13.0 Introduction

This chapter summarizes evaluation methods and design criteria for flood control detention facilities, referencing the Storage chapter of the UDFCD Manual for much of the background information. Criteria presented in the UDFCD Manual shall govern except as modified or added to herein.

13.0.1 Stormwater Quality Considerations. Detention facilities are used both for attenuating peak flows during large flood events and for providing extended detention and sedimentation during small, frequent events to enhance stormwater quality. Extended detention facilities used for water quality management may be incorporated into flood control detention basins or kept separate, as discussed in this Chapter. Extended detention and other water quality best management practices are discussed in Chapter 14, Stormwater Quality, and in Volume 3 of the UDFCD Manual.

13.1 General Requirements

13.1.1 Detention shall be Provided for all New Development, Redevelopment and Expansion. SEMSWA requires that water quality capture volume and flood control detention be provided for all new development, redevelopment, or expansion of a site**.** Storage volume and release rate criteria are based on three design events, as follows:

1. Water quality capture volume (WQCV). This is defined in Volume 3 of the UDFCD Manual.

2. Excess Urban Runoff Volume (EURV). This is the difference between the developed and pre-developed runoff volume, a relatively constant value for a given developed imperviousness over a wide range of storm events.

3. The 100-year event.

Procedures for sizing detention facilities for these design events are discussed in Section 13.3. Facilities that combine the first two events or all three events generally do not require a separate design for WQCV; the WQCV and water quality release rate are “built in” to the Excess Urban Runoff Volume design.

Controlling the Excess Urban Runoff Volume (EURV) and releasing it at a negligibly small rate allows larger storms to be released at discharges and hydrograph shapes similar to predevelopment conditions. This approach matches predevelopment discharges over a wide range of events, especially in the frequent storms where urban runoff impacts are most evident. The approach has been termed “full-spectrum detention”, and is intended to reduce the flooding and stream degradation impacts associated with increases in peak, duration, and frequency of runoff from urban surfaces.

13.1.2 Compatibility of Full-spectrum Detention Policy with Former 10-year/100-year Criteria. The EURV and 100-year detention volumes based on the current policy are similar in magnitude to the 10-year and 100-year volumes associated with the former criteria (as long as WQCV is added to the UDFCD 100-year required volume). The main difference is that the EURV described in Section 13.3 is drained at a much slower rate than the 10-year detention volume was under the former criteria.

If master plans exist that recommend 10-year/100-year detention facilities, SEMSWA generally intends that these will be implemented as full-spectrum facilities; however, the final determination of detention policy will be by SEMSWA.

There may be opportunities to convert existing 10-year/100-year detention facilities into full-spectrum facilities by reducing the capacity of the 10-year control orifice to a EURV release rate, and ensuring that the debris grate for the EURV orifices and the 100-year outlet and emergency spillway for the facility are adequate.

13.1.3 Definition of Redevelopment, Expansion and/or Improvement. Redevelopment of a site occurs when a change in the property use and/or function is desired, and produces physical changes to the site. The redevelopment of a site shall require that onsite detention be provided for the entire site, including those areas that previously had not provided detention due to the site being developed prior to SEMSWA criteria and standards.

Expansion of a site occurs when additional area on the site is to be developed. The expansion of a site shall require that current SEMSWA standards for detention for the **entire site** are met, where feasible. There are two conditions that may arise for site expansion, depending upon whether or not detention has been provided for the existing site prior to expansion.

- Detention has been provided for the existing developed area. The new expansion shall require that additional detention be provided to accommodate the expanded development.
- Detention has not been provided for the existing developed area. Detention will be required for the full expansion and to the extent possible, for the existing site area that has previously been un-detained. SEMSWA will require that a reasonable attempt be made to provide detention storage for the previously developed, un-detained portion of the site.

13.1.4 Exemptions. Exemptions from the detention requirement may be granted for additions to existing buildings and paved areas, provided that the total impervious area of all additions (cumulative over the history of the site expansions) cover less than 2,500 square feet of impervious area and that no adverse impacts to downstream properties would be created by the additional undetained runoff.

Exemptions from the detention requirement may be granted for subdivisions which have individual residential lots that are 19 acres or larger in area, if it can be demonstrated that the development does not create adverse impacts on adjacent properties, and there are not existing drainage problems which may be exacerbated. It may be necessary for the applicant to provide analyses to demonstrate that the subdivision release rates will not cause downstream impacts.

13.1.5 Adjacency to Major Drainageway. It can be demonstrated and hydraulically modeled that for certain scenarios, the undetained release from a site adjacent to the major drainageway will "beat the peak" of the major storm event. It is recognized, however that onsite detention provides other benefits by reducing the more frequent lower flows which contribute to channel degradation and erosion, and by providing water quality benefits. It is also the SEMSWA's standard to recognize the "Reasonable Use Rule" in limiting the impact of developed flows onto downstream properties. SEMSWA's policy shall be to not allow the beat-the-peak analysis when considering onsite detention waiver requests for development adjacent to the major drainageway unless it has been planned as such, and approved in a SEMSWA adopted Master Plan.

13.1.6 Temporary Detention. Temporary detention shall be provided where permanent detention, such as in a regional detention pond is intended, but has not been constructed. Temporary detention shall be provided to ensure that the historical release rates have been maintained for the site. Temporary detention must meet all the standards set forth for permanent detention ponds. Easements to ensure the temporary detention are required.

13.2 Regional, Sub-regional, and Onsite Detention Facilities

There are three basic approaches for configuring detention facilities, as described below.

13.2.1 Regional Detention. Regional detention, as recognized by SEMSWA, refers to online facilities located on a major drainageway, with an upstream watershed area generally ranging from about 130-acres to one-square mile. Regional detention facilities are typically designed as a part of the watershed planning process, in which stormwater management needs for the watershed as a whole are developed in a staged, regional plan. Figure 13-1 provides a generalized illustration of a regional detention approach.

Because of their size, regional interaction with other watershed facilities and significance in floodplain management, regional facilities are not allowed to be privately owned. SEMSWA requires that all regional facilities be owned and maintained by a public agency such as the SEMSWA, a special district or another public entity which has the authority, expertise, and resources to provide the necessary inspections and maintenance. Regional detention facilities within the UDFCD district boundaries must be designed and constructed in accordance with the UDFCD maintenance eligibility program.

Compared to onsite facilities, regional detention facilities are typically more reliable, require less land area, and are more cost effective to construct and maintain. Regional facilities, being larger, can generally provide more favorable riparian habitat and offer greater opportunities for achieving multi-use objectives, such as combining with park and open space resources and connecting to trail systems.

Regional detention facilities meeting the requirements below may be recognized and included in hydrologic modeling of downstream major drainageways. Sub-regional and onsite detention facilities may not be recognized in the determination of flow rates for downstream major drainageways.

Generally, the following conditions shall be met for regional facilities within SEMSWA:

1. Regional detention facilities must be designed to accommodate the fully developed flows from the upstream watershed. Designing for upstream offsite areas is discussed in Section 13.3.2.

2. Regional detention facilities are required to be owned and maintained by a public entity with ownership and maintenance responsibilities clearly defined to ensure the proper function of the facility in perpetuity.

3. Regional facilities within the District must be designed, constructed and accepted for UDFCD maintenance assistance.

4. Drainage easements should be provided to the SEMSWA, so that SEMSWA may ensure that the facility is properly operated and maintained.

5. An Operations and Maintenance Manual is required to be prepared for the regional facility and accepted by SEMSWA. The Operations and Maintenance Manual shall be prepared in accordance with SEMSWA's requirements for O&M Manuals for Regional detention facilities, available on the SEMSWA website at www.semswa.org.

