DENVER STORM DRAINAGE DESIGN AND TECHNICAL CRITERIA MANUAL

Denver Department of Transportation and Infrastructure

DENVER
TRANSPORTATION &
INFRASTRUCTURE

April 2024

Denver Storm Drainage Design and Technical Criteria Manual

Revised April 2024

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RELATIONSHIP TO PREVIOUS VERSIONS OF DENVER STORM DRAINAGE CRITERIA MANUAL

This Denver Storm Drainage Design and Technical Criteria Manual (Manual) updates and supersedes previous versions of the Manual and has been updated several times since 1992. A few noteworthy changes include:

April 2024 revisions:

- General updates to improve consistency with the most current version of Mile High Flood District's Urban Storm Drainage Criteria Manual (MHFD Manual).
- Replaced text of Denver Floodplain Ordinance in Section 4.2 and replaced with reference link to Municode to eliminate duplication and potential for inconsistency with the official version of the Floodplain Ordinance located in Denver Revised Municipal Code (DRMC).
- Revisions to the Rainfall chapter for consistency with NOAA Atlas 14, Volume 8, Version 2, 2013.
- Revisions to the Inlets chapter figures for consistency with the MHFD Manual.
- Revisions to the Detention (Storage) chapter to require use of full spectrum detention, including detention of the Excess Urban Runoff Volume (EURV). Addition of figures illustrating full spectrum detention conceptual designs and the Denver Swirl Bay.
- General updates to the Stormwater Quality chapter and revision of criteria for projects that require stormwater quality treatment. Increased recognition of volume reduction strategies as a stormwater quality treatment approach.
- Addition of stormwater facility operation and maintenance plan requirements referencing Denver's 2024 Stormwater Facility Operation and Maintenance Manual.
- Revisions to Construction Site Stormwater Management to improve consistency with the Colorado Department of Public Health and Environment's (CDPHE's) construction stormwater general permit.
- Minor editorial changes related to terminology, minor reorganization of Policy chapter and editing to improve clarity.
- Removal of outdated standard forms in appendix and removal of commonly observed problems appendix.

November 2013 revision amends Chapter 4:

- Wholesale revision to this chapter to incorporate revised floodplain ordinance which was passed by City Council on November 4, 2013.
- April 2013 revision amends Chapters 1, 14, and 15:
- The Criteria are adopted as a part of the Manager's Rules and Regulations Governing Sewerage Charges and Fees and Management of Wastewater, having been adopted and incorporated by reference in the April 2013 revised Sewerage Regulation.

- Revisions to definitions of types of projects and inclusion of Linear Projects (Construction, Rehab, and Maintenance) definitions. These new definitions are applicable for water quality only.
- Revised best management practice (BMP) requirements depending on type of project. Linear Construction Projects require post-construction water quality BMPs per Table 14-3, whereas Linear Rehabilitation & Linear Maintenance Projects do not require water quality.
- Inclusion of option for regional and subregional water quality treatment, pending completion of pilot project and program approval from the Colorado Department of Public Health and Environment (CDPHE).
- Inclusion of maintenance requirements for water quality facilities.
- Replace references to "Erosion & Sediment Control Permit" with "Construction Activities Stormwater Discharge Permit (CASDP)" and revises associated requirements in accordance with current Construction Activities Stormwater Manual (CASM).
- Additional cross-referencing to MHFD's Urban Storm Drainage Criteria Manual, Volumes 1-3 (MHFD Manual) as updated in 2001 and 2010 and as may be periodically amended. Some of the cross-references are adopted and incorporated by reference into the Criteria; others are referenced only as guidance.
- Consolidate into Chapter 15 (from various other documents previously published by the department) the requirements for construction site stormwater management and erosion control.

January 2006 revision:

- Extensive cross-referencing to the MHFD Manual as updated in 2001 and as may be periodically amended. This has resulted in removal of many equations, tables, figures, and text from these Criteria and significant revision of all chapters. The purpose of this change is to ensure that the Criteria remain consistent with the MHFD Manual as technical changes are made to the MHFD Manual in the future and to eliminate unnecessary redundancy between the manuals.
- New inlet and street capacity charts.
- New details for detention and water quality facilities.
- New emphasis on stormwater quality and construction requirements to reflect Colorado Discharge Permit System (CDPS) requirements.
- Revised drainage and construction plan submittal checklists to improve user friendliness for developers and their engineers.
- Addition of an appendix describing commonly encountered problems to help avoid common pitfalls.

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The City and County of Denver acknowledges and recognizes Mile High Flood District's many decades of investment in development and refinement of Volumes 1 through 3 of the Urban Storm Drainage Criteria Manual and supporting software, which are incorporated by reference into this manual.

ACRONYMS

BMP	Best Management Practice
CAP	Corrugated Aluminum Pipe
CASDP	Construction Activities Stormwater Discharge Permit
CDOT	Colorado Department of Transportation
CDPS	Colorado Discharge Permit System
cfs	cubic feet per second
CDPHE	Colorado Department of Public Health and Environment
CLOMR	Conditional Letter of Map Revision
CMP	Corrugated Metal Pipe
CUHP	Colorado Urban Hydrograph Procedure
CWCB	Colorado Water Conservation Board
DOTI	Department of Transportation and Infrastructure
EDB	Extended Detention Basin
EGL	Energy Grade Line
ELG	Effluent Limitation Guideline
EURV	Excess Urban Runoff Volume
FEMA	Federal Emergency Management Agency
FHAD	Flood Hazard Area Delineation
FHWA	Federal Highway Administration
FIRM	Flood Insurance Rate Map
FSD	Full Spectrum Detention
ft	feet
ft/sec	feet per second
GI	Green Infrastructure
HGL	Hydraulic Grade Line
IBC	International Building Code
in	inches
LID	Low Impact Development
LOMR	Letter of Map Revision
MDCIA	Minimizing Directly Connected Impervious Area
MDP	Major Drainageway Plan
MS4	Municipal Separate Storm Sewer System
MHFD	Mile High Flood District
NOAA	National Oceanic and Atmospheric Administration
NOV	Notice of Violation
NRCS	Natural Resources Conservation Service
O&M	Operations and Maintenance
OSHA	Occupational Safety and Health Administration
OSP	Outfall Systems Plan
RCP	Reinforced Concrete Pipe
SCM	Stormwater Control Measure
SDI	Stormwater Detention and Infiltration Design Data
SEO	State Engineer's Office
SPCC	Spill Prevention Control and Countermeasure
SWMM	Stormwater Management Model

SWMP	Stormwater Management Plan
TMDL	Total Maximum Daily Load
WQCV	Water Quality Capture Volume
WQE	Water Quality Event
WQPF	Water Quality Peak Flow

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1.0 General Provisions

1.0 Introduction

These criteria and design standards and all future amendments will be known as the City and County of Denver Storm Drainage Design and Technical Criteria (hereafter called Criteria) as adopted and incorporated by reference in the Department of Transportation and Infrastructure (DOTI) Rules and Regulations Governing Sewerage Charges and Fees and Management of Wastewater (hereafter called Rules and Regulations).

1.1 Enactment Authority

The Rules and Regulations have been adopted, issued, and amended by the Manager of the Department of Transportation and Infrastructure (Manager) in accordance with the authority contained in the Charter and Chapter 56 of the Revised Municipal Code of the City and County of Denver (Denver). These Criteria have been adopted and incorporated by reference into the Rules and Regulations.

1.2 Jurisdiction

These Criteria apply to all land within Denver, including any public lands. These Criteria apply to all storm drainage systems and facilities constructed in or on Denver rights-of-way, easements dedicated for drainage across public or private property, easements for public use, and to all privately owned and maintained stormwater conveyance, detention, retention, and water quality facilities. Additional or different requirements may apply for land under the jurisdiction of Denver International Airport.

1.3 Purpose

Presented in these Criteria are the policies and minimum technical criteria for the planning, analysis and design of storm drainage systems within the boundaries of Denver. All subdivisions, re-subdivisions, planned unit developments, or any other proposed construction submitted for acceptance under the provisions of the Rules and Regulations must include adequate and appropriate storm drainage system planning, analysis, management, and design. Such planning, analysis, management, and design must conform with or exceed the criteria set forth herein. Storm drainage system planning, analysis, management, and design that require policies and technical criteria not specifically addressed in these Criteria must follow the provisions of the Mile High Flood District's (MHFD) Urban Storm Drainage Criteria Manual, Volumes 1, 2, and 3, as amended (MHFD Manual), which is incorporated in these Criteria by reference.

1.4 Amendments and Revisions

The policies and criteria may be amended as new technology is developed or if experience gained in the use of these Criteria indicates a need for revision. All technical criteria and policy changes must be recommended by the Manager. Revisions may be made by the Manager as an amendment to the Rules and Regulations. The Manager will monitor the performance and effectiveness of these Criteria and will recommend amendments and revisions as needed.

1.5 Enforcement Responsibility

It is the duty of the Manager or his/her designee to enforce the provisions of these Criteria.

1.6 Review and Acceptance

Denver will review all drainage submittals for general compliance with these Criteria. An acceptance by Denver does not relieve the owner, engineer, or designer from the responsibility of ensuring that the design, calculations, plans, specifications, construction, and record drawings are in compliance with these Criteria as stated in the engineer's certifications.

Denver will refer reports and construction plans required by these Criteria to MHFD where major drainageway improvements, outfalls to major drainageways, regional detention or water quality facilities, or floodplain modifications are proposed. MHFD approval will be required for the design and construction of the improvements. All MHFD maintenance-eligible stormwater facilities constructed in Denver must meet the MHFD maintenance eligibility requirements.

Submittals that impact Federal Emergency Management Agency (FEMA)-designated floodplains must be submitted to FEMA for review in accordance with the provisions of Chapter 4.

Denver may, but is not required to, refer submittals to other agencies that have an interest or responsibility for drainage and/or water quality issues. Other review agencies may include federal and state agencies responsible for floodplains, water quality, wetlands, water rights and other stormwater related issues, as well as other impacted jurisdictions.

1.7 Interpretation

In the interpretation and application of the provisions of these Criteria by the Manager, the following will govern:

- These Criteria are the minimum requirements to protect the public health, safety, comfort, convenience, prosperity, and welfare of the residents of Denver, protect property, and minimize adverse impacts to the environment.
- Whenever a provision of these Criteria and any other provision of the Rules and Regulations or any provision in any law, ordinance, resolution, rule or regulation of any kind, contains any requirement(s) covering any of the same subject matter, the requirements that are more restrictive or impose higher standards will govern.
- These Criteria do not abrogate or annul any easements, permits, drainage reports or construction drawings, recorded, issued, or accepted by Denver prior to the effective date of these Criteria.
- The Manager has final authority to resolve any conflicting interpretation of these Criteria.

1.8 Relationship to Other Standards

These Criteria are written to be consistent with the MHFD Manual. If the state or federal government imposes stricter criteria, standards, or requirements, these may be incorporated into Denver's Criteria after due process and, if needed, the Rules and Regulations will be modified accordingly.

The reader is advised to consult the reference documents listed in Chapter 16.

1.9 Variances from these Criteria

Variances from the provisions of these Criteria will be considered on a case-by-case basis. Formal requests for variances from the standards, policies or submittal requirements of these Criteria must be submitted with appropriate documentation and justification to the Manager. The variance request and supporting documentation will be reviewed by the Manager or his/her designee and a final decision will be made and a formal written response to the variance request will be provided to the applicant.

Variance requests must be submitted in writing to the Manager and must, at a minimum, contain the following information:

- Criteria from which the applicant seeks a variance.
- Justification for not complying with the criteria.
- Alternate criteria or standards that are proposed to comply with the intent of the Criteria.
- Supporting documentation, including necessary calculations, analysis, and other relevant information.

1.10 Use of Modeling Software and Design Spreadsheets

MHFD computer software programs, models, and spreadsheets are referenced in these Criteria as design aids that may be useful in designing drainage improvements. Use of these design aids is in no way a substitute for sound engineering judgment, proper engineering qualifications and common sense. Although the design aids recommended in these Criteria have been developed using a high standard of care, it is likely that some nonconformities, defects, bugs, and errors with the software programs will be discovered as they become more widely used. Denver does not warrant that any version of these design aids will be error free or applicable to all conditions encountered by the designer, and Denver will not be held liable for their use.

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2.0 Drainage Report and Construction Drawing Submittal Requirements

2.1 Introduction

The chapter describes requirements for preparation and submittal of drainage reports and construction drawings for stormwater management systems in Denver. The requirements presented are the minimum necessary and will be used to determine the adequacy of all submittals to Denver. (Note: Construction Activities Stormwater Discharge Permit (EC Permit) submittal requirements for stormwater management plans are provided separately in Chapter 15.)

2.2 Review Process

All development and redevelopment projects in Denver's jurisdiction must submit drainage reports, construction drawings, specifications and as-constructed information in conformance with the requirements of these Criteria. Complete submittal requirements (Application, General Notes, Permit, etc.) can be found on the Department of Transportation and Infrastructure website (www.denvergov.org/doti/).

2.2.1 Subdivision Process

The general requirements and conditions for the subdivision of land in Denver are set forth in Chapter 50 of the Revised Municipal Code. See the Subdivision Rules and Regulations for standards and procedures for the review and approval of subdivision plats.

2.2.2 Permit Process

Any structure or other development or redevelopment that requires a building permit under the Denver Building Code may also require a Sewer Use and Drainage Permit to be issued by the Wastewater Management Division. A Sewer Use and Drainage Permit will only be issued upon conformance with requirements contained in these Criteria, as evidenced by approval of the Final Drainage Report (as described in Section 2.5) and Construction Drawings (as described in Section 2.6).

2.2.3 Pre-submittal Meeting

In some cases, Denver may recommend a pre-submittal meeting, particularly for large developments, redevelopments or where special conditions or problems have become apparent during the development review process. The pre-submittal meeting will enable the applicant to consult with Denver regarding general information on regulations, required procedures, possible drainage problems, and specific submittal requirements for projects.

2.2.4 Review by Referral Agencies

The review and approval by others, such as state or federal agencies, other local governments, affected jurisdictions, and other referral agencies may be required for some submittals. The applicant must address referral agency comments and obtain approvals when necessary.

2.2.5 Stand-alone Drainage Report

The drainage report must be a stand-alone document. When references are made or assumptions are based on previously approved submitted reports, the drainage report must include the appropriate excerpts, pages, tables, and maps containing the referenced information. Assumptions made in previous reports must be verified and substantiated. All submitted reports must be clear and legible, including photocopies of charts, tables, nomographs, calculations, or any other referenced material.

2.2.6 Submittal Adequacy

The submittal checklist provided at the end of this chapter and the requirements specified in Sections 2.4 through 2.6 will be used by Denver to determine the adequacy of the submittal. Incomplete or absent information may result in the report being returned to the applicant without review. Denver reserves the right to require additional information with any submittal.

2.3 Approval

2.3.1 Final Drainage Report and Construction Drawings Approval Required for Construction

Approval of a Final Drainage Report and construction drawings must be obtained prior to construction of any drainage improvements within Denver. Preliminary Drainage Reports are conceptual and are reviewed by Denver, but they do not receive a formal approval and cannot be used for construction. The approval of a drainage report based on submitted documents and information does not prevent DOTI from requiring the correction of errors.

2.3.2 One-year Approval Period

Final drainage reports will be considered approved for a period of one year. Construction based upon any approved drainage report must commence within this one-year period.

2.3.3 Expired Approval

Approved drainage reports that have exceeded the one-year period may be re-approved on a case-by-case basis. In order to be re-approved, it must be demonstrated that the report is consistent with the current Criteria. If new drainage concepts and standards have been developed, or if any drainage concept or pattern has changed, a new report will be required. Preliminary and Master Drainage Reports conducted for a Master Development Plan are conceptual and are not affected by the approval period.

2.4 Preliminary Drainage Report

If Denver determines during the development review process that the project is of sufficient size or complexity, a Preliminary Drainage Report may be required in advance of the Final Drainage Report. This may also be done at the developer's request. The Preliminary Drainage Report must be prepared and signed by a professional engineer licensed in the State of Colorado and submitted to Denver for review.

2.4.1 Preliminary Drainage Report Contents

The purpose of the Preliminary Drainage Report is to conceptually define the nature of the proposed development or project, describe all existing conditions and propose facilities needed to conform to the requirements of these Criteria. The following is an outline of the minimum[1] Preliminary Drainage Report requirements:

1. General Location and Description

    A. Location

        i. City, county, state highway and local streets within and adjacent to the site or the area to be served by the drainage improvements.

        ii. Township, range, section, ¼ section, subdivision, lot and block.

        iii. Names of surrounding developments.

    B. Description of Property

        i. General project description, including proposed land use.

        ii. Area in acres.

        iii. Ground cover (type of trees, shrubs, vegetation, hydrologic soil group, topography, and slope).

        iv. Major drainageways and drainage facilities.

        v. Existing major irrigation facilities such as ditches and canals.

        vi. History of flooding.

        vii. Easements within and adjacent to the site.

2. Major Drainage Basins and Sub-basins

    A. Major Basin Description

        i. Reference to major drainageway planning studies such as flood hazard area delineation (FHAD) reports, major drainageway master planning reports and flood insurance rate maps (FIRMs); include a copy of current FIRM showing the location of subject property.

        ii. Major basin drainage characteristics, existing and planned land uses within the basin, as defined by Denver.

[1] Denver reserves the right to require additional information with any submittal.

iii. All nearby irrigation facilities within 100 feet of the property that will influence or be influenced by the local drainage.

B. Sub-basin Description

i. Historic drainage patterns of the subject property.

ii. Onsite and offsite sub-basin characteristics.

3. Drainage Facility Design

A. General Concept

i. Drainage concept and typical drainage patterns.

ii. Compliance with offsite runoff considerations.

iii. Anticipated and proposed drainage patterns.

iv. Tables, charts, figures, and/or drawings supporting concept.

B. Specific Details

i. Design flows and volumes.

ii. Existing stormwater conveyance and storage facilities.

iii. Proposed stormwater conveyances, storage facilities and outlet structures.

iv. Relationship to both upstream and downstream properties and impact of the development's drainage on these properties; include discussion of offsite drainage flow patterns and impact on development under existing and fully developed basin conditions as defined by Denver.

v. Drainage problems encountered and solutions at specific design points.

vi. Maintenance (whose responsibility and frequency), public safety and access aspects of the drainage facilities.

vii. Compliance with other local, state and federal requirements.

viii. Structural and non-structural stormwater control measures (SCMs) that will be part of stormwater management design.

ix. When deemed necessary by the Review Engineer, information may be requested in order to update to the Denver Drainage Master Plan in a format specified by the Review Engineer.

4. Conclusions

A. Compliance with Standards

i. Denver Criteria.

ii. Major Drainageway Planning Studies.

iii. MHFD Manual.

iv. Denver's Colorado Discharge Permit System (CDPS) Municipal Separate Storm Sewer System (MS4) Permit.

v. Discussion and justification for any requested waiver.

B. Drainage Concept

i. Effectiveness of drainage design to control damage from storm runoff.

ii. Influence of proposed development on master drainage plan recommendation(s).

iii. Drainage impacts of proposed development on upstream and downstream properties.

C. Water Quality

i. Measures implemented to treat the Water Quality Capture Volume (WQCV).

ii. Measures implemented to reduce runoff volumes.

5. References

Reference all criteria, master plans, and technical information used in support of concept. The Preliminary Design Report must be a stand-alone document including portions of relevant documents referenced in the report. This supporting information may be included as an appendix.

6. Appendices

Appendices should be provided, as needed, to provide supporting information for the report.

2.4.2 Preliminary Drainage Plan Contents

Preliminary Drainage Plan requirements for drawings include:

1. Overall Drainage Plan

A. Electronic format capable of being plotted to 24" x 36" in size.

B. Boundaries of entire development or project.

C. Limits of all major basins, including offsite basins.

D. General drainage patterns and flow paths, including those entering and leaving the site.

E. Any existing or proposed major stormwater management facilities, upstream, downstream or within the site.

F. Title block, legend, P.E. stamp, north arrow, flow arrow, scale.

2. Detailed Drainage Plan

A. Electronic format capable of being plotted to 24" x 36" in size at a scale of 1" = 20' to 1" = 100'.

B. Existing (dashed or screened) and proposed (solid) contours (use NAVD 88 Datum) with a 1-foot maximum interval. Contour intervals may be increased to 2-foot intervals for sites over 5 acres. Existing and proposed contours must extend a minimum of 100 feet beyond property lines.

C. All existing and proposed drainage facilities (e.g., detention facilities, storm drains, swales, riprap, outlet structures, irrigation ditches, culverts, cross pans).

D. Floodplain boundary based on the most current information (e.g., FHAD, master plan, FIRM, etc.).

E. Major basin and sub-basin boundaries.

F. Any offsite feature or basin influencing development.

G. Runoff summary table. See Table 2-1 (at the end of this section).

H. Detention basin summary table. See Table 2-2 (at the end of this section).

I. Location and footprints of detention facilities.

J. Include north arrow, scale, benchmark, and flow arrow.

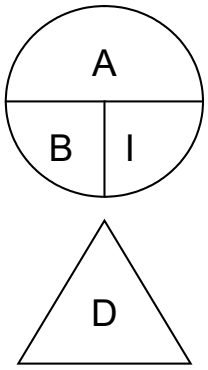
K. Legend to define map symbols. See Table 2-1 (at the end of this section).

L. Project name, address, engineering firm and seal, and date in title block in lower right corner.

M. Denver Drainage Master Plan Basin I.D. number.

N. All relevant Denver project numbers.

Table 2-1. Drawing Symbol Criteria and Hydrology Review



A = Basin Designation

B = Area in Acres

I = % imperviousness

D = Design Point Designation

Summary Runoff Table
(to be placed on Drainage Plan)

Design Point	Contributing Basin(s)	Contributing Area (acres)	2 or 5-Year Runoff (cfs)	100-Year Runoff (cfs)
x	xx	xx.xx	xx.x	xx.x

Table 2-2. Detention Basin Summary Table to be Placed on Drainage and Construction Plan

	Water Surface Elevation (feet)	Volume (cubic feet or acre-feet)	Release Rate (cfs)
Water Quality Capture Volume			
Excess Urban Runoff Volume			
100-year			

2.5 Final Drainage Report

The Final Drainage Report serves to define and expand the concepts shown in the Preliminary Drainage Report and to ensure conformance to these Criteria. The final report may be submitted at any point during the permitting and platting process; however, it must be reviewed and approved prior to approval of the subdivision plat or issuance of the Sewer Use and Drainage Permit. An electronic copy of the report must be submitted to Denver. Reports must be typed in 8½" x 11" format with all pages numbered and include a cover letter presenting the design review.

2.5.1 Certification Statement

The report must contain a certification page with the following statement:

This report for the drainage design of (Name of Development) was prepared by me (or under my supervision) in accordance with the provisions of City and County of Denver Storm Drainage Design and Technical Criteria and was designed to comply with the provisions thereof. I understand that the City and County of Denver does not, and will not, assume liability for drainage facilities designed by others.

By: _____
Licensed Professional Engineer
State of Colorado
No. _____
Affix Seal

2.5.2 Final Drainage Report Contents

The report must be in accordance with, but not limited to, the following outline and contain the applicable information listed below. Denver reserves the right to require additional information with any submittal.

1. General Location and Description. See Section 2.4.1, #1
2. Major Drainage Basins and Sub-basins. See Section 2.4.1, #2
3. Drainage Design Criteria
    A. Regulations: Discuss optional provisions selected or deviations from the Criteria, if any, and their justification.
    B. Development Criteria References and Constraints.
        i. Previous drainage studies (e.g., project master plans, MHFD outfall system plans, Denver Drainage Master Plan) for the site that influence, or are influenced by, the proposed drainage design and how the studies will affect drainage design for the site.
        ii. Relationship to and implications of adjacent drainage studies.
        iii. Drainage impact of site constraints such as streets, utilities, transit ways, existing structures, and development or site plans.
        iv. Geotechnical report (P.E. signed and stamped)
    C. Hydrologic Criteria
        i. Design rainfall.
        ii. Hydrologic soil group.
        iii. Runoff calculation method(s).
        iv. Detention discharge and storage calculation method.

v. Design storm recurrence intervals.

vi. Justification for other criteria or calculation methods used that are not presented in or referenced by the Criteria.

D. Hydraulic Criteria

i. Various capacity methods.

ii. Hydraulic grade line (HGL) calculation method and head loss coefficients.

iii. Routing method used.

iv. Other drainage facility design criteria used that are not presented in the Criteria.

E. Water Quality Requirements Under Denver's MS4 Permit

i. Design procedures.

ii. Calculated WQCV and Excess Urban Runoff Volume (EURV) for the site.

iii. Calculated volume reduction (if applicable).

iv. Permanent, post-construction SCMs for treatment of the WQCV or EURV.

v. Documentation of any MS4 Permit-allowed exclusions utilized.

vi. Documentation of why it is not practicable to treat 100% of the applicable development site (e.g., driveway access that drains directly to street; if applicable, see Chapter 14).

vii. Landscaping requirements.

F. Waivers from Criteria

i. Attach approved waivers, including description of waiver and supporting documents.

ii. Reference specific criteria by section number to which the waiver is being requested.

4. Drainage Facility Design

A. General Concept. See Section 2.4.1, #3 (A).

B. Specific Details. See Section 2.4.1, #3 (B) and in addition include:

i. Easements and tracts for drainage purposes, including the conditions and limitations for use.

ii. All structural and non-structural BMPs, including tributary areas, sizing, treatment volumes, design features, etc.

5. Stormwater Detention and Infiltration Design Data (SDI) Worksheet, or acceptable alternative calculations for upload to state Compliance Portal, demonstrating compliance with state law regarding maximum detention drain times.

6. Facility Operation and Maintenance Plan for stormwater management facilities. (See Denver Stormwater Facility Operation and Maintenance Manual for requirements.)

7. Conclusions. See Section 2.4.1, #4.

8. References

   Reference all criteria and technical information used. The final report must be a stand-alone document including portions of relevant documents referenced in the report. This supporting information may be included as an appendix.

9. Appendices

   A. Hydrologic Computations

      i. Land use assumptions regarding adjacent properties.

      ii. Time of concentration and runoff coefficients for each basin.

      iii. Minor and major storm runoff at specific design points.

      iv. Connectivity diagram showing relationship/connectivity of basins, conveyance facilities, detention basins and design points.

      v. Electronic copy and hard copy of input/output listings for computer models used.

   B. Hydraulic Computations

      i. Street capacity as compared to allowable capacity using Figure 7-1.

      ii. Inlet capacity as compared to allowable capacity using Figures 8-1 and 8-2.

      iii. Storm drain capacity, including HGL elevations and head loss coefficients.

      iv. Energy grade line (EGL) when the storm drain is designed for events larger than the minor event or is requested by Denver.

      v. Open channel design, low flow and trickle channel design, stabilization and grade control improvements.

      vi. Energy dissipation at pipe outlets.

      vii. Water surface profiles.

      viii. Culvert capacities.

      ix. Stage-Storage-Discharge determination for detention basins.

x. Downstream/outfall system capacity of the major drainageway.

xi. Charts, figures and tables related to hydraulic computations.

xii. Electronic and hard copy of input/output listings for computer models used.

C. Stormwater Quality BMPs

i. Completed MHFD Manual Volume 3 MHFD SCM Design worksheet.

ii. Design and sizing.

iii. Charts, figures, tables, and details related to design.

D. Excerpts from supporting documents, if referenced in report.

2.5.3 Final Drainage Plan Contents

Final Drainage Plan requirements for drawings include:

1. Overall Drainage Plan. See Section 2.4.2, #1
2. Detailed Drainage Plan. See Section 2.4.2, #2 and in addition include:

A. Property lines and easements with purposes noted.

B. Adjacent developments or property ownerships.

C. Street cross-section indicating right-of-way width, flow-line width, cross slope, sidewalk, and curb type.

D. Street slope and flow direction and cross-pan.

E. Proposed storm drains and open drainageways, including inlets, manholes, culverts, and other appurtenances, including riprap protection.

