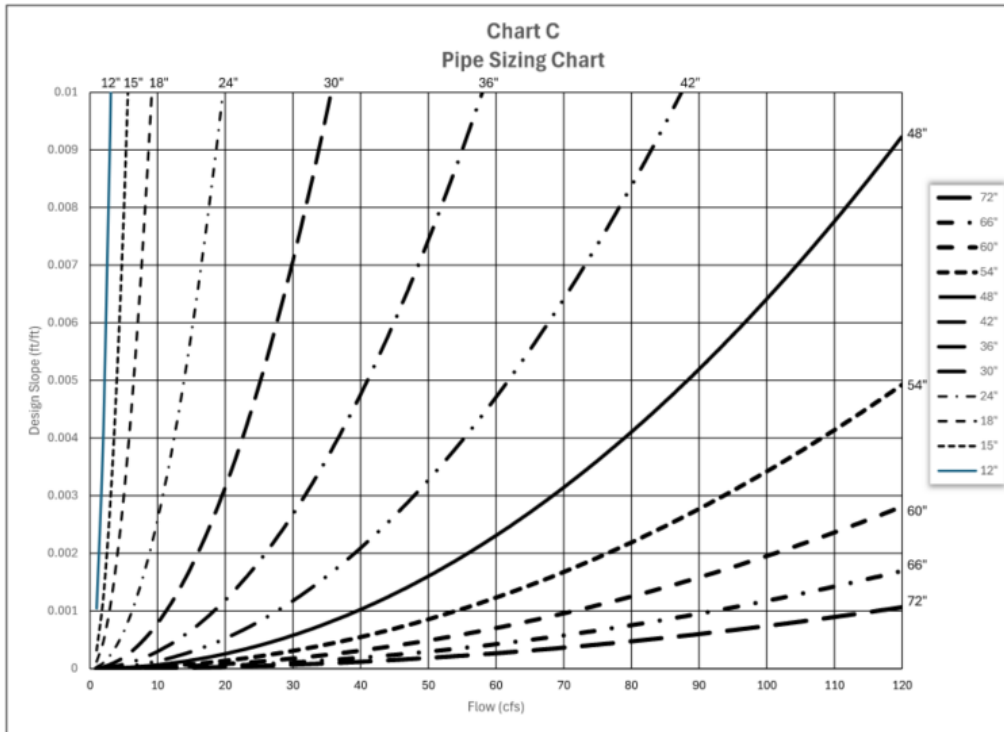


Figure 4-3 - Pipe Sizing Chart



## 4.03 HYDRAULICS

### A. GENERAL

1. All storm drain pipelines, and open channels shall be designed for the specified frequencies as described in the previous section. For the ten-year (10) frequency storm, storm drain pipelines shall be designed without static head at all entrances unless specifically permitted by the City Engineer. In no case will less than one (1) foot of freeboard be permitted between flow line of gutter and hydraulic gradient of the ten-year (10) frequency design flow for pipeline storm drain systems. In addition, under no circumstance shall the 100-yr HGL exceed the adjacent top face of curb elevation. In the case of a rural road, as defined within these Standards, the 100-yr HGL shall be contained within the road right-of-way. The 10- yr and 100-yr hydraulic grade line (HGL) shall be delineated on the plans at all drain inlets and manholes per Section 2 of these Design Standards.
2. An overland release path for flows generated by a hundred-year (100) frequency storm shall be clearly delineated on the plans. Under no circumstances shall the one hundred (100) year HGL exceed the adjacent top face of curb elevation. In case of rural roads, as defined within these Standards, the one hundred (100) year HGL shall be contained within the road right-of-way.

### B. DESIGN CRITERIA - The following criteria shall be followed in all hydraulic computations unless otherwise approved in writing from the City Engineer.

1. Manning's formula shall be used to compute capacities of all open and closed conduits other than culverts.
2. King's formula shall be used to compute capacities of all culverts. (Refer to King's Handbook of Hydraulics and California Department of Transportation nomograph for the solution of King's formula).
3. The "n" values to be used in Manning's formula shall conform to the following:
  - a. A roughness coefficient,  $n = 0.015$  is used for sizing conduits when no allowance is made for minor losses (head loss at inlets, bends, junctions, expansions, etc.). If minor losses are accounted for, a roughness coefficient,  $n = 0.013$  or per manufacturer's recommendations may be used.
4. Min. Inside Diameter - Twelve (12) inches.
5. Min. Velocity - Two (2) feet per second, when flowing full.
6. Max. Velocity - Based on pipe or channel conditions and available head. (Generally, twelve to fifteen (12-15) feet. per second for pipelines).
7. The Consultant Engineer, in the design of the system, shall account for all losses in head at junctions, bends, manholes, entrances, and outlets, and at any other location where a change in direction or restriction to flow occurs

which would tend to create a loss in available energy when required by the City Engineer.

