



**CHAPTER 12. OPEN CHANNEL DESIGN**  
**Design Checklist for Open Channel Design**

Yes	No	N/A	Design Requirements
<b>I. INITIAL SITE PLANNING</b>			
			<b>A. Major and Minor Drainageways</b>
			1. The drainageway has been classified as minor or major based on the following. Major drainageways consist of a channel which drains a watershed area greater than 130-acres.
			2. Major drainageways are preserved and cannot be relocated or replaced with a pipe.
			3. Drainageway features listed in Section 12.1.1 are protected and preserved.
			3. Minor drainageways may be reconstructed, relocated, or replaced with a storm sewer in combination with flood conveyance in the street network, but where practicable, vegetated surface channels are created and/or preserved.
			<b>B. Jurisdictional Streams</b>
			1. The drainageway has been determined to be jurisdictional or non jurisdictional based on the Corps of Engineer's designation as jurisdictional under Section 404 of the Clean Water Act.
			2. If a stream is jurisdictional, disturbance limitations are determined and mitigation requirements that may be imposed by the 404 Permit have been identified.
			<b>C. Initial Planning Documents</b>
			1. Initial site planning documents accurately identify all existing drainageways, floodplains, and other site features that must be protected and preserved.
			2. Initial site planning documents include an evaluation of environmental conditions, including studies/reports on threatened and endangered species, wetland surveys, photographs of drainageways, etc.
<b>II. GENERAL DESIGN CONSIDERATIONS</b>			
			<b>A. Governing Criteria</b>
			1. All open channel design is in accordance with the Major Drainage Section in Volume 1 of the UDFCD Manual, unless otherwise noted in Chapter 12.
			<b>B. Stabilization of Natural Drainageways</b>
			1. Channel stabilization measures are implemented for drainageways contained within a development or adjacent to the development as a condition of development approval.
			2. Improvements listed under Item #1 in Section 12.1.2 will be implemented to preserve drainageways that have not yet experienced degradation.



**CHAPTER 12. OPEN CHANNEL DESIGN**  
**Design Checklist for Open Channel Design**

Yes	No	N/A	Design Requirements
			3. A new natural drainageway is proposed for construction because it can be demonstrated that it is not feasible to preserve an existing drainageway or because surface channels are desired in an area where no drainageways are evident.
			<b>C. Master Planning</b>
			1. The drainageway has been determined to be or not to be included in a UDFCD Outfall Systems Planning or Major Drainageway Planning Study.
			2. If a master plan exists for the drainageway, it may be used for general stabilization concepts as long as they are consistent with the current design details, technology and philosophies for channel stabilization described in Chapter 12.
			<b>D. Design Flows</b>
			1. The flowrates used for design have been approved by the County and UDFCD.
			2. Open channel improvements are designed for the 100-year event, assuming a fully urbanized watershed.
			3. Open channel design includes evaluation of baseflows and frequent storm events, including the 2-year storm.
			<b>E. Permitting and Regulations</b>
			1. The appropriate agencies have been contacted to determine all permits required for working within drainageway (i.e. Floodplain Development, 404 Permit, Threatened and Endangered Species, etc.)

**III. DESIGN CRITERIA FOR MAJOR DRAINAGEWAYS**

			<b>A. Create Shallow Base Flow Channel</b>
			1. Width of a proposed base flow approximates the existing base flow channel width in the design reach or in a stable reference reach upstream or downstream of the project.
			2. The constructed baseflow channel has a meandering pattern typical of a natural channel.
			3. Capacity of the baseflow channel is approximately less than 1% of the 100-year event for large stream systems (i.e. Cherry Creek) and approximately 3-4% of the 100-year event for channels with just over 130 acres of tributary area.
			<b>B. Establish Longitudinal Slope Using Grade Control Structures</b>
			1. Unless otherwise approved by the county, the baseflow channel slope is in accordance with Figure 12-4.
			2. The maximum height of grade control structures is in accordance with Table 12-1 unless otherwise approved.
			<b>C. Utilize Vegetated Benches to Convey Overbank Flow</b>