F. Proposed outfalls or exit points for runoff from the developed area and facilities to convey flows to the final outfall point without damage to downstream properties.

G. Finished floor elevation of proposed and existing structures.

H. Proposed detention basin grading and detention basin outlet schematic, include overflow directions and amounts and emergency spillway.

I. Stormwater Quality BMPs schematic.

2.6 Construction Drawings

2.6.1 Improvement Requirements

Drainage improvements within Denver are required to be designed, constructed and approved in accordance with Denver standards and criteria. Construction plans are required to be approved by DOTI for all facilities within Denver.

The information required for the plans must be in accordance with sound engineering principles, these Criteria, Denver's MS4 Permit, and other applicable Denver ordinances, regulations, criteria or design guidelines. The plans may also be subject to review by outside agencies such as MHFD, FEMA, U.S. Army Corps of Engineers, U.S. Environmental Protection Agency or others as required. All plans must comply with the requirements of the current *International Building Code* and *International Plumbing Code,* as may be amended. The approval of construction plans based on submitted documents and information does not prevent DOTI from requiring correction of errors.

2.6.2 Certification

Construction drawings submitted for review and acceptance must be prepared by a professional engineer licensed in the State of Colorado. The construction drawings must include the following statement on the cover sheet:

> These construction drawings for (name of subdivision, development, or project) were prepared by me (or under my direct supervision) in accordance with the requirements of the Wastewater Capital Projects Standard Construction Specifications, Wastewater Management Standard Detail Drawings and the Storm Drainage Design and Technical Criteria of the City and County of Denver.
>
> By: _____
> Licensed Professional Engineer
> State of Colorado
> No. _____
> Affix Seal
>
> Name of Firm_____

2.6.3 Construction Plan Requirements

The construction plans (24" x 36") for drainage improvements must include both general drainage improvement and specific design feature information, as described below. Denver reserves the right to require additional information with any submittal.

1. General Information Required for All Drainage Improvement Projects

   A. Cover sheet

      i. Vicinity map.

ii. Professional engineer certification.

iii. Title block, sheet index.

iv. Denver DOTI Storm and Sanitary Standard Notes (access online at the DOTI Document Center).

B. Overall utility plan showing water, sanitary and storm drain facilities.

C. Grading plan (Use NAVD 88 Datum).

D. Drainage plan.

E. Basic information.

i. Property and right-of-way lines, existing and proposed easements, tracts, structures, fences, and other land features.

ii. Relation of site to current floodplain boundaries.

iii. Maintenance access.

iv. Utilities adjacent to or crossing stormwater management facilities.

v. Additional design details as required.

vi. Any non-Denver standard details.

2. Specific Design Feature Information

A. Storm Drains and Culverts

i. Plan and profile of proposed pipe installations, inlets, manholes, junction boxes and outlet structures with pertinent elevations, dimensions, types, designs and pipe full flow rates and horizontal controls shown. Plan and profile must be included on same sheet.

ii. Minor storm HGLs.

iii. Major storm HGLs if the facility is designed for events greater than the minor storm.

iv. Pipe outlet protection on plan and profile views.

v. Utilities adjacent to or crossing storm drain or culvert alignment in plan and profile.

vi. 1” = 20’ scale, minimum, grading details for all pipe and culvert inlets and outlets.

B. Detention/Storage Facilities

i. Detention basin grading, trickle channel, inlet, outlet, and emergency overflow spillway locations.

ii. Detention facility summary, Table 2-2 (at the end of Section 2.4.2).

iii. Forebay, micropool, trickle channel and outlet construction details, including safety features, such as racks at openings.

iv. Finished floor elevation of all existing and proposed structures within the property.

C. Open Channels, Swales, Channel Stabilization

i. Plan view showing horizontal locations of existing and proposed channels and swales, including locations of grade control structures and stabilization measures, such as check structures, drop structures, toe protection, bank stabilization, low-flow or trickle channels, with appropriate horizontal controls, safety features, etc.

ii. Profile along channel alignment with all invert elevations and top-of-channel bank elevations and design flow rates.

iii. Water surface limits in plan view.

iv. Water surface profiles for the minor and major storms.

v. Side tributary channels and pipe outlets.

D. Stormwater Quality BMPs

i. Plan and profile of improvements as required.

ii. Design details as required.

2.7 As-built Drawings and Certifications

Upon completion of construction, as-built drawings must be submitted electronically in PDF format. Certifications of the as-built drawings are required as follows:

- Licensed Land Surveyor: A licensed land surveyor in the State of Colorado must certify the as-built detention basin volumes and outlet structure sizes and elevations, storm drain sizes and invert elevations at inlets, manholes and discharge locations, longitudinal slopes and representative cross sections of open channels and dimensions of drainage structures, and elevations of all detention basin spillways and detention containment berms.

- Licensed Professional Engineer: The responsible design engineer must submit a completed "Certificate of Inspection." See the DOTI website (www.denvergov.org/doti/) for requirements.

Certificate of Inspection and as-built drawings and all necessary approvals from all the entities (e.g., MHFD approval for master drainageway improvements, FEMA approval for floodplain, etc.) will be required prior to the issuance of a sanitary sewer connection permit or the signing of a Certificate of Occupancy.

2.8 Submittal Checklists

The checklists below identify major topics required for reports. The report outlines presented earlier in this chapter identify additional detail that must also be provided. Not all information in these tables is required for preliminary reports.

Table 2-3. Drainage Report Checklist

Drainage Report			Received or Not Applicable	To be Submitted
i	**Electronic Report in PDF**			
ii.	**P.E. Certification**			
1	**General Location and Description**			
	A	Location, Name of Surrounding Developments		
	B	Description of Property, Area, Irrigation Facilities, Major Drainageways, Easements		
2	**Major Drainage Basins and Sub-Basins**			
	A	Major Basin Description, Copy of Current FIRM		
	B	Sub-basin Description, Impact from On- and Off-site Basins		
3	**Design Criteria**			
	A	Regulations: Optional Provisions and Deviations		
	B	Development Criteria References/Constraints: Master Plan, Outfall System Plan, Adjacent Studies		
	C	Hydrologic Criteria: Rainfall, Soils, Runoff and Storage Calculation Methods, Design Storm Recurrence Interval		
	D	Hydraulic Criteria: Conveyance Facility Capacities, HGL Calculations, Routing Methods		
	E	Water Quality Requirements: WQCV, BMPs for Treatment of the WQCV; Volume Reduction; Minimizing Directly Connected Impervious Area; Maintenance		
	F	Approved waivers from Criteria, including description of waiver and supporting documents		
4	**Drainage Facility Design**			
	A	General Concept: Discussion of Drainage Patterns and Impact on Upstream and Downstream Properties		
	B	Specific Details: Flows, Volumes, EURV, WQCV; Existing and Proposed Facilities; Detention Storage and Outlet Design; Maintenance Access; Structural and Non-Structural BMPs; Appearance and Safety		

Drainage Report			Received or Not Applicable	To be Submitted
	C	Right of Way or Easements Provide Adequate Space for Drainage Facilities and Construction Area Requirements		
5	**SDI Worksheet, or acceptable alternative calculations**			
6	**Operations and Maintenance Plan**			
7	**Conclusions**			
	A	Compliance with Standards		
	B	Drainage Concept, Effectiveness of Drainage Design		
	C	Water Quality Measures Implemented to Treat the WQCV		
8	**References**			
9	**Appendices (Final Report Only)**			
	a	Hydrologic Computations		
		1. Land Use Assumptions		
		2. Reasonable Time of Concentration (First Design Point Between 5 to 10 minutes)		
		3. Minor and Major Storm Runoff Calc. for On- and Off-site Basins		
		4. Connectivity Diagram/SWMM Schematic		
		5. Electronic and Hard Copy of Input/Outputs for Computer Models Used.		
	b	Hydraulic Computations		
		1. Street and Inlet Capacities		
		2. Storm Drain Capacities: HGL in Minor Event within the Pipe and HGL in Major Event 1 Foot Below Ground		
		3. Open Channel, Low Flow and Trickle Channel Design, Stabilization and Grade Control Improvements		
		4. EGL When Storm Drain Designed for Events Greater than Minor Storm		
		5. Riprap or other Energy Dissipation Design		
		6. Water Surface Profiles and Culvert Capacities		
		7. Stage-Storage-Discharge for Detention Basins		
		8. Downstream/Outfall System Capacity for Major Drainageway		
		9. Charts, Figures, Tables for Related Hydraulic Computations		
		10. Electronic and Hard Copies of Inputs/Outputs of Models		
	c	Water Quality BMP Design Information Including Design Forms from Volume 3 of the MHFD Manual and Related Charts, Figures, Tables, Forms		
	d	Excerpts from Supporting Documents		

Table 2-4. Drainage Plan Checklist

Drainage Plan			Received or Not Applicable	To be Submitted
1	**Overall Drainage Plan**			
	a	Delineation of Entire Development and Off-site Basins		
	b	Delineation of all Major Basins		
	c	Identification of Major Storm Drainage Facilities		
	d	General Drainage Paths with Flow Arrows		
2	**Detailed Drainage Plan**			
	a	Existing (dashed or screened) Contours		
	b	Proposed (solid) Contours, Spot Elevations of Critical Points		
	c	All Existing and Proposed Drainage Facilities (e.g., Detention Facilities, Storm Drains, Swales, Riprap, Outlet Structures, Irrigation Ditches, Culverts, Cross Pans)		
	d	Existing and Proposed Pipe Sizes		
	e	Floodplain and Floodway Boundaries and Information Source		
	f	Delineation of All Major Basins and Sub-basins, Key Off-site features		
	g	Runoff Summary Table – See Table 2-1		
	h	Detention Basin Summary Table – See Table 2-2		
	i	Cross Sections of Drainage Ditches		
	j	Finished Floor Elevation		
	k	Property and Right-of-Way Lines, Existing and Proposed Easements with Purposes Noted, Tracts, Structures, Fences, Wetlands, Waters of the State and Other Land Features		
	l	Adjacent Developments or Ownerships		
	m	Street Cross Sections Indicating Right of Way Width, Flow-line to Flow-line Width, Cross Slope, Sidewalk, Curb Type		
	n	Street Slope, Flow Direction and Cross Pan		
	o	Proposed Detention Basin Grading and Detention Basin Outlet Schematics		
	p	Overflow Directions and Amounts, Emergency Spillway		
	q	Stormwater Quality BMPs Schematic		

Table 2-5. Construction Plan Checklist

Construction Plan			Received or Not Applicable	To be Submitted
For information on Application to Construct (Private or Public), Surety (if Public) with Cost Estimate and Review Fee, see www.denvergov.org/doti/				
General Information Required for All Drainage Improvement Projects				
1	**Cover Sheet**			
	A	Vicinity Map 1"=2000' and North Arrow		
	B	Professional Engineer Certification		
	C	Title Block, Sheet Index, NAVD 88 Bench Mark		
	D	Denver DOTI Storm and Sanitary standard notes (access online at the DOTI Document Center).		
2	**Overall Utility Plan Showing Water, Sanitary Sewer and Storm Drain Facilities**			
	A	Pipe Size and Type		
3	**Grading Plan**			
4	**Drainage Plan**			
5	**General Information**			
	A	Street Names, Property and Right-of-Way Lines, Existing and Proposed Easements, Tracts, Structures, Fences, and Other Land Features, Legend		
	B	Floodplain Boundaries and Information Source		
	C	Maintenance Access		
	D	Utilities Adjacent to or Crossing Stormwater Management Facilities		
	E	Notes and Design Details as required; any **non-Denver** Standard Details		
Specific Facilities or Components Information				
1	**Storm Drains and Culverts**			
	A	Plan and Profile of Proposed Pipe Installations, Inlets, Manholes, Junction Boxes and Outlet Structures with Pertinent Elevations, Dimensions, Slopes, Types, Sizes, Design and Pipe Full Flow Rates and Horizontal Controls Shown		
	B	Plan and Profile Must be on Same Sheet; Key Map for Multiple Plans and Profiles		
	C	Design Storm HGLs		
	D	Pipe Outlet Protection on Plan and Profile Views; Rip Rap Details and Cross Sections		
	E	Utilities Adjacent to or Crossing Storm Drain or Culvert Alignment		
	F	1” = 20’ Scale Minimum, Grading Details for All Pipe and Culvert Inlets and Outlets		

Table 2-5. Construction Plan Checklist (continued)

Construction Plan			Received or Not Applicable	To be Submitted
2	**Detention/Storage Facilities**			
	A	Detention Basin Grading, Trickle Channel, Inlet, Outlet, and Emergency Overflow Spillway Locations, Safety Features		
	B	Detention Facility Summary, Table 2-2		
	C	Forebay, Micro Pool and Basin Outlet Construction Details		
	D	Trickle Channels from Forebay to Basin Outlet		
	E	Finished Floor Elevation of Structures Adjacent to Detention Basin		
3	**Open Channels, Swales, Channel Stabilization**			
	A	Plan View Showing Horizontal Locations of Existing and Proposed Channels and Swales, Including Locations of Grade Control Structures and Stabilization Measures, such as Check Structures, Drop Structures, Toe Protection, Bank Stabilization, Low Flow or Trickle Channels, with Appropriate Horizontal Controls		
	B	Profile along Channel Alignment with all Invert Elevations and Top of Channel Bank Elevations, and Design Flow Rates		
	C	Water Surface Limits in Plan View		
	D	Water Surface Profiles for the Minor and Major Storms		
	E	Side Tributary Channels and Pipe Outlets		
4	**Stormwater Quality BMPs**			
	A	Plan and Profile of Improvements, as Required		
	B	Design Details Specific to the Site		

3.0 Stormwater Management Policy and Principles

3.1 Introduction

Stormwater and floodplain management are necessary to preserve and promote the general health, welfare, economic and environmental well-being of Denver. When considered in a comprehensive manner on a regional level with public and private involvement, stormwater management facilities can enhance the general health and welfare of the region and support optimum economic and social relationships. This chapter describes the principles that Denver follows to manage drainage and summarizes policies followed for planning, design, operation and maintenance, irrigation facilities, flood control and water quality. These principles and policies form the underlying basis of the criteria established in this Manual.

3.2 Principles

Denver follows well-established principles for urban stormwater management adapted from the MHFD Manual:

1. Drainage is a regional phenomenon that does not respect the boundaries between government jurisdictions or between properties. This makes it necessary to formulate programs that include both public and private involvement. Overall, the governmental entities most directly involved must provide coordination and master planning, but drainage planning must be integrated on a regional level if optimum results are to be achieved. The manner in which proposed drainage systems fit into existing regional systems must be quantified and discussed in drainage master plans.

2. A storm drainage system is a subsystem of the total urban water resources system. Stormwater system planning and design for any site must be compatible with comprehensive regional plans and should be coordinated with planning for land use, open space and transportation. Erosion and sediment control, flood control, site grading criteria, and water quality are integral to urban stormwater management. Any individual master plan or specific site plan should normally address all of these considerations.

3. Every urban area has an initial (i.e., minor) and a major drainage system, whether or not they are actually planned and designed. The initial drainage system, sometimes referred to as the “minor system,” is designed to provide public convenience and to accommodate moderate, frequently occurring flows. The major system carries more water and operates when the rate or volume of runoff exceeds the capacity of the minor system. Both systems should be carefully considered.

4. Runoff routing is primarily a space allocation problem. The volume of water present at a given point in time in an urban region cannot be compressed or diminished. Channels and storm drains serve both conveyance and storage functions. If adequate provision is not made for drainage space demands, stormwater runoff will conflict with other land uses, result in damages, and impair or disrupt the functioning of other urban systems.

5. Planning and design of stormwater drainage systems should not be based on the premise that problems can be transferred from one location to another. Urbanization tends to increase downstream peak flow by increasing runoff volumes and velocities. Stormwater

runoff can be stored and slowly released via detention facilities to manage peak flows, thereby reducing the drainage capacity required immediately downstream.

6. An urban storm drainage strategy should be a multi-objective and multi-means effort. The many competing demands placed upon space and resources in an urban region argue for a drainage management strategy that meets multiple objectives, including water quality enhancement, groundwater recharge, recreation, wildlife habitat, wetland creation, protection of landmarks/amenities, control of erosion and sediment deposition, and creation of open spaces.

7. Design of the storm drainage system should consider the features and functions of the existing drainage system. Every site contains natural features that may contribute to the management of stormwater without significant modifications. Existing features such as natural streams, depressions, wetlands, floodplains, permeable soils, and vegetation provide for infiltration, help control the velocity of runoff, extend the time of concentration, filter sediments and other pollutants, and recycle nutrients. Each development plan should carefully map and identify the existing natural system. Techniques that preserve or protect and enhance the natural features are encouraged. Good designs improve the effectiveness of natural systems rather than negate, replace or ignore them.

8. In conjunction with new development and redevelopment, efforts should be coordinated to minimize increases in, and reduce where possible, stormwater runoff volumes, flow rates, and pollutant loads to the maximum extent practicable. Key practices include:

    - The perviousness of the site and natural drainage paths should be preserved to the extent feasible. Areas conducive to infiltration of runoff should be preserved and integrated into the overall runoff management strategy for the site.

    - The rate of runoff should be slowed. Preference should be given to stormwater management systems that maximize vegetative and pervious land cover. These systems will promote infiltration, filtering and slowing of runoff. It should be noted that, due to the principle of mass conservation, it is virtually impossible to prevent increases in post-development runoff volumes for all storm events when an area urbanizes. Existing stormwater regulations typically require control of peak flows to predevelopment levels to the maximum extent practicable, and increasingly, regulatory agencies are implementing requirements focused on the control of runoff volumes for smaller, frequently occurring events. Increased flow volumes may not cause flooding problems if a watershed has a positive outfall to a stream or river; however, increases in runoff volumes may cause problems for small, enclosed watersheds (i.e., draining to a lake) or into streams of limited capacity. Increases in runoff volumes, if not appropriately managed, can also adversely affect stream stability.

    - Pollution control is best accomplished by implementing a series of measures, which can include source controls, minimizing directly connected impervious area, and construction of on-site and regional facilities to control both runoff and pollution. Implementing measures that reduce the volume of runoff produced by

frequently occurring events through infiltration and disconnection of impervious areas is one of the most effective means for reducing the pollutant load delivered to receiving waters.

9. The stormwater management system should be designed beginning with the outlet or point of outflow from the project, giving full consideration to downstream effects and the effects of offsite flows entering the system. The downstream conveyance system should be evaluated to ensure that it has sufficient capacity to accept design discharges without adverse upstream or downstream impacts such as flooding, stream bank erosion, and sediment deposition. Additionally, the design of a drainage system should take into account the runoff from upstream sites, recognizing their future development runoff potential (e.g., imperviousness).
10. The stormwater management system requires regular maintenance. Failure to provide proper maintenance reduces both the hydraulic capacity and pollutant removal efficiency of the system. The key to effective maintenance is clear assignment of responsibilities to an established entity and a regular schedule of inspections to determine maintenance needs and to ensure that required maintenance is conducted. Local maintenance capabilities should be considered when selecting specific design criteria for a given site or project.
11. Floodplains should be preserved whenever feasible and practicable. Nature has claimed a prescriptive easement for floods, via its floodplains, that cannot be denied without public and private cost. Floodplain encroachment must not be allowed unless competent engineering and planning have proven that flow capacity is maintained, risks of flooding are defined, and risks to life and property are strictly minimized. Preservation of floodplains is a policy of MHFD to manage flood hazards, preserve habitat and open space, create a more livable urban environment, and protect the public health, safety, and welfare (White 1945).
12. Reserve sufficient right-of-way for lateral movement of incised floodplains. Whenever an urban floodplain is contained within a narrow non-engineered channel, its lateral movement over time can cause extensive damage to public and private structures and facilities. For this reason, whenever such a condition exists, it is recommended that, at a minimum, the channel be provided with grade control structures and a right-of-way corridor be preserved of a width corresponding to normal depth calculations for the future stable channel geometry, plus maintenance access requirements.

3.3 Policies

In keeping with the principles of storm drainage planning, Denver has developed specific policies that must be followed. These policies are discussed in the following categories: planning, design, operation and maintenance, irrigation and storage facilities, and water quality.

3.3.1 Drainage Planning

1. All land development and redevelopment proposals must receive full site planning and engineering analyses. A drainage report and plan consistent with the submittal

requirements in these Criteria is required for all new development and redevelopment in Denver's jurisdiction.

2. Stormwater management planning is required in the initial planning stages for all developments and redevelopments to ensure that adequate space is allocated for the drainage facilities.

3. Denver encourages multi-purpose uses of storm drainage facilities that are compatible with adjacent land uses, Colorado Water Law and water quality enhancement objectives. Special care must be taken when storm drainage facilities are located in recreational, park and open space areas to ensure that uses are compatible.

4. Denver supports and pursues a jurisdictionally unified approach to drainage to ensure an integrated comprehensive regional drainage plan.

5. Denver will continue to participate in and encourage the development of detailed regional master plans that establish site drainage requirements for development and identify the required public improvements. Master plans will be approved, adopted, and revised as necessary to accommodate changes that occur within the specific drainage basin.

6. Where practicable and feasible, site planning and design techniques should minimize directly connected impervious areas in order to decrease the volume and velocity of stormwater runoff from a site.

7. Denver encourages the design of multipurpose detention facilities that are safe, maintainable, and aesthetic community assets.

8. Denver defines a major drainageway as any drainage flow path with a tributary area of 130 acres or more.

9. Major drainageways must remain in open channels and must not be piped.

10. Denver considers stormwater runoff to be an integral part of Denver's surface and groundwater resource and recognizes its potential for other uses.

11. Denver recognizes that some intra-watershed transfer or diversion of runoff occurs within major drainageway watersheds, as sub-watershed boundaries are changed with development. Such diversions and transfers should be minimized to the extent possible. Historic outfall locations to natural drainageways must be maintained, and any potential adverse impacts resulting from drainage transfers must be mitigated with the stormwater management design.

12. Historic major drainage pathways must be maintained, and inter-basin transfers of storm drainage must be avoided to the maximum extent practicable. Deviations from this policy may be granted on a case-by-case basis, but only when the following criteria are met:

    i. No other viable alternative exists.

ii. No additional potential damage is created by the proposed transfer.

iii. No injury to water rights is caused.

iv. No other regulatory requirement is violated.

13. Denver encourages and will continue to participate in the development of detailed regional drainage master plans that set forth the requirements for new developments and identify required public improvements.

14. Denver will carefully consider implementing the recommendations of master plans, within the context of available public funds and overall priorities specified in the Denver Comprehensive Plan 2000 (and as amended). Prior to implementing master plan recommendations based on modeling, Denver will require reasonableness checks of modeling results based on site observations and other information (e.g., maintenance records, flooding problems due to existing pipe size), where such information is reasonably available.

15. In areas with known drainage problems or water quality impairments, development and redevelopment project plans must include measures that minimize further impacts.

16. All development and redevelopment projects must drain to an acceptable outfall in accordance with the Denver-approved Final Drainage Report for the initial drainage system and the applicable master drainage plan for the major drainage system. Where no approved master drainage plan exists, the proponent must prepare and obtain approval for a master drainage plan for the affected area.

17. Retention ponds are not allowed in most circumstances. In areas where downstream outfall systems are inadequate or non-existent and where provision of outfall facilities is technically infeasible, Denver may allow on-site retention for new development and redevelopment projects. When required, retention must be designed in accordance with MHFD Criteria and all other applicable regulations (e.g., water rights, dam safety).

18. Denver regulates and manages floodplains in accordance with Denver's Floodplain Ordinance (Article V, Chapter 56, Revised Municipal Code) and as described in Chapter 4 of these Criteria.

19. Denver recognizes the possible effects of the drainage system on water rights. In such cases, the State Engineer's Office should be consulted.

20. Groundwater can adversely impact the construction, capacity, long-term function, and maintainability of stormwater management facilities. Those potential impacts must be quantified to the extent possible and considered during the design of stormwater management facilities. Water quality and pipe capacity will be evaluated by Denver before accepting discharges of groundwater to the storm drain system.

3.3.2 Flood Detention (Storage) and Stormwater Quality Facilities

1. On-site Full Spectrum Detention (FSD) of flood flows for all development and redevelopment projects is required to reduce urban drainage problems and the costs of drainage facilities. Exemptions from FSD may be granted under these conditions:

   i. Project area less than 0.5 acre. Projects less than 0.5 acre are required to reduce runoff volumes to the maximum extent practicable. This can be done by minimizing directly connected impervious area and using other low impact development practices.

   ii. Project is immediately adjacent to a major drainageway or precedes the fully developed peak runoff to the first major drainageway. On these sites, the following conditions must be met:

   - The EURV must be provided to provide minor event flood attenuation and to protect downstream channel stability.
   - The major drainageway must be capable of safely conveying the fully developed basin 100-year flood.
   - The fully developed 100-year flow from the project must be safely conveyed to the major drainageway without adversely impacting private properties or right of way. At a minimum, a safe conveyance determination must meet the requirements for streets in Table 7-2 (e.g., may not overtop arterial streets), not overtop rail tracks or regional trails, and consider other site-specific factors.

   iii. Project is tributary to a publicly owned and maintained regional detention facility designed to accommodate flows from a fully developed basin, and safe and adequate conveyance of 100-year developed flows is provided from the development to the regional facility.

   All exemptions are subject to approval at the sole discretion of DOTI and may require additional analysis to demonstrate that no adverse effects to the overall drainage system will result from the exemption.

2. Flood detention and water quality facilities must be designed to be safe, maintainable and aesthetically pleasing, serving as community assets rather than liabilities.

3. Planning for water quality and flood detention must be integrated for all development and redevelopment projects. In this context, site planning and design techniques must reduce runoff volumes and velocities to the maximum extent practicable by implementing measures that minimize directly connected impervious area, as specified in Volume 3 of the MHFD Manual and Chapter 14 of these Criteria.

4. All development and redevelopment projects must comply with the terms and conditions of Denver's Colorado Discharge Permit System (CDPS) municipal separate storm sewer (MS4) discharge permit to minimize the discharge of pollutants to receiving waters to the maximum extent practicable through implementation of stormwater control measures.

5. Permanent stormwater control measures must be designed to treat stormwater runoff from the fully developed project site, as specified in Chapter 14 of these Criteria.

6. All development and redevelopment projects in Denver must implement BMPs to control erosion, sedimentation, and pollutant laden stormwater discharges during construction activities in accordance with Chapter 15 of these Criteria and Volume 3 of the MHFD Manual.

7. Denver reserves the right to require implementation of temporary construction BMPs on development and redevelopment sites less than one acre in size.

8. Regional or subregional detention and stormwater quality facilities must be designed and constructed prior to development of any properties that are to be served by the facility.

3.3.3 Drainage Design

1. The design criteria presented in this Manual are minimum requirements for stormwater management. These criteria will be revised and updated as necessary to reflect advances in the field of urban drainage engineering and water resources management. All storm drainage facilities must be planned and designed in accordance with these Criteria, the Denver Rules and Regulations and the MHFD Manual.

2. All development and redevelopment projects must include planning and design for both the minor (initial) and major drainage systems in accordance with the storm recurrence intervals defined in Table 3-1.

Table 3-1. Design Storms for the Minor and Major Drainage Systems

Land Use	Minor System	Major System
Residential	2-year	100-year
Commercial	5-year	100-year
Industrial	5-year	100-year
Open Space	2-year	100-year
Sump Conditions	5-year	100-year

3. The minor drainage system must be designed to transport runoff with minimum disruption to the urban environment and to discharge to an acceptable outfall. Initial storm drainage may be conveyed in the curb and gutter of the street, roadside ditch, storm drain, channel, or other conveyance facility, provided that capacity exists under fully developed future conditions. Street conveyance must comply with encroachment limits specified in Table 7-1. The minor drainage system must be sized without accounting for peak flow reductions from upstream detention.