#### **4.04 ALIGNMENT**

- A. PIPELINES - Pipelines for storm drainage shall be straight between manholes, junction boxes, and/or catch basins except under the following conditions:
  - 1. The inside pipe diameter is equal to or greater than twenty-four (24) inches.
  - 2. Minimum radius of curvature is equal to or greater than two hundred (200) feet. In no case will the radius of curvature be less than the manufacturer's recommendations for the particular pipe size under consideration.
- B. DRAINAGE PIPELINES - Drainage pipelines shall be located in the street whenever practicable. The location of storm drainage pipelines in new streets shall be six (6) feet north or west of and parallel with the centerline of the street, unless otherwise approved by the City Engineer. Meandering and unnecessary angular changes of pipelines shall be avoided. Angular changes in alignment shall be no less than ninety (90) degrees with the downstream section of the storm drain main.
- C. LATERALS - All laterals shall connect with the mainline at a manhole or junction box and shall have an alignment that provides an angle of intersection with the downstream section of the storm drain main of no less than ninety (90) degrees, unless otherwise approved by the City Engineer.
- D. JOINT DEFLECTION - Joint deflection shall not exceed eighty (80) percent of the manufacturer's recommendations.
- E. PIPE DIAMETER - When a change in pipe diameter occurs, the top-of-pipe elevations of the inflow and outflow pipes shall match whenever practicable.

#### **4.05 COVER REQUIREMENTS**

- A. ALIGNMENTS
  - 1. All storm drainpipe alignments shall be designed to allow a minimum of two (2) feet of cover as measured from the top of finished grade to the exterior top of pipe. If, for sound engineering reasons, two (2) feet of cover cannot be obtained, the pipe shall either be encased in concrete or provided with a concrete cover as approved by the City Engineer.

#### **4.06 APPURTENANCES**

- A. MANHOLES
  - 1. All storm drain manholes shall be constructed in accordance with the Standard Details.

2. Manholes shall be located at junction points, lateral connections, changes in pipe grade, changes in conduit size, and on curved alignments at the BC and EC of the curve and at no more than three hundred (300) foot intervals along the curve. For straight alignments, the spacing of manholes shall not exceed five hundred (500) feet.
  3. At manholes, whenever a change in the size of pipe, or a change in the alignment of twenty (20) degrees or more occurs, the flow line of the incoming pipe shall be a minimum of twelve hundredths (0.12) of feet above the flow line of the outgoing pipe. If there is a change in pipe size or a lateral entering the manhole, the top of pipe of the incoming pipes shall match the outgoing pipe in accordance with Section 4.04E, unless otherwise approved by the City Engineer. The invert elevations in and out of the proposed manhole shall be shown on the improvement plans.
- B. JUNCTION BOXES - Junction boxes shall be constructed in accordance with the Standard Details. Junction boxes constructed on storm drainage conduits greater than sixty (60) inches in diameter shall be of special design requiring written approval by the City Engineer.
  - C. SADDLE MANHOLES - All saddle manholes shall be constructed in accordance with the Standard Details. Saddle manholes will be allowed to be constructed on storm drain conduit thirty-six (36) inches or greater in diameter provided that no junction exists with any other storm drain conduit at the manhole as determined by the City Engineer.
  - D. CATCH BASINS/INLETS - Catch basins/inlets shall conform to the Standard Details. Catch basins/inlets shall be designed and spaced such that they intercept and fully contain the ten-year (10-yr.) storm with one (1) foot freeboard per Section 4.03A above. Catch basins/inlets shall be installed so that the length of flow in the gutter does not exceed five hundred (500) feet. All catch basin/inlets shall be stamped with the Storm Drain Marker as shown on Std. Detail 306.
  - E. SIPHONS - Inverted siphons will not be permitted, unless approved by the City Engineer.
  - F. VALLEY GUTTERS - Valley gutters are only allowed within public alleys and will not be permitted to cross any street, unless approved by the City Engineer.
  - G. SUBDRAINAGE - Subdrain facilities shall be provided when required by the City Engineer.
  - H. BOX CULVERTS - Box culverts may be used when designed on an individual basis and approved by the City Engineer.
  - I. HEADWALLS, WINGWALLS, ENDWALLS, ETC. - Shall be considered on an individual basis, and in general, designed in accordance with Section 51 of the State Standard Specifications.
  - J. DRAINAGE PUMP STATIONS - May be permitted on an individual basis with the written approval of the City Engineer.