6. A Stormwater Facilities Maintenance Agreement must be provided for the facility.

7. The creation of a jurisdictional dam shall be avoided.

8. The facility must be permitted under applicable environmental permits and clearances.

9. Construction of the regional facility must be coordinated with development in the upstream watershed. If the regional facility has not been constructed, temporary onsite detention (and water quality) shall be required to be provided with development projects until the regional facility is available.

10. The drainageways upstream of regional water quality facilities must be stabilized in accordance with the criteria in Chapter 12 and Section 14.1, Step 3 *and* the upstream developments must implement reduced directly connected imperviousness to the levels identified in Section 14.2.2.

11. The drainage system that conveys flows to the regional facility shall be designed to accommodate fully-developed flows to the regional facility.

13.2.2 Sub-regional Detention. Sub-regional detention, as defined by SEMSWA, refers to facilities serving more than one lot that are not a part of the regional master-planned watershed system, and are typically located on a minor drainageway. The definition of a minor drainageway is discussed in Section 12.0.4. Figure 13-2 illustrates a typical sub-regional detention approach.

Sub-regional detention facilities may be constructed by a public entity such as a municipality or special district to serve several landowners in the upstream watershed or by a single landowner. It may be possible for a single landowner to construct a sub-regional facility that serves other properties, provided that the responsibilities for construction, operation and maintenance of the sub-regional facility are clearly defined and agreed to by all property owners. A maintenance agreement specific to the facility shall be required. Sub-regional detention offers many of the same benefits as regional facilities in comparison to onsite detention. As such, SEMSWA requires that new development implement regional or sub-regional detention at a subdivision level in lieu of onsite detention at the time each lot is developed.

SEMSWA reserves the right to approve any sub-regional detention facilities. Generally, the conditions listed in Section 13.2.1 for regional facilities shall be adhered to for sub-regional facilities, with the exception that sub-regional facilities need not be owned and maintained by a public entity. Requirements for clearly defining ownership and maintenance responsibilities, preparing an O&M Manual, providing adequate easements, and the other conditions listed for regional facilities are required for sub-regional detention facilities. SEMSWA reserves the right to require that sites upstream of sub-regional water quality facilities reduce directly connected impervious area to the levels identified in Section 14.2.2, depending on the impacts to receiving streams from undetained site runoff. This will be determined by SEMSWA on a site-specific basis.

13.2.3 Onsite Detention. Onsite detention refers to facilities serving one lot or a group of contiguous lots managed by a single entity, generally commercial or industrial sites draining areas less than 20 acres. SEMSWA prefers that regional or sub regional facilities be available to serve proposed development. In lieu of this availability, onsite detention may be allowed. Figure 13-3 illustrates a typical onsite detention approach.

Onsite detention facilities may not be recognized in the determination of flow rates for downstream major drainageways. Onsite detention facilities shall be designed for runoff from the site and any upstream offsite areas that are routed

into the pond. Generally, offsite flows shall not be routed through an onsite detention pond, but shall be routed around the pond. Section 13.3.2 describes criteria regarding offsite flows.

Integrating Detention in Landscape Areas. Locating detention basins in landscape areas generally works well, especially if ample space is reserved for the facility. Incorporating detention into landscaped areas generally creates detention facilities which are easy to access and inspect, are relatively easy to maintain, and can enhance the overall aesthetics of a site. Further discussion regarding landscaping improvements in detention facilities is provided in Section 13.6.

Parking Lot Detention. Parking lot detention is acceptable on commercial and business sites and can offset some of the storage volume that needs to be provided on landscape areas. Parking lot detention shall meet the requirements of Section 13.4. Parking lot detention is not appropriate for all cases, and therefore SEMSWA will review the use of parking lot detention on a case-by-case basis. Parking lot detention is not allowed in residential, including multi-family land uses.

Underground Detention. Underground detention is only allowed on a case-by-case basis as approved through the variance process bySEMSWA.

Rooftop Detention. Rooftop detention is prohibited by SEMSWA..

13.3 Detention Basin Design Criteria

13.3.1 Sizing Methodology. Three different procedures for sizing full-spectrum detention volumes are described in the Storage chapter of the UDFCD Manual. A set of simplified equations or a design spreadsheet may be used for drainage areas up to 130 acres and a hydrograph approach is outlined for watershed areas up to one square mile. The drain time for the Excess Urban Runoff Volume shall be 72 hours, as specified in the UDFCD Manual, or, if approved by SEMSWA, up to the 2-year allowable release rate.

The Water Quality Capture Volume and the incremental portions of the Excess Urban Runoff Volume, and the 100-year volume of a full-spectrum detention basin are normally combined into one facility with one outlet structure. However, any combination, as shown in Figure 13-4, is acceptable.

13.3.2 Onsite Detention and Addressing Offsite Flows. Two approaches are generally acceptable for addressing offsite flows that must be conveyed through a site, and the potential impacts to the onsite detention.

1. Design for No Pass-through. In this approach, offsite runoff is not allowed to be “passed through” the detention pond. Flows not intended to be detained in the pond shall be routed around the detention pond, and reconnected below the pond at the outfall if necessary.

2. Design for Offsite Flows. An alternative method is to design the detention basin for the entire upstream watershed area, including the future development flows from offsite areas without giving any credit to offsite detention facilities. This method may be practical if the offsite tributary area is relatively small.

Further discussion regarding detention benefits in offsite flow analysis can be found in Section 6.8.

13.3.3 Multiple Small Detention Basins. Extended detention basins providing Water Quality Capture Volume, Excess Urban Runoff Volume, and 100-year detention typically function best if configured in one or a few large basins as opposed to multiple small basins with very small orifices. Therefore, the minimum number of detention installations is generally preferable. The same is not necessarily true for porous landscape and porous pavement detention, which may be configured in multiple small installations.

13.3.4 Detention Basins in Series. Locating two or more detention basins in series on an individual development site inherently leads to inefficiencies in the required storage volume of the downstream facilities and is generally discouraged, especially for the Water Quality Capture Volume and the Excess Urban Runoff Volume portion of a full-spectrum detention facility.

If site runoff is detained by two or more detention facilities in sequence before leaving the site, hydrograph approaches, as described in Section 3.4 of the Storage Chapter in Volume 2 of the UDFCD Manual, shall be used to determine the effect of sequential detention and to determine the detention capacity that is needed to reduce runoff peaks to the specified predevelopment flow rates at the end of the system.

13.3.5 Interconnected Ponds. When sequential ponds are located in close proximity, separated by a short culvert or pipe at a roadway crossing, or when sequential ponds have similar invert elevations, the ponds may have to be modeled as “interconnected ponds”. This situation could also occur if other downstream conditions cause variable backwater effects that influence the discharge of the detention pond outlet pipe. In these scenarios, the water surface elevation in the downstream pond can reduce the discharge rate from the upper pond and in some cases reverse flow can occur from the downstream pond into the upstream pond. The routing analysis is much more complex because the ponds are hydraulically connected and the water surface elevations continuously vary and change the discharge characteristics. It is the responsibility of the design engineer to ensure that the appropriate analyses are performed and submitted when ponds are “interconnected”.

13.3.6 Outlets into Streets. Detention ponds that have an outlet pipe terminating in the gutter of a street, such as through a chase section, present potential ponding and icing problems in the gutter, and create hazards to the traveling public

during periods in which the pond is emptying rapidly. Therefore, detention ponds shall be designed to outlet into a storm sewer, drainageway, or other designated drainage system that is reasonably available, as determined by SEMSWA. It must be shown that the storm sewer, drainageway, or other designated drainage system to which the pond outlets, has the capacity to convey the detention pond flows.