4. The capacity of the minor system of the downstream development must be equivalent to, or greater than, the capacity of the upstream system.

5. The major drainage system must be designed to convey runoff from the 100-year recurrence interval flood to minimize health and life hazards, damage to structures, and interruption to traffic and services and must discharge to an acceptable outfall.

6. The major drainage system must be designed and sized without accounting for peak flow reductions from onsite or offsite detention unless permanently dedicated, publicly maintained detention facilities have been constructed.

7. Storm runoff must be determined by the Colorado Urban Hydrograph Procedure (CUHP) Method or the Rational Method, depending on the catchment size and complexity, as determined by the criteria provided in Table 6-1.

8. Streets are an integral part of the urban drainage system and may be used for drainage in accordance with the limitations identified in Tables 7-1 through 7-3 of these Criteria. Streets must not be used for drainage in a manner that unduly restricts the primary purpose of streets, which is for traffic.

3.3.4 Operation and Maintenance of Drainage Facilities

1. Storm drainage facilities, including channels, flood detention and water quality facilities, storm drains, and related appurtenances require on-going maintenance and periodic repair and restoration to ensure proper functioning. Safe and adequate maintenance access must be provided in designs for all storm drainage facilities. Maintenance requirements and access provisions must be clearly defined in the drainage plan, storm drain construction plan and site plan submittals.

2. Easement widths must be provided in accordance with Table 3-2 and should be based on maintenance access needs and overflow widths, if any. Drainage easements must be shown on the corrected plats, drainage plan, and storm drain construction plan and state that Denver has the right of access on the easements, which must be kept clear of obstructions restricting flow and/or maintenance access.

Table 3-2. Required Maintenance Easements for Drainage Facilities

Facility Type	Easement Width
Single Pipe	$W = B_c + 2H + 3$ where B_c = outside span of pipe in feet H = depth from top of pipe to final surface elevation in feet W = easement width, rounded to the next highest 5-foot increment with a minimum width of 20 feet.
Multiple Pipe Installation	Width calculated on a case-by-case basis
Open Channels and Swales	Q_{100} less than 20 cfs: 20 ft Q_{100} 20 to 100 cfs: 25 ft Q_{100} greater than 100 cfs: See MHFD Manual
Detention Basin	Width as required to contain storage, freeboard and associated facilities plus no less than 10 feet for maintenance access around the perimeter. When multiple lots are involved, a dedicated tract of land is required.

3. For detention and stormwater quality facilities, Denver requires submittal of an Operation and Maintenance Plan as part of the Final Drainage Report, prepared in accordance with Denver's Operation and Maintenance Manual.

4. The landowner is responsible for maintenance of private drainage facilities located on their land unless the facilities are designated as public facilities and are within dedicated public easements.

5. To be eligible for maintenance by MHFD, all drainage facilities must be designed and constructed in accordance with the most current version of MHFD's Maintenance Eligibility Guidelines posted on MHFD's website.

3.3.5 Storm Drainage Planning and Irrigation Facilities

Irrigation facilities and storm drainage facilities are designed for separate purposes and must comply with the following criteria:

1. Irrigation facilities such as ditches and reservoirs must not be used as drainage facilities, except where the requirements of this section are met.

2. Irrigation ditches must not be used as basin boundaries when evaluating the interaction of irrigation ditches with a major drainageway for the purpose of basin delineation. Drainage analysis must assume that irrigation ditches do not intercept storm runoff from the upper basin and that the upper basin is tributary to the basin area downstream of the ditch. During major storms, ditches will generally be flowing full, near full or sometimes overflowing; therefore, the tributary basin runoff would flow across the ditch.

3. Development and redevelopment projects must avoid discharging into irrigation canals and ditches, except as required by water rights, and must instead direct runoff into

historic and natural drainageways. As a general rule, the flat slopes, limited carrying capacities, and potential for abandonment of ditches make them inappropriate for storm drainage usage.

4. Discharge of runoff into irrigation ditches will be approved only under these conditions:

    i. The discharge is consistent with the relevant master drainage plan.

    ii. Thorough hydrologic and hydraulic analysis indicates the discharge does not cause adverse impacts.

    iii. The owner's liability for ditch failure is clearly defined.

    iv. Written consent of the ditch company is submitted to Denver.

    v. The practice is determined to be in Denver's best interest.

5. Whenever irrigation ditches cross major drainageways within a developing area, the developer must design and construct appropriate structures to separate storm runoff from ditch flows.

6. Any modifications to existing topography or placement of drainage structures that affect water quality and/or drainage patterns to ditches or other utilities must comply with the criteria listed above.

7. For hydrologic purposes, all private dams must be ignored in the definition of floodplains.

8. All development and redevelopment projects downstream of irrigation storage facilities must obtain flood hazard maps from the State Engineer's Office to determine dam hazard classifications pursuant to Section 37-87-123, CRS.

9. All development and redevelopment projects must be located outside of the reservoir's high-water line based on the design flood for the structure's emergency spillway.

10. All development and redevelopment projects must be located outside of the high-water line based on the breach of a dam (except high hazard classified dams that have passed inspection by the State Engineer's office in accordance with 37-87-105 et seq.

11. All development and redevelopment projects must be located outside existing or potential future emergency spillway paths, beginning at the dam and proceeding to the point where the flood water returns to the natural drainage course.

4.0 Floodplain Regulations

4.1 Introduction

The regulation of floodplains is necessary to preserve and promote the general health, welfare, and economic well-being of the region. The general purposes of floodplain regulations are:

1. To reduce the hazard of floods to life and property.

2. To protect and preserve hydraulic characteristics of water courses used for conveyance of flood waters.

3. To protect the public from extraordinary financial expenditures for flood control and relief.

Floodplains shall be regulated and managed in accordance with Denver's Floodplain Ordinance (Article V, Chapter 56, Revised Municipal Code). It is the designer's responsibility to use the most current adopted floodplain maps and to ensure compliance with the current Denver ordinances and federal regulations. Floodplains shall be left in a natural state or used as open space recreational areas to the maximum extent practicable. In essence, the Ordinance states that:

1. Most construction within the floodway is prohibited.

2. Residential construction within the floodplain must elevate the lowest floor (including basement), including all associated machinery and equipment, to a minimum of the flood protection elevation.

3. Commercial or industrial development must elevate the lowest floor (including basement) or dry floodproof, including all associated machinery and equipment, to a minimum of the flood protection elevation.

4. Flood protection elevation is 1.5 feet above the base flood elevation or depth of flooding defined for the regulatory floodplain.

5. Elevation certificates are required for all structures built within the regulatory floodplain.

In cases where the floodplain will be altered, it is the developer's responsibility to first obtain a Conditional Letter of Map Revision (CLOMR) early in the planning process and obtain a final Letter of Map Revision (LOMR) when the project is complete. All analysis and associated costs are the responsibility of the developer.

Denver encourages floodproofing of existing structures that are not in compliance with Denver's Floodplain Ordinance. Floodproofing may not necessarily bring the structure into compliance or reduce flood insurance premiums, but floodproofing techniques can be effective at reducing flood losses. In addition to the requirements set forth in the Denver Floodplain Ordinance, floodproofing shall be completed in accordance with the criteria specified in the Floodproofing chapter of the MHFD Manual, the latest version of the Colorado Flood Proofing Manual (CWCB

1983), the City and County of Denver Flood Protection Handbook (Denver and MHFD 2003), FEMA guidance, other any other Denver guidance.

Construction of critical facilities, such as hospitals, nursing homes, schools, fire stations, should be avoided in the floodplain.

4.2 Denver Floodplain Ordinance

See Denver Revised Municipal Code, Chapter 56, Article V.

5.0 RAINFALL

5.1 Introduction

The design rainfall data to be used to complete hydrologic analyses described in the Runoff chapter of these Criteria are presented in this section. More specifically, this chapter provides: 1) point precipitation values for Denver, 2) information on the Colorado Urban Hydrograph Procedure (CUHP), and 3) an intensity-duration-frequency table for use with the Rational Method. All hydrological analyses within Denver must use the rainfall data presented herein for calculating storm runoff. There may be cases where the designer needs to consider events more extreme than the 100-year storm (e.g., for public safety).

The design storms and intensity-duration-frequency tables for Denver were developed using the rainfall data and procedures presented in the MHFD Manual and are presented herein for convenience.

5.2 Rainfall Depth-Duration-Frequency Values

Based on the isopluvial maps presented in the *National Oceanic and Atmospheric Administration Atlas 14, Precipitation-Frequency Atlas of the United States, Volume 8* (NOAA Atlas 14), variations in rainfall depths across the city are minimal, and rainfall characteristics for Denver can be represented by a single rainfall zone.

The 1-hour point rainfall is necessary for use with both the Rational Method and CUHP. For watersheds 15 square miles and larger, the 6-hour rainfall depth is also required for use with CUHP. Table 5-1 summarizes point rainfall values for various durations. The point rainfall depths in Table 5-1 were taken from NOAA Atlas 14 for the State Capitol Building location in Denver. The values in this table must be used for design rainfall in Denver. For the Water Quality Event (WQE), which is used to calculate the Water Quality Capture Volume (WQCV) and Water Quality Peak Flow Rate (WQPF), a precipitation depth of 0.6 inches is used. The WQE is the 80th percentile runoff producing storm, as discussed in the MHFD Manual.

Table 5-1. Point Rainfall Depths

	Rainfall Depth (inches)							
Return Period	**5-Minute**	**10-Minute**	**15-Minute**	**30-Minute**	**1-Hour**	**2-Hour**	**3-Hour**	**6-Hour**
2-Year	0.26	0.39	0.47	0.66	0.83	0.99	1.07	1.26
5-Year	0.35	0.51	0.63	0.88	1.09	1.30	1.40	1.64
10-Year	0.43	0.63	0.77	1.08	1.33	1.58	1.70	1.99
50-Year	0.65	0.95	1.16	1.62	1.99	2.36	2.54	2.96
100-Year	0.75	1.10	1.35	1.87	2.31	2.75	2.96	3.43

Reference: NOAA Atlas 14, Volume 8, Version 2, 2013. Data reported for State Capitol Building.

These point rainfall depths must be distributed temporally (e.g., 5-minute increments) for use with the CUHP model. Area adjustment of these point rainfall values is required based on watershed size when using CUHP. CUHP automatically calculates temporal adjustments to rainfall distribution for various storm events and watershed sizes in accordance with the Rainfall chapter of the MHFD Manual.

Table 5-2 provides the rainfall intensity-duration values calculated for use with the Rational Method in small watersheds that are 90 acres or less in size, based on the following equation:

$$I = \frac{28.5\, P_1}{(10 + T_c)^{0.786}} \qquad \text{(Equation 5.1)}$$

in which:

I = rainfall intensity (inches per hour)

P_1 = 1-hour point rainfall depth (inches)

T_c = time of concentration (minutes)

Table 5-2. Rainfall Intensity Duration Values for Use with the Rational Method

Time	Rainfall Intensity (in/hr)					Time	Rainfall Intensity (in/hr)				
Min.	2-yr	5-yr	10-yr	50-yr	100-yr	Min.	2-yr	5-yr	10-yr	50-yr	100-yr
5	2.82	3.70	4.51	6.75	7.84	35	1.19	1.56	1.90	2.85	3.30
10	2.25	2.95	3.60	5.38	6.25	36	1.17	1.53	1.87	2.80	3.25
11	2.16	2.84	3.46	5.18	6.01	37	1.15	1.51	1.84	2.75	3.19
12	2.08	2.74	3.34	5.00	5.80	38	1.13	1.48	1.81	2.71	3.14
13	2.01	2.64	3.22	4.82	5.60	39	1.11	1.46	1.78	2.66	3.09
14	1.95	2.56	3.12	4.67	5.42	40	1.09	1.44	1.75	2.62	3.04
15	1.88	2.47	3.02	4.52	5.24	41	1.08	1.41	1.72	2.58	2.99
16	1.83	2.40	2.93	4.38	5.08	42	1.06	1.39	1.70	2.54	2.95
17	1.77	2.33	2.84	4.25	4.94	43	1.04	1.37	1.67	2.50	2.91
18	1.72	2.26	2.76	4.13	4.80	44	1.03	1.35	1.65	2.47	2.86
19	1.68	2.20	2.69	4.02	4.67	45	1.01	1.33	1.62	2.43	2.82
20	1.63	2.14	2.62	3.91	4.54	46	1.00	1.31	1.60	2.40	2.78
21	1.59	2.09	2.55	3.81	4.43	47	0.99	1.29	1.58	2.36	2.74
22	1.55	2.04	2.49	3.72	4.32	48	0.97	1.28	1.56	2.33	2.71
23	1.51	1.99	2.43	3.63	4.22	49	0.96	1.26	1.54	2.30	2.67
24	1.48	1.94	2.37	3.55	4.12	50	0.95	1.24	1.52	2.27	2.64
25	1.45	1.90	2.32	3.47	4.03	51	0.93	1.23	1.50	2.24	2.60
26	1.41	1.86	2.27	3.39	3.94	52	0.92	1.21	1.48	2.21	2.57
27	1.38	1.82	2.22	3.32	3.85	53	0.91	1.20	1.46	2.18	2.54
28	1.36	1.78	2.17	3.25	3.77	54	0.90	1.18	1.44	2.16	2.50
29	1.33	1.74	2.13	3.19	3.70	55	0.89	1.17	1.42	2.13	2.47
30	1.30	1.71	2.09	3.12	3.62	56	0.88	1.15	1.41	2.11	2.45
31	1.28	1.68	2.05	3.06	3.55	57	0.87	1.14	1.39	2.08	2.42
32	1.25	1.65	2.01	3.00	3.49	58	0.86	1.13	1.38	2.06	2.39
33	1.23	1.62	1.97	2.95	3.42	59	0.85	1.11	1.36	2.03	2.36
34	1.21	1.59	1.94	2.90	3.36	60	0.84	1.10	1.34	2.01	2.33

Revised: Feb. 2017
Calculated based on Equation 5.1

6.0 RUNOFF

6.1 Introduction

Proper calculation of runoff is critical to proper planning and sizing of storm drainage facilities. Erroneously high runoff calculations can result in higher cost facilities, while erroneously low runoff calculations can result in damage or loss of life or damage to infrastructure, property and natural resources. This chapter identifies the methodology to be used for determining the storm runoff design peaks and volumes for preparation of storm drainage studies, plans, and facility designs in Denver. The background, equations, examples, and spreadsheets for these methods should be obtained from the Runoff chapter of the MHFD Manual. The Colorado Urban Hydrograph Procedure (CUHP) and the Stormwater Management Model (SWMM) computer models for calculating and routing runoff may be downloaded from MHFD's website. MHFD has also developed spreadsheets for the Rational Method for peak flow calculations and for street capacity and inlet design that are available on MHFD's website.

6.2 Runoff Calculation Methods

Four methods of hydrologic analysis are commonly used for design of storm drainage infrastructure in Denver:

1. **The Rational Method:** Originally introduced in 1889, most engineering offices in the U.S. continue to use this method. Although this method has frequently come under academic criticism for its simplicity, no other practical drainage design method has evolved to such a level of general acceptance by the practicing engineer.

2. **CUHP:** CUHP is a regionally calibrated model for generating hydrographs from watersheds. Modelers often use CUHP in conjunction with EPA SWMM, using EPA SWMM to combine and route the hydrographs generated using CUHP.

3. **Use of published runoff information:** Hydrologic studies have been conducted for most of the major drainage systems within Denver, and published hydrology data are available for most of these watersheds and streams from Denver's Storm Drainage Master Plan (2019); MHFD Outfall Systems Plans (OSPs), Major Drainageway Plans (MDPs), and Flood Hazard Area Delineations (FHADs); or other credible sources such as Flood Insurance Studies (FISs) and Letters of Map Revision (LOMRs).

4. **Statistical analysis of stream gage data (such as USGS Bulletin 17C analysis):** This approach requires a long-term record of quality flow measurement data conforming to the assumptions of the statistical analysis methods.

The Rational Method is applicable to urban catchments that are (1) not complex and (2) generally 90 acres or smaller. The Rational Method only calculates peak flow rates and not runoff hydrographs. Calculate peak flows using the Rational Method by hand or use the MHFD-Rational Excel workbook available at www.mhfd.org.

Since 1969, CUHP has been used extensively in this region. It has been calibrated by MHFD using regional data collected from various watersheds to develop empirical relationships between

the input hyetograph and observed output flows. Many major drainageways and storm drainage systems within Denver are designed based on hydrology calculated using CUHP and hydraulics evaluated using EPA SWMM or MHFD's UD-SWMM, an earlier adaptation of SWMM software. Use CUHP and SWMM for larger catchments and whenever a runoff hydrograph is needed for analysis.

Table 6-1 summarizes the applicability of the Rational Method and CUHP.

Table 6-1. Applicability of Hydrologic Methods

Catchment Size (acres)	Is the Rational Method Applicable?	Is CUHP Applicable?
0 to 90	Yes	Yes
90 to 160	No	Yes
160 to 3,000	No	Yes[1]
Greater than 3,000	No	Yes (subdividing into smaller catchments required)[1]

[1] Subdividing into smaller subcatchments and routing the resultant hydrographs using SWMM may be needed to accurately model a catchment with areas of different soil types or percentages of imperviousness.

When modeling large catchments, subcatchment discretization methods and sizes can influence results. If heterogeneous land uses are "lumped" together into large subcatchments, the models may not accurately account for the "flashy" nature of runoff from impervious surfaces, and peak rates of runoff may be underestimated. On the other hand, defining very small subcatchments can lead to complicated and unrealistic routing that can overestimate peak rates of runoff.

All criteria specified in the MHFD Manual must be followed for preparation of drainage reports and storm drainage facility designs in Denver.

6.3 Assumptions for Storm Flow Analysis

When determining design storm flows, the engineer must follow the criteria and guidelines specified in the MHFD Manual and summarized in Table 6-2 to ensure that minimum design standards and uniform drainage approaches are maintained throughout Denver.

Table 6-1. Assumptions for Onsite and Offsite Storm Flow Analysis in Denver

Analysis Type	Requirements for Use in Denver
Onsite Analysis	The proposed fully developed land use plan must be used to determine runoff coefficients. Changes in flow patterns (from the undeveloped site conditions) caused by the proposed street alignments must be considered. The maximum time of concentration to the first design point in an urbanized area is 10 minutes.
Offsite Analysis for the Minor Storm Event	The fully developed minor runoff will be used without consideration of onsite detention. Inadvertent storage provided by road crossings, railroad embankments and similar structures will not be credited as runoff reduction.
Offsite Analysis for the Major Storm Event	Where the offsite area is fully or partially undeveloped, the runoff must be calculated assuming the basin is fully developed as defined by the Planning Department. If this information is not available, then the runoff must be calculated using the coefficients defined in the Runoff chapter of the MHFD Manual. No runoff reduction credit will be given for onsite detention in the offsite area for any design frequency unless otherwise approved by Denver; however, credit may be given for permanent, publicly maintained detention facilities. Inadvertent storage provided by road crossings, railroad embankments and similar structures will not be credited as runoff reduction.

7.0 STREETS

7.1 Introduction

The criteria presented in this chapter must be used in the evaluation of the allowable drainage encroachment within public streets. The criteria, evaluation techniques, and design examples provided in the Streets/Inlets/Storm Drains chapter of the MHFD Manual are hereby incorporated by reference and not repeated herein, unless modified by Denver or applied to conditions in Denver. The MHFD-Inlet software program (downloadable from MHFD's website) may also be used in the hydraulic evaluation of street flows.

7.2 Function of Streets in the Drainage System

The primary function of urban streets is for safe traffic movement; therefore, stormwater drainage and conveyance in streets is subservient to this function and must be properly designed to prevent interference with traffic, especially at intersections. When the drainage in the street exceeds allowable limits set forth in Section 7.3, a storm drain system (Chapter 9) or an open channel (Chapter 10) is required to convey the excess flows. Streets are also part of the major drainage system when they carry flows in excess of the minor storm, also subject to the limitations of Section 7.3.

7.3 Allowable Use of Streets for Storm Flows

Allowable use of streets for storm flows is summarized in Tables 7-1 through 7-3. The minor storm referenced in these tables is either the 2-year or 5-year event in accordance with Chapter 3, Table 3-1, and the major storm is the 100-year event. No curb overtopping during the minor storm is allowed for any street regardless of classification. The maximum allowable street flow for the minor storm runoff is the product of the flow calculated at the "Maximum Theoretical Street Encroachment" and the required reduction factor, following the hydraulic evaluation techniques in the Streets/Inlets/Storm Drains chapter of the MHFD Manual, or 10 cfs, whichever is more restrictive. In accordance with Table 7-3, cross-street flow is only allowed on local streets when no storm drains are available and cross pans are provided to carry these flows.

Table 7-1. Allowable Use of Streets for Minor Storm Runoff

Street Classification	Maximum Street Encroachment
Local	No curb overtopping. Flow may spread to crown of street.
Collector	No curb overtopping. Flow spread must leave at least one lane free of water.
Arterial	No curb overtopping. Flow spread must leave at least one lane (10 feet) free of water in each direction and should not flood more than two lanes in each direction.

Table 7-2. Allowable Use of Streets for Major Storm Runoff

Street Classification	Maximum Depth and Inundated Area
Local, Collector and Arterial	Residential dwellings, public, commercial, and industrial buildings must not be less than 12 inches above the 100-year water surface elevation at the ground line or lowest water entry into the building. The depth of water over the gutter flow line must not exceed 12 inches.
Arterial	Residential dwellings, public, commercial, and industrial buildings must not be less than 12 inches above the 100-year water surface elevation at the ground line or lowest water entry into the building. To allow for emergency vehicles, the depth of water must not exceed the street crown or 12 inches at the gutter flow line, whichever is more restrictive.

Table 7-3. Allowable Cross-street Flow When Cross Pans Are Allowed[1]

Street Classification	Minor Storm Flow	Major Storm Flow
Local	6 inches of depth in cross pan, if cross pan allowed.	12 inches of depth in cross pan or gutter flow line.

[1]Cross pans are not allowed to convey flow across collector or arterial streets or where a storm drain is available.

7.4 Hydraulic Evaluation Techniques

Hydraulic calculations must be completed to determine the capacity of street gutters and the resulting encroachment onto the street section. These calculations use the hydrology developed in Chapters 5 and 6 and will subsequently be used in calculations for inlets and storm drain sizing.

The following factors should be taken into consideration when designing street flow:

- Public safety.
- Nuisance flows.
- Other factors that could reduce the conveyance capacity of the street.

7.4.1 Allowable Gutter Flow Depths and Spreads

Table 7-4 summarizes the allowable gutter flow depth and flow spread into the roadway for various Denver street types with a 6-inch curb and a 2-percent cross slope for the minor storm. For the minor storm, the allowable flow depth in the gutter does not overtop the curb and is limited by the maximum permitted flow of 10 cfs. Table 7-5 provides the same information for the major storm.

Table 7-4. Street Types, Permitted Flow Spread and Depths for Minor Storm for 6-inch Curb and 2-percent Cross Slope

Street Type	Flowline to Flowline Street Width (ft)	Minor Event Criterion	Maximum Allowable Spread (ft)	Maximum Allowable Depth at Gutter Flow Line (ft)
Local	32	No curb overtopping/spread to crown	16	0.45
	36		18	0.49
	40		18.5	0.50
Collector	36	No curb overtopping/one 10-foot lane free	13	0.39
	40		15	0.43
	44		17	0.47
Arterial (median present, street width based on 1/2 street)	25	No curb overtopping/one lane free each direction	15	0.43
	30		18.5	0.50
	36		18.5	0.50

Table 7-5. Street Types, Permitted Flow Spread and Depths for Major Storm for 6-inch Curb and 2-percent Cross Slope

Street Type	Flowline to Flowline Street Width (ft)	Major Event Criterion	Maximum Allowable Spread (ft)	Maximum Allowable Depth at Gutter Flow Line (ft)
Local	32	Depth not to exceed crown/1 ft. max @ gutter flow line	16	0.45
	36		18	0.49
	40		20	0.53
Collector	36	Depth not to exceed crown/1 ft. max @ gutter flow line	18	0.49
	40		20	0.53
	44		22	0.57
Arterial (median present, street width based on 1/2 street)	25	Depth not to exceed crown/1 ft. max @ gutter flow line	25	0.63
	30		30	0.73
	36		36	0.85

Note: See www.denvergov.org/doti for typical street cross sections.

7.4.2 Allowable Street Capacities and Assumptions for Capacity Curves

Figure 7-1 provides the allowable street capacity for the minor and major storm events based on the allowable spread and depths from Tables 7-1, 7-2, 7-4 and 7-5. These figures are calculated using the Q-Allow worksheet of the MHFD-Inlet (Version 4.04) spreadsheet model, which completes a hydraulic evaluation of street capacity by calculating street gutter flow capacity based on allowable spread and gutter depth for the minor and major design storms. The following assumptions were used to develop these curves:

- The maximum allowable flow rates presented in Figure 7-1 are primarily dictated by the allowable spread criteria (e.g., at the maximum allowable spread, the maximum depth at the gutter flow line is less than 6 inches). The curves are provided as a guide only and individual hydraulic calculations should be performed using the latest version of MHFD-Inlet. Other street cross slopes, alternate gutter dimensions, assumptions about capacity behind the curb, and other factors will yield different results.
- The reduction factor has already been applied based on Reduction Factors for Gutter Flow (Guo 2000) in the Streets/Inlets/Storm Drains chapter of the MHFD Manual. The MHFD-Inlet workbook automatically incorporates the reduction factor.
- The allowable spread for the major storm is to the crown for all street types.
- The allowable spread for the minor storm is as provided in Table 7-4 for all street types.
- The maximum allowable flow depth at the gutter flowline is 12 inches for the major event for local, collector and arterial streets. The allowable spread is typically the more restrictive criterion for standard street cross sections.
- Gutter depression ("a") is 1.52 inches, based on a standard gutter section.
- Gutter width is 2 feet, based on a standard gutter section.
- Manning's "n" is 0.016.
- Cross slope is 2 percent.

7.5 Design Considerations

Representative considerations that the designer must address include:

1. The primary function of urban streets is for safe traffic movement. Where a storm drain is available, inlets must be provided at intersections.
2. Provide an inlet where a catch curb changes to a spill curb.
3. The maximum allowable street capacity for the minor event is 10 cfs or gutter capacity, whichever is less.

4. Allowable street capacity for major and minor storms is subject to safety considerations using the reduction factor (Guo 2000) in the Streets/Inlets/Storm Drains chapter of the MHFD Manual. The MHFD-Inlet workbook incorporates the reduction factor.

5. Nuisance flows must be carried by gutters or pans to an inlet. Nuisance flows are not allowed to cross a driving lane.