#### 4.07 OPEN CHANNELS

- A. DEFINITIONS - For the purposes of these Design Standards, a ditch shall be classified as an open channel when its capacity exceeds twenty-five (25) CFS. Open channels conveying less than twenty-five (25) CFS are considered bench drains or diversion ditches as detailed in Section 4.09 of these Design Standards.
- B. DESIGN CRITERIA - Drainage may not be conveyed through a development in open channels without the written approval of the City Engineer. Open channels shall be designed in accordance with the following:
  - 1. Velocity range shall be two and a half (2.5) to six (6) feet per second in unlined open channels and three (3) to twelve (12) feet per second in lined open channels.
  - 2. Channel lining shall be either finished concrete, sacked concrete, or doweled and sacked concrete. The minimum weight of burlap sack concrete bags shall be a minimum of sixty (60) pounds unless otherwise approved by the City Engineer.
  - 3. All open channels shall be designed to carry the one-hundred-year (100) frequency flood. Per Section 4.02, the hydraulic grade line of the ten-year (10) and one-hundred-year (100) storms shall be calculated and plotted on all channel profiles. All computations, including a narrative of the design shall be clearly documented and submitted to the City Engineer for approval.
  - 4. Freeboard shall be a minimum of two (2) feet for the one-hundred-year (100) event or comply with the latest FEMA regulations, whichever is greater.
  - 5. Side slopes shall be three (3) feet horizontal to one (1) foot vertical or flatter and the minimum bottom width of the channel shall be twice channel depth.
  - 6. Profile of existing channels or other drainage conveyances for a minimum of one thousand (1,000) feet at each end of the development shall be shown on the construction plans to establish an average profile grade.
  - 7. Easement widths shall not be less than the width of the channel plus four (4) feet on one side and fourteen (14) feet on the opposite side. A twelve (12) foot wide gravel road, serviceable for year-round use, shall be constructed along the fourteen (14) foot side of the channel.
  - 8. Special headwalls, end walls, reinforced concrete transitions to culvert crossings, riprap, concrete aprons, energy dissipators, and other hydraulic devices shall be installed where required. All such devices shall be shown on the plans and approved by the City Engineer prior to construction.
  - 9. All open channels may be fenced or otherwise designed to prevent unauthorized access and include safety devices as required by the City Engineer and City Fire Department.

#### **4.08 ROADSIDE DRAINAGE DITCHES FOR RURAL ROADS**

##### **A. DESIGN CRITERIA**

1. Ditches shall be designed in accordance with Section 4.02 of these Standards.
2. Roadside ditches shall not drain more than fifteen hundred (1,500) feet parallel to the roadway.
3. Ten-year (10) storm hydraulic gradients for roadside ditches shall be shown on the plans and shall be below the roadway structural section.
4. Driveway culverts shall be sized according to hydraulic calculations. Minimum size for the culvert shall be twelve (12) inches and a minimum length which extends one (1) foot beyond the edge of driveway fill at the invert of the ditch. The driveway culvert shall be Class IV RCP or approved equal.

#### **4.09 BENCH DRAINS AND DIVERSION DITCHES**

- A. DEFINITION - A ditch shall be considered a bench drain or diversion ditch as long as its design capacity does not exceed twenty-five (25) CFS. Any ditch with a capacity greater than twenty-five (25) CFS, shall be considered an open channel and designed in accordance with Section 4.07. Diversion ditches will be allowed only upon approval of the City Engineer.
- B. DESIGN CRITERIA - Bench drains and diversion ditches shall be concrete lined and designed in accordance with the following:
1. Velocity range shall be three (3) to twenty (20) feet per second.
  2. At changes in alignment and at inlets, adequate measures such as banking, circular curves, or energy dissipators shall be used to confine water to the channel.
  3. At locations where the overflow of a bench drain or diversion ditch could cause flooding, erosion, or other damage, the channel section shall be designed to carry the one hundred (100) year runoff event.

#### **4.10 EASEMENTS**

- A. REQUIREMENTS - Publicly owned drainage conduits and channels will not be allowed on private property unless they lie within a dedicated public easement. Where minor improvement of a drainage channel falls on adjacent property (such as daylighting a ditch profile) written permission from the adjacent property owner(s) for such construction shall be required. A copy of the document, which grants approval, shall be submitted to the City Engineer prior to the approval of the improvement plans.
- B. WIDTH
1. Easements for closed conduits shall meet both of the following width criteria:

- a. Minimum width of any easement for a closed conduit shall be fifteen (15) feet.
  - b. All easements for closed conduits shall have a minimum width equal to the required trench width according to the standard detail for trench backfill plus two (2) additional feet of width for every foot of depth of the pipe as measured from the bottom of the pipe to finished grade. All conduits shall be centered within their easements.
2. Drainage easements for open channels shall have sufficient width to contain the open channel plus a fourteen (14) foot wide right-of-way width on one side and a four (4) foot wide right-of-way on the opposite side. The toe of an exterior bank shall not be within five (5) feet of an easement boundary. Easement boundary lines shall, at changes in alignment, have a radius sufficient enough to provide turning room for vehicles operating on the service road.

#### **4.11 IMPROVEMENTS REQUIRED TO MEET STATE MS4 PERMIT REQUIREMENTS**

The California Phase II MS4 permit, and the City of West Sacramento require project proponents to incorporate into its design required post-construction measures that reduce the volume of runoff and mitigate pollutants in runoff of the proposed development project. All improvements required to be incorporated within the proposed project shall be designed, constructed, and maintained in accordance with the City Post-Construction Standards Plan.