

**SECTION 9  
STORM DRAINAGE DESIGN**

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## SECTION 9 STORM DRAINAGE DESIGN

### 9-1 DEFINITIONS

The following terms, abbreviations, or definitions shall apply, and the intent and meaning shall be interpreted as stated herein wherever they are encountered in these Standards or in any documents or instruments referenced by these Standards.

10-Year Storm	A storm with a ten percent chance of being equaled or exceeded in any given year.
100-Year Storm	A storm with a one percent chance of being equaled or exceeded in any given year.
Adverse Impact	An impact that can be measured by an increase in flood stages, flood velocity, and flows, to an extent including but not limited to an increase in base flood elevation equal to or greater than 0.1 foot on upstream, downstream, or adjacent properties. Increases in base flood elevation less than 0.1 foot are considered adverse impacts if existing structures are flooded or if flooding of existing structures is exacerbated. Also, the potential for erosion and sedimentation, degradation of water quality, or increased cost of public services. This definition is supplemental to the County of Sacramento Floodplain Management Ordinance definition.
ASTM	American Society for Testing and Materials.
Base Flood	A flood that has a one percent chance of occurring in any given year (also called the “100-year flood”).
Base Flood Elevation	The water surface elevation of the base flood. For the purpose of these Standards, this includes the highest water surface elevation from any source of flooding determined by engineering analysis, measured high water, or Flood Insurance Rate Map (FIRM).
CLOMA/LOMA	Conditional Letter of Map Amendment / Letter of Map Amendment issued by the Federal Emergency Management Agency (FEMA).
CLOMR/LOMR	Conditional Letter of Map Revision / Letter of Map Revision issued by FEMA.

Consulting Engineer	The engineer of record in responsible charge of the design of improvement and/or grading plans, as defined by the California Board for Professional Engineers and Land Surveyors.
County	The unincorporated County of Sacramento.
Credit Agreement	An agreement identifying eligible trunk drainage credits taken against drainage impact fees as outlined in the County of Sacramento Water Agency Code Title 2.
Director	Director of County of Sacramento Department of Water Resources.
SacDOT	The County of Sacramento Department of Transportation.
Drainage Easement	A dedication, condemnation, or reservation of an area of land for drainage purposes.
Federal Flood Zone	An area at risk of flooding as determined by the FEMA FIRMs.
FEMA	Federal Emergency Management Agency.
FIRM	Flood Insurance Rate Map.
Freeboard	The vertical distance measured from the design water surface elevation or Base Flood Elevation to the top of bank or other critical grade adjacent to or at channels or basins, or to the ground elevation over the design water surface elevation in an underground storm drain system. Freeboard is used as a factor of safety usually expressed in feet.
Greenfield Development	Development on previously undeveloped parcels in suburban or non-urban locations with limited existing infrastructure and development.
Interim Facility	A temporary facility that is constructed pursuant to these Standards and that will be abandoned in the ultimate condition.
Local Flood Zone	An area possessing a flood risk in the Base Flood and is not defined on a FEMA FIRM.

Master Plan	A plan that meets the parameters and intent of the Specific Plan statutes contained in the California Government Code, which requires a land use plan, a circulation plan, an infrastructure plan, and implementation measures.
NFIP	National Flood Insurance Program.
Nolte Method	County of Sacramento design standard for sizing storm drain pipes.
NPDES	National Pollutant Discharge Elimination System.
Overland Release	A drainage feature that allows the passage of surface floodwater through a development in a manner to protect structures.
Pad Certification	A signature block, certifying that final graded elevations in the field are the same as those shown on the plans, within two-tenths of a foot. Also, a signature block, stating that the pad was graded in substantial conformance with the geotechnical report if provided and as further defined in Section 10 of these Standards.
Right-of-Way	A strip of land dedicated, condemned, or reserved for public use.
SacCalc	Sacramento calculator is a Microsoft Windows-based application using the Nolte Method, the Sacramento Method preprocessor, and the US Army Corps of Engineers Hydraulic Engineering Center HEC-HMS hydrology software. A free program download is available at ( <a href="http://www.waterresources.sacounty.gov">www.waterresources.sacounty.gov</a> , search for SacCalc).
SCWA	Sacramento County Water Agency, a statutorily created district operating under the authority of and pursuant to the provisions of the Sacramento County Water Agency Act (West's California Codes, Water Code Appendix, Chapter 66, commencing at Section 66-1, et seq.; Deering's California Codes, Water, Uncodified Acts, Act 6730a).

Specifications	County of Sacramento Standard Construction Specifications.
Standards	These storm drain design standards.
Through Drainage	A storm water conveyance that accepts drainage from one or more offsite properties.
Trunk Drainage	Drainage facilities that serve a watershed area of thirty (30) acres or greater.
Urban Level of Flood Protection (ULOP)	The level of flood protection that is necessary for new development to withstand a 200-year storm event in accordance with criteria developed by the State of California Department of Water Resources.
Water Resources	For the purposes of these Standards, the County of Sacramento Department of Water Resources.
Zone 11	An area designated within the SCWA boundaries created to finance trunk drainage systems (see Titles 1 and 2 of the SCWA Code). Zone 11 is subdivided into various subzones described in Title 2 of the SCWA Code.

## 9-2 GENERAL POLICIES

- A. The planning, design and construction of public drainage facilities shall comply with these Standards.
- B. It is the intent of Water Resources to require that all standards and policies described in this document are satisfied and to consider alternatives when standards and policies cannot be satisfied due to physical constraints. In such situations, Water Resources will evaluate alternatives presented by the Consulting Engineer to ensure the intent of the standards is met.
- C. Water Resources shall decide all questions of interpretation of "good engineering practice," guided by the standards and manuals of the discipline in question and matters of County policy.
- D. In addition to these Standards, other specific requirements for the design and construction of drainage facilities are set forth in the County of Sacramento Standard Construction Specifications, the County of Sacramento Hydrology Standards (Hydrology Standards), the Sacramento County Water Agency Code Titles 1 and 2, the Stormwater Quality Design Manual for the Sacramento Region (Stormwater Quality Design Manual), the County of Sacramento Department of Water Resources Plan Submittal Take-in Checklist, the County of Sacramento Local Hazard Mitigation Plan, and the County of Sacramento Floodplain Management Ordinance.

- E. The latest adopted version of these Standards and all external documents referenced herein or their respective successor documents shall be used for design.
- F. All submitted plans and documents shall be stamped and signed by a registered California Professional Engineer (Civil, Structural, Geotechnical, etc. as appropriate) prior to approval and all work shall be in accordance with these Standards and good engineering practice. The unsigned stamp shall be displayed on all sheets during the plan or document review process.
- G. Regional channel and/or basin improvement plans shall be titled, and the facilities labeled, consistent with the facility title in the approved subdivision improvement or grading plan.
- H. All public drainage facilities shall be located within the County's right-of-way when possible. Adequate right-of-way and/or easements shall be required to provide access for installing, repairing, maintaining, improving, operating, constructing, and reconstructing on- and off-site drainage facilities.
- I. Existing storm drain facilities outside the public right-of-way that will be abandoned due to proposed improvements must be completely removed or filled with Controlled Low-Strength Materials (CLSM). Abandonment of existing facilities within the public right-of-way shall be pursuant to the Specifications.
- J. The design of a new storm drain system shall include consideration of the downstream creek or storm drain facilities in accordance with Section 9-8B of these Standards. The Consulting Engineer shall show that the existing storm drain system can convey flows from the proposed development without adverse flooding, erosion, or other water quality impacts to upstream, downstream or adjacent facilities or areas; or that such facilities or areas are being improved or protected to the point where the drainage can be conveyed without Adverse Impacts. Alternatively, the project may mitigate onsite and demonstrate that the existing conditions downstream are not worsened by the proposed development.
- K. All new structures shall be protected from the Base Flood. When pad certification is required, pad elevations shall be set at least one and two tenths feet (1.2') above the Base Flood Elevation or as required by the latest version of the County of Sacramento Floodplain Management Ordinance, whichever is higher. See Section 9-14 of these Standards for additional information.
- L. Private storm drainage facilities shall be clearly noted on the plans. Maintenance responsibilities shall be described in a private drainage maintenance covenant to be provided in a form approved by Water Resources. Residential projects shall include provisions for maintenance of the private drainage facilities in the development's Covenants, Conditions and Restrictions (CC&Rs) or other similar recorded document.
- M. All proposed storm drain systems, private and public, shall be tested in conformance with the Specifications.
- N. Storm drain facilities shall be accepted prior to the issuance of building permits, unless it can be demonstrated that the site improvements will have no Adverse Impacts to the drainage conditions of the existing and proposed buildings.