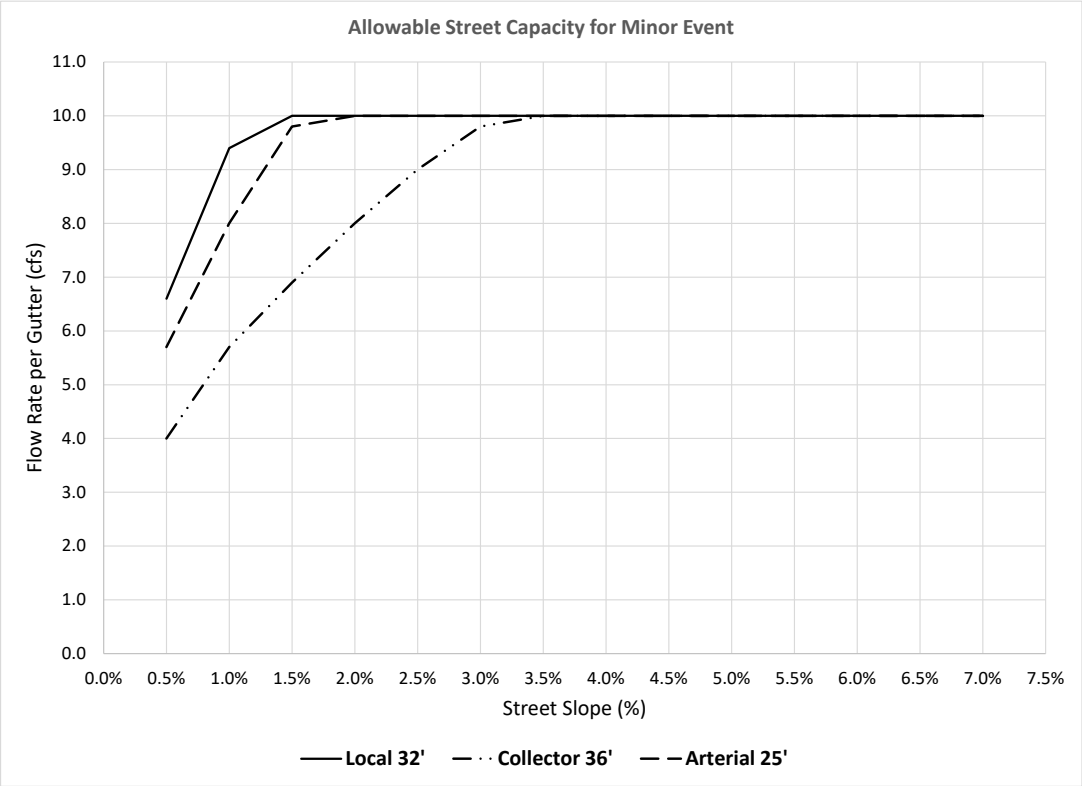
6. Cross pans are not allowed to cross collector or arterial streets or where a storm drain is available.

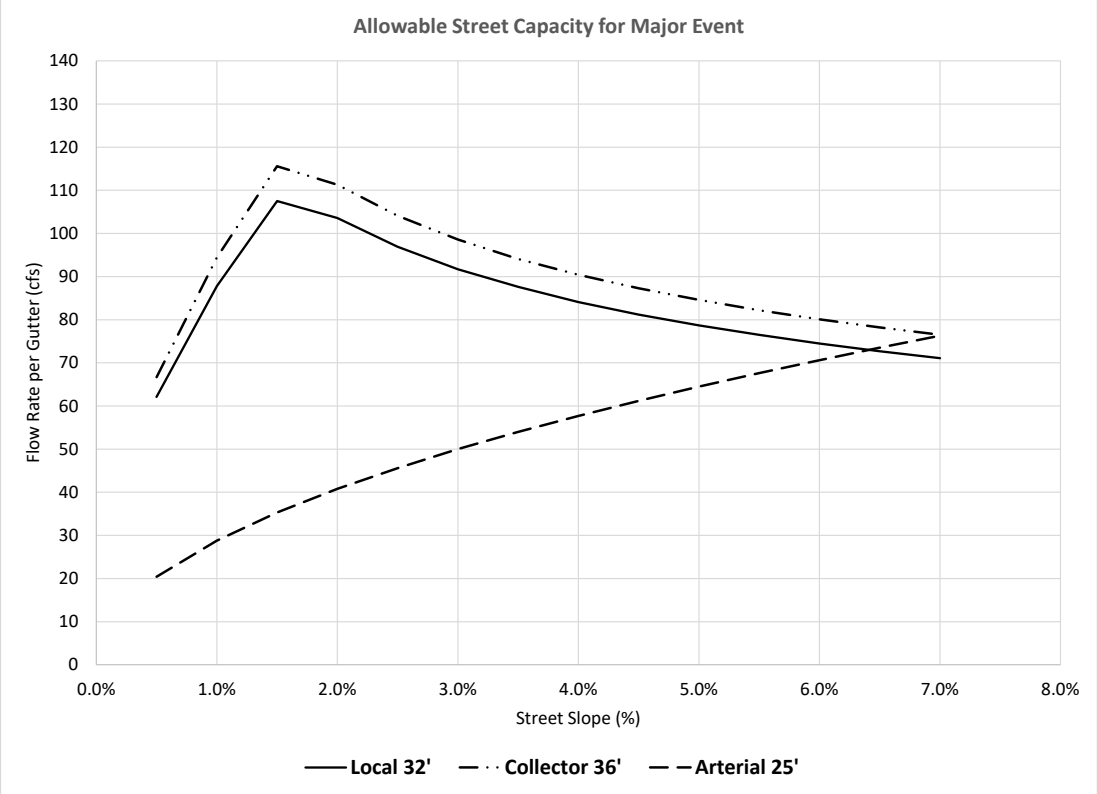
7. Cross pans are not allowed within an approach to a signalized intersection.

8. Bulbouts (curb extensions) tend to reduce street capacity. Care needs to be taken that bulbout effects to surface flows will not violate any depth or spread criteria found in this chapter.

9. In areas of minimal or no setback from curbline, care needs to be taken to protect buildings from street flooding.

Figure 7-1. Allowable Street Capacity for Minor and Major Events
Note: See Section 7.4.2 for assumptions used to generate these curves.





8.0 INLETS

8.1 Introduction

This chapter presents the criteria and methodology for design and evaluation of storm drain inlets located in Denver. Except as modified herein, all storm drain inlet criteria must be in accordance with the Streets/Inlets/Storm Drains chapter of the MHFD Manual. The review of all planning submittals will be based on the criteria presented herein. Important basic information on the function and types of inlets includes:

- **Function of Inlets:** The primary purpose of storm drain inlets is to intercept excess surface runoff and convey it into a storm drainage system, thereby reducing or eliminating surface flooding. Roadway geometry often dictates the location of street inlets along the curb and gutter. In general, inlets are placed at all low points (sumps), along continuous grade curb and gutter, median breaks, intersections, and crosswalks. The spacing of inlets along a continuous grade segment of roadway is governed by the allowable spread of flow and flow depth. See further details of allowable spread of flow in Chapter 7, Streets.

- **Types of Inlets:** There are two major types of inlets approved for use within Denver right-of-way: curb opening and grate. A third type, a combination inlet, has a grate and a curb opening. Inlets are further classified as being on a "continuous grade" or in a "sump." The term "continuous grade" refers to an inlet placed in curb and gutter such that the grade of the street has a continuous slope past the inlet and, therefore, water ponding does not occur at the inlet. The sump condition exists whenever an inlet is located at a low point resulting in ponding water.

8.2 Standard Inlets

The standard inlets permitted for use in Denver are provided in Table 8-1.

Table 8-1. Inlet Types

Inlet Type	Standard Detail[1]
No. 14 Inlet (Curb Opening)	S620.1 & S620.2
No. 16 Inlet (Valley)	S616V
No. 16 Inlet (Combination)	S616.1, S616.2, S616.3
Inlet Type C	CDOT M Standard: M-604-10
Inlet Type D	CDOT M Standard: M-604-11

[1] Denver Standard Details can be downloaded from www.denvergov.org/ and CDOT M Standards can be downloaded from www.dot.state.co.us/.

8.3 Inlet Design

Proper inlet design includes both the proper inlet hydraulic capacity and appropriate inlet placement. The sizes and types of inlets shall be designed based on the required hydraulic capacity of the inlet. The criteria and procedures in the Streets/Inlets/Storm Drains chapter of the

MHFD Manual must be followed for inlet design in Denver, except as modified and supplemented herein. Additional information on hydraulic design and placement of inlets follows.

8.3.1 Hydraulic Design

Provided that the MHFD Manual criteria are met, a variety of approaches can be used to size inlets, including computer programs and charts. The MHFD-Inlet spreadsheet, which can be downloaded from MHFD's website, is appropriate for use with on-grade and sump inlet designs.

8.3.2 Inlet Capacity Curves

Inlet capacity curves are presented for convenience in Figures 8-1 through 8-4 for No. 14 and No. 16 Combination inlets for on-grade and sump conditions. On-grade capacity curves in Figures 8-3 and 8-4 only apply when street flow is at the **maximum allowable depth**. For lower gutter depths, the inlet interception rate will decrease. No. 14 and No. 16 Combination inlets may be used in either on-grade or sump conditions.

The following assumptions were used for developing these curves using MHFD-Inlet:

- Local depression at No. 14 inlets is 3 inches.
- Local depression at No. 16 Combination inlets is 2 inches.
- A clogging factor of 0.1 was applied to the curb openings (No. 14 and No. 16 Combination inlets).
- A clogging factor of 0.7 was applied for single grate inlets (No. 16 Combination inlet).

Type C and D inlets may only be used in sump conditions. Use MHFD-Inlet for determining capacity and design of Type C and D inlets.

8.3.3 Inlet Location and Spacing

Inlets are required in the following locations:

- Sumps.
- Median breaks (e.g., where traffic turns across the median).
- Areas where street capacity (e.g., allowable design flow spread) would be exceeded without them.
- Upstream of pedestrian curb ramps with less than 1 percent slope on the curb return when a storm drain is available (see Figure 8-5 for example).

8.4 Design Considerations

1. In general, inlets should be located upstream of pedestrian curb ramps and spaced in a manner to prevent clogging. This is particularly critical for flat grades and sump conditions; approximately 20-foot spacing is recommended under these conditions.

2. Flanking inlets are required in sump conditions without overflow (e.g., underpasses) and in sump conditions requiring more than a triple inlet.

3. Type No. 14 inlets are preferred unless utilities are present, in which case No. 16 inlets are allowed.

4. A minimum 2-foot apron must be used with valley inlets when no curb and gutter is present.

5. Use common sense regarding inlet placement, such as placing inlets upstream rather than downstream of driveways.

6. An emergency overflow route must be provided in sump areas for new development. For other projects, the emergency overflow paths and depths must be addressed to prevent adverse impacts to properties and structures.

7. No grate inlets are allowed at bus stops.

Figure 8-1. Allowable Inlet Capacity – Type 14 Inlet, Sump Conditions
Source: MHFD Manual 2016

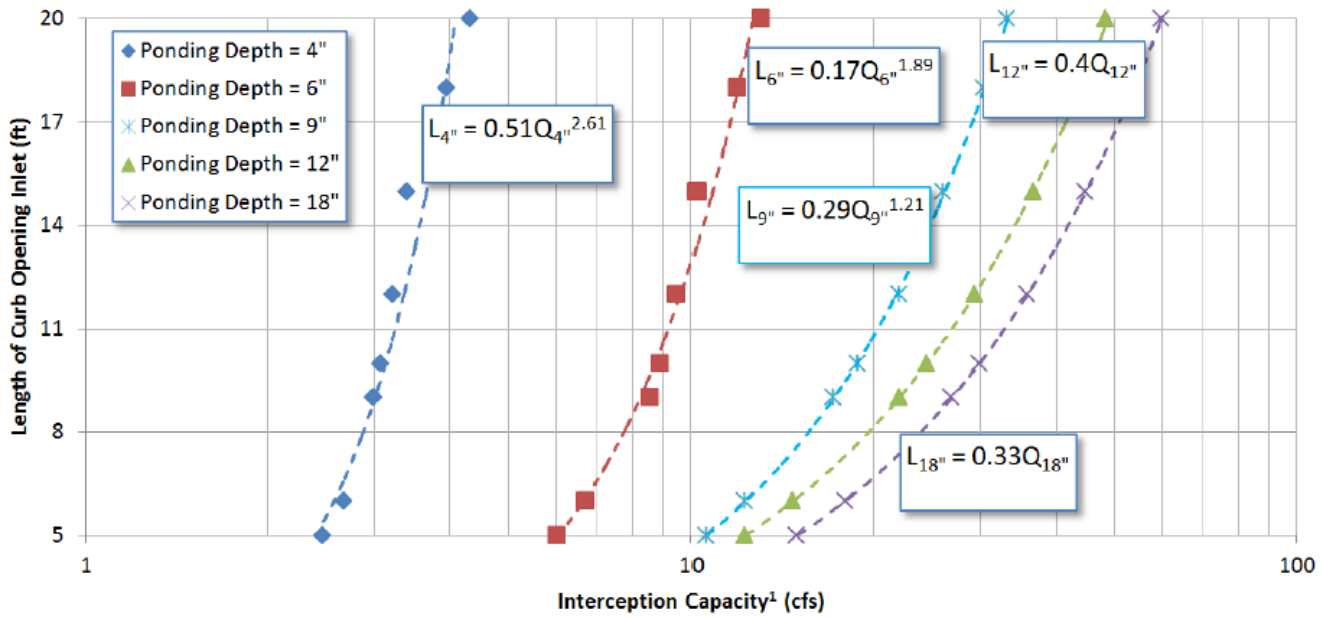


Figure 8-2. Allowable Inlet Capacity – Type 16, Sump Conditions
Source: MHFD Manual 2016

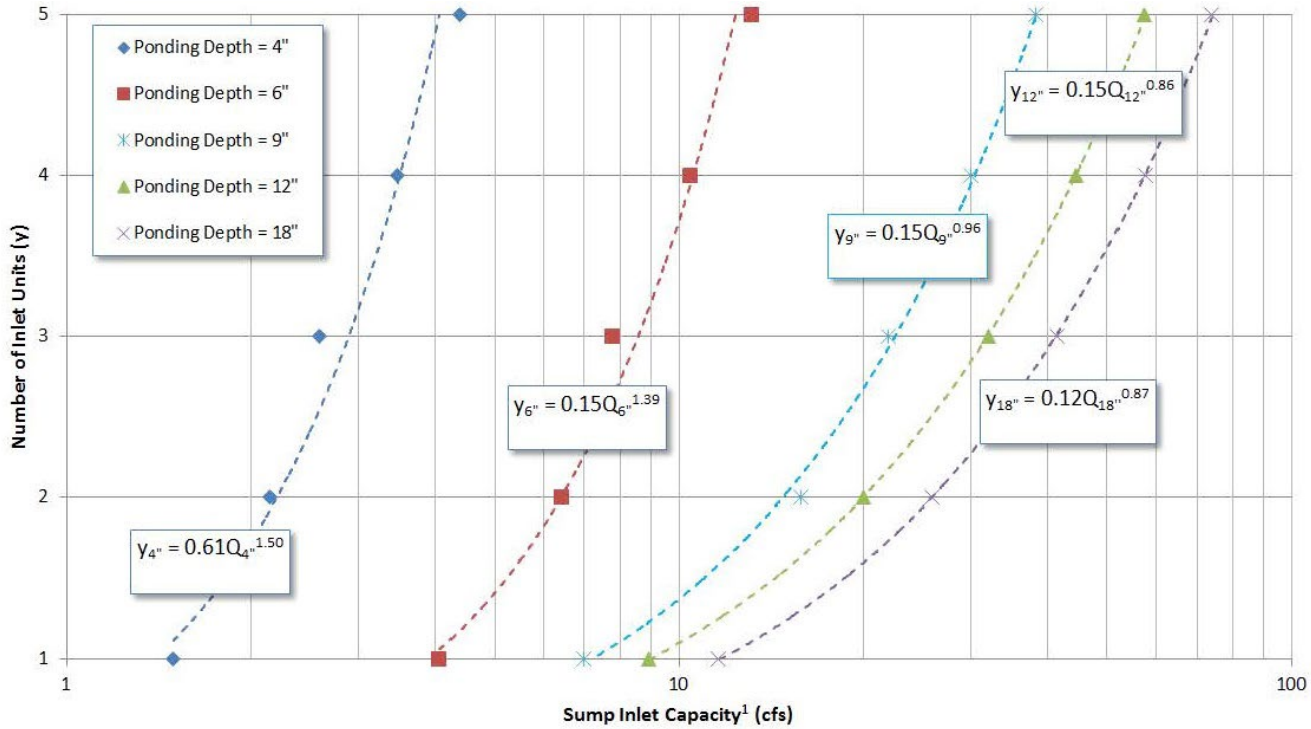


Figure 8-3. Allowable Inlet Capacity – Type 14 Inlet, On Grade Conditions
Note: See Section 8.3.2 for assumptions.

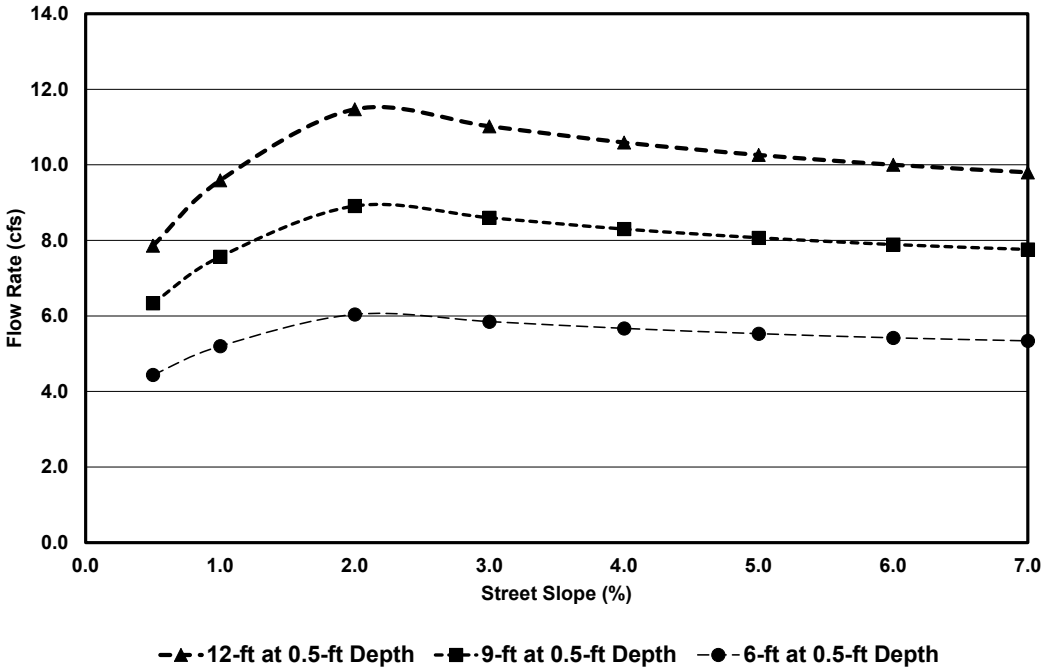


Figure 8-4. Allowable Inlet Capacity – Type 16 Combination Inlet, On Grade Conditions
Note: See Section 8.3.2 for assumptions.

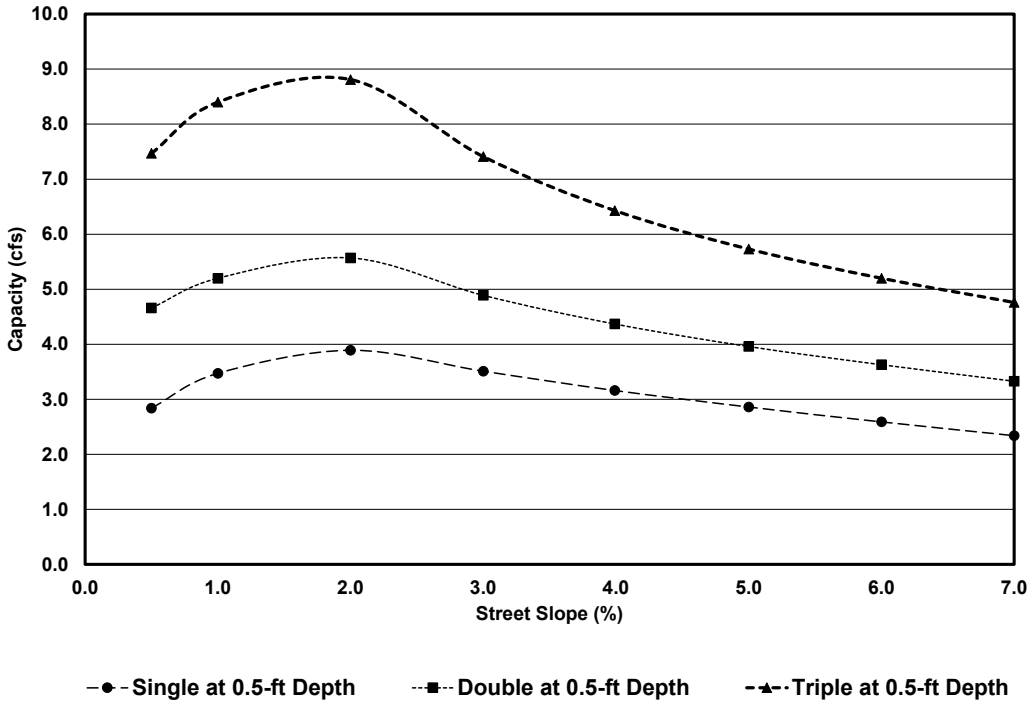
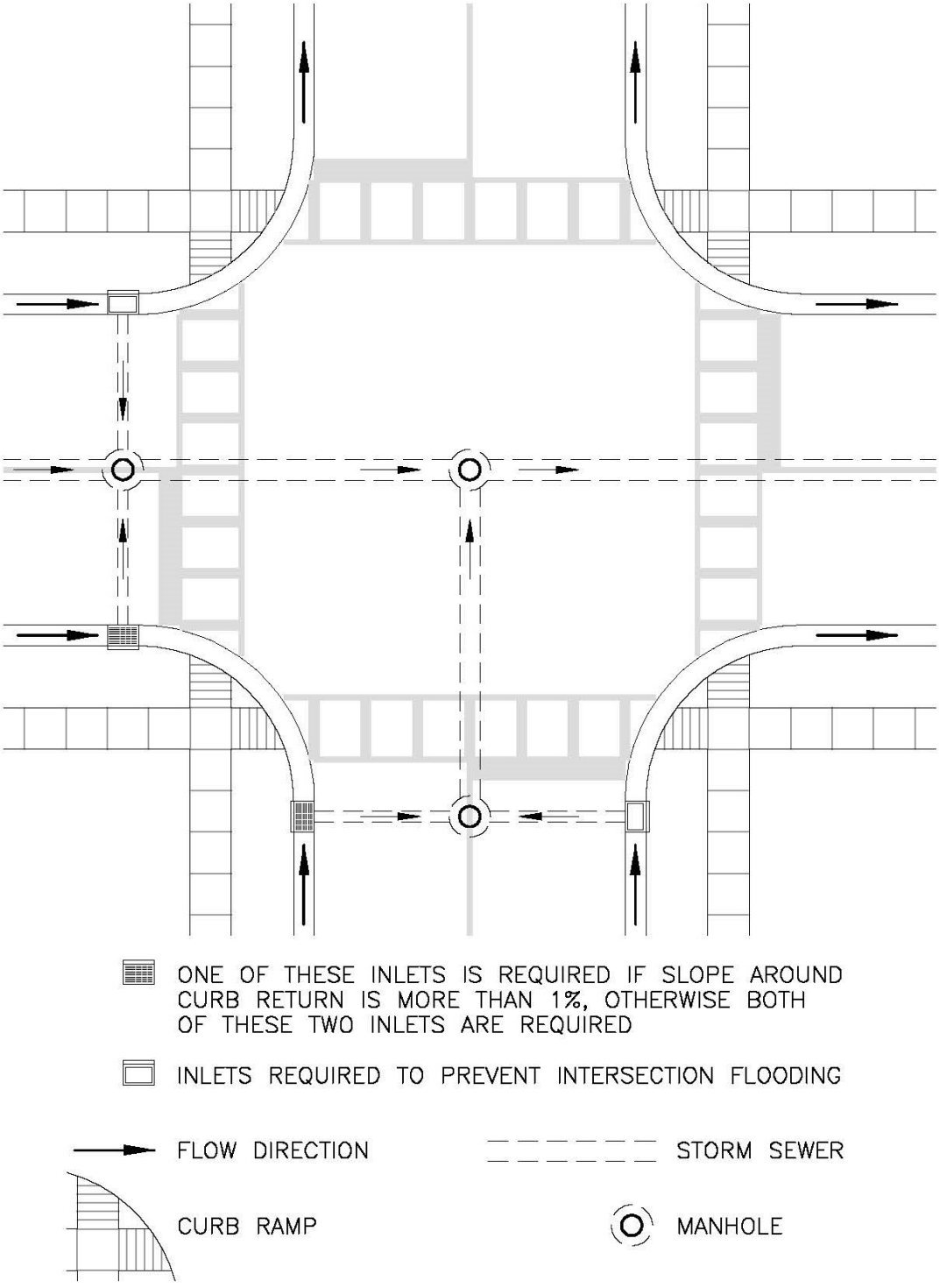


Figure 8-5. Inlet Placement at Intersections



9.0 STORM DRAINS

9.1 Introduction

Storm drains are the portion of the urban drainage system that provides subsurface conveyance of flows to control the depth and spread of runoff in streets and other surface drainage systems. Except as modified herein, the design of storm drains must be in accordance with the Storm Drain Systems section of the Streets/Inlets/Storm Drains chapter of the MHFD Manual.

9.2 Design Storms for Sizing Storm Drain Systems

Two design storms must be considered for sizing storm drain systems, the minor (2- or 5-year) storm and the major (100-year) storm. In each case, storm drains must be sized to carry the portion of runoff that cannot be conveyed on the surface, as dictated by the available capacity in streets and swales during these two events.

9.2.1 Minor Event Design Storm

At a minimum, storm drains must be sized to convey any minor storm runoff that exceeds the minor event capacity of the street or roadside swales (discussed in Chapter 7, Streets). Inlets are located at these points to intercept excess flow and route it to the storm drain. Storm drains must be designed to convey the minor storm flood peaks while flowing at 80 percent of the full pipe capacity. Section 9.3 provides additional information on hydraulic design methods for the minor storm.

9.2.2 Major Event Design Storm

There are conditions when the storm drain system will be sized to convey flows greater than the minor storm runoff, including locations where:

1. The street capacity for the major storm is exceeded, especially where the grade slopes down behind the curb and the major storm capacity is limited to the height of the curb.

2. Regional storm drains are designed for the major storm.

3. The storm drains must convey undetained flows to a regional detention basin.

If a storm drain is to be designed to carry major storm flows, the inlets to the storm drain must be designed accordingly. In pipes designed to convey up to the major storm, the hydraulic grade line (HGL) is allowed to rise above the top of the storm drain, but must be kept at least 1.0 foot below manhole lids, inlet grates and inlet curb openings. Section 9.3 provides additional information on hydraulic design methods for the major storm.

9.3 Hydraulic Design

Storm drains must be designed to convey the minor storm flood peaks while flowing at 80 percent of the full pipe capacity. To ensure that this objective is achieved, the hydraulic and energy grade lines must be calculated by accounting for pipe friction losses and pipe form losses.

Total hydraulic losses must be calculated accounting for friction, expansion, contraction, bend, and junction losses following the methods in the Storm Drain Systems section of the Streets/Inlets/Storm Drains chapter of the MHFD Manual. Additionally, for convenience, a chart identifying the hydraulic properties of circular pipe is provided in Figure 9-1. This chart assumes that the friction coefficient and Manning's n do not vary with depth, which is a common design assumption. EPA Stormwater Management Model (SWMM) or other software may be used to design storm drains.

The maximum velocity in all storm drains is 18 ft/sec. The minimum velocity is 3 ft/sec at half-full flow conditions.

The final EGL must be at or below the proposed ground surface for the design event. The HGL must not exceed the crown of the pipe for the minor storm. In cases where the conduit is designed to convey up to the full 100-year flow, the allowable HGL must be 1.0 foot below inlet elevations or 1.0 foot below ground where no inlets are present.

9.4 Construction Materials

Construction materials must be in accordance with the most current Denver Wastewater Standard Details and the Wastewater Capital Projects Management Standard Construction Specifications.

9.5 Pipe Size

The minimum allowable pipe size for storm drains is dictated by ease of maintenance rather than hydraulics. The length of the pipe also affects the ability to maintain a storm drain. Table 9-1 presents the minimum pipe sizes for public storm drains.

Table 9-1. Minimum Size Criteria for Public Storm Drains

Type	Minimum Equivalent Pipe Diameter
Main Trunk	18 inches
Lateral from Inlet	15 inches

9.6 Vertical and Horizontal Alignments

Table 9-2 provides the vertical alignment requirements for storm drains.