**CHAPTER 12. OPEN CHANNEL DESIGN**  
**Design Checklist for Open Channel Design**

Yes	No	N/A	Design Requirements
			1. Establishment of wide, flat, and well-vegetated overbank areas adjacent to the baseflow channel is proposed.
			2. The necessity of supplemental vegetation on the overbanks to create a durable cover to retard flood flows and resist erosion has been determined.
			<b>D. Slope Back and Stabilize Eroding Banks</b>
			1. All existing steep and unstable banks within the 100-year floodplain are sloped back and stabilized. Bank stabilization measures are approved by the County.
			2. Appropriate bank stabilization measure(s) have been determined by evaluating the existing channel bank conditions, angle of attack, channel geometry, longitudinal slope, existing vegetation, underlying soils, available right-of-way, potential for future erosion, and the proximity of infrastructure to eroded bank.
			3. Steep and unstable banks are sloped back preferably to a 4:1 slope or flatter; slopes greater than 3:1 are approved by the County.
			4. Riprap bank protection is designed in accordance with the Riprap-Lined Channel section of the Major Drainage Section of the UDFCD Manual.
			5. Bioengineered bank protection is designed in accordance with Section 4.5 of the Major Drainage Section of the UDFCD Manual.
			<b>E. Analyze Floodplain Hydraulics</b>
			1. The existing natural channel and the proposed improved channel have been evaluated for the 2-year and 100-year flow conditions and velocities using HEC-RAS.
			2. Constructed drainageways designed to emulate natural channels meet the design criteria provided in Table 12-2 for both the 2-year and 100-year storm.
			3. Proposed design conditions for existing natural channels meet the design criteria provided in Table 12-2 for the 2-year storm.
			4. Proposed design conditions for existing natural channels have been evaluated for the 100-year event and compared to the recommended values in Table 12-2. The results of this evaluation have been reviewed with the County to determine if additional improvements will be required.
			5. The existing and proposed 100-year floodplains have been delineated for the project reach. Floodplain analysis is based on future-developed flow rates, long term channel roughness, and potential aggradation over time.
			6. A minimum of 2-feet of freeboard is provided between the proposed 100-year base flood elevation and the lowest finished floor elevation of all structures.



**CHAPTER 12. OPEN CHANNEL DESIGN**  
**Design Checklist for Open Channel Design**

Yes	No	N/A	Design Requirements
			7. A minimum of 1-foot of freeboard is provided between the proposed 100-year base flood elevation and facilities which are not structures (e.g. roadways, utility cabinets, parks and trails, etc.).

**IV. DESIGN CRITERIA FOR MINOR DRAINAGEWAYS**

			A. Natural Channels
			1. Natural channels for minor drainageways are designed to meet the criteria for major drainageways. See items A through E under Section III, Design Criteria for Major Drainageways.
			B. Grass-Lined Channels
			1. Grass-lined channels are designed in accordance with the criteria in Section 4.1 of the Major Drainage chapter of the UDFCD Manual.
			2. Grass-lined channels may be used for drainageways with a small tributary area and no base flow. Sod-forming native grasses are recommended for grass-lined channels.
			3. If irrigated bluegrass sod is proposed for the grass-lined channel, a small low-flow channel shall be constructed and vegetated with wetter sod-forming native grasses.
			4. Grade control structures and/or rock stabilization are proposed if the longitudinal slope exceeds the values in Table 12.3
			C. Composite Channels (Wetlands Bottom Channels)
			1. Composite channels are designed in accordance with the criteria in Section 4.2 of the Major Drainage chapter and Section 10.0 of the Structural BMP Chapter of the UDFCD Manual.
			D. Bioengineered Channels
			1. Bioengineered channels are designed in accordance with the criteria in Section 4.5 of the Major Drainage chapter of the UDFCD Manual.

**V. GRADE CONTROL STRUCTURES**

			A. 100-Year Drop Structures
			1. Drop structures are designed per the criteria provided in Section 2.0 of the Hydraulic Structures chapter of the UDFCD Manual.
			2. The proposed drop height does not exceed 4-feet. Proposed drop structure heights greater than 4-feet must be approved by the County.
			B. Low Flow Drop Structures
			1. Low flow drop structures are designed per the criteria provided in Section 2.9 of the Hydraulic Structures chapter of the UDFCD Manual.
			2. The primary design flow for a low flow drop structure is the



**CHAPTER 12. OPEN CHANNEL DESIGN**  
**Design Checklist for Open Channel Design**

Yes	No	N/A	Design Requirements
			discharge that completely fills the check structure at its crest (typically the 2-year event).
			3. The secondary design flow for a low flow drop structure is the discharge that causes the worst condition for lateral overflow around the abutments of the check and back into the low flow channel below (i.e. 5-, 10-, or 100-year event).
			4. Low flow drop structures are designed to survive the event that creates the worst condition (see #3 above) with minimal or reasonable damage to the floodplain below.
			5. Low flow drop structures have been evaluated for seepage control. Cutoff walls extend laterally at least 5 to 10 feet into the undisturbed bank.
			<b>C. Drop Structure Types</b>
			1. The County has approved the type of drop structure to be used prior to final design.

**VI. EASEMENTS AND OWNERSHIP**

			<b>A. Drainageway Easements</b>
			1. Major and minor drainageways within residential areas that convey flows from other properties are placed on tracts of land owned by a common entity (i.e., Park or Metro District, Homeowner's Association, County, or other regional agency).
			2. Major and minor drainageways within business/commercial developments that convey flows from other properties are placed in drainage easements or separate tracts with drainage easements.
			3. Easements for natural drainageways are wide enough to provide conveyance for design flowrates, required freeboard, and access for maintenance.
			4. Minimum easements widths for natural drainageways are determined using Figure 12-5.