- O. The design of stormwater quality facilities shall be incorporated for new and redevelopment projects in accordance with these Standards and the latest Stormwater Quality Design Manual.
- P. Retention facilities and Low Impact Development (LID) features that rely on infiltration to drain, though allowed for stormwater quality purposes pursuant to the Stormwater Quality Design Manual, shall not be allowed for flood control.
- Q. Water Resources may maintain public detention basins designed to meet only stormwater quality design requirements (runoff treatment, hydromodification, LID) if a funding source is provided by a park district, Home Owner's Association, CFD, or other appropriate entity other than Water Resources.
- R. Water Resources shall not maintain LID features within private residential lots.
- S. All overland drainage must enter and leave the project area at its pre-project location unless all potential offsite impacts are analyzed and mitigated to the satisfaction of Water Resources.
- T. Concentration of flows onto adjacent properties is not allowed without appropriate mitigation, including but not limited to:
  - 1. Mitigation for any Adverse Impacts due to increased flows.
  - 2. Energy dissipation/erosion control.
  - 3. Acquisition of offsite easements and construction of offsite drainage facilities.
- U. Project proponent shall provide copies of all resource agency permits prior to being final for review by Water Resources. Any concerns expressed by Water Resources regarding maintenance obligations described in the permits will need to be addressed in the permit prior to final approval by the resource agency.
- V. All storm drain pipe systems shall be designed to accommodate the ultimate development of the entire upstream watershed consistent with the best available zoning information for the upstream watershed and consistent with Hydrology Standards.
- W. All gravity drainage improvements shall drain freely to a daylight condition. No bubble-up systems are allowed within the public stormdrain system.
- X. Improvement plans utilizing phased facilities shall include design information for the ultimate planned facilities and shall include all future facility abandonments, or easements dedications or abandonments.
- Y. Drainage shed diversions shall not be allowed except in the rare circumstance where no other physical solutions are available. The shed shift may only be approved after an analysis has been performed by the Consulting Engineer and approved by Water Resources to identify and mitigate any potential Adverse Impacts.
- Z. Improvement Plans shall be consistent with applicable Master Plans. Deviations from the Master Plan may require a formal amendment in accordance with the latest County of Sacramento Master Plan procedures according to the County of Sacramento Planning Department.

AA. Any proposed or needed deviations from approved improvement plans related to storm drain facilities or other utilities that could affect existing or proposed public storm drain facilities, must be approved by Water Resources. The need for formal revisions to the County will be evaluated on a case-by-case basis in coordination with the County of Sacramento Construction Management and Inspection Division (CMID).

### **9-3 STORMWATER UTILITY ANNEXATION**

- A. At the discretion of Water Resources, parcels within the Urban Services boundary may be required to annex into the County of Sacramento Stormwater Utility and any applicable Community Facilities District prior to plan approval.
- B. At the discretion of Water Resources, parcels outside the Urban Services Boundary may be required to annex into the County Sacramento Stormwater Utility and any applicable Community Facilities District or form a benefit assessment district for drainage facility maintenance, prior to plan approval.
- C. Notice of Intent for Annexation must be heard by the Board of Supervisors as a condition of plan approval.

### **9-4 FEDERAL FLOOD PROGRAM**

- A. The County of Sacramento is a participant in the NFIP and all development in the County shall comply with FEMA regulations and the County's Floodplain Management Ordinance.
- B. These standards do not preclude additional requirements by the County, State, or Federal Government, to protect the public from projected flood runoff.

### **9-5 DRAINAGE FEES AND CREDITS**

- A. All developments in Zones 11A, 11B, and 11C, and all sub-zones of the SCWA are subject to payment of a drainage fee.
- B. The SCWA provides drainage fee credits for the construction of Trunk Drainage facilities, where the County requires such work, according to a predetermined credit schedule. Requirements regarding drainage fees and credits as well as an annually updated fee and credit schedule can be found in SCWA Code, Titles 1 and 2.
- C. Credit agreements must be prepared by Water Resources and signed by the property owner (with notary acknowledgement) before approval of improvement plans and payment of drainage fees.
- D. Request for drainage credits shall be made in writing to Water Resources and shall contain at a minimum the following:
  - 1. Jurisdiction where the project is located.
  - 2. Type of Project (residential, commercial, etc.).
  - 3. Owner name (as it appears on the grant deed), address, phone, business affiliation, and email address.
  - 4. Copy of Grant Deed.



5. Assessor's Parcel Number (APN).
6. How credits are apportioned among multiple parties and/or a list of APNs.
7. Total amount of drainage credits requested.
8. List of Trunk Drainage facilities with unit prices to be credited labeled as Exhibit "A".
9. Improvement plans for the Trunk Drainage facilities.
10. Vicinity map & diagram of facilities to be credited labeled as Exhibit "B".
11. Copy of Insurance Certificate.
12. Drainage study using the Nolte Method, approved by Water Resources, with exhibits showing which facilities are Trunk Drainage facilities based on watershed acreage. The drainage study shall show that APNs with credits apportioned to them are served by the Trunk Drainage facilities being credited.
13. Earthwork calculations and exhibits, approved by Water Resources, supporting cut and fill quantities.
14. Steel and concrete quantity calculations and exhibits, approved by Water Resources, for all creditable items (i.e., trash racks, outfall structures, etc.).

#### **9-6 DRAINAGE STUDY REQUIREMENTS**

- A. Drainage Studies consistent with current County of Sacramento Improvement Standards, Hydrology Standards, Floodplain Management Ordinance, Stormwater Quality Design Manual, and the Drainage Study Requirements document are required to identify and propose mitigation for any potential Adverse Impact due to the proposed development.
- B. Design-level studies (Level 4 as described in the Drainage Study Requirements document available online at <https://waterresources.saccounty.gov>) must be reviewed and approved by Water Resources before improvement plans can be accepted for review. Alternatively, the Water Resources parallel review process may be followed.
- C. Floodplains identified in approved drainage studies shall be shown and clearly labeled on the improvement plans (worst case from storm frequencies and durations described in the Hydrology Standards. Applicable frequencies and durations will be agreed upon during the scoping process described in the Drainage Study Requirements document).
- D. Water supply well sites that discharge pump-to-waste flows into the public storm drain system shall provide calculations to show the public system can convey standard design flows and pump-to-waste flows while meeting freeboard requirements (see section 9-8). Consulting Engineers have the option to increase pump-to-waste flows in dry weather by demonstrating that the pump-to-waste flows do not exceed the capacity of the public system and by providing a discharge schedule (dry and wet weather). Identified flow restrictions shall be documented in an agreement.

## **9-7 STORMWATER QUALITY**

- A. Improvement plans shall include a Post-Construction Stormwater Quality Plan for all projects required to incorporate stormwater quality measures, pursuant to the Stormwater Quality Design Manual.
- B. The Stormwater Quality Design Manual shall be used for the selection and design of multiple categories of post-construction stormwater quality control measures.

## **9-8 STORM DRAIN PIPES**

- A. Piped storm drainage conveyance is limited to watershed areas of 160 acres or the capacity of a seventy-two-inch (72”) pipe.
- B. Evaluation of existing storm drain pipes may be necessary when any of the following circumstances are present:
  - 1. A proposed development project requests a rezone to a higher density land use.
  - 2. Existing storm drain pipes downstream are smaller than twelve inches (12”).
  - 3. There are known flooding issues downstream.
  - 4. A project proposes a shed shift or change in pipe tie-in.
  - 5. A culvert connection to a storm drain pipe system.
- C. Storm drain pipe flows shall be determined using the Nolte design method. Pipe designs for flows larger than Nolte (i.e., 100-year) are not allowed unless it is determined by SacDOT that dry lanes along a given street/road are required during large storm events for emergency access, or when overland release is not feasible or lacks capacity due to physical constraints. In such cases, the Consulting Engineer shall provide a dynamic model of both the storm drain pipes and street sections, assuming 50% clogging of inlets, and extending down to the system outfall using an appropriate 100-year storm tail water.
- D. Pipe system hydraulics:
  - 1. Hydraulic grade line calculations for Nolte design flow calculations shall be determined using an acceptable pipe calculator (i.e., spreadsheet, or computer program), and shall begin at the highest 10-year water surface elevation in the receiving channel or basin. For existing downstream Nolte systems, at the discretion of Water Resources, water surface elevations may begin one foot (1.0') below the rim of a downstream manhole at a location specified by Water Resources.
  - 2. The hydraulic grade line along main storm drain pipes conveying Nolte design flows shall maintain a minimum of one foot (1.0') freeboard below manhole covers. For storm drain laterals within a typical road section, the hydraulic grade line shall maintain a minimum of half a foot (0.5') freeboard below the inlet grate elevation.
  - 3. The Consulting Engineer shall determine the hydraulic gradient in all drainage pipes except driveway culverts unless otherwise required by Water Resources.

4. Pipe system analyses shall use the Manning’s roughness coefficient ( $n$ ) values in Table 9-1 below. When friction and minor losses are not calculated in detail, values in the left column shall be used. When friction and minor losses are calculated in detail, values in the right column shall be used.