Table 9-2. Vertical Alignment Requirements for Storm Drains

Vertical Alignment of Storm Drain Relative to:	Minimum Vertical Clearance (above or below)	Comment
Cover	Minimum cover depends upon the pipe size, type and class, and the soil bedding condition.	The drain grade must be such that a minimum cover is maintained to withstand AASHTO HS-20 (or as designated by Denver) loading on the pipe.
Water Main	18 inches	Approval from Denver Water will be required for lesser clearances.
Sanitary	12 inches	Additionally, when a sanitary sewer main lies above a storm drain, or within 18 inches below, the sanitary sewer must have an impervious encasement or be constructed of approved sewer pipe with the nearest joint 9 feet from the centerline of the crossing.
Other		For vertical drops greater than 8 feet, special designs are required that address potential cavitation and energy dissipation. These situations will require special review. See *Design and Construction of Urban Stormwater Management Systems* (ASCE and WEF 1992) for guidelines for drop shaft structures.

In most cases, storm drain alignment between drainage structures (inlets or manholes) must be straight, using manholes to accommodate changes in alignment. Storm drain horizontal alignment may be curvilinear for pipes with diameters of 48 inches or greater, but only when approved in writing by the Review Engineer. The applicant must demonstrate the need for a curvilinear alignment. The radius limitations for pulled-joint pipe are dependent on the pipe length and diameter and amount of opening permitted in the joint. The minimum parameters for radius-type pipe must be in accordance with the manufacturer's specifications.

Storm drains parallel to the street must not be placed under the tree lawn or the sidewalk.

9.7 Manholes/Cleanouts

Manholes are required whenever there is a change in size, direction, elevation, grade, or where there is a junction of two or more drains. A manhole may be required at the beginning and/or at the end of the curved section of storm drain. The maximum spacing between manholes is 500 feet. The required manhole size must be in accordance with the Denver Wastewater Management Division Standard Details.

Larger manhole diameters or a junction structure may be required when large diameter pipe alignments are not straight through manholes or when more than one storm drain line goes through the manhole. A special structure is required for 42-inch or larger pipe when the angle of deflection is more than 45 degrees.

Cleanouts for maintenance access, instead of manholes, are allowed only for private, on-site storm drains 10 inches in diameter or smaller **and** must be the same size as the pipe to be cleaned. Spacing of cleanouts must conform to the requirements of the most current version of the International Plumbing Code.

9.8 Outlets

Proper design of storm drain outlets is necessary to minimize erosion at the outfall location and to protect public safety. Key guidance on these topics is presented in the following sections.

9.8.1 Conduit Outlet Protection

Adequate erosion protection must be provided at all storm drain outlets in accordance with Section 3 of the Hydraulic Structures chapter of the MHFD Manual, which provides criteria for riprap aprons, low tailwater stilling basins, concrete impact stilling basins, concrete baffle chutes, and grouted boulder outfalls.

9.8.2 Safety

Headwalls and wingwalls associated with storm drain outlets must be provided with guardrails, handrails, or fencing in conformance with Denver building codes and roadway design safety requirements. Handrails are required in all areas where the drop from the headwall or wingwall exceeds 30 inches. The height of the handrail must be 42 inches for pedestrian walkways or open areas and 54 inches when bicycle and/or equestrian traffic will be near the storm drain outlet (AASHTO 2002).

9.9 Abandonment

Storm drains to be abandoned in place must be plugged with clean concrete and standard manufactured plugs or caps at both upstream and downstream ends of the abandoned section. If manholes are also abandoned in place or if the structure is to be removed completely, all storm drains must be plugged upstream and downstream of the removed structure following removal. Storm drains to be abandoned with an internal diameter of 8 inches and larger must be filled with sand, pumped grout mixtures, or flowable fill to minimize future subsidence attributable to the potential collapse of the abandoned facility. Storm drains with an internal diameter smaller than 8 inches must be plugged at entrance and exit ends with approved grout mixtures or concrete.

9.10 Design Considerations

All of the design criteria in this chapter must be followed. Several key considerations that the designer must take care to address include:

1. Design the EGL below the ground surface for the design event.
2. Design the HGL not to exceed the pipe's crown for the minor storm.
3. Design the HGL not to exceed 1.0 foot below ground when the conduit is designed to convey the major event.

4. Account for all losses in the EGL and HGL calculations including outlet, form, bend, manhole, and junction losses.

5. Provide adequate erosion protection at the outlet of all drains.

6. Provide cross sections for rip rap protection.

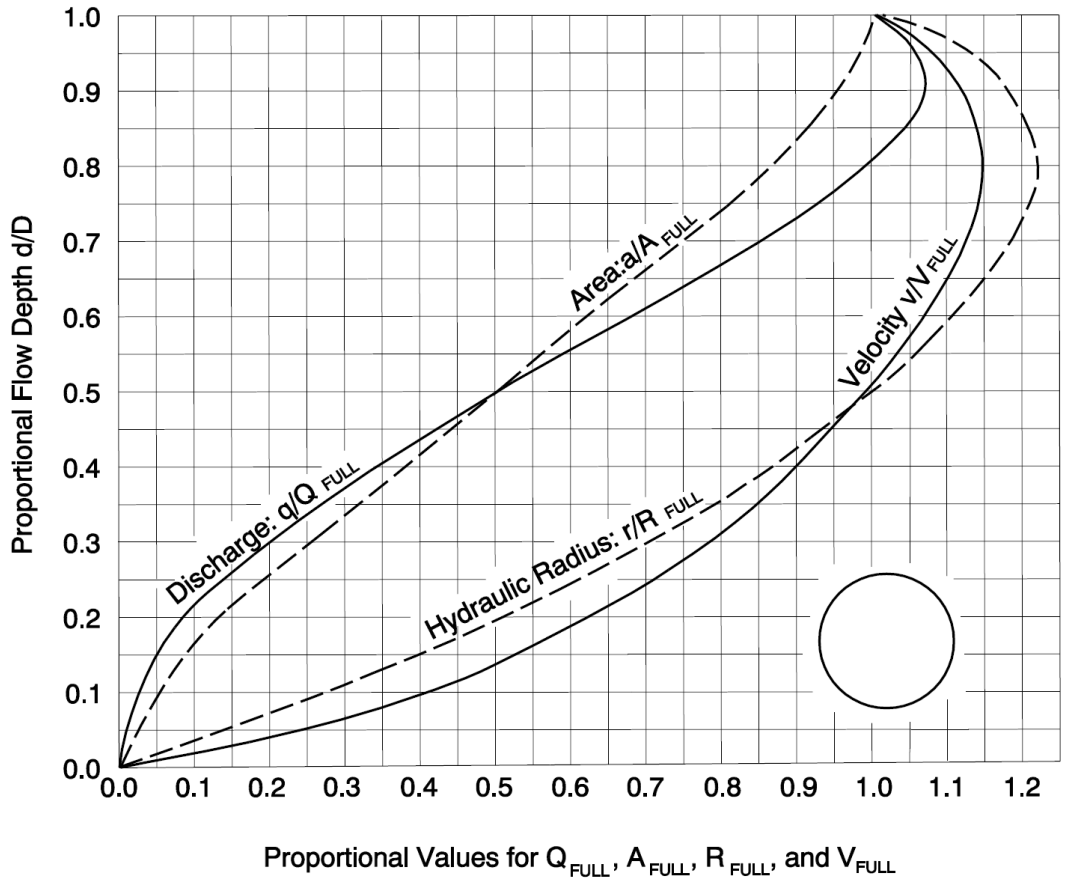
7. Check for minimum pipe cover and clearance with utilities.

8. Check overflow under sump conditions.

9. When a storm drain flows into a detention or water quality facility, design the invert of the inflow pipe to be higher than the anticipated water quality level in the pond.

10. Backflow prevention devices such as flap gates for storm drain outlets should only be considered as a last option.

Figure 9-1. Hydraulic Properties of Circular Pipe



Reference: Chow, Open Channel Hydraulics (1959, reissued 1988), figure from Oregon Department of Transportation Hydraulics Manual (2014)

10.0 Open Channels

10.1 Introduction

This chapter provides the minimum technical criteria for the hydraulic evaluation and design of open channels in Denver. In many instances, special design or evaluation techniques will be required. Design criteria in the Open Channels chapter of the MHFD Manual are hereby incorporated by reference. Except as modified herein, all open channel designs must be in accordance with the MHFD Manual.

10.2 Natural Channel Design

The Open Channels chapter of the MHFD Manual emphasizes natural channel design. The MHFD Manual provides guidance for preserving, protecting, and enhancing existing natural channels and for designing naturalized channels where new channels are to be constructed.

Although much of Denver is urban in character, many of the streams that flow through the community can be enhanced through the natural channel design principles described in the MHFD Manual. These include the large "backbone" streams such as the South Platte River, Cherry Creek, and Sand Creek, and major tributaries to these streams (e.g., Lakewood Gulch, Harvard Gulch, and Westerly Creek). Dozens of other tributary streams, shown on the interactive map resources featured on the MHFD website, exist in Denver where natural channel design approaches can be incorporated. Additionally, there are opportunities to daylight streams that are currently being conveyed in closed conduits and create naturalized open channel systems.

As previously discussed in Chapter 3, a major drainageway is defined as any drainage flow path with a tributary area of 130 acres or more. Minor drainageways convey flows from tributary areas less than 130 acres. The design principles in the MHFD Manual apply to both classifications of streams. Additionally, the Open Channels chapter of the MHFD Manual provides design information for grass swales based on several standard cross sections.

10.3 Denver Design Criteria

The following criteria apply to natural channels and constructed channels within the City and County of Denver.

1. **Master Plan Information**. If published MHFD or Denver outfall system or drainage master plans exist, then channel designs should be completed with consideration of the projected future condition hydrology and recommendations of these plans; however, conformance to or variation from any existing master plans will be determined by the Review Engineer.

2. **Hydraulic Analysis**. A detailed hydraulic analysis of the design reach and any upstream or downstream area of influence must be conducted to inform the design following the guidance in the MHFD Manual. The analysis must be based on HEC-RAS for a suitable range of design events including the 2-year, 10-year and 100-year events, at a minimum. A two-dimensional hydraulic analysis may be appropriate for the project and used as specified or approved by the Review Engineer.

3. **Regulatory Floodplain Analysis**. A regulatory floodplain analysis must be performed in conformance with Denver floodplain permitting requirements, as approved by the Denver Floodplain Administrator.

4. **Filling of the Floodplain**. Filling of the floodplain must be avoided because it generally increases erosion potential on the stream, reduces valuable channel storage capacity, and tends to increase downstream runoff peaks

5. **Channel Freeboard**. A minimum of 18 inches of freeboard above the 100-year water surface to the top of bank must be provided in major and minor drainageways. Where feasible, a minimum of 18 inches of freeboard must also be provided to property lines.

6. **Bridge Freeboard**. A minimum of 3 feet, measured from the lowest low chord to the proposed 100-year water surface, for new pedestrian and/or vehicular bridge over a major drainageway. For minor drainageways, a minimum of 18 inches must be provided. This freeboard criteria does not apply to culverts or low-water crossings, but these types of drainageway crossings must still be considered in hydraulic analysis.

7. **Pipe Bridges (Utility Pipe Crossing)**. Pipe bridges are highly discouraged over any drainageway and will only be allowed if all other options have been exhausted. Any new pipe bridge shall provide minimum of 3 feet of freeboard above the 100-year water surface to the lowest component of the pipe bridge system crossing the channel.

8. **Utilities**. Utilities within and/or crossing drainageways are necessary to provide core services to citizens; however, these situations should be minimized due to potential for damage to the utility, pollution, and other negative impacts to the environment and the natural/beneficial functions of the corridor. Key considerations include:

    a) Wet and dry utility crossings of drainageways must be minimized to the maximum extent possible.

    b) New overhead utilities in/crossing drainageways are highly discouraged and will only be allowed if alternate alignment and/or underground crossing is not feasible.

    c) New underground utility crossings must provide sufficient cover to prevent exposure and/or damage to the utility. Refer to Denver's Utility Project Floodplain Permit Requirements for minimum cover required for dry utilities.

    d) When a utility crossing is necessary, encasement or other protection should also be considered and may be required.

    e) Placement of new utility appurtenances (e.g., poles, cabinets, manholes, meters, etc.) must be minimized in all drainageways to the maximum extent possible. Any appurtenances necessary within the drainageway must also meet floodplain permit requirements, as applicable.

f) Depth and location of new utility alignments must consider future channel configuration from existing master plans.

g) Utility crossings may leverage existing bridge crossings, but consideration must be given to existing bridge freeboard, remaining bridge lifespan, constructability, avoiding impacts to flood conveyance through the bridge, and approval by the bridge owner.

9. **Swales**. Design charts shown in Section 6 of the Open Channels chapter of the MHFD Manual may be used for 100-year design discharges up to 40 cfs.

10. **Synthetic Lining and other Proposed Materials**. Generally, stable conditions are to be achieved relying on the principles and materials described in the MHFD Manual. The use of synthetic fabrics for lining of channels and other material differing from standard materials (i.e., vegetation, rock, temporary coir or biodegradable erosion control blanket) identified in the MHFD Manual will be allowed only upon written approval from the Review Engineer.

11. **Preservation of Natural Features**. Natural channel boundaries and alignments must be preserved, maintained or enhanced in their natural condition to serve as landscape and visual amenities, to provide focal points for development projects, and to help define "edges" in and around communities. Vegetation groups, rock outcroppings, terrain form, soils, waterways, and bodies of water must be preserved to the extent practicable.

12. **Allowance for Future Vegetation**. Channel capacity must be provided to accommodate anticipated future growth of vegetation within the floodplain, as approved by the Review Engineer. Manning's roughness coefficient must account for the ultimate anticipated mature vegetation. Overstory canopy trees are allowed and encouraged within the floodplain when they do not conflict with intended conveyance or otherwise create potential for increased flood damage (e.g., row of trees aligned perpendicular to flow that would capture debris).

13. **Future Bridges**. Appropriate allowances for known future bridges or culverts, which can raise the water surface profile and cause the floodplain to be extended, must be included in the hydraulic and design analysis. The applicant must contact DOTI for information on future bridges and roads.

14. **Design Drawings**. The existing stream in the design reach and any proposed channel improvements must be clearly shown in plan, profile, section, and detail, as approved by the Review Engineer.

15. **Pre-submittal Meeting**. For any improvements to a natural channel or plans to construct a naturalized channel, the applicant must meet with DOTI to discuss the concept and obtain the requirements for planning and design documentation. Approval of the concept and design will be made in accordance with the requirements of Chapter 2 of these Criteria.

16. **MHFD Maintenance Eligibility**. All projects on major drainageways are required to be designed to meet MHFD Maintenance Eligibility. To be eligible for MHFD maintenance, the most current version of MHFD's Maintenance Eligibility Guidelines (downloadable from MHFD's website) must be met.

17. **Environmental Permitting**. A variety of federal (e.g., 404 permit, ESA compliance), state (e.g., dewatering, stormwater) and local permits (stormwater, parks) are often required when constructing open channels. The engineer must obtain necessary permits.

11.0 HYDRAULIC STRUCTURES

11.1 Introduction

The criteria to be used in the design of hydraulic structures must be in accordance with the Hydraulic Structures chapter of the MHFD Manual, unless modified herein. Hydraulic structures described in the MHFD Manual include grade control structures in open channels and outfalls and rundowns to convey tributary runoff into streams.

11.2 Denver Design Criteria

Design criteria applicable to hydraulic structures in Denver include the following:

1. **Hydraulic Analysis**. Grade control structures may be designed using the simplified design approach described in the MHFD Manual if applicable. Otherwise, grade control structures must undergo the detailed hydraulic analysis approach described in the Manual.

2. **Grade Control Structures**. Grade control structures must be grouted stepped boulder or sculpted concrete unless otherwise approved. Ungrouted rock grade control structures may only be used if approved by the Review Engineer based on a detailed HEC-RAS hydraulic analysis and rock sizing evaluation.

3. **Pipe Outfalls and Rundowns**. As described in the Hydraulic Structures chapter of the MHFD Manual, pipe outfalls are preferred over rundowns for conveying tributary runoff into open channels. Rundowns may only be used if approved by the Review Engineer. If rundowns are used, the applicable criteria described in the MHFD Manual must be met and riprap protection must be provided on the opposite bank to protect against any impinging flow.

12.0 CULVERTS

12.1 Introduction

A culvert is defined as a conduit for the conveyance of water under a roadway, railroad, canal, or other embankment. In addition to serving hydraulic functions, culverts also must carry overhead loads from traffic and other activities, thereby serving a structural function. Proper culvert design is essential because culverts often significantly influence upstream and downstream flood risks, floodplain management and public safety. The criteria presented in this chapter must be used in the design of culverts. The criteria, techniques, and design examples provided in the Culverts and Bridges chapter of the MHFD Manual are hereby incorporated by reference and not repeated herein, unless modified by Denver.

12.2 General Design and Hydraulic Evaluation

The hydraulic principles, criteria, roughness coefficients, entrance loss coefficients, culvert capacity charts and other information provided in the Culverts and Bridges chapter of the MHFD Manual must be used in the hydraulic evaluation, sizing and design of culverts, except as modified herein. The MHFD-Culvert spreadsheet (downloadable from MHFD's website) may also be used in the hydraulic evaluation of culverts.

The MHFD Culverts and Bridges chapter provides detailed information on culvert hydraulics, culvert sizing and design, culvert inlets and outlet protection. The MHFD Culverts and Bridges chapter also provides references for additional information, including the Federal Highway Administration's 2005 Hydraulic Design Series No. 5, *Hydraulic Design of Highway Culverts*.

12.3 Culvert Sizing Criteria

For street crossings, the minimum culvert size is based on the allowable street overtopping for the various street classifications as set forth in Table 12-1 and allowable headwater depths as discussed in Section 12.6. Street overtopping is not allowed for the 10-year frequency or smaller storm. Other conditions may be present that will require a larger culvert size, particularly with regard to public safety concerns and upstream and downstream impacts. In some cases, the minimum criteria may result in some structures remaining in the 100-year floodplain, which may require an increase in culvert size to lower the floodplain elevation. Also, if only a small increase in culvert size is required to prevent overtopping, then the larger culvert is required.

Table 12-1. Allowable Roadway Overtopping at Culvert Crossings

Street Classification	10-year Storm Event	100-year Storm Event
Local	No road overtopping allowed	Overtopping at crown governed by maximum depth of 12-inches at gutter flowline.[1]
Arterial and Collector	No road overtopping allowed	No overtopping at crown. Maximum depth of 12 inches at gutter flowline.[1] Ratio of maximum headwater (H_w) to culvert diameter (D) may not exceed 1.5 ($H_w/D \leq 1.5$).

[1] See Chapter 7, Streets, for further discussion regarding allowable flow depth in the street based on street classification.

See the MHFD Manual for criteria and design procedures for culvert applications other than street crossings.

12.4 Construction Material and Pipe Size

Within Denver, culverts must be constructed from reinforced concrete. Other materials for construction are subject to written approval by the Review Engineer. The minimum pipe size for culverts within a public right of way is 18-inch-diameter culvert. The minimum pipe size for roadside ditch culverts for driveways is 15-inch-diameter culvert.

12.5 Inlet and Outlet Configuration

Within Denver, all culverts must be designed with headwalls, wingwalls and aprons, or with flared end sections at the inlet and outlet. Flared end sections are only allowed on pipes with diameters of 30 inches (or equivalent) or less. Refer to the MHFD Culverts and Bridges chapter for design guidance on culvert headwalls and wingwalls.

Outlet protection is required at culvert outfalls to minimize the potential for erosion immediately downstream of culverts. Outlet protection such as riprap armoring or concrete aprons helps to stabilize the transition from the culvert to the downstream channel. See the Culverts and Bridges and Hydraulic Structures chapters of the MHFD Manual for guidance and criteria on outlet protection.

For design of culvert inlets and outlets, the designer should consider compatibility with the upstream and downstream channels including geometry, hydraulics, and aesthetics.

12.6 Headwater Considerations

The maximum headwater (Hw) for the 100-year design flows must be no more than 1.5 times the culvert diameter (D), or 1.5 times the culvert rise dimension for shapes other than round. Also, the headwater depth may be limited by the street overtopping criteria in Table 12-1.

12.7 Structural Design

As a minimum, all culverts must be designed to withstand an HS-20 loading (unless designated differently by Denver) in accordance with the design procedures of the American Association of State Highway and Transportation Officials (AASHTO) in *Standard Specifications for Highway Bridges* and with the pipe manufacturer's recommendation.

12.8 Safety Grates

The use of safety grates should be considered for culverts and underground pipes that may be accessed by the public, while also evaluating effects on hydraulic forces and clogging potential. Designers should follow the guidance and criteria in the MHFD Culverts and Bridges chapter for safety grates.

12.9 Design Considerations

All of the design criteria in this chapter must be followed. Key factors to consider for design include:

- No street overtopping is allowed for the 10-year storm.
- Check minimum and maximum culvert velocities.
- The minimum culvert size for crossing the public right of way is 18-inch diameter or equivalent.
- The minimum culvert size for roadside ditches at driveways is 15-inch diameter or equivalent.
- Headwalls and wingwalls must be provided for all culverts with a diameter larger than 30 inches.
- Check maximum headwater for design conditions. The ratio of maximum headwater to culvert diameter, Hw/D, may not exceed 1.5. Street overtopping criteria in Table 12-1 must also be satisfied.
- Check structural requirements and emergency overflow route.
- Consider public safety including accessibility to the public, maximum velocities, guard rails, embankment, slopes, and other factors.

13.0 DETENTION (STORAGE)

13.1 Introduction

This chapter provides technical criteria for the hydraulic evaluation and design of detention (storage) facilities in Denver. Design criteria in the Storage chapter of the MHFD Manual are hereby incorporated by reference. Except as modified herein, all detention facility designs must be in accordance with the MHFD Manual.

Detention of flood flows for all development and redevelopment projects is required in accordance with these criteria for the purpose of reducing urban drainage problems and the costs of drainage facilities. The main purpose of a detention facility is to store the excess storm runoff associated with increased watershed imperviousness and discharge this excess at a rate similar to the rate experienced from the basin without development.

13.2 Full Spectrum Detention

All detention facilities must be designed to provide Full Spectrum Detention (FSD) in accordance with the Storage chapter of the MHFD Manual. As such, three control volumes are integrated into the design: the water quality capture volume (WQCV), excess urban runoff volume (EURV), and the 100-year event volume.

An emergency spillway must be provided with freeboard, as described in Section 13.9.3.

13.3 Integration of Water Quality and Flood Control Detention

FSD integrates water quality and flood control detention. As described in the Storage chapter of the MHFD Manual. FSD may combine the three control volumes into one facility or have separate facilities for any of the three volume components: WQCV, EURV, or 100-year detention.

FSD may adopt one of five types of structural stormwater control measures (SCMs) to provide WQCV treatment. These include:

1. Extended detention basin
2. Retention pond
3. Constructed wetland basin
4. Sand filter
5. Bioretention

Fact sheets for each of these types of SCMs are provided in the MHFD Manual Volume 3.

Planning for water quality and flood detention must be integrated within all development and redevelopment. In this context, site planning and design techniques must reduce runoff volumes

and velocities to the maximum extent practicable by implementing measures that minimize directly connected impervious area.

Denver requires integration of flood control detention and water quality treatment. The following references describe strategies to achieve this integration:

- Chapter 14 of these Criteria.
- Volume 2 of the MHFD Manual (Storage chapter).
- Volume 3 of the MHFD Manual.
- Denver's Ultra-Urban Green Infrastructure Guidelines, also downloadable from http://www.denvergov.org/publicworks/.

13.4 Exemptions from Flood Control Detention

Exemptions from flood control detention are described in the Drainage Policy chapter.

13.5 Regional Detention Facilities

For Denver to consider regional detention facilities, the following criteria must be met:

1. A Denver-approved plan recommends the regional detention facility.
2. The regional detention facility is designed to accommodate the fully developed flows from the upstream watershed.
3. The regional detention facility is constructed or will be constructed in phases with the development; otherwise, temporary detention must be provided.
4. Legally-binding ownership and maintenance responsibilities by a public entity are clearly defined to ensure the proper function of the facility in perpetuity.
5. There is adequate conveyance of the fully developed flows from the site to the regional detention basin.
6. Design is completed in accordance with the MHFD Manual, considering these criteria:
    a. Multi-use (e.g., recreation) must be considered in the design of detention basins.
    b. The creation of jurisdictional dams is strongly discouraged.
    c. Basins must be located on existing publicly-owned lands whenever possible.
    d. If regional flood control detention facilities incorporate regional WQCV for stormwater quality, developments upstream of the regional facility must provide onsite stormwater quality enhancement (MDCIA, LID) as identified in Chapter 14, Water Quality.

13.6 Relationship to Adjacent Properties and Structures

Impacts to upstream and downstream properties relative to proposed detention facilities must be considered and minimized through appropriate facility design. If an adequate outfall does not exist or if some portions of the proposed development drain directly off-site, then Denver may require the new development to over-detain, thereby incorporating more restrictive release rates and larger detention volumes.

Designs must take into account the location of structures near detention facilities and plan accordingly to reduce the likelihood of seepage into basements and structural damage by ensuring finished floor elevations are 1.5 feet above the water surface elevation when the emergency spillway is conveying the maximum design flow or emergency flow.

13.7 Maintenance

All detention facilities must be designed with adequate maintenance access provisions and in a manner that facilitates maintenance. Figure 13-5 provides maintenance access road details. Maintenance access also includes providing storage and staging areas for sediment and debris removal during maintenance activities. Denver requires all regional facilities to be eligible for MHFD maintenance. Download the most current version of MHFD's maintenance eligibility requirements and contact MHFD early in the planning process to expedite their review.

An operations and maintenance (O&M) plan is required for each detention facility in accordance with Denver's Stormwater Management Facility Operations and Maintenance Manual.

13.8 State Engineer's Office Coordination

13.8.1 Jurisdictional Dam Requirements

Any dam constructed for the purpose of storing water with a surface area, volume, or dam height as specified in Colorado Revised Statutes 37-87-105, as amended, requires the approval of the plans by the State Engineer's Office (SEO). Those facilities subject to state statutes must be designed and constructed in accordance with the criteria of the state, in addition to the criteria in this Manual.

13.8.2 Drain Time Requirements

Detention facilities must undergo a notification process with the SEO in conformance with Colorado Revised Statutes 37-92-602(8) and present documentation that drain times conform with the requirements of this statute.

13.9 Design Standards for Above-ground Detention Basins

Figure 13-1 presents a generalized illustration of a FSD basin with WQCV being provided in the configuration of an extended detention basin (EDB). Individual components of an above-ground detention facility are discussed in the subsections below.

13.9.1 Grading Requirements

The bottom of the detention basin must slope toward the trickle channel as shown in Figure 13-3. Grading requirements for embankments must be in accordance with Table 13-1. All earthen embankments must be covered with a minimum of 6 inches of approved topsoil and revegetated with grass in accordance with the Revegetation chapter of the MHFD Manual.

Table 13-1. Grading Criteria for Embankments

Embankment Height	Criteria
5 feet in height or less	No steeper than 4 (horizontal) to 1 (vertical).
Higher than 5 feet	Slopes must not be steeper than 3 (horizontal) to 1 (vertical), but 4 (horizontal) to 1 (vertical) is preferred.

13.9.2 Use of Retaining Walls

The use of retaining walls within detention basins is discouraged. However, if walls are unavoidable, low-height walls less than 30 inches that are constructed of natural rock or landscape block are preferred. No plain-faced concrete walls are allowed. Long-term maintenance access, safety and aesthetics are important design considerations. Walls may not be continuous around a detention facility, but must allow access for maintenance equipment. Maintenance equipment must be able to safely reach the bottom of the facility, including the forebay and outlet structure, and have adequate space to operate and turn.