SEMSWA may allow an outlet to discharge into the gutter in cases where the minor storm (5-year) peak flow for the tributary area is less than 3.5-cubic feet per second and a storm sewer or other drainage system is not reasonably available. It must be demonstrated that the street has adequate capacity to convey the excess runoff within the allowable limits. A transition from the outlet pipe to a curb chase will normally be required, and the chase section shall be designed to reduce the velocity and spread of flow as much as possible. The location of the outlet shall be designed to minimize potential problems or conflicts with other improvements, and shall be angled toward the downstream slope of the gutter to direct flows downstream instead of perpendicularly into the street.

13.3.7 Excavated and Embankment Slopes. All excavated or embankment slopes from the pond bottom to the 100-year water surface elevation shall be no steeper than 4 (horizontal) to 1(vertical). Excavated slopes above the 100-year water surface elevation and the slope on the downstream side of embankments shall be 3 to 1 or flatter. Embankments shall be provided with a top width of at least 10 feet. An emergency overflow spillway shall be provided as described in Section 13.3.13.

It is the responsibility of the design engineer to ensure that the design of any earthen embankment is based on specific recommendations of a geotechnical engineer and that the design requirements are clearly identified within the construction plans. In addition, the construction of large embankments or dams may fall under the jurisdiction of the Office of the State Engineer as discussed in Chapter 3, Stormwater Management and Development, Section 3.3.2.

All earthen slopes shall be covered with topsoil and revegetated in accordance with SEMSWA's GESC (Grading, Erosion and Sediment Control) Manual requirements. Adequate provisions for the establishment and maintenance of the vegetation, such as temporary or permanent irrigation should be provided.

13.3.8 Freeboard Requirements. The minimum required freeboard for detention facilities is 1.0-foot above the computed water surface elevation when the emergency spillway is conveying the maximum design flow. Section 13.3.13 provides design information for the emergency spillway and embankment protection.

13.3.9 Low Flow Channels. All grassed-bottom detention ponds shall include a low flow channel sized to convey a minimum of 1% of the 100-year peak inflow. The low flow channel shall be constructed of concrete, concrete with boulder edges, soil-riprap, or other materials accepted by SEMSWA. The trickle channel shall

have a minimum depth of 0.5-ft. and a minimum width of 2-ft. for private ponds, and 4-ft for regional ponds. The minimum slope shall be 0.5-percent and the design longitudinal slope should ensure that non-erosive velocities are maintained adjacent to the low flow channel when the design capacity is exceeded.

If accepted by SEMSWA, an unlined low flow channel may be used. The unlined low flow channel shall be at least 1.5-feet deep below adjacent grassed benches and shall be vegetated with herbaceous wetland vegetation or riparian grasses, appropriate for the anticipated moisture conditions. The minimum longitudinal slope shall be 0.5-percent and the minimum width of the grassed bench adjacent to the low flow channel shall be 12-feet on one or both sides where equipment can access. The maximum side slope below the bench shall be 4 to 1 and the maximum bottom width of the channel shall be 12-feet if equipment can access one side of the channel and 24-feet if equipment can access both sides.

Typical cross-sections of low flow channels are shown in Figure 13-5.

13.3.10 Bottom Slope. For grassed detention facilities, the pond bottom shall be sloped at least 4.0-percent for the first 25-feet adjacent to a lined low flow channel and at least 1- to 2-percent thereafter to drain toward the low flow channel or outlet, measured perpendicular to the low flow channel. The benches above unlined low flow channels, if approved, shall slope at least 1- to 2-percent toward the low flow channel.

13.3.11 Inlet Facilities. Unless otherwise accepted by SEMSWA, runoff shall enter a detention facility via a stabilized drainageway, a 100-year drop structure, or a storm sewer with energy dissipater. Riprap rundowns are generally not accepted due to a history of erosion problems. Figures 14-8 and 14-9 illustrate concepts for incorporating sediment forebays into storm sewer outfalls entering a detention facility.

13.3.12 Outlet Configuration and Safety/Debris Grates. Detention basin outlets shall be functional for controlling the design release rates, provided with oversized safety/debris grates to reduce the potential for debris plugging, easy to maintain, and designed with favorable aesthetics.

Four example concepts of a combined outlet for full-spectrum detention are shown in Figures 14-4 through 14-7. Two figures show parallel wingwalls with a flush bar grating (one with an external micropool and the other with an internal micropool) and the others show a concept with flared wingwalls and handrails.

The minimum net open area of the trash rack protecting the Excess Urban Runoff Volume orifices and the flood control orifice shall comply with Figure 7 of Volume 3's Typical Structural Best Management Practice Details. The safety grate criteria discussed in the Culverts section of the Volume 1 of the UDFCD Manual, shall also apply.

If the control orifices are 2.5-inches or greater in diameter or 2-inches square, standard fabricated bar grating (with nominal openings of 1- by 4-inches) may be used as a debris grate instead of well-screen. The larger grate may reduce the potential for clogging with debris. If approved by SEMSWA, the vertical spacing between orifices may be increased to 8-inches or 12-inches and the orifice areas increased by a factor of two (for 8-inch spacing) or three (for 12-inch spacing) to enable larger orifices and larger trash rack openings.

Bar grating may be used on parallel sloping wingwalls, either as the primary debris grate (if orifices are at least 2.5 inches in diameter) or as a course screen and safety grate in lieu of handrail. Sloping bar grating shall have a lockable hinged section at least 2-feet square to allow access to the orifice plate or well-screen. Manhole steps shall be provided on the side of the wingwall directly under the hinged opening. The bearing bars for steel bar grating shall be designed to withstand hydrostatic loading up to the spillway crest (assuming the grate is clogged and bears the full hydrostatic head), but generally not designed for larger loads (like vehicular loads) so that the hinged panels are not excessively heavy. Panels of bar grating shall be no more than 3-feet wide and all parts of the grating and support frames shall be hot-dipped galvanized. Bar grating shall be fastened down to the outlet structure.

The flood-flow orifice shall be sized to provide the allowable 100-year release rate when the 100-year detention volume is completely full. The weir crest at the top of the 2-year volume shall pass the allowable 100-year release rate at a head that is at least 0.5-feet below the completely-full 100-year full-spectrum volume, maintaining control at the 100-year orifice in the design event.

13.3.13 Emergency Spillway and Embankment Protection. Whenever a detention basin uses an embankment to contain water, the embankment shall be protected from catastrophic failure due to overtopping. Overtopping can occur when the pond outlets become obstructed or when a storm larger than a 100-year event occurs. Erosion protection for the embankment may be provided in the form of a buried riprap layer on the entire downstream face of the embankment or a separate emergency spillway constructed of buried riprap or concrete. In either case, the emergency protection shall be constructed to convey the 100-year developed flow from the upstream watershed without accounting for any flow reduction within the detention basin.

The invert of the emergency spillway shall be set at the 100-year water surface elevation. A concrete wall shall be constructed at the emergency spillway crest extending at least to the bottom of the riprap and bedding layers located immediately downstream. The crest wall shall be extended at the sides up to one foot above the emergency spillway design water surface.

Riprap embankment protection shall be sized based on methodologies developed specifically for overtopping embankments. Two such methods have been documented by Colorado State University (USNRC, 1988) and by the US Department of Agriculture (ASAE, 1998) and designers are referred to these

publications for a complete description of sizing methodology and application information. Figure 13-7 illustrates typical rock sizing for small (under 10-feet high) embankments based on these procedures that may be used during preliminary design to get an approximate idea of rock size. Final design shall be based on the more complete procedures documented in the referenced publications. The thickness and bedding requirements shall be based on the criteria identified in the UDFCD Manual.