**Table 9-1:  $n$  values for closed conduits.**

Pipe Material	$n$ Value	
	Without Losses*	With Losses
Precast Concrete Pipe	0.015	0.012
Polypropylene Pipe (PP)	0.015	0.012
Polyvinylchloride Pipe (PVC)	0.015	0.012
High-density polyethylene (HDPE) **	0.015	0.012
Concrete Box Culvert - (within a closed conduit system) **	0.016	0.013
Concrete Cast-In-Place Pipe	0.017	0.014
Ribbed Metal Pipe **	0.015	0.013
Corrugated Metal Pipe 2-2/3" x 1/2" Corrugations **	0.024	0.024
Corrugated Metal Pipe 3" x 1" or 5" x 1" Corrugations **	0.028	0.028

\* Taken from *Modern Sewer Design Manual – Fourth Edition* 1999. \*\* For evaluation of existing systems only, not for use in new development.

5. The minimum Nolte flow velocity shall be no less than two (2) feet per second to prevent sedimentation buildup in the pipe unless otherwise specified by Water Resources.
  6. The maximum pipe flow velocity, at full-pipe capacity, shall be twelve feet per second (12 ft/s).
  7. Locations where flow transitions from supercritical to subcritical must be identified and special provisions must be implemented to manage the hydraulic jump. Special provisions shall be taken as necessary to prevent erosion, pipe displacement, and manhole lid surcharge.
  8. Trash-rack head losses shall be included in hydraulic calculations for trash-racks with less than a 4:1 area ratio (rack open area to drain area) and other critical situations as determined by Water Resources.
- E. Profile views shall be shown on improvement plans for all public storm drain pipes, displaying the Nolte hydraulic grade line elevation at each manhole/junction structure. If the storm drain pipe system conveys greater than Nolte flows, the design hydraulic grade line shall also be shown.
  - F. The storm drain pipe material and alternatives, pipe size, slope, invert elevations, and length shall be shown on the plan/profile sheets of the improvement plans.

- G. The nominal pipe size shall be no less than twelve inches (12").
- H. At locations where an outgoing pipe is larger than an incoming pipe, the upstream soffit must be at or above the downstream soffit.
- I. Publicly maintained underground drainage pipes shall not be connected to culverts. If connection is required, the culvert shall be replaced with an underground drainage pipe and appurtenances that meet these Standards and the Specifications.
- J. For ditch/channel and/or detention basin installations, all pipes at inlets and outfalls shall be concrete, and all inlets and outfalls shall be per Section 9-11 of these Standards.
- K. Material options (all allowed materials shall conform to the Specifications):
  - 1. Reinforced Concrete Pipe.
  - 2. Polyvinyl Chloride Pipe.
  - 3. Concrete Cast-In-Place Pipe (see the Specifications for minimum size allowed for Cast-In-Place Pipe).
  - 4. Polypropylene Pipe.
- L. Cover requirements:
  - 1. Minimum and maximum cover shall be pursuant to the Specifications and manufacturer's specifications respectively.
  - 2. For pipes with cover greater than 10 feet (10'), Water Resources may require manufacturer's specifications and/or calculations regarding maximum burial depth.
  - 3. At locations where the minimum cover requirements are not feasible, the stormdrain pipe shall be protected with a concrete cap (see the Specifications) with SacDOT approval if within the public right-of-way or other methods of pipe protection. For cover less than the thickness of the concrete cap per the Specifications, provide H-20 loading calculations stamped by a licensed Civil Engineer as part of the improvement plan submittal.
- M. Minimum and maximum trench width and depth shall be in accordance with the Specifications.
- N. Spacing and alignment:
  - 1. To ensure adequate compaction between multiple adjacent storm drain pipes, pipes shall be spaced so that their sides are no closer than two feet (2'). For parallel pipes larger than forty-eight inches (48") the spacing shall be no less than one-half (1/2) the nominal diameter. Spacing is measured from the outside pipe diameter.
  - 2. Special bedding and backfill considerations shall be taken when depths of parallel pipes vary.
  - 3. The location of storm drain pipes in new minor residential streets (see Section 4 of the Sacramento County Improvement Standards for definition) shall typically be three feet (3') north or west of and parallel to the centerline of the street, and six feet (6') north or west of and parallel to the centerline for larger streets.
  - 4. Storm drain pipes aligned under the street concrete gutter shall not be allowed.

5. Pipes shall be laid straight in both horizontal and vertical planes between junction structures (acute angles are not allowed). Horizontal curves and angular changes in direction may be allowed when necessary to conform to street alignment (with appropriate manholes/junction structures at angle changes).
  6. Pipeline Radius Criteria: All pipe placed on curves to match roadway alignments shall meet manufacturer's recommendations for curved alignment and documentation shall be submitted to Water Resources for review and approval. For all curved pipes, the curve radii, length of pipe joints, pipe material, and pipe diameter shall be shown on the plans. The minimum radius of curvature for concrete cast-in-place pipe shall be determined by the formula  $R = 30D$  where  $R$  = radius of curvature, and  $D$  = nominal internal pipe diameter, with  $R$  and  $D$  expressed in the same units.
  7. Utility facilities shall maintain a minimum vertical and horizontal separation from drainage pipes of one foot (1') and three feet (3') respectively when open trenching is used, and three feet (3') minimum for both horizontal and vertical separation when boring or jacking are utilized. Special provisions are necessary at utility crossings less than standard and are subject to approval by Water Resources.
- O. Pipe stubs shall be provided as required by Water Resources for potential future development and shall be designed as though they are permanent and installed as deep as possible to provide for future extension. Any inlet stub raised to grade shall use a Type F, standard manhole with a beehive grate, or other Water Resources approved catchments.
- P. All storm drain pipes, manholes, and fitting connections, including drain inlet laterals shall be designed to provide a water-tight seal in accordance with the Specifications.
- Q. A concrete-filled cutoff barrier shall be required at inlets and outlets where water may penetrate pipe backfill material. This shall be detailed on the improvement plans.
- R. Main drainage pipes may be located beneath traffic circles given that there are no proposed monuments, sculptures, fountains, trees, or any other ornamental feature within the circle that would interfere with maintenance access to the pipe. Landscaping within the circle shall be limited to what is allowed by Water Resources' standard drainage easements. Minor drainage pipes from storm drain inlets shall be placed a minimum of 3 feet (3', measured horizontally) outside traffic circles.
- S. Where a pipe is proposed to connect to an existing pipe, the existing and proposed pipe materials shall be shown on the improvement plans. If the pipes differ in material, a standard manhole or junction structure shall be provided at the connection.

## **9-9 STORM DRAIN INLETS**

- A. Curb inlets, or curb-and-grate combination inlets shall be installed for public streets.
- B. Inlets for public streets shall be placed so that the gutter length of flow does not exceed 500 feet, as measured from the upstream highpoint or inlet.

- C. Inlets in Class "A" and "B" streets shall be placed at lot lines in residential subdivisions. When it is not feasible for an inlet to be at the lot line, details shall be added to the improvement plans showing the clearance between the inlet, including curb transitions, and the proposed driveway.
- D. Inlets at curb returns shall be constructed so that they are outside of Americans with Disabilities Act (ADA) sidewalk ramps.
- E. Type F inlets shall be used in roadside ditches, swales, unimproved medians, and outside of the paved right-of-way in areas not subject to traffic. A manhole with a beehive cover may be used as an alternative to the Type F provided it has capacity necessary for the drainage shed.
- F. All connections to drainage inlets shall be on the face or side allowing for a minimum of 6 inches from the inner corner of the inlet. Connections to corners of drain inlets is not allowed.
- G. All alternatives to not exceed the maximum deflection angle for a standard boot connector, per the Specifications, must be exhausted before using monolithic connections.
- H. Improvement plans shall show on the plan and profile views the Specifications Standard Drawing number, grate elevation, and invert elevations for each proposed inlet type. Additionally, special details specifying undefined dimensions on referenced Standard Drawings must be included on the improvement plans.
- I. All new and replacement storm drain inlets on public rights-of-way, private property, and drainage easements shall include a "No Dumping- Drains to Creek" concrete stamp or other approved permanent marker on the curb, gutter, sidewalk, or concrete band adjacent to the drainage inlet in accordance with the Specifications.
- J. In addition to overland release analyses (see Section 9-14 of these Standards), inlet capacity calculations, assuming 50% clogging, shall be addressed in standard Nolte-flow applications in situations that involve any of the following:
  - 1. Street inlets on steep slopes (2% or greater), for which flow bypass could be significant.
  - 2. Inlets located at road sags, for which depth of ponding is a concern and/or with an approaching gutter longitudinal slope of 2% or steeper, the inlets shall be designed to account for additional bypassed flows from upstream inlets of at least 0.7 cfs/acre runoff.
  - 3. Inlets that will receive runoff from more than five (5) acres.
  - 4. Inlets associated with underground detention facilities.
- K. Inlet capacity calculations for curb, grate, and combination inlets shall be pursuant to the current version of the Hydraulic Engineering Circular No. 22 (HEC-22).
- L. Where additional inlet capacity is needed beyond a standard type C, B, J, or G inlet, a standard 300-1 or 301-1 inlet shall be installed.