If several adjacent retaining walls are used, a separation of at least 4 feet must be provided. Foundation walls of buildings may not be used as detention basin retaining walls.

If accepted by Denver, any retaining walls exceeding a height of 30 inches (as measured from the ground line to the top of the wall) must be provided with handrails and require a Building Permit. Appropriate measures (typically an all-weather access road to the basin bottom) must be included to allow for access by maintenance equipment.

A licensed professional engineer must perform a structural analysis of retaining walls that exceed 30 inches in height for the various loading conditions the wall(s) may encounter. The wall design and calculations must be stamped by a professional engineer and submitted to Denver for review. The structural design details and requirements for the retaining wall(s) must be included in the construction drawings.

Basins with walls should be located away from major pedestrian routes, and emergency egress routes from detention basins must be provided.

13.9.3 Emergency Spillway and Freeboard

The emergency spillway flow is the 100-year undetained flow. For contributing drainage areas greater than or equal to 5 acres, the elevation of the top of the embankment must be a minimum of 1 foot above the water-surface elevation when the emergency spillway is conveying the maximum design or emergency flow. For contributing drainage areas of less than 5 acres, the

elevation of the top of the embankment must be either: 1) a minimum of 1 foot above the computed 100-year water-surface elevation in the detention facility and/or spillway or 2) at least equal to the water-surface elevation when the emergency spillway is conveying the maximum design or emergency flow, whichever is greater.

Some situations may require more stringent emergency spillway criteria than presented in the Storage chapter of the MHFD Manual. When the storage facility falls under the jurisdiction of the SEO as a dam, the spillway's design storm is prescribed by the SEO (SEO 1988). Also, analysis of downstream hazards may indicate that the spillway design storm will need to be larger than the 100-year event.

13.9.4 Inlet and Forebay

Inlets and sediment forebays must be sized in accordance with the MHFD Manual with the structure, shape and configuration based on the Denver Swirl Bay shown in Figure 13-2. The intent of the forebay is to reduce loading of sediment and debris to the main body of a detention facility. Alternative designs may be considered with Denver's approval; however, a forebay or equivalent pre-treatment facility is required for all detention basins.

13.9.5 Trickle (Low Flow) Channel

All grassed bottom detention basins must include a trickle channel designed according to the MHFD Manual. Figure 13-3 illustrates two types of concrete trickle channels as a standard design, depending on drainage area. An optional vegetated, benched approach is also provided. Denver's approval is required to use the vegetated channel approach and markers are required to provide a reference to the correct invert when removing accumulated sediment during maintenance.

13.9.6 Outlet Configuration

The MHFD Manual and MHFD's website provide design guidance, design details and examples for several detention basin outlet configurations. Use these criteria and example details for orifice plate and trash rack design and for micropool configuration. Figure 13-4 provides Denver's standard full spectrum detention basin outlet structure concept.

All detention facilities in Denver must incorporate the following:

1. All mounting hardware for the orifice plate and trash racks must be stainless steel.

2. Orifice plate must be stainless steel.

3. Orifice plate must have a neoprene gasket between the plate and structure to prevent leakage.

4. A single column of three orifices must be used as a standard installation, as shown in the MHFD-Detention spreadsheet available on the MHFD website. Fewer orifices may be used with Denver's approval. The intent is to increase the size of required orifices to

reduce the likelihood of plugging while still meeting required drain times stipulated in the Storage chapter of the MHFD Manual.

5. Well screens are necessary to protect orifices less than 1.25 inches. Depending on the characteristics of the contributing area and potential for debris and trash, the designer may also want to consider well screens when an orifice dimension is in the range of 1.25 to 2.5 inches. Use bar grating for orifices 2.5 inches or greater. Weigh the risk of clogging an orifice versus the risk of clogging the well screen when deciding to provide a well screen or bar grating for orifices ranging in size from 1.25 to 2.5 inches. Outlets must incorporate micropools in conformance with the Storage chapter of the MHFD Manual Volume 2.

6. All outlets must be designed to minimize unauthorized modifications that affect proper function. A sign with a minimum area of 1.5 square feet must be attached to the outlet or posted nearby (if unable to be posted to the outlet) with the following message:

WARNING
This is a Water Quality Treatment Facility.
Keep screen and grate clean.
Unauthorized modification of this outlet is a code violation.

13.9.7 Landscaping Requirements

Water diversion/detention areas and embankments should be designed and constructed to blend with their surroundings, creating site amenities rather than eyesores. Denver's Aesthetically Enhanced Detention and Water Quality Manual (2010) should be referenced for more guidance on designing aesthetically pleasing facilities. In open space or natural areas, techniques to be considered include creation of topographic changes that mimic natural conditions (including a variety of slope changes), using natural materials such as stone, blending with the textures and patterns of the surrounding landscape, and using materials that match the local environment. No plain-faced precast or cast-in-place (CIP) concrete is allowed. Existing drainage patterns should be preserved whenever possible.

Vegetate all above-ground detention basins in accordance with the criteria in the Revegetation chapter of Volume 2 of the MHFD Manual. Landscaping improvements should enhance the aesthetics of the basin. When determining landscaping, long-term maintainability of the facility should be a high priority. The following is a list of guidelines (adapted from Douglas County Storm Drainage Criteria Manual, 2005) for basin landscaping:

- Detention areas should have attractive natural-looking features, fit into the surrounding landscape and add to the overall character of an area. The shape of the detention basin should be as natural looking as practical, with terracing of the slopes and bottom. The tops and the toes of slopes should vary, and there should be an undulation in the shape and grading of the sides of the detention area.

- Slopes should be well vegetated to prevent erosion. The use of appropriate groundcovers and grasses at the top of the slope help to soften the appearance of the detention area and can incorporate the detention area into the landscape design. Appropriate plant material,

such as wetland species or drought tolerant species, should be planted in the detention area and on the slopes. Shrubs and trees should be offset from the top of the slope and placed such that they do not interfere with maintenance and so that tree roots will not cause structural issues. Native and perennial species should be used to the extent practical.

- Use of wood mulch in and adjacent to detention facilities is discouraged because of its potential to be displaced and clog outlet structures. Mulch placed over filter fabric is particularly susceptible to displacement and should not be used on slopes greater than 6 (horizontal) to 1 (vertical) or below the 100-year water surface elevation. The use of rock mulch is discouraged because it is difficult to remove sediment from the rock.

- Typically, runoff is conveyed to detention basins in a storm drain pipe. When runoff is conveyed to the detention basin via a swale or when the storm drain pipe discharges higher up on the pond embankment, rundowns may be needed to minimize erosion at inflow points. When rock or concrete rundowns are used, they should be attractive and compatible with the overall design.

13.9.8 Multiple Use Considerations

Multiple uses of detention facilities are encouraged; however, it is critical to minimize conflicting uses. For example, areas used as soccer fields or golf courses need to drain within a reasonable timeframe to prevent soggy fields incompatible with recreational use. Other park and detention facility conflicts may relate to safety in areas used for child play, mosquito-borne illness (e.g., West Nile virus) concerns, and/or protection and enhancement of wildlife. Considerations for multiple use facilities include:

- Compatibility with design, historic designation or other protective constraints including wildlife habitat and protection.

- Compatibility with recreational uses. The level of organized and informal activity in a park must be considered.

- Technical constraints and opportunities including soil characteristics, turf management, or terrain.

- Potential for new natural areas and wildlife corridors.

- Size and configuration of the park. For example, a small neighborhood park under five acres would probably not be appropriate for a large detention facility.

- Maintenance and operations, funding resources, successful techniques for dealing with silt, debris, trash, etc. (These considerations should be reflected in the facility O&M plan.)

- The configuration and easements for underground utilities and their impact on the existing park land.

- Potential for total rehabilitation of existing sites to accommodate multi-purpose uses.
- Impacts on all aspects of the open space system: Highline Canal and trails, South Platte River Greenway, natural areas including potential areas such as along gulches, traditional parks, and other publicly owned lands.

13.10 Design Standards for Parking Lot Detention

13.10.1 Depth Limitation

The maximum allowable design depth of ponding in parking lots for the 100-year flood is 12 inches. Whereas the 100-year flood is allowed within the parking lot area, the WQCV and EURV are not allowed to be within the parking lot. Storage of the WQCV and EURV must be provided outside the paved area of the parking lot.

13.10.2 Outlet Configuration

Where using a drop inlet to discharge to a storm drain or drainageway, design the outlet pipe to convey 120 percent of the 100-year outflow and use a minimum diameter of 8 inches for private systems (public system pipe sizing requirements are provided in Table 9-1). Where a small diameter outlet through a 6-inch curb is used to control releases from the parking lot detention, a tapered slot (1.5”x 3.5” on back of curb tapered to 1.5”x 2.5” on front of curb) should be used to control releases from the parking lot detention.

13.10.3 Performance

To ensure that the detention facility performs as designed, maintenance access must be provided in accordance with Drainage Policy chapter. The outlet must be designed to minimize unauthorized modifications. Any repaving of the parking lot must be evaluated for impact on volume and release rates and is subject to approval by DOTI. A sign must be attached or posted in accordance with Section 13.10.4.

13.10.4 Flood Hazard Warning

All parking lot detention areas must have multiple signs posted identifying the detention basin area. The signs must have a minimum area of 1.5 square feet and containing the following message:

WARNING
This area is a detention basin and is subject
to periodic flooding to a depth of (provide design depth).

Any suitable materials and geometry of the sign are permissible, subject to approval by DOTI.

13.11 Design Standards for Underground Detention

Underground detention is strongly discouraged in Denver for the following reasons:

- Underground detention is not visible; therefore, it tends to be "out-of-sight, out-of-mind." As a result, these devices may not receive regular maintenance or performance evaluation.
- Maintenance access may be more complex, which can be a deterrent to maintenance.
- Anaerobic (absence of dissolved oxygen) conditions in bottom sediments are more likely to develop in underground devices. This condition can release pollutants that were bound to the sediment and cause bad odors.
- Vegetation within above-ground systems provides benefits beyond stormwater management, including the removal of air pollutants, mitigation of the urban heat island effect, and improvement of habitat.

Nevertheless, Denver recognizes that there are some cases where the use of underground facilities is necessary due to extreme space constraints in smaller, ultra-urban redevelopment sites. Denver will consider the use of underground detention under these circumstances; however, the applicant must comply with the following restrictions prior to receiving authorization for its use:

- Water quality treatment must be above ground.
- Clear evidence must be provided documenting why detention cannot be provided on the ground surface and why the use of an underground facility is the best choice for the site, considering factors such as initial installation, maintenance, and ability to ensure long-term function.

13.11.1 Materials

Underground detention must be constructed using corrugated aluminum pipe (CAP), reinforced concrete pipe (RCP), concrete vaults or approved equivalents. Refer to the Pipe Material Selection Charts in the MHFD Storm Sewer Pipe Material Technical Memorandum (most current edition) for acceptability of alternate materials. Galvanized pipes are not acceptable. The pipe thickness, cover, bedding, and backfill must be designed to withstand HS-20 loading, or as otherwise required by Denver.

13.11.2 Configuration

Pipe or vault segments must be sufficient in number, height, and length to provide the required minimum storage volume. The minimum headroom height of the pipe or vault segments must be provided as needed to permit maintenance, subject to Denver approval, but in no case less than 4.0 feet. A sump inlet must be provided at the upstream end where possible to indicate that the underground facility is not functioning properly, and an emergency overflow outlet or backup system is required.

Manholes for maintenance access must be placed as required to facilitate maintenance operations, as approved by Denver, but in no case at a spacing of more than 200 feet. A depressed sump at least 1 foot deep must be provided below each access manhole to facilitate

maintenance using a vacuum truck. Permanent buildings or structures must not be placed directly above the underground (pipe) detention system.

13.11.3 Inlet and Outlet Design

Inlets to detention facilities can be surface inlets, pipes and/or a local private storm drain system.

Outlets from underground detention must consist of a pipe that can convey 120 percent of the 100-year outflow, with a minimum diameter of 8 inches for private systems (public system pipe sizing requirements are provided in Table 9-1). The invert of the outlet pipe must be set at the lowest point in the detention facility to ensure that it fully drains. The outlet pipe(s) must discharge into a standard manhole, standard inlet, an open drainageway with erosion protection, or an acceptable outfall. If an orifice plate is required to control the release rates, the plate(s) must be firmly bolted or secured to the wall to prevent leakage around the edges.

13.11.4 Maintenance Access

Access easements to the detention facility must be provided. Maintenance access designs must take into consideration Occupational Safety and Health Administration (OSHA) requirements for confined space entry.

13.12 Design Standards for 100-year Runoff Retention Ponds

13.12.1 Allowable Use

See the Storage chapter and Fact Sheet T-7 of the MHFD Manual for allowable uses for Retention Ponds.

13.12.2 Design Standards for Retention Ponds

See the Storage chapter and Fact Sheet T-7 of the MHFD Manual for Retention Pond Design Standards.

13.13 Design Considerations

All of the design criteria in this chapter must be followed. Several key considerations that the designer must take care to address include:

1. Grade earth slopes per Section 13.9.1.
2. Provide trickle channels in above-ground detention areas.
3. Provide proper trash racks and micro-pool at all outlet structures.
4. Provide signs as required.
5. Provide maintenance access to all structures (inlet, swirl bay, and outlet).
6. Provide emergency spillway per Section 13.9.3 and check emergency overflow path.

7. Check finished floor elevation of any structure near the detention basin.

8. Ensure that failure of underground detention is clearly evident from above ground.

9. Design the invert of the inflow pipe to the detention basin to be higher than the water quality level.

10. Any detention system must be 4 feet above the seasonal high groundwater. Groundwater infiltration is not allowed into detention systems.

Figure 13-1. Full Spectrum Detention Basin

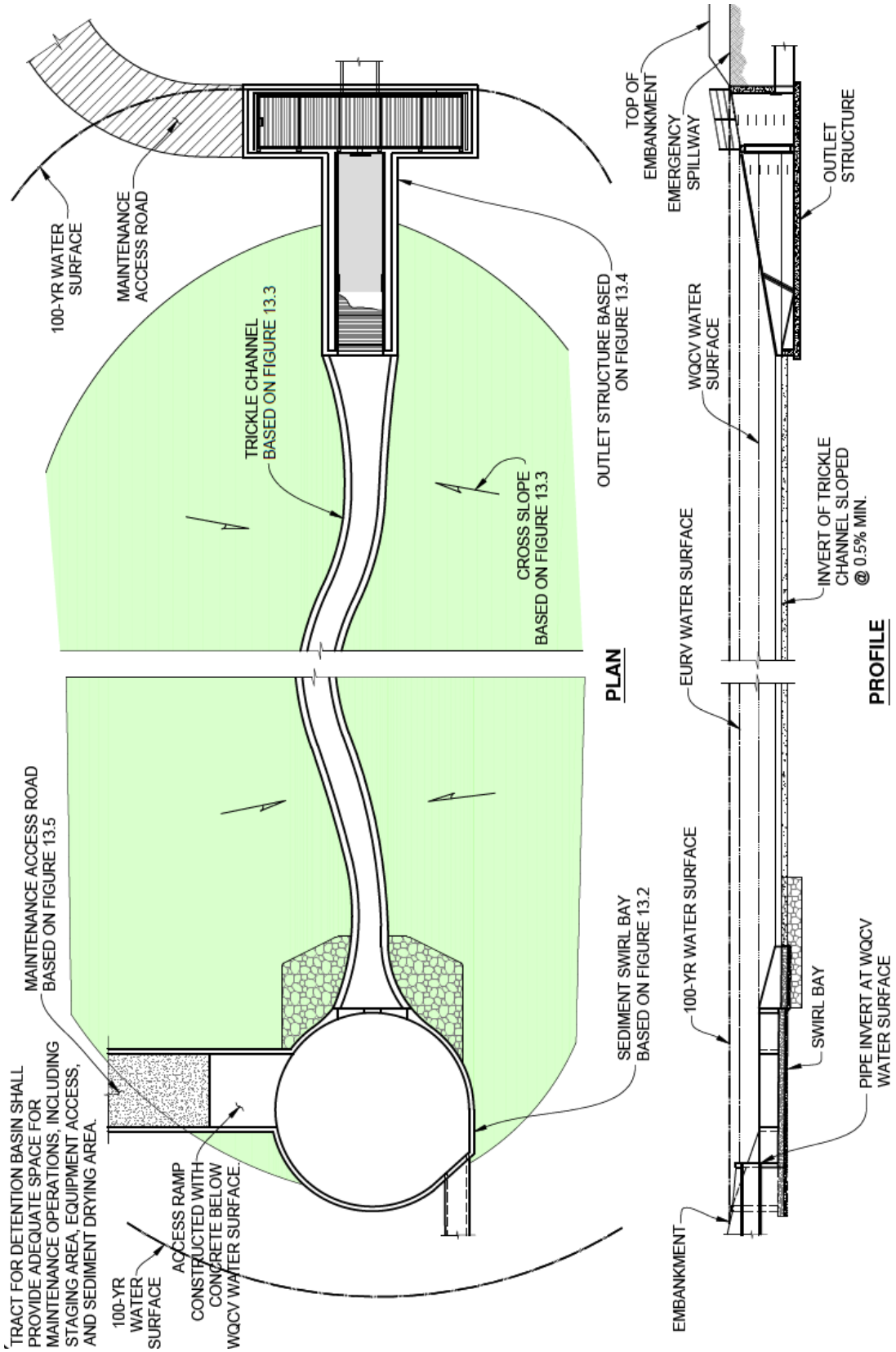
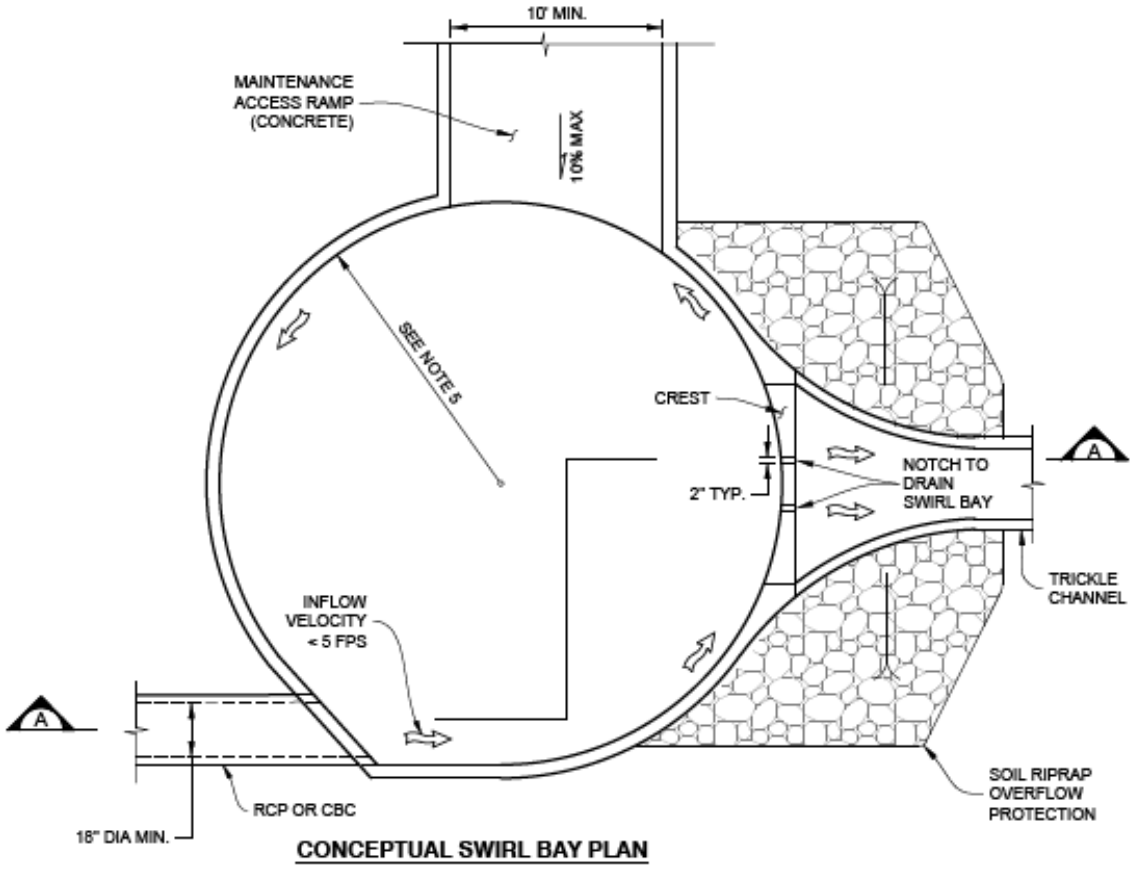
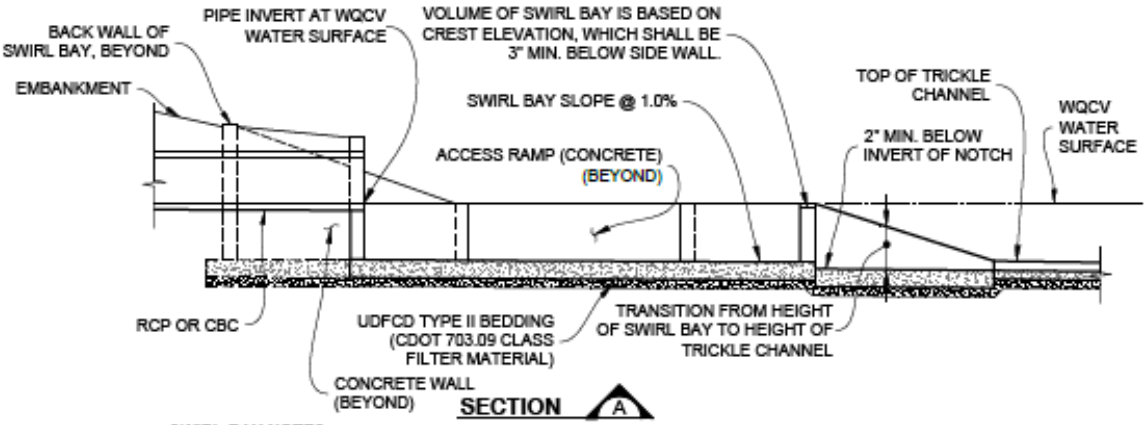


Figure 13-2. Standard Denver Swirl Bay





SWIRL BAY NOTES:

1. IT IS THE RESPONSIBILITY OF THE DESIGN ENGINEER TO DETERMINE IF A HANDRAIL SHOULD BE INCLUDED. HANDRAILS ARE RECOMMENDED FOR STRUCTURES WHERE PEDESTRIAN TRAFFIC WILL BE IN CLOSE PROXIMITY OF THE STRUCTURE.
2. IT IS THE RESPONSIBILITY OF THE DESIGN ENGINEER TO SIZE, DESIGN, AND DETAIL ALL SWIRL BAY STRUCTURES, INCLUDING, BUT NOT LIMITED TO, THE REQUIRED STEEL REINFORCEMENT IN CONCRETE STRUCTURES.
3. MIN. VOLUME OF SWIRL BAY = (1-3% WQCV) SEE UDFCD VOLUME 3, T-5, TABLE EDB-4
4. MAINTENANCE ACCESS RAMP CAN BE PROVIDED ON ONE OR BOTH SIDES OF SWIRL BAY.
5. MIN. RADIUS OF SWIRL BAY IS 5 FEET.

Figure 13-3. Standard Full Spectrum Detention Basin Trickle Channel Details
(Source: MHFD 2024)

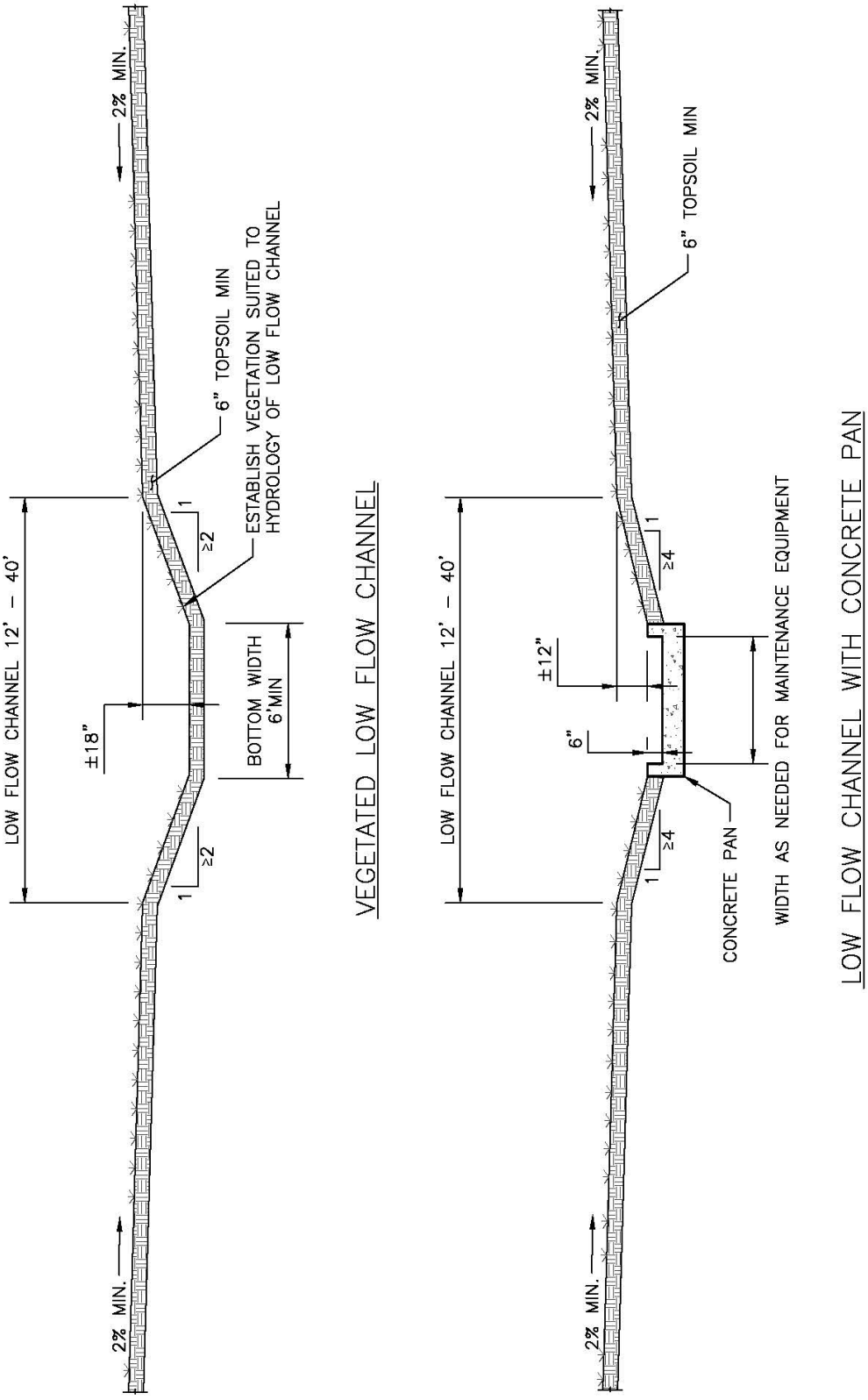


Figure 13-4. Standard Full Spectrum Detention Basin Outlet Structure Concept with Internal Micropool and Sloping Trash Rack
(Source: MHFD 2024)