**VII. REQUIREMENTS FOR MAINTENANCE**

			<b>A. Maintenance Access for Major Drainageways</b>
			1. Continuous maintenance access is provided along the entire length of the drainageway.
			2. Maintenance access meets all UDFCD requirements.
			3. If a maintenance access has a centerline radius greater than 80-feet, it has a stabilized surface at least 8 feet wide and has a minimum clear width of 12-feet.
			4. If a maintenance access has a centerline radius between 50 and 80-feet, it has a stabilized surface at least 8-feet wide and a



**CHAPTER 12. OPEN CHANNEL DESIGN**  
**Design Checklist for Open Channel Design**

Yes	No	N/A	Design Requirements
			minimum clear width of 14-feet. The minimum centerline radius is 50-feet.
			5. The maximum longitudinal slope for the maintenance access is 10 percent.
			6. The maintenance access stabilized surface consists of all-weather construction and is capable of carrying loads imposed by maintenance equipment.
			<b>B. Maintenance Access for Minor Drainageways</b>
			1. Continuous maintenance access is provided along the entire length of the drainageway.
			2. A maintenance access with a centerline radius greater than 80-feet has minimum clear width of 12-feet.
			3. A maintenance access with a centerline radius between 50 and 80-feet has a minimum clear width of 14-feet. The minimum centerline radius is 50-feet.
			4. The maintenance access may require a continuous stabilized surface; this is dependant upon the channel size, expected maintenance activities and the proximity of local streets and parking areas. Consult with the County for additional information.
			<b>C. Maintenance Responsibility</b>
			1. Maintenance responsibility is designated on the Final Plat and Final Development Plan, and described in the drainage report.
			2. Maintenance operations are designated in the Operations and Maintenance Manual. See Section 4.8 for additional information.
			<b>D. UDFCD Maintenance Assistance</b>
			1. Major drainageways within the UDFCD boundary must be designed and constructed in accordance with UDFCD maintenance eligibility requirements.



**CHAPTER 12. OPEN CHANNEL DESIGN  
Construction Plans Checklist**

**Yes No N/A Construction Plan Requirements**

**I. OPEN CHANNEL IMPROVEMENTS PLAN VIEW, the following information is shown:**

			A. Title block with project information, including a list of sheet revisions and an approval block
			B. Boundaries of project and plan sheet layout (key map)
			C. Existing and proposed roadways, sidewalks, culverts, storm sewer structures/pipes, irrigation ditches and other surface features
			D. Channel control line with horizontal control dimensions
			E. Existing and proposed utilities (overhead and underground)
			G. Existing and proposed contours
			H. Right-of-way and easement lines
			I. Construction access location(s)
			J. North arrow and scale bar
			K. Proposed structures along channel reach (i.e. drop structures, storm sewer outfalls, etc.)
			L. Limits of cut and fill along channel reach
			M. Proposed limits of channel bank protection
			N. Location(s) of geotechnical test holes
			O. Flow arrows indicating direction of channel flow.

**II. OPEN CHANNEL IMPROVEMENTS PROFILE VIEW, the following information is shown:**

			A. Title block with project information, including a list of sheet revisions and an approval block
			B. Horizontal and vertical scale bars
			C. Existing and proposed ground along channel centerline
			D. Existing and proposed utilities along channel centerline
			E. Existing and proposed design water surface elevations and design flow rates (typically 2-year and 100-year).
			F. Proposed structures along channel centerline, including specific reference (control) stations and elevations (i.e. drop structures, etc.)
			G. Flow arrows with proposed channel centerline longitudinal grades

**III. OPEN CHANNEL IMPROVEMENTS CROSS SECTIONS, the following information is shown:**

			A. Title block with project information, including a list of sheet revisions and an approval block
			B. Horizontal and vertical scale bars
			C. Existing and proposed ground along cross section
			D. Existing and proposed utilities along cross section
			E. Existing and proposed design water surface elevations



**CHAPTER 12. OPEN CHANNEL DESIGN  
Construction Plans Chacklist**

Yes	No	N/A	Construction Plan Requirements
			F. Proposed sideslopes of channel
			F. Existing features along cross section (i.e. bike trails, access roads, storm sewer outfalls, etc.)
			G. Proposed structures along cross section (i.e. bank protection, sidewalks, etc.)

**III. OPEN CHANNEL IMPROVEMENTS DETAILS, the following information is shown:**

			A. Additional cross sections or details of proposed channel improvements, as needed (i.e. drop structures, bank protection, etc.)
			B. Include any additional structure details or special connections that are not included in the Arapahoe County Standard Details or Colorado Department of Transportation M & S Standard Plans