## 9-10 MANHOLES AND JUNCTION STRUCTURES

- A. All connections to public storm drain pipes require manholes or junction structures pursuant to the Specifications and are subject to approval by Water Resources.
- B. Drainage inlets should not be used as junction structures. An exception is granted for private-public system transitions per Section 9-10C and given that the incoming pipe is 15 inches (15”) in diameter or smaller. In these circumstances, a standard inlet with a manhole access per the Specifications may be used as a junction structure.
- C. Manholes and junction structures for connection to the public storm drain system shall be located within the public right-of-way, Public Utility Easement (PUE), or drainage easement, and must be clearly labeled on the improvement plans as private-public transitions.
- D. Blind-tie connections to storm drain pipes are not allowed.
- E. Junction structures shall be standard pre-cast or cast-in-place manholes, saddle type manholes (allowed for cast-in-place pipe only) or special manholes or junction boxes (see section 9-10R of these Standards) as required and consistent with the Specifications. The design of special manholes and junction boxes must be submitted to Water Resources for approval.
- F. Manholes shall be sized to provide minimum wall spacing (concrete leg) between pipe core holes as described in the Specifications. Water Resources may require special plan-view details showing the manhole diameter, and pipe materials, pipe outer diameters, and angles between pipes to be shown on the improvement plans. For incoming pipes with different invert elevations, a side-view detail may be required.
- G. Manholes and junction structures shall be located at junction points, changes in horizontal and/or vertical direction, and changes in pipe size and/or materials.
- H. Spacing of manholes and junction structures along straight pipelines shall conform to Table 9-2 below.

**Table 9-2: Maximum allowed junction structure spacing along straight pipelines.**

Storm Drain Diameter (inches)	Maximum Spacing (feet)
12-15	400
18-36	500
>42	600

- I. On curved pipes, manholes and junction structures shall be placed at the beginning and end of the curved and spaced along the curve per Table 9-3 below. Exceptions to these spacing requirements shall be allowed if the resulting manholes or junction structures are within one hundred feet (100') of existing or proposed manholes or junction structures. There are no exceptions for required manholes or junction structures at the beginning and end of curves (see Section 9-8N of these Standards for when curved pipes are acceptable).

**Table 9-3: Maximum allowed junction structure spacing along curved pipelines.**

Curve Radius (feet)	Storm Drain Diameter (inches)	Maximum Spacing (feet)
<200	≥12	Determined on a case-by-case basis
200-400	≥12	300
>400	Use Table 9-2 for maximum spacing	

- J. All manholes and junction structures shall have standard manhole frames and covers consistent with the Specifications.
- K. Beehive grate manhole covers or Type F inlets per the Specifications shall be used in unpaved areas to accept minor drainage. Grate type manhole covers per the Specifications shall only be used in paved areas outside of roads if clogging is not a concern.
- L. Lids shall be bolted to the manhole or junction structure frames consistent with the Specifications at locations subject to system surcharge, including but not limited to, low points, shallow pipes, abrupt changes in longitudinal slope, abrupt changes in horizontal alignment, at the junction point of two or more incoming large pipes, and other circumstances where flow may transition from supercritical to subcritical based on modeling results. A pressure resistant manhole or junction structure design may be required by Water Resources at locations subject to high flow pressure.
- M. A standard flat top manhole (no cone) consistent with the Specifications shall be required when any pipe would otherwise enter the manhole in any portion of the cone section.
- N. A one-foot (1.0') sump is required for manholes within the public right-of-way with outfall pipes equal to or less than twenty-one inch (21") diameter. There shall be no sumps in public manholes outside of the public right-of-way.
- O. Utility facilities shall maintain a minimum horizontal clearance of four feet (4') to all manholes and junction structures. Utility crossings under storm drain manholes or junction structures shall not be allowed.



- P. Manholes and junction structures shall be placed outside traffic circles. When meeting this standard is infeasible, manholes and junction structures in traffic circles shall have no sump and the circle may be required to be designed to allow for maintenance vehicle access.
- Q. Manholes and junction structures placed adjacent to traffic circles shall have their base placed a minimum of three feet (3', measured horizontally) outside the traffic circle.
- R. Junction boxes may be used in situations where standard manholes cannot be constructed due to the size of the connecting pipes or other physical constraints, subject to the following requirements:
  - 1. Junction boxes shall be constructed of pre-cast or cast-in-place reinforced concrete with a minimum wall thickness of six inches (6"). The Consulting Engineer shall submit calculations stamped by a licensed Civil Engineer indicating the junction box is designed to withstand H-20 loading.
  - 2. The inside dimensions shall be such as to provide a minimum of six-inch (6") horizontal and vertical clearance to inner corners, and a minimum of twelve-inch (12") horizontal and vertical clearance between pipe cutouts.
  - 3. The minimum horizontal inside dimension shall be forty-eight inches (48").
  - 4. Junction boxes larger than ten feet (10') in any dimension shall have two standard manhole access points.
- S. The following shall be shown on improvement plans, at a minimum, for all public manholes and junction structures:
  - 1. The Specifications Standard Drawing number (plan and profile views) and size of the manhole (not needed when custom junction boxes are used).
  - 2. Stationing at the center of the barrel or box (profile view).
  - 3. Elevation of frame and lid assemblies when adjusting grade (plan and profile views).
  - 4. Size, elevation, orientation, material, and existing/proposed indication for all connecting pipes (profile view).
  - 5. The design HGL (profile view).
  - 6. Structural details for all design requirements described in Section 9-10 of these Standards.

## **9-11 HEADWALLS AND RACKS**

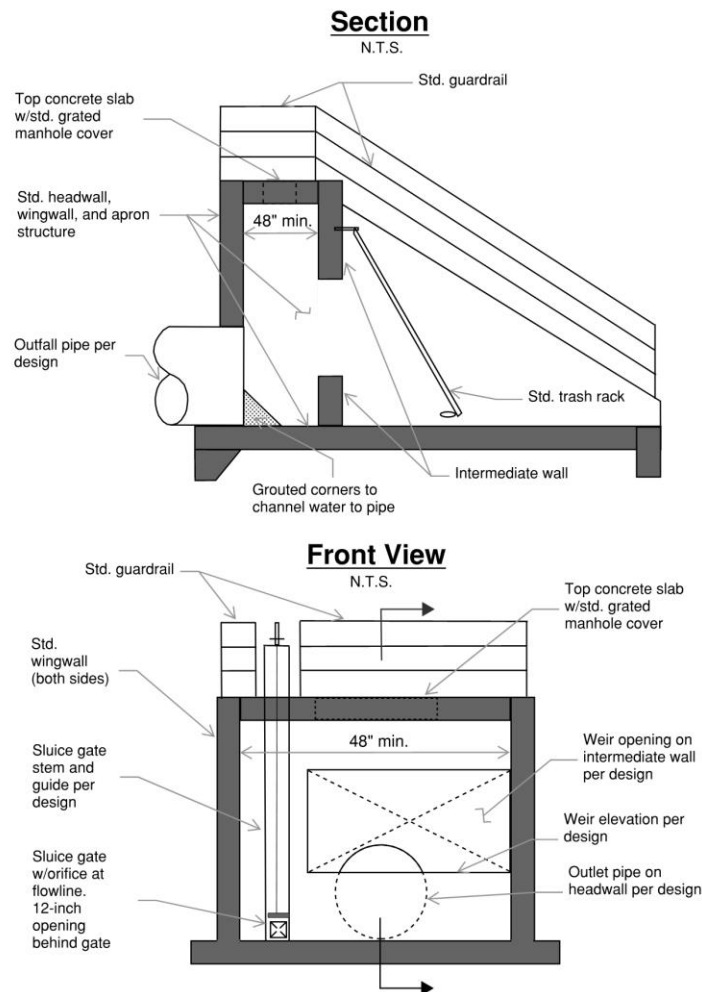
- A. Headwalls, flared end sections, and other entrance structures shall be designed to increase hydraulic efficiency, prevent erosion adjacent to the conduit and provide stability. Headwalls, flared end sections, and/or rock aprons shall be used at discharge points to prevent erosion.