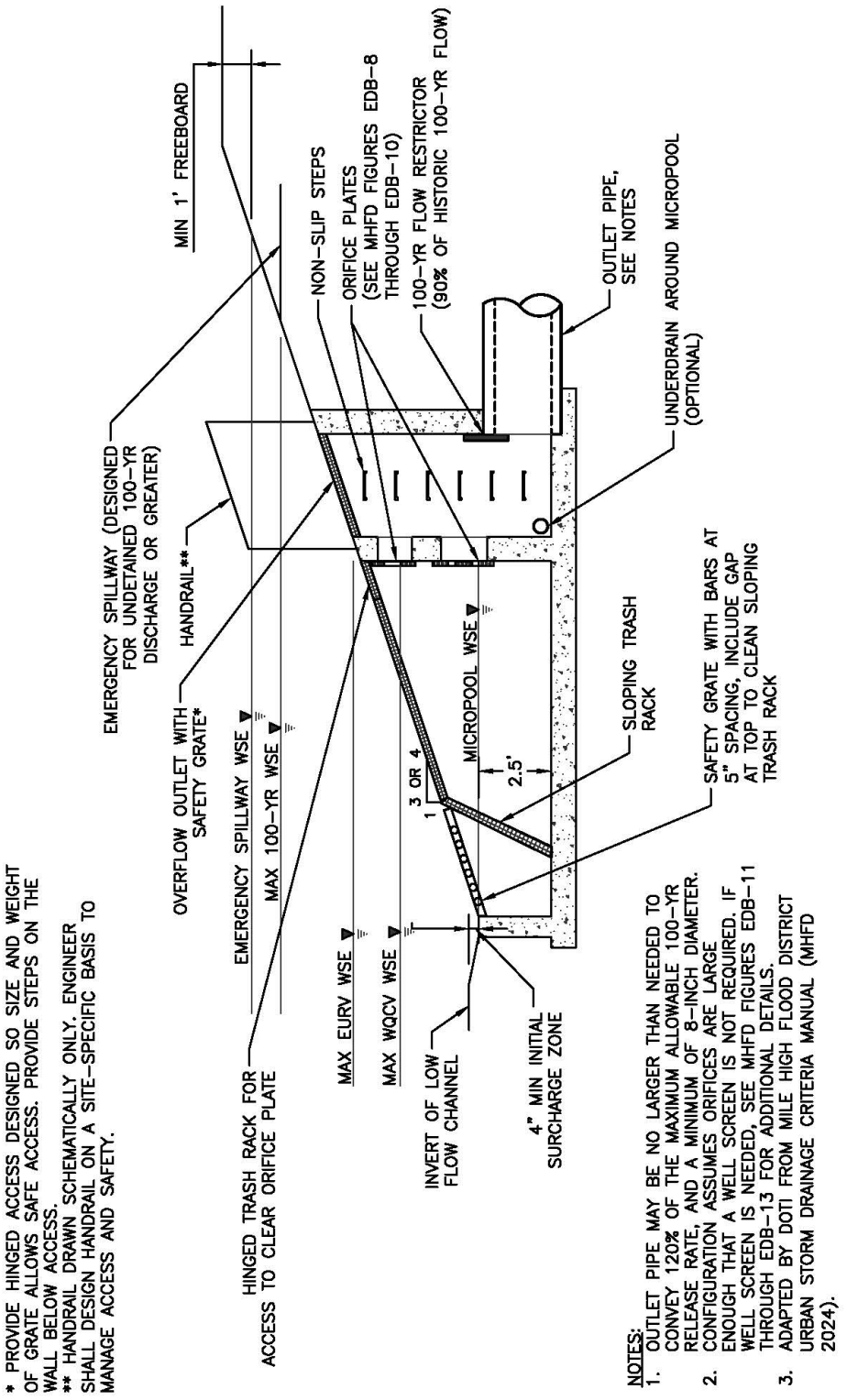
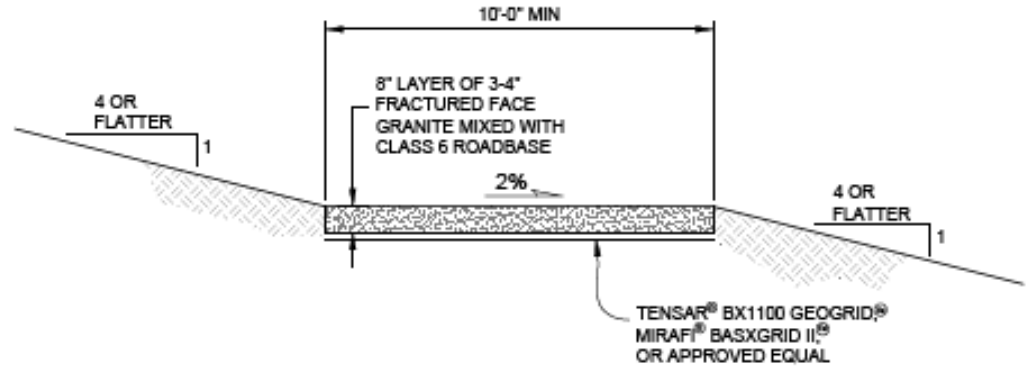
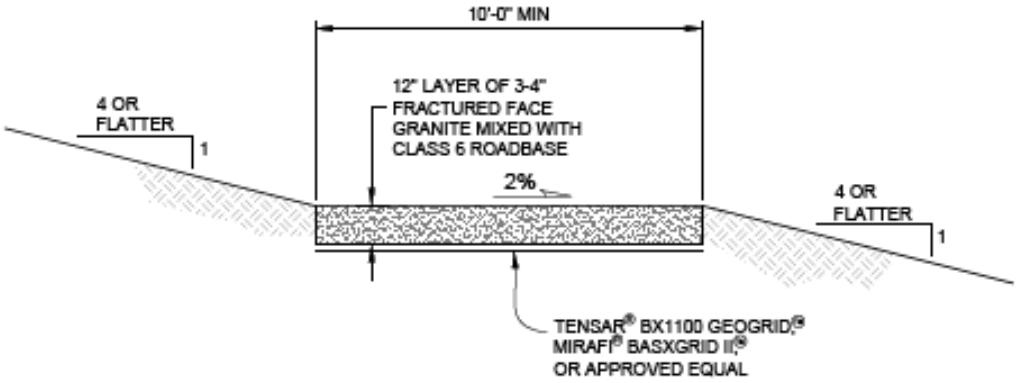


Figure 13-5. Standard Full Spectrum Detention Basin Maintenance Road Details



CROSS SECTION
ABOVE EURV WATER SURFACE



CROSS SECTION
BELOW EURV WATER SURFACE

NOTE: ROAD BASE QUANTITY IS 30% OF GRANITE QUANTITY

14.0 Stormwater Quality

14.1 Introduction

Denver requires permanent stormwater quality control measures (SCMs) to be implemented on development and redevelopment projects to protect Denver's streams, lakes and wetlands. These requirements are also necessary for Denver to comply with Colorado's water quality regulations, Denver's municipal separate storm sewer system (MS4) permit, and total maximum daily load (TMDL) requirements in certain watersheds. Denver adopts Volume 3 of the Urban Storm Drainage Criteria Manual as the basis for its design criteria, supplemented by City and County of Denver Ultra-Urban Green Infrastructure Guidelines (Denver DOTI 2016).

14.2 Applicability

All development and redevelopment projects in Denver must implement stormwater control measures to enhance the water quality of storm runoff via runoff reduction/minimized directly connected impervious area (MDCIA).[2] If a proposed development or redevelopment project disturbs one acre or more, including smaller sites that are part of a larger common plan of development or sale exceeding one acre of disturbance ("applicable development site"), then permanent stormwater control measures are also required. Limited exclusions (e.g., utility projects, stream projects) may be allowed in accordance with Denver's MS4 permit.

Definition of Larger Common Plan of Development or Sale

A "larger common plan of development or sale" means a contiguous area where multiple separate and distinct construction activities may be taking place at different times on different schedules but remain related. CDPHE has determined that "contiguous" means construction activities located in close proximity to each other (¼ mile). Construction activities are considered "related" if they share the same development plan, builder or contractor, equipment, storage areas, etc.

[2]Minimized Directly Connected Impervious Area (MDCIA) must be implemented in a manner that does not cause adverse impacts to structures or adjacent property.

14.3 Design Approach

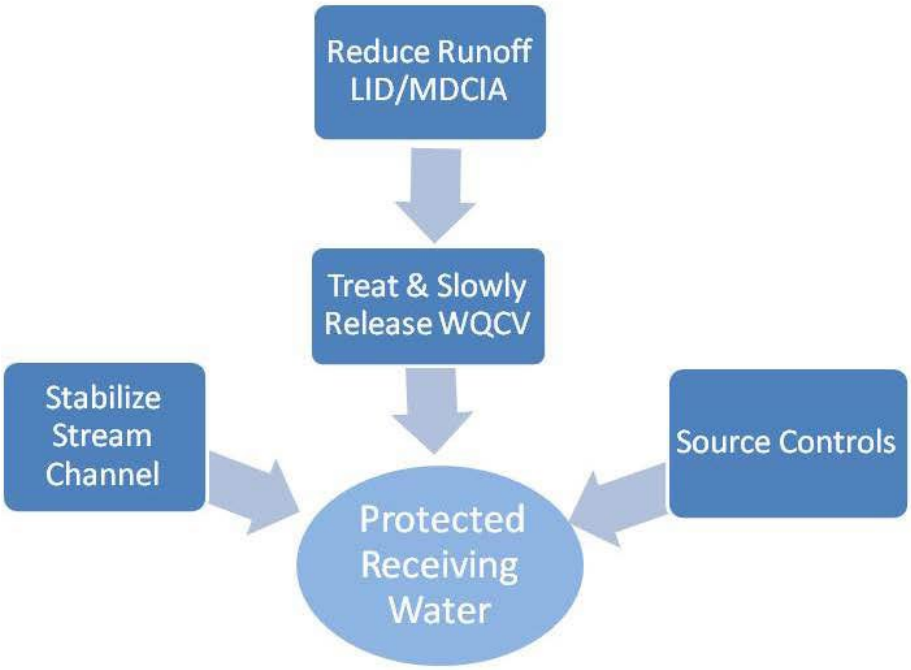
Stormwater quality management approaches in Denver are based on the "Four-Step Process" described in Volume 3 of the MHFD Manual (Figure 14-1). Additionally, Denver encourages integration of water quality and flood control in full spectrum detention facilities, as described in Chapter 13 Storage.

As described in MHFD Volume 3, effective stormwater management: 1) integrates pollutant source controls, 2) reduces runoff volumes through MDCIA, 3) treats the water quality capture volume (WQCV), and 4) incorporates stream stabilization. This section focuses on runoff reduction (MDCIA) and treatment of the WQCV.

Terminology

The term stormwater control measure (SCM) refers to any best management practice (BMP) or other method used to prevent or reduce the discharge of pollutants to Waters of the State. Control measures include, but are not limited to, green infrastructure (GI), green stormwater infrastructure (GSI) and low impact development (LID).

Figure 14-1. MHFD's Four Step Process for Stormwater Quality Management



In order for MDCIA to be implemented on a site, it must be considered early in the land development planning process. On some small sites, it may be possible to meet stormwater quality management requirements through the use of MDCIA. On larger sites, the size of WQCV facilities may be reduced through implementation of MDCIA. Denver adopts MHFD's method for quantifying volume reduction described in Volume 3, Treatment BMP Fact Sheet T-1 Receiving Pervious Areas.

MHFD Volume 3 Chapter 2 BMP Selection provides SCM selection guidance considering factors such as watershed size, soils, depths to groundwater and bedrock, baseflows, watershed conditions and targeted pollutants.

Conserving Existing Amenities

During the planning phase of development, identify portions of the site that provide stormwater quality benefits and should be protected or improved. Such areas may include mature trees, stream corridors, wetlands, and type A/B soils with higher infiltration rates. Natural areas to be preserved must be protected from compaction during the construction phase. Consider temporary construction fence for this purpose. In areas where disturbance cannot practically be avoided, rototilling and soil amendments should be integrated to restore the infiltration capacity of areas that will be restored with vegetation.

14.4 Scale of Application

There are three general approaches to providing stormwater quality treatment in Denver: 1) on-site, 2) subregional and 3) regional. Space constraints at most redevelopment and infill development in Denver will result in on-site or subregional implementation of stormwater quality treatment. On-site facilities serve individual lots. Subregional facilities serve two or more lots with a total contributing drainage area less than 130 acres. Regional facilities serve drainage areas between 130 acres up to one square mile and may be applicable for larger development and redevelopment projects. Regional facilities that provide stormwater quality treatment must comply with the regional detention facility requirements described in Chapter 13 Storage.

If regional or subregional facilities provide stormwater quality treatment and are located within a water of the state, then the following conditions for an applicable development site must be met:

1. **MDCIA Requirement**. At least 20 percent of the of the applicable development site must be disconnected and drain through pervious areas or features comprising a footprint of at least 10% of the impervious area draining to it. The receiving pervious area must consist of some combination of landscaped buffers, swales, or permeable pavement.

2. **Stream Stabilization**. All stream conveyance between the applicable development site and the regional or sub-regional water quality facility must be fully stabilized in accordance with Chapter 13, Open Channel Design. Any new or existing outfalls leading to a regional drainageway must be designed, constructed, and stabilized in accordance with MHFD criteria and are subject to MHFD review and inspection to ensure maintenance eligibility.

3. **Source Control**s. Where applicable in industrial areas or other developments that have the potential for significant source pollution, source control measures are strongly encouraged for the individual parcels upstream of the regional or sub-regional facility.

The contributing drainage area is an important consideration both on the site level and at the regional level. On the site level, there is a practical minimum size for certain SCMs, largely related to the ability to drain the WQCV over the required drain time. For example, it is technically possible to size the WQCV for an extended detention basin for a half-acre site; however, designing a functional outlet to release the WQCV over a 40-hour drain time is practically impossible due to the very small orifices that would be required. For this size watershed, bioretention would be more appropriate. At the other end of the spectrum, there must be a limit on the maximum drainage area for a regional facility to ensure adequate treatment of rainfall events that may produce runoff from only a portion of the area draining to the SCM. If the overall drainage area is too large, events that produce runoff from only a portion of the contributing area will pass through the SCM outlet (sized for the full drainage area) without adequate residence time in the SCM. As a practical limit, the maximum drainage area contributing to a regional water quality facility should be no larger than one square mile.

14.5 Design Criteria

Design of conveyance-based SCMs (e.g., grass buffers, swales) is based on design flow rates specified in Volume 3 of the MHFD Manual. Storage-based SCMs (e.g., extended detention basins, bioretention, sand filters) are based on storing and slowly releasing the WQCV unless Full Spectrum Detention designs are implemented providing treatment of the Excess Urban Runoff Volume (EURV), as described in Chapter 13 Storage. The WQCV is calculated using methods in Volume 3 of the MHFD Manual. MHFD's SCM Design spreadsheet tool can be used as a design aid for SCM selection and sizing, as well as to quantify runoff reduction achieved through disconnection of impervious area. Denver requires treatment of the full WQCV unless the required treatment volume is reduced through implementation of volume reduction methods. Reductions in WQCV treatment volumes must be quantified following the Receiving Pervious Area Fact Sheet T-1 described in MHFD Volume 3.

Additionally, the entire applicable development site must be tributary to an approved SCM. When it is deemed technically infeasible to treat 100% of the applicable development site, up to 5% of the site (but not to exceed one acre) may be excluded from treatment, provided that technical justification of infeasibility, as well as the proposed untreated acreage, is documented in the drainage report and approved by Denver. Also note that if a regional or subregional facility is used, it must be designed to treat 100% of the site with no allowable excluded area.

Volume 3 of the MHFD Manual provides design criteria for SCM types appropriate for use in Denver. Denver adopts MHFD's design criteria for SCMs listed in Table 14-1. Additionally, Denver may approve use of other SCM types with demonstrated performance on a case-by-case basis.

The City and County of Denver Ultra-Urban Green Infrastructure Guidelines (Denver DOTI 2016) are also adopted as guidance for implementation of stormwater control measures in ultra-

urban areas characterized by space constraints and high levels of imperviousness. These guidelines provide detailed design guidance for streetside stormwater planters, bumpout stormwater planters, green alleys and tree trench/pits.

Table 14-1. Stormwater Control Measures (SCMs) Allowed in Denver

SCM Type	Comment
Receiving Pervious Areas including Grass Buffers and Grass Swales	Can be used to disconnect impervious area and provide runoff reduction. As stand-alone practices, these do not treat the WQCV and are usually part of a treatment train with other practices that provide the WQCV. Can provide pretreatment for underground SCMs.
Bioretention	Can be designed for WQCV or EURV. Well suited for smaller sites, infill and redevelopment. Not suited for sub-regional or regional SCMs unless pretreatment is provided and depths and areas guidelines are strictly followed. See Denver's Ultra-Urban Green Infrastructure Guidelines for applications in ultra-urban areas.
Green Roof	Primarily provides volume reduction. Also see Denver's Green Roof Ordinance.
Extended Detention Basin	Not recommended for drainage areas with less than 2 impervious acres and not allowed for sites with less than 1 impervious acre. Can be designed for WQCV or EURV.
Sand Filter	Suitable for drainage areas less than 1 acre. Denver prefers aboveground sand filters. A variance is required for underground sand filters. If contained in a vault, additional requirements for underground facilities apply as described in the Storage chapter. Can be designed for WQCV or EURV.
Retention Pond (Wet Pond)	Water rights and space constraints may limit application in Denver. Only allowed for drainage areas greater than 1 acre. Can be designed for WQCV or EURV.
Constructed Wetland Pond	Water rights and space constraints may limit application in Denver. Only allowed for drainage areas greater than 1 acre. Can be designed for WQCV or EURV.
Permeable Pavement	Suitable for parking areas, alleys and low use areas without potential for groundwater contamination. Enables use of SCM surface area for other purposes. Can be designed for WQCV and flood control.
Underground SCMs, including Manufactured Treatment Devices (MTDs)	Denver requires above-ground treatment approaches. A variance is required for underground SCMs and may be approved on a case-by-case basis when no above-ground alternatives are feasible. An additional variance is required for any MTD, per Denver's Proprietary Device policy. Hydrodynamic Separators (HDSs) are not stand-alone treatment devices and serve as pretreatment only.

14.6 Additional Requirements for Infiltration-Based Practices

Soils with good permeability, most typically associated with Hydrologic Soil Groups A and B, provide opportunities for infiltration of runoff and are well-suited for infiltration-based SCMs such as rain gardens, permeable pavement systems, sand filter, grass swales, and buffers, often without the need for an underdrain system. Even when soil permeability is low, these types of SCMs may be feasible if soils are amended to increase permeability or if an underdrain system is used. In some cases, however, soils restrict the use of infiltration-based SCMs. When soils with moderate to high swell potential are present, infiltration should be avoided to minimize damage to adjacent structures due to water-induced swelling. In some cases, infiltration-based designs can still be used if an impermeable liner and underdrain system are included in the design; however, when the risk of damage to adjacent infrastructure is high, infiltration based SCMs may not be appropriate.

Use of infiltration-based practices is generally not appropriate for subregional or regional water quality facilities due to the large area and shallow depth requirements that should be strictly adhered to in all cases. If subregional or regional infiltration practices can meet these design requirements, additional pre-treatment must be provided to reduce sediment loading, which will otherwise reduce the effectiveness of the SCM over time.

Consult with a qualified geotechnical engineer when planning an infiltration-based SCM. This is necessary to select the appropriate system type and establish minimum distances between the SCM and structures of concern or provide recommended measures to mitigate potential impacts. A geotechnical engineer also can assist in estimating the range of surface and subgrade infiltration rates to be used for design based on laboratory testing that identifies the hydrologic soil type and field infiltration testing that estimates in-situ rates of infiltration. Follow guidance provided in Chapter 4 of Volume 3 of the MHFD Manual (MHFD 2024), which also includes considerations related to known or suspected contamination and depth to groundwater. Key aspects of the geotechnical report that affect drainage or water quality should be discussed in the Drainage Report submittal as they relate to the design of SCMs.

14.7 Safety

Stormwater control measures must be designed and maintained considering both public safety and safety of maintenance personnel. Design criteria in Volume 3 of the MHFD Manual incorporate safety considerations.

14.8 Aesthetics

Stormwater control measures should be designed to be aesthetically compatible with surrounding land use. Consultation with a landscape architect is recommended. Additionally, MHFD Volume 3 (MHFD 2024), the Denver Ultra-Urban Green Infrastructure Guidelines (Denver DOTI 2016), and Aesthetically Enhanced Detention and Water Quality Ponds (Denver 2010) provide recommendations for aesthetically-pleasing designs that complement rather than detract from the development and support community values.

14.9 Maintenance

All stormwater quality facilities must be designed with adequate maintenance access provisions and in a manner that facilitates maintenance. Denver requires that an O&M Plan be completed for all permanent SCMs in accordance with Denver's Operation and Maintenance Manual. In addition to providing operation and maintenance requirements, this plan must state that at least two inspections per year are required.

14.10 Stormwater Facility Reporting Requirements Related to Water Rights

In 2015, Colorado Revised Statute (CRS) §37-92-602 (8) (also known as Senate Bill 15-212) became law. This statute provides water rights related legal protection for any regional or individual site stormwater detention and infiltration facility in Colorado, provided the facility meets these criteria:

1. It is owned or operated by a governmental entity or is subject to oversight by a governmental entity (e.g., required under an MS4 permit).

2. It continuously releases or infiltrates at least 97% of all of the runoff from a rainfall event that is less than or equal to a 5-year storm within 72 hours after the end of the event.

3. It continuously releases or infiltrates as quickly as practicable, but in all cases releases or infiltrates at least 99% of the runoff within 120 hours after the end of events greater than a 5-year storm.

4. It operates passively and does not subject the stormwater runoff to any active treatment process (e.g., coagulation, flocculation, disinfection, etc.).

5. If it is in the Fountain Creek (tributary to the Arkansas River) watershed it must be required by or operated in compliance with an MS4 permit.

The statute specifies that runoff treated in stormwater detention and infiltration facilities must not be used for any other purpose by the owner/operator/overseer (or that entity's assignees), must not be released for subsequent diversion or storage by the owner/operator/overseer (or that entity's assignees), and must not be the basis for a water right or credit (MHFD 2016).

Under this statute, new stormwater detention and infiltration facilities must complete certain reporting requirements facilitated by an on-line mapping system for Stormwater Detention and Infiltration Facility Notification (https://maperture.digitaldataservices.com/gvh/?viewer=cswdif). This information must be filed prior to operation of the facility and include the following:

1. Location.

2. Approximate surface area at design volume.

3. Data that demonstrate that the facility has been designed to comply with the release rates described in Items 2 and 3 above.

Not all stormwater facilities are required to complete filing requirements and certain types of facilities are not protected under this statute, as summarized in Table 14-2. Neither retention facilities nor constructed wetlands are protected under 37-92-602(8) CRS. These facilities expressly require a water right. Temporary construction sedimentation basins should not be uploaded to the on-line portal unless it will be used as a permanent detention basin. In such case, the final detention configuration should be completed before uploading the record.

Table 14-2. Stormwater Facility Reporting Requirements under Senate Bill 15-212
(Source: MHFD 2016)

SCM Type	Water Quality Only	Flood Control Included
Grass Buffers	Not Required	Not Required
Grass Swales	Not Required	Not Required
Bioretention (with or without an underdrain)	Not Required	Required
Green Roof	Not Required	Not Required
Extended Detention Basin	Required	Required
Sand Filter	Not Required	Required
Permeable Pavement Systems	Not Required	Required
Media Filter Drain	Not Required	Not Required
Underground Detention Vaults	Required	Required
Constructed Wetland Pond	N/A, Subject to Water Rights	
Constructed Wetland Channel	N/A, Subject to Water Rights	
Retention Pond	N/A, Subject to Water Rights	

15.0 Construction Site Stormwater Management and Erosion Control

15.1 Introduction

Denver requires stormwater management at construction sites to control erosion and discharges of sediment and other pollutants associated with construction activities in accordance with Chapter 10 of Denver's Rules and Regulations Governing Sewerage Charges and Fees and Management of Wastewater.

This chapter identifies the triggers for a Construction Activities Stormwater Discharge Permit (CASDP, also known as an EC Permit), requirements for Stormwater Management Plans (SWMPs), and the minimum technical criteria for stormwater management and control measures at construction sites. This chapter hereby incorporates by reference Chapter 7 Construction BMPs in Volume 3 of the Urban Storm Drainage Criteria Manual (MHFD Manual) pertaining to the design and implementation of construction-related best management practices (BMPs), also known as and referred to throughout this chapter as "control measures" or SCMs.

Construction Site Stormwater Management Principles

1. Implement erosion and sediment control measures to reduce soil loss from all construction sites to the maximum extent practicable.
2. Manage construction sites to prevent discharges of chemicals, construction wastes and other pollutants from construction sites.
3. Prevent damage to properties adjacent to construction sites arising from sediment, debris, chemical wastes or other pollutants.
4. Protect the Municipal Separate Storm Sewer System (MS4), Waters of the State, and wetlands from damage caused by erosion, sedimentation, chemical wastes, or other pollutants arising from construction activity.

15.2 Denver's Construction Site Stormwater Management Policies

1. All development, redevelopment, street, utility, pipeline, transmission line, and oil exploration projects meeting the permit triggers for Denver's CASDP are required to address erosion, sediment control, and potential chemical water quality issues by submitting a SWMP to the Denver Department of Transportation and Infrastructure (DOTI) for review and approval.

2. All construction projects, whether required to obtain a CASDP or not, are subject to implementing stormwater control measures at construction sites. Inspection and escalating enforcement action by DOTI may occur from the beginning of site demolition or site grading until the site has achieved final stabilization and any required permits are closed. For sites not required to obtain a CASDP, Denver may initiate enforcement under its illicit discharge program.

3. Structural and non-structural control measures must be implemented in accordance with this chapter and the technical criteria in Volume 3 of the MHFD Manual. Factors such as project type, size, duration, soil type, site slope and proximity to Waters of the State must be considered when selecting control measures. Guidance for selection of control measures for construction sites can be obtained from Volume 3 of the MHFD Manual.

15.3 Construction Activities Stormwater Discharge Permit (CASDP)

15.3.1 Permit Triggers

A construction site is defined by construction activities that involve ground surface disturbance and associated activities including, but not limited to, clearing, grading, excavation, demolition, installation of new or improved haul roads and access roads, staging areas, stockpiling of fill materials, and borrow areas. All of these areas must be included in calculating the construction site area, even if the area is located at a different part of the property from where the primary construction activity will take place or on a different piece of property.

Denver DOTI requires a CASDP to be obtained prior to earth disturbance activities at a project if any of the following criteria are present:

1. The construction site area is one acre or more; or
2. The construction site is under one acre in area, but meets one of the following:
    a. The project site is part of a larger overall common plan of development or sale[3] and the overall development plan will ultimately disturb one or more acres;
    b. The project site has been identified by Denver DOTI as having a significant potential for erosion, based on site characteristics including topography;
    c. The project site is known to contain contaminated soils on site or has a pre-existing condition warranting special care during construction; or
    d. The project site is adjacent to Waters of the State.[4]

In addition to a CASDP from Denver, construction projects that disturb one or more acre, or that are part of a one acre or larger development or sale plan, must also obtain a "Stormwater Discharge Permit Associated with Construction Activities" from the Colorado Department of Public Health and Environment (CDPHE). In some cases, a CASDP may be required even when a CDPHE permit is not. Projects requiring both a CDPHE permit and Denver's CASDP must obtain and comply with permits from both entities.

[3] Common Plan of Development or Sale means a contiguous area where multiple separate and distinct construction activities may be taking place at different times on different schedules but remain related. "Contiguous" means construction activities located in close proximity to each other (within ¼ mile). Construction activities are considered to be "related" if they share the same development plan, builder or contractor, equipment, storage areas, etc.

[4] Section 10.02 of the Sewerage Regulation defines Waters of the State: "Any and all surface and subsurface waters which are contained in or flow in or through this State, but does not include waters in sewage systems, waters in treatment works of disposal systems, waters in potable water distribution systems, and all water withdrawn for use until use and treatment have been completed."