The emergency spillway is also needed to control the release point and direction of the overflow. The emergency spillway and the path of the emergency overflow downstream of the spillway and embankment shall be clearly depicted on the drainage plan. Structures shall not be permitted in the path of the emergency spillway or overflow. The emergency overflow water surface shall be shown on the detention facility construction drawings.

13.3.14 Retaining Walls. The use of retaining walls within detention basins is generally discouraged due to the potential increase in long-term maintenance costs and concerns regarding the safety of the general public and maintenance personnel. If retaining walls are proposed, footings shall be located above the excess urban runoff volume. Wall heights shall not exceed 30-inches, and walls shall not be used on more than 50-percent of the pond circumference. If retaining walls are terraced, a separation of at least 5-feet shall be provided between walls. Additional width may be required to address the wall design, anchoring system and maintenance requirements. The engineering analysis shall include a discussion and the necessary calculations to determine the appropriate “bench” width. The maximum ground slope between adjacent walls shall be 4-percent. All detention pond retaining walls shall require a Building Permit (unless waived by the Building Department) and shall be provided with handrails or guardrails designed to meet safety criteria as well as International Building Code (IBC) requirements.

Retaining walls may not be used where live loading or additional surcharge from maintenance equipment of vehicle traffic could occur unless the wall is designed to accommodate the live loading condition. Foundation walls of buildings shall not be used as detention basin retaining walls. The distance between the top of any retaining wall in a detention area and any adjacent sidewalk, roadway curb or structured feature is to be a minimum of three times the height of the wall. The horizontal distance to any maintenance access drive not used as a sidewalk or roadway shall be at least four feet.

Any future outfalls to the pond shall be designed and constructed with the detention basin. This reduces the likelihood of disturbing the retaining walls when constructing the “future” outfall.

Perimeter fencing to limit access, safety railing, or guardrail may be required depending upon the location of the wall relative to roadways, parking areas and pedestrian use areas.

A Professional Engineer licensed in the State of Colorado shall perform a structural analysis and design the retaining wall for the various loading conditions the wall may encounter, including the hydrostatic pressure differential between the front and the back of the wall and live loading conditions, if applicable. A drain system should be considered behind the wall to ensure that hydrostatic pressures are equalized as the water level changes in the pond.

The wall design and calculations shall be stamped by the professional engineer and submitted to the City's Building Division for review. The design details and requirements for the retaining wall(s) shall be included in the construction drawings.

Retaining walls shall not be used within the limits of any impermeable lining of water quality basins or detention ponds.

Variances may be considered in accordance with Section 1.8.

13.3.15 Landscaping Guidelines. Integration of detention and site landscaping requirements is encouraged as outlined in Section 13.2.3. The landscaping guidelines described in Section 13.6 shall be followed to provide a detention facility that blends with the site, is attractive, and well vegetated.

13.3.16 Signage. Appropriate warning signage shall be provided for each detention facility. All signs shall be fabricated using red lettering on a white background.

1. Outlet Modification Sign. A sign, with a minimum area of 0.75-square feet shall be attached to the outlet or positioned nearby with the following message:

WARNING
UNAUTHORIZED MODIFICATION OF
THIS OUTLET IS A CITY OF
CENTENNIAL LAND DEVELOPMENT
CODE VIOLATION

2. Flood Hazard Warning Signs. Two signs, each with a minimum area of 3-square feet shall be provided around the perimeter of the pond with the following message:

WARNING
THIS AREA IS A STORMWATER
FACILITY AND IS SUBJECT TO
PERIODIC FLOODING

13.3.17 Easement Requirements. Easements for detention facilities shall be provided in accordance with Chapter 3. Drainage easements shall be provided to ensure the proper design, construction and maintenance of the detention basins and outlet facilities. Drainage easements shall be granted to SEMSWA for inspection

and maintenance purposes, and shall be shown on the Drainage Plan, Final Plat and Final Development Plan. The drainage easement shall state that SEMSWA has the right of access on the easements for inspection and maintenance purposes. Drainage easements shall be kept clear of obstructions to the flow and shall allow maintenance access. The minimum requirements for detention basin easements are as required to contain storage and water quality capture volume including freeboard, associated facilities, and adequate maintenance access around the perimeter based on the access road width criteria provided in Section 13.7. Access to the basin shall be provided in an easement.

13.3.18 Maintenance. The maintenance of detention facilities shall be performed by the property owner, or as otherwise designated by legal agreement. Maintenance operations shall be in accordance with the approved operations and maintenance manual (O&M Manual) for the project as described in Section 4.8. Routine maintenance of detention basins shall include sediment and debris removal. Non-routine maintenance may include the repair and/or replacement of outlet structures, trickle channel, outlet pipes, channel slopes, and other related facilities. When appropriate maintenance is not provided, SEMSWA shall provide the necessary maintenance and assess the associated cost to the property owner. All detention basins, with or without retaining walls, shall be designed in accordance with the maintenance requirements identified in Section 13.7.

13.4 Design Standards for Parking Lot Detention

13.4.1 Easement Requirements. Easements for parking lot detention shall be provided in accordance with Chapter 3. Easements shall include the area of the parking lot that is inundated by the 100-year water surface elevation, and the outlet structure and conveyance facilities.

13.4.2 Maintenance Requirements. Maintenance of parking lot detention ponds and facilities shall be provided in accordance with Chapter 3. The property owner shall be required to ensure that the release structures are maintained.

13.4.3 Depth Limitation. The maximum allowable design depth above pavement surfaces for the Excess Urban Runoff Volume is 3-inches and for the 100-year flood is 9-inches. However, to account for future overlays or parking lot resurfacing, the design volumes shall be attained even with an assumed 2-inch overlay (translating to an allowable depth of 1-inch for the Excess Urban Runoff Volume and 7-inches for the 100-year event). The Water Quality Capture Volume shall be located entirely out of (below) the pavement area, possibly in one or more landscaped parking islands or adjacent landscaping. An emergency spillway sized for the 100-year inflow peak shall be provided with a crest set at the 100-year water surface elevation and a maximum flow depth over the emergency spillway of 6-inches. A minimum of 1.0-feet of freeboard is required above the 100-year emergency water surface to the first floor elevation of any adjacent structures (equivalent to 18-inches over the 100-year water surface).

13.4.4 Outlet Configuration. The outlet configuration shall be designed in accordance with criteria shown in Volume 3 of the UDFCD Manual, as modified by Chapter 14 for the type of Water Quality Capture Volume facility selected for the site. Outlets for the Excess Urban Runoff Volume and 100-year events shall limit peak flows to the maximum design release rates.

13.4.5 Signage. Appropriate warning signage shall be provided for parking lot detention. All signs shall be fabricated using red lettering on a white background.

1. Outlet Modification Sign. A sign, with a minimum area of 0.75-square feet shall be attached to the outlet or positioned nearby with the following message:

WARNING
UNAUTHORIZED MODIFICATION OF
THIS OUTLET IS A CITY OF
CENTENNIAL LAND DEVELOPMENT
CODE VIOLATION

2. Flood Hazard Warning Signs. Two signs shall be provided identifying the detention pond area. Each sign shall have a minimum area of 1.5-square feet with the following message:

WARNING
THIS AREA IS A DETENTION POND AND
IS SUBJECT TO PERIODIC FLOODING
TO A DEPTH OF 9-INCHES OR MORE.

Any suitable materials and geometry of the sign are permissible, subject to approval by the County. The property owner shall be responsible to ensure that the signs are provided and maintained at all times.