- B. Where drainage systems discharge into a channel or basin, permanent erosion protection (rip rap) shall be installed and designed to accommodate the greater of the channel flow or pipe discharge and to dissipate energy. Slopes around headwalls, wingwalls, endwalls, trash racks, and other inlet and outlet concrete structures shall also be protected from erosion. Type of rock, rock apron dimensions, and placement methods shall be specified on the improvement plans. Sizing calculations by a licensed Civil Engineer may be required by Water Resources at locations subject to high flow velocities and forces.
- C. A flap gate may be used for backflow prevention. When used, the vertical face of the headwall shall be set back a sufficient distance from the channel side slope to allow a fully opened position without encroachment of the flap past the face of the channel side slope. An access control rack shall be required when flap gates are used.
- D. Outlet structures with flow control orifices shall be based on the Specifications Standard Drawings for headwall/wingwall/endwall structures and guardrails with the following modifications (see Figure 9-1 on page 9-19):
  - 1. An intermediate wall for the orifice, overflow weir, and trash rack. The minimum dimension between the headwall and the intermediate wall shall be 48-inches in both directions.
  - 2. A sluice gate for the orifice (required only for orifices smaller than six inches (6") in any dimension). The gate must be offset from the overflow weir to prevent damage to the stem structure. The orifice shall be on the sluice gate, and the minimum opening on the intermediate wall behind the gate shall be twelve inches (12").
  - 3. A top concrete slab between the headwall and the intermediate wall with a grated manhole cover per the Specifications standard drawings for access.
  - 4. Structural and component details for all modifications shall be shown on the improvement plans.
- E. Headwalls/wingwalls/endwalls and trash racks shall be required for pipes twenty-four inches (24") or larger in diameter and shall be designed in accordance with the Specifications. Any nonstandard headwall/wingwall/endwall configuration shall be shown on the improvement plans and are subject to approval by Water Resources. Structural calculations by a licensed Civil Engineer shall be provided for any nonstandard headwall/wingwall/endwall.
- F. Project specific dimensions for all headwalls/wingwalls/endwalls shall be shown on the improvement plans. Special details shall be provided on the improvement plans for nonstandard structures.
- G. The Specifications Standard Drawings shall be called out on improvement plans (plan and profile views) for all standard headwalls/wingwalls/endwalls and trash racks.
- H. For pipes less than twenty-four inches (24") in diameter pre-cast concrete flared end sections may be used at outfalls. At facilities accessible to the public such as basins, parks, and other open areas, pre-cast flared end sections may be used at inlets given that a trash rack acceptable to Water Resources is provided. A concrete filled cutoff barrier shall be required at inlets and outlets with flared end sections where water may

penetrate the pipe backfill material. Details shall be provided on the improvement plans.

- I. Trash racks shall be designed in accordance with the Specifications. When non-standard trash racks are necessary, they shall be designed such that the ratio of open rack area to drain opening is at least 4:1.
- J. Access control racks per the Specifications Standard Drawings shall be required at the outfall of pipes twenty-four inches (24") or larger and for all pipes that begin or end in a park, play field, residential property, or any other site used for recreation or open to the public.
- K. A metal beam guardrail pursuant to the Specifications shall be required at outfall structures, culverts, headwalls/wingwalls/endwalls, and box culverts that propose a drop of thirty-six inches (36") or more from the top of the structure to the flow line of the apron, and at steep side slopes. The location and extent of guardrails shall be clearly shown on the improvement plans.

**Figure 9-1: Outlet structure with flow control orifices schematic (not for use on improvement plans).**



## 9-12 CULVERTS

The following standards are applicable to culverts outside typical roadside ditches, that are within drainage easements, and/or that convey through drainage. For driveways crossing over typical roadside ditches (conveying runoff from the adjacent road and parcels only), the Consulting Engineer should contact SacDOT.

- A. Flows for culvert design shall be based on the Sacramento Method as described in the Hydrology Standards, and hydraulic analysis shall be performed using HEC-RAS or other computer software approved by Water Resources.
- B. Culvert analysis shall extend downstream of the culvert a sufficient distance to consider all downstream backwater conditions that could impact the performance of the culvert, and sufficiently upstream to ensure no Adverse Impacts upstream.
- C. Where no overland release is possible, the flow area of the culvert shall be increased by at least fifty percent (50%) above the size required to safely pass the 100-year flow. An analysis of the downstream system may be required to ensure the greater flow capacity of the culvert does not impact downstream properties. Greater flow area increases and/or other additional measures (i.e., trash racks, redundant barrels, evaluating bridge alternatives, etc.) may be required, at the discretion of Water Resources, for situations where the absence of a dedicated overland release path poses a risk to existing and/or proposed structures upstream.
- D. Where major roads are not to be overtopped, as determined by SacDOT, the culvert soffit shall have one foot (1') minimum of freeboard over the 100-year water surface elevation.
- E. The base flood water surface elevation shall be freely spanned by a bridge, with a minimum of one foot (1') of freeboard above the base flood elevation, whenever practicable.
- F. Culverts shall be designed to pass the 10-year design storm without overtopping the road.
- G. Culvert design computations shall include a description of the headwall, flared end section, or other entrance configuration at the upstream end.
- H. Culverts shall have headwalls or cutoff walls to prevent backfill erosion. Special details shall be included on the improvement plans.
- I. Field substitutes for changes of either culvert material and/or geometry shall require hydraulic analysis and submittal of an improvement plan revision to Water Resources for approval.

## 9-13 OPEN CHANNELS

The following standards are not applicable to overland release paths/channels. For overland release requirements, see Section 9-14 of these Standards.

- A. Open channels are required whenever the design flow rate exceeds the Nolte capacity (see Section 9-8) of a seventy-two-inch (72") pipe, the outfall is at an elevation such that minimum cover cannot be obtained over the pipe, and/or County, State or Federal Government policies necessitate open channels.
- B. Open channel design shall include a water surface profile analysis using the Army Corps of Engineers HEC-RAS computer program, or other hydraulics simulation program approved by Water Resources.
- C. The water surface elevation shall be determined for the 2-year, 10-year, and 100-year design storms pursuant to the Sacramento Method as described in the Hydrology Standards. The 200-year design storm may be required for projects subject to ULOP regulations. Flows shall be determined using the Sacramento method.
- D. Open channels shall be designed to convey the 100-year flood event with a minimum freeboard or one and two tenths of a foot (1.2'). Greater freeboard may be required depending on the sensitivity of the model, potential for obstructions, risk to surrounding property, and watershed characteristics.
- E. Super elevating the outside bank on bends may be required to maintain specified freeboard.
- F. Channels three feet or deeper shall be constructed to have a cross-section with a maximum side slope of 3:1 (H:V).
- G. The centerline curve radius of an open channel shall be designed according to flow characteristics: a minimum 3:1 ratio of curve radius to channel bed for subcritical (tranquil flow) and based on the Engineer Manual 1110-2-1601 by the U.S. Army Corps of Engineer for supercritical flow (rapid flow).
- H. Open channels shall have a bottom width of at least 6 feet (6').
- I. Channels shall consist of vegetated earth using native grasses or other vegetative ground cover subject to approval by Water Resources. Vegetation shall be established prior to the start of the wet season (October 1) or additional appropriate soil stabilization materials to prevent erosion in accordance with Section 11 of the Improvement Standards shall be placed on all graded areas. A note shall be added to improvement plans stating, "Vegetated open channels shall not be accepted by the County until 70% of the vegetation is established."
- J. Low-flow channels when needed, shall be designed to be self-sustaining so that little maintenance is required; and to take into account the ability of the soil to resist erosion and the meandering pattern that natural streams develop from both flood and low flows (sinuosity and channel belt width). The bottom width of the main channel shall be wide enough to avoid erosion of the side slopes due to migration of the low-flow channel.
- K. The Manning's roughness coefficient ( $n$ ) values used in open channel analyses shall conform to those in Table 9-4 below but may be adjusted based on good engineering practice if warranted due to the channel configuration or depth of flow.

**Table 9-4: *n* values for open channel analysis.**

Channel Surface	<i>n</i> Value
Concrete pipe	0.015
Corrugated Metal Pipe*	0.024
Concrete-lined channel	0.015
Earth Channel – straight and 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/stony/partial vegetation	0.060
Natural Channel – debris/pools/rocks/full vegetation	0.070
Floodplain – isolated trees/mowed grass	0.040
Floodplain – few trees/shrubs/weeds	0.080
Floodplain – scattered trees/shrubs	0.120
Floodplain – numerous trees/dense vines	0.200

Notes: Values above are from the Hydrology Standards. \*For evaluation of existing systems only, not for use in new development.

- L. The maximum velocity at design flow shall be as follows:
  1. Earth channels, three and a half (3.5) ft/s
  2. Bottom-lined channels, eight (8) ft/s
  3. Lined channels, ten (10) ft/s
  4. For sand and/or sandy silt and other erosive materials, refer to Engineer Manual 1110-2-1601 published by the U.S. Army Corps of Engineers.
  
- M. Rock armoring (riprap) shall be provided to prevent erosion at critical locations, including but not limited to, bends and unavoidable abrupt changes in flowline elevation. Type of rock, rock apron dimensions, and placement methods shall be specified on the improvement plans. Sizing calculations by a licensed Civil Engineer may be required by Water Resources for locations subject to high flow velocities and forces.
  
- N. Open channel design shown on improvement or grading plans shall be consistent with the corresponding approved Level 4 drainage study.