15.4 CASDP Application Submittal Requirements

A CASDP application must be submitted electronically to DOTI using the application on Denver's website (Stormwater & Sanitary Sewer Permits - City and County of Denver (denvergov.org)). To issue a CASDP, Denver also requires the submittal and approval of a SWMP prepared in accordance with the criteria in this chapter. A Narrative Report Information Worksheet supporting preparation of the SWMP can also be downloaded from Denver's website. The completed application must include a co-permittee's certification signed by the owner and the permittee, or their authorized agents. Denver may request additional information before approval of the CASDP. Upon approval, an electronic, City-stamped copy of the CASDP and SWMP will be delivered to the permittee to be kept onsite and made available during site inspections by Denver, while the permitted activity is occurring.

15.4.1 Permittee's Duty to Comply

The permittee is the primary responsible party for day-to-day compliance with Denver's CASDP. The CASDP is a legally binding agreement between the permit holder and the City, subject to compliance inspection and enforcement. The permittee must comply with the terms and conditions of the CASDP, including implementation of the approved SWMP. Failure to comply with the CASDP may result in escalating enforcement actions by Denver as described in Section 15.9. These infractions are also subject to potential referral to the CDPHE Water Quality Control Division.

15.4.2 Transfer of Permit

When all or a portion of a permitted site is sold or otherwise transferred to a different entity or the responsibility of a permitted site is transferred to another entity, the new entity must apply to Denver DOTI for amendment and/or transfer of the existing CASDP or apply for a new permit. The sale or transfer of a property does not constitute relief from any of the CASDP requirements until an amendment, transfer or new CASDP is approved.

15.4.3 Term, Expiration or Suspension of Permit

1. The CASDP remains active and in effect until the project is completed and final stabilization has been confirmed by DOTI. Final stabilization requirements are further discussed in Section 15.5.3 b). Additionally, all temporary construction control measures must be removed following the achievement of final stabilization, an inactivation request must be submitted to DOTI, and the site must pass a final inspection from DOTI.

2. The CASDP expires if construction has not commenced within 12 months of the approval of the SWMP. An expired CASDP must be reapplied for and approved prior to the start of construction.

3. Failure to pay any required CASDP fees will result in the immediate suspension of the CASDP.

15.5 Requirements for Construction Site Stormwater Control Measures

The permittee must implement control measures to minimize the discharge of pollutants from all potential pollutant sources at the site. Control measures must be installed for activities that may contribute pollutants to stormwater discharges prior to commencement of construction activities, during each phase of construction, and through completion of final stabilization. Stormwater runoff from all disturbed areas and soil storage areas must utilize or flow to at least one control measure to minimize erosion or sediment in the discharge. Control measures must be selected, designed, installed, and maintained in accordance with good engineering, hydrologic and pollution control practices. Control measures implemented at the site must be designed to prevent pollution to the storm sewer system or degradation of State Waters. The permittee must implement structural and/or nonstructural control measures that effectively minimize erosion, sediment transport, and the release of other pollutants related to construction activity.

15.5.1 Control Measures for Erosion and Sediment Control

Control measures for erosion and sediment control may include, but are not limited to, wattles/sediment control logs, silt fences, earthen dikes, drainage swales, sediment traps, subsurface drains, pipe slope drains, inlet protection, outlet protection, gabions, sediment basins, temporary vegetation, permanent vegetation, mulching, geotextiles, sod stabilization, slope roughening, maintaining existing vegetation, protection of trees, and preservation of mature vegetation. Design criteria for these practices are described in Volume 3 of the MHFD Manual. The following minimum erosion and sediment control measures are required:

a) Vehicle Tracking Controls: Vehicle tracking controls must be implemented to minimize vehicle tracking of sediment from disturbed areas to paved surfaces.

b) Street Sweeping: Paved surfaces adjacent to construction sites must be swept by the close of each business day (and during the day as needed) when sediment and other materials are tracked or discharged onto them. Sweeping by hand or mechanical street sweepers is acceptable. Mechanical street sweepers using water while sweeping may be required in order to minimize dust. Washing off paved surfaces with water is prohibited.

c) Inlet Protection: Inlet protection must be implemented on all existing or proposed storm drain inlets in the vicinity of the project site that may receive site runoff. The control measure must be appropriate to the type of storm inlet and appropriate for the ground surface at the inlet. The control measure shall have minimum impacts to the inlet capacity.

d) Perimeter Control: Perimeter control measures must be installed along the edge of the construction site to filter and control surface runoff leaving the construction site. The type of perimeter control used must be determined based on site and location, with consideration to tributary area.

e) Sedimentation Basin Discharges: Sedimentation basin discharge outlets (pipes) must withdraw water from or near the water surface of the basin, unless infeasible.

f) Vegetative Buffers: Pre-existing vegetation or equivalent control measures must be maintained for areas within 50 horizontal feet of receiving waters as defined by this permit, unless infeasible.

g) Soil Compaction: Soil compaction must be minimized for areas where future permanent infiltration control measures will occur or where final stabilization will be achieved through vegetative cover. Where soil compaction cannot be avoided in these areas, decompaction may be required before final stabilization of the area.

h) Topsoil Preservation: Unless infeasible (or inappropriate due to contamination or poor quality), topsoil must be preserved for those areas of a site that will utilize vegetative final stabilization.

i) Stockpiled Soil and Materials: The following control measures are required for stockpiles of soil, land clearing debris, or construction materials containing soil or sediment:

   a. Locate the piles outside of any natural buffers and away from waterways and onsite drainage pathways.

   b. Protect stockpiles located within 100 feet of perimeter controls, inlets, or stormwater conveyances with additional controls. Examples of acceptable controls include compacted dirt berms, silt fence, and sediment control logs.

   c. Where practicable, provide cover or appropriate temporary stabilization to avoid the stockpile's direct contact with precipitation and to minimize sediment discharge.

j) Soil Exposure: Minimize the amount of soil exposed during construction activity, including the disturbance of steep slopes, through phasing and temporary stabilization practices.

15.5.2 Control Measures for Other Common Pollutants

a) Petroleum Products and Other Chemicals: Bulk storage of 55 gallons or greater for petroleum products and other liquid chemicals must have secondary containment or equivalent protection to contain spills and prevent spilled material from entering state waters.

b) Concrete Washout: Discharges of concrete washout waste to the ground are allowed, provided that such discharges do not leave the site as surface runoff. A containment area must be designated for the washout of cement truck delivery chutes and masonry operations contained on site. This containment area must be designed so that all wash water is totally contained. Water discharged into the containment area is allowed to infiltrate, evaporate, or be removed from the site to an appropriate facility. The permittee must ensure the washing activities do not contribute pollutants to stormwater runoff, or receiving waters. Discharges that may reach groundwater must flow through soil that has buffering capacity prior to reaching groundwater. The concrete washout location must not be located in an area where shallow groundwater may be present and would result in

buffering capacity not being adequate, such as near natural drainages, springs, or wetlands. Dried cement waste must be removed and properly disposed.

c) Construction Waste and Debris: All construction site wastes must be properly managed to prevent potential pollution of state waters.

15.5.3 Stabilization Requirements

The following temporary and permanent site stabilization requirements must be implemented for each site.

a) Temporary stabilization must be implemented for earth disturbing activities on any portion of the site where ground disturbing construction activity has permanently ceased, or temporarily ceased for more than 14 calendar days. Temporary stabilization methods may include, but are not limited to, tarps, biodegradable soil tackifier, and hydromulch. The permittee may exceed the 14-day schedule when either the function of the specific area of the site requires it to remain disturbed, or, physical characteristics of the terrain and climate prevent stabilization. The SWMP must document the constraints necessitating the alternative schedule, provide the alternate stabilization schedule, and identify all locations where the alternative schedule is applicable on the site map.

b) Final stabilization must be implemented for all construction sites. Final stabilization is reached when all ground surface disturbing activities at the construction site are complete and either a uniform vegetative cover with an individual plant density of at least 70 percent of what would have been provided by native vegetation in a local, undisturbed area is established, or equivalent permanent alternative stabilization methods are implemented. Denver may approve alternative final stabilization criteria for specific operations.

   Final stabilization must be designed and installed as a permanent feature. Final stabilization measures for obtaining a vegetative cover or alternative stabilization methods include, but are not limited to, the following as appropriate:

   1. Seed mix selection and application methods.

   2. Soil preparation and amendments.

   3. Soil stabilization methods (e.g., crimped straw, hydromulch or rolled erosion control products (must be biodegradable netting unless approved otherwise by Denver)).

   4. Appropriate sediment control measures as needed until final stabilization is achieved.

   5. Permanent approved pavement, hardscape, landscape, stabilized driving surfaces.

   6. Other alternative stabilization practices as applicable.

c) All temporary control measures must be removed from the construction site once final stabilization is achieved.

15.5.4 Additional Site-specific Requirements

In addition to the minimum requirements identified in Sections 15.5.1 through 15.5.3, Denver requires additional control measures be implemented on sites meeting the following conditions:

1. Potential for High Flow Conditions. Sites that are located directly adjacent to Waters of the State or that have areas tributary to the site that may generate large volumes of runoff must be protected by control measures that provide flow control and diversion. Acceptable control measures include slope drains, temporary swales and channels, diversion dikes, coffer dams, sand bag barriers, and other comparable practices.

2. Steep Slopes. Sites that have slopes 3:1 or steeper must implement control measures to prevent or minimize slope erosion. The use of one or more of the following control measures or approved control measures providing equivalent protection is required:

    a. Geotextiles and Matting: Fabric, jute matting and other materials that provide a surface cover on slopes to minimize erosion from raindrop impact or sheet flow runoff. Geotextiles and matting must be properly installed and secured to the surface.

    b. Slope Roughening/Terracing: Slope roughening is similar to the agricultural erosion measure known as contour plowing where furrows are plowed along elevation contours. Care must be taken to prevent foot or vehicular traffic across areas where this control measure is used because even minimal traffic can destroy the control measures effectiveness.

3. On-site Drainageway. Sites that are adjacent to drainageways, have a drainageway within the site, or are constructing a drainageway within the site must provide control measures in accordance with the MHFD's criteria for construction in waterways. Examples include, but are not limited to (these control measures may require a permit from the Army Corps of Engineers):

    a. Velocity Reduction/Sediment Entrapment: Check dams, sediment traps or similar measures to reduce the velocity of flow and entrap sediment are required. Waters of the State must not be used as sediment collection facilities (unless authorized by another permitting authority). Control measures must be used to control sediment prior to a discharge to waters of the state.

    b. Temporary Diversion Methods: A temporary diversion method is required when water is rerouted from a drainageway, or flows are restricted to a designated portion of the drainageway. MHFD's criteria for Temporary Diversion Methods must be followed.

    c. Temporary Stream Crossing: A temporary stream crossing is required where repeated crossing of a drainageway by construction equipment may be necessary. MHFD's criteria for Temporary Stream Crossings must be followed.

4. Contaminated Site. Sites where there is known contamination by solid waste or toxic, radioactive, or other hazardous material must implement any additional requirements identified in these plans and be noted in the SWMP:

    a. Construction Management Plan

    b. Stockpile Protection and Site Stabilization

    c. Groundwater Dewatering, Management, Remediation Plan(s)

    d. Remediation Plan

    e. Contaminated Materials Management Plan

    f. Asbestos-Containing Materials/Asbestos-Contaminated Soils Management Plan approved by the Colorado Department of Public Health and Environment, in accordance with the Colorado Solid Waste Regulations

15.6 Maintenance and Corrective Actions

The permittee must ensure that all control measures remain in effective operating condition and are protected from activities that would reduce their effectiveness. Control measures must be maintained in accordance with good engineering, hydrologic and pollution control practices. Observations leading to the required maintenance of control measures can be made during a site inspection, or during general observations of site conditions. The necessary repairs or modifications to a control measure requiring routine maintenance must be conducted to maintain an effective operating condition.

The permittee must assess the adequacy of control measures at the site, and the need for changes to those control measures, to ensure continued effective performance. When an inadequate or a failure to implement a control measure is identified (i.e., new or replacement control measures become necessary), then corrective actions must be implemented.

15.7 Stormwater Management Plan (SWMP) Requirements

The CASDP requires submittal of a SWMP to DOTI for approval prior to beginning construction activities. A SWMP must be developed for each construction site in accordance with good engineering, hydrologic and pollution control practices. SWMP preparation templates and standard forms can be obtained from DOTI's website. Once the submitted SWMP is approved by DOTI, it becomes an enforceable part of the CASDP. The SWMP must be implemented as written and updated, from commencement of construction activity until final stabilization is complete.

15.7.1 SWMP Narrative Content and Site Map(s)

The SWMP, at a minimum, must include the following elements:

i. Qualified Stormwater Manager.[5] The SWMP must list the initial preparer of the SWMP, and the anticipated individual(s) by title and name or third-party consultant who are designated as the site's qualified stormwater manager(s) responsible for implementing the SWMP in its entirety. This role may be filled by more than one individual.

ii. Spill Prevention and Response Plan. The SWMP must have a spill prevention and response plan. The plan may incorporate by reference any part of a Spill Prevention Control and Countermeasure (SPCC) plan under Section 311 of the Clean Water Act or a Spill Prevention Plan required by a separate CDPS permit. The relevant sections of any referenced plans must be available as part of the SWMP.

iii. Materials Handling. The SWMP must describe and locate all control measures implemented at the site to minimize impacts from handling significant materials that could contribute pollutants to runoff. These handling procedures can include control measures for pollutants and activities such as, exposed storage of building materials, paints and solvents, landscape materials, fertilizers or chemicals, sanitary waste material, trash, and equipment maintenance or fueling procedures.

iv. Potential Sources of Pollution. The SWMP must list all potential sources of pollution which may reasonably be expected to affect the quality of stormwater discharges associated with construction activity from the site. This shall include, but is not limited to, the following pollutant sources:

    a. disturbed and stored soils

    b. vehicle tracking of sediments

    c. management of contaminated soils

    d. loading and unloading operations

    e. outdoor storage activities (erodible building materials, fertilizers, chemicals, etc.)

    f. vehicle and equipment maintenance and fueling

    g. significant dust or particulate generating processes (e.g., saw cutting material, including dust)

[5] A Qualified Stormwater Manager is an individual knowledgeable in the principles and practices of erosion and sediment control and pollution prevention, and with the skills to assess conditions at construction sites that could impact stormwater quality and to assess the effectiveness of stormwater controls implemented to meet the requirements of this permit.

h. routine maintenance activities involving fertilizers, pesticides, herbicides, detergents, fuels, solvents, oils, etc.

i. on-site waste management practices (waste piles, liquid wastes, dumpsters)

j. concrete truck/equipment washing, including washing of the concrete truck chute and associated fixtures and equipment

k. dedicated asphalt, concrete batch plants and masonry mixing stations

l. non-industrial waste sources such as worker trash and portable toilets.

v. Implementation of Control Measures. The SWMP must include design specifications that contain information on the implementation of the control measure in accordance with good engineering hydrologic and pollution control practices. This information may include applicable drawings, dimensions, installation information, materials, implementation processes, control measure-specific inspection expectations, and maintenance requirements.

The SWMP must include a documented use agreement between the permittee and the owner or operator of any control measures located outside of the permitted area, that are utilized by the permittee's construction site for compliance with this permit, but not under the direct control of the permittee. The permittee is responsible for ensuring that all control measures located outside of their permitted area, which are being utilized by the permittee's construction site, are properly maintained and in compliance with all terms and conditions of the permit. The SWMP must include all information required of and relevant to any such control measures located outside the permitted area, including location, installation specifications, design specifications and maintenance requirements.

vi. Site Description. The SWMP must include a site description which includes, at a minimum, the following:

a. Nature of the construction activity at the site.

b. Proposed schedule for the sequence for major construction activities and the planned implementation of control measures for each phase. (e.g., clearing, grading, utilities, vertical, etc.).

c. Estimates of the total acreage of the site, and the acreage expected to be disturbed by clearing, excavation, grading, or any other construction activities.

d. Summary of any existing data used in the development of the construction site plans or SWMP that describe the soil or existing potential for soil erosion.

e. Description of the percent cover of native vegetation on the site if the site is undisturbed, or the percent cover of native vegetation in a similar, local undisturbed area if the site is disturbed. If a percent cover is not appropriate for

the site location (i.e., arid), describe the technique and justification for the identified cover of native vegetation.

f. Description of any allowable non-stormwater discharges at the site, including those being discharged under CDPHE's low risk discharge guidance policy.

g. Description of areas receiving discharge from the site. Including a description of the immediate source receiving the discharge. If the stormwater discharge is to a municipal separate storm sewer system, the location(s) of the storm sewer discharge, and the ultimate receiving water(s).

h. Description of all stream crossings located within the construction site boundary.

vii. Site Map. Denver requires that the SWMP include one or more site maps at one of the following scales: 1"=20', 1"=30', 1"=40', 1"=50' or 1"=100'. The scale selected must be suitable for practical use and readability. Two-foot contour intervals are required for these plans. The site map(s) must include the following elements:

a. Construction site boundaries.

b. Flow arrows that depict stormwater flow directions on-site and runoff direction.

c. Existing and proposed topography, including cross-sections showing both existing and proposed grades and clearly marked existing and proposed grading contours (legible with elevations) extending 100 feet beyond the project boundaries.

d. All areas of ground disturbance including areas of borrow and fill and including phased limits of grading and clearing.

e. Locations of areas used for storage of soil.

f. Locations of all waste accumulation areas, including areas for liquid, concrete, masonry, and asphalt.

g. Locations of dedicated asphalt, concrete batch plants and masonry mixing stations, including containment areas for chute washout.

h. Locations of fuel, lubricant and chemical storage areas and equipment maintenance and fueling locations.

i. Locations of sanitary facilities.

j. Locations of contaminated areas.

k. Locations of construction entrances.

l. Locations of all structural control measures.

m. Locations of all non-structural control measures. Nonstructural control measures (e.g., street sweeping) without specific location may be notated.

n. Locations of springs, streams, wetlands and other state waters, including areas that require pre-existing vegetation be maintained within 50 feet of a receiving water. Natural features within 100 feet of the site boundary must also be shown.

o. Locations of all stream crossings located within the construction site boundary.

p. Location of existing and proposed structures on-site, with structures subject to demolition clearly identified.

q. Locations of all storm runoff discharge points at site boundaries or internal to site if a drainageway is located on-site.

r. All applicable Denver Standard Notes.

s. Installation details for all proposed construction control measures.

t. Details for all proposed structural permanent stormwater quality control measures.

u. Professional Engineer's stamp and signature

viii. Final Stabilization and Long-Term Stormwater Management. The SWMP must describe the practices used to achieve final stabilization of all disturbed areas at the site and identify permanent stormwater controls (e.g., detention ponds, rain gardens) that will be in place after construction operations are completed. Some post-construction water quality structural control measures such as extended detention basins may be used as construction control measures when site conditions allow. A description of the procedures to be employed to convert an active construction control measure to a permanent water quality feature may also be required to ensure final design standards are met without any reduction in capacity or function resulting from the use of the control measure during construction. Some infiltration-oriented control measures, such as bioretention facilities, are not suitable for use during the construction phase.

ix. Inspection Reports. After construction begins, the on-site copy of the SWMP must include documented inspections.

x. Permittee Certification. Each SWMP will include a signed certification by each co-permittee as follows:

> I am duly authorized to submit, on my own behalf as (insert name of co-permittee applicant) or as a duly authorized representative of (insert name of co-permittee applicant), this Stormwater Management Plan in connection with an application to the Wastewater Management Division of the City and County of Denver for a Construction Activities Stormwater Discharge Permit for the Project named above as described herein. I understand that erosion control, sediment control and water quality enhancing measures

beyond those described herein may be required in accordance with a finally approved Stormwater Management Plan that is adopted and incorporated into a Construction Activities Stormwater Discharge Permit for the Project named above as described herein. Further, I understand that, once approved by Denver's issuance of the requested Permit, my obligations to implement the approved Plan must continue until such time as the Plan is properly completed, modified or terminated.

15.7.2 Supporting Technical Information and Documents

When applicable to the project, copies of additional plans and/or technical materials must be available for review upon request at the time of CASDP application. Issuance of the CASDP may be delayed until Denver has received and reviewed applicable requested plans and materials, which may include:

1. Drainage report
2. Soils/geotechnical studies
3. Environmental audits (for sites under environmental remediation)
4. Copies of applications for related Colorado Discharge Permit System (CDPS) Permits, including:
    a. Stormwater Discharge Associated with Construction Activity
    b. Construction Dewatering
    c. Remediation Activities Discharging to Surface Water or Groundwater
5. Air Pollution Emission Notification – Fugitive Dust or other Air Pollution Permits
6. Copies of correspondence with other governmental jurisdictions related to:
    a. Wetlands
    b. Floodplains
    c. Waterways
    d. Discharges to or from other jurisdictions
    e. Total Maximum Daily Load (TMDL) related requirements specified by CDPHE
7. Copies of temporary access agreements with adjacent landowners
    a. Use of land for material storage or lay down
    b. Stabilization and restoration of disturbed areas

c. Acceptance of flow to or from adjacent sites

15.8 Responsibilities of Permittee

15.8.1 Maintain SWMP and CASDP Onsite

Permittees must keep an electronic or hard copy of the CASDP and SWMP onsite at all times. The onsite SWMP should be the originally approved documents with all revisions noted to match current site conditions. The SWMP must be made available upon request during site inspections by DOTI.

15.8.2 SWMP Modifications, Permit Amendments

Permittees are required to amend, adapt, and adjust their SWMP to accurately reflect phased construction changes and current conditions of the site. Permittees must keep a record of SWMP changes made that includes the date and identification of the changes. The SWMP must be modified when any of the following occur:

1. A change in design, construction, operation, or maintenance of the site requiring implementation of new or revised control measures;

2. The SWMP proves ineffective in controlling pollutants in stormwater runoff in compliance with the permit conditions;

3. Control measures identified in the SWMP are no longer necessary and are removed; or

4. Corrective actions are taken onsite that result in a change to the SWMP.

A notation must be included in the SWMP that identifies the date of the site change, the control measure removed, or modified, the location(s) of those control measures, and any changes to the control measure(s). The permittee must ensure the site changes are reflected in the SWMP.

SWMP modifications are categorized as major or minor modifications that have differing approval requirements:

1. Major Modifications. Major modifications are changes to the SWMP that remove or add area to the project, modify the final hydrology or drainage of the final design, replace the approved SWMP, or otherwise expand or contract the scope of the approved project. A revised SWMP and any revised supporting documents must be submitted to Denver for review. Major modifications are not effective until approved by Denver. Payment of additional review and acreage fees is also required.

2. Minor Modifications. Minor modifications are changes to the SWMP that do not increase the scope or change hydrology of the project but modify or improve specific control measures in use at the site, indicate progression in phasing of the project, or specify relocation of previously approved control measures within the project. Minor modifications can be made in the field by the permittee if the permittee can demonstrate that the modified controls are equivalent to, or better than, the originally approved control

measures. Minor modifications must be thoroughly documented in the permittee's SWMP narrative, drawings and specifications and notified to Denver at the proceeding site inspection. If DOTI deems the minor field modification inadequate, the permittee must make specific modifications as directed. Minor modifications are expected and encouraged as part of standard practice for ongoing compliance with requirements for maintenance and operation of control measures and SWMP implementation corresponding with evolving site conditions.

15.8.3 Inspections

Construction site stormwater inspections include an initial site inspection by Denver and mandatory self-inspections by the permittee. Additional inspections by Denver and/or other regulatory authorities may also be conducted. Inspection requirements and responses include:

1. Permittees must contact the appropriate Denver authority, as noted on the CASDP, no less than 48 hours in advance of any site demolition, clearing, grubbing, grading, or excavation activity. The permittee must not commence any such activity until the site passes the initial inspection by Denver.

2. Permittees must ensure self-inspections of the erosion and sediment control measures occur at least once every 7 days and after every significant precipitation event or significant snow melt until such time as permanent non-erosive conditions are established or active disturbance at site is mitigated to the extent that Denver approves a modified/extended inspection schedule. Inspections must be conducted by a Qualified Stormwater Manager[6].

3. If the permittee's self-inspections or an inspection by Denver shows that control measures in the initially approved SWMP are not functioning as intended, the permittee must begin implementing additional or revised control measures and/or other corrective actions immediately. Changes must be documented in the SWMP, with major modifications approved by Denver as described in Section 15.8.2.

4. The permittee must keep a record of inspections. Inspection records must be made available to Denver upon request. Uncontrolled releases of sediment or polluted stormwater or measurable quantities of sediment found off-site must be recorded with a brief explanation describing the measures taken to prevent future releases as well as any measures taken to clean up the sediment that has left the site. Note: documentation of uncontrolled releases at site does not alleviate any state or federal requirements for reporting of discharges or upset conditions. Care should be taken to ensure compliance with all regulatory requirements at site.

[6] A Qualified Stormwater Manager is an individual knowledgeable in the principles and practices of erosion and sediment control and pollution prevention, and with the skills to assess conditions at construction sites that could impact stormwater quality and to assess the effectiveness of stormwater controls implemented to meet the requirements of this permit.

15.9 Compliance Assistance and Enforcement

Denver provides compliance assistance, site inspections, and enforcement actions to reduce the discharge of pollutants from public and private construction sites. The objectives of Denver's Compliance Assistance and Enforcement Policy include:

1. Achieve and maintain voluntary compliance at permitted public and private construction sites at the outset by the establishment of consistent permitting standards to ensure stormwater pollution prevention;
2. Achieve voluntary compliance throughout the duration of the construction project;
3. Require and, whenever necessary, enforce compliance with the terms and conditions of the CASDP and other requirements and;
4. Establish a credible, fair, and equitable "Compliance Assistance and Enforcement Presence" for the regulated community so that non-compliance is deterred.

In the event of noncompliance with the terms and conditions of a CASDP, one or more of the following compliance assistance or enforcement actions may be taken. Escalated enforcement actions may be taken for inadequate control measures resulting in an increase discharge of pollutants, the failure to implement control measures, or illicit discharges have been identified at the site.

1. **Verbal Warning:** This is considered to be advisory in nature. A file notation will be made of the warning.
2. **Compliance Advisory:** This includes written recommendation(s) and/or requirement(s) to remedy potential non-compliance that is non-egregious in nature but may result in impairment to the MS4 or a minor discharge of sediment. Compliance advisories are considered in the determination or establishment of recalcitrant or chronic violators/violations.
3. **Notice of Violation (NOV) with Corrective Order:** This directs field correction of an identified permit violation. The NOV with Corrective Order may be issued for a violation that results in significant potential and/or observed discharges to the MS4 that are non-egregious to egregious in nature. An NOV with Corrective Order will be issued when a permittee is considered to have permit violations that result in overall site conditions that present potential for significant discharge to the MS4 and/or observed discharges to the MS4 that require reasonable remedial action to restore the impaired segment of the MS4.
4. **Notice of Violation (NOV) with Stop Work Order:** This is an order to halt all construction activity on-site except for those activities associated with bringing the project into compliance with the terms and conditions of the CASDP. The NOV/Stop Work Order may be issued if/when the requirements of an NOV with Corrective Order have not been satisfied in a timely manner, site conditions present significant potential for discharge to the MS4, actual discharges to the MS4 are observed, and/or site operators have begun work prior to obtaining a CASDP. Additionally, DOTI may place holds on approvals of permits and/or other inspections pending receipt of proof that the permitted project has been returned to compliance.

5. **Notice of Violation (NOV) with Referral:** This may be issued to permittees with single or multiple permitted projects under active construction that are alleged to be knowingly or willfully operating in non-compliance with the terms and conditions of their CASDP, or when observed discharges are egregious in nature. Pursuant to Section 56-107(b) of the Revised Municipal Code of the City and County of Denver, the City may impose a civil penalty of not more than $10,000 per day during which violation of the conditions and requirements of the permit are occurring and will be assessed after a hearing before the Manager of DOTI. The hearing will be conducted in accordance with DOTI Rules and Regulations Governing Hearings Before the Manager of DOTI.

16.0 References

16.1 Primary References

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16.2 Supplemental References and Additional Resources

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