13.5 Stormwater Retention

13.5.1 Stormwater Retention. Stormwater runoff retention has been used in areas where there exists no viable alternative for providing an outfall for a detention pond. However, problems with past retention basins including soil expansion, siltation, and lack of infiltration capacity have created a nuisance to the general public. Further, retention has the potential of depriving downstream water rights of their legal right to the retained water. Use of retention should be minimized, except where significant environmental, recreational, or recharge benefits are apparent and water rights issues have been addressed with the State Engineer's Office.

13.5.2 Facility Requirement. Stormwater retention shall not be permitted, except as approved on a case-by-case basis. Stormwater retention may be approved as

an interim measure in areas where an outlet collector storm sewer system has been planned, but has not been constructed. When allowed, retention shall be considered as interim solution, and shall be required to be converted to detention when the outlet system is available. Costs for converting the retention to detention are the responsibility of the Developer and shall be guaranteed in the Subdivision Improvements Agreement.

13.5.3 Minimum Sizing Requirements. SEMSWA will decide if retention or detention is appropriate for a particular site and is not a developer's design option. When SEMSWA determines that stormwater retention is acceptable as an interim measure, the facility shall be sized using the following criteria:

1. The minimum retention volume shall equal the watershed area upstream of the retention basin (including offsite areas) times the unit runoff amount shown in Figure 13-6 based on the estimated future development percent imperviousness for the entire upstream watershed. Figure 13-6 is based on 1.5 times the estimated runoff from a 24-hour 100-year storm to account for storms larger than a 100-year event, storms of longer duration, or back-to-back storms. Additional considerations when implementing a retention facility are discussed in Section 3 of the Storage Chapter in Volume 2 of the UDFCD Manual.

13.5.4 Minimum Design Requirements. When the SEMSWA determines that stormwater retention is acceptable as an interim measure, the facility shall be designed using the following criteria:

1. An overflow section shall be provided for the retention facility that will protect embankments from overflow resulting from a 100-year storm when the pond is full and the tributary area is fully developed.
2. Side slopes shall not be steeper than four (4) horizontal to one (1) vertical.
3. One (1) foot minimum freeboard above the maximum retention volume water surface.
4. The applicant must evaluate or assess the impacts of the retention facility on local groundwater levels and the potential for damage to nearby properties.
5. A slow release will be permitted of 0.25-cubic feet per second or less if the small flows will be conveyed to a major drainage way and will not cause nuisance conditions.
6. This policy does not relieve the land developer of making permanent detention improvements on his property as a condition of subdivision approval.
7. A drainage maintenance easement shall be granted to SEMSWA to ensure that emergency maintenance and access can be legally provided to keep the facility operable. This easement may be vacated when the retention pond function is no longer needed.
8. Retention ponds shall be required to be drained as necessary to maintain the required retention volume. Where retention is proposed, the drainage

report must include a maintenance plan describing how the pond shall be drained, and where it shall be drained to. The maintenance plan should specify a timeframe for emptying the pond. The owner or operator of the retention facility shall provide all pumps, drains, hose, and other appurtenances necessary to maintain and drain the retention facility.

13.6 Landscaping Guidelines

Integration of detention and site landscaping requirements is encouraged as outlined in Section 13.2.3. Consideration to the type and quantity of landscaping materials should be given, to ensure that the capacity of the pond is maintained, and that future maintenance activities can be performed with minimal disruption of vegetated areas. The following is a list of recommendations for pond grading and landscaping:

a. Wherever possible, involve a landscape architect in the design of detention facilities to provide input regarding layout, grading, and the vegetation plan.

b. Create a basin with a pleasing, natural shape that is characterized by variation in the top, toe, and slopes of banks. Avoid boxy, geometric patterns that are easy to draw using CAD. Better results are usually achieved by creating a grading plan by hand and then smoothly digitizing the proposed contours in to the design drawings. A "golf course look" is more attractive than straight lines and straight slopes.

c. Grass selection and plant materials are key in softening the appearance of a detention area and blend it in with the surrounding landscaping and natural features. Species are to be suitable for the particular hydrologic conditions in the basin; with wetland or riparian species selected for the bottom areas subject to frequent and prolonged inundation. Bluegrass rarely works well in the lowest, water quality portion of a basin. Guidelines for revegetation, along with recommended seed mixes, are provided in the UDFCD Manual.

d. Multipurpose detention facilities are encouraged with recreation activities such as passive open space areas, pedestrian paths, children's play areas, and active recreation areas. It is recommended that active recreation facilities be located above the 2-year water surface to avoid frequent inundation.

e. To reduce the potential for clogging of debris grates, no straw mulch shall be used within the Excess Urban Runoff Volume of a detention basin. Instead, erosion control blanket shall be installed for a width of at least 6-feet on either side of concrete low flow channels or up to a depth of 1-foot in soil riprap or benched low flow channels. The blanket shall comply with the materials and installation requirements for erosion control blankets (straw coconut or 100% coconut) shown in the County's Grading, Erosion, and Sediment Control (GESC) Manual. Additional blanket or other erosion control measures may be required by the County.

f. Trees shall not be planted within the Excess Urban Runoff Volume. Trees such as Cottonwood, Willow, and Aspen shall not be planted within the 100-year water

surface of a detention basin to avoid nuisance spreading of root systems within the facility.

13.7 Designing for Maintenance

Detention facilities shall be designed to facilitate ongoing maintenance operations. The following provisions for maintenance shall be required.

13.7.1 Access for Sediment Removal. A stable access and working bench shall be provided so that equipment can remove accumulated sediment and debris from the detention basin and perform other necessary maintenance activities at all components of the facility. Unless otherwise approved by the County, the horizontal distance from the working bench to the furthest point of removal for the forebay, bottom of the detention basin, or outlet structure shall be no more than 24-feet. The working bench and access drive shall slope no more than 10-percent, and be at least 12-feet wide for a centerline radius greater than 80-feet and at least 14-feet wide for a centerline radius between 50- and 80-feet. The minimum centerline radius shall be 50-feet. Unless otherwise approved, the working bench and access drive shall be constructed of the following materials:

Below any permanent water surface: CDOT Class P concrete, at least 6-inches thick with minimum reinforcement consisting of No. 4 reinforcing bars at 12-inches each way, centered in slab. Surface of concrete shall be provided with a grooved finish to improve traction, with grooves oriented to drain water away to one or both sides. Concrete shall be placed over at least 6-inches of 1.5-inch crushed rock compacted in a 6-inch thick lift over at least a 6-inch layer of compacted subgrade.

Below the Excess Urban Runoff Volume water surface: Concrete as specified above, or Class 5 or 6 aggregate base course per CDOT 703.03, or any graded crushed rock smaller than 2-inches may be used. The granular material shall be compacted in a 12-inch thick lift over at least a 6-inch layer of compacted subgrade.

Above the Excess Urban Runoff Volume and below the 100-year water surface: Concrete as specified above, or Class 5 or 6 aggregate base course per CDOT 703.03, or any graded crushed rock smaller than 2-inches may be used. The granular material shall be compacted in an 8-inch thick lift over at least a 6-inch layer of compacted subgrade.

The use of reinforced turfgrass meeting applicable UDFCD criteria, if proposed in this zone for an access drive, will be considered by SEMSWA on a site-specific basis. If used, a system of marking the edges is required so that its location is evident to maintenance crews. Also, shrubs, trees, sprinkler heads and valve boxes shall not be located in the reinforced turfgrass area.

As stated above, any retaining walls shall to be laid out in a manner that avoids access restrictions. Any handrails or fences, likewise, shall permit vehicular

access. The entrance to an access drive from a roadway or parking lot shall be located so that traffic safety is not compromised.