- O. Access requirements (all access features such as gates, ramps, road, etc. must be detailed on the improvement plans):
1. A primary fourteen-foot (14') wide asphalt service road having a twelve-foot (12') paved surface and one-foot (1') wide four-inch (4") thick aggregate base shoulders shall be provided adjacent to the top of bank, and a secondary ten-foot (10') wide eight-inch (8") thick aggregate base service road shall be provided on the opposite side of the channel adjacent to the top of bank. The structural section of the primary service road shall be three inches (3") of asphalt concrete over eight inches (8") of aggregate base. Curve radii shall be a minimum of forty-two feet (42') along the centerline. Turnouts shall be placed as required by Water Resources and shall be no greater than one-thousand feet (1000') apart. Use of alternative materials and/or alternative locations may be granted, subject to approval by Water Resources, for natural preservation areas or parks adjacent to the top of the banks. The top of bank is defined as the break point in the land which separates the channel bank from the adjacent stable land, excluding any unstable overhang which may exist because of channel erosion.
  2. Service roads shall connect to the public right-of-way. Ingress/Egress easements shall be provided as needed.
  3. Service road transitions to streets shall consist of reinforced Portland concrete or asphalt concrete and shall conform to County driveway standards. For gravel/aggregate roads, there shall be a minimum of twenty feet (20') of concrete or asphalt surface between the gravel/aggregate surface and the public right-of-way.
  4. Access ramps from primary service roads are required for all channels on the upstream side of road crossings and other locations required by Water Resources, to allow for emergency and routine maintenance. Ramps shall be constructed per the Specifications.
  5. Fencing along top of banks and on the outer perimeter of service roads may be required if deemed necessary for public safety. Fencing including vehicular and pedestrian access gates shall be per the Specifications.
  6. Vehicular access gates shall be located a minimum of twenty feet (20') away from the street edge of pavement and be marked *No Parking and No Trespassing*.
  7. Pedestrian access gates may be required by Water Resources at outfalls and other critical locations.
- P. For all channels, constructed or natural, the following items shall be shown on improvement plans at a minimum:
1. Typical cross-sections clearly identifying at a minimum top of banks, side slopes, design water surface elevations, service roads, drainage easements, ingress/egress easements, and low flow channels and/or preserve/park/mitigation planting areas as applicable.
  2. Channel profile showing stationing, flowline (low flow channel and main channel must be specified if applicable), top of banks, hydraulic structures (bridges, culverts, weirs, etc.), design water surface profiles, and existing grades upstream and downstream.

3. Plan view showing cross sections and stationing consistent with the approved Level 4 drainage study, preserve areas/parks/mitigation plantings if present, permanent erosion control features, hydraulic structures, outfalls, trails, service roads and ramps, fencing and gates, overland release discharge points, crossings, signage, and all existing and proposed easements.
  4. A grading certification sheet for the proposed channel dimensions and elevations. The vertical tolerance shall be two tenths of one foot (0.2') and the horizontal tolerance is to be evaluated on a case-by-case basis depending on the sensitivity of the channel. Grading certification sheets shall be reviewed and approved by Water Resources prior to field acceptance.
- Q. If grading certification shows the channel facilities are not substantially consistent with the approved drainage study, the drainage study shall be revised to reflect the differences and submitted to Water Resources for review and approval prior to acceptance of facilities by the County. Should the revised drainage study identify Adverse Impacts, then the channel facilities shall be physically corrected to its approved design or an acceptable alternate design.

## **9-14 OVERLAND RELEASE**

Piped storm drain systems are not designed to convey peak flow from infrequent high intensity storm events. When pipes and inlets are clogged or overwhelmed, surface runoff will pond in low areas and flow overland along designated overland release paths.

- A. The Consulting Engineer shall provide overland release calculations for engineered overland release channels consistent with these Standards.
- B. Water Resources may ask for calculations by a Licensed Civil Engineer for overland release through roads/streets and residential parking areas in special circumstances such as, but not limited to, large overland flows concentrated on a single street or road, areas with reduced freeboard, or streets/roads with special emergency access requirements. For all other applications, overland release shall be evaluated using grading information shown on the improvement plans subject to these Standards.
- C. When required, overland release calculations shall adhere to the following:
  1. Overland release design flows shall be based on the 100-year design storm using the Sacramento Method as described in the Hydrology Standards.
  2. The 100-year design flow shall be calculated assuming the underground storm drain system is completely clogged and inoperable, and the water surface may be determine using simple open channel or weir calculations as appropriate. The Consulting Engineer may consider pipe capacity in overland release calculations if the analysis includes inlet capacity calculations assuming fifty percent (50%) clogging of the inlets, and dynamic modeling of both pipe and surface features using an appropriate 100-year storm tail water condition is provided up to the system outfall.
- D. Existing overland release control elevations for incoming off-site overland release flows shall not be raised.



- E. Depth of ponding in streets for the 100-year design storm shall not exceed one foot (1') above the gutter flowline. When required by SacDOT, ponding in streets used for emergency access shall be limited to keep the number one lane dry.
- F. The depth of ponding in parking and drive areas shall be limited to depths set by the Floodplain Management Ordinance.
- G. Building pads shall be at least one and two-tenths of a foot (1.2') above the overland release maximum water surface elevation, and buildings and structures constructed on raised foundations must have the finished floor at least one and one-half foot (1.5') above the maximum overland release water surface elevation. The stricter freeboard requirement between these Standards and the County of Sacramento Floodplain Management Ordinance must be used.
- H. In areas with steep terrain where roadways are above adjacent lots, the minimum pad elevation shall be evaluated based on an appropriate control elevation downstream. If the adjacent roadway meets the criteria in Section 9-14B, the Consulting Engineer shall demonstrate that overland release flows are contained within the roadway section or shall identify an adequate overland release route consistent with Section 9-14C.
- I. Engineered overland release channels shall have a concrete flowline.
- J. In residential areas, engineered overland release channels shall not split between property lines.
- K. Where overland release channels have side slopes greater than 3:1 (H:V), they shall have fencing or other barrier acceptable to Water Resources along the top of banks at locations where the depth of the channel exceeds three feet (3').
- L. Drainage easements shall be required for engineered overland release channels at residential developments. Drainage easements over engineered overland release channels at commercial/industrial developments may be required when residential overland release drains onto commercial/industrial development.
- M. A stamped concrete or epoxy affixed message "*EMERGENCY DRAINAGE RELEASE PATH - DO NOT BLOCK*" shall be placed at a minimum where the overland release path is outside the right-of-way. Details shall be included on the improvement plans.
- N. Improvement plans shall include sufficient information to clearly identify overland release paths and points of discharge including, but not limited to, on- and off-site flow directional arrows, proposed spots elevations and/or contours, highpoint and grade break elevations, proposed overland release discharge point and elevation, existing off-site spot elevations and/or contours at least 50 feet (50') from the project boundary or one hundred feet (100') when off-site grades are relatively flat, locations where through drainage enters the site, and special details for openings at fencing or walls to allow for overland release runoff to flow through.

## 9-15 DETENTION SYSTEMS

- A. Analysis of detention systems shall be based on the Sacramento Method (inflow hydrograph) to reduce peak outflow or meet other flood control objectives, and for determining the required appropriate storage and outlet control structure. Flood detention system designs shall be based on the worst-case storm duration, which may require an evaluation of both short and long-duration storms as defined in the Hydrology Standards (typically the 24-hour, 5-day, or 10-day durations). The detention system study and design shall be performed using an approved computer program.
- B. Surface flood detention basins for small public residential development (10 acres or less) are discouraged. For small public residential development, the Consulting Engineer shall first evaluate alternatives to detention basins including, but not limited to, flow attenuation using underground storm drain pipes and/or storing excess runoff on streets (see Section 9-14 of these Standards for maximum depth of ponding allowed) or other suitable depressed areas. If it is determined that a detention basin is needed for a small public residential development, then the Consulting Engineer shall discuss with Water Resources the design and location of the basin, which of the following standards should apply, and any other additional requirement based on site specifics.
- C. All detention basins shall be designed with a spillway (exceptions may be granted to pumped basins if it is demonstrated that a spillway is impractical) and shall have at least one and two tenths of a foot (1.2') of freeboard to the worst-case duration maximum 100-year water surface elevation. If the spillway is used as part of the design discharge, then freeboard is measured to the top of basin. If the spillway is used for emergency release, then freeboard is measured to the spillway elevation. Greater freeboard may be required by Water Resources based on project specifics and existing conditions downstream.
- D. In addition to requirements described above, the design of underground detention systems (storage vaults, oversized pipes, etc.) that discharge directly into a public storm drain system shall be conducted as follows:
  1. The Consulting Engineer has the option of, (1) dynamically model the system downstream to a point agreed upon by Water Resources and assuming an appropriate tailwater condition based on an agreed upon storm frequency and duration, or (2) configure the underground detention system to discharge at the corresponding Nolte flow.
  2. For the purposes of flood control, the storage available in the underground detention system shall be limited to the volume provided by the portion of the vault or pipe that drains by gravity and not by infiltration. For private systems with perforated vaults or pipes, the storage provided by gravel beds shall be neglected for flood control purposes.
- E. The water surface elevation used at the start of the surface flood detention basin sizing analysis shall be the highest water surface as described below and as appropriate for the purpose of the basin:

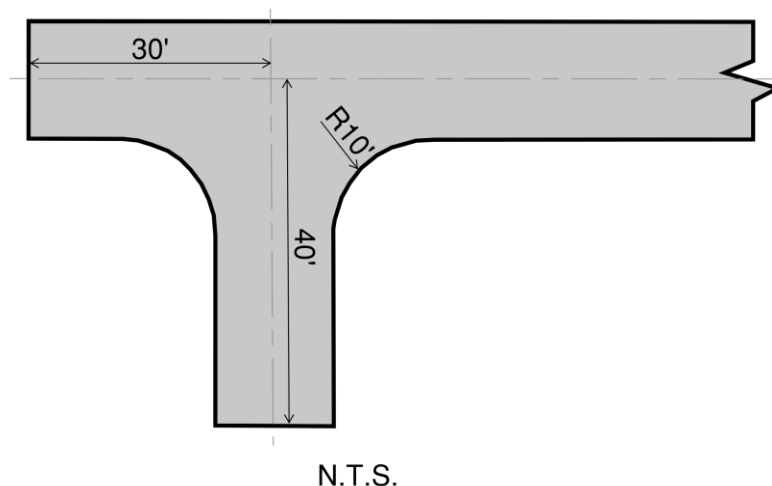
1. Gravity detention basin: for the purposes of flood control, the starting water surface elevation shall be based on a drawdown analysis of the 2-year, 10-day design storm run 12 hours past the end of the rainfall. Alternatively, the basin may be assumed to be full up to the spillway and allowed to drawdown for 12 hours.
  2. Public Gravity detention basins with flow control orifices/openings: orifices and openings smaller than six inches (6") in any dimension (rectangular, circular, notches) shall be assumed to be clogged and the associated volume shall be considered "dead storage" and unable to drain throughout the simulation. In this situation, the flood control drawdown analysis per Section 9-15E.1 above shall neglect orifices/openings smaller than six inches (6") in any dimension and the associated volume. For water quality drawdown and hydromodification analyses orifices smaller than 6 inches in any dimension may be assumed to remain open.
  3. Detention basins for pump stations (if allowed. See Section 9-18 of these Standards): For wet and combination basins the starting water surface shall be the higher between the water quality volume elevation and the water surface elevation per Section 9-15E.1 above the permanent pool.
- F. When a detention basin is designed adjacent to a developed area without designed overland release paths, the basin shall be designed to contain, consistent with Section 9-15C, the volume of the 100-year, 24-hour or 10-day design storm assuming fifty percent (50%) clogging of the outlet structure; or the 500-year, 24-hour or 10-day design storm assuming an open outlet structure; whichever is greater. The outlet control structure sizing shall be designed without the clogging factor.
- G. When allowed, detention basins with pump stations (see Section 9-18 of these Standards for when pump stations are allowed and for applicable requirements) shall be evaluated using the 100-year, 200-year, and 500-year design storms (24-hour, 5-day, and 10-day durations), and the detention volume shall be designed in conjunction with the pump station operation.
- H. Detention basins requiring stormwater runoff treatment volumes shall be analyzed and designed following procedures in the current Stormwater Quality Design Manual. Due to the need for a supplemental water source and the higher maintenance costs, publicly maintained wet and combination (wet/dry) basins are discouraged unless when required to accommodate a pump station.
- I. Detention basins designed to meet hydromodification mitigation shall follow the procedures in the Stormwater Quality Design Manual and the Sacramento Stormwater Quality Partnership Hydromodification Plan.
- J. Detention basins incorporating LID measures should follow the procedures in the Stormwater Quality Design Manual and are subject to approval by Water Resources. LID features within public detention basins shall be located away from the basin outfall structure and the basin access ramp. Mulch and other materials subject to flotation are not permitted within public flood control basins.
- K. Detention basins subject to groundwater intrusion shall be designed in accordance with the City of Sacramento Design and Procedures Manual.
- L. Detention basins maintained by the County shall have 3:1 (H:V) maximum side slopes.

- M. Detention basins subject to summer and/or nuisance flows shall include a concrete low-flow channel from the inlet of the basin to the outlet of the basin. The low-flow channel should be a vertical curb and gutter shape along the toe of the basin and shall discharge into a submerged gravel bed just upstream of the outfall structure. Sediment forebays, or other acceptable means of sediment capture, may also be required by Water Resources. All details regarding low-flow channels and forebays shall be shown on the improvement plans.
- N. Detention basin facilities shall be permanent and based on an approved design. Interim basin facilities may be allowed on a case-by-case basis subject to the following minimum requirements:
1. The design shall meet all standards as of a permanent facility and drain by gravity unless the ultimate design is for a pump station.
  2. An easement shall be required. To alter or abandon the facility in the future, this easement will need to be abandoned.
  3. A plan to abandon the interim facility or to expand it to its ultimate configuration shall be provided to Water Resources for review and approval.
- O. All detention basin facilities, including privately maintained basins, shall be encumbered by a drainage easement unless located in a parcel dedicated to the County. Drainage easements over privately maintained detention basin facilities are meant to prevent the removal or modification of these facilities without proper review and approval by Water Resources.
- P. Public detention basin facilities shall be designed with aesthetics in mind by installing landscape screening between the basin and the right-of-way with a minimum width of eight feet (8') or greater as required by the Sacramento County Zoning Code. No aesthetic features shall be located within the detention basin footprint or at maintenance access points. Aesthetic features outside of the basin shall be according to the landscape plans.
- Q. Maintenance of aesthetic features shall be funded and performed by a park district or other appropriate maintenance district.
- R. Vegetation shall be established prior to the start of the wet season (October 1) or additional appropriate soil stabilization materials to prevent erosion in accordance with Section 11 of the Improvement Standards shall be placed on all graded areas. A note shall be added to improvement plans stating, "Vegetated basins shall not be accepted by the County until 70% of the vegetation is established." Vegetation within the basin is limited to fast growing, local grass mix.
- S. Public detention basins shall be located within public park land where feasible and basins within private residential development shall be located within a Home Owners Association (HOA) owned parcel.
- T. Access requirements (all access features must be detailed on the improvement plans):

1. A primary fourteen-foot (14') wide asphalt service road having a twelve-foot (12') paved surface and one-foot (1') wide four-inch (4") thick aggregate base shoulders shall be provided adjacent to the top of bank. The structural section of the service road shall be three inches (3") of asphalt concrete over eight inches (8") of aggregate base. Curve radii shall be a minimum of forty-two feet (42') along the centerline. Service roads shall extend around the basin perimeter to provide access to all basin structures or shall extend to each structure individually with an area to turn around at the structures per Figure 9-2 on page 9-30. Use of alternative materials and/or alternative locations may be granted, subject to approval by Water Resources, for natural preservation areas or parks adjacent to the top of the banks.
  2. In situations where a public street or public paved trail are located adjacent to the top of the bank, a dedicated service road may not be required if the public street or public paved trail meet minimum requirements described in these Standards. If the basin is to be fenced, then dedicated service roads per these Standards are required between the basin and the fence.
  3. Service roads shall connect to the public right-of-way. Ingress/Egress easements shall be provided as needed.
  4. Service road transitions to streets shall consist of reinforced Portland concrete or asphalt concrete and shall conform to County driveway standards. For gravel/aggregate roads, there shall be a minimum of twenty feet (20') of concrete or asphalt surface between the gravel/aggregate surface and the public right-of-way.
  5. At least one access ramp from the service road to the basin bottom shall be provided to allow for emergency and routine maintenance. Ramps shall be constructed pursuant to the Specifications. Additional access may be required for maintenance based on Water Resources review of the detention basin configuration.
  6. Six-foot (6') steel tubular fencing consistent with the Specifications, is required along the top of the basin and on the outer perimeter of service roads, including vehicular and pedestrian access gates, for County-maintained basins. Post-and-cable fencing may be allowed for joint-use basins given that the land is owned by a Park District or HOA.
  7. Vehicular access gates shall be located a minimum of twenty feet (20') away from the street edge of pavement and be marked *no parking and no trespassing*.
  8. Pedestrian access gates may be required by Water Resources at outfalls and other critical locations.
  9. Additional access features may be required by and to the satisfaction of Water Resources at storm drain pipe outfalls.
- U. For all detention basin facilities, the following items shall be shown on a separate sheet within the improvement plans, at a minimum:
1. Typical cross-sections showing existing and proposed grades.
  2. Plan and profile for connecting outfall channel(s) or pipe(s), and for basin outlet structures.

3. Plan view clearly showing preserve areas/parks/mitigation plantings if present, permanent erosion control features, outfalls, outlet structures, trails, service roads and ramps, fencing and gates, overland release discharge points, vegetation, crossings, signage, and all existing and proposed easements.
  4. Stormwater quality, hydromodification, 10-year, 100-year, and any other required design storm water surface elevations, as applicable.
  5. Depth-volume-area rating curves for flood control and stormwater treatment consistent with the approved Level 4 drainage study.
  6. Grading certification sheet showing as-built dimensions and elevations to the satisfaction of Water Resources. The vertical tolerance shall be two tenths of one foot (0.2') and the horizontal tolerance is to be evaluated on a case-by-case basis depending on the sensitivity of the basin. Grading certification sheets shall be reviewed and approved by Water Resources prior to field acceptance.
- V. If grading certification shows the detention basin facilities are not substantially consistent with the approved Level 4 drainage study, the drainage study may be required to be revised to reflect the differences and submitted to Water Resources for review and approval prior to acceptance of facilities by the County. Should the revised drainage study identify Adverse Impacts, then the detention basin facilities shall be physically corrected to its approved design or to an acceptable alternative design.
- W. A project discharging to an existing detention or retention facility shall demonstrate with calculations and an as-built design analysis that the existing facility is designed and constructed to accommodate project-increased flows and/or volume of runoff. The analysis is not required if a prior Water Resources-approved drainage study shows the detention or retention facility was designed to accommodate the project.
- X. Detention basins shall not be designed as jurisdictional dams as defined by the California Department of Safety of Dams.