13.7.2 Other Improvements to Facilitate Maintenance. Other improvements that could facilitate maintenance operations in the future are encouraged. These could include:

a. Providing adequate room for staging the equipment involved in clean-out operations.

b. Providing a power receptacle adjacent to the detention basin to enable dewatering operations using an electric pump. Electric pumps are quieter and require less attention in the event pumps need to operate overnight.

c. For larger, natural sites, it may be worthwhile to reserve a suitable location for disposing sediment that is cleaned out of the pond. This has to be carefully thought through, however, to make sure it is feasible to dump the material onsite, allow it to dry, then spread it and re-seed and much the area, without causing erosion problems.

d. Designing configuration and dimensions of grates to allow debris to be raked off using standard garden tools.

FIGURE 13-1
REGIONAL DETENTION APPROACH

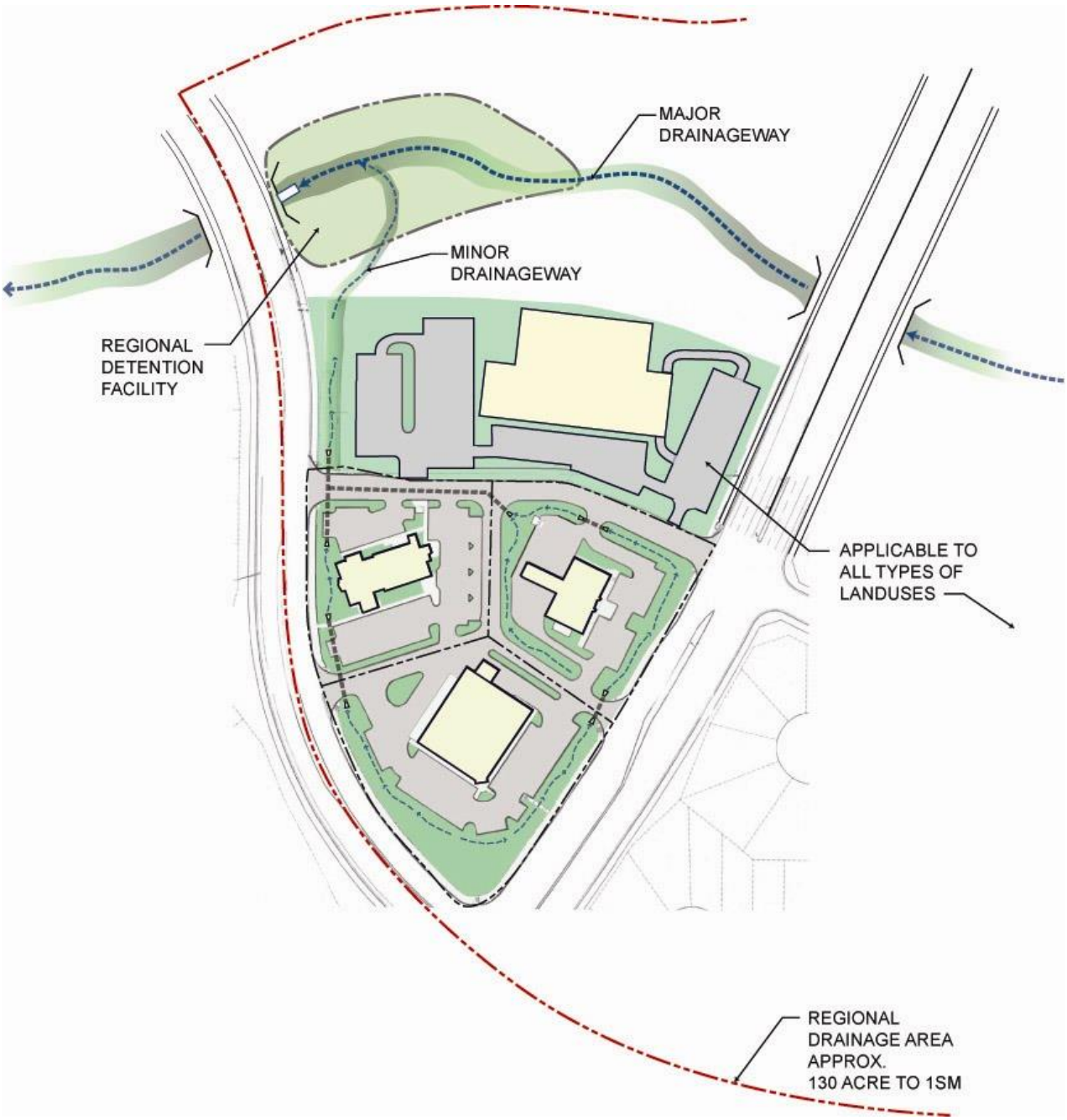


FIGURE 13-2
SUB-REGIONAL DETENTION APPROACH

FIGURE 13-3
ONSITE DETENTION APPROACH

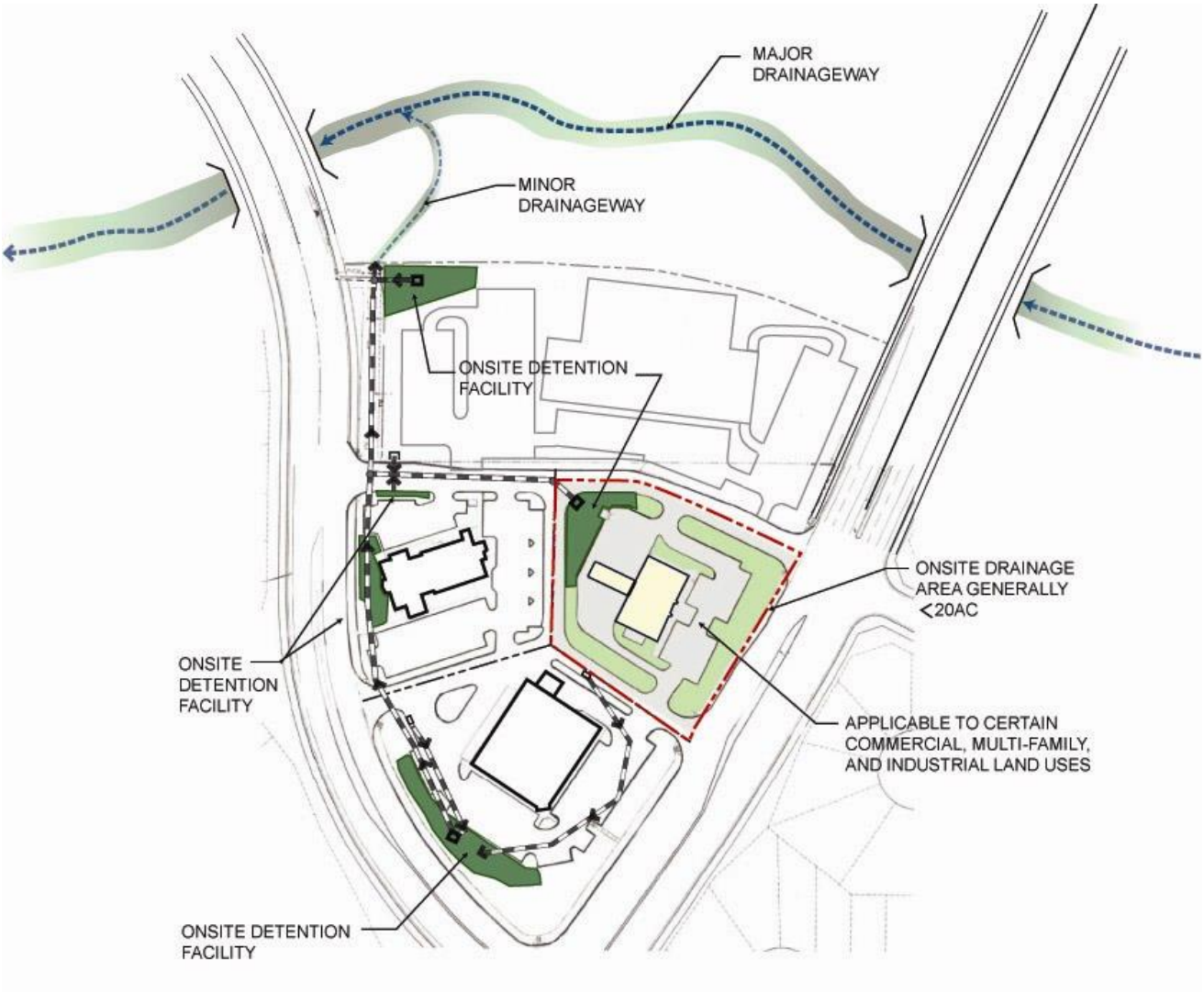


FIGURE 13-4
DESIGN OPTIONS FOR DETENTION BASINS

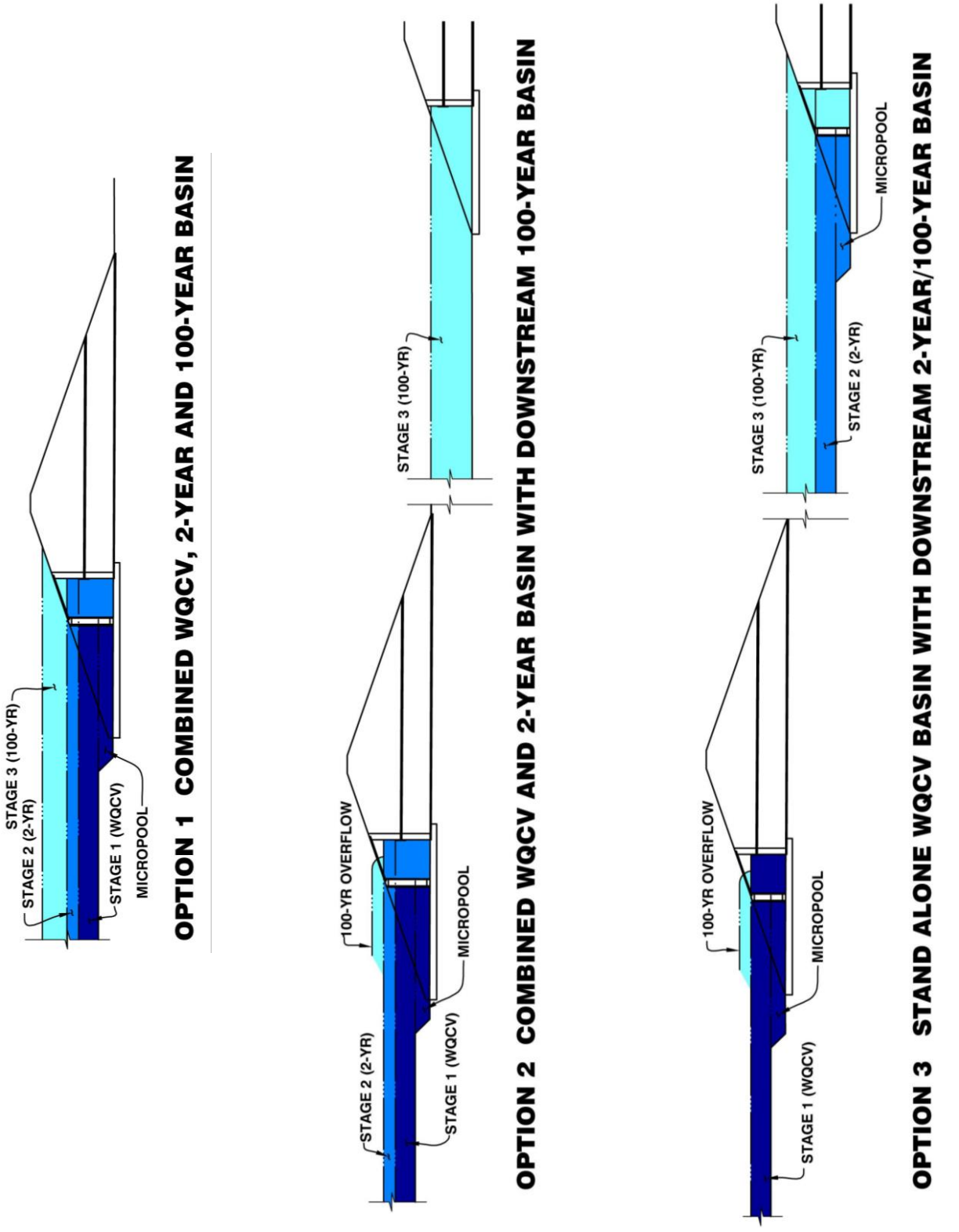
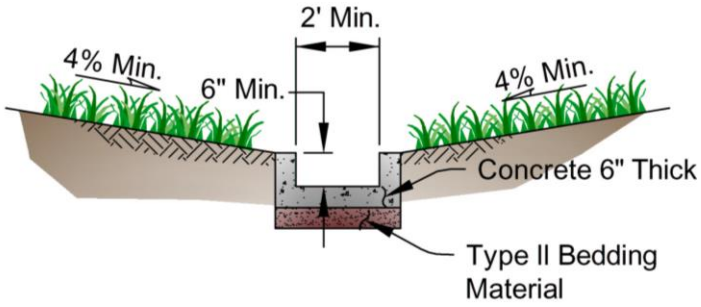
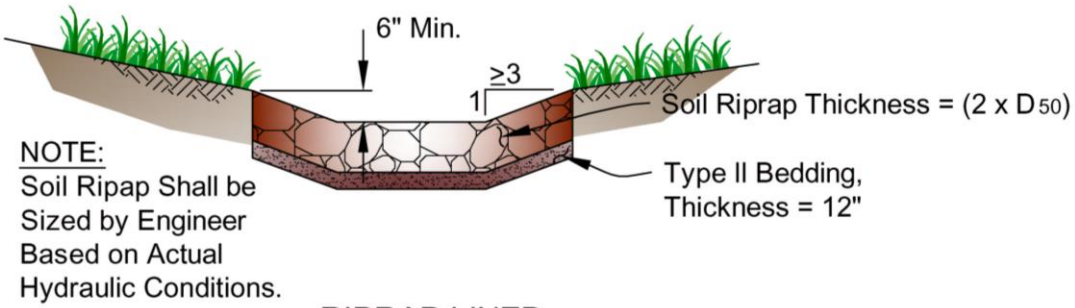


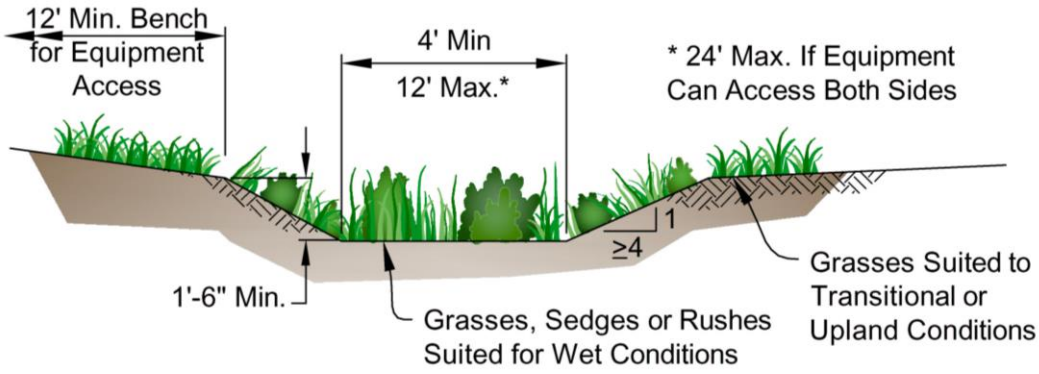
FIGURE 13-5
TYPICAL LOW FLOW CHANNEL DETAILS