**Figure 9-2: Detention basin turnout schematic (not for use on improvement plans).**



## 9-16 DETENTION BASIN AND CHANNEL OPERATION AND MAINTENANCE MANUAL

- A. An operation and maintenance manual for basins and channels shall be required for review and approval by Water Resources prior to the approval of the improvement plans.
- B. Operation and maintenance manuals shall include the following at a minimum:
  - 1. A vicinity map and narrative describing the location of the basin and/or channel.
  - 2. A shed map of the area served by the basin and/or channel.
  - 3. Landscaping/plantings/irrigation operation and maintenance plan.
  - 4. A narrative describing the operation of the basin and/or channel (i.e., the basin provides flood detention and stormwater quality treatment, shed area served, peak flows, etc.).
  - 5. Basin and channel design documentation including the following at a minimum:
    - i. Pre- and post-project channel and/or detention basin topography.
    - ii. Cut and fill calculations and exhibits.
    - iii. A plat map depicting all easements and property lines overlaying the channel and/or detention basin.
    - iv. Legal descriptions of the property and all easements.
    - v. Depth-volume rating curves for flood control and stormwater treatment in accordance with approved drainage study.
    - vi. Design storm water surface elevations, and stormwater quality treatment and/or hydromodification water surface elevations.
    - vii. Inverts of inlets, outlets, and other hydraulic features.
  - 6. A map of the channel and/or detention basin identifying any jurisdictional or open space areas, plantings to be protected, etc.
  - 7. When there are overlapping requirements from other regulatory agencies, the documentation shall include a narrative describing what maintenance activities are acceptable and their frequency, and any prohibitions against maintenance activities within the basin or channel.
  - 8. For detention basins with stormwater quality features that require specialized maintenance, the documentation shall include detailed maintenance activities and their frequencies.
  - 9. Copies of all federal and state permits, preserve maintenance agreements, etc. that may limit maintenance activities in or around the channel and/or detention basin.
- C. A final operation and maintenance manual for basins and channels containing as-built documentation shall be required for review and approval by Water Resources prior to field acceptance of the facilities. The final manual shall be signed and stamped by a Licensed Professional Engineer.

**9-17 FLOOD PROTECTION BARRIERS**

- A. Any earthen or other material barriers that prevent flooding of low-lying lands shall be certified by a licensed Civil Engineer to meet CFR44 65.10 standards. This certification shall be required before acceptance of the drainage facilities conveying the flood flows, the barrier, or the development or improvements located within the low-lying lands being protected from flooding. Additional freeboard and setback requirements shall apply for areas subject to ULOP or other applicable regulations.
- B. A State-approved maintenance entity shall be secured for any earthen or other material barriers that prevent flooding of low-lying lands. The County shall not be appointed as the maintenance entity for any flood protection earthen or other material barriers.

**9-18 DRAINAGE PUMPS**

- A. Pumping stations shall not be allowed unless as a part of an approved master drainage study or in situations where a gravity system is not possible.
- B. Pumping stations, when allowed, shall be designed in accordance with the City of Sacramento Design and Procedures Manual in conjunction with operation criteria described in Table 9-5 below. Additionally, pump stations shall be designed to have duty pumps with the same capacity, one redundant pump, and stationary standby power generators on-site.

**Table 9-5: Pump station operation criteria.**

Storm Frequency	Storm Duration	Pump Operation	Peak Water Surface Criteria
10-year <sup>‡</sup>	All durations	Duty pumps 1 and 2 operating	For pipe design and setting elevation for 3 <sup>rd</sup> pump.
100-year	All durations	All duty pumps operating	Minimum 1 foot freeboard in basin and not to exceed 1 foot over street gutter flow line.
		One duty pump not operating.	Not to exceed building pad elevation.
500-year	All durations	All duty pumps operating	Not to exceed building pad elevation.

<sup>‡</sup>For the Natomas Basin only. For all other applications engineering judgment may be used to set the 10-year water surface elevation.

- C. Allowed drainage pumping plants shall be designed in accordance with the latest edition of the Hydraulic Institute Standards.
- D. When allowed, pump stations must be fenced with a minimum 7-foot-tall wrought iron or chain link fence per the Specifications with razor wire on top.



## **9-19 DRAINAGE ALONG CLASS C STREETS**

- A. Through drainage crossing development projects with class C streets, shall not be conveyed by roadside ditches. Exceptions may be granted on a case-by-case basis in situations where separating through drainage from roadside ditches is infeasible due to physical constraints. Roadside ditches allowed to convey runoff from through-drainage channels/ditches/swales shall be designed per sections 9-13 or 9-14 of these Standards as appropriate. For roadside ditches that convey runoff from the road and adjacent properties, the Consulting Engineer should contact SacDOT.
- B. To prevent end of pipe distortion, driveway culverts for roadside ditches conveying through drainage shall include a flared end section at the upstream and downstream ends or place a six inch (6”) thick concrete collar and headwall.

## **9-20 PRIVATE STORM DRAIN SYSTEMS**

- A. Private storm drain systems that connect to County-maintained drainage facilities shall have a standard manhole at the edge of and within the public right-of-way or drainage easement. The manhole shall be labeled as “private/public transition” on the improvement plans.
- B. Private storm drain systems serving single-family residential development shall be designed and built per these Standards.
- C. It shall be made clear on improvement plans which facilities are private.
- D. For commercial and multi-family private systems, a notarized private drainage maintenance agreement is required prior to improvement plan approval.
- E. For single-family residential private drainage systems, private drainage maintenance responsibilities shall be recorded in the covenants conditions and restrictions for each parcel or other similar recorded document.
- F. Commercial or industrial projects proposing a drainage system that supports upstream private commercial or industrial parcels shall enter into a joint use and maintenance agreement, to the satisfaction of Water Resources, including all parcels that drain through the private storm drain system. The agreement shall be recorded by the project proponent to the affected parcels prior to plan approval.

## **9-21 DRAINAGE EASEMENTS**

- A. Drainage easements must be wide enough to accommodate normal construction equipment and shall be easily accessible to such equipment as necessary to construct, operate, maintain and reconstruct the facility. The easement shall be dedicated to the County of Sacramento, Sacramento County Water Agency.
- B. Off-site drainage easements shall be required for projects that need off-site drainage improvements through private property.
- C. When off-site easements cannot be acquired through negotiation, the County may condemn necessary rights-of-way providing the person, firm, or corporation requesting such condemnation enters into a written agreement to pay all costs and expenses of the

- condemnation. The agreement shall require a cash deposit that will consist of the estimated cost of condemnation plus twenty-five percent (25%), plus soft costs. It shall require payment of all costs and expenses of the deposit as specified by the County. Any additional costs shall be paid to the County and funds not spent by the completion of the condemnation will be returned. Project proponents shall demonstrate to the County that all reasonable efforts to try to acquire off-site easement have been exhausted before the County considers condemnation.
- D. Dedication of drainage easements may be via Final Map or a Water Resources-approved easement document. Dedication of drainage easements via Parcel Map is only allowed to cover existing drainage features.
  - E. Trees, non-drainage structures (monument signs, guard sheds, storage units, barns, etc.), private utilities, private storm water quality features (runoff treatment, LID, hydromodification, trash full capture, and any other storm water quality feature required at the time of proposed development), and decorative/ornamental features shall be located outside of drainage easements.
  - F. All proposed and existing drainage easements shall be shown on improvement and grading plans. All recorded drainage easements and their number shall be shown on the record drawings. All required on- and off-site drainage easements shall be recorded prior to the approval of improvement and/or grading plans.
  - G. At the discretion of Water Resources, existing on-site drainage easements that are no longer needed may be required to be formally abandoned. Evidence that a complete abandonment application has been accepted by the County for processing shall be submitted to Water Resources prior to the approval of improvement and/or grading plans.
  - H. Easements for drainage pipes shall meet the following criteria:
    - 1. The minimum easement width shall be equal to the greater of fifteen feet (15') or the required trench width according to the standard detail for pipe bedding and initial backfill per the Specifications plus two feet (2') of additional width for every foot of depth as measured from the bottom of the pipe to finished grade.
    - 2. All pipes shall be centered within their easements.
  - I. Easements shall not be split along property lines.
  - J. Drainage easements for open channels and basins shall have sufficient width to contain the ultimate channel or basin, including fencing and access features (See sections 9-13 and 9-15 of these Standards).
  - K. Easements for flowage/floodplain shall be wide enough to contain the 100-year flood event.
  - L. Access easements may be required where drainage easements are not adjacent to the public right-of-way.