CONCRETE LINED



RIPRAP LINED
Must be Approved by County Prior to Use



BENCHED SYSTEM (UNLINED)
Must be Approved by County Prior to Use

FIGURE 13-6
100-YEAR REQUIRED RETENTION VOLUME

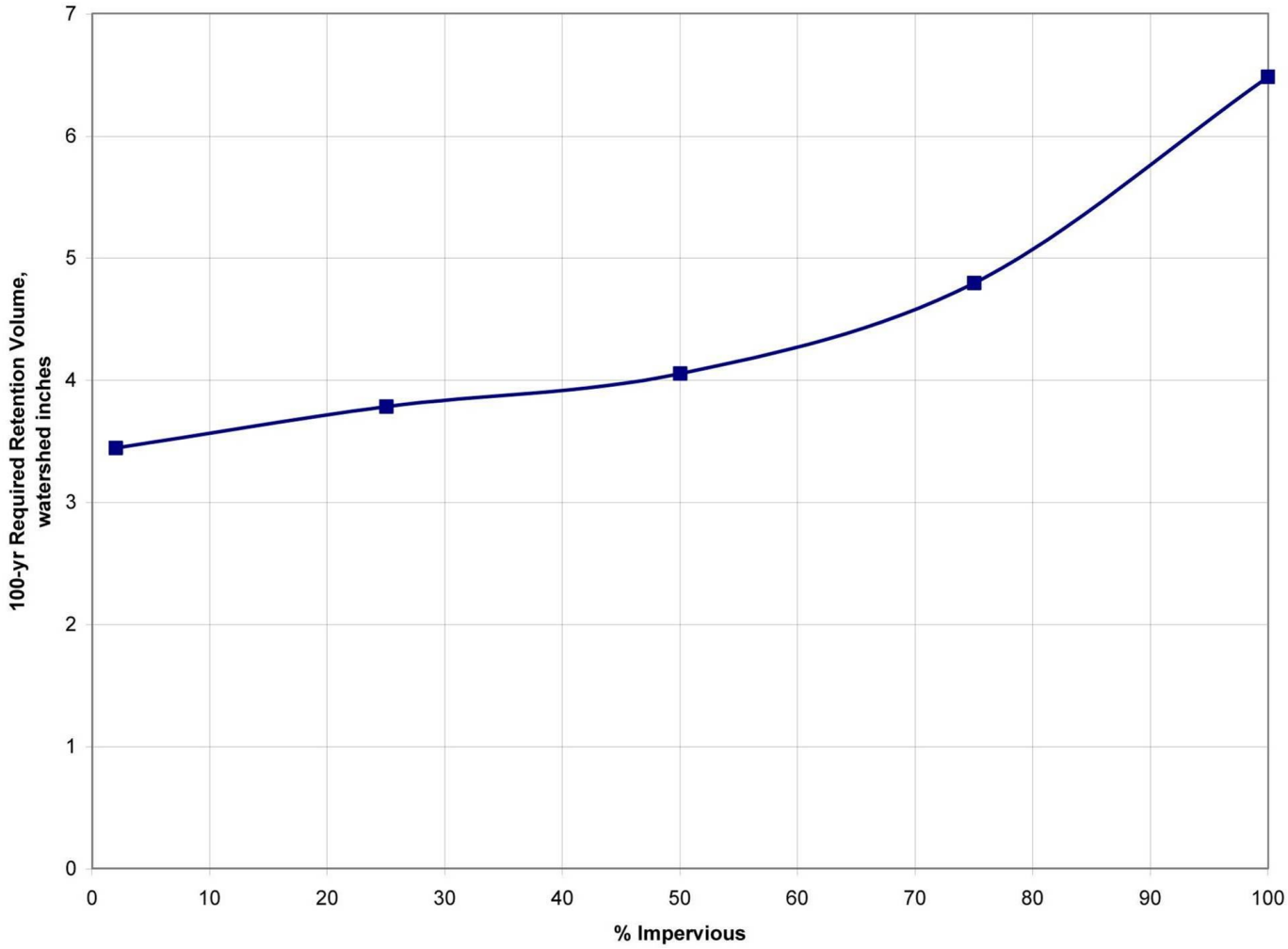
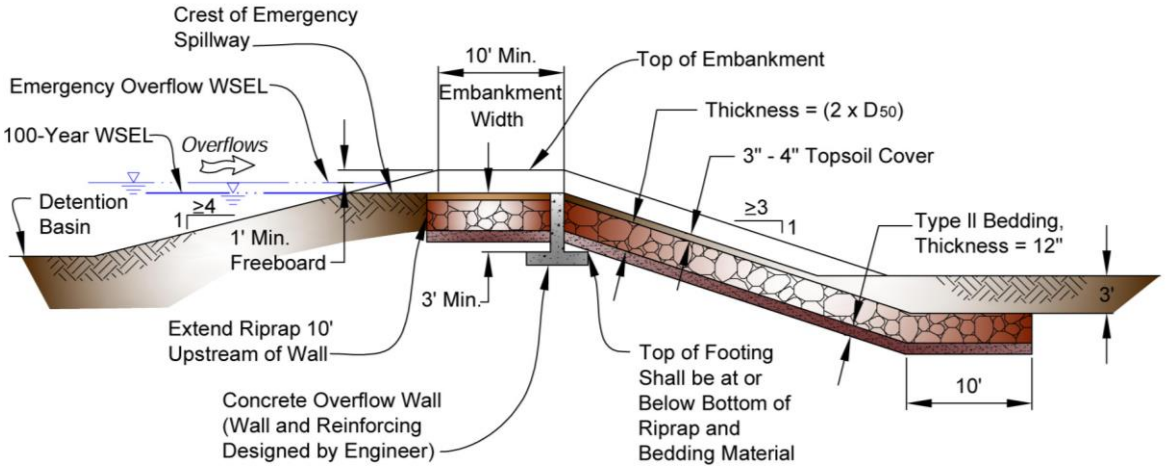
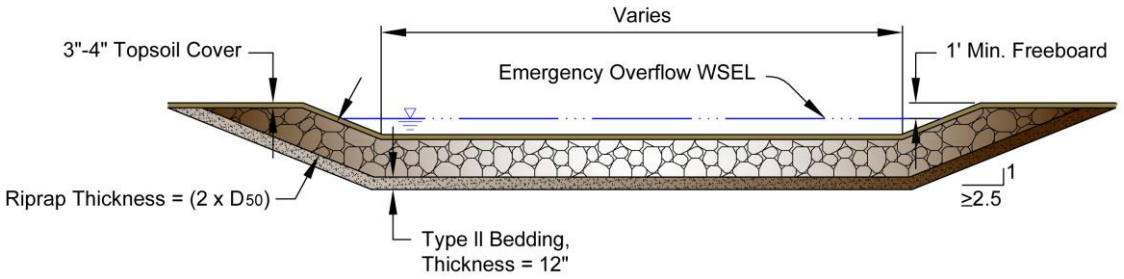


FIGURE 13-7
EMBANKMENT PROTECTION DETAILS AND ROCK SIZING CHART



EMERGENCY SPILLWAY PROFILE



SPILLWAY CHANNEL AT CREST AND DOWNSTREAM SIDE OF EMBANKMENT